Clean Tech Handbook for Asia Pacific
May 2010

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Table of Contents

Foreword

This Handbook was initially producd to assess the growth and opportunities in the Clean Technology space in Asia Pacific. The pace and scale at which countries in the Asia Pacific Region such as China and India have set targets, aligned policy with indutsry and then followed through with implementation is breathtaking. This version of the Handbook is focused on renewable energy and power generation and is meant to serve as a reference guideand provide an overview of the region by country and sector.

The author welcomes any comments or suggestions for future editions.

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EXECUTIVE SUMMARY

The Asia Pacific Region (APR) will be the largest Energy Market and Clean Technology Market in the world, by 2030. According to the EIA, the APR will consume over 250 Quadrillion BTU by 2030 and generate 15,000 TWh in power by 2030.

Countries within the APR are already gearing up for the impact of Climate Change by setting aggressive renewable targets. Clean Technology is seen as a growth industry that generates jobs, while reducing carbon emissions and energy security in the process. What is surprising is the speed of change and the level of investment set aside by governments to ensure that countries become world leadrs in this space. According to Thomson Reuters Scientific, China and Japan lead the world in terms of patents filed in Clean Technology and this is re-enforced by the levels of investment by government. For the purpose of the country review, the APR can be divided into four sub regions:

- North Asian countries that include China, Japan, South Korea and Taiwan, These countries are resource poor, leaders in manufacturing and are positioning themselves the be global leaders in this space. North Asia will account for 75% of the total APR power generated in 2010 and thiis expected to increase to over 80% by 2020, mainly driven by China.
- India, while a potentially large market, does not have the level of investment and manufactiuring capability, as its Northern Asian neighbours.
- South East Asia will be as largest as the Indian market in aggregate by 2030. These countries are resource rich and focused on geothermal, hydro and biomass sectors.
- Pacific (Australia and NZ) which are developed, resource rich and highly innovative countries that lead the region in new technologies such as wave, geothermal and CCS technologes.

The Handbook has focused primarily on renewable energy for power generation and technologies to reduce impact from fossil fuels, such as CCS and Clean Coal. In terms of Key Clean Technology sectors, the key sectors fall into the following categories:

- ***Infrastructure***. For a lot of countries in the APR, Clean Technology is simply building new power capacity to keep up with growth. The largest contributors to renewable energy will be Hydro (14%), followed by Nuclear Power (8-9%). Renewable Energy will only account for 4% of total power generation by 2030.
- ***Commoditised Sectors***. Manufacturing of Wind and PV Solar are moving to North Asian countries and in particular China, where there is high quality and there is a significant cost advantage.

- ***Innovation***. Beyond, Wind, Solar and Biomass, countries such as Australia and New Zealnd lead in new sectors, such as Wave/Tidal, Geothermal and CCS.
- Even with all these proposed targets, power generated from fossil fuels will still account for over 70% of the power generation mix by 2030. Other mitigation measures, such as energy efficiency such as CCS will need to be included into projections to reduce the overall energy consumption and emissions in the APR.

1 INTRODUCTION

This Clean Tech Handbook is meant as a reference guide for people interested in investing in the Clean Technology space in the Asia Pacific Region (APR). It provides an overview of the different sectors by geography as well as highlights of the different policies and drivers for each market. The Handbook will:

- Define the Clean Tech market in the Asia Pacific Region by sector and geography
- Size the market opportunity by sector and geography
- Highlight the regulatory framework and the drivers across the Asia Pacific Region
- Highlight the key players within each sector and each geography from new emerging private companies to public companies listed on the stock market
- Looks at the various support structures for Clean Technology from government, private sector funding, academic institutions and highlights key technologies from universities

1.1 What is Clean Technology?

There are many different definitions of Clean Technology or "Clean Tech" for short. Here the term is loosely applied to a number of fragmented technologies that will either replace existing supply of fossil fuels or use energy more efficiently. Part B goes into detail on each sector of the energy markets.

1.2 Why Clean Technology in Asia Pacific?

The basic need for energy to keep up with economic growth will mean that renewable and Clean Technology will be required by countries to manage their energy resources for security, economic and environmental reasons. In addition Clean Technology is seen as a job creator by a key new industry which APR countries plan to dominate. With the breath-taking pace of change in the region, this Handbook will highlight some of the key issues of the APR which will provide impetus for development:

- In some sectors, Clean Technologies in APR could leapfrog the developed markets, particularly in infrastructure as most of the projects will be new
- Governments and large corporations in APR are already leading the Intellectual Property race and are leaders in patent filings (proxy for innovation) for Clean Technology
- Governments have set ambitious Renewable Energy targets to incentivize domestic players. This will accelerate the technology transfer and commoditization of these businesses, as they have done successfully in other markets, such as manufacturing

1.3 Factors driving the Clean Tech Market in Asia Pacific

- ***Largest growing market*** - Increase in growth of APR economies, with a corresponding increase in carbon emissions and need for Clean Technologies. It is expected that APR will make up over 50% of the global emissions and most of the economic growth[1]

- ***Intellectual Property*** - While Asia is seen as a follower of technology, recent research by Thomson Reuters Scientific shows that Asia leads the innovation in Clean Tech with more patents produced than any other region. There will be opportunities for Asian companies to further develop and lead the Clean Tech revolution[2]

- ***High quality/low cost manufacturing*** - In addition, what the last technology boom has shown, is that technology can be adopted quickly in Asia and often leapfrog developed countries, as the infrastructure put in place is new – a key example will be the set-up of utilities and a smart grid. Solar, wind and marine technologies will become quickly commoditised and the move of the move to Asia, where high quality, low cost manufacturing will accelerate – as with other manufacturing sectors such as cars, silicon chips, and computers.

- ***Incentives for technology transfer*** – will further accelerate this transfer[3]

- ***Restricted International Participation*** - In addition, there are also regulatory or protectionist measures in place that may favour domestic players – such as the wind and solar market in China.

- ***Speed of change*** – While US and Europe overcome the credit crisis, with all the factors in place, there will be a much quicker transfer of Clean Technology to APR than many people expect.

1.4 Key Challenges for the Clean Tech Market in Asia Pacific

- ***International Government Support and Policy*** – China and India have already set renewable targets in key sectors which will be the driver for set up of domestic industries that will supply both the domestic and international markets. The Chinese government in particular has used its fiscal policy to inject investment in key sectors such as solar and wind by encouraging lending until the end of 2009 and view this economically, rather than politically. However, without a framework in place this may lead to bilateral deals, thus the expansion of Chinese products may be confined to the region rather than the US and Europe.

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[1] See Figure 2.2, "Primary Energy Demand in Asia"

[2] See Figure 2.6, "Number of Patent Filings in Clean Technology by country" and Section 2.5, "Research & Development"

[3] See Section 2.4, "Targets and Incentives"

- ***Private Sector Funding Framework***- What is missing is a framework which allows new companies to grow: a gap exists in the market for early round investment. The Venture Capital and Private Equity businesses are still a nascent industry, compared with the US and European markets.

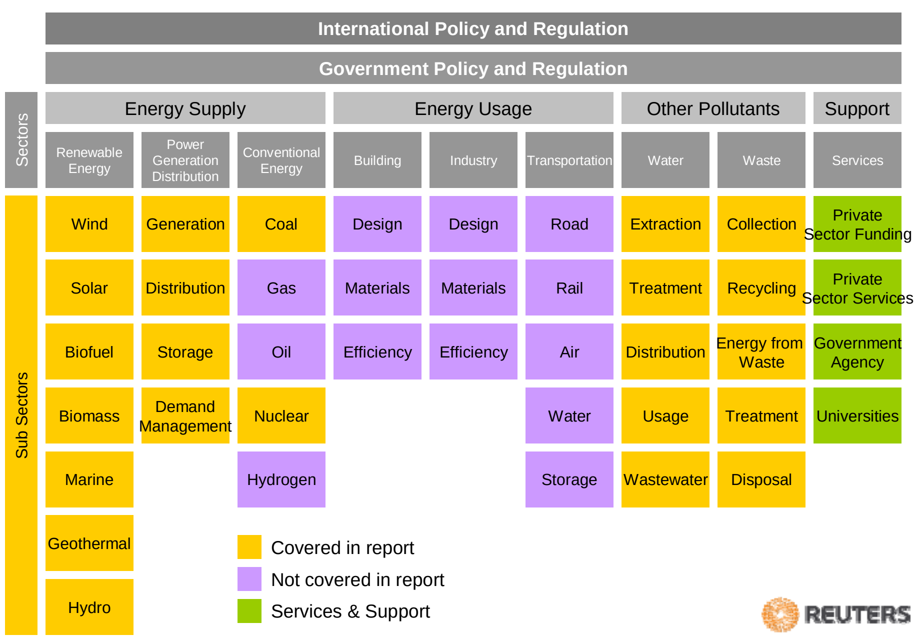
1.5 Who would be interested in this Report?

- Venture Capital and Private Equity Funds and banks interested in which countries, sectors and companies to target their investment
- Government and public institutions
- Financial advisors
- Individual investors

1.6 Structure of the Handbook

While Clean Technology involves many different sector includingenergy efficiency, this version of the Handbook will focus on renewables and other key technologies affecting power generation, notably CCS and Smart Grid.

Figure 1.1 – Asia Pacific Clean Tech Market Map



The Handbook is written in two parts for ease of reference by country or by energy sector:

- ***Part A - Country Review*** – focused on country policy and incentives, such as regulation, renewable energy targets and Feed in Tariffs

- ***Part B – Energy Sector Review*** – focused on the process and supply chain of sector and key companies within each sector

PART A – COUNTRY REVIEW

2 COUNTRY OVERVIEW

2.1 Background

The Asian Pacific Region (APR) can be broken down into four sub regions:

2.1.1 North Asian Countries

China (Section 3.2), Japan (Section 3.3), South Korea (Section 3.4), Taiwan (Section 3.5), Hong Kong (Section 3.6). These five lead the world in engineering and manufacturing, with strong links between government and industry. Additionally North Asian countries are resource poor, therefore are net importers of oil and other commodities, thereby raising the issue of energy security. Clean Technology is viewed as a new strategic industry where there still no dominant companies. Clean Technology has many synergies with existing industries such as electronics for photovoltaic cells (PV) and heavy industry for wind generation. Key characteristics include:

- Leaders in Manufacturing – synergies with existing industries
- Net Importers of energy
- Largest emitters of carbon by country
- Close ties between government and industry means that policy has the potential to be implemented more effectively

2.1.2 South Asia

India (Section 3.7). While India will be the second largest market after China, it does not have the same drivers as it North Asian Colleagues. Key characteristics include:

- Large emerging market, but relatively poor compared with North Asia
- Net importer of energy
- Large emitter of carbon
- Follower of technology andmanufacturing
- Government 5-year planning, but less directive than North Asia

2.1.3 South East Asia

Singapore (Section 3.8), Indonesia (Section 3.9), Malaysia (Section 3.10), Philippines (Section 3.11), Thailand (Section 3.12) and Vietnam (not included). Key characteristics include:

- Large emerging market but still relatively poor compared with North Asia
- Large geography (archipelagos), no infrastructure in place – favour decentralized power system
- Rich in renewable resources
- Follower and importer of technology and manufacturing

2.1.4 Pacific

Australia (Section 3.13) and New Zealand (Section 3.14) are both OECD countries and culturally 'Anglo Saxon' and not Asian. Howvever, due to their geographic location, are part of the APR and will be a key area in Clean Technology, due to:

- Developed countries
- Resource-rich
- Leaders in innovation
- Established capital markets

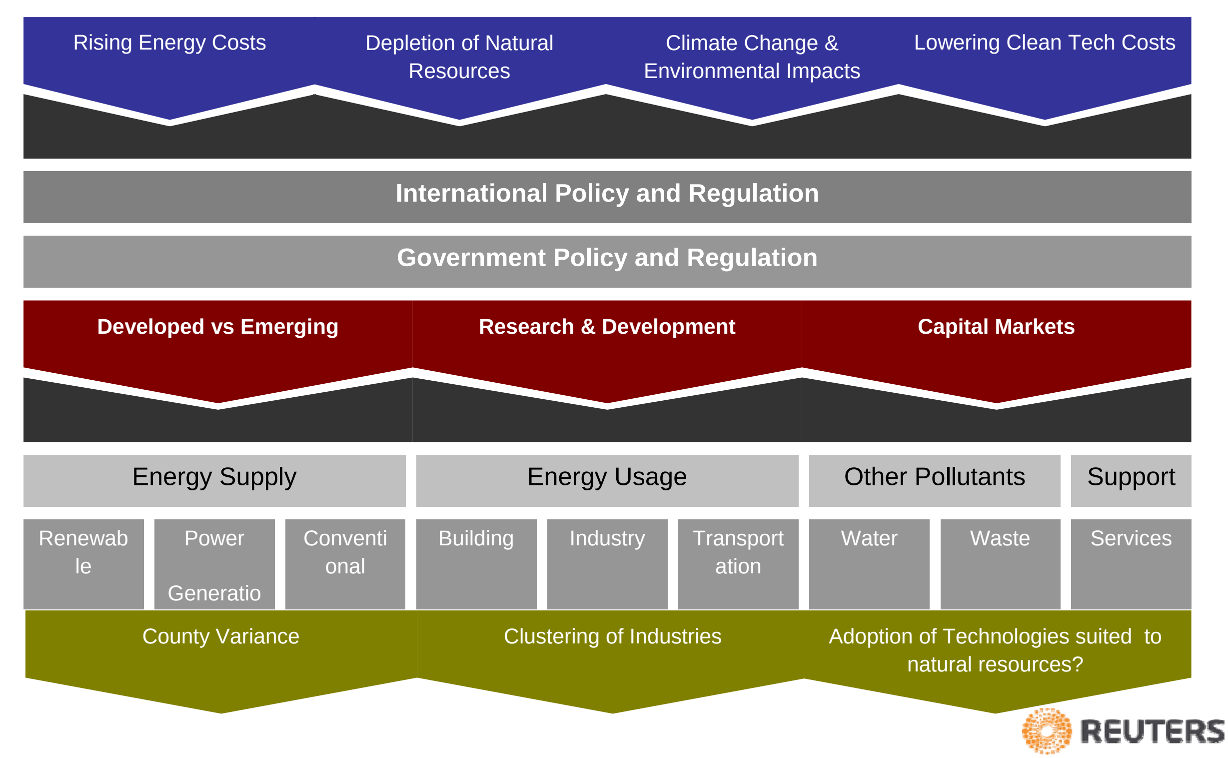
2.1.5 Key Drivers for Clean Tehnology

Key drivers for Clean Technology within these countries include:

- Market Size & Growth
- Policy/Regulation
- Developed vs. Emerging Markets
- R&D/Manufacturing
- Capital Raising

The following figure summarises the motivation, framework, sectors and factors of the Clean Tech market in APR:

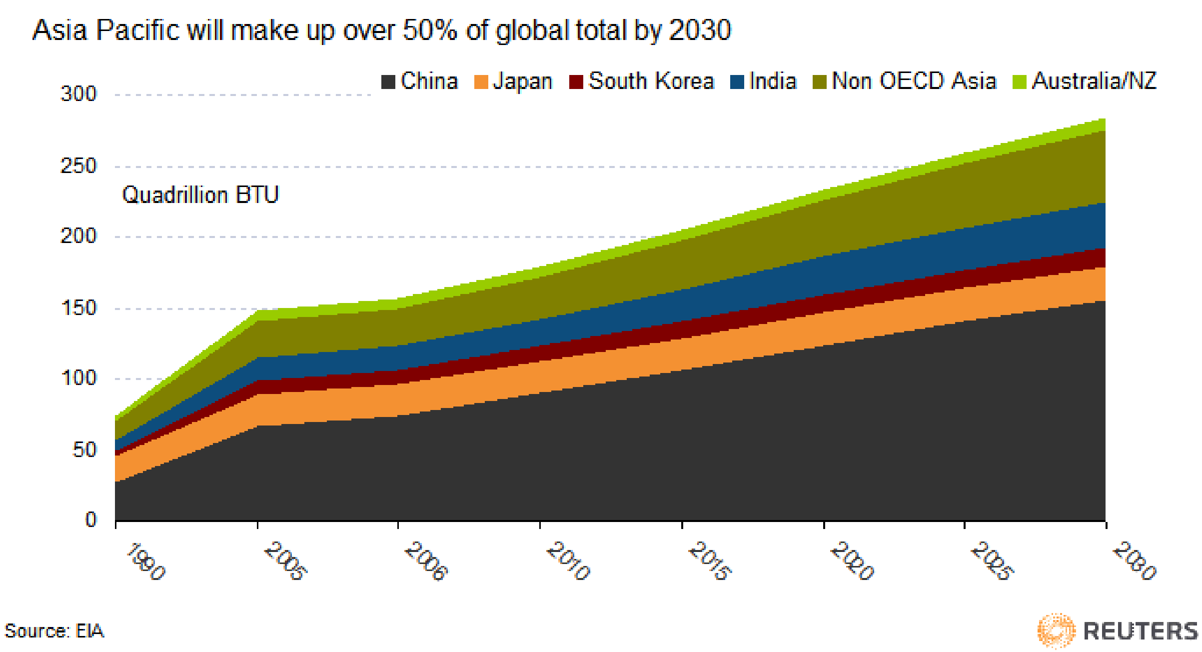
Figure 2.1 Asia Pacific Clean Tech Drivers



2.2 Market Size & Energy Mix

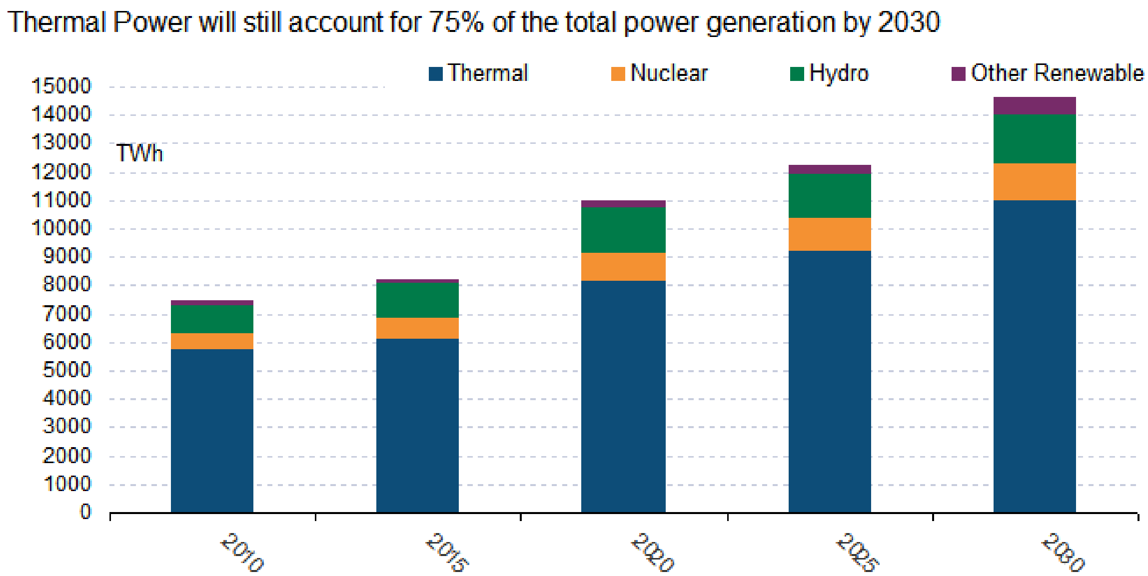
If we look at the potential market sizes for Clean Technology, then the region will contain some of the largest markets, based on energy usage rather than GDP. In 2009, Asia Pacific has three of the top ten countries in installed renewable energy, with around 2,338 TWh by 2030.

Figure 2.2 Primary Energy Demand in Asia Pacific



If growth factors are applied, then APR will account for three of the top five largest energy users globally: China, India and Japan. It is estimated that China will double power generation by 2020 and North Asia will account for over 75% of the total power generation for APR. According to the EIA forecasts, South East Asia in aggregate is projected to be a similar size to India by 2030.

Figure 2.3 Power Generation in Asia Pacific



Source: EIA, IEA, CARMA, Estimates

2.3 Policy and Renewable Regulation

Countries in APR are undergoing a huge transformation in industrialization and urbanization. This will lead to migration from rural areas to cities and thus lead to an increase in demand for power generation in urban areas. While discussions over emissions and setting a price on carbon were not resolved in Copenhagen, APR countries have already embraced Clean Technology and put in place new aggressive targets for 2020. Countries such as China and India understand that they will be some of the most affected countries due to climate change, but politically Clean Technology is an easier sell over a reduction in emissions as it promotes the:

- Creation of strategic domestic industries, that can eventually export internationally
- Taking advantage of the high quality, low cost manufacturing base
- Reduction of energy usage
- Technology transfer and payment of credits

There is a possible risk of allocating too much resource to Clean Tech over emissions targeting, resulting in inefficient deployment of capital by government. If government sets renewable targets which drive investment, then they may misapply investment such as the Feed in Tariff for PV Solar in Germany and Japan. A case for a “Carbon tax” or “Carbon Trading Scheme” is that it internalizes the cost of carbon and thus leaves decision making to the private sector, which in theory should be more efficient.

2.4 Targets & Incentives

Key targets and incentives for Clean Technology have been focused on intermittent wind and solar power which only affect peak loads rather than base load generation. China is already experiencing problems in managing the changes in supply to the grid4. The various ***"Feed in Tariffs" (FiT)*** that are primarily focused on solar and wind may distort the market and exacerbate the problem.

Figure 2.4 – Summary of Renewable Energy Incentives by Country

	Generation TWh 2010/20		RE Targets	FiT	CapEx Subsidy	Tax & VAT Incentive
China	3968	6344	20% by 2020	Yes	na	Yes
Japan	1063	1182	20% by 2020*	Yes	Yes	Yes
Korea	412	537	7% by 2010	Yes	na	na
Taiwan	218	354	12% by 2020	Yes	na	na
India	863	1463	10% by 2012	Yes	Yes	na
Indonesia	180	290	17% by 2025	Yes	Yes	na
Philippines	70	115	2010	2010	Yes	Yes
Thailand	170	260	20% by 2022	Yes	na	na
Malaysia	130	150	5% by 2050	Yes	na	na
Australia	282	300	20% by 2020	State Level	Various	na
NZ	45	50	90% by 2025	Yes	na	na

Source: Government Publications, Thomson Reuters

2.4.1 Feed in Tariffs (FiT)

There are currently around 40 FiT programs to promote and encourage renewable sources, with Germany's FiT solar program held up as the successful model. Asian countries are in the process of applying FiTs, with a summary below:

[4] Thomson Reuters

- ***China*** –has put in place its "***Golden Sun***" scheme to encourage investment in the solar industry. There are plans for a FiT for China, but at the time of writing it is not clear when it will be put in place and whether it will be set at the national level or at the provincial level[5].

- ***Japan*** –has put in place a FiT scheme specifically for grid-connected solar power systems. The initial rate paid to the owners of systems will be around 50 yen per surplus kWh ($55 per MWh) produced. Utilities will be obligated to participate in the scheme. Japan aims to have solar power systems installed on over 70% of new houses and aims to regain its top spot as the largest solar market in the world.[6]

- ***Taiwan*** - The MOEA announced the final FiT scheme for renewable energy at the end of 2009. The tariffs were set at TWD 11.12 (USD 35 cents) per kWh for Photovoltaic (PV) projects and TWD 2.38 (USD 7 cents) per kWh for wind projects[7].

- ***India*** - India's ***Central Electricity Regulatory Commission*** (CERC) in New Delhi announced new regulations for a FiT system for both wind and solar energy on Sepetember 17th, 20098.

- ***Australia*** –does not have a national FiT, but relies on states to set their own rates. Rates range from around 20 to 60 cents per KWh.9

[5] NDRC, Medium and Long Term Development Plans for Renewable Energy
[6] Thomson Reuters, Yomiuri Shimbun
[7] MOEA, Government Publicatiion
[8] Government Publication
[9] Based on Government Publication and Website

Figure 2.5 – Summary of FiTs by Country

	General	Wind	Solar	Biomass	Hydro	Geothermal
China		$0.075/kWh	$0.16-0.22/kWh			
Japan	$0.24/kWh		$0.5/kWh			
Korea	Standard Price					
Taiwan		$0.07/kWh	$0.35/kWh			
India		$0.63-0.89/kWh		$0.57-0.87/kWh	$0.49-0.80/kWh	
Indonesia	$0.07/kWh					% of production cost
Philippines	To be set in 2010					
Thailand	See Breakdown	$0.16/kWh	$0.24/kWh	$0.08/kWh	$0.01-0.02/kWh	
Malaysia	$0.06/kWh					
Australia	$0.40-0.54/kWh					
NZ						

Source: Government Publications, Thomson Reuters

REUTERS

2.4.2 Baseload Power Generation

Factors such as the move to the electric vehicle will put further pressure on base load power generation. Currently the primary energy source for base load power generation in APR is still coal, which still accounts for over 70% of the total power generation in China, India and

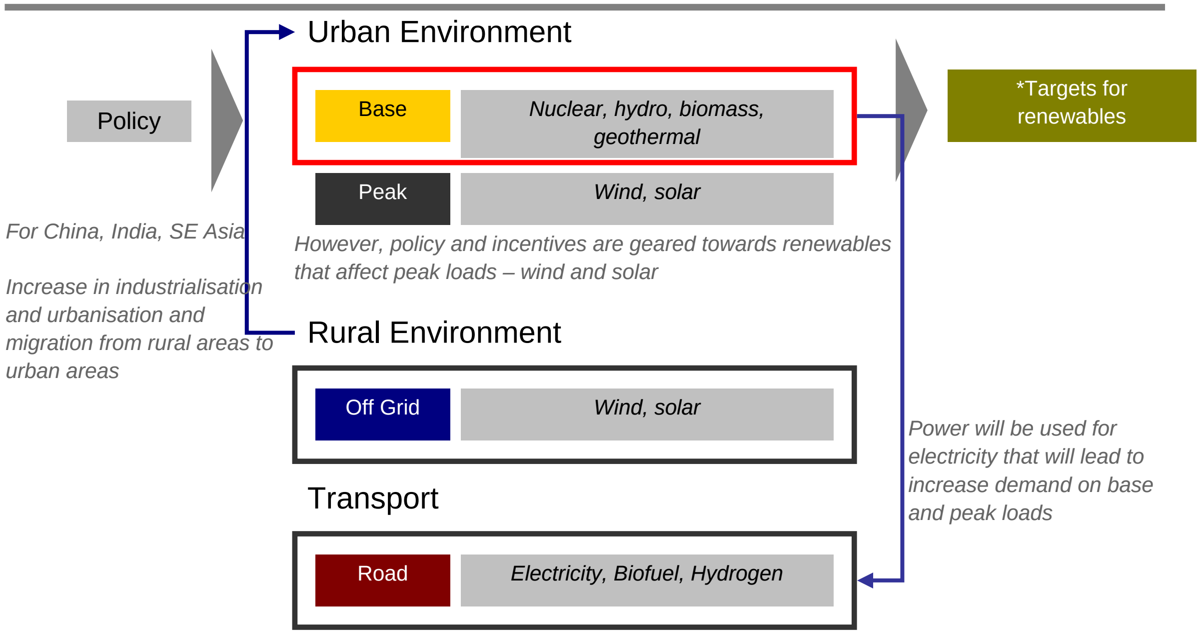
Australia. Addressing how to reduce reliance on coal for baseload power generation will be key to addressing the issues of carbon emissions in the APR.

A key driver for Clean Technology should be to increase renewable targets for the generation of base load power instead of just the peak load.

Short term investment and targets should be focused on renewables (or non-fossil), such as nuclear, hydro, biomass and geothermal which can provide reliable base load power.

Key targets and incentives for Clean Technology have been focused on intermittent wind and power, that only affect peak load, rather than base load generation. China is already experiencing problem is managing the changes in supply to the grid. The various Feed in Tariffs (FiT) that are primarily focused on solar and wind, may distort the market and exacerbate the problem.

Figure 2.6 Policy and Incentives



In Asia, countries such as China, India and SE Asia are undergoing huge transformation in urbanisation
Policy is focused on renewable targets that affect baseload and there is a focus on nuclear, hydro, geothermal and biomass that represent the major short term solutions

REUTERS

Power Generation in Asia

	2010					2020				
	Generation (TWh)	Capacity (GW)	Thermal	Nuclear	Renewable	Generation (TWh)	Capacity (GW)	Thermal	Nuclear	Renewable
China	3968	801	81.22%	1.64%	17.14%	6344	1116	76.41%	4.51%	19.08%
Japan	1063	253	61.84%	27.37%	10.79%	1182	260	59.23%	29.27%	11.50%
South Korea	412	70	64.32%	34.47%	1.21%	537	87	58.24%	39.33%	2.43%
Taiwan	218		75.23%	17.40%	7.37%	354		77.99%	16.38%	5.63%
India	863	177	77.29%	4.29%	18.42%	1463	247	71.79%	8.15%	20.06%
Indonesia	180		85.85%	0.00%	14.16%	290		87.17%	0.00%	12.83%
Malaysia	110		81.85%	0.00%	18.16%	150		76.91%	0.00%	23.09%
Philippines	70		62.83%	0.00%	37.17%	115		65.96%	0.00%	34.04%
Thailand	170		93.51%	0.00%	6.50%	260		94.33%	0.00%	5.67%
Australia	282		90.70%	0.00%	9.31%	300		89.74%	0.00%	10.26%
New Zealand	45		27.00%	0.00%	73.01%	50		26.21%	0.00%	73.79%

Source: EIA, IEA, CARMA, BP Statistics, Estimates

The key driver for power generation is cost. In the absence of an ‘internalised’ Carbon Price, coal is the still the cheapest source of power generation, followed by Natural Gas and Nuclear. The following section highlights and compares the cost and intermittency of generation from renewable sources. Some technologies such as Wave technology are still 4-5 times more expensive than coal and are thus still mot commercially viable.

The cost of power generation will vary by country and power station. Costs for power generation can be broken down into:

- Capital Costs;
- Operation & Maintenance; and
- Fuel Costs

Based on the 2005 IEA study, the average generation costs for different types of power stations (based on 5% discount rate) are:

A) By Conventional Power:

(i) Baseload generation

- Coal fired power station generation costs range between 25 and 50 USD/MWh

- Natural Gas fired power station generation costs range between 37 USD/MWh and 60 USD/MWh

B) By Renewable Energy:

(i) Baseload generation

- ***Nuclear*** power station generation costs range 21 and 31 USD/MWh

- ***Biomass*** - generating electricity range between 25 and 65 USD/MWh for most Combined Heat and Power plants (CHP) but reaches more than 120 USD/MWh for the small biomass-fuelled plant.

- ***Waste to Energy and Landfill Gas*** – generating electricity ranges from negative values (service value of burning waste) to around 24 USD/MWh

- ***Geothermal*** - generating electricity are 27.1 USD/MWh. Although this is based on one plant in the US and the cost are much higher for other technologies and can reach 100 USD/MWh for geothermal in Australia

- ***Hydroelectricity*** - generation costs range between some 40 and 80 USD/MWh for all plants except in Japan where they reach more than 140 USD/MWh.

(ii) Peak generation

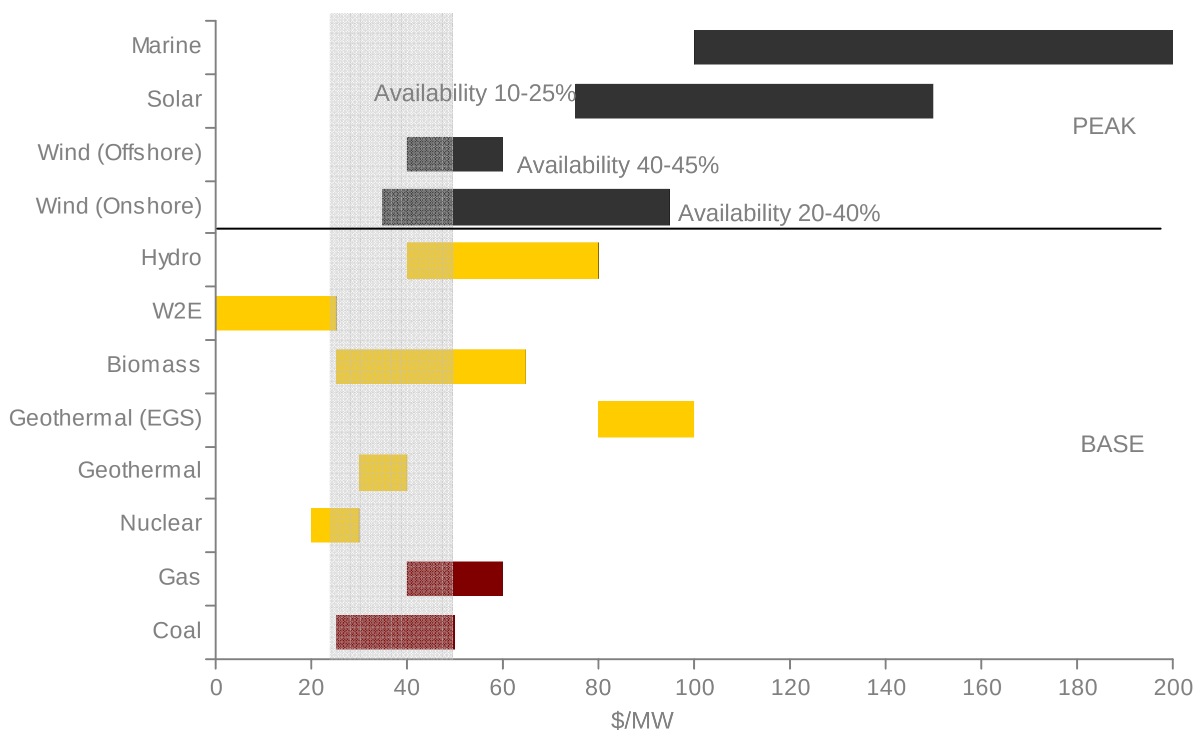
- ***Wind-generation*** costs for the wind power plants considered in the study range between 35 and 95 USD/MWh, but for a large number of plants the costs are below 60 USD/MWh.

However, costs have fallen in recent years and should be in the lower range. The main issue for wind is intermittency and availability/capacity factors of wind power range between 17% and 38% for onshore plants, and between 40% and 45% for offshore plants and cannot be use for baseload power.

- ***Solar-generation*** costs of electricity were around 150 USD/MWh in 2005 and have fallen drastically, whereas they are now commercially viable without FiT subsidies at certain times in the day in sunny locations such as the Mediterranean and California. Solar also suffers from intermittency issues, with availability/capacity factors reported for solar plants varying from 9% to 24% for the solar PV plants.

- ***Wave/Tidal Technology*** – generating electricity is still in it pilot scheme: costs can reach up to 225 USD/MWh.

Figure 2.7 - Cost of Generation



Source: IEA. Estimate

2.4.3 Clean Development Mechanism Projects (CDM)

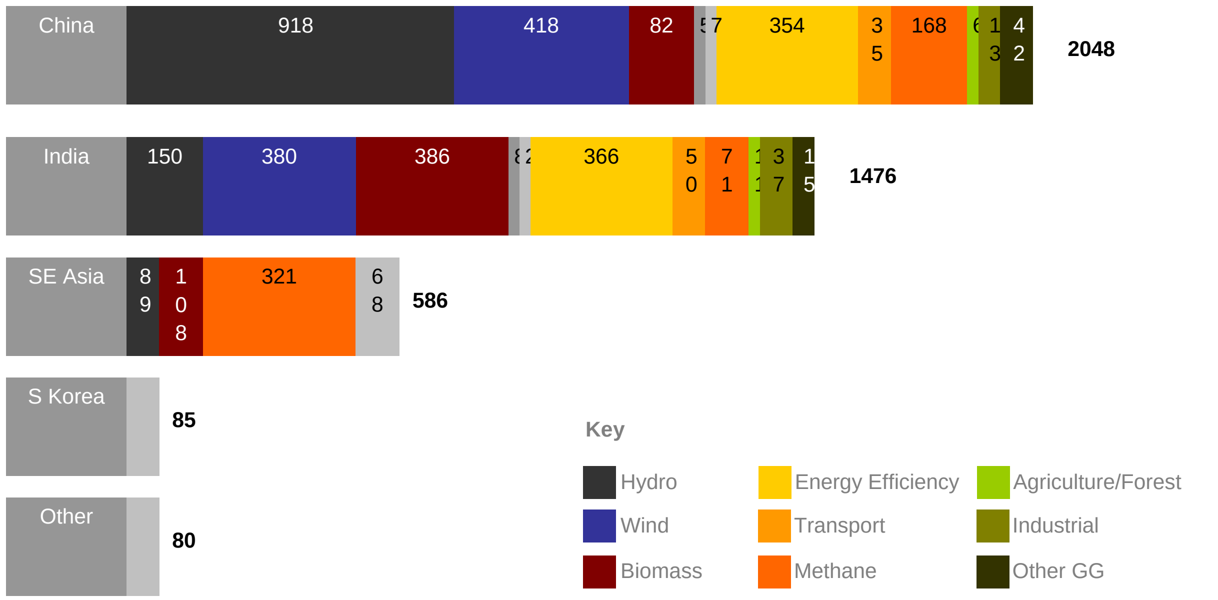
In the absence of a Carbon Price, CDM plays a key role in subsidising renewable energy for many non Annex I countries in the APR[10]. CDM has been an additional incentive for Non Annex 1 countries[11] to generate additional revenues and encourage the generation of renewable energy.

Asia accounts for over three quarters of all 5,516 CDM projects globally. China and India are the two largest markets globally, with 2,048 and 1,477 projects respectively. China's projects are focused on hydro, wind, biomass, EE and coal bed methane projects, while India is biomass, wind and EE projects.

While no other country comes close to China and India - South East Asia - Indonesia, Malaysia, Thailand, and Vietnam- is the other sub region that accounts for the other major source of CDM credits.

[10] Annex I of the FCCC lists the countries who were members of the OECD in 1992, 11 countries undergoing the process of transition to a market economy, and the European Economic Community. Annex I parties are committed to adopt national policies and take measures to mitigate climate change.

Figure 2.8 - CDM Projects in Asia



China and India dominate the CDM projects globally and in Asia

China is dominated by hydro, wind and energy efficiency projects

Renewables make up over 50% of CDM projects

Source: UNFCC

Due to the muted response at Copenhagen the question is now, “What next?” CDM is viewed as time consuming, project specific and thus not scalable. There are attempts to move to sector specific targets that will allow for quicker adoption of standards and best practice and thus an ability to scale more quickly. Other discussions concern a developed country fund to finance key technologies through some form of ***Foreign Direct Investment*** (FDI), although there could be strings attached – such as funding of developed country technologies to be used in developing countries. Developed countries, such as Japan already employ such tactics in its dealing with developing countries and this approach is sure to increase.

2.5 Research & Development

Another key driver is the Research and Development in the Clean Technology market. In APR, this tends to be dominated in the northern Asian countries – Japan, Korea, Taiwan and China because they are closely aligned to their existing manufacturing expertise. It is also interesting to note that governments have taken initiatives such as regulation, subsidies and fostering the development of domestic Clean Technology industries – for example, solar in Japan, solar and wind in China – even at the expense of technologies that are more aligned with countries’ natural resources. For instance, Japan has abundant wind, wave and geothermal resources, yet subsidizes and promotes the solar industry at the expense of other more suitable technologies. In some ways, this close integration between government policy and industry – will act as the key driver for these northern Asian countries.

A study was undertaken by Thomson Reuters Scientific on patent filings in the renewable sector and a comparison between 1997-1999 and 2006-2008. This study included 12,000 filings and focused on the three main renewable sectors, namely: wind, solar and marine technologies. Patent filings are an indicator of research and development in sector and "statement of intent" by a country or company to invest in a particular industry.

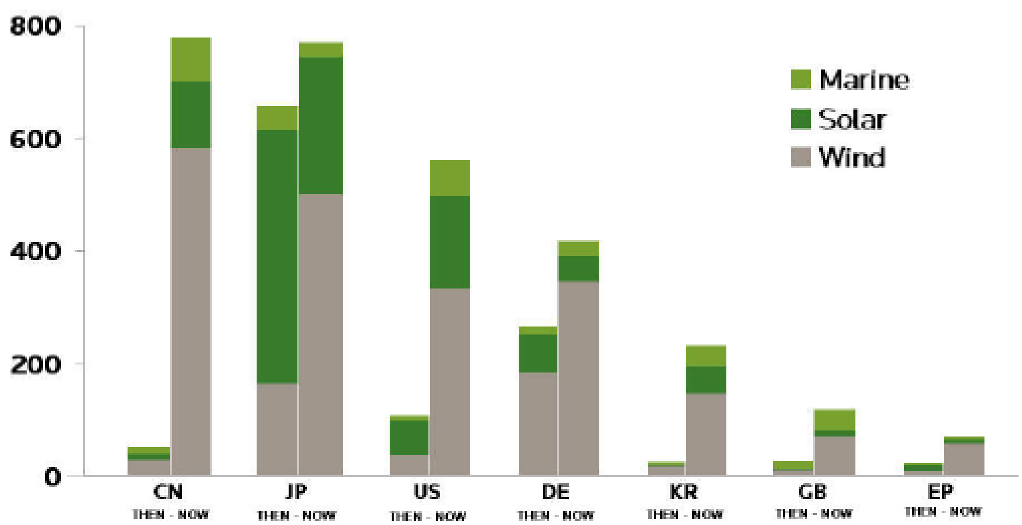
China, Japan and Korea are the leaders of such filings globally which is bourne out by their respective positions in the wind, solar and marine sectors. It is also interesting to note India's comparative weakness in this area.

- ***China*** - It may be a surprise to see China listed first, but Chinese inventions are increasing rapidly in almost every field. All 3 areas of wind, solar and marine are represented currently, with wind dominating. It is also ironic for a country that has in the past paid little respect to Intellectual Property Rights in its domestic market, should now file so many patents in the international markets to protect its own intellectual property

- ***Japan*** - The number of Japanese inventions is high and holding fairly steady. What is notable is a switch in emphasis from solar to wind, as well as a decrease in marine technology

- ***Korea*** - Korean inventions are taking off rapidly, but are still far below China and Japan. Wind energy predominates.

Figure 2.9 Number of Patent Filings in Clean Technology by country



Source: Thomson Reuters Scientific

2.6 Financing

2.6.1 Public Funding

Countries in Asia Pacific recognize the importance of Clean Technology, as a driver for growth and have set aside funds to promote the development of their own domestic industries. Key countries include:

- ***Japan*** – now spends around 3 to 3.5% of GDP on R&D. Several funds and initiatives have been set up to promote R&D in Clean Technology via NEDO and AIST. METI has a budget of JPY500 billion (USD 5 billion), which it disburses to a range of agencies, universities, public research organisations and the not-for-profit sector for R&D.

- ***South Korea*** - will invest KRW 107 trillion (USD 96 mm) over the next five years in solar projects, energy-saving lighting, hybrid cars and other commercially viable, environmentally friendly businesses, its presidential office has announced. The Korean government will invest 2% of GDP annually in renewable energy from 2009 to 2013.

- ***Singapore*** - has embarked on a comprehensive and ambitious program to become a Clean Tech hub for Asia. Through the Economic Development Board (EDB), it has allocated SGD$1 billion (USD 727 mm), as part of its Sustainable Blueprint for 2030. In addition, it has set aside SGD$680 million (USD 494 mm) in Clean Energy (SGD$350m) and environment and water (SGD$330m).

- ***Philippines*** - The Department of Energy (DoE) has awarded 87 contracts to 18 companies to harness renewable energy in November 2009, investing a total of P90.4 billion (US$ 1.9 billion)

- ***Thailand*** - The World Bank said it plans to offer Thailand USD 700m for its clean energy projects and to boost energy efficiency.

- ***Australia*** - The Renewable Energy Development Initiative was a $100 million fund to supporting renewable energy innovation and commercialisation.

2.6.2 Private Funding

- ***Australia*** - COAL21 Fund is raising more than AUD 1 billion over 10 years from a voluntary levy on black coal production to support the pre-commercial demonstration of low emissions technologies in the power generation sector.

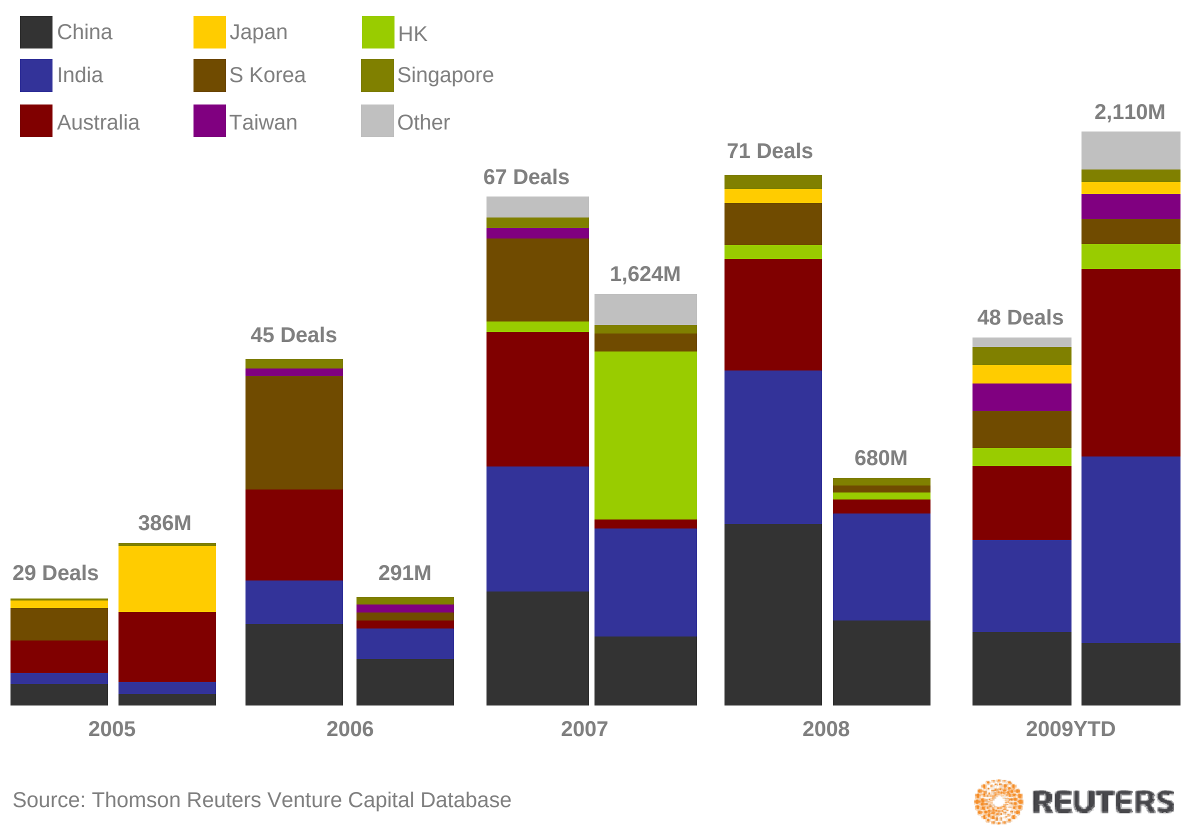
2.6.3 Private Equity/Venture Capital

The traditional Asian model of governments working into tandem with large corporations means that a lot of R&D and hence investment falls within large corporations – rather than via small and emerging venture capital backed ventures.

China, India and Australia lead the Venture Capital and Private Equity deals in Asia Pacific. The notable laggard is Japan, where it is a leader in research and development and Intellectual Property, but no way of accessing and leveraging that knowledge.

Also note that there are significant restrictions for Venture Capital funds to have a licence in China. The Chinese Government only granted a licence to an Israeli fund this year to start a fund in China. All other investments to date have been in joint venture with local partners.

Figure 2.10 - VC/PE Clean Tech Deals in Asia

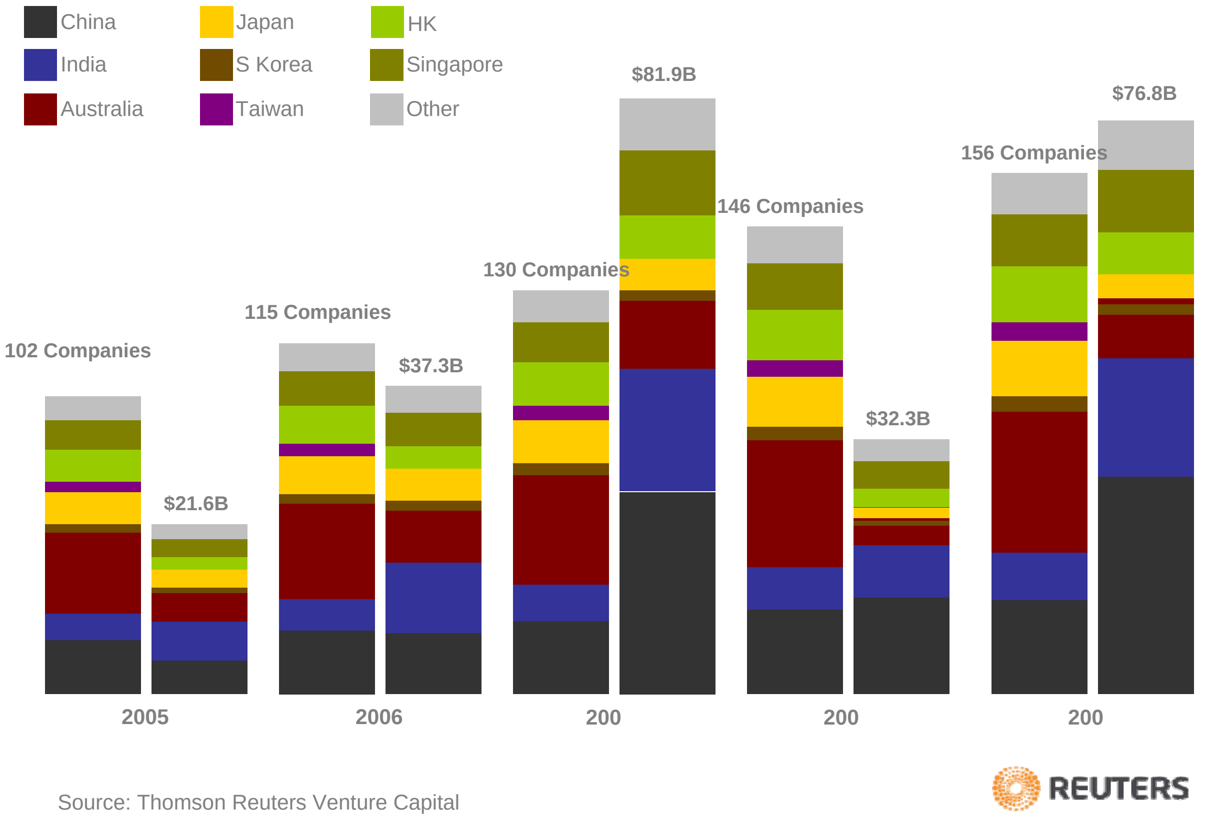


2.6.4 Public Companies

Only the ASX has defined companies in the Clean Tech sector and lists 73 companies in the Clean Tech sector. For other exchanges, Clean Tech companies fall into a number of different sectors – environmental sector services, industrial engineering (wind, marine), and semi conductors (solar)

China has multiple listings for many of its companies on the US and HK Stock exchanges, as a way to allow Chinese companies to access foreign capital.

Figure 2.11 – Public Clean Tech Companies in Asia

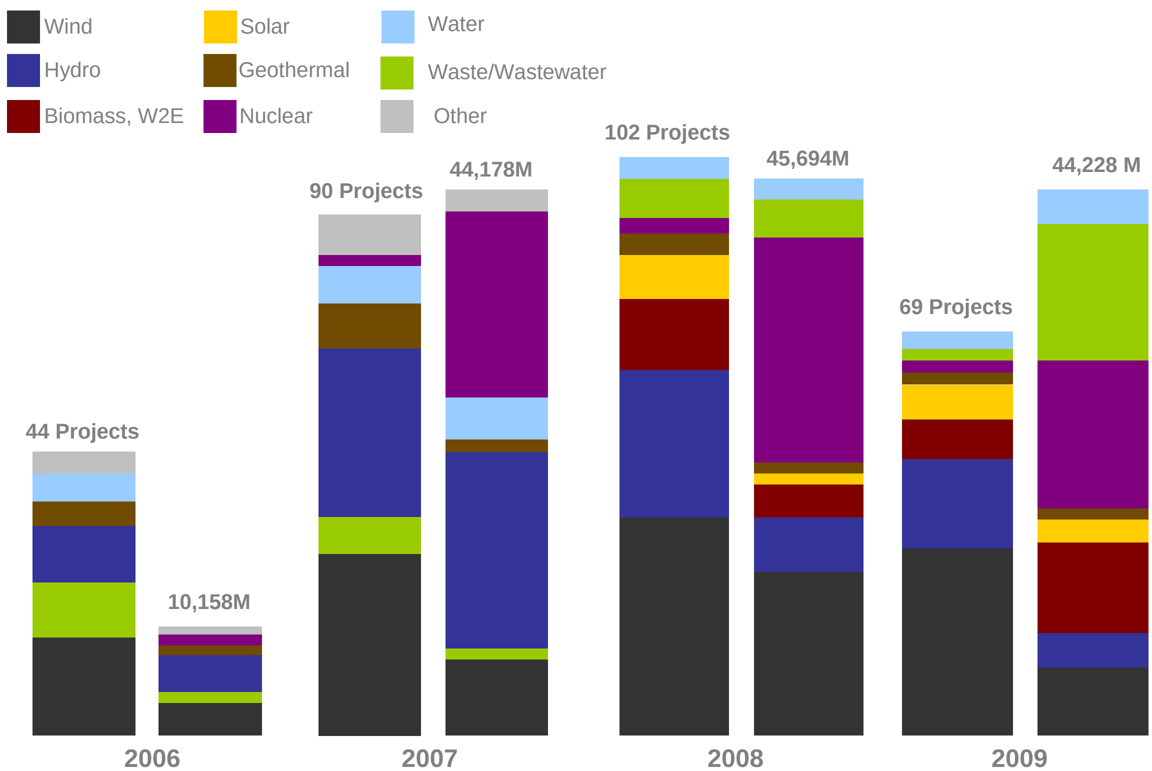


Source: Thomson Reuters Venture Capital

2.6.5 Project Financing

A significant proportion of Renewable Energy projects are large scale infrastructure projects funded by project finance. There was a slight decrease in amount of project finance in Clean Technology in 2009 compared with 2008. The projects were in Nuclear, Hydro, Biomass and Wind technologies.

Figure 2.12 Project Finance Deals in Asia PacificSector



Source: Thomson Reuters

3 COUNTRY, BY ENERGY SECTOR

3.1 Summary

2009 marked a point in time when APR countries recognized the importance of clean energy in terms of energy security, reduction in carbon emissions and growth of a new industry. This has lead to the announcement of new renewable energy targets and Feed-in-Tariffs.

3.2 China

3.2.1 Background

China is expected to announce a new set of aggressive renewable targets, as part of the 12th Plan and raise targets to 20% of total usage by 2020. Encouraged by its "***Made in China***" fiscal stimulus in 2009, China views Clean Technology as key to:

- Growth of a new strategic domestic industry;
- Energy security and reduce reliance on imported energy sources; and
- Combat growing carbon emissions and reduction in energy intensity

China has made progress in laying a foundation for the future growth of green technologies and has rapidly emerged as one of the world's leading providers in key sectors, most notably wind and solar. It is also taking significant steps to use energy resources more efficiently.

3.2.2 Market Size and Energy Mix

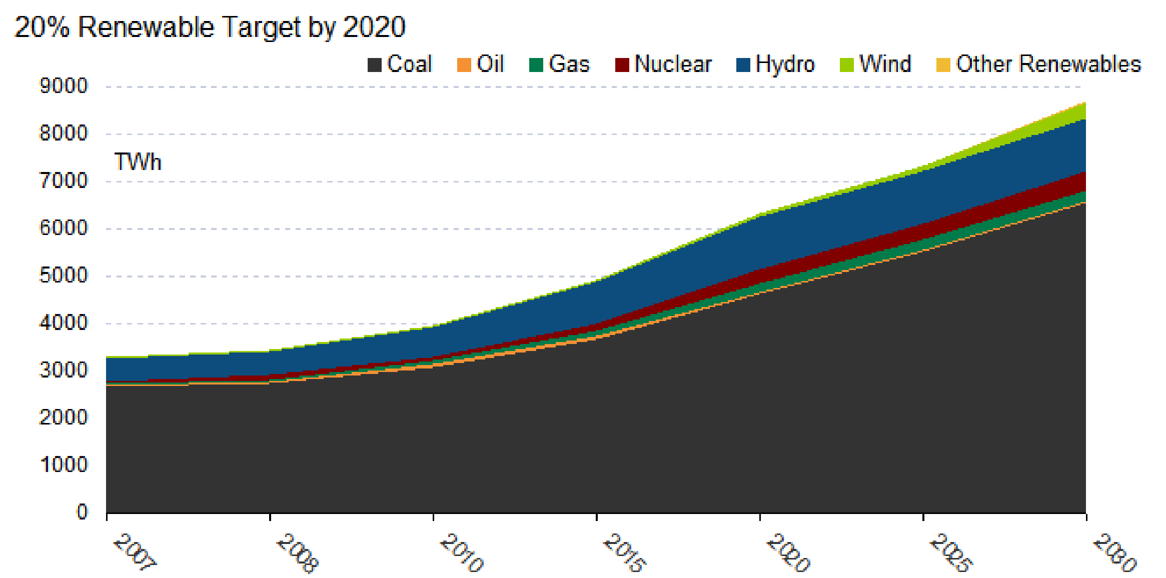
Primary Energy Demand

Based on the EIA international outlook for 2009, China's energy usage is expected to grow to 155 Quadrillion BTU by 2030 and account for nearly a quarter of the world's energy usage. Coal usage will make up 63% of China's total energy mix and 80% of its power generation.

Electricity Demand

Coal makes up 80% of China's power generation and is expected remain the major source of power generation for the foreseeable future. However, the EIA projections do not include the latest changes in renewable targets, such as the 100GW target for wind (40GW assumed) and 30GW target for PV (4GW assumed).

Figure 3.1 China Power Generation Mix



Source: EIA, IEA, BP Statistics, CARMA, Estimates

REUTERS

Gasoline/Diesel Demand

According to the EIA, demand for Gasoline is around 67.5 million tonnes in 2007 and 150 million tonnes for diesel.

China has a target of 10 million tonnes for ethanol and 2 million tonnes for biodiesel by 2020.

3.2.3 Government Agencies

China's national government develops targets, guidelines and regulations, while there are provincial and local governments that are involved in the implementation of these regulations and policies. A summary of key agencies involved in Clean Technology are:

- ***National People's Congress*** (NPC) is the country's highest legislative body and responsible for formulating China's laws as well as approving and tracking implementation of China's Five Year Guidelines for Economic and Social Development
- The ***State Council*** is China's highest executive body, and takes direction from the NPC. The State Council enacts key government regulations and coordinates the activities of China's various ministries.
- ***National Development and Reform Commission*** *(NDRC)* established the policy document for the medium (2010) and long term (2020) development plan for Renewable Energy in China. Plays a key role in developing and implementing Five-Year Guidelines

- ***National Energy Commission*** *(NEC).* The Chinese government has set up the NEC in January 2010 as the highest level state agency to manage energy issues and co-ordinate overall planning between ministries.

- ***National Energy Authority*** *(NEA)* is the main energy regulator and currently drafting the energy planning during the period 2011 to 2015.

- ***Ministry of Environment Protection*** (MEP). Responsible for China's overall environmental management. Sets pollution as well as energy and resource efficiency standards

- ***China Atomic Energy Authority*** *(CAEA).* Under the control of the Commission for Science, Technology & Industry for National Defence under the State Council of Ministers, the CAEA (www.caea.gov.cn) is responsible for planning and managing the peaceful use of nuclear energy and promoting international cooperation. Since being split from the old China National Nuclear Corporation (CNNC) in 1998, CAEA has been the key body planning and managing civil nuclear energy and reviewing and approving feasibility studies for new plants.

3.2.4 Clean Technology Regulation

Clean Technology

- ***12th Five Year Plan****.* China makes use of its national five year programs for Economic and Social Development to respond to policy and drive through new renewable targets through the China's National People's Congress. China is in its 11th Plan (2005 to 2010) and in the process of outlining targets for the 12th Plan in 2010. Based on comments from reports, it appears that renewable targets for the 12th Plan will be significantly increased to position China as a world leader in Clean Technology. Updated renewable targets are shown in Section 3.2.5, below.

- ***Draft Energy Law****.* China drafted the Energy Law in 2006 and submitted to the Legislative Affairs Office of the State Council in February 2009. The Law will need to be submitted to the National People's Congress and is expected to come into force in 2010.

Renewable Energy Law

The Renewable Energy Law, which came into effect 1 January 2006, outlines provisions on public funding for renewable energy development, discounted lending and tax preferences and connection of renewable generation to China's electricity grid.

Under the law, grid operators are required to purchase all electricity generated from renewable energy sources within their domain or compensate renewable energy producers for their losses.

China's legislature is amending the law to set a minimum annual quota that power grid operators must purchase from renewable energy sources, in an effort to encourage them to buy more electricity from wind farms, solar farms and biomass projects. An amendment was submitted and approved by the NPC in December 2009 require electricity grid companies to buy all the power produced by renewable energy generators.

A renewable energy development fund will be set up to help cover levied surcharges on renewable energy prices.

Medium and Long Term Plans

"Medium and Long-Term Plans" are policy planning tools used by China's regulators, providing cross-ministry policy guidance for 10-20 year periods and complementing the more detailed five-year plans. Recent plans include ***Energy Development*** (2004-2020) and ***Renewable Energy Development*** (2007-2020)

Local Government

Provincial and local governments play an important role in regulating China's cleantech policies. Most central government agencies have corresponding bodies at local levels that are commonly tasked with implementing the policies of the central regulators, yet this interaction can often lead to discrepancies between central government policy and local implementation, as provinces vie to establish themselves the leading region for Clean Technology.

3.2.5 Renewable Targets & Incentives

As part of the 12th Plan, China is expected to increase its renewable target to 20% by 2020. This will include target increases in key Clean Technology sectors, including: wind, solar, hydroelectricity and nuclear.

Chinese Renewable Targets

Year	2005	2010	2020
Renewable Target	7%	10%	20%
Hydro	117GW	190GW	300GW
Wind	1.3GW	10GW	100GW
Solar PV	0.07GW	0.3GW	20GW
Solar Water Heating	80 Mm^2	150 Mm^2	300 Mm^2
Biomass	2GW	5.5GW	30GW
Nuclear	7GW	9GW	60GW
Bioethanol	1 MT	3 MT	10 MT
Biodiesel	0.05 MT	0.2 MT	2 MT
Biomass Pellets	0	1MT	50 MT
Biogas and biomass gasification	8 billion m3/year	19 billion m3/year	44 billion m3/year

Source: NDRC, Medium and Long Term Development Plans for Renewable Energy, EIA, IEA, GWC, WNA, World Energy Council, Government Publications, Thomson Reuters

- ***Hydro***. China plans to double its existing power generating hydroelectric capacity from about 150 GW to 300 GW by 2020, primarily through large scale hydro projects, such as Three Gorges Dam.

- ***Wind.*** China is expected to increase its 2020 target from 10GW (which it has already exceeded) to 100GW by 2020. In addition, there is a new Feed in Tariff in place since August 2009 to encourage wind power to the grid.

- ***Solar.*** China has introduced government subsidies and encourages investment in the growth of domestic solar market in 2009. From a market of virtually zero (150 MW in 2008), China is expected to increase targets in PV solar to 20GW by 2020.

- ***Solar Water Heating***. One area of renewable energy in which China has emerged as an unchallenged leader is solar water heating. Currently, China boasts the world's largest installed base of solar water heaters, over 125 millions m^2, with one in ten families having adopted the technology. Analysts estimate that over 95% of core solar water heating technology is held by Chinese firms, such as Himin Solar Energy Group. China's annual production of solar water heaters in 2007 reached 40 million m^2, accounting for two thirds of global output.

- ***Nuclear***. Nuclear projections are 60GW installed capacity by 2020, with 20 Nuclear Power stations under construction. In addition, a further statement from the State Council in 2009 is considering raising the 2020 target to 86 GW installed.

- ***Biomass.*** China has increased it biomass target to 30GW, primarily through cogeneration of agricultural waste and waste to energy projects.

- ***Biofuels.*** China has put in place a 10 million tonnes annual target for ethanol and 2 million tonnes target for biodiesel. However, the government has also put in place a ban on biofuels generated from grains & oilseeds and this limit the ability to produce biofuels domestically.

Feed in Tariffs (FiT)

China has put in place its ***Golden Sun*** scheme to encourage investment in the solar industry and has recently put in place a FiT for onshore wind for four regions. There are plans for a FiT for China, but it is not clear, when it will be put in place and if it will be set at National level or at a provincial level. Current FiTs in place include:

- ***Wind***. China has set a fixed FiT for new onshore wind power plants in a move to increase wind capacity. The NDRC announced in 2009, four levels of onshore wind projects, which according to region will be able to apply for the tariffs. Areas with bs2

- ***Solar***. The Golden Sun subsidy was aimed at residential installations. There are also plans for FiTs for large scale solar installations, expected to be between 1.09 yuan and 1.5 yuan (US $0.16-0.22) per kWh of electricity produced at large-scale photovoltaic (PV) arrays.

Key Subsidies for Clean Tech in China

Subsidy	Date	Amount	Comment
Large Scale Solar FiT	Tbc	• 1.09 to 1.5 yuan per kWh	• Large scale solar arrays
Wind Power Feed in Tariff	August 2009	• 0.51 to 0.61 yuan per kWh	• FiT for Wind
Golden Sun	July 2009	• 50% of grid connected investment • 70% of off grid investment	• 300kW min capacity • 1 year construction • 20+ year operation
Solar Roofs	March 2009	• 15-20 yuan per watt	• New construction • 50kW installation
PHEV/EV/FC	January 2009	• 28-600k yuan per vehicle	• Fuel saving of at least 5% for passenger vehicles • 10% savings for buses
Wind Turbines	August 2008	• 600 yuan per kW	• Only Chinese turbine manufacturers • 50 split between component suppliers and manufacturers
Biomass Power	July 2008	• Temporary tariff increase by 0.1 yuan/kWh	• Limited feedstock
Coal Bed Methane	April 2007	• 0.2 yuan per m^3	• Methane for consumer and chemical industry

Source: NDRC, Government Publications, Thomson Reuters

Impact of Targets and Incentives

Based on the increased targets, China will install an additional 120GW more Renewable Energy by 2020, compared with EIA assumptions.

Comparison of EIA Assumptions and Government RE Targets

Year	2020 Targets	EIA Assumptions	Difference
Renewable Target	20%	19% (24% with Nuclear)	
Hydro	300GW	310GW	-10GW
Wind	100GW	40GW	60GW
Solar PV	20GW	4GW	16GW
Biomass	30GW	0	30GW
Nuclear	60GW	36GW	24GW
		Total	**120GW**

In order to meet a 20% renewable target by 2020, as proposed by the government, it will require an estimated additional 60 billion kWh (including hydro).

Capacity Requirement to meet 20% Renewable Target by 2020

	Solar	Wind	Geothermal
Renewable Target	26-66GW	16-33GW	7GW

Assumption that solar is 10-25% available, Assumption that wind is 20-40% available, Assumption that wind is 90% available

3.2.6 Research & Development

The central government subsidies R&D on key renewable energy technologies through NDRC and ***Ministry of Science and Technology*** (MoST) and also subsidies local government initiatives. An example is that China has jointly launched the ***Sino-Danish Renewable Energy Development*** program with Denmark to help stimulate clean energy development. The Danish government will provide its sector experience and grant USD 18.3m to the program. In July 2009 it decided to jointly invest USD 15m with the US to establish a Sino-US Clean Energy Research Centre.

3.2.7 Financing

Public Sector Funding

Central government and some local governments provide the investment subsidies for the development of renewable energy through several big national programs, for example, rural small hydropower program, rural household biogas program, and providing subsidies to small scale PV systems and wind systems in remote areas.

Private Sector Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, China leads Asia, in terms of Clean Tech Venture funding, with 12 Deals totaling $147million in 2009. This is down from 2008.

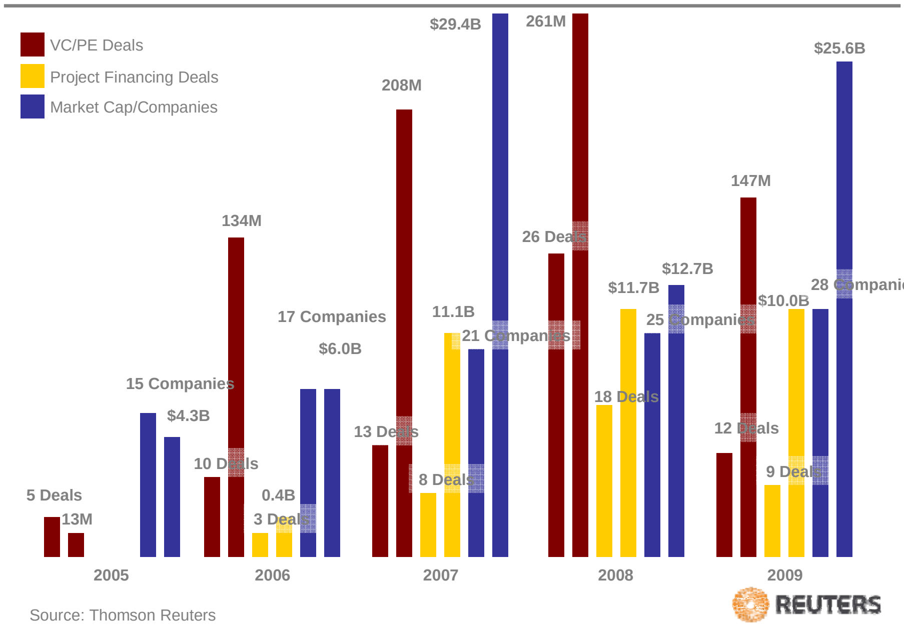
Project Finance

China also leads the number of project finance deals in Asia, with 9 deals amounting to over $10 billion, which was down from 2008.

Public Companies

Most Chinese Companies involved in Clean Tech are listed on the Shanghai and Shenzhen Exchanges, with an inceasing number of companies listed in Hong Kong. There were 28 companies listed on the Shanghai and Shenzhen Stock Exchanges, with a Market Cap of $25.6 billion in 2009.

Figure 3.2 - Private Sector Funding in China



3.3 Japan

3.3.1 Background

Japan is globally the second largest economy, the fifth largest emitter of carbon and along with Chindia, an important player in terms of their energy use. However, unlike China and India, Japan is a Kyoto signatory therefore committed to a carbon emission reduction by 2012.

Japan is one of the leading countries in Clean Technology, with leading companies such as Sharp and Kyocera leading photovoltaic (PV) technology. It is second to China in terms of patent filings in Clean Technology.

3.3.2 Market Size & Energy Mix

Primary Energy Demand

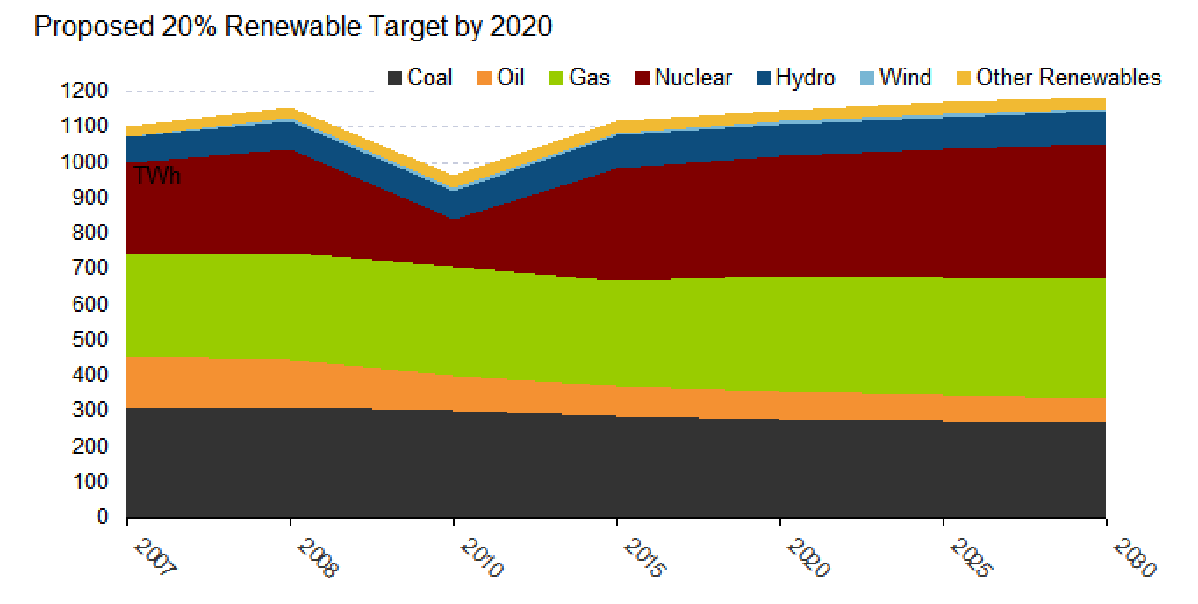
Oil is the most consumed energy resource in Japan, although its share of total energy consumption has declined by about 30 percent since the 1970s. Coal continues to account for a significant share of total energy consumption, although natural gas and nuclear power are increasingly important sources, particularly as Japan pursues environmental policies. Japan is the third largest consumer of nuclear power in the world, after the United States and France. Hydroelectric power and renewable energy account for a relatively small percentage of total energy consumption in the country. Total energy consumption from 2003 to 2030 is forecast to grow by 0.3 percent per year on average, relatively small as compared to China's forecast growth rate of 4.2 percent per year on average, according to EIA data.[12] The total primary energy production was 4.295 Quadrillion Btu in 2006.[13]

Power Generation

Japan has a large proportion of nuclear power with an expected increase to over 40% of the total power generation by 2030.

The various government forecasts do not taken into account recent statements by the government to increase renewables to 20% by 2020, which would also have a substantial impact on the energy mix. However, the Japanese power market is dominated by 10 utilities, which effectively act as regional monopolies and require their support to effectively increase renewable energy targets in Japan.

Figure 3.3 Japan Power Generation Mix



Source: EIA, IEA, BP Statistics, CARMA, Estimates

In order to meet a 20% renewable target by 2020, as proposed by the government, it will require an additional 98 billion kWh (including hydro) to 190 billion kWh (excluding hydro), when compared with EIA forecasts.

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[12] Source: EIA, http://www.eia.doe.gov/emeu/cabs/Japan/Background.html

[13] Source: EIA, http://tonto.eia.doe.gov/country/country_energy_data.cfm?fips=JA

Capacity Requirement to meet 20% Renewable Target by 2020

	Solar	Wind	Geothermal
Renewable Target (excluding Hydro)	86-216GW	54-108GW	24GW
Renewable Target	45-112GW	28-56GW	12.5GW

Assumption that solar is 10-25% available, Assumption that wind is 20-40% available, Assumption that wind is 90% available

Gasoline and Diesel Demand

Demand for gasoline and diesel was 57.5 million KL and 33.7 million KL in 2008, respectively.

As part of the ***Biomass Nippon Strategy***, Japan has a 500,000KL target by 2010 for biofuels (210,000 KL for ethanol and 290,000 KL for biodiesel) that may increase to 6 million KL by 2030 with the use of cellulosic ethanol.

This equates to 0.6% of the total gasoline demand for ethanol and 1.4% of the total diesel demand for biodiesel.

3.3.3 Government Agencies

There are a number of government agencies involved in Clean Technology. The key agencies are summarized below:

Renewables

- ***Ministry of the Environment*** *(MOE).* The Ministry passes the legislation that sets the requirements (standards, bans, etc.) and targets that create the framework for environmental policies. The MOE cooperates on programs with other institutions, such as METI and Ministry of Agriculture on renewable and biofuel policy. The MOE supervises the National Institute for Environmental Studies (NIES), which is focused on Climate Change, Sustainable Material Cycles, Environmental Risk, and the Asian Environment.

- ***Ministry of Economy, Trade and Industry*** *(METI)*. METI is a key driver for innovation in Clean Technology and sees this as an area where Japan can compete globally and act as an engine for growth. METI supplies significant research and development (R&D) budgets and is working on maintaining Japan's leading position in patent applications in Clean Technology, as highlighted in **Section 2.5**.

- ***Agency of Natural Resources and Energy*** *(ANRE)*. As a part of METI, the ANRE deals with; energy conservation policy, and new energy policy.

- ***New Energy and Industrial Technology Development Organization*** *(NEDO).* NEDO is Japan's largest public management organisation promoting R&D as well as the dissemination of industrial, energy and environmental technologies. NEDO's mission is to enhance Japan's industrial competitiveness and address energy and global environmental problems, and its role is to comprehensively coordinate and professionally manage R&D activities.

- ***National Institute of Advanced Industrial Science and Technology*** *(AIST).* AIST is one of the largest independent administrative institutions in Japan. In 2001, 16 research laboratories from the former Agency of Industrial Science and Technology were merged.

- ***Nippon Keidanren***. The mission of Nippon Keidanren is to accelerate growth of Japan's economy via the private sector into one that is sustainable among other stated goals. In 1997, Keidanren business federation adopted its "***Voluntary Action Plan on the Environment***", a commitment to reduce emissions of carbon dioxide by 2010 to a level lower than year 1990. By the year of 2005, 35 industries were engaged in applying measures toward this goal (altogether representing 45% of Japan's total CO_2- emissions in 1990). A follow-up has shown that CO_2 emissions for 2004 were 0.5% lower than in 1990, and the reduction target has been achieved every year since 2000 (Nippon Keidanren, Nov 2005).

Energy Efficiency

- ***The Energy Conservation Centre, Japan*** *(ECCJ)*. The Energy Conservation Centre contributes to promoting the efficient use of energy, protection of the global warming and sustainable development.

3.3.4 Clean Technology Regulation

Renewables

- The ***National Energy Strategy*** *(2006)* focusses on the promotion of energy diversification with the aim to lower the oil demand of the primary energy mix to 40% by 2030. It also aims to increase nuclear power make-up to 30-40% of the total power generation by 2030. There is also a stated goal of improving energy conservation by 30% by 2030.

- ***National Emissions Target***. As part of the Kyoto Protocol, Japan is committed to reducing emissions targets by 6% from 1990 levels. Japan is in the process of agreeing to post 2012 targets.

- ***Biomass Nippon Strategy***. Japan has a target of 500,000KL, as part of the strategy. It also looks at increasing potential supply to 6 million KL by 2030 with the introduction of cellulosic ethanol.

Energy Efficiency

Regional cooperation for energy efficiency. Japan encourages energy efficiency through promoting energy conservation standards and assessment systems by sectors in the Asia-Pacific region. In particular, Japan seeks to establish a regional framework to save energy. The "***Asia Energy and Environmental Cooperation Strategy***" seeks to promote energy conservation by working with other countries in Asia mainly, China and India, given the rapid increase of their energy demand.

3.3.5 Renewable Targets & Incentives

Japan, as a Kyoto signatory, is committed to a 6% decrease from 1990 levels by 2012. With a change in government in 2009, the DPJ has proposed a more aggressive target of 25% on 1990 levels by 2020, which was an increase over 15% reduction on 2005 levels (8% reduction on 1990 levels).

In an interview given to Yomiuri Shimbun, Japanese Environment Minister Sakihito Ozawa stated the government is aiming to introduce a new target for the country's environmental protection effort – 20% renewable energy generation by 2020. The new target will be promoted through a basic bill to be submitted to the ordinary Diet session in 2010.

The new goal is more than 10 times higher than the existing renewable target (1.3%) and twice as high as the one proposed by the Democratic Party of Japan in their manifesto in 2009.

If the bill passes, Japan will be vying for increased solar, wind, marine, hydropower, biomass and other renewable energies in the near future - in line with China and Australia's 20% renewable targets. Japan's renewable energy accounts for 10% of the country's total power production, and excluding hydropower it is about 2%, according to a white paper published by the government.

According to a government estimate, Japan's plan to cut greenhouse gas emissions is expected to boost the nation's share of electricity from nuclear power to 44% from the current 31%.

The government intends to expand power generation capacity from PV by 20 times by 2020, up to 28 million kW. These measures announced in April 2009 are estimated to boost the share of renewables in electricity generation to 6% from the current 1%. Geothermal is a notable absence in the targets set.

Japan Renewable Targets

Year	2008*	2010T	2020T	2030T
Electricity Capacity	251GW	253GW	259GW	255GW
Electricity Generation	1099TWh	1144TWh	1147TWh	1186TWh
Renewable Target	na	1.3%	20%*	
Hydro	13.8GW	13.8GW	13.8GW	
Nuclear	47.5GW		76GW*	
Wind	1.9GW	3GW		
Solar PV	2GW		14GW	
Geothermal	535MW	535MW	535MW	
Biomass		2.6 million KL		20.5 million KL
Bioethanol		210,000KL		6 million KL
Biodiesel		290,000KL		

Source: EIA, IEA, GIA, NWA, Estimates, * Proposed Target

Feed in Tariffs (FiT)

The ***Renewable Portfolio Standard*** (RPS) scheme came into effect in 2003 and covered renewable contributions to the grid. Renewable energy sources included:

- Solar
- Wind
- Biomass Generation
- Small Hydro (up to 1MW)
- Geothermal

The targets set up by METI were 1.35% of the total electricity capacity by 2010. However, due to the monopolistic structure of the power market, there have been ceilings and restrictions imposed by the 10 utilities that have hampered the growth of renewable power.

Solar

After the removal of solar subsidies in 2008, the government launched a net model FiT scheme to increase solar demand, where owners of grid connected solar power systems will be paid a premium rate for surplus electricity generated. The initial rate paid to owners of systems will be around 50 yen per surplus kilowatt hour produced, double the current rate of 24 yen. The premium rate was calculated in order to enable customers who have purchased grid connect systems to recover their initial outlay over 15 years. All electricity utilities in Japan will be required to participate in the scheme. It's expected the additional cost will be passed on to consumers and the government hopes to limit the increase in electricity bills to less than 100 yen per month on average. Japan announced funding of 9 billion yen (USD$100 million) in the first quarter of 2009 for other incentives to encourage home solar power; with further funding to come. Japan aims to have solar power systems installed on over 70% of new houses. The MOE estimated in 2009 that Japan's solar power generation could increase to 37GW by 2020. The study panel concluded that a fixed-price system for the purchase of renewable energy and a RPS would help the country hit a target of 16% to 18% renewable energy generation by 2020 or 9% to 10% excluding large hydro.

Wind

While the RPS has a low target, limited grid access and the monopolistic hold over the power grids by regional utilities have restricted wind contribution. Japan trails China and India in the contribution of wind power to its power generation.

Biomass

Biomass accounted for around 43% of the total RPS in 2008[14]

[14] Agency for Natural Resources and Energy Agency

Restrictions on Wind Power to the Grid

Utility	Capacity	Restriction	%
Tokyo	60GW	No restriction	n/a
Kansai	37GW	No restriction	n/a
Chubu	33GW	No restriction	n/a
Kyushu	19GW	700MW (2006)	3.7%
Tohoku	16GW	520MW (2006)	3.25%
Chugoku	12GW	400MW (2005)	3.3%
Hokuriku	8GW	80MW (2006)	1%
Shikoku	7GW	200MW (2005)	2.9%
Hokkaido	6GW	50MW (2006)	<1%
Okinawa	2GW	25MW (2006)	1.2%

Source: Institute for Sustainable Energy Policy

3.3.6 Research & Development

Japan is a world leader in terms of R&D expenditure, with spending estimated at around 3 to 3.5% of GDP. Several funds and initiatives have been set up to promote the R&D phase of new environmental technologies via NEDO and AIST. METI has a budget of JPY500 billion (3.5 billion Euro), which it disburses to a range of agencies, universities, public research organisations and the not-for-profit sector for R&D. The main focus for METI are: industrial competitive performance, environmental and energy problems.

NEDO promotes research and development across a wide spectrum of technological stages through the following activities:

- National projects (medium- to long-term, high-risk R&D projects);
- Support for practical application by business enterprises;
- Grants to universities and other research organizations for the discovery of technological seeds.

Drawing on the combined efforts of industry, academia and government, NEDO mainly carries out national R&D projects that stimulate the economy through enhanced Japan's industrial competitiveness. It also endeavors to provide solutions to energy and environmental problems.

AIST covers six research fields, i.e. life science & technology, information technology & electronics, nanotechnology, materials & manufacturing, environment & energy, geological survey and applied geoscience, metrology and measurement technology. In particular, AIST is engaged in developing technologies based on sustainable energy having low environmental impact.

Some examples of R&D programs in Japan include:

- ***The Industrial Cluster Policy***. In 2001, Japan launched an Industrial Cluster Policy following the international debate on Clusters and Systems of Innovation. Some of METI's Industrial Clusters relate to environmental themes. Budget is available for industry-academic network formation, technical development, incubator and related facilities for entrepreneurs, and market development and collaboration with financial institutions.
- ***The Eco-town project***. METI and MOE introduced the eco-town initiative in 1997. Financial support by both ministries triggered regional scale initiatives that targeted the effective resource circulation of a full range of by-products based on three industrial ecological principles: (a) the zero emissions concept; (b) principle of 3Rs; and (c) green procurement and EMSs. There are 26 eco-town projects in Japan. There are also efforts to promote cooperation among eco-towns through clustering.
- ***Biomass-towns***. As part of the Nippon Biomass Strategy, the government planned to launch 300 biomass towns by 2010.

3.3.7 Financing

Public Sector Funding

The Japanese government announced that it would contribute $40m to the ***Scaling Up Renewable Energy in Low Income Countries program*** (SREP), and $60m to the ***Forest Investment Program*** (FIP).

Private Sector Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there were only 2 deals completed in 2009. For more information, contact the ***Japan Venture Capital Association***.

Project Finance

According to Thomson Reuters Project Finance Database, there we no deals associated with Clean Technology in Japan in 2009.

Public Companies

Most Japanese Companies involved in Clean Tech are listed on the Tokyo Stock Exchange. There were 14 companies, with a market capitalisation of $1.9 billion in 2009. This excludes the large comglomerates such as Mitsubishi Heavy Indutries, where most of the investment in Clean Technology in Japan is made.

3.4 South Korea

3.4.1 Background

South Korea has decided on a 30% reduction of greenhouse gas emissions from their forecast levels in 2020 even though it is not an Annex 1 country. According to a statement from the presidential office, the goal is to cut the country's greenhouse gas emissions from its business as usual (BAU) level in 2020 which is equivalent to reducing the country's emissions by 4% from their 2005 level.

3.4.2 Market Size & Energy Mix

Primary Energy Demand

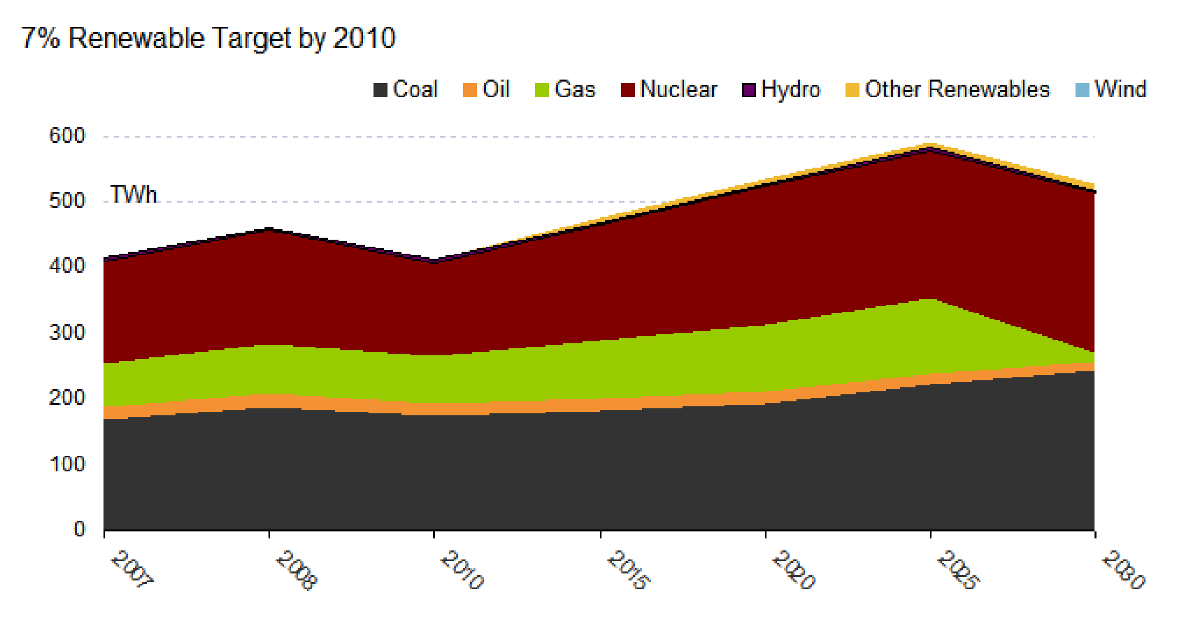
The total energy demand of South Korea in 2006 was 1.514 Quadrillion Btu.[15]

Electricity Demand

While South Korea has set ambitious targets to reduce carbon emissions, it has not set renewable targets like China, India, Japan and Australia.

South Korea has embarked on a large nuclear power generation program through ***Korea Nuclear Hydro Power*** (KNHP) and expected to increase generation to 243 billion kWh.

Figure 3.4 South Korea Power Generation Mix



Source: EIA, IEA, BP Statistics, CARMA, Estimates

[15] Source: EIA, http://tonto.eia.doe.gov/country/country_energy_data.cfm?fips=KS

3.4.3 Government Agencies

- ***Ministry of Environment*** *(MOE).* The Korean Ministry of Environment is responsible for work related to the protection of natural and ambient environment as well as the prevention of environmental pollution.

- ***Korea's Energy Management Corporation*** (KEMCO) receives its mandate from MKE: MKE regulates; KEMCO implements and reports to MKE. The focus is on energy efficiency, new sources of energy and renewables (fuels cell, photovoltaic, and wind power).

- The ***Ministry of Knowledge Economy*** (MKE) is in charge of development and distribution of renewable energy and offers financial support to targeted sectors, such as solar, wind, small hydro and geothermal energy.

3.4.4 Renewable Regulation

- ***Alternative Energy Act*** *(1997, revised 2002).* This policy constitutes the initial framework for the development of new and renewable energy technologies. It aims to secure cost-effective renewable energy by fitting the energy supply to the characteristics of the supplied area by cost effective business modeling. It encourages the installation of waste-incineration plants to generate heat and power. It also promotes residential solar heaters, small hydropower plants and facilities to use methane gas.

- ***10-year Basic Plan for the Development and Dissemination of New and Renewable Technology****.* The 10-Year National Plan for Energy Technology Development, released in 2003, brings to the fore fuel cells, photovoltaic (PV), wind power as high-priority areas. The Korean government plans to invest approximately US$ 200 million in the development and dissemination of fuel cell from 2004 to 2011 and US$2.42 billion for the photovoltaic.

- ***Strategies for Environmental Technology Development****.* The First Phase Environmental Industry Development Strategy (2001~2003) and the Mid- & Long-term Strategy on Fostering Environmental Industry (2005~2012) aims at advancing the Environmental Technology to the level of other developed countries by 2012

- ***The Long-term Vision for Science and Technology Development Toward 2025****.* The Korean government launched this long-term strategic initiative "***Vision 2025***" in 1999. The plan sets the direction and goal of the Korean government's science and technology (S&T) policies. Among its major features, the plan promotes: a shift of innovation from government-led to private sector-led ones; improving the effectiveness of national R&D investment; aligning R&D from a domestic to a global network; with the aim to meeting the challenges of the information technology and biotechnology revolution.

3.4.5 Renewable Targets & Incentives

As part of South Korea new "***Green Deal***" in 2009, it put in place an aggressive plan to increase its investment in the renewable space. However, apart from a biofuels mandate planned for 2013, there are no clear renewable targets.

South Korean Renewable Targets

Year	2008	2010	2020	2030
Electricity Capacity	67GW*	70GW	87GW	102GW
Electricity Generation	462TWh	412TWh	534TWh	650TWh
Renewable Target		7%		
Hydro		1,584MW	1,584MW	1,584MW
Nuclear		17.5GW	26GW	30GW
Biofuel		0.32MT	0.7MT	

Source: Government Publication, EIA, BP Statistics

- ***Biofuels***. South Korea is planning to introduce a renewable fuel standard system by 2013 to mandate a double-digits proportion of biodiesel fuel contained in gasoline.

Feed-in Tariffs

The ***Electricity Business Law*** governs both the purchase and the fixed price of electricity generated from renewable sources. Any renewable energy generator that is connected to the grid is eligible to sell electricity to the grid at fixed prices. KEPCO is responsible for purchasing electricity from renewables. The government compensates for the difference between N&RE power generation cost and fossil fuel generation prices. From October 2006 onwards, the power sources subject to the standard price have been extended. Standard prices were set for 19 prices for 9 power sources. A reduced rate will be applied to photovoltaics and wind power from 2009; and similarly a reduced rate will apply to fuel cell from 2010 onwards. The standard price for each power source will be applicable for 15 years. The requirements for minimal capacities for the feed in tariffs are as follows: 100, 1000, 50 MW for photovoltaics, wind power and fuel cell respectively.

3.4.6 Research & Development

The Korean Government leads research and development (R&D) activities in collaboration with industry, universities and research institutes. Priority projects are financed by the government budget and energy-related funds from the government and industry. Three important long term projects focusing on R&D are:

- ***21st Century Frontier R&D Program***. The Frontier 21 program, launched in 1999 and run by the MOST, is a 10 year effort to develop core technologies in near-to-market areas by 2010. This program supports 23 projects in areas such as bioscience, nanotechnology, and information technology, at a total cost of over US$3.5 billion. Among these, the government financed projects on ***Carbon Dioxide Reduction and Sequestration*** (in 2002), and on ***Hydrogen Energy*** (in 2003).

- ***Eco-Technopia 21 Project***. The project has started to follow up the G7 project since 2001, which was a 10-year project, run by MOE, launched in 1992 with the aim to develop seven areas of environmental technology to the level of G7 countries. The G7 project helps close the technological gap that exists between Korea and advanced countries – especially on the so called 'post-treatment technologies' such as dust collection, advanced waste water treatment, and small-scale incineration. High efficiency dust collecting technology and exhaust gas desulfurization technology have been improved as a result.[16]

- ***Eco-STAR (Eco-Science & Technology Advancement Research).*** The Eco-STAR plan, which is a part of Eco-Technopia 21 Project developed by MOE, sets mid- and long-term strategies to develop promising environmental technologies by sector. It is focused on projects which can deliver world-class technologies that will compete on global markets. The rationale is to maximise synergistic effects through joint or multilateral R&D on projects unable to achieve targets independently. Projects are selected according to their commercialisation and success potential; they are financed through a matching fund system where the government works with industry. In 2004, two pilot centres were set up: the 'Centre for Environmentally Friendly Vehicle' focusing on developing technologies for vehicle emission reduction (with the investment of 65 billion won (USD 60 mm) by 2010), and the 'Innovation & Integration Centre for XXIst Century Water Technology', devoted to advancing sewage and wastewater treatment technologies (with an investment of 65 billion won). Based on the outcomes and experiences from these pilot initiatives, MOE plans to promote a gradual expansion of the Eco-STAR Project by launching two new centres in 2007: the 'Centre for Aquatic Ecosystem Restoration', devoted to restoring and controling the eco-system; and the 'Centre for Waste Eco-Energy and Greenhouse Gases', designed to respond to energy needs and climate change.

- ***National Research Laboratory*** *(NRL).* The program identifies and cultivates outstanding laboratories in core technologies for national competitiveness. This strategic national R&D program maintains and develops technologies that can be the common basis for many industries and products. It also supports the efficient utilization of the science and technology resources in industry, academia, and research institutes throughout the nation. By 2005 about 40 laboratories set up in this context were related to environment.

3.4.7 Financing

Public Sector Funding

According to the presidential office, South Korea will invest KRW 107 trillion (USD 100 bn) over the next five years in solar projects, energy-saving lighting, hybrid cars and other commercially-viable, environmentally-friendly businesses. The Korean government will invest 2% of GDP annually in renewable energy from 2009 to 2013. Korea has already allocated KRW 11.5 trillion of this year's budget for its "***Green Growth***" plan, which is expected to generate as much as KRW206 trillion (USD 163bn) in industrial output and create as many as 1.8m jobs.

The South Korean government is setting up a KRW 100 bn (USD 73m) clean energy fund, with half of the amount to be contributed by private investors. The fund will be used to bolster investments in solar, wind and hydro power technologies and projects. Among these are plans for

[16] Source, Net. http://koetv.or.kr/engpage.do?mode=activities1

26 wind turbines to be built in coastal areas, a feasibility study for a future 40MW wind farm in Saemangeum, a tidal flat on the coast of the Yellow Sea, domestic fuel cell adoption, and a bioethanol pilot plant. 50% of the funds will be used for funding of wind power projects and to aid consolidation in the domestic solar industry.

- ***Demonstration & Dissemination Program.*** To promote the marketing of developed New and Renewable Energy (N&RE) technologies, the government subsidizes 70 percent of the associated installation costs. Some 10.5 billion won (USD 9.5 mm) of subsidies were provided by the government from 1993 to 2003: for PV Power Generation Systems, Solar Thermal Water Heating Systems and Bio-Methane Generation Systems. Another 4.7 billion won (USD 4.2 mm) were provided in 2004 to deploy developed N&RE technologies: PV, solar thermal water heating, geothermal systems and wind power generation systems.

- ***Environmental Venture Fund.*** In order to support environmental technologies, the ***Korean Ministry of Environment*** has created an Environmental Venture Fund and has actively identified and supported promising venture companies. ***Environmental Technology Business Incubator*** (ETBI) has been set up under the supervision of the ***Korea Institute of Environmental Science and Technology*** (KIEST) to assist venture activities of those at the frontier of environmental technology development.

South Korea's ***Ministry of Strategy and Finance*** has reduced import duties on equipment and components used for renewable energy projects by 50% as of 23 September 2009. The 31 products to benefit from the reduction include components used to harness solar energy, wind power, hydrogen fuel cells and geothermal power. Items include transparent electrodes used in thin-film solar cells, generators, glass or carbon fiber for wind blade manufacturing, fuel cells and compressors for geothermal plants. The ministry estimates about KRW 10.8 bn (USD 8.97 m) reduction in tariffs to be paid by the companies importing these products with the new policy. [17]

Private Sector Funding

The state-run ***Export-Import Bank of Korea***, in collaboration with 12 public and private firms, is set to establish a KRW 100bn (USD 85m) joint carbon fund. This semi-private fund is aimed to help local firms to cut greenhouse gas emissions, provide capital for feasibility studies and buy emission rights in advance. ***Eximbank*** had earlier said that it will invest KRW15 bn (USD 13m) in the fund with the funds to come from the ***Ministry of Knowledge Economy***, public and private businesses interested in CDM projects. The ***Korea Investment Trust Management Company*** is acting as a fund manager. Media reports suggest that the fund is expected to expand to KRW 100 bn as more firms are likely to participate in the initiative.[18]

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[17] Source: BusinessGreen.com, http://www.businessgreen.com/business-green/news/2249866/south-korea-slashing-import

[18] Source: Korea Times, http://www.koreatimes.co.kr/www/news/biz/2010/02/283_52405.html

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there were 5 deals completed in 2009, totaling 80 million. For more information, contact the Korean Venture Capital Association.

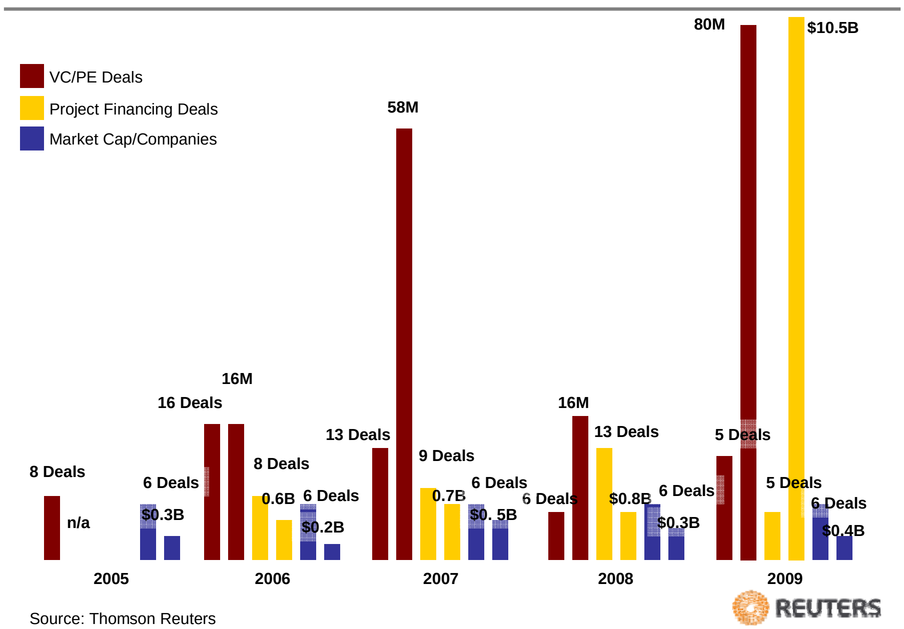
Project Finance

According to Thomson Reuters Project Finance Database, there were 5 deals totaling $10.5 billion, associated with Clean Technology in Korea in 2009.

Public Companies

Most Korean Companies involved in Clean Tech are listed on the Korean Stock Exchange. Excluding large conglomerates, there were 6 companies, with a Market Capitalisation of $300 million in 2009.

Figure 3.5 South Korea - Private Sector Funding



3.5 Taiwan

3.5.1 Background

Taiwan passed a renewable energy act in 2009 to promote the use of renewable energy. Like other Asian countries, it has embarked on an ambitious program to increase its consumption from renewable energy due to: energy security, carbon emissions and growth of its domestic industry. In particular Taiwan aims to position itself as a global leader in the solar market.

3.5.2 Market Size & Energy Mix

Primary Energy Demand

Oil is by far the dominant fuel in Taiwan's energy mix, accounting for 46 percent of total primary energy consumption in 2003. Coal also plays an important role (36 percent of total energy consumption), followed by nuclear power (9 percent), natural gas (7 percent), and hydroelectric power (less than 2 percent). Taiwan has very limited domestic energy resources and relies on imports for most of its energy requirements. The country's industrial sector accounts for about 42 percent of total energy demand, but this share is expected to decline slightly, since Taiwan's economy is moving toward newer, less energy-intensive industries.[19]

Electricity Demand

Taiwan is heavily reliant on imported fossil fuels, which account for around 70% of production. It plans to target solar and wind power to reduce its reliance on fossil fuels.

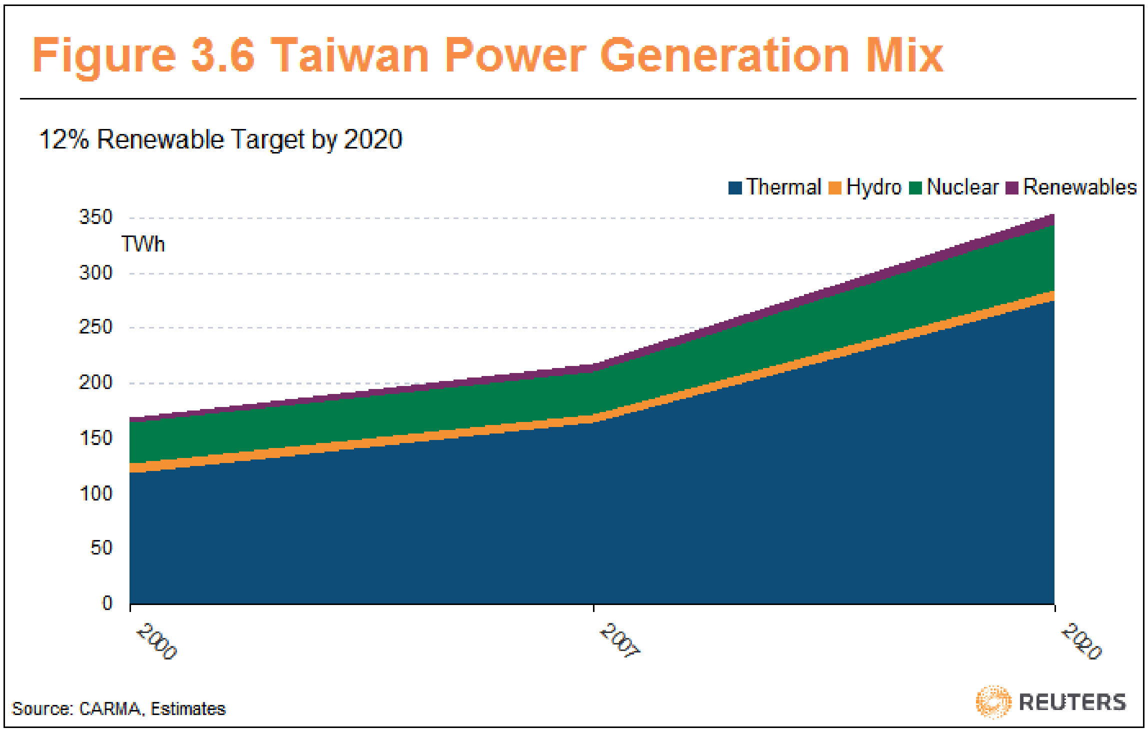


Figure 3.6 Taiwan Power Generation Mix

3.5.3 Government Agencies

The state environmental machinery in South Korea came to develop rapidly in 1990s with the expansion of civil society and the proliferation of NGOs, which have facilitated the transformation of the developmental state into the welfare state. Vigorous civil activism on environmental issues has helped prompt the creation of governmental environmental agencies, laws and enforcement mechanisms.

- The process requires Executive Yuan to pass legislation for the Ministries to implement. The administration passed a renewable energy act in 2009 with the goal of increasing Taiwan's renewable energy generation capacity by 6.5 million kW to 10 million kW within 20 years.

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[19] EIA (2005), http://www.eia.doe.gov/emeu/cabs/taiwan.html

- The ***Ministry of Economic Affairs*** (MOEA) continues to implement the various economic policies in Taiwan's interests, and has targeted Clean Technology as a key sector.

- The ***Bureau of Energy*** (BOE) is responsible for the implementation of the energy policy including the "Renewable Energy Development Act".

- ***Environmental Protection Administration*** (EPA) On August 22, 1987, the Environmental Protection Bureau, the Department of Health, Executive Yuan, was upgraded as the "Environmental Protection Administration" governing seven departments: comprehensive planning, air quality protection and noise control, water quality protection, waste management, environmental sanitation and toxic substance management, supervision evaluation and dispute resolution, environmental monitoring and information management. Taiwan Provincial Government upgraded the Environmental Protection Bureau as the Department of Environmental Protection on January 15, 1988. In coordination with the re-engineering of governmental organization, the Department was reformed as the Central Taiwan Office in July 1999, and was annexed to the EPA in March 2001 and re-organized as the EPA Inspectorate. Each city and county government gradually set up an Environmental Protection Bureau to enhance environmental protection work and function between 1988 and 1991. With the establishment of the Environmental Protection Bureau of Lienchiang County, in January, 2003, the environmental protection organization and structure was complete.

- The ***Atomic Energy Council*** (AEC) consists of representatives from relevant government ministries. The Radwaste Administration is a subsidiary body regulating radioactive wastes The Nuclear Regulatory Division and Radiation Protection Division are also parts of the AEC. The AEC is also responsible for nuclear safety. The Atomic Energy Law came in to force in 1968 and various regulations have been promulgated under it.

3.5.4 Clean Technology Regulation

- The ***Renewable Energy Development Act*** was passed in June 2009 to promote the development of renewable energy in Taiwan. The legislation is expected to promote the growth of the renewable energy industry and increase power generated from renewable from 6,500 to 10,000 MW by 2030. The law provides incentives to encourage providers to intensify their efforts of producing energy from renewable resources. It will also introduce a pricing mechanism for each renewable energy resource such as wind and solar power industry.[20]

- The ***2005 Taiwan Energy Policy Whitepaper*** outlines strategies for future energy development with a goal of 12% of installed capacity of renewable energy sources.[21]

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[20] Source: Council for Economic Planning and Development, http://www.cepd.gov.tw/encontent/m1.aspx?sNo=0012048

[21] Source: Industrial Technology Research Institute, http://re.org.tw/Re2/Eng/promotion.aspx

3.5.5 Renewable Targets & Incentives

Taiwan Energy Policy targets a 10% contribution by renewable energy of the total installed capacity in 2010, with an increase in capacity to 12.5% by 2035.

There is also a target to use B2 diesel by 2010 and E3 gasoline by 2011, with a projected demand of about 400,000 tonnes by 2010.

Taiwan Renewable Targets

Year	2005	2010	2020	2025
Electricity Generation	209TWh		354TWh	
Renewable Target (Installed Capacity	4.3% (2,500MW)	10%(5130MW)	12% (7-8,000MW)	9-10,000MW
Hydro	1,911MW	2,168MW		
Nuclear	4 power stations in operation	6 power stations in operation		
Wind	23.9MW	2,159MW		3,000MW
Solar PV	1MW	21MW		
Solar Water Heating	1.315M m^2	2.15 M m^2		
Biomass	562MW	741MW		
Geothermal	0	50MW		
Biofuel	0	0.4M T		

Source: Government Publications, WNA, BP Statistics, EIA, Estimates, CARMA

Feed in Tariffs

The MOEA announced the final feed-in tariffs (FiT) for renewable energy at the end of 2009. The tariffs were set at TWD 11.12 (USD 35 cents) per kWh for PV projects and TWD 2.38 (USD 7 cents) per kWh for wind projects.

3.5.6 Research & Development

The government will allocate TWD20bn (USD 636m) for Research & Development programs to raise the standards of renewable energy technologies in a statement in January 2010.

3.5.7 Financing

Government Funding

The government said it plans to invest TWD 25bn (USD 786m) in renewable energy and energy efficiency projects over the next five years to help reduce carbon emissions.

Private Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there were 3 deals completed in 2009, totaling 50 million in Clean Technology. For more information, contact the Taiwan Venture Capital Association.

Project Finance

According to Thomson Reuters Project Finance Database, there were 2 deals totaling $791 million, associated with Clean Technology in Taiwan in 2009.

Public Companies

Most Taiwanese Companies involved in Clean Tech are listed on the Taiwan Stock Exchange. There were 12 companies, mainly in the PV solar sector, with a Market Capitalisation of $4 billion in 2009.

3.6 Hong Kong

3.6.1 Background

Despite being a small terriotory, Hong Kong serves as a regional capital-raising hub for Clean Technology companies, particularly from China. Many of the leading Chinese Clean Technology companies have chosen to go public on the Hong Kong Stock Exchanges.

3.6.2 Market Size & Energy Mix

The total energy consumption in 2008 was 1.164 quadrillion BTU[22] and power generation was 37Twh in 2008.

3.6.3 Government Agencies

- ***Environmental Protection Department*** *(EPD)* of ***Environmental Bureau*** is the regulator of the Energy markets in Hong Kong. In 2008, a Memorandum of Understanding (MoU) with the ***National Energy Administration*** (NEA) was signed to secure a clean energy supply for the longer term.

3.6.4 Clean Technology Regulations

In 2000, a study commissioned by Electrical and Mechanical Services Department found that solar power, energy from waste and wind energy have the potential for wider use in Hong Kong: it aims for renewable energy to account for 2% of its total electricity supply by 2012.

Legislation by the Enviromental Bereau introduced mandatory implementation of Building Energy Codes. Hong Kong's two power companies (Hong Kong Electric and China Light & Power) signed the Scheme of Control Agreement in 2008 which provide incentives for over-achieving the emission caps and penalties for under-achieving them.

$1 Billion was injected into the ***Environment and Conservation Fund***, under which two funding schemes are set up:

- $150 million fund to subsidise carbon audits; and
- $300 million used to subsidise energy efficiency projects in buildings.

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[22] Source: EIA, http://tonto.eia.doe.gov/country/country_energy_data.cfm?fips=HK

One very important aspect is Hong Kong's relationship with mainland China and its implication to renewable energy development. It is possible for Hong Kong to make use of the mainland's renewable energy resources to meet its energy need in an environmental friendly and sustainable way as HK's electricity transmission system is interconnected with the Guangdong Province on the mainland.

3.6.5 Renewable Targets & Incentives

In 2005 that the Hong Kong Government published it's ***First Sustainable Development Strategy*** – setting a target of having one per cent to two per cent of Hong Kong's total electricity supply met using renewable energy by 2012.

3.6.6 Research & Development

The ***Environment and Conservation Fund*** (ECF) funds environmental research, technology demonstration and conference projects. Projects costing more than HKD$2Million (USD 250k) need to be approved by the ECF committee with lower cost projects approved by the respective sub-committees of the relevant field.

The development of renewable energy is an important element of developing the ***Pearl River Delta Region*** into a Green PRD Living Area, jointly promoted by Hong Kong and Guangdong. To create the Green PRD Living Area, both sides will examine how to strengthen research and development (R&D) as well as application of renewable energy.

The ***Shenzhen-Hong-Kong Innovation Circle*** was set up to promote technological collaboration between the two parties, also provides $35 Million (USD 4.5mm) funding for research projects.

3.6.7 Financing

Public Sector Funding

The Hong Kong government announced plans to set up a HKD 300m (USD 38.6m) pilot ***Green Transport Fund*** to encourage environment-friendly vehicles. The announcement was made at a Legislative Council meeting for the budget proposals for the fiscal year 2010 to 2011.

Private Sector Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there were 2 deals completed in 2009, totaling 87 million in Clean Technology. For more information, contact the **Hong Kong Venture Capital Association**.

Project Finance

According to Thomson Reuters Project Finance Database, there were no deals, associated with Clean Tecnology in Hong Kong in 2009.

Public Companies

Most Clean Tech companies listed on the Hong Kong Stock Exchange are mainland Chinese companies. There were 13 companies listed, with a Market Capitalisation of $13.7 billion in 2009.

3.7 India

3.7.1 Background

India has a dedicated ***Ministry of New and Renewable Energy*** (MNRE). In 2009, India has put in place renewable targets including wind and solar.

Coal accounts for more than half of India's total energy consumption followed by oil, which comprises 31% of total energy consumption. Natural gas and hydroelectric power account for 8 and 6% of consumption respectively. Although nuclear power comprises a very small percentage of total energy consumption at this time, it is expected to increase in light of recent international civil nuclear energy cooperation deals. According to the Indian government, 30% of India's total energy needs are met through imports.

3.7.2 Market Size and Energy Mix

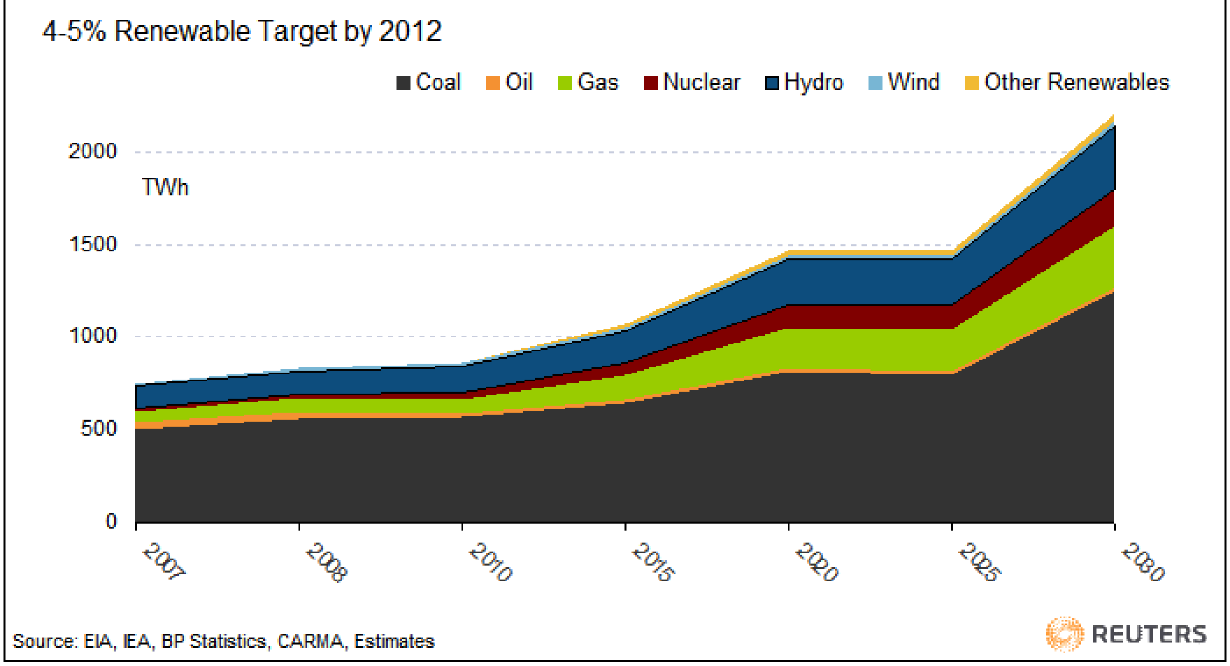
Primary Demand

India's ***Integrated Energy Policy*** says the country's total power generation capacity should increase to nearly 800 GW from current capacity of 160 GW by 2032 to sustain an annual 8-10% economic growth.

Electricity Demand

- In 2010, India is expected to have around 177GW of installed electric capacity and generated 863 billion kWh.
- Majority of power in India is generated with conventional thermal sources, which is expected to account for around 65% of electricity in 2010.
- Hydroelectricity has been a consistent source of power in India, and should account for nearly 26% of power generated in 2010.
- Nuclear energy is expected to contribute 3% of electricity in 2010, while wind and other renewable sources will account for around 6%.

Figure 3.7 India Power Generation Mix



Gasoline/Diesel Demand

The Indian government continues to heavily subsidize prices of diesel and thus demand compared to gasoline has surged in the past few years.

The national biofuels policy was announced in December 2009 to target a minimum of 20% ethanol-blended petrol and diesel by 2017.[23] In India ethanol is produced by the fermentation of molasses – a by-product of sugar manufacture. India is the fourth largest ethanol producer after Brazil, the United States and China, its average annual ethanol output amounting to 1,900 million litres with a distillation capacity of 2,900 million litres per year. For a 5 per cent ethanol blend in petrol nationally, the ethanol required would be 640 million litres of ethanol in 2006-2007 and 810 million litres in 2011-2012.[24]

3.7.3 Government Agencies

- ***Ministry of New and Renewable Energy*** *(MNRE)* is responsible for managing one of the largest renewable energy programs, covering renewable energy technologies for a variety of

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[23] iGovernment Bureau, http://igovernment.in/site/India-approves-biofuel-policy/

[24] United Nations Conference on Trade and Development, 2006, “An Assessment of the Biofuels Industry in India” http://www.unctad.org/en/docs/ditcted20066_en.pdf

grid and off-grid applications. The country has the largest decentralized solar energy program, the second largest biogas and improved cooking stoves program, and the fifth largest wind power program in the world.

- ***Ministry of Petroleum and Natural Gas*** - The Ministry of Petroleum & Natural Gas is entrusted with the responsibility of exploration and production of oil and natural gas, their refining, distribution and marketing,import, export, and conservation of petroleum products and Liquified Natural Gas.

- ***Ministry of Rural Development*** - The Ministry has been acting as a catalyst effecting the change in rural areas through the implementation of wide spectrum of programmes which are aimed at poverty alleviation, employment generation, infrastructure development and social security. Over the years, with the experience gained, in the implementation of the programmes and in response to the felt needs of the poor, several programmes have been modified and new programmes have been introduced. This Ministry's main objective is to alleviate rural poverty and ensure improved quality of life for the rural population especially those below the poverty line. These objectives are achieved through formulation, development and implementation of programmes relating to various spheres of rural life and activities, from income generation to environmental replenishment.

The major programs supported by the government include the following:

- Rural Energy, which includes biomass and energy efficiency sectors
- Solar Energy
- Power from Renewable Energy
- Energy from Urban and Industrial wastes
- Hydrogen Fuel Cells and Others new technologies

3.7.4 Renewable Regulation

- ***12th Five Year Plan*** *(2012 to 2017).*The draft is in formulation stage. No targets finalized yet.

The ***11th Five Plan*** includes a 4-5% renewable target.

- ***Electricity Act*** (2003). Electricity Act in 2003 deregulates all types of power generation (except of hydroelectricity above 10 MW), it also includes 10% renewable target.

- ***National Electricity Policy*** (NEP). In 2005 the Government of India put out the National Electricity Policy as required by the Electricity Act of 2003. The National Electricity Policy outlines a plan for rural electrification increased generation capacity. The policy states that "maximum emphasis" would be put on the development of hydro power. Use of thermal power could be made cleaner by using low-ash coal, improving lignite mining, and increased use of natural gas and nuclear power. The policy also sets recommendations for improving the power grid with better transmission and distribution of power. It also calls for the use of the most efficient technologies and more funding for R&D.

- ***Energy Policy***. The Energy policy outlines the challenges that India faces as it develops and must generate and provide increasing amounts of energy. Measures include addressing energy security by acquiring abundant supplies of coal and gas,and increasing hydro and nuclear power. India seeks to improve energy efficiency by reducing energy intensity across many sectors including mining, electricity distribution, transportation, industry and building construction. The policy also outlines methods to promote renewable energy and increase R&D.

The ***Energy Conservation Act*** in 2001 empowers the Central Government and State Governments to:

- specify energy consumption standards for notified equipment and appliances;
- direct mandatory display of label on notified equipment and appliances;
- prohibit manufacture, sale, purchase and import of notified equipment and appliances not conforming to energy consumption standards;
- notify energy intensive industries, other establishments, and commercial buildings as designated consumers;
- establish and prescribe energy consumption norms and standards for designated consumers

The ***Bureau of Energy Efficiency*** (BEE) was established in 1st March, 2002 to implement the Act and drive through energy efficiency.

Regulatory Drivers

Date	Event
Regulatory Body	
1998	The Central Electricity Regulatory Commission (CERC) was established in 1998
	The State Electricity Regulatory Commission (SERC) serves as the electricity regulator for the individual states. All the states except Nagaland and Arunachal Pradesh have either constituted or notified SERCs
2006	Ministry for New and Renewable Energy (MNRE) formed (formerly Ministry of Non-Conventional Energy Sources)
2007	The Petroleum and Natural Gas Regulatory Board (PNGRB), was established on June 2007
	The Chairperson and members of CERC are appointed by the Central Government on the recommendation of the Selection Committee. The Chairperson and members of SERC are appointed by the State Government on the recommendation of the Selection Committee. The members of the PNGRB are appointed by the central government.
Regulatory Framework	
2009	National Solar Mission

2003	National Mission on Biodiesel
2003	The Electricity Act (2003) mandate SERCs to specify a percentage of energy to be procured from renewable energy sources
2001	The Energy Conservation Act (2001)
Regulatory Roles	
	CERC roles include regulation of tariffs for generation companies and promoting competition
	SERCs roles include tariff regulation and promotion of cogeneration and electricity generation from renewable
Issues	
	Lack of a methodology for deciding the quotas and tariff for renewable generation under the Electricity Act 2003

3.7.5 Renewable Targets & Incentives

- India does not have a carbon reduction target but has stated that it plans to cut its carbon intensity by 20% by 2020 from 2007 levels.

- The Indian government's stated target is for renewable energy to contribute 10% of total power generation capacity by 2012.

- ***Solar***. As part of the Solar Mission, India has revised its Solar PV target to 20GW by 2022.

- ***Wind***. A target of 10.5 GW was proposed, as part of the 11th Plan. 10 out of the 29 Indian States have now implemented quotas for a renewable energy share of up to 10% and have introduced preferential tariffs for electricity produced from renewable sources. These states are Kerala, Rajasthan, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh, West Bengal, Gujarat and Haryana. In addition, several states have implemented fiscal and financial incentives for renewable energy generation, including: energy buy back schemes and FiTs; preferential grid connection and transportation charges and electricity tax exemptions.

- ***Hydro***. As part of the 12th Five Year Plan (2012-17), the government has identified an additional 38,242MW to be added in that time period. Based on the 2005 Electricity Plan, India, the government expects to increase hydro capacity to 94,000 MW by 2027[25]. A target of 1,400MW was proposed for the 11th Plan for small hydro.

[25] India Central Electricity Authority

- ***Biomass***. A target of 1,700MW was proposed through cogeneration by 2012, as part of the 11th Plan. In addition, a 400MW target was proposed for waste to energy projects in urban areas.

- ***Biofuels***. India has announced a 20% indicative blending target for ethanol and biodiesel by 2017, but these are not firm targets.

- ***Nuclear***. India plans to have 20,000 MW nuclear capacities on line by 2020.

India Renewable Targets

Year	2008	2012 (11th Plan)	2017 (12th Plan)	2022 (13th Plan)	2027 (14th Plan)
Electricity Capacity	161GW*	195GW*	230GW*	263GW*	294GW*
Electricity Generation	811TWh	966TWh*	1266TWh*	1466TWh*	1839TWh*
Renewable Target		10% (power generation)			
Hydro	26%				94GW
Small Hydro		1,400MW			
Nuclear	3%			20GW	
Wind	10GW	10.5GW			
Solar PV	0.2GW	1GW	4GW	20GW	
Solar Water Heating	$140Mm^2$				
Biomass		1,700MW			
Nuclear				20GW	
Bioethanol	5% in 9 states		20% indicative blending target		
Biodiesel		20% blend with Jatropha	20% indicative blending target		

Source: Government Publications

Feed in Tariff (FiT)

As part of the Electricity Act, the law encourages a 10% contribution from renewable energy in some regions. This is achieved through a Feed in Tariff, focused on Wind, Biomass and Small Hydro.

Tariff	Rs/kWh	$/MWh*	Region
Wind	2.90-4.08	63-89	Tamil Nadu, Haryana
Biomass	2.63-4.00	57-87	Andhra Pradesh, Haryana
Small Hydro	2.25-3.66	49-80	Madhya Pradesh, Punjab

Source: Government Publications, * 1 USD=46 INR

3.7.6 Research & Development

Based on the Patent Filing research, India trails the North Asian countries, in terms of research & development. This is notable, in terms of patents filed by Indian companies compared with China, Japan, South Korea and Taiwan. This may put India at a significant disadvantage, in terms of setting up a high quality manufacturing sectors, required for Clean Technology sectors, such as solar and wind.

While the government has put in place promotional policies and programs, such as the NRSE, aimed at reducing costs and enhancing efficiency, it will be interesting to see, if will be able to make up the technological gaps with its North Asian neighbours. Notable actions to close this technological gap, include:

- Engaged with leading research organizations in the country to undertake R&D projects, accompanied by three specialized technical institutes (SDC, C-WET and the SSSNIRE).
- Provided a market-oriented thrust to R&D efforts and has evolved a policy of supporting R&D with the involvement of the industry.
- Established an R&D Advisory Committee that considers specific proposals for research and also recommends research priorities and strategies.
- The MNES also facilitates the acquisition of patents in the area of renewable technology.

The IREDA is the promotional and financing arm of the Ministry and has emerged as one of the main instruments for promoting developing and financing technologies and projects related to NRSE (renewable sources of energy).

It has been able to tie up funds from leading multilateral agencies such as the UN organizations, the Asian Development Bank and the European Commission, bilateral organizations and domestic financial institutions for lending to end-users, manufacturers, financial intermediaries and entrepreneurs, predominantly in the private sector.

Cumulative loan disbursements by IREDA have risen from around Rs 16 million (USD 360k) in its first year (87-88) to Rs 25,478 million (USD 571 mm) in December 2001, while cumulative sanctions touched Rs 50,447 million (USD 1.1 bn).

In addition, major national financial institutions such as the IDBI, ICICI, IFCI, and PFC have also been financing wind power projects.

3.7.7 Financing

Public Funding

- The IREDA is the promotional and financing arm of the Ministry and has emerged as one of the main instruments for promoting developing and financing technologies and projects related to NRSE (renewable sources of energy).

- It has been able to tie up funds from leading multilateral agencies such as the UN organizations, the Asian Development Bank and the European Commission, bilateral organizations and domestic financial institutions for lending to end-users, manufacturers, financial intermediaries and entrepreneurs, predominantly in the private sector.
- Cumulative loan disbursements by IREDA have risen from around Rs 16 million in its first year (87-88) to Rs 25478 million in December 2001, while cumulative sanctions touched Rs 50447 million.
- In addition, major national financial institutions such as the IDBI, ICICI, IFCI, and PFC have also been financing wind power projects.
- Suzlon Energy Limited, the world's fifth leading wind turbine maker, entered into a Memorandum of Understanding (MOU) with TERI University for setting up and offering an MTech Programme in Renewable Energy Engineering and Management.
- This MOU will facilitate Suzlon Energy to contribute to the Programme through exchange of ideas and expertise, and guest faculty.

Private Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there were 2 deals completed in 2009, totaling 87 million in Clean Technology. For more information, contact the **India Venture Capital Association**.

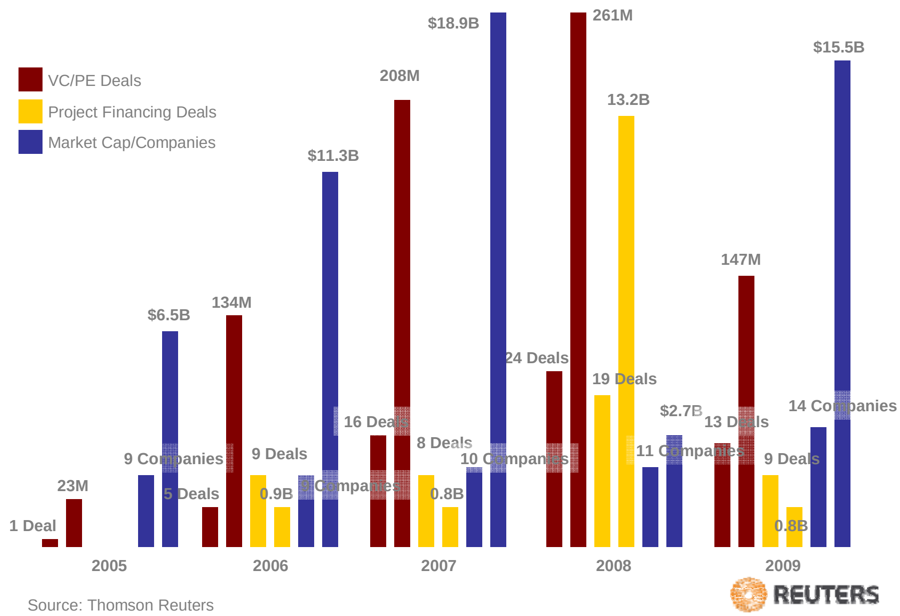
Project Finance

According to Thomson Reuters Project Finance Database, there were 9 deals totallig $792 million, associated with Clean Technology in Indai g in 2009.

Public Companies

Most Clean Tech companies listed on the Bombay Stock Exchange (BSE). There were 14 companies listed, with a Market Capitalisation of $15.5 billion in 2009.

Figure 3.8 - India Private Sector Funding



3.8 Singapore

3.8.1 Background

Singapore is trying to establish itself as a Clean Tech hub for Asia. While, it does not have its own domestic market, it wants to be a leader in research, capital raising and the headquarters for companies looking to set up and expand across Asia.

Singapore has embarked on a comprehensive and ambitious program to become a Clean Tech hub for Asia. Through the ***Economic Development Board*** (EDB), it has allocated SGD$1 billion, as part of its Sustainable Blueprint for 2030 to make 80% of all buildings green, 35% reduction in energy intensity and launch of a solar test bed program.

In addition, it has set aside SGD$650M/USD485M in Clean Energy (SGD$350M/USD250M) and environment and water (SGD$330M/USD235M).

It has launched a number of Clean Tech incubators at NUS and NTU. While Singapore lacks the size and scale of other countries, it aims to be the Clean Tech hub for Asia, in terms of financing and setting up Clean Tech companies and become a test bed for new technologies.

3.8.2 Market Size & Energy Mix

Singapore incinerates 90% of its Municipal Solid Waste through 4 incineration plants and generates roughly 980 kWh of energy, supplying roughly 2% of Singapore's electricity demand. Power Generation in Singapore was 39TWh[26]

3.8.3 Government Agencies

The key government agencies involved in Clean Technology includes:

- ***Ministry of Environment and Water Resources (MEWR)*** – manages water and environmental sustainability.
- ***Ministry of National Development (MND)*** – responsible for providing quality physical infrastructure by working in the public and private sectors.
- ***Economic Development Board (EDB)*** - is responsible for planning and executing strategies to enhance Singapore's position as a global business centre and grow the Singapore economy.
- ***National Research Foundation (NRF)*** - The National R&D Agenda consists of five strategic thrusts, namely: to intensify national R&D spending to achieve 3% of GDP by 2010; to identify and invest in strategic areas of R&D; to fund a balance of basic and applied research within strategic areas; to provide resources and support to encourage private sector R&D; and to strengthen linkages between public and private sector R&D.
- ***Energy Market Authority (EMA) -*** is a statutory board under the Ministry of Trade and Industry. Its main goals are to promote effective competition in the energy market, ensure a reliable and secure energy supply, and develop a dynamic energy sector in Singapore.
- ***National Environment Agency (NEA)-*** is the leading public organization responsible for improving and sustaining a clean and green environment in Singapore.
- ***Building and Construction Authority (BCA)*** - is an agency under the Ministry of National Development, championing the development of buildings, structures and infrastructure for Singapore.
- ***National Climate Change Committee (NCCC)*** - the Ministry of the Environment and Water Resources (MEWR) formed the National Energy Efficiency Committee (NEEC). With the announcement of Singapore's plan to accede to the Kyoto Protocol in 2006, the NEEC has been expanded in scope to cover climate change issues and has been renamed the NCCC to better reflect its expanded function.

3.8.4 Clean Technology Regulations

- The ***National Technology Plan***, 2010, (including EE&C, establishment of national standards) – earmarks SGD 75bn/USD 54bn for science and technology R&D over the coming 5 years, with potential for research into Clean Tech.

[26] EIA

- The ***Singapore Green Plan*** (including EE&C to reduce pollutants) – MEWR promotes a high quality environment with targets for the following areas: Air and Climate Change, Water, Waste Management, Nature, Public Health and International Environmental Relations.

- ***Energy Conservation and Distribution Centre*** to prepare the public towards energy efficient lifestyle.

- ***Energy Audit Scheme*** - is implemented by the NEA in partnership with major industrial consumers under the initiative of the NCCC. The Scheme is voluntary, designed to provide an impetus for industries to improve the energy efficiency of their operations. Its objective is to encourage industries that use large amount of oil and gas to put in place a formal system for the management of energy use, to improve their energy efficiency. Under the Scheme, companies can either use in-house staff or engage external energy audit specialists in carrying out their energy audits. Such audits, which are carried out every 3-5 years, would help industries to systematically identify opportunities for improving energy efficiency regularly. The companies could then take measures to improve the energy efficiency of their facilities.

3.8.5 Renewable Targets & Incentives

Clean Energy

- ***Clean Energy Research and Testbedding Program*** *(CERT).* The Clean Energy Research and Testbedding Program (CERT) by the ***Clean Energy Program Office*** (CEPO) and managed by EDB, is a SGD$17M (USD12M) funding initiative for local and foreign companies and organisations to test and implement clean energy technologies at suitable sites. CERT involves three key partners: the R&D organisations, the technology providers, and the implementers. These three partners are involve in the following areas (obtained from the CERT press release): The R&D organisations will lead and conduct testbedding activities, while the technology providers will be private sector companies providing the Clean Energy equipment and technologies to participate in the testbedding. Government agencies which are providing the testbedding location and facilitating the project are the implementers.

- ***Clean Energy Research Program*** *(CERP).* The Clean Energy Research Program (CERP) by the National Research Foundation (NRF) is a SGD$50M (USD35M) funding initiative for Institutes of Higher Learning, public sector agencies, private companies based in Singapore, and not-for-profit research laboratories, to conduct research and development projects in clean energy. The R&D projects are submitted based on calls for proposals in domains specified by the Clean Energy Program Office (CEPO). Funding support is up to 70% or 100% of approved direct qualifying costs of a project.

- ***Solar Capability Scheme*** *(SCS).* Under the Solar Capability Scheme (SCS), EDB provides funding for new private buildings to install solar technologies. The building must be certified with minimum Green Mark Gold rating by BCA, and the minimum solar system installed should be 10 kW. The funding provided is between 30% to 40% of the total capital cost and capped at $1 million.

- ***Market Development Fund*** is a $5 million funding initiative by the Energy Market Authority to help in the test-bedding of new electricity generation technologies such as solar, wind, hydrogen and fuel cell, which has significant potential and value in the electricity market.

- ***Energy Research Development Fund****.* The EMA has launched a S$25 million Energy Research Development Fund (ERDF) to be disbursed over five years to drive research, development and demonstration initiatives to address issues pertaining to Singapore's energy sector such as energy security, energy efficiency and the development of a competitive energy industry in Singapore. The ERDF is targeted at a wider spectrum of projects that can include solutions to optimise grid operations, enhance energy efficiency in Singapore's industries or facilitate the entry of new sources of fuel into Singapore. The EMA has also recently set up a S$5 million Market Development Fund (MDF) to encourage the adoption of renewable energy solutions. The MDF will help to offset the market charges associated with selling renewable energy into the electricity grid.

Energy Efficiency

The National Environment Agency (NEA) has put in place a number of energy efficiency initiatives, aimed at promoting energy efficiency among business and the public sector. These initiatives are estimated to reduce up to 190,000 tonnes of carbon dioxide emissions by 2012 and help achieve the target of 25% improvement in carbon intensity between 1990 and 2012 (NEA 2005):

- ***Energy Efficiency Improvement Assistance Scheme*** *(EASe).* NEA provides a co-funding scheme called the Energy Efficiency Improvement Assistance Scheme (EASe), to help companies in the manufacturing and building sectors engage accredited Energy Services Companies (ESCOs) to conduct energy audits and recommend energy saving measures. Funding is provided up to 50% of the qualifying costs of engaging an ESCO and capped at $200,000 for a single facility or building over a five-year period.

- ***Grant for Energy Efficient Technologies*** *(GREET).* The Grant for Energy Efficient Technologies (GREET) by NEA provides funding for the Singapore-registered owner or operator of existing or proposed industrial facilities to invest in energy efficient equipment or technologies. Funding is provided up to 50% of the qualifying costs and capped at $2 million per project. Only projects with a payback of more than 3 years and up to 7 years are eligible for funding.

- ***Accelerated Depreciation Tax Allowance****.* The Accelerated Depreciation Tax Allowance scheme by NEA encourages companies to replace old inefficient equipment and invest in energy saving equipment. The capital expenditure on the qualifying energy efficient equipment can be written off in one year instead of three.

- ***Design for Efficiency Scheme*** *(DfE).* The Design for Efficiency Scheme (DfE) by NEA aims to encourage new facilities that are large consumers of energy to integrate energy and resource efficiency improvements into their development plans early in the design stage. Funding is provided up to 80% of the qualifying costs or S$600,000, whichever is lower.

- ***SCEM Training Grant**.* The Singapore Certified Energy Manager (SCEM) Program offers training and certification in energy management, and is for engineering professionals to develop the technical skills and competence to become the Energy Managers of their organisations. The SCEM Training Grant is a co-funding scheme by NEA to fund the training cost at the Professional Level SCEM Program. Successful grant applicants only pay a subsidised course fee of SGD$963 instead of the full course fee of SGD$5,885.

Smart Grid

The Energy Market Authority (EMA) promotes competition in the electricity and piped gas industry and maintains the security and reliability of the power system. Formed on 1st April 2001, EMA is a statutory board under the Ministry of Trade and Industry that regulates the electricity and gas industry and district cooling services in designated areas. The EMA has worked on details of the electricity sector privatisation, as well as efforts to maintain a secure and reliable electricity industry.

Green Buildings

***Green Mark Incentive Scheme for Existing Buildings* (GMIS-EB)**. The government recently announced in the Sustainable Singapore blueprint that it has set a target for 80% of the existing building stock to achieve at least Green Mark Certified rating by 2030. A $100 million Green Mark Incentive Scheme for Existing Buildings (GMIS-EB) was set up by BCA to hencourage private building owners of existing buildings to undertake improvements in energy efficiency. The scheme provides a cash incentive that co-funds up to 35% of the costs for energy efficiency improvements and capped at SGD$1.5 M (US$1.1M).

***Green Mark Incentive Scheme for New Buildings* (GMIS-NB)**. The enhanced $20 M (SGD14M) Green Mark Incentive Scheme for New Buildings (GMIS-NB) by BCA is to accelerate the adoption of green building technologies and design practices. The enhanced scheme provides cash incentives to developers, building owners, project architects and M&E engineers, who achieve at least a BCA Green Mark Gold rating in the design and construction of new buildings.

***Green Mark Gross Floor Area Incentive Scheme* (GM-GFA)**. The Green Mark Gross Floor Area Incentive Scheme (GM-GFA) by BCA and URA is to encourage the private sector to develop buildings that attain the higher Green Mark ratings. URA will grant additional floor area over and above the Master Plan Gross Plot Ratio (GPR) control, up to 1% for Green Mark Gold Plus developments and up to 2% for Green Mark Platinum developments, and subject to a cap of 2,500 m^2 for Gold Plus and 5,000 m^2 for Platinum.

MND Research Fund for the Built Environment. The MND Research Fund for the Built Environment is a SGD$50M (USD35M) funding initiative by the Ministry of National Development (MND) and managed by BCA. The objective of the fund is: To encourage and support applied R&D that will raise the quality of life and make Singapore a distinctive global city. Under the MND Research Fund, some key focus areas include sustainable development projects such as integrating solar technologies into building facades. The fund covers 30% to 75% of the qualifying cost of the project, subject to a cap of SGD$2M (USD1.4M).

3.8.6 Research & Development

- ***Fuel Cells*** - Institute of Materials Research and Engineering, the Institute of Chemical and Engineering Sciences, the Institute of High Performance Computing and the Singapore Institute for Manufacturing Technologies

- ***Solar Energy*** - The ***Solar Energy Research Institute*** of Singapore at the National University of Singapore (NUS) focuses on research in silicon PV technology, nano-structured solar cells and energy efficient buildings.

- ***The Centre for Sustainable Energy Research***, through its Energy Research Institute at Nanyang Technological University (NTU), conducts research on advanced fuel cell technology, charge storage, wind and tidal energy and smart buildings.

3.7.7 Financing

Government Funding

Research institutes under the Agency for Science, Technology and Research (A*STAR) have established research programs in various areas including fuel cells, biofuels, next generation solar PV technology, carbon management and intelligent energy distribution systems.

Private Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there were 2 deals completed in 2009, totaling $13.5 million in Clean Technology. For more information, contact the **Singapore Venture Capital Association (SVCA)**.

Project Finance

According to Thomson Reuters Project Finance Database, there was 1 deal totaling $350 million, associated with a PV Solar project in Singapore in 2009.

Public Companies

Most Clean Tech companies listed on the Singapore Stock Exchange are associated with wastewater companies. There were 12 companies, with a Market Capitalisation of $1.5 billion in 2009.

3.9 Indonesia

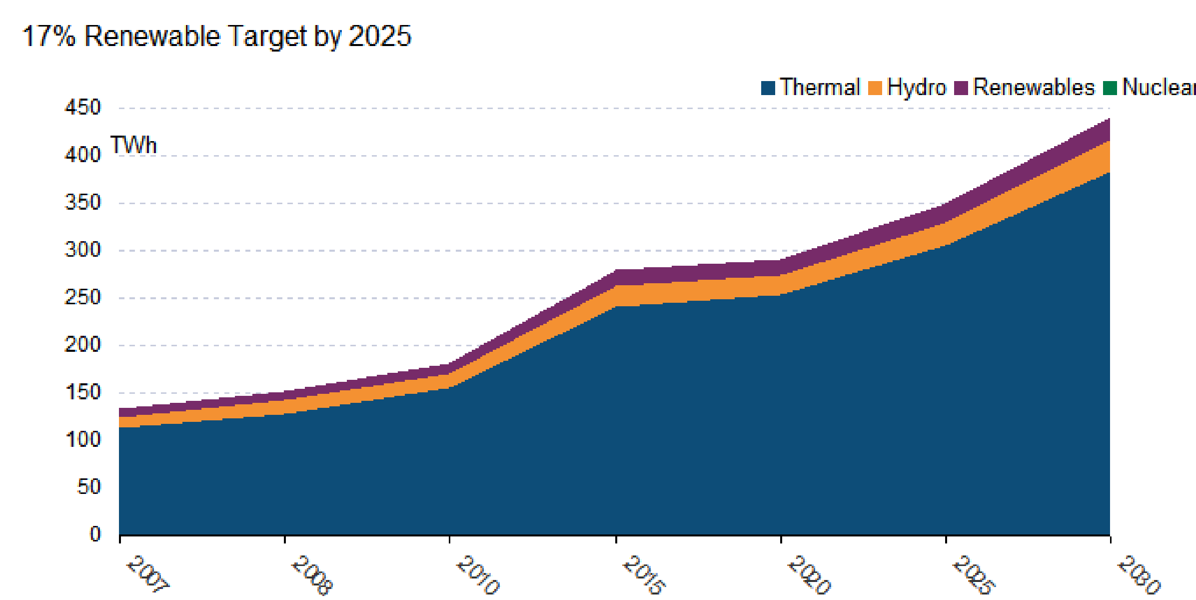
3.9.1 Background

Indonesia is the largest country in ASEAN with a population of over 200 million people spread over 13,000 islands. The country has no unified grids, other than the three islands of Java, Bali and Madura. PT PLN (Persero) is the main player-fully integrated utility with generation, distribution and transmission all under one umbrella. The government announced the 2nd phase of its 10GW of newly installed total capacity program by 2014. 4,733MW of this target has been set aside for geothermal projects. The government will offer most of these projects to private investors. As of 2009, 1,057MW of geothermal capacity has been installed.

3.9.2 Market Size & Energy Mix

Based on the IEA 2009 outlook, Indonesia's primary energy demand is expected to increase from 191 Mtoe to 330 Mtoe in 2030.

Figure 3.9 Indonesia Power Generation Mix



Source: BP Statistics, CARMA, Estimates

Total installed power capacity is projected to increase almost three-fold, from 35 GW in 2007 to 101 GW in 2030.

3.9.3 Government Agencies

- ***Ministry of Energy and Mineral Resources*** (*MEMR*) is the body responsible for the development of Indonesia's energy policy. Under the ***National Energy Policy***, which was introduced in 2006, a target has been set to reduce the share of oil in the fuel mix to below 20% and to increase that of renewables to 17%, both by 2025. The MEMR tendered three projects: 220MW Tangkuban Perahu (awarded to Raser Technologies); 45MW Cisolok Sukarame; and 50MW Tampomas.

3.9.4 Clean Technology Regulation

- In 2007, Indonesia enacted the ***Energy Law***, which is the country's first legislation on energy. Under the new law, the government gives priority to improving energy efficiency and increasing renewable energy development to enhance energy security and improve access to modern energy services.

- ***Renewable Energy Law***. The Indonesian government is drafting a law on new and renewable energy, which includes plans for both supply and demand, and the use of fiscal incentives.

- ***National Energy Policy***. In its national energy policy for 2005-2020, the Indonesian government aims to increase energy efficient, promote renewables, implement demand side management and use cleaner fuels.

3.9.5 Renewable Targets

Indonesia announced the 10,000 MW ***Crash Program Phase II*** in 2008, which aims to increase renewable generating capacity, particularly from geothermal and hydropower. Targets have been set to boost the capacity of micro-hydro power plants to 2.9 GW by 2025, geothermal plants to 9.5 GW by 2025, wind power to 0.97 GW by 2025, solar power to 0.87 GW by 2024 and biomass to 180 MW by 2020.

Since January 2009, the transport, industry and power-generation sectors and fuel distributors in Indonesia have been obliged to use biofuel blends. The government has set the goal that biofuels should contribute 3% of the energy mix by 2015 and 5% by 2025. To boost the development of biomass, the Indonesian government plans to open 6 million hectares of new plantation area for sugar cane, cassava, palm and jatropha by 2025.

Indonesia Renewable Targets

Year	2008	2015	2025	2030
Electricity Capacity	35GW			101GW
Electricity Generation	151TWh	279TWh	290TWh	440TWh
Renewable Target	15.5%		17%	
Hydro	3.2GW		2.9GW	
Geothermal			9.5GW	
Wind			0.97GW	
Solar PV			0.87GW	
Biomass			180MW	
Bioethanol		3%	5%	
Biodiesel		3%	5%	

Source: Government Publications, EIA, IEA, Estimates

Indonesia is now focused in three renewable areas: geothermal, small hydro and biomass.

The Indonesian government has unveiled a USD 255m stimulus package for the oil, gas and geothermal sectors. It is part of a wider USD 4.6bn package to help the country cope with the economic crisis. The package will operate for the 2009 fiscal year.

Two recent regulations have detailed the electricity tariffs for geothermal power plants, based on capacity:

- Plants greater than 55MW will receive 85% of PLN's production cost;
- Plants from 10MW to 55MW will receiver 80%; and
- Plants smaller than 10MW will be dealt with in a separate regulation

Barriers to growth in geothermal still remain, due to issues in the bidding process that does not have a standardized ***Power Purchase Agreement*** (PPA) and limited contractual obligations for the winning bidder that may result in long drawn out negotiation after the award of the contract.

The Geothermal law has shifted the burden onto the provincial governments to confirm the size of geothermal resources, which may lack the investment or technical expertise to identify the resources. High start up costs also deters development, as it is difficult to determine the capacity over a 20 to 30 year period to recoup the initial investment.

Feed in Tariffs (FiT)

MEMR announced in August 2009 that PLN will set a ceiling on rates to encourage investment by resolving tariff uncertainties, which were reported to be between 6.5 and 7 US cents/kWh for renewable energy.

3.9.6 Research & Development

The ***Ministry of Energy and Mineral Resources*** is undertaking research in ***Clean Coal Technology***.

The ***Bandung Institute of Technology*** (ITB), ***Bogor Institute of Agriculture*** (IPB), the Research and Development Division of the Ministry of Energy and Mineral Resources are amongst the scientific institutions that signed the Memoranda of Understanding to support biofuels projects in Indonesia.

3.9.7 Financing

Public Sector Funding

The government is planning to launch a USD 1bn investment fund for clean energy projects. The country's sovereign wealth fund, the ***Government Investment Unit*** will contribute 10% to the fund, and the remainder will be raised from institutional investors and other governments, including the US, Australia, Japan, France, Norway that has shown interest. Indonesia has set a target of cutting greenhouse gas emissions by 26% by 2020. The fund will be launched later in 2010. The fund will co-invest in projects with banks. It will invest no more tan USD80m per project.

Sumitomo Mitsui Financial Group has signed an agreement with the World Bank and the US Agency for International Development to advise Indonesia on funding renewable energy projects as the country plans to boost power generation.

Private Sector Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there was only 1 deal completed in 2009, totaling 45 million in Clean Technology. For more information, contact the **Singapore Venture Capital Association**.

Project Finance

According to Thomson Reuters Project Finance Database, there were 4 projects totaling $513 million, associated with Clean Technology in Indonesia in 2009.

Public Companies

According to the Indonesia Stock Exchange, there is only 1 companies listed in Clean Technology, with a Market Capitalisation of $43 million.

3.10 Malaysia

3.10.1 Background

Malaysia is one of the largest producers of palm oil and exports this as a biofuel to European markets. The Malaysian government said it will rely on biogas, solar, mini hydro and biomass as its main sources for renewable energy.

The government went on to say that it is finalising a program to push for the development of these sources of renewable energy. It wants private firms to help in the deployment of renewable energy.

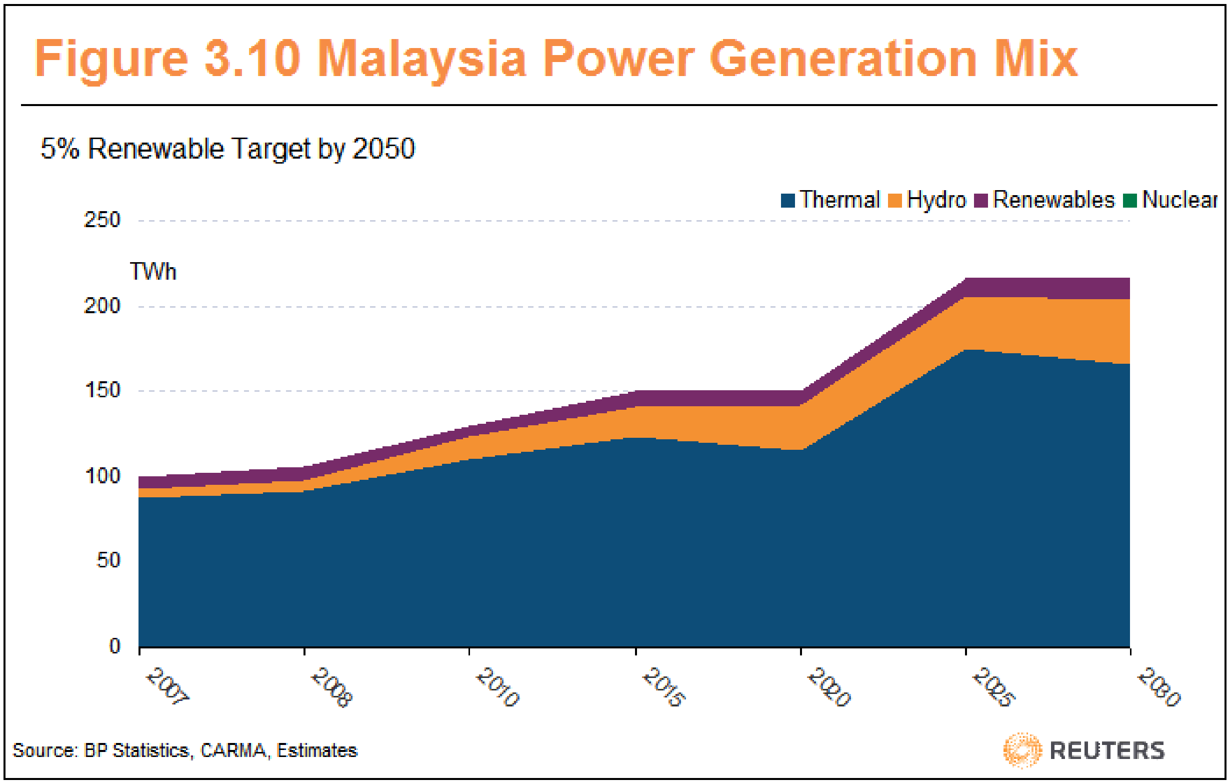
3.10.2 Market Size & Energy Mix

Primary Energy Demand

Based on the IEA 2009 Outlook, Malaysia's primary energy demand is expected to increase from 73 Mtoe to 116 Mtoe in 2030.

Electricity Demand

Total installed power capacity is projected to increase from 26 GW in 2007 to 47 GW in 2030.



3.10.3 Government Agencies

- The ***Economic Planning Unit*** (EPU) and the ***Implementation and Coordination Unit*** (ICU) devise and oversee all energy policy in Malaysia.

- ***Ministry of Energy, Water and Communications***, which regulates the non-oil and gas and electricity sectors.

- The ***Energy Commission of Malaysia*** regulates energy supply activities and enforces energy supply laws.

3.10.4 Clean Technology Regulation

- ***National Energy Plan***. Malaysia is currently in the process of formulating a comprehensive National Energy Plan, which will focus on intensifying energy-efficiency initiatives in order to achieve more productive and prudent use of its remaining reserves. The plan, will increase efforts to develop alternative forms of energy, including solar, wind and biofuels, and will explore the possible use of nuclear energy.

- ***Electricity Supply Act.*** This Act regulates the licensing of electricity generation, transmission and distribution. It enforces licensing and registration provisions.

- ***Ninth Malaysia Plan*** (2006-2010), the government has set a target of 350MW of grid-connected renewable electricity generation by 2010. Currently, the ***Small Renewable Energy Power Program*** (SREP), which was launched in 2001, provides for power generated from renewable resources to access the national grid. SREP developers can sell power to utilities through the ***Renewable Energy Power Purchase Agreement*** (REPPA), which gives plants a license for a period of 21 years to sell up to 10 MW to the national grid system. Under this program, the utilisation of all types of renewable energy is permitted, including biomass, biogas, municipal solid waste, solar, small hydropower and wind.

In 2008, the Malaysian government introduced a broad package of reforms to energy subsidies, which were creating a mounting fiscal burden. The package included subsidy reductions, cash rebates, windfall taxation on certain sectors and an expansion of the social safety net. Malaysian retail gasoline prices were increased by more than 40% in July 2008 and the following month the price of gas for power generation was raised by 124% in Peninsular Malaysia. In line with this increase in the gas price, the average electricity tariff for all sectors of the economy was increased by 24% (from $0.075/kWh to $0.093/kWh).

Malaysia introduced a Five-Fuel Diversification Policy in 2001, which aims to broaden the fuel mix and increase the share of renewables in the supply of electricity. As a result, oil's dominance in the power-generation fuel mix has been reduced significantly, in favour of natural gas and coal. To ensure adequate, secure and cost-effective energy supplies, the Malaysian government formulated a National Depletion Policy in 1981. The policy sets a limit on the total production of crude oil of 650 kb/d and natural gas from Peninsular Malaysia of 56.6 million cubic metres per day.

3.10.5 Renewable Targets & Incentives

Malaysia is still drafting its Renewable Energy legislation and aims to derive 5% of its energy needs from renewable sources by 2050, excluding hydro.

The only other areas of targets is in biofuels, as part of the Five Fuel Diversification, ppromotion of a 5%-mix of processed palm oil with petroleum diesel (B5 diesel) on a trial basis on a fleet of government vehicles.

Malaysia's Renewable Targets

Year	2008	2010	2020	2030
Electricity Capacity	26GW			47GW
Electricity Generation	107TWh	110TWh*	150TWh*	216TWh*
Renewable Target		350MW		

Source: EIA, Government Publications, Estimates

Feed in Tariffs

The Malaysian government is planning to introduce legalisation to make it mandatory for state utility Tenaga Nasional to buy clean energy. The aim of the legislation is for Malaysia to have 2GW of installed capacity by 2020, from the modest 50MW in place currently. A committee is currently drafting legislation to accord greater importance to the role of clean energy. The legislation will have a RPS and mandatory feed-in tariffs (FiT).

State utility ***Tenaga Nasional Bhd*** has been paying a rate of USD 6 cents/kWh for renewable energy projects, most of which have been biomass projects. However, this is still considered an 'informal' rate, and is not an official rate. The government plans would introduce a mandatory FiT which will be higher than this.

3.10.6 Research & Development

It was announced in January 2010 that ***Masdar*** and ***1Malaysia Development Berhad*** (1MDB) would explore Clean Technology projects and investments, including the possibility of building Malaysia's first carbon-neutral city. Masdar and 1MDB also intend to co-operate and invest in carbon reduction projects, under the Kyoto Protocol's CDM and Clean Technology venture capital. If fully implemented the cooperation agreement would lead to the development of new catalytic projects, with an estimated value of USD100 million.

- ***Palm Oil Research Institute Malaysia* (PORIM)**, established by law in 1979, is funded mainly from a research tax from palm oil millers, which brings in 70 million ringitts every year. The Malaysian Board of PORIM includes representatives from the palm oil industry and the government, is advised on the research programmes of the institute by a Programme Advisory Committee formed by experts in their own fields.

3.10.7 Financing

Public Sector Funding

The Malaysian government is implementing a MYR 1.5bn (USD 437m) loan scheme for companies that use clean energy technologies.

The government is targeting biodiesel and biogas plant contractors, oil palm millers installing greenhouse gas capture tanks and biodiesel plant owners for the bulk of the loans.

The scheme is part of the government's 2010 budget and will be implemented together with commercial banks. Suppliers of green technology can borrow up to RM50m (USD 14.6m), while their clients are eligible to take a maximum loan of RM10m (USD 2.9m).

The loans, of which the government will bear 2% of the total interest rate, will be offered from January. The government will also guarantee 60% of the loan amount.

Separately, the government has launched its Incentives for Renewable Energy and Energy Efficiency in Malaysia. The scheme, applications for which will be accepted until 2010, will provide a 10-year income tax break for renewable energy businesses. There is also a full tax allowance on qualifying five-year capital expenditure. Unused allowances can be carried forward until fully absorbed.

Private Sector Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there were no deals completed in 2009 in Clean Technology. For more information, contact the **Malaysian Venture Capital Association.**

Project Finance

According to Thomson Reuters Project Finance Database, there were no projects associated with Clean Technology in Malaysia in 2009.

Public Companies

Most Clean Tech companies listed on Bursa Malaysia are associated with Palm Oil and Biofuels. There were 6 companies, with a Market Capitalisation of $530 million in 2009.

3.11 Philippines

3.11.1 Background

The Philippine government enacted the ***Renewable Energy*** (RE) Act in 2008, a far reaching renewable energy policy in South East Asia at the time.

The Philippines' ***Department of Energy*** (DoE) awarded:

- 87 contracts to 18 companies in November 2009 to invest a total of P90.4 billion (US$ 1.9 billion). Contracts included biomass, geothermal, solar, hydropower, ocean, and wind energy resources, and could generate 4 GW of power. A total of 57 projects involved hydropower development.
- A further 26 contracts were awarded in early 2010, with an investment of USD 278m in investment for small hydro, marine, wind, geothermal and biomass.

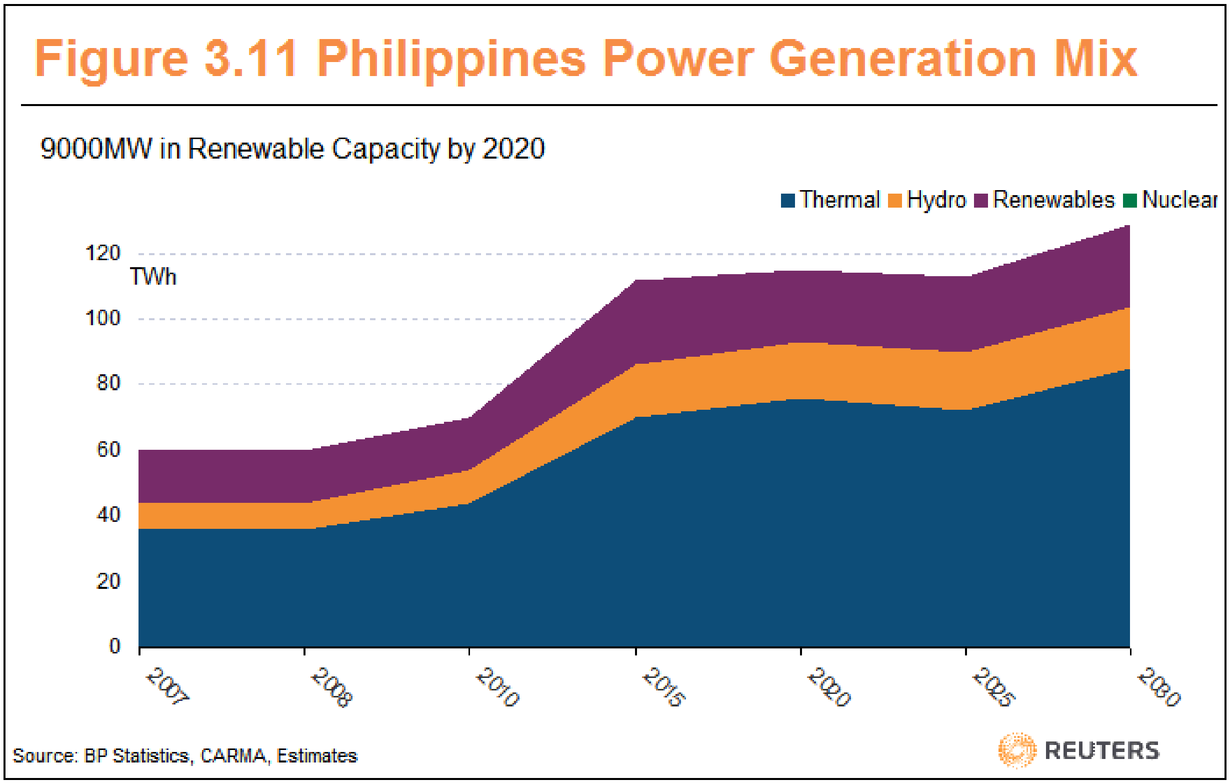
The total number of contracts awarded since the government implemented the Renewable Energy Act of 2008, is 180.

The new contracts signed included developments for small hydro, marine, wind, geothermal and biomass. The contracts were awarded to Bell Pirie Power, Clean Rock Renewable Energy Resources, Energy Development Corporation, Green Power Panay, Natural Power Sources Integration, Pan Pacific Power, PNOC-Renewables, Phil-Korean Energy, SKI Construction Group and SKI Mini-Hydro.

3.11.2 Market Size & Energy Mix

The primary energy demand in the Philippines is projected to grow from 40 Mtoe in 2007 to 73 Mtoe by 2030.

Electricity demand is projected to grow from 15.7 GW in 2008 to 34.3GW in 2030, with a large proportion of renewables.



3.11.3 Government Agencies

- ***Environmental Management Bureau*** (EMB) – part of the Department of Environment and Natural Resources, focussed on air quality management, chemicals management, environmental impact assessment, hazardous waste management, solid waste management and water quality management.
- ***Department of Energy*** (DOE) is the lead agency to implement the Renewal Energy Act. The department is focussed on energy independence and implementing market reforms outlined in the ***Philippine Energy Plan*** (2005-2014)
- ***National Renewable Energy Board*** (NREB) oversees the implementation of the Renewable Energy Act. Key roles:
    - o Recommend the mandated ***Renewable Portfolio Standards*** and minimum generation capacities in off-grid areas
    - o Recommend actions and implementation of the National Renewable Energy Program
    - o Oversee the implementation of the RE Trust Fund– finance research, development, demonstration
    - o and promotion of RE sources for power and non-power applications[27]

[27] ADB: http://www.adb.org/documents/events/2009/CCEWeek/Presentation-Vincent-Perez-Energy-PHI.pdf

- ***Energy Regulatory Commission*** (ERC) - protects long-term consumer interests in terms of quality, reliability and reasonable pricing of a sustainable supply of electricity.

3.11.4 Renewable Regulation

- ***Renewable Energy Act*** *(RE Act).* The RE Act establishes a regulatory structure for the renewable energy industry. The Implementing Rules & Regulation (IRR) appoints the Department of Energy (DOE) to implement the RE Act. The National Renewable Energy Board (NREB) oversees the implementation of the RE Act. The Renewable Energy Management Bureau (REMB) is charged with disseminating information, research and monitoring of policies outlined in RE Act.

The IRR states key policies, timeframes for the completion. Detailed rules will be formulated, reviewed and enacted in one year of the passage of RE Act. Key policies include:

- Creation of renewable portfolio standards (RPS) that obliges generators and utilities to source or produce a percentage of power from renewables
- Establishment of Feed in Tariffs and certain privileges for generators for at least 12 years
- Development of a net metering scheme that allows end users to connect and supply to the grid
- Formation of a renewable energy market for RE Certificates

Incentives

Incentives include:

- 7 year income tax exemption for new or existing projects, from start of commercial operations.
- Duty free import of machinery and equipment required for the project for 10 years from registration of the project
- Realty tax of 1.5% on Net Book Value of construction works, equipment, machinery
- Carry over of net operating loss from the first 3 years of commercial operations
- Corporate tax rate of 10% after expiration of tax exemption
- Projects not receiving tax exemption before full operations, receive accelerated depreciation at twice the rate
- 0% value added tax on sale of power
- Tax free sale of carbon credits
- Tax credit equivalent to 100% of VAT and customs that would have been paid of machinery and equipment

The IRR states that all energy is owned by the state and that each developer will enter into a RE contract with the government and be granted exclusive rights to develop a designated area for a specified period of time. The RE contract will be up to 25 years and cover pre-development and development. The government will receiver 1% (1.5% for geothermal) of gross income received by the developers. This share is split 60% to the National government and 40% to the local government. Biomass projects or small projects less than 100kW do not apply.

The RE Act is expected to be enacted within 2010.

- ***Biofuels Act of 2006****.* Republic Act 9367 signed into law a mandatory biofuels standard which requires a 5% ethanol blend for gasoline within two years, increasing to 10% within four years under the approval of a new National Biofuels Board. A 1% biodiesel blend for diesel is required within 3 months, to be increased to 2% within two years. The amount of bioethanol in gasoline would be increased to 10% four years after the law is passed as determined and recommended by the National Biofuels Board. RA 9367 also zero-rates the specific tax on the biofuels component of blended gasoline or diesel.

3.11.5 Renewable Targets & Incentives

From a current 4,500 MW capacity from renewable energy, the DoE is looking at doubling the figure to 9,000 MW in the next 10 years (2020), mainly from hydro, geothermal and biomass projects.

- ***The Philippines Energy Plan*** *(PEP).* The Philippines Department of Energy has identified long-term goals for RE development, namely: (i) increase RE-based capacity by 100% by 2013; and (ii) increase non-power contribution of RE to the energy mix by 10 MMBFOE in the next years 2003-2012. In support of these general goals, the government shall aim to (i) be the number one geothermal energy producer in the world; (ii) be the number one wind energy producer in Southeast Asia; (iii) double hydro capacity by 2013; and (iv) expand contribution of biomass, solar and ocean energy by about 131 MW. These goals serve as concrete benchmarks for government to advance its vision of a sustainable energy system with RE taking a prominent role in the process.

Philippines Renewable Targets

Year	2008	2010	2020	2030
Electricity Generation	58TWh	70TWh*	115TWh*	129TWh*
Renewable Target		4.5GW	9GW	
Hydro	2.4GW		3GW	
Nuclear			600MW in 2025	2400MW in 2030
Bioethanol		5%		
Biodiesel		2%		

Source: EIA, CARMA, Government Publications, Estimates

Feed in Tariffs

The Philippine government said it is planning to have feed-in tariff program for clean energy projects in place by June 2010. The NREB, which is advising the government on the country's renewable energy policy and framework, said it has started to study the FIT and will submit its proposal to the Energy Regulatory Commission proposals for the scheme by April 2010.

The ERC will then hold public consultations, on the FIT and a planned renewable portfolio standard, both of which are part of the Renewable Energy Law. The NREB said hopes the FIT will be implemented by June 2010, a year after the signing of the implementing rules and regulations governing the Renewable Energy Law.

Under the law, the ERC will, in consultation with the NREB, develop the FiT for different types of renewable sources of energy within a year from the implementation of the renewable energy law (in 2009).

3.11.6 Research & Development

The ***Philippine Council for Industry and Energy Research and Development*** (PCIERD) plays a key role in the implementation of the Biofuels Law as the agency responsible for the development and implementation of an R&D program supporting a sustainable improvement in biofuel production and utilization technology.

The PCIERD through the ***Industrial Technology Development Institute*** (ITDI) is currently testing the Jathropa methyl ester in cooperation with the ***Philippine National Oil Company*** (PNOC). Sweet sorghum is also being studied as possible alternative to sugarcane for bioethanol production. These alternative energy sources are being pursued due to the availability of raw materials and more importantly, they reduce vehicle emission of particulate matter, unburned hydrocarbons, carbon monoxide, among other things and improve the fuel efficiency of vehicles.

3.11.7 Financing

Public Sector Funding

- The Philippines" Department of Energy (DoE) awarded 87 contracts to 18 companies to harness renewable energy in November 2009 to invest a total of P90.4 billion (US$ 1.9 billion). Companies given contracts were: Deep Ocean Power Philippines, Inc.; Trans-Asia Renewable Energy Corp.; Constellation Energy Corp; Century Peak Energy Corp.; PNOC-Renewables Corp.; Energy Development Corp.; First Gen Bukidnon Power Corp.; Luzon Hydro Corp.; Lucky PPH International, Inc.; First Gen Mindanao Hydro Power Corp.; AV Garcia Power Systems Corp.; Benguet Electric Cooperative, Inc.; Alternergy Philippine Holdings Corp.; DOST-Industrial Technology Development Institute; Unisan Biogen, Corp.; AP Renewables Inc.; Mindanao Energy Systems, Inc. and HEDCOR, Inc.

- A further 26 contracts were awarded in early 2010, with an investment of USD 278m in investment for small hydro, marine, wind, geothermal and biomass. The contracts were awarded to Bell Pirie Power, Clean Rock Renewable Energy Resources, Energy Development Corporation, Green Power Panay, Natural Power Sources Integration, Pan Pacific Power, PNOC-Renewables, Phil-Korean Energy, SKI Construction Group and SKI Mini-Hydro.

- The Philippine government is planning to set up a USD 2.8bn clean energy fund to complement its renewables legislation. The Clean Technology Fund is part of the government's plans to invest in renewable energy. It has already implemented a renewable energy legislation, and to complement this, is working out a renewable portfolio standard (RPS) and a FiT mechanism.

International Finance Corporation (IFC), the private sector investment arm of the World Bank Group, said it expects to increase its investment in clean energy projects in the Philippines from

USD 1.3bn currently to USD 3bn by 2011. The IFC has flagged geothermal, hydroelectricity, wind and biomass as projects which offer potential.

It has launched the Sustainable Energy Finance Program 'to assist local banks in moving loan financing away from high energy consuming projects toward those favouring energy efficiency, and emission reduction while meeting the country's growing energy needs."

Through the Sustainable Energy Finance Program, IFC said it will be extending help to local financial institutions develop sustainable energy investments by providing financial and technical support, like entering into risk-sharing agreements.

Private Sector Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there were no deals completed in 2009 in Clean Technology. For more information, contact the **Philippine Venture Capital Investment Group**.

Project Finance

According to Thomson Reuters Project Finance Database, there were 16 projects totaling $3.4 billion, associated with Clean Technology in Philippines in 2009.

Public Companies

Most Clean Tech companies listed on Philippine Stock Exchange are associated with Palm Oil and Biofuels. There were 3 companies, with a Market Capitalisation of $4.3 billion in 2009.

3.12 Thailand

3.12.1 Background

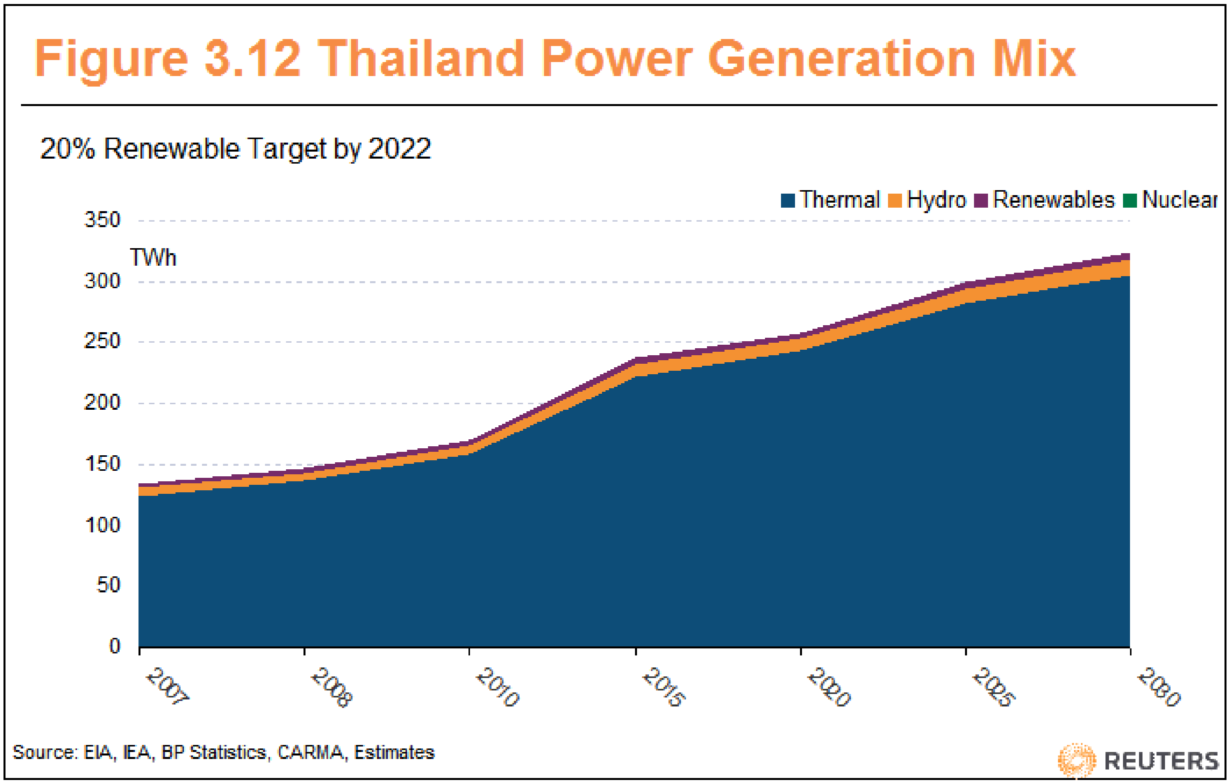
Thailand has put in place a ***15 year Masterplan*** for renewable energy that will push its renewable target to 20% of total target. Unlike other countries in APR, Thailand has a high dependence on gas, as a source of power with up to 70% of total generation. It sees renewable energy, as a way to diversify its energy mix and reduce its reliance on natural gas.

Thailand is also looking in the development of nuclear power by 2020 to further reduce its reliance on natural gas and fossil fuels.

According to the ***Board of Investment*** (BoI), there are 709 projects in services and public utilities with potential investment value at Bt 430.8 billion in 2010. Most of the projects are related to alternative energy such as production of electricity from wind and solar energies as well as natural gas.

3.12.2 Market Size & Energy Mix

According to the IEA Outlook, primary energy demand will increase from 104 Mtoe in 2007 to 174 Mtoe in 2030, with a large reliance on natural gas, primarily for electricity generation.



Electricity demand is forecast to increase from around 30GW in 2008 to 75GW by 2030.

3.12.3 Government Agencies

- Ministry of Energy (MOE)
- Department of Alternative Energy Development and Efficiency (DEDP) of the Ministry of Energy
- National Energy Policy Council (NEPC)
- Board of Investment (BoI) oversees investment in government related projects that include renewable energy projects.
- Electricity Generating Authority of Thailand (EGAT) Thailand's main electric power producer/wholesaler
- Metropolitan Electricity Authority (MEA)
- Provincial Electricity Authority (PEA)
- The Energy Policy and Planning Office (EPPO) is the government agency monitoring the ENCON Fund allocation for renewable energy projects. Grants have been given to encourage R&D on solar energy.

3.12.4 Renewable Regulations

- ***Power Development Plan*** *(PDP)* Thailand's electricity sector is set out in the PDP 2007 which covers the period 2007-2021. Under the plan the EGAT will continue to develop the major power generation projects, while there will be a greater role for the private sector, as purchases from small power producers (SPPs) and independent power producers (IPPs) will increase, as will imports from neighbouring countries. The PDP 2007 projects that the country's generating capacity will increase to 58 GW by 2021. There is also a goal of supplying 2 GW of electricity from nuclear from 2021, with an expectation that this would be increased by a further 2 GW after a further 10 years. The plan seeks to increase the use of renewables in power generation, thereby reducing dependence on natural gas.

- ***PDP 2010***. The Energy Ministry is revising its PDP (2010-2030) to be completed in early 2010. The so-called 'PDP 2010', covering the next 20 years, will focus on sustainability of power generation and environmental preservation and targets power purchase from neighbouring countries of 13-25 % starting 2015. Under such revision, the subcommittee will come up with information needed on 2010's estimated gross domestic product, the forecast of electricity demand over the next 20 years, the plan to purchase electricity from overseas, the development plan for renewable-energy plants and the demand-side management plan. The PDP 2010 plan will be an improvement on the recently revised PDP 2007. Once completed, the office will organise a public hearing before submitting it to the National Energy Policy Council for approval.

3.12.5 Renewable Targets & Incentives

Thailand has an installed generating capacity of 28.5GW, with approximately 13.2% of the capacity from hydropower and 1% from renewables.

The Thai government has set aside a THB 15.6bn (USD 440m) budget in its Masterplan for renewable energy development through to 2022. The 15-year plan targets a 20% contribution of renewable energy to the country's overall energy supply. The Department of Alternative Energy Development and Efficiency said the budget will is for capital needed from state agencies and universities to encourage renewable energy consumption.

A large portion of the budget will go into research and development activities, with the rest meant for incentives to make projects economically viable.

By 2022, the plan represents 5,600MW of renewable electricity generation, the majority of which will come from:

- ***Biomass*** from 1,600MW in 2008 to 3,700MW in 2022. Biomass heat would increase from 2781 ktoe to 6760 ktoe.
- ***Wind*** power would grow from 1MW to 800MW; and
- ***Solar*** – largely photovoltaics – from 32 MW to 500 MW

The MOE expects investment over the 15-year period, from public and private sources, to be some 488 billion Baht (US$ 14.6 billion). Other sectors that will be able to tap into the budget include fuel cells.

Development and promotion of biofuels is one of the top agenda items of the Thai government. Targets have been set to expand the use of ethanol to 9 Ml per day (Ml/d) in 2022 and of biodiesel to 4.5 Ml/d in 2022.

Thailand Renewable Targets

Year	2008	2011	2022	2030
Electricity Capacity	28.5GW			75GW
Electricity Generation	147TWh	170TWh*	280TWh*	325TWh*
Renewable Target		13.5%	20% (5,600MW)	
Hydro		156MW	324MW	
Nuclear	0	0	200MW	400MW
Wind	1MW	115MW	800MW	
Solar PV	32MW	45MW	500MW	
Biomass	1,610MW	2,800MW	3,700MW	
Bioethanol		3Ml/day	9Ml/day	
Waste to Energy		100MW	160MW	
Biogas		30MW	120MW	
Biodiesel		4M.l/day	4.5Ml/day	

Source: Ministry of Energy, Thailand's Energy Policy and Development Plan NEPC, EIA, CARMA, Estimates

In order to reduce its reliance on natural gas, and increase capacity from renewables, it has introduced a couple of programs:

- The Small Power Producer (SPP) program that cover cogeneration and renewable power developers wanting to sell to the grid in the range of 10 to 90MW. The National Energy Policy Council (NEPC) announced in the Power Development Plan in 2009 that provides for firm and non firm SPP capacity of up to 2,000MW by 2013.
- The Very Small Power Producer (VSPP) program introduce in 2002 to provide for small business operations in remote areas to sell power of up to 10MW to the grid. VSPP PPA is not firm and paid on a 'net metering' basis. Most projects were biomass co-generation projects.

As of 2008, there were 61 SPPs in operation, generating 3,877MW and 100 VSPPs generating 540MW[28].

Feed in Tariffs (FiT)

Current support measures for renewables include FiTs, including for biomass, small hydropower, biogas, wind and solar photovoltaic (PV).

The Thai government is planning to increase the tariffs for biomass and biogas projects to make them more competitive.

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[28] PFI, 2nd December 2009/Issue 422

The MOE said the increase in tariffs, through the 'added tariff mechanism' is needed because the cost of feedstock has increased. The adder tariff is a payment above prevailing tariffs for renewable energy projects to encourage investment.

NEPC Proposed Feed in Tariffs in Thailand

Project Type (THB/kWh)	Current Adder	New Adder	Special Adder	Special Southern Adder
Wind <50kW	3.50	4.50	1.50	1.50
Wind >50kW	3.50	3.50	1.50	1.50
Solar	8.0	8.0	1.50	1.50
Biomass <1MW	0.30	0.50	1.00	1.00
Biomass >1MW	0.30	0.30	1.00	1.00
Biogas <1MW	0.30	0.50	1.00	1.00
Biogas >1MW	0.30	0.30	1.00	1.00
Landfill Gas	2.50	2.50	1.00	1.00
Thermal Process	2.50	2.50	1.00	1.00
Minihydro 50-200 kW	0.40	0.80	1.00	1.00
Minihydro< 50kW	0.80	1.50	1.00	1.00

Source: PFI, NEPC

3.12.6 Research & Development

No key research development identified.

3.12.7 Financing

Public Sector Funding

- ***ENCON Fund*** allocation for renewable energy projects. Grants have been given to encourage R&D on solar energy.

- ***Thailand Research Fund*** *(TRF)*, an independent organization under the Office of the Prime Minister, is another institute undertaking R&D and facilitating information on solar cells.

The Thai government is planning to launch a carbon fund later this year, as the country gears up efforts to promote clean energy projects. The Thailand Greenhouse Gas Management Organisation is drafting the structure of the fund and expects to complete this by September. The fund, which could be set up as a joint venture with private firms, would provide low interest rate loans for CDM or co-investment in projects. It will also purchase carbon credits from project developers. The Greenhouse Gas Management Organisation has called on the Board of Investment to offer tax incentives for CDM projects after the Finance Ministry ruled out the possibility of lower taxes for revenue generated from carbon sales.

The World Bank said it plans to offer Thailand USD 700m for its clean energy projects and to boost energy efficiency. The soft loans will be made available through the World Bank's Clean Technology Fund and by its subsidiary the International Finance Corporation. Terms and conditions for accessing the funds will be released to loan applicants later this month. The average interest rate will be from 0.25% to nearly 2% with 20 to 40-year repayment period. The World Bank has estimated that a total of THB 157bn (USD 4bn) investment will be required to develop clean energy projects in Thailand over the next two years.

Private Sector Funding

Venture Capital

Based on the Thomson Reuters Venture Capital Database, there were no deals completed in 2009 in Clean Technology. For more information, contact the **Thai Venture Capital Association.**

Project Finance

According to Thomson Reuters Project Finance Database, there were 2 projects totaling $50 million, associated with Clean Technology in Malaysia in 2009.

Public Companies

Most Clean Tech companies listed on Thai Stock Exchange. There were 5 companies, with a Market Capitalisation of $800 million in 2009.

3.13 Australia

3.13.1 Background

Australia is blessed with abundant sunshine, strong winds, the largest reserves of uranium and unceasing waves in the south from stormy weather whipped up near Antarctica.

At least 20% of the country’s electricity supply is targeted to be generated from renewable sources by 2020. The Government’s ***Renewable Energy Target*** (RET) and the proposed ***Carbon Pollution Reduction Scheme*** (CPRS) are expected to be key long-term drivers of cleantech investment. With 15% of electricity produced by hydro, there only needs to be around a 5% increase from today.

Australia is home to well known Clean Tech companies such as Solahart, Memcor, Geodynamics, Ausra and Pacific Hydro. With its increased investment in R&D by the Government, developed capital markets and internationally recognized institutions, Australia should be well placed in the Clean Tech markets in Asia Pacific.

In May 2009, the Australian Government announced that it will invest $4.5b under its Clean Energy Initiative to support Clean Technologies. Of this amount, $3.5b is new funding to be directed to various programs including large-scale integrated carbon capture and storage projects, and a solar flagship program.

Australia currently generates around 80% of its power from coal, the other sources from hydro and natural gas. It is ironic that it sits on the largest reserves of uranium globally, yet does not have a single nuclear reactor generating electricity. The key question remains, if the government's policy will include nuclear, within the renewable portfolio and look to include nuclear power, as an option of base load power.

Experts forecast Australia needs to install around 11,000 MW of new capacity to meet the targets, possibly unleashing $22 billion in investment in the sector.

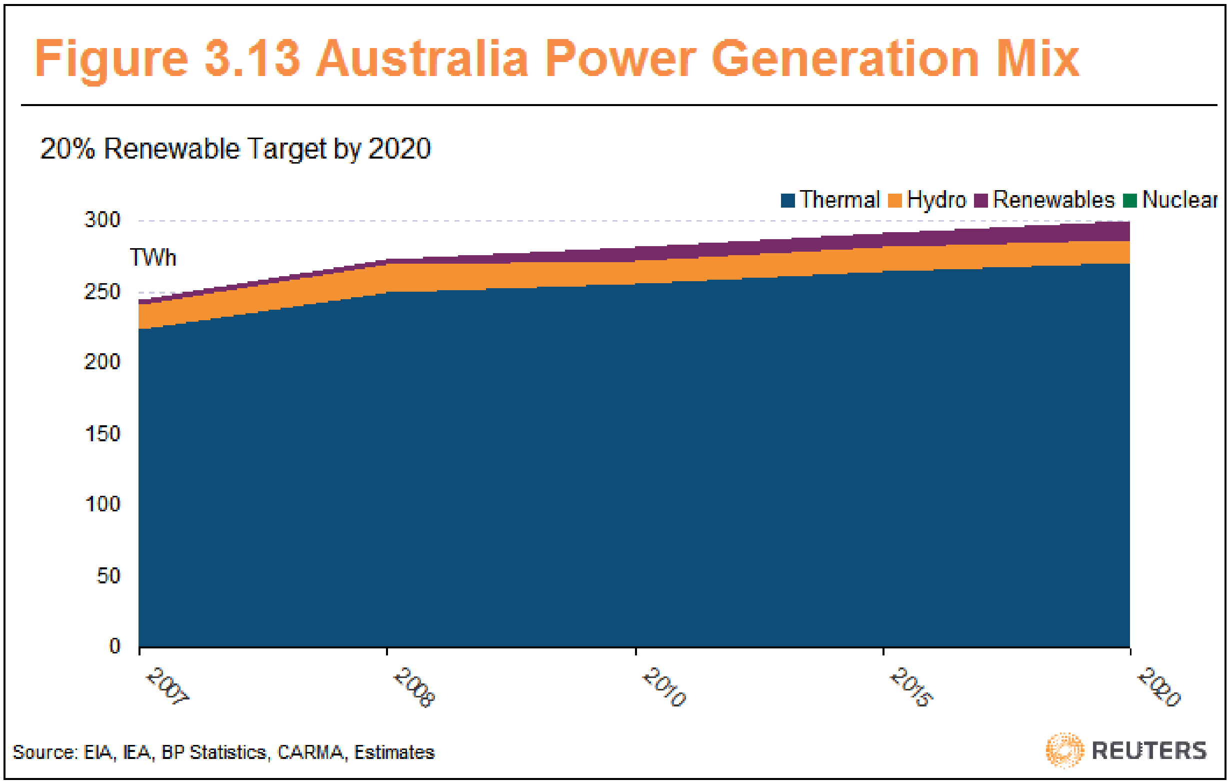
That means more than half of all of the country's new electricity generation capacity between now and 2020 will have to use renewable energy.

3.13.2 Market Size & Energy Mix

Electricity Demand

The Australian Utility Market is split into 3 markets: the ***National Electricity Market*** (NEM); the ***Wholesale Electricity Market*** (WEM) for Western Australia; and the ***Darwin and Katherine Interconnected System*** (DKIS) servicing the Northern Territory.

- NEM was established by the disaggregation of the government vertically integrated system and supplies electricity to 6 states: ACT, NSW, Queenland, Victoria, South Australia and Tasmania and accounts for around 200 GWh per year, over 90% of the total power generation
- WEM was established by the restructuring of Western Power Corporation, into four corporations: Synergy; Horizon Power; Verve Energy and Western Power and accounts for around 16.5 GWh per year.
- DKIS is dominated by the government owned Power and Water corporations and accounts for less than 2 GWh per year



3.13.3 Government Agencies

National

- ***Department of Water and Energy*** *(DWE).* The Australian Department of the Environment and Water Resources develops and implements national policies, programs and legislation to protect and conserve Australia's natural environment and cultural heritage.

- ***Office of the Renewable Energy Regulator*** *(ORER)* The ORER is a statutory authority established to oversee the implementation of the Australian Government's renewable energy target (RET).

- ***Department of Climate Change*** *(DCC)* is responsible for the Carbon Pollution Reduction Scheme (CPRS) and Renewable Energy Target (RET), Solar Credit program,

- ***Department of Energy, Water Heritage and the Arts*** *(DEHWA)* responsible for the Smart Grid Fund and Renewable Energy Equity Fund (REEF), Solar Cities, Green Loans, Low Emission and technology abatement fund, Renewable and remote power program, Solar hot water, rebate program, Energy Efficiency home package

- ***Department of Resources, Energy and Tourism*** *(DRET)* responsible for the Commercialisation Fund, the Energy Efficiency Opportunities, Advanced electricity storage program

- Department of Innovation, Industry, Science and Research (DIISR) responsible for Clean Business Australia, Clean Energy Enterprise,

State

- ***Queenland Office of Clean Energy*** (OCE)
- ***Sustainability Victoria*** (SV)

3.13.3 Clean Technology Regulation

The main regulatory driver for Clean Technology investment is the Mandatory Renewable Energy Target that has increased Australia's renewable target to 20% by 2020. Other key regulations include:

Federal

- ***Renewable Energy Target*** *(RET).* The aim of the renewable energy target is to increase the production of renewable energy: all electricity retailers and wholesale buyers have a legal liability to contribute towards the generation of additional renewable energy. They meet their legal obligation by acquiring renewable energy certificates (REC); certificates can be traded in the REC market, at market price. The Australian Government is committed to reach 9,500GWh of renewable energy by 2010. Furthermore, in 2007 the Australian Government introduced a comprehensive renewable and low-emission energy target, which builds on the market-based framework of the MRET. The new national Clean Energy Target (CET) will be maintained at 45,000GWh of low-emissions energy generation from 2020 until 2030. In February 2010, the Federal Government announced that it will split the RET scheme in two in the wake of criticism it has undermined investment in large-scale technologies in favour of small-scale solar PV. Legislation to create the new small-scale renewable energy scheme (SRES) and large-scale RET (LRET) would be introduced in the winter (Aug) sittings of parliament to start in 2011.
- ***Building Code Australia*** *(BCA).* BCA is managed by the Australian Building Codes Board (ABCB) on behalf of the Australian Government and State and Territory Governments. Its goal is to enable the achievement of minimum necessary standards of relevant health, safety, amenity and sustainability objectives efficiently. The BCA was revised in 2006 to include new Minimum Energy Performance Standards (MEPS) for all classes of buildings.
- ***Greenlight Australia****.* Greenlight Australia provides a framework for reducing energy consumption from Australian lighting over the ten-year period, following a 2005 commitment of the Australian governments and the Australian lighting industry to reduce the energy consumption of lighting by 20% by 2015.
- ***Coal21****.* The Australian Coal Association's program between the coal and electricity industries, governments, researchers and unions to investigate a variety of technologies, including CCS to reduce or eliminate greenhouse gas emissions from coal production and coal-fired power generation.

3.13.4 Renewable Targets & Incentives

Australia Renewable Targets

Year	2008	2010	2020
Electricity Generation	261TWh*	291TWh*	306TWh*
Renewable Target			20% (45,000 GWh)
Hydro	17.8TWh	17TWh	16.8TWh
Nuclear	0	0	0

Source: EIA, CARMA, Government Publications, Estimates

Wind power remains the cheapest form of renewable energy but is still at an early stage, with installed capacity at about 1.3GW - barely 3% of Australia's total installed capacity of 45 GW.

Solar power holds promise in a country known for its sunshine. Australia's solar credits program, which will subsidise the cost of households installing 1.5-kw solar power systems, and subsidised tariffs, should help boost demand. Australia may see increased investment in geothermal power, which taps heat trapped in granite 3 km or more below the earth's surface to run turbines and generate power. Studies suggest that Australia's hot fractured rock geothermal energy could provide up to 2,200 MW of base-load capacity, or up to 40% of the country's renewable target, entailing investment of about AUD$12 billion.

A rush to deploy proven technologies will be at the expense of geothermal and other emerging technologies including concentrated solar power and ocean energy, which require time and huge capital to develop.

Renewable energy would require government subsidies for many years to make it cost competitive against fossil fuels. Marginal costs for wind and geothermal over the long-term would be about $100 per MWh and concentrated solar about $150 per MWh. Wave energy is estimated at about $225 per MWh.

Though costs are expected to trend downwards over time, competing with conventional electricity prices, currently at $30 to $50 per MWh, would be tough. Rising prices for carbon amid earth's limited supply of oil and gas could work towards making clean energy cost-competitive.

For now, the main challenge confronting the renewable energy sector would be securing funding for investment in building new projects. Fiscal stimuli directed towards boosting low carbon energy systems should ease industry's funding concerns.

The South Australian state government said it aims to increase the state's renewable energy production target to 33% by 2020. In a bid to upstage other states, South Australia will aim to reach 20% target by 2014 and announced a new AUD 20m Renewable Energy Fund to accelerate investment in this sector.

Australia's Senate approved laws on August 2009, requiring 20% of the country's energy to come from renewable sources by 2020, opening the door to a $22 billion investment rush and lifting hopes of an emissions trade deal.

The renewable laws aim to come into effect on January 2010 and target production of 45,000 GWh of clean energy, or 20% of Australian energy, over the next decade.

The centre-left government struck a deal with the conservative opposition controlling the largest Senate vote bloc to pass the laws, raising hopes of agreement in November when controversial emissions trade laws will return to parliament, where they were rejected by the Senate last week.

Following are some of the main steps the government hopes to achieve, and industry concerns about the law.

Feed in Tariffs (FiT)

Australia currently has no nationalised FiT program, only state run schemes. A summary of the state arrangements is provided below:

Summary of FiTs in Australia

State	Current status	Max Size	Rate Paid	Program Duration	Model
VIC	Commenced November 2009	5 kW	60c (credit/cash)	15 years	Net
SA	Commenced July 2008	10 kW	44c+	20 years	Net
ACT	Commenced March 2009	under 10 kW - premium rate; over 10kW - 80% of premium rate; over 30 kW - tbc	50.05c/kWh up to 10kw capacity and 40.04c/kWh up to 30kW capacity	20 years	Gross
TAS	Commenced	tbc	20c	tbc	Net
NT	Incentive is available for 225 rooftop PV systems in Alice Springs.	tbc	45.76 c/kWh. Capped at $5 per day, then reverts to 23.11c per kWh.	tbc	Net
WA	To commence July 1 2010	tbc	tbc	tbc	Net
QLD	Commenced July 2008	10 kW	44c+	20 years	Net
NSW	To commence January 2010	10 kW	60c/kWh	7 years	Gross

Source: Government Publications, Energy Matters – www.energymatter.com.au

Renewable Energy Certificates (RECs)

Created under the earlier MRET scheme, each REC represents 1 MWh of green energy produced and is sold to wholesale electricity buyers. These firms are legally bound to meet a share of the renewable energy target in proportion to their share of the national wholesale power market.

RECs are trading around A$35 per MWh and will continue to be used under the expanded renewable target legislation.

Eligible projects that can earn RECs include solar water heaters and small generation units, such as solar panels on household roofs, small wind turbines and micro-hydro.

Certificate Multiplier

Instead of simple cash rebates, the new legislation proposes a complex system of issuing large amounts of RECs upfront for clean-energy installations up to the first 1.5 KW of capacity. Under the scheme, householders can receive up to 15 years of RECs based on the amount of energy calculated to be generated over the 15-year period.

As an extra incentive, the scheme has what is called a REC multiplier during the initial years.

For example, during the first two years, householders can earn one-off subsidies of five times the 15 years' worth of RECs. Once these are issued, no more RECs are given for a particular installation for the deemed 15-year life of the generating unit.

Industry Concerns

First, the industry says the 1.5 KW limit is far too small, since Australian households consume between 3 and 5 KW. The nation's peak clean-tech industry body, the Clean Energy Council, says the limit should be raised to 200 KW to really get green investment going.

Second, the scheme would largely support more proven renewable energy technology, particularly wind power, which could chew up most of the available RECs and leave little for emerging renewable technologies such as geothermal and wave energy.

Third, the creation of "phantom" RECs is a potential worry. For each REC, extra certificates are created under the multiplier scheme for the same output. The scheme target should be increased by the number of additional RECs created by the multiplier, the Council says, to ensure the extra RECs are fully taken into account.

Fourth, coal seam methane, a coal mining waste product, is among the technologies to benefit from the law. Though the technology won't count toward the 20% renewable target, the gas from coal seams isn't exactly renewable.

Long term Target

The RET scheme runs until 2030 but the 45,000 GWh target, set to be reached by 2020, remains the same until 2024, then quickly declines to 23,000 GWh by 2030. In effect, this will lead to a substantial drop in the number of RECs issued. Creation of a boom-and-bust market is an industry concern. The Clean Energy Council fears the trajectory will spook investors and lead investment to stall by 2014 because there will be only a small period in which to recoup funds by 2024.

3.13.6 Research & Development

- The ***Intelligent Grid Research Program*** is an Australian collaboration between the CSIRO and five universities investigating technologies and practices to make our electricity networks smart, greener and more efficient. Intelligent Grid is a 3-year collaborative research project running from July 2008 to June 2011and undertaken by five universities- University of Technology, Sydney, University of Queensland, and University of South Australia, Queensland University of technology and Curtin University. It has $3.4 million in funding from CSIRO and a further $6.1 million from the collaborating institutions.

3.13.7 Financing

Public Sector Funding

National

- Renewable Energy Development Initiative (REDI). REDI was a program launched in 2004 supporting renewable energy innovation and commercialisation. It provided grant funding up to AUS$100 million in competitive grants to Australian businesses over seven years for research and development (R&D), proof-of-concept, and early-stage commercialisation projects with high commercial and greenhouse gas abatement potential. This program ceased funding new projects in January 2008. Projects with contracts in place before this will continue until completion.

- Australian Government Water Fund. The Fund, run by the Australian Government, is a $2 billion program over 2005-2010 funding water infrastructure, improved water management, and better practices in the stewardship of Australia’s scarce water resources. The Fund supports field water projects that will improve Australia’s water efficiency and environmental outcomes.

- Smart Grid Fund. The Government will provide up to $100 million, funded by DEWHA to develop a smart grid energy network to a consortium of State and Local government and private sector companies. Award of the investment is expected in mid 2010.

- *Energy Innovation Fund* has been established to provide $150 million to support the development of Clean Technology and funded by DRET.

- Renewable Energy Equity Fund (REEF) is a $25 million fund for venture capital for renewable energy companies.

- Commercialisation Fund is a $465 million fund to support leading edge technology to bring to market.

- Solar Cities

Private Sector Funding

In March 2003 the Australian Coal Association (ACA) issued initiations to representatives from the coal and electricity industries, unions, federal and state governments and the research community to participate in a process aimed at first identifying and then realising the potential for reducing or eliminating greenhouse gas emissions from coal-based electricity generation in Australia. Agreement to participate by some 40 organisations led to the creation of the COAL21 partnership or program. The program's development work culminated with the release in March 2004 of the COAL21 Action Plan - providing the blueprint for accelerating the demonstration and deployment of technologies to reduce greenhouse gas emissions from coal-based electricity generation. *See:* COAL21 Action Plan - Summary. In 2006 the ACA announced the establishment of the COAL21 Fund as part of a world-first, whole-of-industry, funding approach to support greenhouse gas abatement. The COAL21 Fund is raising more than $1 billion over 10 years from a voluntary levy on black coal production to support the pre-commercial demonstration of low emissions technologies in the power generation sector

Venture Capital

There is a significant financing gap between innovation and commercialisation, particularly at the pre-seed and seed stages. Most VC funds are fully invested and there are only a handful of cleantech-dedicated funds. In addition, there are limited funds available for investment in cleantech demonstration projects. However, Australia is one of the leading countries at raising VC/PE deals in Asia Pacific.

Based on the Thomson Reuters Venture Capital Database, there were 8 deals , totaling $830 million completed in 2009 in Clean Technology. For more information, see the Australian Venture Capital Association.

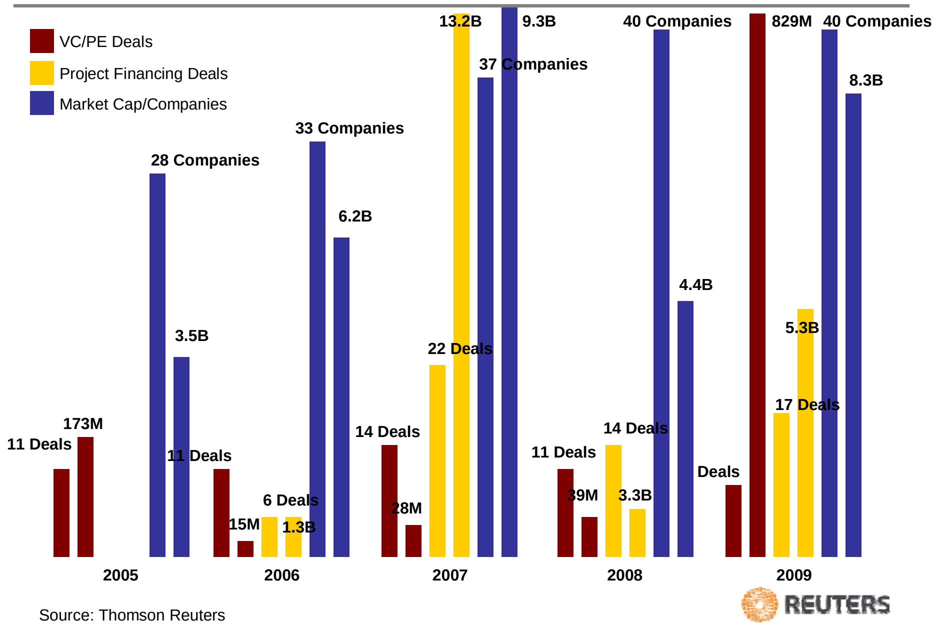
Project Finance

According to Thomson Reuters Project Finance Database, there were 17 projects totaling $5.3 billion, associated with Clean Technology in Malaysia in 2009.

Public Companies

Most Clean Tech companies listed on the ASX. The ASX has over 40 companies listed in the Clean Tech and resource space and one of the leading exchanges in the region at raising capital for this sector.

Figure 3.14 - Australia Private Sector Funding



3.14 New Zealand

3.14.1 Background

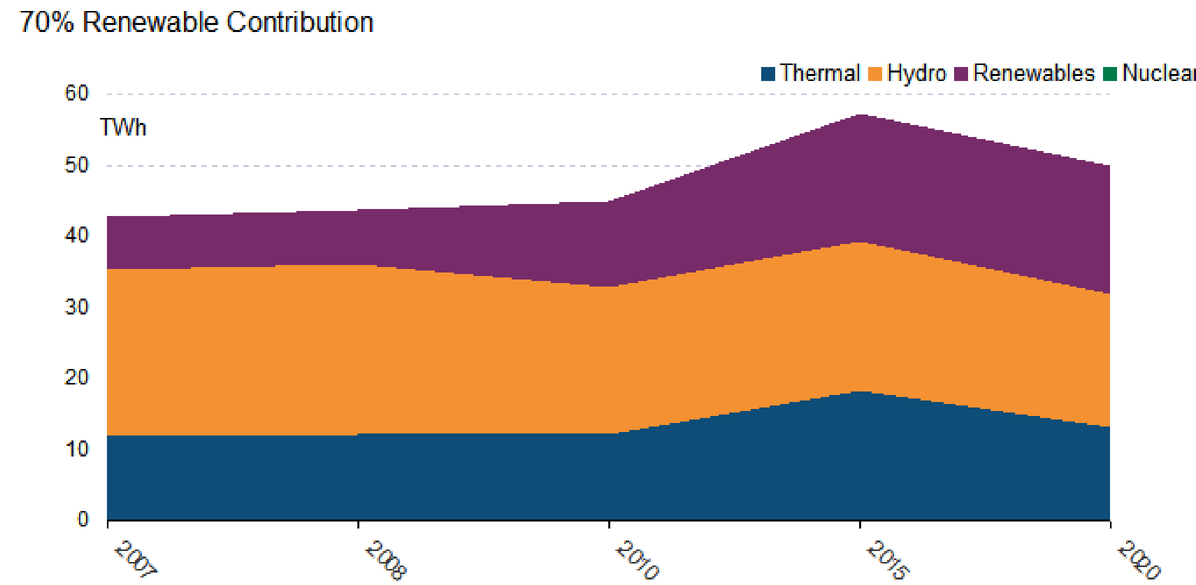
New Zealand has the highest percentage of power generated from renewable energy in the Asia Pacific region. A number of regulations and policies are in place to target that number up to 90% by 2025.

However, a change in government in 2008 has put a stop in some of these policies and a review of the Energy Strategy is likely to change some of the key policies to focus on energy security.

3.14.2 Market Size & Energy Mix

New Zealand currently generates around 70% of its power from renewable sources, mainly from hydro and geothermal.

Figure 3.15 NZ Power Generation Mix



Source: EIA, IEA, BP Statistics, CARMA, Estimates

REUTERS

3.14.3 Government Agencies

- *Ministry for the Environment* is the Government policy agency with over-arching responsibility for the implementation of the Resource Management Act (RMA) and Hazardous Substances and New Organisms Act (HSNO, see below). The Department of Conservation is responsible for the protection of natural and historical heritage.

Central government can issue national policy statements on any aspect of resource management which is of national significance. They will provide direction for district and regional councils. Regional councils are responsible for the mandatory regional policy statements. Other ministries involved in Clean Technology include:

- Ministry of Economic Development
- Ministry of Research, Science and Technology
- Ministry of Agriculture and Forestry
- Ministry of Energy

3.14.4 Renewable Regulation

- ***Resource Management Act*** *(1991)* defines sustainable management in ways that address social, economic, and cultural considerations, including meeting the needs of future generations, safeguarding the life-supporting capacity of natural resources and ecosystems, and avoiding, remedying, or mitigating the adverse environmental effects of human activities.

- ***Energy Strategy*** *2007*, the strategy sets out the Government's vision for a sustainable, low emissions energy system and includes an action plan for implementation. The Strategy sets a target of generating 90% of New Zealand's electricity from renewable energy sources by 2025. The new government announced in 2009 that it is revising the Energy Strategy to focus on security of supply.

- ***Framework for a New Zealand Emissions Trading Scheme*** *(ETS) 2007*. The government has made an in-principle decision that the ETS will include all major sectors and all greenhouse gases specified in the Kyoto Protocol. It is expected that by 2013 all major sectors will be included. However, the ETS is currently under review, with the change in government in 2008

- ***Minimum Energy Performance Standards*** *(MEPS)* The Government introduced regulations in February 2002 which require selected products and appliances to meet minimum energy performance standards (MEPS) and/or energy labelling requirements: Energy Efficiency (Energy Using Products) Regulations 2002

- ***Energy Efficiency (Energy Using Products) Amendment Regulations*** *2004*

- ***New Zealand Waste Strategy****.* This includes a target requiring all substandard wastewater treatment plants to be upgraded, closed or replaced by December 2020. The Ministry for the Environment partners the New Zealand Water and Wastes Association to develop initiatives which improve the country's environmental performance in the area of wastewater.

- **Biofuels Sales Obligation** (2007). The Government announced in 2007 that it would introduce a mandatory obligation for firms that sell petrol or diesel to sell biofuels. However the Sales Obligation was repealed in 2008, with the change in Government.

3.14.5 Renewable Targets & Incentives

New Zealand proposed a 90% renewable energy target by 2025, as part of its Energy Plan in 2007. However, with the change in government in 2008, the Plan is currently under review.

New Zealand Renewable Targets

Year	2008	2010	2025
Electricity Generation	43TWh*	45TWh*	50TWh*
Renewable Target			90%

Source: EIA, CARMA, Government Publications, Estimates

3.14.6 Research & Development

- ***The Foundation for Research, Science and Technology****.* The Foundation was established by the Research, Science and Technology Act 1990 to invest in science and technology research for the benefit of New Zealand. It is a Crown Agent governed by a Board appointed by the Minister of Research, Science and Technology. Its aim is to stimulate prosperity and improve the well-being of New Zealanders and the environment through investing in innovation and fostering the creation of new knowledge. It invests approximately NZ$450 million of public money per annum through a number of funds and schemes to help support:

public good' related science and technology, undertaken by Crown Research Institutes, universities, private researchers and industry led-consortia; private sector business research and development; and top-achieving students and researchers.

- ***Sustainable Business Initiatives***
- ***Pastoral Greenhouse Gas Research Consortium*** *(PGgRc)* Launched in 2002, this is a consortium of organisations from the agriculture industry (AgResearch Ltd, Dairy Insight, DEEResearch, the Fertiliser Manufacturers' Research Association, Fonterra, Meat and Wool New Zealand and Wrightson Ltd) who, with FRST (the Foundation of Research, Science and Technology), match fund investment which aims to understand and provide mitigation solutions for greenhouse gases produced by grazing animals.

3.14.7 Financing

Public Sector Funding

- ***The Energy Intensive Business (EIB) project****.* This project, run by the Energy Efficiency and Conservation Authority (EECA), offers cash grants to businesses to help them adopt energy saving technologies. The project is targeted at companies that spend a high portion of their business costs on energy, allowing them to apply for up to 40% of the capital cost of an energy efficiency project (to a maximum of $100,000). The grants are designed to pay for projects that include energy efficient technologies such as: high efficiency motors; fans and boilers; variable speed drives; dehumidifier dryers; heat recovery; storage and retention; cogeneration; renewable waste product fuels; industrial refrigeration; fishing technologies; and soil moisture sensing.
- ***Bio-energy Gateway****.* This is a program to support the use of wood waste as a renewable energy source from businesses. EECA is coordinating the bioenergy initiative of the Government' s Forest Industry Development Agenda (FIDA) to increase the uptake of renewable energy from the forestry sector. It provides tools, calculator and forums for the business

Private Sector Funding

Based on the Thomson Reuters Venture Capital Database, there were no deals completed in 2009 in Clean Technology. For more information, contact the **NZ Venture Capital Association.**

Project Finance

According to Thomson Reuters Project Finance Database, there was 1 projects totaling $632 million, associated with a Wind Project in 2009.

Public Companies

Most Clean Tech companies listed on NZ Stock Exchange. There were 2 companies, with a Market Capitalisation of $35 million in 2009.

4 REGIONAL COMPARISON

The APR will generate over 15,000 TWh by 2030, which will account for over half the global total. The North Asian Countries account for the largest power generation in APR (76%), mainly driven by China, which will increase to over 80% by 2020.

Hydro accounts for arounc 13-14% of the total power generated in the APR

Nuclaer, which is driven by the North Asian Countries and India, accounts for 8-9% of the total power generated.

Renewables, excluding Hydro accounts for only 2.3% in 2010 and expected to increae to 4% by 2030. Wind Power, Solar and Biomass are the largest contributors to the renewable contribution. Other growing sectors include Geothermal and Wave Technology.

4.1 North Asia

	2010					2020				
	Generation (TWh)	Thermal	Nuclear	Hydro	Renewable	Generation (TWh)	Thermal	Nuclear	Hydro	Renewable
China	3968	3223	65	642	36	6344	4847	286	1118	93
Japan	1063	699	310	79	43	1182	680	336	91	40
South Korea	412	265	142	4	2	537	313	211	4	8
Taiwan	218	164	38	8	8	354	276	58	9	11
North Asia	**5661**	**4351**	**555**	**733**	**89**	**8416**	**6116**	**891**	**1222**	**152**

Source: EIA, IEA, CARMA, Estimates

Hydro is expected to contribute over 1,200 TWh, with over 1,100 TWh contribution from China alone, mainly due to the construction of the Three Gorges Dam.

Nuclear is the second largest contributor with close to 900TWh by 2020, split evenly between Japan, South Korea and China.

Wind , Solar and Biomass are the major contributors to the Renewable Contributions, with 100GW and 30GW target for Wind and Biomass for China in 2020.

4.2 South Asia

	2010					2020				
	Generation (TWh)	Thermal	Nuclear	Hydro	Renewable	Generation (TWh)	Thermal	Nuclear	Hydro	Renewable
India	**863**	**667**	**37**	**138**	**21**	**1463**	**1050**	**119**	**247**	**47**

Source: EIA, IEA, CARMA, Estimates

Hydro is the largest contributor and is expected to oontribute around 250TWh by 2020, followed by Nuclear with 120 TWh by 2020.

Wind and Biomass are expected to be the largest contributor to the renewable contribution.

4.3 South East Asia

	2010					2020				
	Generation (TWh)	Thermal	Nuclear	Hydro	Renewable	Generation (TWh)	Thermal	Nuclear	Hydro	Renewable
Indonesia	180	155	0	15	11	290	253	0	21	16
Malaysia	110	90	0	13	7	150	115	0	27	8
Philippines	70	44	0	10	16	115	76	0	17	22
Thailand	170	159	0	7	4	260	245	0	10	5
South East Asia	**530**	**447**	**0**	**45**	**38**	**815**	**689**	**0**	**74**	**52**

Source: EIA, IEA, CARMA, Estimates

The largest contributor for South East Asia is Hydro with 75 TWh by 2020, contributing around 9% of the total power generation contribution.

Renewables are expected to contribute around 6.5% of the total power generation, mainly driven by Biomass and Geothermal. This is a higher contribution than North Asia countries.

4.4 Pacific

	2010					2020				
	Generation (TWh)	Thermal	Nuclear	Hydro	Renewable	Generation (TWh)	Thermal	Nuclear	Hydro	Renewable
Australia	276	250	0	17	9	306	275	0	18	15
New Zealand	45	12	0	21	12	50	13	0	19	18
Pacific	**321**	**263**	**0**	**38**	**21**	**356**	**288**	**0**	**37**	**33**

Source: EIA, IEA, CARMA, Estimates

The largest contributor for Pacific is Hydro with 37 TWh by 2020, contributing around 10% of the total power generation contribution.

Renewables are expeted to contribute around 9% of the total power generation, mainly driven by Wind and Geothermal.

Australia is a leader in Wave and Geothermal Technologies

4.5 Key Clean Technology Sectors

Based on the country review, key sectors for CleanTechnology in APR include:

- Hydro – which accounts for around 14% of the total power generation
- Nuclear - which accounts for around 8-9% of the total power generation
- Renewable Energy will grow from around 2.5% to 4% by 2030, mainly driven by growth in the Wind, Solar, Biomass and Geothermal sectors.

Other key technologies that will have a large impact on power generation include CCS, Smart Grid, Landfill Gas and Biogas. CCS alone, could account for 1125 projects and 850GW by 2050.

IEA CCS Projects in Power Generation

Region	No. Projects in 2020	CCS Capacity in 2020 (GW)	Captured 2020 (Mt CO_2/year)	No. Projects in 2050	CCS Capacity in 2050 (GW)	Captured 2050 (Mt CO_2/year)
OECD Pacific	2	1.3	9	150	85	510
China & India	6	2.5	13	465	365	1785
Non-OECD	4	1.6	6	610	400	1725
World Total	38	22	131	1670	1140	5510

Source: IEA

PART B – CLEAN TECHNOLOGY SECTOR REVIEW

5 ENERGY SECTOR OVERVIEW

5.1 Market Map of Clean Technology

There are many different definitions of Clean Technology and the term is loosely applied to a number of fragmented technologies that will either replace existing supply of fossil fuels or use energy more efficiently.

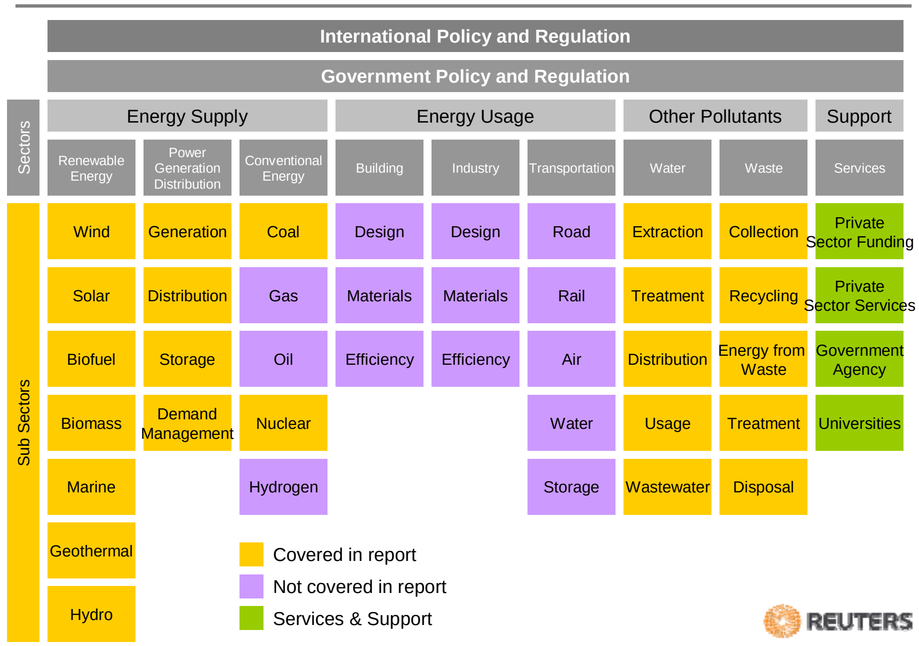
The Handbook has broken down the content into a "Market Map" with 4 main sectors:

- Energy Supply
- Energy Usage
- Other Pollutants (waste and water)
- Services

Each sector is then broken down into smaller sub-sectors. We will use this fragmented Market Map and overlay it onto a diverse set of countries that make up APR and attempt to construct a country profile and highlight particular 'hot spots' for a country. Detailed company profiles are provided in the Appendix.

In addition, this allows a user to take a sector look across APR and compare say - Geothermal in Australia, Indonesia, Japan and Philippines. Please contact the author for further updates.

Figure 5.1 – Asia Pacific Clean Tech Market Map



5.2 Energy Supply

5.2.1 Renewable Energy

5.2.1.1 Wind

Wind is the largest sector in the renewable technology space in APR and continues to lead the way in terms of installed capacity. Breakdown of the wind sector is broken down as:

Wind Turbines

- ***Offgrid / <1 MW / Horizontal*** – Horizontal wind turbine with under 1 MW capacity that generates electricity to be used locally and does not require connection to the power grid
- ***Offgrid / <1 MW / Vertical*** – Vertical wind turbine with under 1 MW capacity that generates electricity to be used locally and does not require connection to the power grid
- ***Ongrid / 1-3 MW / Onshore*** – Horizontal wind turbine with capacity between 1 and 3 MW that is located onshore and feeds the generated electricity onto the power grid
- ***Ongrid / >3 MW / Onshore*** – Horizontal wind turbine with capacity over 3 MW that is located onshore and feeds the generated electricity onto the power grid
- ***Ongrid / >3 MW / Offshore*** – Horizontal wind turbine with capacity over 3 MW that is located offshore and feeds the generated electricity onto the power grid

The supply chain can be broken down into: Gearbox; Blades; Components; and Operators.

For an update on the Wind Sector in Asia Pacific, see **Section 6.1**.

5.2.1.2 Solar

The solar sector covers all technologies related to the capture energy from the sun. These include direct production of electricity using semiconductor-based photovoltaic (PV) materials, use of concentrated sunlight to heat fluid to drive power generation equipment, and passive methods which use solar to replace fossil fuel energy, such as heat water. The photovoltaic sector, along with the wind sector is the largest of the renewable sector in terms of investment and installed capacity.

Photo Voltaic (PV)

The PV Solar supply chain can be broken down into:

- Feedstock
- Wafer
- Cell & Module Manufacturers
- Equipment Manufacturers

There is a move into ***Thin Film PV*** to commercialize new technology, which includes:

- ***Amorphous Silicon Thin Film Photovoltaic Cell (a-Si PV)*** – Type of thin film solar cell based on amorphous silicon chemical compound

- ***Building Integrated Photovoltaic (BIPV)*** – Application of solar photovoltaic materials, whether crystalline or thin film, into actual building structures, normally replacing conventional building materials in parts of the building envelope such as the roof, skylights or facades

- ***Cadmium Telluride Thin Film Photovoltaic Cell (CdTe PV)*** – Type of thin film solar cell based on cadmium telluride chemical compound

- ***CIGS Thin Film Photovoltaic Cell (CIGS PV)*** – Type of thin film solar cell based on copper iridium gallium selenide chemical compound

- ***Crystalline Silicon Photovoltaic Cell (cSi PV)*** – Type of solar cell made from a single crystal or a polycrystalline slice of silicon that was the first type to be widely commercialized

Solar Concentrator

The solar concentrator market is concentrated in Australia and in some parts of China. It is much smaller than the PV solar market in APR. Key technologies include:

- ***Concentrating Photovoltaic (CPV)*** - Device that concentrates sunlight onto photovoltaic surfaces to produce electricity.

- ***Fresnel Mirror*** – Solar thermal energy collector that consists of a series of long, narrow, slightly curved mirrors that focus the light onto linear receivers positioned above the mirrors to be eventually converted into electricity.

- ***Parabolic Dish Stirling Engine*** – Device that concentrates sunlight at a single focal point via a parabolic dish to produce electricity and that can track the sun along two axes by automatically adjusting the direction of the dish.

- ***Parabolic Trough*** – Solar thermal energy collector that consists of a long parabolic mirror and a Dewar tube running its length at the focal point that absorbs energy from the sunlight which is converted into electricity.

- ***Power Towers*** – Type of solar power plant that uses a tower and a high heat capacity component to receive the sunlight focused by an array of flat movable mirrors and convert it into electricity.

Solar Water Heater (SWH)

Solar water heaters are a system which heats water by absorbing energy from sunlight. It normally consists of solar thermal collectors, fluid systems to transport the heat and a water tank, where water is heated and stored. China is the global market leader and accounts for two thirds of global manufacturing.

Solar from Space

While outlandish, there are plans to place PV Solar panels in space. Solar in space benefits from not being affected by weather, while also being able to be positioned so it can generate power 24 hours a day. The two notable issues will be the cost of sending payloads up into space and the transmission of microwaves to land based receivers. A key player in this area is Japan.

For an update on the Solar Sector in Asia Pacific, see **Section 6.2.**

5.2.1.3 Biofuel

Liquid transportation fuels including biodiesel and bioethanol. These can be derived from a range of biomass sources, including palm oil, sugar cane, soybean oil, algae or jaltropha. Biofuel production varies from country to country, with Biodiesel generated from Palm Oil dominating in Malaysia and Indonesia.

- ***Palm Oil Biodiesel*** – Biodiesel produced from Palm Oil. This market is concentrated primarily in Malaysia and Indonesia and is contentious, due to its association with the clearing of tropical rainforests

- ***Jatropha Diesel*** – Biodiesel produced from jatropha crop and can grow on poor soil. However, takes years to produce first crop.

- ***Mircoalgae Diesel*** – Diesel produced from microalgae, which are photosynthetic organisms that can be farmed in water.

- ***Cassava Bioethanol*** – Bioethanol produced from cassava crop.

- ***Cellulosic Bioethanol*** – Bioethanol produced from wood, grasses or other plants.

- ***Sweet Sorghum Bioethanol*** – Bioethanol produced from sweet sorgum crop.

- ***Waste Vegetable Oil Biodiesel*** – Biodiesel produced from waste vegetable oil.

For an update on the Biofuels sector in Asia Pacific, see **Section 6.3.**

5.2.1.4 Biomass

Production and consumption of solid and gaseous fuels derived from biomass. Solid biomass for the energy sector can include a number of specially-grown crops, such as switch grass and wood pellets, but it can also consist of crop residues. Biomass is a key sector in APR, with a consistent feedstock and is being used as an alternative feedstock for developers, generators and utilities in countries, such as Indonesia.

For an update on the Biomass sector in APR, see **Section 6.4.**

5.2.1.5 Hydro

Hydro power is one of leading renewable sources of power in Asia Pacific. Plants can generally be divided into three different categories depending on the type of head and the nature of the plant. There has been a rush of micro hydro projects in Asia, driven by CDM projects.

- ***High-head power plants*** are the most common and generally include a dam to store water at a higher elevation. These systems are commonly used in mountainous areas.
- ***Low-head hydroelectric plants*** generally use heads up to a few metres in elevation or simply function on the run of the river. Low-head systems are typically built along rivers.
- ***Multipurpose hydro power systems*** are generating facilities where the hydro power is subordinate to other activities like irrigation, industrial processes, drinking water supply or

wastewater disposal. Electricity production is thus not the only objective of the plant but often a useful by-product.

For an update on the Hydro sector in Asia Pacific, see **Section 6.5**.

5.2.1.6 Wave/Tidal

The Wave/Tidal sector covers all technologies relating to extraction of energy from the sea and tidal flows. Possibilities include waves and tide, either via tidal barrages or tidal flow generators. Unlike Solar or Wind, there appears to be no leading technology and a number of different technologies are emerging that fall into three main categories: oscillating columns; oscillating bodies; and overtopping technologies. There seems to be less government funding and backing for this sector in APR, even though the potential natural resources appear to be huge.

For an update on the Wave/Tidal sector in Asia Pacific, see **Section 6.6**.

5.2.1.7 Geothermal

Geothermal power has long played a part in the energy mix of countries along the “Ring of Fire”, such as Philippines, Indonesia and Japan. Three power plant technologies are being used to convert hydrothermal fluids to electricity. The type of conversion depends on the state of the fluid (steam or water) and on its temperature:

- ***Dry steam power plants*** use hydrothermal fluids primarily in the form of steam. The steam goes directly to a turbine, which drives a generator that produces electricity. This is the oldest type of geothermal power plant.
- ***Flash steam power plants*** use hydrothermal fluids above 175°C. The fluid is sprayed into a tank (separator) held at a much lower pressure than the fluid, causing some of the fluid to vaporise rapidly, or “flash” to steam. The steam then drives a turbine.
- ***Binary-cycle power plants*** use hot geothermal fluid (below 175°C) and a secondary (hence, “binary”) fluid with a much lower boiling point than water – both passing through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to steam, which then drives the turbines.

For an update on the Geothermal sector in Asia Pacific, see **Section 6.7**.

5.2.2 Power Generation and Distribution

Generation

This sector covers technologies that result in a technological improvement in the generating efficiency of existing power generation equipment. Technologies include motor or generator design, as well as software, sensor and control technologies.

Distribution

As power supply (generated via renewable sources) become more variable the importance of reducing grid losses becomes higher with higher power costs, so the significance of improving power distribution will grow. This sector includes a number of technologies that target such improvement, from the forecasting of renewable resource availability, through software to balance supply and demand or find grid faults, to technology that allows peak shifting or intelligent meter reading.

Storage

Many renewable energy and emerging energy technologies are either intermittent, or have responses that are unable to follow the dynamic demands that will be put on them when deployed. Batteries and other energy storage technologies become important for any shift to these technologies. Leading storage technologies include:

- ***NaS Battery*** – Sodium-sulphur battery with high energy density and high efficiency of charge/discharge that requires high operating temperatures.
- ***Vanadium Redox Battery*** – Flow battery with deep cycling life that can be mechanically refueled and has low negative environmental impact.

Smart Grid

This a sector that is gaining favour with venture capitalists and investors, as countries look to upgrade their grid infrastructure to cater for decentralised power generation from multiple sources. Key technologies include:

- ***Advanced Metering Infrastructure (AMI)*** – Integrated system that measures, collects, stores and analyzes utility usage, such as electricity, gas or water usage; is a broader concept than AMR-IP based solution.
- ***Digital Substation*** – Automated and computerized substation that provides greater transparency, higher reliability and efficiency of operations.
- ***IP-Based Automatic Meter Reading (AMR)*** – Solutions that automatically gather data from energy metering devices and transmit to a central processing facility where billing is handled and consumption patterns are analysed.
- ***Real-Time Information Processing*** – Solutions that enable real time communication between core nodes in the electric network, including customer premise, and allow better management of demand, improved reliabiliity and flexibility of the network.
- ***Wide Area Management System (WAMS)*** – Integrated system that monitors and controls elements of the electrical power grid to ensure availability and improve reliability and efficiency of the network.

For an update on the Smart Grid sector in Asia Pacific, see **Section 6.8.**

5.2.3 Conventional Energy

Coal

Cleaner coal includes solutions such as ***Coal Screening and Scrubbing***, ***Integrated Gasification Combined Cycle*** (IGCC) and ***Carbon Capture and Sequestration*** (CCS).

For an update on the CCS sector in Asia Pacific, see **Section 6.9.**

Gas

Cleaner gas consists of solutions such as ***Capture and Use of Coal Mine Ventillation Air Methane*** and ***Natural Gas Combined Cycle*** (NGCC).

Oil

Cleaner oil is made up of solutions such as ***Efficient Oil Extraction***, ***Water Reinjection*** and ***Optimized Reservoir Management*** that allows oil to be extracted in ways which minimize negative impact on the natural environment.

Nuclear

Nuclear power is energy derived via controlled nuclear fission of radioactive materials at nuclear power plants. While not renewable, it is currently the only non fossil fuels available to replace fossil fuel baseload power generation. This section also looks at the advances in new reactor design and new materials required to build the next generation of reactors.

For an update on the nuclear sector in Asia Pacific, see **Section 6.10.**

5.3 Energy Usage

5.3.1 Building (Residential and Commercial)

Green Buildings covers planning, building and operating solutions that are more sustainable, efficient than existing buildings. This includes retrofitting existing buildings.

Design

Integrated Design such as ***LEED accreditation*** can lead to significant energy savings and efficiency gains.

Materials

Improvements in materials such as: insulation, double glazing and building material will lead to more efficiency gains in trapping heat in winter and cooling in summer.

Efficiency

Improvement is energy and water efficiency in the residential and commercial building. This will include energy efficiency in air conditioning coolers.

- ***Green Devices*** – Electronic devices used inside buildings, including lighting solutions, appliances and consumer electronics that are more energy efficient than conventional alternatives. This section overlaps and integrates into the ***Smart Grid*** section.

- ***Smart Buildings*** – Buildings that rely on integrated IT-based resource use measurement and monitoring, intelligent analysis of the internal environmental and performance data, and automation of connected building systems.

- ***Advanced Envelope*** – Includes insulation, windows, roofing and other passive solutions

- ***Building-Integrated Heat and Power*** – Combination of heating and power generation solutions that could be integrated into a building, such as solar photovoltaic cells, wind turbines and solar water heaters.

5.3.2 Industry

This section covers planning, building and operating solutions which are more sustainable and efficient than existing industrial processes.

Design

Integrated Design for industrial processes in industries, such as manufacturing, refining, which can lead to significant energy savings and efficiency gains.

Materials

Improvements in materials in industrial processes that will lead to more efficiency gains.

Efficiency

Improvement is energy and water efficiency in industrial processes.

5.3.3 Transportation

Road

Cleaner road transportation includes more efficient engines, alternative vehicle energy systems, as well as comprehensive road network planning and development.

Rail

Cleaner rail transportation refers to energy efficient trains, electrification of railways and Optimized Railway Operations Management.

Air

Cleaner air transportation includes Fuel Efficient Aircraft, well planned and constructed airport infrastructure and Optimized Air Traffic Management.

Water

Cleaner waterway transportation covers Fuel Efficient Ships, well planned and constructed waterway infrastructure and Optimized Water Traffic Management.

Storage – Hydrogen, Fuel Cells, Batteries

This sector includes hydrogen from the production, storage and trasportation of hydrogen, as well as the applications in which it can be used. Fuel cells can burn a variety of hydrocarbon fuels. Batteries are an important component for transportation, particularly for road.

5.4 Other Pollutants

5.4.1 Wastewater

The Wastewater sector will focus on wasterwater treatment and biogas. However technologies include:

- ***Extraction Solutions*** - Solutions that help locate, access and extract water from underground sources.
- ***Desalination*** - Process that removes salt and other minerals from saline water, such as sea water, in order to make it suitable for human consumption or irrigation.
- ***Secondary Treatment Solutions*** - Solutions that substantially remove the biological content of sewage, including derivates of human waste, food waste, soaps and detergent.
- ***Sludge Treatment and Disposal*** - Solutions including dewatering, landfill storage and fertilizer conversion that treat sludge generated from wastewater treatment to remove usable substances and properly dispose of residual wastes.
- ***Tertiary Treatment Solutions*** - Solutions that provide a final treatment to raise the effluent quality of the water before it is discharged into the receiving environment.
- ***Improved Irrigation*** - Irrigation solutions such as sprinkler or drip irrigation that use water more efficiently than China's conventional irrigation methods with equal or greater benefit to the user.
- ***Low-Flow Fixtures*** - Faucets and other water use systems that use less water that conventional systems but deliver the same or greater benefit to the user.

For an update on the Wastewater sector in Asia Pacific, see **Section 6.11**

5.5 Waste

Waste management services including collection, recycling, energy from waste (including landfill gas and incineration), treatment and disposal. The focus will be on waste to energy technologies, primarily incineration and landfill gas.

For an update on the Waste sector in Asia Pacific, see **Section 6.12**

5.6 Service & Support

5.6.1 Private Sector Funding

This includes Venture Capital Funds, Private Equity and Capital Markets. Asian financial capital markets are still quite nascent compared with their western counterparts.

5.6.2 Private Sector Services & Support

The rapid growth of the clean energy industry will require the development of a complete sector of service companies dedicated to serving the needs of technology and equipment suppliers, owners of renewable energy and biofuels assets, and so on. In this sector we put providers of information and research, specialised clean energy financial services companies and consultants.

5.6.3 Government Agencies

Government and quasi government agencies that support, sponsor and subsidize Clean Technology.

5.6.4 Universities

Research and Development and Incubators set up for Clean Technology.

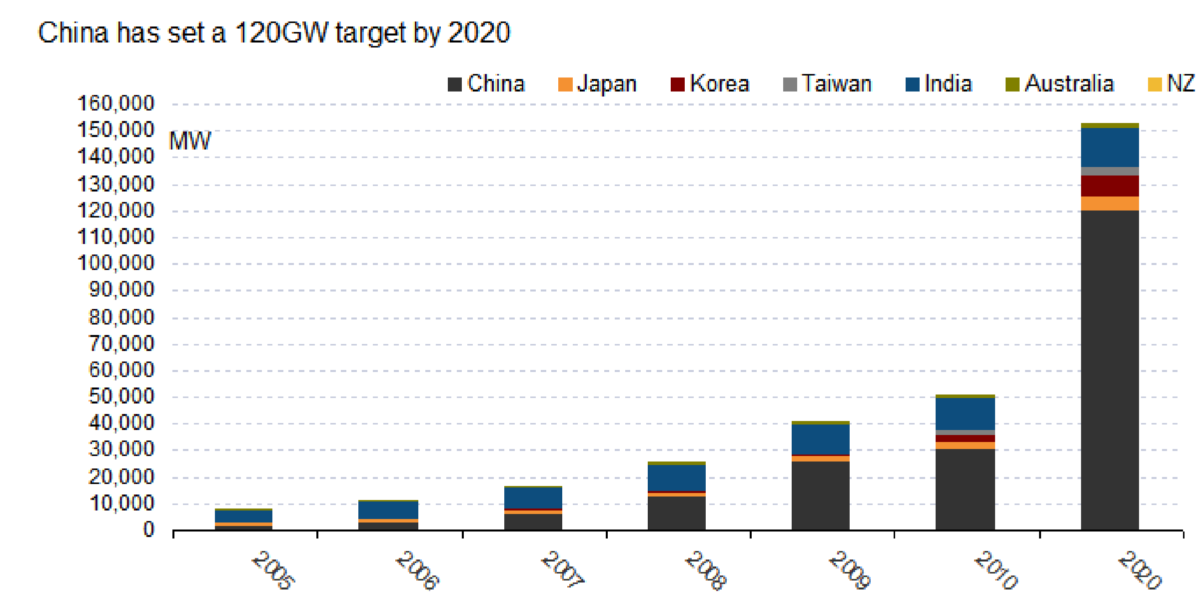
6 ENERGY SECTOR, BY COUNTRY

6.1 Wind

6.1.1 Background

China became the world's largest market for wind in 2009, with total capacity of nearly 26GW. The 2020 target for wind in China is expected to be raised from 30 GW to around 120GW. In 2008, wind provided less than 1% of China's total electricity needs, but will form a key part of China's push to produce 20% power from renewables by 2020.

Figure 6.1 Asia Pacific Wind Sector



Source: GWEC, IEA, Govt Publications, Estimates

REUTERS

Total Installed capacity (MW)

Year	2005	2006	2007	2008	2009	2010T	2020T
China	1,260	2,599	5,910	12,210	25,777	30,000	120,000
Japan	1,049	1,309	1,538	1,880	2,000	3,000	
South Korea	119	176	192	278	300	2,250[29]	8,000
Taiwan	103,7	187,7	279,9	358	360	2,159	3,000[30]
India	4430	6270	7850	9587	10,926		
Indonesia	0.8	0.8	1	1.2	2		970[31]
Philippines	25.2	25.2	25.2	25.2	30		
Australia	708	817	824	1,306	1,400		
NZ	168	171	322	326	350		

Source: GWEC, IEA, Govt Publications, Estimates

6.1.2 Targets & Incentives

China and India have the greatest installed capacity in APR. Japan is a notable laggard and is expected to fail to meet its 2010 target of 3 GW.

- China has put in place an aggressive renewable plan with increased its target for Wind Power by 2020. It has also highlighted wind, as a strategic sector to receive funding from the ‘made in China’ fiscal stimulus in 2009 and encouraged cheap financing to build up its domestic industry.
- India followed China, in its bid to set ambitious renewable targets, in a bid to build up its domestic industry.

6.1.3 Wind Supply Chain

The wind supply chain can be broken down into turbines, blades, gearbox, components and operators.

The Europeans have traditionally dominated the wind manufacturing sector, with Vestas the global market leader. However, China has aggressively increased the number of manufacturers and encouraged loans and investments in this space. There are around 70 manufacturers in China alone which account for the oversupply in the wind sector.

[29] 2012 Target, IEA

[30] 2025 Government Target

[31] 2025 Government Target

Figure 6.2 – Wind Supply

	Blades	Gearbox	Turbines	Components	Operators
China	Tianjin Xinmao,	CHST, Chongqing,	Goldwind, Sinovel,	Wafangdian	China Wind Power,
Japan			MHI, Fuji Heavy	Komai Tekko	Japan Wind Farm
S Korea	Hyundai, Daewoo,	Hyundai, Daewoo,	Hyundai, Daewoo,	Hyunjin Materials,	Unison
Taiwan		Formosa Heavy	TECO Electric	China Steel Machinery	Taipower
India	Suzlon	Suzlon	Suzlon, RRB	Suzlon	India Energy, ITC
Australia					Infigen

Source: Company Reports, Thomson Reuters

REUTERS

6.1.4 Research & Development

GE, Mitsubishi Electric <6503.T> and Enercon have been the traditional leaders in the wind sector with a number of patents filed. However, Mitsubishi Electric appears to be placing less emphasis in this sector. Enercon (Aloys Wobben) is a maturing small company that was a technology founder, but it has relatively few new inventions. Among smaller entities, the recent entrants are perhaps unexpected, emphasizing the utility of segmentation to find technical niches that ordinarily might be overlooked. Vestas Wind Systems is in litigation regarding its activity in this field. The academic-government entities at the top of the list show how heavily Chinese universities are invested in technology development.

LARGER PRESENCE IN FIELD	06-08	97-08	% RECENT
SHANGHAI JIUNENG ENERGY SCI & TECHNOLOGY	26	27	96
NTN CORP	42	45	93
GENERAL ELECTRIC CO	125	176	71
REPOWER SYSTEMS AG	52	75	69
NORDEX ENERGY GMBH	27	39	69
MATSUSHITA ELECTRIC WORKS LTD	26	50	52
FUJI HEAVY IND LTD	17	42	40
SIEMENS AG	18	53	34
HITACHI LTD	24	73	33
DAIWA HOUSE KOGYO KK	7	30	23
AERODYN ENG GMBH	5	36	14
MITSUBISHI ELECTRIC CORP	18	136	13
EBARA CORP	3	36	8
ENERCON - ALOYS WOBBEN	6	125	5

Source: Thomson Reuters Scientific

SMALLER PRESENCE IN FIELD	06-08	97-08	% RECENT
DAUBNER & STOMMEL GBR BAUWERK-PLANUNG	10	10	100
WUJIANG FANGXIA ENTERPRISE INFORMATION CO	10	10	100
TAIHEIYO CEMENT CORP	9	11	82
KANZAKI KOKYUKOKI MFG CO LTD	6	10	60
CLIPPER WINDPOWER TECHNOLOGY INC	5	10	50
YANMAR DIESEL ENGINE CO	5	10	50
SKF AB	5	15	33
FJC KK	4	14	29
ZEPHAR KK	4	15	27
KANSAI DENRYOKU KK	2	10	20
SHISUTECH KK	1	12	8
VESTAS WIND SYSTEMS AS	1	18	6
TACKE WINDENERGIE GMBH	0	12	0

Source: Thomson Reuters Scientific

ACADEMIC - GOVERNMENT	06-08	97-08	% RECENT
UNIV NANJING AERONAUTICS & ASTRONAUTICS	8	8	100
UNIV HEBEI AGRIC	5	5	100
UNIV HUAZHONG SCI & TECHNOLOGY	5	5	100
UNIV KANSAI	4	4	100
UNIV XIAN TECHNOLOGY	4	4	100
UNIV ZHEJIANG	4	4	100
CHINESE ACAD SCI ELECTRICAL ENG INSTITUTE	3	3	100
UNIV SHANGHAI JIAOTONG	25	29	86
UNIV SOUTHEAST (CN)	4	5	80
UNIV TOKAI GH	3	6	50
GH CHIKOJI GAKUEN	1	3	33
ENERGIE-UMWELT-BERATUNG EV INSTITUT	0	7	0

Source: Thomson Reuters Scientific

6.1.5 China

Market Size & Growth

China leads the way in wind generation capacity and is now the second largest market, after the US in 2009.

In 2008, the newly-established ***National Energy Administration*** (NEA) highlighted wind energy as a priority for diversifying China's energy mix. It selected six locations with the best wind resources: Xinjiang, Inner Mongolia, Gansu, Hebei and Jiangsu. Each site will have more than 10 GW of installed capacity by 2020, known as the '***10 GW Size Wind Base Program***'. The Wind Base projects will ensure more than 100 GW of installed capacity by 2020 and help in reaching the government's National Mid and Long-Term Development Plan of 3% non-hydro renewable electricity production by 2020.

In addition, Wind was targeted as a strategic industrial sector in 2009 and due to a combination of government policy, financial incentives and access to cheap credit, this led to the establishment of 70-80 local providers[32]. By mid 2009, there was a concern of oversupply in the domestic market, combined with flagging demand in the European markets.

[32] China Wind Energy Association

European manufacturers have complained that the bidding process for local contracts is opaque, claiming lopsided order wins from national concession projects.

Along with government policy, the ***Clean Development Mechanism*** (CDM) provides a further incentive to wind energy development in China.

Drivers & Constraints

A constraint on the growth of renewable power is the ability of China's grid system to cope and incorporate wind generated electricity. This rapid growth of installed power is far ahead of the national plan, and the grid connection which is still run by the Government, will be a constraining factor in the further expansion of wind power.

Market Players & Competition

At the end of 2009, there were over 70 manufacturer operating in China. However, the top three manufacturers in China: Goldwind, Sinovel and DEC (Dongfeng Electric), dominate the market with an annual manufacturing capacity of 4 GW, while the international companies in China (Vestas, Suzlon, GE, Gamesa, Nordex and Repower) have similar capacity. This has already led to intense price competition and charges by the EU Chamber of Commerce in China that the new government projects favour domestic manufacturers. A summary of key domestic players are provided below:

Turbine Manufacturers

- **Xinjiang Goldwind <002202.SZ> -** Goldwind is a leading wind turbine manufacturer in China, and develops, constructs and operates wind farms. It supplies various kinds of wind turbines ranging from 600KW to 1.5MW, and has 2.5MW, 3MW and 5MW class wind turbines in R&D. The company acquired a 70% stake of Vensys Energy, significantly enhancing its R&D capability and establishing a solid foundation for overseas expansion. For a detailed company profile, see Appendix A.

- **Dongfang Electric <1072.HK, 600875.SS>** is one of the leaders in power generation equipment, ranging from thermal, wind, hydro and nuclear power generation. It entered the wind power industry in 2004 by purchasing the user rights of turbine design for 1.5MW wind turbine from Repower and is developing 2MW, 2.5MW and 3MW class turbines. Dongfang Electric is the most vertically integrated domestic wind turbine manufacturer. For a detailed company profile, see Appendix A.

- **Shanghai Electric <2727.HK, 601727.SS>** launched its wind turbine business in early 2006 by purchasing 1.25MW turbine technology from Dewind. To date, it has produced small quantities of a 2MW direct drive turbine that it jointly designed with Aerodyn. It also has a 3.6MW offshore wind turbine at the R&D stage. In 2008, Shanghai Electric installed 178.75MW of turbines, accounting for 2.86% of the newly-increased wind power capacity in China. The company plans to achieve annual capacity of 100 units, 800 units and 180 units of 1.25MW, 2MW, and 3.6MW, respectively, in 2012. For a detailed company profile, see Appendix A.

- **Huayi Electric Apparatus <600290.SS>** primarily produces high-voltage apparatus and diversified into the wind power space in 2002. It has independently developed 780kW class turbines, using Aerodyn's wind turbine technology and has jointly developed 1.5MW wind turbines. Furthermore, The R&D of 2.0MW/3.0MW wind turbines is underway. By 2010, the company aims to achieve capacity of 750MW.

- **Xiangdian Electric <600416.SS>** produces a broad range of wind turbine generators, and it made China's first 1300KW wind turbine in 2005. In 2006, together with Japan's Harakosan Xiangdian Electric, established Hara Xiangdian Windpower, which has the capacity to produce 300 units of 2MW direct-drive turbines in 2009.

- **Sinovel** <Unlisted> is a subsidiary of Dalian Heavy Industry Group focused on developing, engineering and marketing wind power generator equipment, with factories in Dalian, Inner Mongolia and Jiangsu. Its main product is a 1.5MW turbine, the technology license for which it purchased from Fuhrlander, and has 2MW/3MW/5MW class turbines at the R&D stage. The company aims to produce 2000 units of 1.5MW turbines and 100 units of 3MW offshore turbines in 2009. In 2008, Sinovel delivered 1402.4MW in turbines, becoming the No.1 manufacturer in China in terms of newly increased capacity that year.

- **Zhejiang Windey** <Unlisted> After purchasing the licence for 750KW class turbine production technology from Repower, Zhejiang Windey (Windey) started production in 2003. It is now producing an 800KW turbine with its own intellectual property, which it has exported to Thailand, and has begun small batch production of a 1.5MW class turbine. The company plans to achieve annual capacity of more than 2000MW in 2012. Windey is also developing a 2.5MW class turbine with technical support from Garrad Hassan.

- **Guangdong Mingyang** <Unlisted> In 2006 Guangdong Mingyang (Mingyang) began cooperation with Aerodyn, with 1.5MW and 2.5MW turbines under batch production and a 'Super Compact Drive' offshore turbine at the sample phase. In January 2009, it signed a joint venture program of manufacturing wind turbine conversions with IDS. This made Mingyang the only domestic manufacturer with the core control technology of a 1.5MW turbine. Mingyang is aiming to build its in-house production of key components and developing offshore turbines. According to the company the capacity could reach 2850MW when all the manufacturing bases are built up.

- **Jiangsu New Unite** <Unlisted> Jiangsu New Unite was co-founded by Changqian Group and HongKong New Unite group in 2007, to focus on developing, manufacturing and marketing wind turbines in China. It has obtained a technology license of 1.5MW turbine from Shenyang Industrial University, and begun batch production. It is manufacturing a 2MW direct-drive turbine on a small scale and designing a 3MW turbine. The company expects the capacity to be 700-800 units of turbine and 2000 pieces of blades in 2011.

- **Chongqing Haizhuang** <Unlisted> Chongqing Haizhuang, a subsidiary of China Shipping Industry Corporation, entered the wind power industry in 2007. It obtained a technology license from Frisia to produce 850KW turbines, and jointly designed a 2MW turbine with

Aerodyn. It is also working on 5MW offshore turbine. The company has annual capacity of 1000MW turbines.

Gearbox

- **China High Speed Transmission <0658.HK> -** China High Speed Transmission Equipment is a leading mechanical transmission equipment producer in China with a history dating back to 1969. It is a major supplier of mechanical transmission equipment for wind turbines in China. As well as wind power generation, it also produces equipment for marine vessels, rail transport, aerospace, metallurgy, petrochemicals, construction and mining. The wind gear transmission equipment sector was a major revenue contributor and key revenue driver in 2008. In 2007, China High Speed Transmission was listed on the Hong Kong Stock Exchange. For a detailed company profile, see Appendix A.

- **Chongqing Gearbox** <Unlisted> Chongqing Gearbox, a subsidiary of China Shipping Industry Corp, specializes in developing and manufacturing gearboxes for ships and wind turbines, couplings, dampers, and reducers. Its wind gearboxes range from 600KW to 2MW with annual capacity of 1000 sets currently. In January 2009, the company started construction of wind gear project, which it has indicated will be put into operation in 2011.

- **Hangzhou Advance Gearbox** <Unlisted> Hangzhou Advance Gearbox specialises in designing and manufacturing transmission and powder metallurgical products. It has developed wind turbine gearboxes for 275KW, 280KW, 634KW, 645KW, 880KW, 1660KW turbines. In June 2009, the company started construction of wind gear manufacturing base with annual capacity of 1,000 sets.

Blade Manufacturers

- **Zhonghang Huiteng** <Unlisted> Zhonghang Huiteng mainly develops and manufactures wind turbine blades and related glass fibre product components. It has developed and marketed a wide range of blades from 600KW to 3MW, with annual production capacity of 1000 600KW sets, 2400 750KW sets, 2000 1.5MW sets and 500 other MW sets. Its customers are major wind turbine manufacturers domestically and globally. For a detailed company profile, see Appendix A.

- **China National Building Material <3323.HK> -** China Composites Group is a subsidiary of China National Building Material (CNBM), which is mainly engaged in cement, lightweight building materials, glass fibre and products and engineering services. In 2007, it acquired NOI German and set up overseas company SINOI for capacity expansion and technology sourcing of wind turbine blades. The main blades produced by CNBM are 1.5MW and 2MW with a total annual capacity of 5000 pieces.

- **Sinoma Science &Technology <002080.SZ> -** Sinoma Science & Technology is involved in the research, design, manufacture and sale of specialty fibre composites in China, entered the wind blade business in 2006. Currently, the company can produce wind blades for 750KW, 850KW, 1.5MW and 2MW turbines, and believes it will be able to produce 1300 sets per year after completion of MW blade projects in late 2009.

Main Shaft Bearings

- **Wafangdian Bearing <200706.SZ> -** Wafangdian Bearing is a leading bearing manufacturer in China. Its main products are industrial bearings, CV joints and precision ball screws, which are widely applied in transport, metallurgy, mining, and general machinery, petrol, and electric power. The company launched R&D on wind turbine bearings in 2006, and has developed full sets of bearings for wind turbines, including main shaft bearings. It has begun to produce main shaft bearings for wind turbines from 750KW to 3MW in batches while it has bearings for 5MW is at the R&D stage. In late 2009, the company expected to reach annual capacity of 6000 sets main shaft bearings.

6.1.6 Japan

Market Size & Growth

Japan's wind energy industry has grown in recent years, partly spurred by a government requirement for electricity companies to source an increasing percentage of their supply from renewables, as part of the new government's mandate to reduce emissions by 25% by 2020. Development has also been encouraged by the introduction of market incentives, both in terms of the price paid for the output from renewable plants and in the form of capital grants towards clean energy projects. Power purchase agreements for renewables also have a relatively long lifespan of 15 to 17 years, which helps to encourage investor confidence. The result has been an increase in Japan's installed capacity from 136 MW at the end of 2000 to 1,880 MW at the end of 2008. In 2008, 346 MW of new wind capacity was added in Japan. However, Japan trails behind both China and India, in terms of wind power installed.

Drivers & Constraints

Japan has a target to reduce the level of its greenhouse gas emissions by 6%, compared with 1990 levels, in the period from 2008 to 2012; and now further has increased it reduction target to 25% by 2020. The official government target for wind power in Japan by 2010 is 3,000 MW but is unlikely to reach that target. The Japanese government introduced a ***Renewable Portfolio Standard*** (RPS) law in April 2003 with the aim of stimulating renewable energy to provide 12.2TWh (1.35%) of total electricity supply in 2010. RPS targets will be reviewed every four years, and a new target of 16.0 TWh (1.63%) by 2014 was established in 2007. However, the government has proposed a new renewable target of 20% by 2020.

Growth in the wind sector has been hampered by restrictions imposed by the incumbent utilitility companies that limit the amount of wind capacity that can be added to the grid, citingissues with intermittency.

Restrictions on Wind Power to the Grid

Utility	Capacity	Restriction	%
Tokyo	60GW	No restriction	n/a
Kansai	37GW	No restriction	n/a
Chubu	33GW	No restriction	n/a
Kyushu	19GW	700MW (2006)	3.7%
Tohoku	16GW	520MW (2006)	3.25%
Chugoku	12GW	400MW (2005)	3.3%
Hokuriku	8GW	80MW (2006)	1%
Shikoku	7GW	200MW (2005)	2.9%
Hokkaido	6GW	50MW (2006)	<1%
Okinawa	2GW	25MW (2006)	1.2%

Source: Institute for Sustainable Energy Policy

In addition, the restrictions are compounded by grid infrastructure, where leading areas for wind power in Japan are Tohoku and Hokkaido in the north of the country and Kyushu in the south. However, the greatest electricity demand is concentrated in the center of Japan, while most potential wind power sites are located in remote areas where grid capacity is relatively small.

Market Players & Competition

Japan has placed less emphasis on the wind sector and has lost ground to international competitors, with foreign manufacturers such as Vestas, GE and Enercon dominating the Japanese market. Unlike the Solar PV market, the lack of ambitious targets and incentives – reflects the lack of commitment from Japanese industry in this space. This is also highlighted in the drastic drop in patent fillings by Japanese companies and so, despite its significant offshore wind energy potential, Japan has so far only developed 11 MW. The government has recently investigated the feasibility of offshore projects, and offshore wind measurements will start in 2009 under the NEDO project.

Turbine Manufacturers

Japan's four main wind turbine manufacturers are:

- **Mitsubishi Heavy Industries** **<7011.T>** MHI is one of Japan's largest industrial manufacturers. It has six divisions, that include: Marine Vessel and Ocean Division; Machinery and Iron Structure Division; Aviation and Space Division and the Power Engine Division that includes the development of wind turbines. MHI has developed wind turbines a varying sizes, ranging from 250kW to 2,400kW and have manufactured more than 2,250 units globally, mainly the in the US. For a detailed company profile, see Appendix A.

- **Fuji Heavy Industries <7270.T>** Fuji Heavy Industries Ltd. is a Japan-based industrial manufacturing company engaged in four business segments: the Automobile segment; Industrial Machinery segment; the Aerospace segment; and Others segment, where the wind power generation systems are located.

- **Japan Steel Works <5631.T>** JSW's Wind Power business uses technology from Europe, has the JSW J82 turbine and have installed over 30 units in Japan.

- **Komai Tekko <5915.T>** is a Japan-based manufacturing company. The Company operates in two business segments. The Steel Structure Products segment is engaged in the design, manufacture and installation of bridges, the construction and maintenance of steel bridges, the procurement of construction materials, the design, manufacture and erection of iron frames and iron towers, the design, manufacture and installation of construction and transportation equipment, the planning, design, construction and management of building works, as well as the provision of consulting services, among others.

6.1.7 South Korea

Market Size & Growth

Korea has over 600MW of capacity installed by 2009 and is expected to increase significantly, due to the impetus of the "New Green Deal' and the proposed wind generation capacity target of 2,250 MW by 2012, with 675MW (30%) allocated to offshore wind.

Drivers & Constraints

South Korea will need to significantly increase its installation of wind capacity, in order to meet its 2012 target. In o2009, the government unveiled a plan to invest KRW 6 trillion (USD4.37 billion) in the next four years for investment in research and development of renewable energy in 2009. The aim of the funding is to close the technology gap with advanced countries across different sectors in the renewable energy space. Under the plan, the government and 73 local companies will support 15 key sectors to drastically boost domestic know how.

Market Players & Competition

Wind was identified, as one the key sectors for the 'New Green Deal', with the country's major companies participating.

- **Hyundai Heavy Industries <009540.KS>** The world's No.1 shipbuilder said in its first-half report in 2009, that it had chosen renewable energy as its new growth engine and was investing 105.7 billion won in the wind power business.

- **Daewoo Shipbuilding & Marine Engineering <042660.KS>** The world's No.2 shipbuilder announced in August that it would enter the wind power business, hoping its expertise in offshore plants and vessels would help it in maritime wind power development. It signed a deal to buy Dewind, a wind power turbine-making unit of U.S. Composite Technology Corp, for $50 million.

- **Samsung Heavy Industries <010140.KS>** The world's No.3 shipbuilder will spend 600 billion won on wind power generating facilities by 2015, aiming to generate 3 trillion won in revenue and enter the global top seven makers by that time, according to local media.

- **Hyosung** <Unlisted> Hyosung's extensive background in development of heavy electrical equipment has contributed to the development of the Hyosung wind turbine system. Hyosung's core competence in development and production of gearboxes, generators, power control systems and other equipment has resulted in the world class, reliable wind turbine.

6.1.8 Taiwan

Market Size & Growth

There is currently around 400MW installed in 2009, mainly by Taipower.

Drivers & Constraints

There is a government target of 3,000 MW (including 1,700 MW of off-shore wind power) for wind power by 2025 has been set by Ministry of Economic Affairs (MOEA) in 2007.

Market Players & Competition

As part of the Wind Energy Industry Alliance, Taiwan has formed an alliance of domestic companies to work together to research and develop a domestic industry. The following companies include:

Turbines

- **TECO Electric & Machinery Co <1504.TW>** had received GE Energy certification for 750 kW generator, and is working on 1.5 MW and larger generators. Teco is principally engaged in the manufacture and distribution of heavy electrical equipment and electrical control products, as well as home appliances and air conditioners.

Equipment

- **China Steel Machinery Corporation** <Unlisted> is a subsidiary of the China Steel Corporation. The company manufactures products such as products of Fabrication and Machining. The company has provided most of tower racks domestically.

Gearbox

- **Formosa Heavy Industries Corporation** <Unlisted> is a manufacturer / contractor for petrochemical process equipment and power plant equipment. It also conducted evaluation during the construction of first wind power system domestically.

6.1.9 India

Market Size & Growth

As with China, India is experiencing a large growth in the wind sector. India added 1,800 MW of new wind generating capacity in 2008, taking the cumulative figure up to more than 9.6 GW. Wind power has been concentrated in a few regions, especially the southern state of Tamil Nadu, which accounts for 44% of India’s total wind capacity. Other states include: Maharashtra, Gujarat, Rajasthan and Karnataka, West Bengal, Madhya Pradesh and Andhra Pradesh. This will result in annual capacity addition of up to 2,000 MW in the coming years.

Drivers & Constraints

The Indian government's stated target is for renewable energy to contribute 4-5% of total power generation capacity by 2012. This means that renewable energy would need to grow at a faster rate than traditional power generation, accounting for around 20% of the total added capacity planned in the 2008-2012 timeframe.

10 out of the 29 Indian states have now implemented quotas for a renewable energy share of up to 10% and have introduced preferential tariffs for electricity produced from renewable sources. These states are Kerala, Rajasthan, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh, West Bengal, Gujarat and Haryana. In addition, several states have implemented fiscal and financial incentives for renewable energy generation, including: energy buy back schemes and FiTs; preferential grid connection and transportation charges and electricity tax exemptions.

Market Players & Competition

India has a solid domestic manufacturing base, dominated by Suzlon (accounting for over half of the market), Vestas Wind Tech and RRB. In addition, international companies have set up production facilities in India, including Enercon, Repower, Siemens and LM Glasfiber and the new entrants like ReGen Power Tech, WinWinD, Kenersys and Global Wind Power. India's new ambitious renewable plan has stimulated the growth of the domestic manufacturing sector and companies source more than 80% of the components for their turbines in India.

Turbines

- **Suzlon <SUZL.BO>**. Suzlon Energy Limited is the fifth largest global wind turbine generators and India's largest wind power company. The Company is engaged in the manufacture of wind turbine generators (WTGs) of various capacities and its components. Its other operations include sale/sub-lease of land, infrastructure development income, sale of gear boxes, sale of foundry and forging components, and power generation. It has manufacturing plants at Daman, Pondichery, Bhuj, Chhadwel (Dhule) and Vadodara. The Company's subsidiaries include Hansen Drives Limited, Hansen Drives Pte Limited, Hansen Wind Energy Drives (China) Co Ltd., PowerBladesGmbH, PowerBlades SA, REpower Australia Pty Ltd. and REpower Canada Inc. During the fiscal year ended March 31, 2009, the Company acquired a 37.82% interest in REpower Systems AG. The Company operates in India, Europe, United States and China. For a detailed company profile, see Appendix A.

6.1.10 Singapore

Market Size & Growth

Due to its small size, Singapore has set itself up as a testbed for companies to set up operations and export products across the region. It has attracted international companies, such as Vestas, which is building a manufacturing plant to export across the region.

Drivers & Constraints

Singapore does not have any suitable sites for Wind Power.

Market Players & Competition

- **Vestas <VWS.CO>** Vestas announced in 2008, the opening of its regional R&D Hub for Asia in Singapore. It marks the first milestone of the company's 10-year plan to invest up to S$500 million in Singapore to advance research in wind power technologies.

6.1.11 Indonesia

Market Size & Growth

The market in Indonesia is small, with less than 2MW of installed capacity. The major constraint is the relatively high cost and intermittency issues for wind power.

Drivers & Constraints

The government has focused its renewable targets on geothermal, small hydro and biomass projects and therefore wind will not make up a major part of the renewable portfolio mix in Indonesia. However a target of around 1GW has been proposed by 2025.

Market Players & Competition

The power market in Indonesia is dominated by PLN. There are some small IPP set up to provide off grid power supply.

3.1.12 Malaysia

Market Size & Growth

The market in Malaysia is small, although there is a government survey underway in East Malaysia (Sabah) to assess the wind potential.

Drivers & Constraints

Wind power is not a priority in Malaysia, as it is expensive and intermittent, when compared with biomass and hydro projects.

Market Players & Competition

There are no companies identified in this sector.

3.1.13 Thailand

Market Size & Growth

The wind power market in Thailand is small and estimated to be less than 1MW.

Drivers & Constraints

Wind has been included in the 15 year Renewable Energy Master Plan to increase to 800MW by 2022 which will help drive growth in Thailand.

Market Players & Competition

The ***Electricity Generation Authority of Thailand*** (EGAT) responsible for power generation and transmission. The ***Metropolitan Electricity Authority*** (MEA) responsible for distribution in Bangkok and vicinity and the ***Provincial Electricity Authority*** (PEA) responsible for distribution to the rest of Thailand. Companies involved in providing Wind Power to the grid include:

- **National Wind Power Co., Ltd** <Unlisted> invested 4.43 billion Baht in producing 70MW electricity from wind power to supply to The Provincial Electricity Authority. The location of the plant will be in Sakonnakorn.

- **Thai Wind Power Co., Ltd** <Unlisted> invested 3.57 billion Baht in producing 50MW electricity from wind power. The facility will be located in Mukdaharn.

3.1.14 Philippines

Market Size & Growth

There is only an estimated 25MW of installed capacity in the Philippines. However, with the enactment of the RE Act, and award of new wind project, the market is expected to increase significantly.

Drivers & Constraints

While the ***Renewable Energy Act of 2008*** (RE Act) put in place a regulatory framework for renewable energy in the Philippines, renewable energy is still focused on hydro and geothermal.

Market Players & Competition

- **Northpoint Wind Power** <Unlisted> announced to begin construction on a 40MW wind farm in Aparri, Cagayan province by 2011. Northpoint Wind Power is a subsidiary of Danish firm Northwind Power.

- **UPC Asia Wind Management** <Unlisted> announced it will invest USD 200m to develop a 80MW wind farm in Pagudpud, Ilocos Norte, Philippines. UPC Asia Wind is a unit of UPC Group, a European wind farm developer.

- **Korea East West Power** <Unlisted> will invest USD 50m in wind power projects in the northern provinces of the Philippines. Korea East West Power is a subsidiary of KEPCO.

6.1.12 Australia

Market Size & Growth

Australia is now home to 50 wind farms, with a total capacity of close to 2GW in 2009, with six projects totalling 555 MW expected to be commissioned in 2009. This increase is driven by the ***Renewable Energy Target*** (RET). Additional wind energy projects that will provide a combined output of 5 GW have been proposed for development in all states of Australia. Most of these are either currently applying for, or have received, government planning approvals.

Drivers & Constraints

In 2007 the Australian Government committed to ensuring that 20% of Australia's electricity supply would come from renewable energy sources by 2020 by establishing the expanded national RET scheme. The national RET scheme will increase the existing MRET, which was introduced in 2001 with a target of 9,500 GWh by 2010, by more than four times, to 45,000 GWh in 2020. The wind sector is included in these targets and currently has the fourth largest installed capacity in Asia Pacific, after China, India and Japan.

Market Players & Competition

The wind industry has continued its work on the ***Certified Wind Farms Australia*** (CWFA) scheme, developed by the ***Clean Energy Council***. A number of key wind energy companies in Australia have joined the CWFA, including Pacific Hydro, Roaring 40s, Wind Power and Wind Prospect. Wind companies on the ASX are:

Operators

- **Infigen Energy** **<IFN.AX>** Infigen Energy, formerly Babcock & Brown Wind Partners, is engaged in renewable energy business, which owns and operates wind farms in Australia, the Unites States, Germany and France. Infigen's business comprises interests in 41 wind farms that have a total installed capacity of approximately 2,246 megawatts (MW) and are diversified by wind resource, currency, equipment supplier, off-take arrangements, and regulatory regime. Its subsidiaries include Allegheny Ridge Wind Farm LLC, Aragonne Wind LLC, Babcock & Brown Cedar Creek LLC, Bluarc Management Group LLC, B&B Blue Canyon LLC and B&B Caprock LLC. For a detailed company profile, see Appendix A.

- **Transfield Services Infrastructure** **<TSI.AX>** The principal activities of the Company consisted of provision of operations and maintenance, asset management, project and capital management outsourcing and infrastructure development services, and investment in and management of Transfield Services Infrastructure Fund. In June 2009, the Company sold two wind farm developments to AGL Energy Ltd

- **WHL Energy** **<WHN.AX>** WHL Energy Limited (WHL), formerly Wind Hydrogen Limited, is an Australia-based diversified energy company with projects in the United Kingdom and the

United States. The Company focused on developing and commercializing energy assets including wind energy, solar, biomass and clean fossil fuels

- **Viridis Clean Energy Trust I <VIR.AX>** Viridis Clean Energy Group (VCEG) is an Australia-based company. VCEG is engaged in investing in and managing a global portfolio of clean energy assets. VCEG's investment focus is on assets that generate electricity or other consumable energy from renewable, waste or inherently low-emission energy sources, including wind, hydro, biomass, geothermal, solar, waste fuel, coal seam methane and natural gas.

6.1.13 New Zealand

Market Size & Growth

New Zealand has nine operating wind farms, with a combined installed capacity of 492.8MW[33] and supplies about 3% of New Zealand's annual electricity generation. A further 20 projects are in the process of development and could add over 1,000MW.

Site	Developer	Project capacity (MW)	Region	RMA application status	RMA application publicly notified
Awhitu	Genesis	18	Franklin	Consented after appeal but on hold	April 2004
Titiokura	Unison/Roaring 40s	Up to 48	Hastings	Consented after appeal	April 2005
Hawkes Bay	Hawkes Bay Wind Farm	Up to 225	Hastings	Consented after appeal	May 2005
Taumatatotara	Ventus	Up to 20	Waikato	Consented but on hold	
Mahinerangi	TrustPower	Up to 200	Clutha	Consented after appeal	November 2006
Kaiwera Downs	TrustPower	Up to 240	Gore	Consented after appeal	November 2007
Project Hayes	Meridian	Up to 630	Central Otago	Declined after appeal	November 2006
Taharoa	Taharoa C and PowerCoast	up to 100	Kawhia	Consented but appealed	
Project Central Wind	Meridian Energy	Up to 130	Ruapehu and Rangitikei	Consented but appealed	July 2008
Mill Creek	Meridian	Up to 71	Wellington	Consented but appealed	April 2008
Mt Cass	MainPower	Up to 69	Hurunui	Application declined, decision appealed	June 2008
Waitahora	Contact Energy	Up to 177	Southern Hawkes Bay	Application declined, decision appealed	September 2008

[33] New Zealand Wind Energy Association

Hauauru ma raki	Contact Energy	Up to 540	Waikato	Called in to a Board of Inquiry, application publicly notified	September 2008
Mt Stuart	Pioneer Generation	Up to 6	Clutha	Applied for consent, application publicly notified	December 2008
Turitea	Mighty River Power	Up to 360	Manawatu	Called in to a Board of Inquiry, application publicly notified	January 2009
Long Gully	Windflow / Mighty River Power	Up to 12.5	Wellington	Consent granted, subject to an appeal period	May 2009
Te Rere Hau expansion	NZ Windfarms	Up to 28	Manawatu	Applied for consent, application publicly notified	
Lulworth	Energy 3	Up to 1	Marlborough	Applied for consent, application publicly notified	December 2009
Slopedown	Wind Prospect CWP		Southland	Not yet applied	
Puketiro	RES		Wellington	Not yet applied	

Source: NZ Wind Energy Association

A study completed for the Electricity Commission indicated that the country's economic wind resource is sufficient to meet annual demand several times over. The study identified that areas with an annual wind speed of greater than about 8.5 m/s have the potential to generate over 50,000 GWh per year. An even larger resource was identified in the next band of wind speed, from 7.5 m/s to 8.5m/s. New Zealand's total electricity generation in 2007 was 42,374 GWh.

While this wind energy potential is unlikely to be realised in full because of economic, environmental and community considerations, it is realistic for wind to generate 15 to 20% of electricity by 2025.

Drivers & Constraints

In New Zealand, wind farms do not receive subsidies. For this reason, wind farm developers will only build a wind farm if it can produce electricity at a cost that is competitive with other forms of generation.

Market Players & Competition

- **Windflow Technology** **<WTL.NZ>** constructs Wind Turbinesin New Zealnd for customerssuch as New Zealand Windfarms <NWF.NZ>. WTL and NWF are locked in a dispute over the design of turbines

Operators

- **New Zealand Windfarms** **<NWF.NZ>** is engaged in the business of development and operation of wind power generation assets for the purpose of generating and selling electricity. The subsidiaries of the Company are NZWL-TRH Limited and WindPower Maungatua Limited.

- **Contact Energy** **<CEN.NZ>** Contact Energy Limited is a diversified and integrated energy company, focusing on the wholesale generation of electricity and the retail sale of electricity, natural gas and liquefied petroleum gas (LPG). The Company operates a number of wind farms, as part of its power generation portfolio mix

- **Meridian Energy** <Unlisted> Meridian is the largest state-owned electricity generator in New Zealand and operates and generates electricity from hydro stations on the Waitaki River in the South Island and at Lake Manapouri in Fiordland National Park. It also generates power from three wind farms at Palmerston North (Te Apiti), Mossburn in Southland (White Hill) and at Makara, Wellington (West Wind).

- **Mighty River Power** <Unlisted> Mighty River own and manage a diverse and expanding portfolio of generation assets throughout the North Island of New Zealand. Its portfolio includes the Waikato Hydro System, with nine power stations along the Waikato River; geothermal plants within the Taupo and Bay of Plenty regions; the Southdown co-generation station, bioenergy production and an active wind development programme. Mighty River Power sells electricity and gas to more than 380,000 customers through our retail business Mercury Energy. Mighty River Power's metering business Metrix provides meters and meter-reading services to residential and commercial customers across Auckland, and to other electricity retailers.

6.1.14 Summary of Companies in the Wind Sector

Code	Company Name	Market Cap (M Dollars)	PE Ratio	Country	Segment
200706.SZ	Wafangdian Bearing Co Ltd	$119.9	56.3	China	Industrial Components
3323.HK	China National Building Material Co Ltd	$4,597.0	16.1	China	Building Materials & Components
000836.SZ	Tianjin Xinmao Science & Technology Co Ltd	$354.0	85.7	China	Business & Public Services
002080.SZ	Sinoma Science & Technology Co Ltd	$736.2	55.1	China	Chemicals
044490.KQ	Taewoong Co Ltd	$1,148.8	40.4	South Korea	Metals - Steel
0658.HK	China High Speed Transmission Equipment Group Co Ltd	$2,711.0	26.7	Hong Kong	Machinery & Engineering
053660.KQ	HYUNJIN MATERIALS CO LTD	$306.4	14.2	South Korea	Metals - Steel
7011.T	Mitsubishi Heavy Industries Ltd	$13,117.9	1238.5	Japan	Machinery & Engineering
7270.T	Fuji Heavy Industries Ltd	$3,946.0	N/A	Japan	Automobiles
5631.T	Japan Steel Works Ltd	$4,333.1	21.6	Japan	Machinery & Engineering
WHN.AX	WHL Energy Ltd	$9.7	N/A	Australia	Energy Sources
SUZL.BO	Suzlon Energy Ltd	$2,571.7	N/A	India	Energy Equipment & Services
002202.SZ	Xinjiang Goldwind Science&Technology Co Ltd	$6,799.1	26.6	China	Energy Equipment & Services
600875.SS	Dongfang Electric Corp Ltd	$6,198.3	85.7	China	Electrical & Electronics
601727.SS	Shanghai Electric Group Co Ltd	$15,133.2	48.8	China	Machinery & Engineering
600290.SS	Huayi Electric Co Ltd	$672.8	23.2	China	Energy Equipment & Services
600416.SS	Xiangtan Electric Manufacturing Co Ltd	$802.9	41.5	China	Electrical & Electronics
034020.KS	Doosan Heavy Industries & Construction Co Ltd	$8,354.1	N/A	South Korea	Machinery & Engineering
BHEL.BO	Bharat Heavy Electricals Ltd	$25,668.8	31.1	India	Electrical & Electronics
2766.T	Japan Wind Development Co Ltd	$409.9	N/A	Japan	Multi-Industry
IFN.AX	Infigen Energy Ltd	$1,026.1	4.5	Australia	Financial Services
TSI.AX	Transfield Services Infrastructure Fund	$226.1	N/A	Australia	Financial Services
VIR.AX	Viridis Clean Energy Group	$24.8	N/A	Australia	Financial Services
WTL.NZ	Windflow Technology Ltd	$10.3	N/A	New Zealand	Business & Public Services
NWF.NZ	New Zealand Windfarms Ltd	$21.9	N/A	New Zealand	Utilities-Electrical & Gas
Unlisted	Chongqing Gearbox Co., Ltd.	N/A	N/A	China	Gearbox
Unlisted	Hangzhou Advance Gearbox Group Co Ltd	N/A	N/A	China	Gearbox
Unlisted	Zhonghang Huiteng Windpower Equipment Co.Ltd	N/A	N/A	China	Gearbox
Unlisted	Sinovel Wind Co. Ltd.	N/A	N/A	China	Turbines
Unlisted	Zhejiang Windey Engineering Co., Ltd.	N/A	N/A	China	Turbines
Unlisted	Guangdong Mingyang Electric Group Co., Ltd.	N/A	N/A	China	Turbines

Source: Thomson Reuters

6.2 Solar

6.2.1 Background

The solar sector consists primarily of Photo Voltaic (PV), followed by solar concentrator and solar used for water heating.

Up until 2006, this was effectively just a Japanese and German market, driven by government subsidies and feed in tariffs. The manufacturing is primarily based in APR, most notably Japan, China, South Korea and Taiwan. These countries have a tradition of high quality manufacturing in the silicon chip industry and have translated this expertise into the PV solar market. These countries also lead the Research & Development into this sector, as highlighted in the patent filing research – a proxy for Research & Development and a 'statement of intent' for countries and companies.

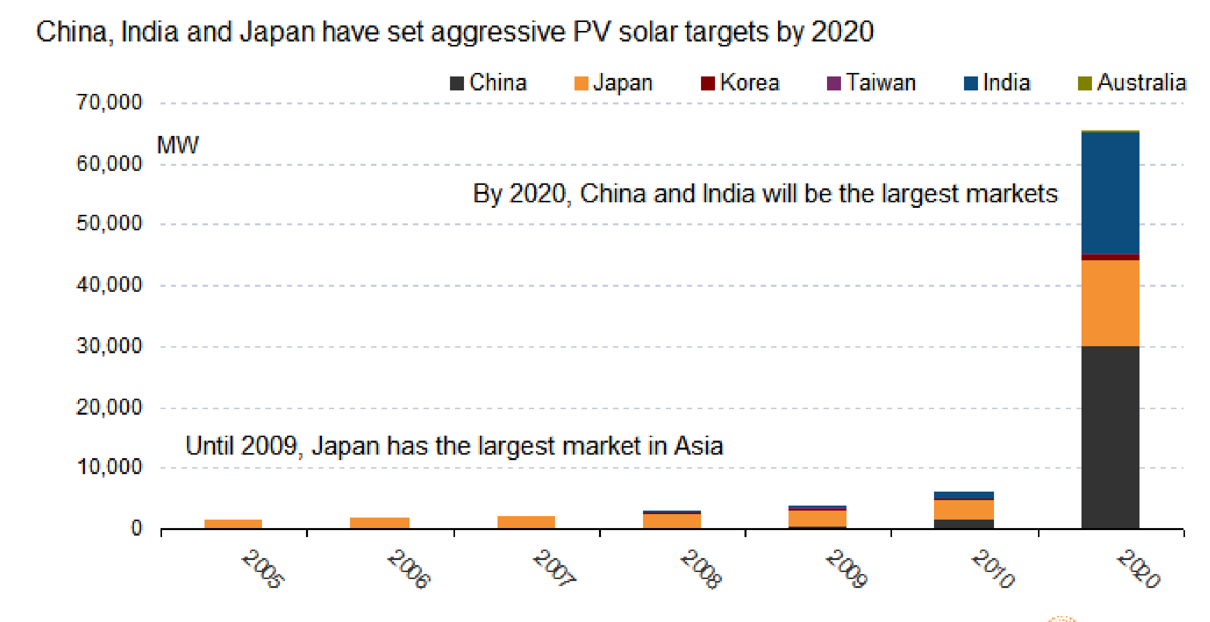
After a change in government, Japan has renewed its efforts to re-establish itself, as the largest PV market globally, with a new target for 2020 and 2030.

The most impressive country is China: from a virtual production of zero, it is expected to provide nearly half of all feedstock production in 2010. In addition, China has applied a similar approach it has applied in other manufacturing sectors to the PV Solar market and instituted a financial stimulus package to invest and allow banks to lend to domestic companies in the PV Solar market. This has also been coupled with the surprise increase in the PV solar market to 20GW by 2020 to further stimulate growth in the domestic market. It also dominates the Solar Water Heating market and accounts for two thirds of the total manufacturing globally.

India has also moved aggressively in this market, by proposing new aggressive targets for PV Solar, with a target of 1GW by 2012 and 20GW by 2022, which would make it the second largest market, after China. However, India does not have the same manufacturing expertise and Research & Development, as the Northern Asian countries and it is expected that China will be the main beneficiary of the increased demand in India, at least in the short term.

This has lead to a huge oversupply in the PV solar market, which will lead to some consolidation of the market and drive the move of production from the US and Europe to Asia. This move of manufacturing to low cost countries in Asia, such as China will accelerate the drive in costs down that should further facilitate the growth in the PV solar market.

Figure 6.3 Asia Pacific Solar Sector



Source: IEA, Thomson Reuters, Government Publications

Total Installed capacity (MW)

Year	2005	2006	2007	2008	2009	2010E	2020T
China			20	40	300	1,500	30,000
Japan	1,421	1,708	1,918	2,144	2,600	3,000	14,000
Korea	13	35	81	357			
India						1,000	20,000[34]
Malaysia		5	7	8		10	975
Thailand	20	25	40	60	120	150	500[35]
Australia	60	70	82	104		120	

Source: IEA, Thomson Reuters, Government Publications

6.2.2 Targets and Incentives

There are five main markets for PV solar in Asia Pacific, driven by targets and incentive schemes. Out of these, China, India and Japan will account for over 90% of the Asian market.

[34] 2022 Target, 5 Year Plan

[35] 2022 Target, Thailand 15 Year Energy Masterplan

- ***Japan*** - The ***Residential PV System Dissemination Program*** was the main driver for the growth in the PV solar market in Japan, until 2008. Incentives and subsidies have been put in place to continue the growth, with a target of 14GW installed capacity set for 2020 and 53 GW by 2030. Japanese companies have used its expertise in electronics and high end manufacturing to extend to the PV solar market, such as Sharp and Kyocera.

- ***China*** - The existing domestic installed base in China is miniscule compared with its domestic production capacity. China has turned to developing domestic demand in 2009 to help meet oversupply with the slump in overseas markets. In addition, the government has put in place a target of 30GW installed capacity by 2020, coupled with encouragement of loans to PV solar companies that has lead to the growth of over 30 domestic companies that will make China the number one PV market globally. By 2010, China is expected to account for nearly half the feedstock market, from a market of nearly zero a few years ago.

- ***India*** - India has followed China and set an ambitious target of 20GW installed capacity by 2022. Interestingly, India does not have the same domestic manufacturing market and Chinese companies are expected to be the main beneficiary of this increased demand. Unlike, its Northern Asian neighbours, India does not have the traditional expertise in high end manufacturing, nor research and development and intellectual property to create a domestic industry.

- ***South Korea*** - As with Japan, South Korea is leveraging its expertise in electronics and high end manufacturing to enter into this market. However, it is starting relatively late and will need to be able to differentiate itself from market leaders like Japan, to low cost competitors such as China.

- ***Taiwan*** - While Taiwan does not have a large domestic installed base, it is a key provider to the PV solar markets and has leveraged its capability in the electronics space.

- ***Australia*** - has set an ambitious renewable target of 20% by 2020, with solar playing a big part. Its government grant scheme has been the main driver for installation of PV solar into off grid residential homes and farms. It also has a FiT at the state level to promote and encourage solar power. While Australia is not a manufacturer of PV solar, due to its abundance of sunshine it is also looking into the PV solar concentrator market.

Figure 6.4 – PV Supply Chain

	Feedstock	Wafers & Ingots	Cell & Module Manufacturing	Equipment Manufacturers
China	LDK, Tianwei, Zhongsheng	LDK Solar, Solargiga	Suntech, China Sunergy	
Japan	Tokuyama, Mitsubishi Mat	SUMCO Kanematsu	Sharp, Kyocera Sanyo, MHI	
S Korea	KCC, LG Chem	Woongin Energy, Nexolon	KPE, Sinsung Holdings	
Taiwan		Sino American, Green Energy	Motech, Gintech, Eton	
India			Moser Baer, BHEL	Tata Power

Source: Company Reports, Thomson Reuters

6.2.3 PV Supply Chain

There are four basic steps in the manufacture and production of PV:

- Feedstock
- Wafer & Ingots
- Cell and Module Manufacturing; and
- Final Assembly

Feedstock

The main source of silicon feedstock for PV cells is polysilicon and the process is essentially the same as producing semiconductor grade silicon. However, the producers have simplified some steps in their processes for supplies to the PV industry. There are many attempts to replace the current expensive purification process, based on chemical gaseous purification, by cheaper alternatives including metallurgical purification (condensed phase).

The solar photovoltaic grade silicon feedstock supply was traditionally dominated by the three major producing countries: Germany, the US and Japan. However, China is expected to supply nearly half of the silicon feedstock by 2010, while Korea and India are also entering the market.

Ingots and Wafers

Highly purified silicon is used to make single crystal silicon ingots, multi-crystalline silicon ingots or multi-crystalline silicon ribbons. The ingots are then cut into bricks or blocks and then sawn into thin wafers, whereas the ribbons are cut directly into wafers. Silicon ingots are of two types:

single crystal and multi-crystalline. The first type, although with different specifications regarding purity and specific dopants, is also produced for microelectronics applications, while multi-crystalline ingots are only used in the PV industry. Ingot producers are in many cases also producers of wafers. Norwegian, German, Japanese, Taiwanese, Korean and Chinese companies feature most prominently in this section of the industry supply chain.

Photovoltaic cell and module production

Germany replaced Japan as the leading producer of photovoltaic cells during 2008. However, China is expected to be the market leader by 2010, with the aggressive targets and incentives put in place by the government.Taiwan accounted for some 830 MW to 900 MW of cell production, consolidating its position at number four in terms of national production behind China, Germany and Japan.

Equipment Manufacturing

From a cost perspective, balance of system (BOS) components account for 20-70 % of the total system costs. Accordingly the production of BOS products has become an important sector of the overall PV industry. Particularly with the rapid expansion of the worldwide market for grid-connected PV systems, inverters are currently the focus of the interest.

PV Solar Concentration

At present, concentrating solar power (CSP) technology can be exploited through three different systems:

- ***Parabolic Trough***;
- ***Parabolic Dish***; and
- ***Power Tower***.

All the CSP technologies rely on four basic elements: concentrator, receiver, transport-storage and power conversion. The concentrator captures and concentrates direct solar radiation, which is then delivered to the receiver. The receiver absorbs the concentrated sunlight, transferring its heat energy to the power-conversion system. In some CSP plants, a portion of the thermal energy is stored for later use. The parabolic trough system, commonly known as the "***Solar Farm***", uses linear parabolic mirrors to reflect sunlight. The parabolic dish system, generally known as a "***Dish/Engine System***", collects sunlight through a round parabolic solar collector. The "***Power Tower System***" employs heliostats to concentrate sunlight onto a central tower-mounted receiver.

Parabolic trough plants are currently the most mature CSP technology. Power towers, with potentially low-cost and more efficient thermal storage, could offer dispatchable power from solar-only plants with a high annual capacity factor in the medium term.

Dish/engine systems will be used in smaller, high-value applications. In theory, power towers and parabolic dishes can achieve higher solar-to-electric efficiencies and lower costs than parabolic trough plants. Parabolic dish systems are the most efficient of all solar technologies, with currently about 25% solar-to electricity efficiency. The 4-95 stirling power conversion unit (PCU) now holds the world's efficiency record for converting solar energy into grid-quality electricity, with almost 30% efficiency at 1 000 watts per square metre. Because of their thermal nature, each of the CSP system technologies can be “hybridised”, or operated in combination with conventional fossil fuels. Hybridisation has the potential to dramatically augment the usefulness of CSP technology by increasing its dispatchability, improving its performance by making more effective use of power generation equipment, and reducing technological risk by using conventional fuel when needed. Hybridisation efforts are currently focused mainly on the parabolic trough, but the learning from these studies may be transferred to the other types of systems. The integrated solar combined-cycle system (ISCCS) design offers a number of potential advantages to both the solar plant and the combined cycle plant. For power tower systems, hybridisations are possible with natural gas combined-cycle and coalfired or oil-fired Rankine plants. Initial commercial-scale power towers will likely be hybridised with conventional fossil-fired plants. Because dish/engine systems use heat engines, they have an inherent ability to operate on fossil fuels. However, hybridisation for dish/engine systems is still a technological challenge.

Solar in Space

The US and Japan are investigating ways to put solar arrays in space and transmit power down to the surface of the Earth, using microwaves. Mitsubishi Electric has put together a group of companies to research and development in this space.

6.2.4 Research & Development

None of the larger players in this field have been as active recently as they were in the past Research in solar power was very intense in the periods 2000-2005, and has diminished, particularly in Japan. The largest holdings are with Canon, Sharp and Sanyo.

Some of the newer work among the smaller entities is focused on the use of less silicon and on improving thin films to increase the yield of electricity.

Academic and government interest in this area is less China-dominated, and includes institutions from the US, Japan, Switzerland, Germany and Korea as well. Research covers nanotubes and dye-enhanced solar cells.

The following table lists the number of patent filings by companies or entities:

LARGER PRESENCE IN FIELD	06-08	97-98	% RECENT
NTT FACILITIES KK	12	32	38
KYOCERA CORP	24	98	24
TOYOTA JIDOSHA KK	7	30	23
MATSUSHITA ELECTRIC WORKS LTD	12	69	17
SANYO ELECTRIC CO LTD	19	112	17
SHARP KK	24	143	17
MITSUBISHI ELECTRIC CORP	15	96	16
HITACHI LTD	5	52	10
SEKISUI CHEM IND CO LTD	5	81	6
CANON KK	7	175	4
KANEKA CORP	2	53	4
TOSHIBA KK	1	28	4
FUJI ELECTRIC CO LTD	1	40	3

Source: Thomson Reuters Scientific

SMALLER PRESENCE IN FIELD	06-08	97-98	% RECENT
MSK KK	6	8	75
SHINETSU HANDOTAI KK	3	9	33
TOPPAN PRINTING CO LTD	4	13	31
KONARKA TECHNOLOGIES INC	2	10	20
BRIDGESTONE CORP	2	11	18
BP CORP NORTH AMERICA INC	2	11	18
TDK CORP	1	9	11
NISSHIN ELECTRICAL CO LTD	0	12	0
JX CRYSTALS INC	0	10	0
HUGHES ELECTRONICS CORP	0	8	0
OMRON KK	0	8	0
YKK ARCHITECTURAL PROD KK	0	8	0

Source: Thomson Reuters Scientific

ACADEMIC – GOVERNMENT	06-08	97-98	% RECENT
UNIV CHICAGO	4	4	100
CHINESE ACAD SCI ELECTRICAL ENG INST	3	3	100
UNIV CALIFORNIA	3	4	75
UNIV TOHOKU	3	4	75
UNIV KYOTO	3	4	75
UNIV TOKAI GH	2	3	67
ECOLE POLYTECHNIQUE FEDERALE LAUSANNE	2	3	67
UNIV SHANGHAI JIAOTONG	2	5	40
UNIV NANJING AERONAUTICS & ASTRONAUTICS	1	3	33
KOREA ADV INST SCI & TECHNOLOGY	1	3	33
UNIV PRINCETON	1	3	33
FRAUNHOFER GESELLSCHAFT	2	8	25
KAGAKU GIJUTSU SHINKO JIGYODAN	0	6	0
DEUT ZENT LUFT & RAUMFAHRT EV	0	5	0
ZH KANAGAWA KAGAKU GIJUTSU ACAD	0	4	0

Source: Thomson Reuters Scientific

Samsung and TSMC are both among the top US patent holders for solar, along with Canon and Sharp. Samsung's solar patent portfolio is focused on a wide range of thin-film technologies. TSMC recently formed a strategic alliance with Motech Industries and could be considering ways to squeeze more Watts out of traditional cells, which currently convert 16-18% of the sunlight that hits them into electricity, versus a theoretical limit of 30%.

6.2.5 China

Market Size & Growth

While China is a global leader in the manufacturing of PV solar, its domestic market was relatively small, compared with domestic supply. This changed in 2009, with the slump in the growth of international markets and led to the government putting in aggressive domestic demand to drive domestic demand to compensate in the loss the export market.

Drivers & Constraints

China has put in place a set of aggressive targets and incentives schemes to increase capacity in its domestic PV industry. In particular, key policy and targets include:

- The “***Golden Sun Project***” will subsidise 50% of the upfront cost for grid-connected solar systems (the bulk of demand) and 70% for off-grid.
- The government has put in place an aggressive target of 30GW by 2020 and encouraged loans to finance new companies in 2009

PV solar manufacturers have benefited from the access to cheap finance in 2009, as part of China’s fiscal stimulus and the sheer scale of growth has been breath taking, with over 80 PV cell manufacturers in China. Invariably this has led to excess supply and there have been recent steps to control funding. Despite this, provincial and municipal governments still continue to build their own local renewables industries.

China has shown, as with other industries, how quickly it can ramp up and expand, when the right policies are aligned with incentives. Ultimately, sustained growth will depend on how central policy dictates are complemented by provincial and municipal interests.

Feedstock

From virtually no production capability a few years ago, the Chinese feedstock sector now includes over 20 suppliers, driven by access to cheap finance. Companies include:

- **LDK Solar <LDK.N>.** LDK Solar is the leading manufacturer of multicrystalline solar wafers in China. LDK Solar sells multicrystalline wafers globally to manufacturers of photovoltaic products, including solar cells and solar modules. In addition, LDK Solar provides wafer processing services to monocrystalline and multicrystalline solar cell and module manufacturers. LDK is one the largest producers in China and produces 400MW annually. For a detailed company profile, see Appendix A.

- **Tianwei Sichuan Silicon Industry** <Unlisted> is a producer of polysilicon with plans to produce 3000 ton/year.

- **Zhongsheng Semiconductor** <Unlisted> is a Joint Venture between ReneSola and Linzhou Zhongsheng Steel Co., Ltd with plans to produce polysilicon.

Ingots & Wafers

There are over 140 ingot and wafer manufacturers listed in China. The largest producers include:

- **Solargiga <0757.HK>** Solargiga makes monocrystalline silicon ingots and wafers, key components for producing solar-power photovoltaic (PV) cells. It is the PRC’s second largest manufacturer of monocrystalline silicon ingots by output and sales. Sales are mainly to solar-wafer or cell manufacturers or traders, which include Isofoton, Sharp, Sumitomo and Suntech. For a detailed company profile, see Appendix A.

- **Comtec Solar <0712.HK>** Comtec Solar is principally engaged in the wafer producing business. Located in Nanhui district, Shanghai, the company has a wafer capacity of 200MW and expected to ramp up production to 500MW.

Cells and Module Manufacturing

There are over 80 Cell and Module manufacturers in China alone, with a large oversupply in the market. The top 10 producers are highlighted below:

Company Name	Code	MW Produced	Cell Technology
Suntech Power	STP.N	1,000*	Monocrystalline, Polycrystalline, Amorphous
Yingli Green Energy	YGE.N	400*	Polycrystalline
JA Solar	JASO.O	425*	Monocrystalline, Polycrystalline
Trina Solar	TSL.N	200	Monocrystalline, Polycrystalline
Solarfun Power	SOLF.O	360*	Monocrystalline, Polycrystalline
China Sunergy	CSUN.O	320*	Monocrystalline, Polycrystalline
Eging Photovoltaic	na	106	Monocrystalline
Canadian Solar	na	103	Monocrystalline, Polycrystalline
Ningbo Solar	na	90	Monocrystalline, Polycrystalline
Jiangyin Jetion S&T	na	65	Monocrystalline, Polycrystalline

Source: Company Reports and websites

As PV prices are driven down globally, Chinese PV companies are expected to benefit, due to their low cost of manufacturing. In particular, Trina Solar has performed the best in 2009, as it is seen as a low cost leader.

- **Suntech Power <STP.N>** Suntech Power is one of the leading global PV cell manufacturer, but has been primarily focused on exporting its product to the US and European markets. However, as part of its push into the domestic market, Suntech recently announced that it expects to develop approximately 20% of the 91MW of solar projects that were approved under China's Solar Rooftop Program. It also started to develop 10MW solar power plants in Shizuishan, and Dongtai. See Appendix A for company profile.

- **Trina Solar <TSL.N>** Trina Solar is viewed as the global leader in cost and is expected to gain market share, as the prices for PV are driven lower in 2010. It has outperformed other Chinese PV Cell & Module Manufacturers, who have in turn outperformed other countries. See Appendix A for company profile.

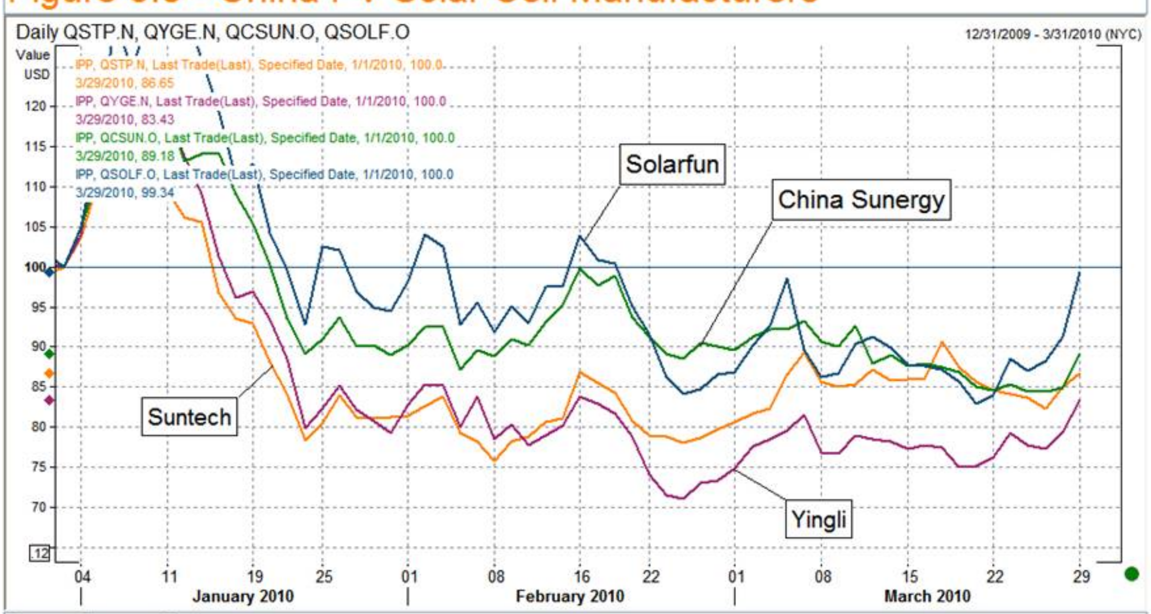
- **Yingli Green <YGE.N>** Yingli is currently one of the largest manufacturers of PV products in China as measured by annual production capacity, with an annual production capacity of 400 MW of polysilicon ingots and wafers, 400 megawatts of PV cells and 400 megawatts of PV modules. See Appendix A for company profile.

- **JA Solar <JASO.O>** JA Solar Holdings Co., Ltd. is a leading manufacturer of high-performance solar cells. The company sells its products to solar manufacturers worldwide, who assemble and integrate solar cells into modules and systems that convert sunlight into electricity for residential, commercial, and utility-scale power generation. Q3 2009 reports that total shipments in the third quarter were a record 177MW, compared with the second quarter shipments of 77MW, representing a sequential growth of 130%. For a detailed company profile, see Appendix A.

- **Solarfun Power <SOLF.O>** Solarfun is a vertically integrated manufacturer of silicon ingots and photovoltaic cells and modules in China. It announced in January 2010, a capacity expansion and will increase its PV module production capacity from 550MW to 700MW by April 2010 and its PV cell production capacity from 360MW to 480MW by July 2010. For a detailed company profile, see Appendix A.

- **China Sunergy <CSUN.O>** China Sunergy is a leading manufacturer of solar cell products in China and has increased its annual production to 320MW. For a detailed company profile, see Appendix A.

Figure 6.5 - China PV Solar Cell Manufacturers



Source: Thomson Reuters

6.2.6 Japan

Market Size & Growth

The Japanese government has renewed its efforts to re-establish Japan as a global leader, after a brief hiatus in 2008 and has put in place and an action plan sets targets to increase the amount of installations of PV systems to 14 GW by 2020 and 53 GW by 2030.

During 2008 a total of about 225 MW of PV were installed in Japan, a slight increase on the 210 MW installed the previous year. The primary factor leading to the flat growth was the termination of the budget for the ***Residential PV System Dissemination Program***. Most of these installations (around 221 MW) continued to be grid-connected distributed PV systems, with a further almost 4 MW comprising grid-connected centralized plants. In 2008 cumulative installed PV capacity in Japan exceeded 2 GW.

2008 represented an important milestone in Japan's efforts to develop the institutional frameworks, policy support and budget enhancements necessary to accelerate the widespread installation of PV from around 2009 onwards.

Market Players & Competition

Japanese companies are market leaders across the whole PV solar supply chain and the government's renewed push in solar energy, will further promote investment into the sector.

In the area of solar-grade silicon and wafers, manufacturers have been increasing production capacities and expecting growth of future demand for solar cells.

Feedstock

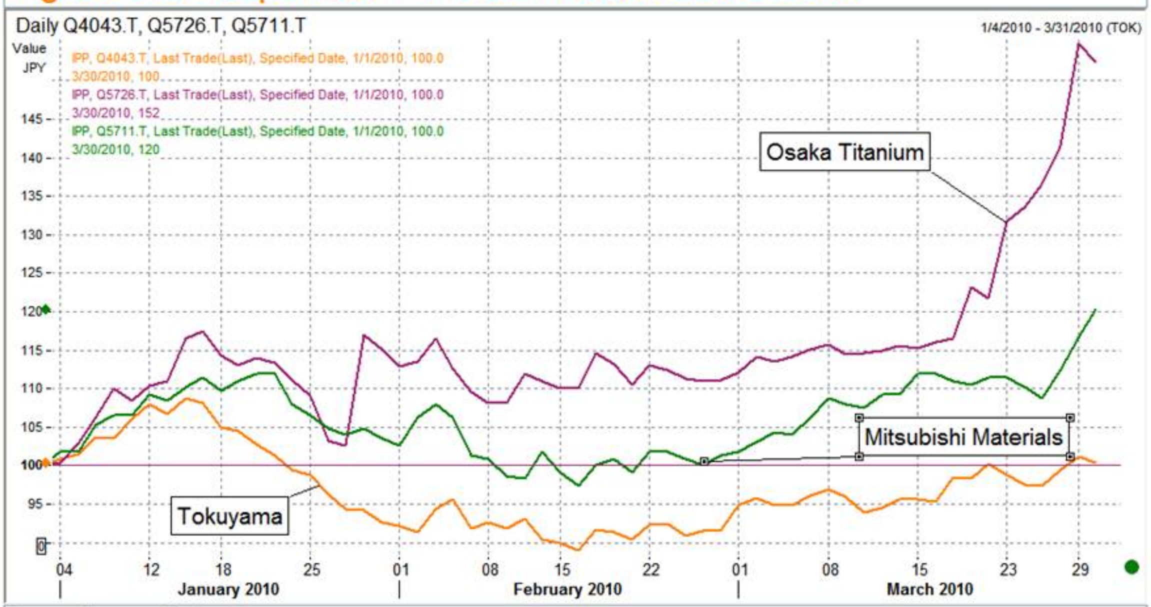
Market leaders for polysilicon feedstock in Japan include:

- **Tokuyama** **<4043.T>** is the one of the largest producers of polysilicon with production of around 8,200 tonnes. It supplies feedstock to SUMCO and built a plant in Malaysia to produce 6,000 tonnes. For a detailed company profile, see Appendix A.

- **OSAKA Titanium Technologies** **<5726.T>** manufactures and sells semiconductor products, such as polycrystalline silicon, high-purity titanium and titanium tetrachloride solution, as well as environmental- and energy-related products, such as silicon monoxide, photocatalysts, silicon powder and porous silicon. It produces about 1,500 tonnes a year of feedstock. For a detailed company profile, see Appendix A.

- **Mitsubishi Materials** **<5711.T>** is a Japan-based manufacturing company engaged in five main business segments: Cement segment, Copper segment, Aluminum segment and the Processing segment that includes the manufacture and sale of polycrystalline silicon feedstock. Mitsubishi Materials plans to increase polycrystalline silicon production by 1,000 tonnes to 4,300 tonnes a year by 2011

Figure 6.6 - Japanese PV Solar Feedstock Stocks



Source: Thomson Reuters

Wafers

Market leaders in the wafer segment are **SUMCO <3436.T>,** which has constructed a new production facility aiming to achieve 1 GW/year production. **Space Energy**, which was acquired by Nippon Oil <5001.T> also increased production capacity to 8 million wafers/year.

Silicon wafer slicing companies such as **Ishii Hyoki, TKX** and **Shinko Manufacturing** are also enhancing production capacity, and **Kanematsu Corporation** has announced the establishment of a silicon wafer processing company.

- **SUMCO <3436.T>** Sumco Corporation is one of Japan's leading manufacturing company that is mainly engaged in the high-purity silicon business. The Company operates through two business divisions. The Semiconductor Silicon Wafer division manufactures and sells various silicon wafers for semiconductors, including polished wafers, epitaxial wafers and special wafers. The Others division, through its subsidiaries, manufactures silicon wafers for solar batteries, and manufactures and sells high-purity quartz crucibles.

- **Kanematsu <8020.T>** Kanematsu Corporation is a Japan-based trading company. It operates in five business segments. The Information Technology (IT) segment provides semiconductors, semiconductor and crystalline liquid (LC) manufacturing equipment, electronic components, communication-related equipment and components and optical devices and has established a silicon wafer processing company.

Cell and Module Manufacturing

- **Sharp <6753.T>** announced a series of plans to increase production of thinfilm silicon PV modules, starting from the completion of a new 160-MW production line for thin-film silicon PV modules at its Katsuragi Plant. Currently, a 1 000-MW/year thin-film silicon PV module plant is under construction, on the premises of a plant for large-sized liquid crystal display panels in Sakai City of Osaka Prefecture, scheduled to start operation in 2010. Furthermore, Sharp announced a plan to construct a 480-MW/year plant to produce thin-film silicon PV modules through a joint venture with ENEL of Italy. For a detailed company profile, see **Appendix A**.

- **Kyocera** **<6971.T>** completed the expansion of its MieIse Plant and announced a plan to construct a new solar cell plant in Shiga Prefecture for the purpose of increasing the production capacity to 650 MW/year by 2011. For a detailed company profile, see Appendix A.

- **Mitsubishi Electric** **<6503.T>** plans to establish a production framework with the capacity of 600 MW/year by 2011. Alongside that, Mitsubishi will enhance its global sales networks and is also considering the commercialization of thin-film silicon solar cells.

- **Kaneka** **<4118.T>** revised up its plan to increase its domestic production capacity to 150 MW/year, along with construction of a new overseas production facility with the capacity of 200 MW/year. It has announced a plan to further increase production capacity to 1 GW/year by 2015.

- **Mitsubishi Heavy Industries** **<7011.T>** plans on increasing production capacity to 130 MW/year in 2010, and 250 MW/year in 2012.

The production facilities for PV cell/module in Japan are concentrated in the Kansai and Kyushu regions. As seen in the automobile and electronic industries, related industries have been established to produce a stable supply chain for solar cells.

Solar in Space

Mitsubishi Electric <6503.T> and IHI Corp. <7013.T> will join a 2 trillion yen (USD $21 billion) Japanese project intending to build a giant solar-power generator in space within three decades and beam electricity to earth. A research group representing 16 companies, including Mitsubishi Heavy Industries Ltd. <7011.T>, will spend four years developing technology to send electricity without cables in the form of microwaves, according to a statement on the trade ministry's Web site today. Japan is developing the technology for the 1-gigawatt solar station, fitted with four square kilometers of solar panels, and hopes to have it running in three decades, according to the trade ministry in August 2009. Being in space it will generate power from the sun regardless of weather conditions, unlike earth-based solar generators.

Transporting panels to the solar station will be prohibitively costly, so costs for transportation will need to be drastically reduced before the solar station can become commercially viable.

The trade ministry and the Japan Aerospace Exploration Agency, which are leading the project, plan to launch a small satellite fitted with solar panels in 2015, and test beaming the electricity from space through the ionosphere, the outermost layer of the earth's atmosphere, according to the trade ministry document. The government hopes to have the solar station fully operational in the 2030's.

6.2.7 South Korea

Market Size & Growth

A key goal of the Government's 2003 second 10-year ***National Basic Plan for NRW (New and Renewable) Technology Development and Deployment*** is to supply 5% of domestic energy requirements through renewable and alternative energy sources by 2010, as well as produce 1GW of solar energy by 2012. Since the introduction of the Government's feed-in-tariff policy in 2002, the number of photovoltaic installations has increased rapidly. However the 400MW of installed capacity may fall short of the 1GW target by 2012.

Drivers & Constraints

As part of the "***New Green Deal***" in 2009, South Korea has embarked on a push into the Clean Tech space to increase its presence in this space and to leverage its expertise in manufacturing. This has led to companies like Hyundai Heavy Industries and Samsung entering into the market, leveraging its investment in research and development.

Market Players & Competition

Feedstock

The main feedstock producer in South Korea is Dongyang Chemical Co (OCI) <010060.KS> has expanded their annual production capacity up to 16,000 tonnes in 2009. Other companies including, KCC corp., LG Chemical and Samsung Petrochemical are expected to start production of feedstock.

- **Dongyang Chemical Co (OCI) <010060.KS>** OCI Company Ltd, formerly DC Chemical Co., Ltd., is a Korea-based chemical company specialized in the areas of inorganic chemicals, coal and petrochemicals and fine chemicals processing business. It is the second largest feedstock producer in world, with an increased capacity of 16,000 tonnes, with the completion of its second Polysilicon plant in Gunsan.

- **KCC Corporation <002380.KS>** has a long term supply contract worth approximately US$100M for 6 years from 2008 to 2013 with Solar Power Industries of the US.

- **LG Chemical <051910.KS>** has created a subsidiary called LG Solar Energy which supplies polysilicon to LG Electronics to construct solar cells. It plans to manufacture approximately 520,000 solar modules a year using silicon wafers with a total capacity of 120MW.

Wafers

Companies in the wafer segment include Woongjin Energy and Nexolon.

- **Woongjin Energy** <Unlisted> is a joint venture between Woongjin Coway and SunPower of the US, with plans to develop and manufacture monocrystalline silicon ingots for solar cells. Woongjin Energy operates the largest solar ingot pulling facility in Korea.

- **Nexolon** <Unlisted> is a manufacturer of mono and multicrystalline solar wafers. It has an annual solar wafer manufacturing capacity of 150MW for 2008, and is in the next phase of expanding the capacity to achieve a target of 1,000MW by the end of 2011.

Cells and Module Manufacturing

The largest manufacturers in Korea are Kyungdong Photovoltaic Energy (KPE), Hyundai Heavy Industry, Samsung Electronics and Millinet Solar. Other companies in this sector include: Sinsung Holdings, STX Solar, KISCO and Alti-Solar.

- **Kyungdong Photovoltaic Energy** <Unlisted> is the largest commercialized solar cell manufacturer in Korea specializing in solar cell manufacturing and domestic PV system integration. It currently has a total annual production capacity of 100MW.

- **Hyundai Heavy Industry** **<009540.KS>** Hyundai Heavy Industries Co., Ltd. is the world largest ship builder and multinational conglomerate engaged in industrial manufacturing. As part of the "New Green Deal" in 2009, it has targeted the PV Solar market, as a sector for new growth.

6.2.8 Taiwan

Market Size & Growth

While Taiwan is one of the top 5 global producer in the PV Solar market, its domestic market is only about 20MW due to a lack of incentives or targets.

Taiwan has a Solar Water Heater (SWH) incentive in place and is one of the largest domestic markets with an estimated 2.15 million m^2 by 2010.

Drivers & Constraints

In April 2009, the "***New Trillion Dollars Energy Industry Flagship Plan***" and the "***Green Energy Industry Sunrise Plan***" put in place plans for Taiwan to produce 20% of the global supply of the PV solar market. However, the "***Renewable Energy Development Act***" announced on 8th July 2009, is the first attempt to develop the domestic solar photovoltaic industry and it mainly includes the incentives related to the setup of the solar photovoltaic systems such as feed-in tariff rate and equipment subsidy.

Market Players & Competition

There are 7 silicon ingot & wafer firms, 45 PV solar cell & module firms and 29 downstream system installation firms in Taiwan that include:

- **Motech Industries Inc** **<6244.TWO>** Motech Industries, Inc. is engaged in the manufacture and distribution of solar cells. The Company also provides power supply machines, signal generation machines, communication transmission wire testing machines, radio frequency (RF) training systems, inductance and capacitance impedance testing machines, asymmetric digital subscriber line (ADSL) testing machines, solar portable power boxes, solar power converters and others. The Company also offers consulting, integrating, technical development and training services of solar power generation systems. Top contract chipmaker TSMC <2330.TW> <TSM.N> said in December 2009 that it has formed a strategic alliance with Motech by buying a 20% stake in the company. For a detailed company profile, see Appendix A.

- **E-TON Solar Tech. Co Ltd <3452.TWO>** is primarily engaged in development, manufacture and distribution of solar cells. The Company provides four-inch single crystalline solar cells, five-inch single crystalline solar cells, five-inch multi crystalline solar cells, six-inch single crystalline solar cells and six-inch multi crystalline solar cells. For a detailed company profile, see Appendix A.

- **Gintech Energy Corp <3514.TW>** specializes in the development and manufacture of solar cells. The Company's major products include six-inch multicrystalline and monocrystalline solar cells, as well as five-inch multicrystalline and monocrystalline solar cells. The Company's solar cells are mainly applied in power generation plants, residential buildings, solar electronic bicycles, battery chargers, watches and others. For a detailed company profile, see Appendix A.

- **Green Energy Technology Inc <3519.TW>** is engaged in manufacture and distribution of solar silicon wafers and solar silicon ingots. The Company provides 5-inch multi-crystal solar silicon wafers, 6-inch multi-crystal solar silicon wafers, 5-inch mono-crystal solar silicon wafers, 6-inch mono-crystal solar silicon wafers, multi-crystal silicon ingots and thin film solar modules, among others. Its products are applied in manufacture of solar photovoltaic modules. Green Energy Technology announced that it will invest USD 6.16 million in a Weifang-based new energy technology company in Mainland China in September 2009.

- **Sino-American Silicon Products Inc <5483.TWO>** is primarily engaged in manufacture and sale of silicon wafers and ingots. The Company provides silicon ingots, polished wafers, non-polished wafers, high-power electronic wafers, diffused wafers, mono crystalline wafers, multi crystalline wafers and sapphire polished wafers, among others. Its products are applied in manufacture of integrated circuits (ICs), diodes, power devices and photovoltaic products. For a detailed company profile, see Appendix A.

- **Wafer Works Corp <6182.TWO**> is engaged in the development, design, manufacture and distribution of semiconductor silicon wafers and ingots, as well as solar silicon wafers and ingots. The Company also provides double-sided polished wafers, thin wafers and epitaxial wafers, as well as optoelectronic products such as sapphire wafers. The Company's semiconductor silicon wafers and ingots are mainly applied in the processing and design of integrated circuits (ICs). For a detailed company profile, see Appendix A.

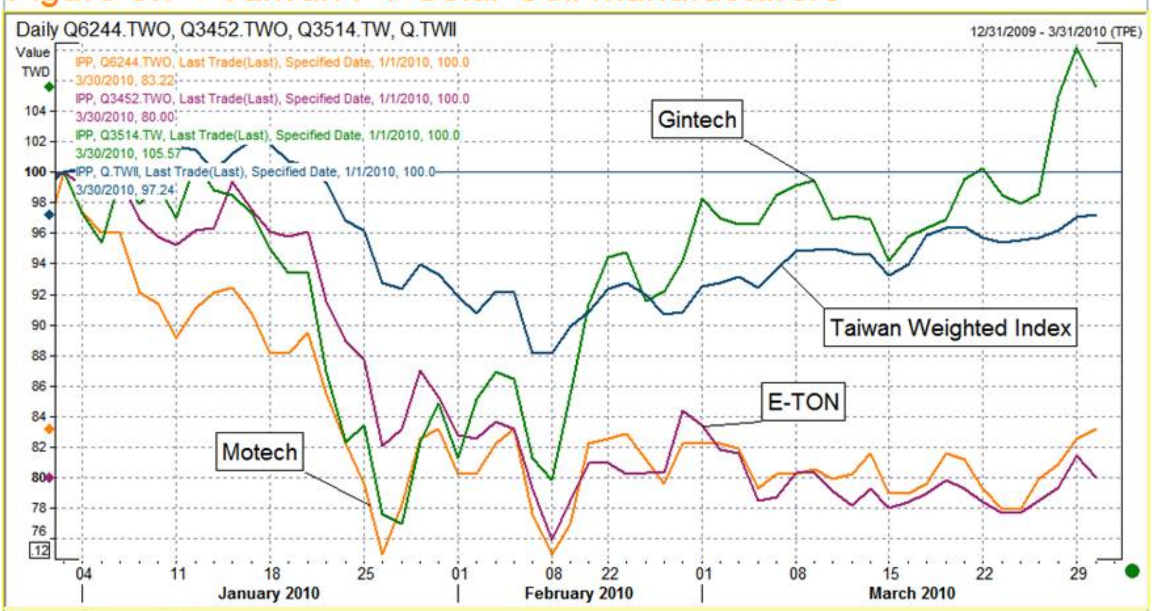
- **Tainergy** <Unlisted> Tainergy plans to double its production capacity to 120MW in Taiwan by Q1 2010. The company expects to target 1GW of PV cell production capacity by 2014, including the production in Taiwan and Mainland China. The company plans to launch its initial public offering the Taiwan Stock Exchange in 2010.

Summary of Analyst Consensus for Taiwanese PV Solar Sector

Company Name	Code	Mkt Cap (Mill)	PE	Consensus	Mean Value	No. of Analysts	Updated
Motech Industries Inc	6244.TWO	NT$41,704	269.08	HOLD	3.26	19	Dec 2009
Green Energy Technology	3519.TW			HOLD	2.67	3	Dec 2009
E-TON Solar Tech	3452.TWO			HOLD	3.43	7	Dec 2009
Gintech Energy Corp	3514.TW						
Sino-American Silicon Products	5483.TWO	NT$25,532	52.53	OUTPERFORM	2.44	10	Dec 2009
Wafer Works Corp	6182.TWO						

Source: Thomson Reuters

Figure 6.7 - Taiwan PV Solar Cell Manufacturers



Source: Thomson Reuters

6.2.9 India

Market Size & Growth

India, like China has ambitions to capture a significant share of the global solar manufacturing industry and this is unlikely to be achieved in the absence of a significant domestic market.

Drivers & Constraints

India's government is set to announce its ***National Solar Mission*** with targets for solar capacity addition to be around 1GW by 2012 and 20GW by 2022. This New Mission should add to the existing FiT put in place by the MNRE in 2008, which set a maximum of 15 INR/kWh (< 0,25 EUR/kWh) guaranteed for no more than 10 years and capped at 50 MW of capacity.

In addition, in 2009, the State governments have offered discrete support for PV. At the start of the year, Gujarat announced its Solar Power Policy 2009 initiative, targeting installation of 500 MW of solar power plant over the next five years.

This should be a benefit for domestic providers such as Moser Baer, Tata Power and new entrants like BHEL and Bharat Electronics.

India has a Ministry focused on New and Renewable Energy (MNRE). The MNRE programs have resulted in the installation of an estimated 5 MW of street lighting systems, 450 000 home lighting systems, 730 000 solar lanterns and over 7 000 PV pumps.

Estimates by the European PV Industry Association suggest that some 28 MW of new PV capacity were installed in India in 2008, corresponding to a total installed capacity of over 160 MW.

Market Players & Competition

- **Moser Baer** **<MOSR.BO>** Moser Baer, is one of India's leading technology companies. It is one of the leading manufacturer of Optical Storage media like CDs and DVDs. It has diversified into other sectors, including Solar Energy.

- **Tata Power** **<TTPW.BO>** has entered into a joint venture with BP Solar to create Tata BP Solar which runs a fully integrated Solar Manufacturing Plant, including Cell Manufacture, Module Assembly and Balance of Systems (BOS). It has a capacity of manufacturing 52MW Solar Cell.

- **Bharat Heavy Electricals** **<BHEL.BO>** is an engineering and manufacturing company in the energy-related and infrastructure sector. The Company caters to sectors, including to the power generation and transmission, industry, transportation, renewable energy and defense. BHEL manufactures a range of products and systems for thermal, nuclear, gas and hydro-based utility power plants. Bharat Heavy Electricals has entered into the PV Solar sector and recently secured an order worth INR420 million to build a 3MW solar power plant in the southern state of Karnataka for Karnataka Power Corp Ltd.

- **Bharat Electronics** **<BAJE.BO>** offers products and services in a wide spectrum of technology like Radars, Military Communications, Naval Systems, Electronic Warfare Systems, Telecommunications, Sound and Vision Broadcasting, Opto-Electronics, Tank Electronics, Solar Photovoltaic Systems, Embedded Software and Electronic Components. It has also signed a memorandum of understanding with Bharat Heavy Electronics Limited to explore formation of a joint venture company for solar photo voltaic business setting up manufacturing facility for silicon wafer, solar cells and modules and to identify suitable vendor/partners for the supply of raw material including poly silicon for solar PV business. The JVC, besides export, will cater to Indian products requirements.

6.2.10 Singapore

Market Size & Growth

The capacity for solar power in Singapore is limited. However a solar testbed has been started to trail new PV technologies at demonstration sites.

Drivers & Constraints

The Singapore Government has ambitions to build the nation into a 'Clean Energy Hub' and has already been successful in attracting significant investment from major international PV businesses to establish manufacturing capacity in the country. On the implementation side, a '***Solar Capability Scheme*** (SCS)' has been initiated providing up to one million SGD (30 % to 40 % of the total capital cost of PV projects) for projects promoting innovative design and integration of solar technologies into energy efficient buildings

Market Players & Competition

- **REC <REC.OL>.** REC will build the largest PV solar plant in the world in Singapore, due to start operations in 2010. The plant will be able to produce products that can generate up to 1.5 GW of energy annually.

6.2.11 Indonesia

Market Size & Growth

The market for PV Solar in Indonesia is negligent, as the cost of generation is mauch higher, compared with geothermal, hydro and biomass.

Drivers & Constraints

Indonesia is focused in three renewable areas: geothermal, small hydro and biomass. However, a target of 870MW in solar capacity has been proposed by 2025.

Market Players & Competition

There are no companies identified.

6.2.12 Malaysia

Market Size & Growth

Malaysia plans to introduce a FiT scheme in the 10th Malaysian Plan (2011 – 2015) for renewable energy market acceleration. By 2011, Malaysia aims to achieve 217 MW of renewable energy in the electricity supply system, with PV contributing 7 MW; by 2015 the corresponding figures are 975 MW and 55 MW; and by 2030 renewable energy is expected to represent 13% (3 484 MW) of total system capacity.

By the end of 2008 Malaysia had a total installed PV capacity of about 9 MW, of which 776 kW (54 installations) were grid-connected. The largest installation is the 362 kW system at the Enterprise Four Building at Technology Park Malaysia. During 2008 there were over 135 kW of grid-connected systems installed and an estimated 1 625 kW of offgrid systems. Of the 24 new grid-connected installations in 2008, two were for office buildings and 22 for residences. The two commercial buildings made up 40 % of the total installed grid-connected PV capacity in 2008.

Drivers & Constraints
The main market driver for grid-connected PV systems is the financial incentive program provided by SURIA 1000, based on a bidding process that spreads over six calls with the final call ending 1st December 2009. Other incentive programs are the Demonstration Category (providing 25 % capital incentive for a total of 200 kW) and Showcase (providing 100 % capital incentive for a total of 100 kW). Both programs have been fully awarded. By the end of 2008, SURIA 1000 had completed four of the six calls, with the following results: a total of 342 kW of PV installed (compared with the target of 300 kW); 13 % drop in the price of grid-connected PV systems; and, by the fourth call, bidders' willingness to pay reaching 51.8% of total system price, up from 46.7% during the first call.

During August 2008 the Government of Malaysia announced an exemption on import duty and sales tax for PV systems – this should decrease the price of PV systems by 5 % to 10 %. Companies continued to enjoy the double tax allowances (investment tax and capital allowances) announced in the previous year's budget.

The cumulative installed capacity of grid connected PV systems in Malaysia is expected to reach 980 kW to 1 MW by the end of 2009. The cumulative capacity of off-grid PV systems is expected to reach about 10 MW by this time.

Market Players & Competition
Foreign companies dominate the domestic market, with 5 firms established in Malaysia: First Solar Inc at the Kulim Hi Tech Park (KHTP), SunPower Corp in Malacca, ReneSola in Johor Baru, Q-Cells in Selangor Science Park 2, and the Japanese firm Tokuyama Corp in Sarawak.

Three public-listed companies in Penang, P. I.E. Industrial Bhd, Ire-Tex Corp Bhd, and Pentamaster Corp Bhd, have recently invested in Solar to tap into the growing market demand for solar products in the country and in the world.

6.2.13 Thailand

Market Size & Growth
The Thai PV market is around 100MW in installed capacity by 2009 and expected to rise to 250MW by 2011.

Drivers & Constraints
A PV Solar target of 500MW has been proposed by 2022, as part of the 15 year Renewable Energy Masterplan.

Market Players & Competition
Solartron Public Company Limited is Thailand's leading solar module manufacturer. Solartron holds about 80% of the domestic market share, with an annual production of 30MW.

6.2.14 Philippines

Market Size & Growth

There is only an estimated 25MW of installed capacity in the Philippines. However, with the enactment of the RE Act, and award of new wind project, the market is expected to increase significantly.

Drivers & Constraints

While the ***Renewable Energy Act of 2008*** (RE Act) put in place a regulatory framework for renewable energy in the Philippines, renewable energy is still focused on hydro and geothermal.

Market Players & Competition

- SunPower Philippines Manufacturing Limited (SPML), was the first semiconductor fab in the Philippines and the first large-scale, solar cell facility in Southeast Asia, established in 2004. The plant will initially turn out 25MW per year of high-efficiency silicon solar cells to meet the increasing worldwide demand for clean, reliable solar electric power systems.

6.2.15 Australia

Market Size & Growth

The total installed capacity in Australia reached 104.5 MW in 2008. The largest installed capacity of PV in Australia is for off-grid industrial and agricultural applications.

Drivers & Constraints

The market for PV installations connected to the main electricity grids continues to increase and represented the largest market for PV in 2008. The majority of installations took advantage of a government grant program under the "***Solar Homes and Communities Plan***" (SCHP) which contributed up to 80 % or more of up-front capital costs. The main applications are rooftop systems for private residences, schools and community buildings. Commercial and light industry sector interest is also growing, with support available to selected projects through the ***Solar Cities Program***. All grid-connected PV systems can create Renewable Energy Certificates for the Renewable Energy Target. While, there are no National FiT, there are FiT set at the State level, which range from $0.2 to $0.6 per kWh

Australian Government support programs impacted significantly on the 2008 PV market, contributing funding towards 74 % of PV capacity installed over the year. The SCHP provided rebates up to 8 000 AUD for 1 kW of PV installed on residential buildings and up to 50 % of the cost of PV systems up to 2 kW installed on community buildings. From late 2009, the rebate is expected to be replaced by extra ***Renewable Energy Certificates*** from the ***Renewable Energy Target***.

Whilst there is no specific national PV program, there are a number of key PV support mechanisms which drive the Australian market. These include the ***Solar Homes and Communities Plan***, the ***Renewable Remote Power Generation Program*** (RRPGP) which has provided 50% of off-grid renewable energy system costs, with the aim of reducing diesel fuel use, but now has restricted grants to smaller systems via a AUD 200,000 cap; the ***Solar Cities*** program, which is creating a useful driver for PV installations for the next 5 years, particularly in the otherwise neglected commercial sector; and the ***Solar Schools*** program, which could see the installation of 20 MW of PV over the next 8 years. The majority of small PV systems installed create ***Renewable Energy Certificates*** (RECs) under the ***Renewable Energy Target*** (RET) scheme.

Market Players & Competition

There is only one module manufacturer in Australia – BP Solar, which produces its own cells and modules from imported wafers. Solar Systems manufacture concentrator PV systems using imported cells, but is in the process of setting up cell manufacture in Australia. There are a number of Australian manufacturers of inverters, battery charge controllers and inverter/chargers, particularly catering for the off-grid system market, including Selectronics, Plasmatronics, Latronics and Solar Energy Australia. Some of these manufacturers also supply inverters suitable for grid interconnection. Inverter prices typically range from AUD 0.5 – 1.5 per W. Although some battery components are made in Australia, only a few companies manufacture complete solar batteries. These include Exide's Energystore products and Battery Energy's Suncycle range. Battery Energy, in conjunction with the Commonwealth Scientific & Industrial Research Organisation (CSIRO), has also developed a solar gel battery, *Sungel.*

- **Selectronics** <Unlisted> designs and manufactures a wide range of wire wound components and a range of high quality sine wave power inverters. They also manufacture Solar Controllers and Inverters.

- **Plasmatronics** <Unlisted> is an Australian company which specialises in the design and manufacture of electronic regulating and metering devices for solar power systems..

- **Latronics** <Unlisted> manufactures grid connected solar inverters, pure sinewave inverters, AC transfer switches, turbine controllers and battery chargers.

Solar Concentrators

- **SunSeeker Energy** **<SSE.NZ>** is engaged in commercializing the SunSeeker technology throughout Australasia. It manufactures, markets, and sells the SunSeeker solar energy system in Australasia. The SunSeeker solar concentrator technology was developed and is licensed by Hong Kong-based SunSeeker Energy Limited (SunSeeker Energy).

6.2.16 New Zealand

Market Size & Growth

The PV Solar market in New Zealand is small and no data found on installed capacity.

Drivers & Constraints

PV Solar is not a focus for Renewable Energy targets in New Zealand.

Market Players & Competition

- **BP Solar** <Unlisted> is a subsidiary of UK oil giant BP, the company designs, manufactures, supplies, and installs photovoltaic (PV) solar cells and modules that provide power for homes , remote villages and industrial facilities, commercial businesses, and local government. Its plants are in the US, India, China., Australia and NZ

6.2.17 Summary of Companies in PV Sector

Code	Compay Name	Market Cap (M Dollars)	PE ratio	Country	Sector
SSE.NZ	SunSeeker Energy (Australasia) Ltd	$13.1	N/A	New Zealand	Energy Sources
7966.T	LINTEC Corp	$1,539.4	21.5	Japan	Misc. Materials & Commodities
7911.T	TOPPAN PRINTING CO LTD	$6,229.4	N/A	Japan	Business & Public Services
3402.T	TORAY INDUSTRIES INC	$7,918.0	N/A	Japan	Textiles & Apparel
5816.T	Onamba Co Ltd	$76.0	17.8	Japan	Electrical & Electronics
6826.T	HONDA TSUSHIN KOGYO CO LTD	$40.9	N/A	Japan	Electronic Components & Instruments
6941.T	YAMAICHI ELECTRONICS CO LTD	$80.8	N/A	Japan	Electronic Components & Instruments
6804.T	Hosiden Corp	$960.9	8.6	Japan	Industrial Components
5331.T	NORITAKE CO LTD	$452.8	N/A	Japan	Industrial Components
5108.T	BRIDGESTONE CORP	$13,763.4	1149.3	Japan	Industrial Components
5202.T	Nippon Sheet Glass Co Ltd	$1,965.6	N/A	Japan	Misc. Materials & Commodities
5201.T	Asahi Glass Co Ltd	$13,093.6	58.2	Japan	Misc. Materials & Commodities
010060.KS	OCI Co Ltd	$3,764.0	10.0	South Korea	Chemicals
3800.HK	GCL-poly Energy Holdings Ltd	$3,867.2	10.0	Hong Kong	Utilities-Electrical & Gas
4043.T	Tokuyama Corp	$1,967.8	19.9	Japan	Chemicals
5711.T	Mitsubishi Materials Corp	$3,656.1	N/A	Japan	Metals - Non Ferrous
5726.T	OSAKA Titanium technologies Co Ltd	$1,278.0	110.7	Japan	Metals - Non Ferrous
051910.KS	LG Chem Ltd	$13,838.3	11.2	South Korea	Chemicals
4091.T	TAIYO NIPPON SANSO	$3,634.8	23.1	Japan	Chemicals

	CORP				
4183.T	Mitsui Chemicals Inc	$3,147.5	N/A	Japan	Chemicals
5411.T	JFE Holdings Inc	$24,401.9	N/A	Japan	Metals - Steel
002380.KS	KCC Corp	$3,297.4	9.9	South Korea	Building Materials & Components
4204.T	Sekisui Chemical Co Ltd	$3,699.5	81.2	Japan	Chemicals
CMH.TO	Carmanah Technologies Corp	$32.6	N/A	Canada	Energy Sources
6753.T	Sharp Corp	$13,202.4	N/A	Japan	Appliances & Households
6971.T	KYOCERA CORP	$18,141.2	N/A	Japan	Electronic Components & Instruments
7011.T	Mitsubishi Heavy Industries Ltd	$13,117.9	1238.5	Japan	Machinery & Engineering
6503.T	Mitsubishi Electric Corp	$19,005.4	N/A	Japan	Electrical & Electronics
6764.T	SANYO Electric Co Ltd	$10,096.3	N/A	Japan	Appliances & Households
3452.TWO	E-TON Solar Tech. Co Ltd	$511.9	N/A	Taiwan	Electronic Components & Instruments
3514.TW	Gintech Energy Corp	$909.3	N/A	Taiwan	Electronic Components & Instruments
5483.TWO	Sino-American Silicon Products Inc	$743.3	47.4	Taiwan	Electronic Components & Instruments
6244.TWO	Motech Industries Inc	$1,471.9	208.3	Taiwan	Electronic Components & Instruments
BAJE.BO	Bharat Electronics Ltd	$3,703.5	15.4	India	Electronic Components & Instruments
BHEL.BO	Bharat Heavy Electricals Ltd	$25,668.8	31.1	India	Electrical & Electronics
CSUN.O	China Sunergy Co Ltd	$180.0	N/A	China	
ESLR.O	Evergreen Solar Inc	$261.9	N/A	China	Electronic Components & Instruments
JASO.O	JA Solar Holdings Co Ltd	$794.6	N/A	China	Electronic Components & Instruments
MOSR.BO	Moser Baer India Ltd	$281.4	3792.5	India	Data Processing & Reproduction
SOLA.L	ReneSola Ltd	$417.1	N/A	China	Electrical & Electronics
SOLF.O	Solarfun Power Holdings Co Ltd	$336.0	N/A	China	Electronic Components & Instruments

STP.N	Suntech Power Holdings Co Ltd	$2,654.0	29.8	China	Electrical & Electronics
TSL.TH	Trina Solar Ltd	$1,612.4	14.8	China	Electronic Components & Instruments
TTPW.BO	Tata Power Co Ltd	$7,042.5	29.1	India	Utilities-Electrical & Gas
WESL.BO	Websol Energy Systems Ltd	$56.8	38.6	India	Utilities-Electrical & Gas
YGE.TH	Yingli Green Energy Holding Co Ltd	$1,783.5	N/A	China	Electronic Components & Instruments
002218.SZ	Shenzhen Topraysolar Co Ltd	$1,002.1	155.2	China	Data Processing & Reproduction
0155.HK	China Solar Energy Holdings Ltd	$178.9	N/A	Hong Kong	Financial Services
0750.HK	China Singyes Solar Technologies Holdings Ltd	$253.0	12.3	China	Energy Equipment & Services
4118.T	KANEKA CORP	$2,260.4	22.2	Japan	Chemicals
DSTI.O	DayStar Technologies Inc	$11.4	N/A	USA	Electronic Components & Instruments
0712.HK	Comtec Solar Systems Group Ltd	$295.1	N/A	China	Energy Equipment & Services
0757.HK	Solargiga Energy Holdings Ltd	$402.8	N/A	Hong Kong	
3436.T	SUMCO CORP	$5,222.4	N/A	Japan	Electronic Components & Instruments
3519.TW	Green Energy Technology Inc	$393.6	26.3	Taiwan	Electronic Components & Instruments
6182.TWO	Wafer Works Corp	$438.9	N/A	Japan	Electronic Components & Instruments
5981.T	TOKYO ROPE MFG CO LTD	$436.1	N/A	Japan	Industrial Components
8020.T	KANEMATSU CORP	$351.0	10.3	Japan	Wholesale & International Trade
6890.Q	Ferrotec Corp	$317.5	N/A	Japan	Electrical & Electronics
6336.T	ISHII HYOKI CO LTD	$101.4	N/A	Japan	Machinery & Engineering
Unlisted	Selectronics	N/A	N/A	Australia	Battery chargers
Unlisted	Plasmatronics	N/A	N/A	Australia	Battery chargers
Unlisted	Latronics	N/A	N/A	Australia	Battery chargers
Unlisted	Solar Energy Australia	N/A	N/A	Australia	Battery chargers

Unlisted	Mitsubishi Aluminum	N/A	N/A	Japan	BOS/Back Sheets
Unlisted	Mitsubishi Plastics	N/A	N/A	Japan	BOS/Back Sheets
Unlisted	Toyo Aluminium	N/A	N/A	Japan	BOS/Back Sheets
Unlisted	Mitsui Chemicals Fabro	N/A	N/A	Japan	BOS/EVA
Unlisted	C.I. Kasei	N/A	N/A	Japan	BOS/EVA
Unlisted	M. Setek	N/A	N/A	Japan	Feedstock
Unlisted	Dongyang Chemical Co	N/A	N/A	South Korea	Feedstock
Unlisted	Samsung Petrochemical Co	N/A	N/A	South Korea	Feedstock
Unlisted	Space Energy	N/A	N/A	Japan	PV Cells and Modules
Unlisted	BP Solar	N/A	N/A	Australia	PV Cells and Modules
Unlisted	STX Solar	N/A	N/A	South Korea	PV Cells and Modules
Unlisted	Millinet Solar	N/A	N/A	South Korea	PV Cells and Modules
Unlisted	KISCO	N/A	N/A	South Korea	PV Cells and Modules
Unlisted	Alti-Solar	N/A	N/A	South Korea	PV Cells and Modules
Unlisted	Solar Systems	N/A	N/A	Australia	PV Concentrator
Unlisted	Woongin Energy	N/A	N/A	South Korea	Wafers
Unlisted	Nexolon Co	N/A	N/A	South Korea	Wafers
Unlisted	Sinsung Holdings	N/A	N/A	South Korea	Wafers

Source: Thomson Reuters

6.3 Biofuel

6.3.1 Background

Unlike other renewable sources, the biofuel sector is used primarily for the transportation industry, as opposed to power generation. The biofuel sector is also contentious as it is heavily linked to the agricultural industry and has become highly politicized and can be argued that there is only marginal improvement to existing fossil fuels, as it releases carbon dioxide into the atmosphere. Having said that, biofuels, can be broken down into the following major categories:

- ***Ethanol*** generated from cereals, grains, sugar crops and other starches, which can be used either as a motor fuel in pure form or blended in gasoline. Leading producers in the world are the US and Brazil. For Asia, bioethanol produced from Cassava has been generated in refineries in China.

- ***Bio-diesel*** generated from oil-seeds such as palm oil, jatropha, rapeseed, soybean and even microalgae and converted into methyl esters and used in pure form or blended with diesel.

The major market for bio-diesel is the EU, which the major global diesel market. Biodiesel from Palm Oil is the leading process in Asia, with Malaysia and Indonesia the leading producers. Jatropha is another biodiesel crop gaining acceptance in Asia, particularly in India, as it does not require valuable land used for agriculture and can grow in poor non arable land. Both Japan, China and Korea are researching the development and commercialization of biodiesel generated from algae.

- Fuel generated from *cellulosic* materials, including grasses, trees, and various waste products from crops, wood processing facilities and municipal solid waste. However, this process is yet to become commercially viable.

6.3.2 Targets & Incentives

- China has a target of 10 million tonnes by 2020 for ethanol and 2 million tonnes for biodiesel by 2020. China has a ban on biofuels produced from grains, so it appears that it will have to import, due to the shortfall in domestic production to meet its 2020 targets.

- Japan has a target of 500,000 KL (0.43 million tonnes by 2010) and estimates a total capacity of 5.2 million tonnes by 2030, if cellulosic ethanol is commercially viable.

- India has a 20% target by 2017, which equates to around 11 to 12 million tonnes of biofuel.

- South Korea has a 20% biodiesel mandate and 3% ethanol mandate by 2012, which should increase demand to 0.7 million tones by 2012.

- Taiwan has a 1% mandate for biodiesel blending into diesel and 3% mandate for ethanol blending into gasoline, which will equate to about 0.4 million tonnes of biofuel demand.

- Australia has in place blending mandates set at the state level, with Queenland, Victoria and Western Australia setting a 5% target and NSW setting a 10% blending mandate for ethanol by 2011. Demand is likely to increase to around 0.3 to 0.4 million tonnes of biofuel in 2010.

- New Zealand has a 2.5% blending mandate by 2010 that equates to around 0.14 million tonnes per year demand for biofuels.

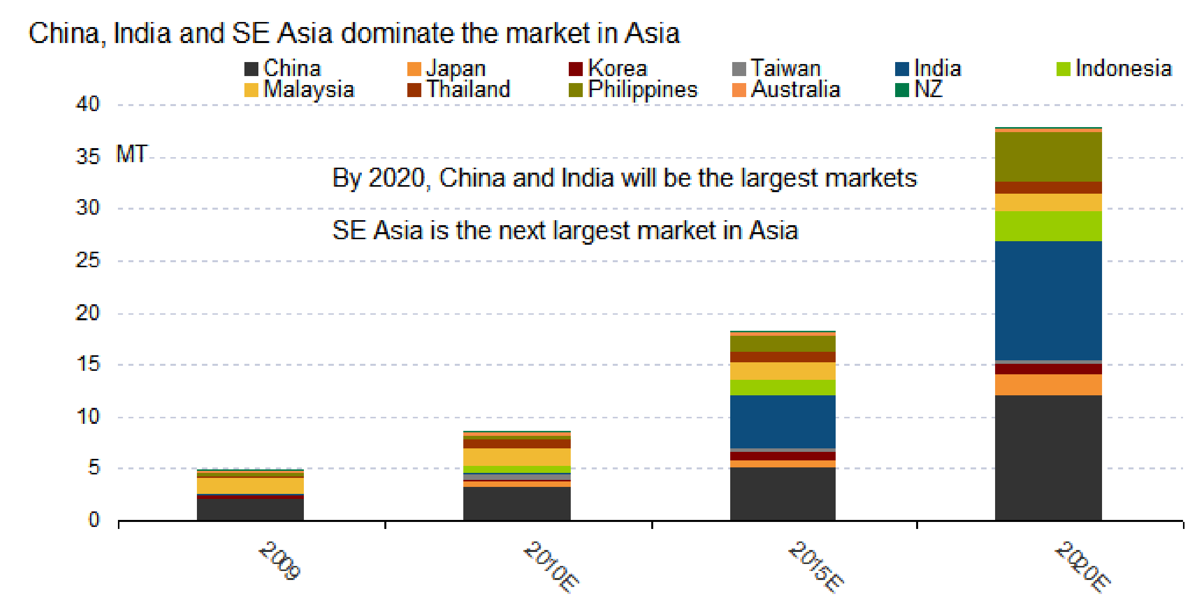
- Indonesia has a blending mandate for biofuels that increase to 20% by 2025 for biodiesel and 15% for ethanol. This equates to 2.7 million tonnes by 2020. However, it is not clear how Indonesia can achieve this target, when there are no clear incentives for industry to produce biofuels and gasoline is heavily subsidized.

- Malaysia has a capacity of 1.7 million tonnes, primarily for export. The Biofuel Act passed in 2007, will be the main driver for biofuel demand in Malaysia and mandate a 5% blend of palm oil into diesel. However, the Act has been put on hold.

- Thailand has a 20% blending rate for gasoline and 2% blending rate for diesel. Demand is expected to increase to 0.8 million tonnes in 2010.

- Philippines has a 5% blending mandate for ethanol and 2% blending rate for biodiesel (that may be raised to 3%). Philippines has to import ethanol to meet demand and the government is looking to increase domestic demand and to stop importation over fours years.

Figure 6.8 Asia Pacific Biofuel Sector



Source: IEA, Thomson Reuters, Government Publications

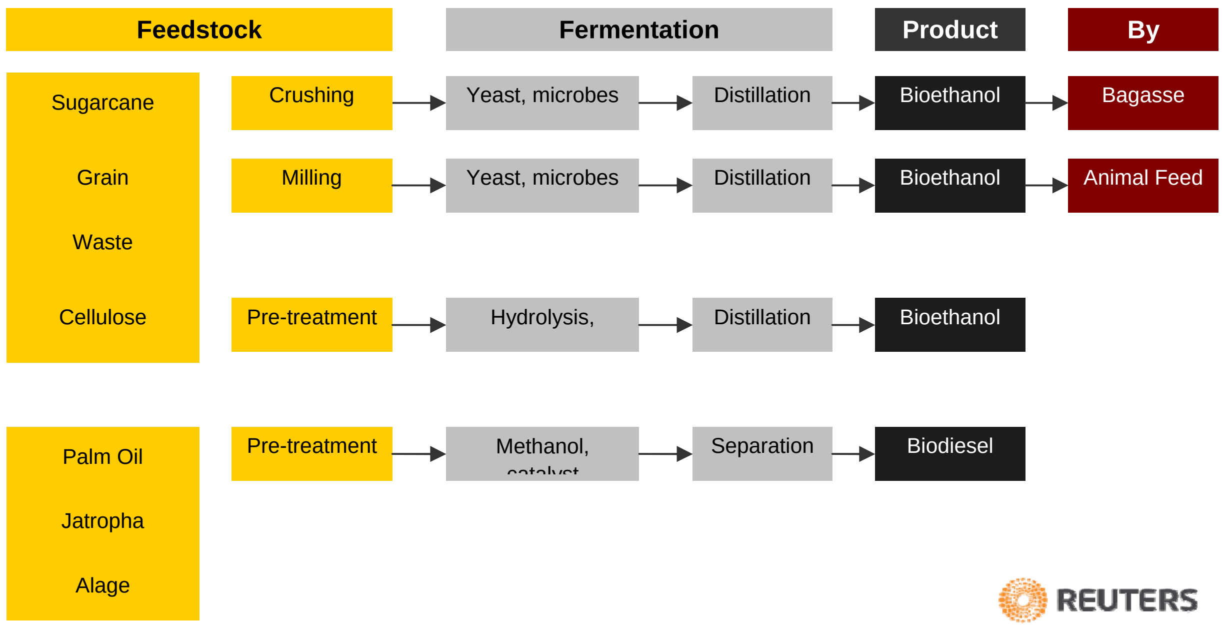
Asia Pacific Biofuel Market (Million Tonnes per year)

Country	2009	2010E	2015E	2020E
China	2.1	3.2	5*	12
Japan	0	0.43	0.8*	2*
S Korea	0.3	0.32	0.7	1*
Taiwan	0	0.4	0.4	0.4
India	0.12	0.2	5*	11.5
Indonesia	0.03	0.7	1.66	2.73
Malaysia	1.5	1.7	1.7	1.7*
Thailand	0.1	0.8	1*	1.2*
Philippines	0.37	0.4*	1.5*	4.8
Australia	0.22	0.31	0.3*	0.3*
NZ	0.14	0.14	0.15*	0.15*
Total	**4.88**	**8.6**	**18.2**	**37.8**

Source: EIA, Government Publications, Estimates

6.3.3 Biofuel Supply Chain

Figure 6.9 - Biofuel Process



Sugar to Bioethanol

In order to produce ethanol from sugar crops, the feedstock must first be processed to remove the sugar through crushing, soaking and chemical treatment. The sugar is fermented to produce alcohol, using yeasts and other microbes. A final step distils the ethanol to the desired concentration and removes water to produce “anhydrous ethanol” that can be blended with gasoline. In the sugar cane process, the crushed stalk of the plant, the “bagasse”, consisting of cellulose and lignin, can be used for process energy in the manufacture of ethanol.

Grain to Bioethanol

The grain-to-ethanol production process starts by separating, cleaning and milling the starchy feedstock. Milling can be “wet” or “dry”, depending on whether the grain is soaked and broken down further either before the starch is converted to sugar (wet) or during the conversion process (dry). In both cases, the starch is converted to sugar, typically using a high-temperature enzyme process. The next stages in the process are similar to that for sugar crops, where sugars are fermented to alcohol using yeasts and other microbes. A final step distils the ethanol to the desired concentration and removes water. The grain to-ethanol process also yields several co-products, such as protein-rich animal feed (e.g. distillers dry grain soluble, or DDGS) and in some cases sweetener, although this varies, depending on the specific feedstock and process used.

Biodiesel

Biodiesel from fatty acid methyl esters (FAME) can be produced by a variety of esterification technologies, though most processes follow a similar basic approach. First the oil is filtered and pre-processed to remove water and contaminants. If free fatty acids are present, they can be removed or transformed into biodiesel using pre-treatment technologies. The pre-treated oils and fats are then mixed with an alcohol (usually methanol) and a catalyst (sodium or potassium hydroxide). The oil molecules (triglycerides) are broken apart and reformed into esters and glycerol, which are then separated from each other and purified to produce biodiesel.

Cellulose to Bioethanol

The first step in converting biomass to ethanol is pre-treatment, involving cleaning and breakdown of materials. A combination of physical and chemical processes are applied, which allows separation of the biomass into its cellulose, hemicellulose and lignin components. Some hemicellulose can be converted to sugars in this step, and the lignin removed. Next, the remaining cellulose is hydrolysed into sugars, the major ‘saccharification’ step. Common methods are dilute and concentrated acid hydrolysis. Research is currently focused on the development of biological enzymes that can break down cellulose and hemicellulose. The first application of enzymes to wood hydrolysis in an ethanol process was to simply replace the cellulose acid hydrolysis step with a cellulose enzyme hydrolysis step. This is called ‘separate hydrolysis and fermentation’ (SHF). An important process modification made for the enzymatic hydrolysis of biomass was the introduction of ‘simultaneous saccharification and fermentation’ (SSF), which has recently been improved to include the co-fermentation of multiple sugar substrates. In the SSF process, cellulose, enzymes and fermenting microbes are combined, reducing the required number of vessels and improving efficiency. As sugars are produced, the fermentative organisms convert them to ethanol. Finally, researchers are now looking at the possibility of producing all required enzymes within the reactor vessel, thus using the same “microbial community” to produce both the enzymes that help break down cellulose to sugars and to ferment the sugars to ethanol. This is known as “consolidated bioprocessing” (CBP).

Algae to Biodiesel

Biofuel can be made from Algae and does not use land that would be used for agriculture. The first step is photosynthesis, where the algae and other photosynthetic organisms capture carbon dioxide and sunlight and convert it into oxygen and biomass. Studies show that algae can produce up to 60% of their biomass in the form of oil. Companies looking to commercialise Algae use Photobioreactors that pumpinutrient-laden water through plastic tubes that are exposed to sunlight. There is also work to use Wastewater to provide the nutrients to Algae.

6.3.4 China

Market Size & Growth

Ethanol

China’s fuel ethanol production is forecast to rise to 1.70 million tonnes in 2009, an increase of 8%, compared to 2008 and is produced in 5 plants. Due to the ban by the government on use of grain based feedstock, any new domestic production will need to come from other feedstock such as cassava and jatropha.

Summary of Bioethanol Production in China

Location *(Province, City)*	Company Name	Principal Feedstock	Estimated 2008 Production *(MT/year)*	2009 Production Capacity	Supply Location
Heilongjiang, Zhaodong	China Resources Alcohol Co.	Corn/Rice	180,000	180,000	Heilongjiang
Jilin, Jilin	Jilin Fuel Ethanol Co.	Corn	470,000	500,000	Jilin Liaoning
Henan, Nanyang	Henan Tian Guan Fuel-Ethanol Co.	Wheat	410,000	450,000	Henan Hubei (9 cities) Hebei (4 cities)
Anhui, Bengbu	Anhui BBCA Biochemical Co.	Corn	400,000	440,000	Anhui Shandong (7 cities) Jiangsu (5 cities) Hebei (2 cities)
Guangxi	Guangxi COFCO Bio-Energy Co.	Cassava	120,000	200,000	Guangxi
		Total	**1,580,000**	**1,770,000**	

Source: USDA Foreign Agriculture Service

Biodiesel

Overall annual biodiesel production capacity in 2008 is estimated at 3 million tonnes, however actual biodiesel production in 2008 is estimated at 250,000 MT. Feedstock for biodiesel production is scarce in China, given that China is a net importer of vegetable oils such as soy and palm oil for food consumption. Currently, the main feedstock is waste cooking oil from restaurants, which is difficult to collect on a commercial scale for biodiesel production. Sinopec and CNOOC have signed deals with Indonesia to produce biodiesel in Indonesia to make up for the shortfall in domestic production.

Summary of Biodiesel Production in China

Company Name	Location	Production Capacity (MT)
China Biodiesel International Holding Co., LTD	Fujian Province	100,000
Wuxi Huahong Biofuel Company	Jiangsu Province	100, 000
Hainan Zhenghe Biofuel Energy Company	Hebei Province	300,000
Gushan Environmental Energy Limited	Sichuan, HeBei, Fuzhou, Beijing	340,000
	Total	**840,000**

Source: USDA Foreign Agriculture Service

Summary of Jatropha Demonstration Plants in China

Participants	Location	Production Capacity (MT)
Petro China	Sichuan Province	60,000
SinoPec	Guizhou Province	50,000
CNOOC	Hainan Province	60,000
	Total	**170,000**

Source: USDA Foreign Agriculture Service

Drivers & Constraints

China announced a revised biofuel target in 2009, as part of its renewable energy push for 2020 and expects to increase production by 10 times for bioethanol and by 40 times for biodiesel. It aims to increase this production from a variety of non-food related sources including cassava and ethanol from cellulose, as the government has put a ban on grain based fuel ethanol production in 2007.

However, the sector's future domestic growth will be constrained by limited feedstock supplies, which compete with land use for grain production for ethanol and competition for oilseed feedstock for biodiesel. According to government policy, cassava, sweet potato, and sweet sorghum are viewed as potential feedstock for new ethanol plants and Jatropha for biodiesel. Due to the potential shortfall in domestic supply, China may need to import, if it wants to achieve its 2020 targets and the recent investments by Sinopec and CNOOC in Indonesia in 2009, reflect a response to secure more supply from other countries.

China	2005	2010	2020
Bioethanol	1 MT	3 MT	10 MT
Biodiesel	0.05 MT	0.2 MT	2 MT

Source: Government Publications

Market Players & Competition

China's major oil refiners, Sinopec, CNOOC and PetroChina are the major providers of biofuels to the Chinese market.

- **Sinopec** **<0386.HK>,<600028.SS>** has teamed up with China's COFCO and Novozymes <NZYMb.CO> for a biofuel project, will jointly invest up to 90 billion yuan ($13.17 billion) to to collect agricultural waste, process it into bioethanol and distribute the clean fuel through petrol stations. Sinopec has also built a biodiesel production plant with an annual output of 100,000 tons in Panzhihua, Sichuan Province, together with an auxiliary energy forest base of 400,000-500,000 mu (up to 128 square miles). It has also signed a deal in Indonesia worth $5.5 billion to produce biodiesel from Palm Oil.

- **China National Offshore Oil Corporation** **<CEO.N>, <0883.HK>** has a biodiesel plant in Dongfang City, Hainan Province with an annual output of 60,000 tons. Feedstock is supplied from jatropha in Hainan.

- **CNPC** **<0135.HK>** signed a total cooperative framework agreement on the development of biomass energy with China National Forest Bureau. Starting in 2007, both parties will launch one jatropha curcas demonstrating base with a scale not less than the raw material supply needed for an annual biodiesel output of 20,000-30,000 tons in Yunnan and Sichun respectively. The scale of CNPC's plantation base in Yunnan might reach 400,000 mu this year. CNPC will actively participate in the development of biomass energy, said Jiang Jimin, President of CNPC. Its annual production capacity of non-grain ethanol will exceed 2 million tons, with an annual 200,000 tons of biodiesel from forests in a commercialized scale together with more than 400,000 hectares of a raw material biomass energy base by the end of 2011.

Bioethanol

- **China Resources Alcohol Corporation** <Unlisted> (CRAC) is currently the fourth largest ethanol producer in China and the owner of a cellulosic ethanol pilot demonstration plant. The technology was provided by SunOpta BioProcess Group in September 2006 and the plant began production of ethanol from local corn stover (stalks and leaves) in October 2006. CRAC's goal is to install increase from 5,000 tonnes per year at the end of 2007 and 1,000,000 tonnes per year by 2012.

- **Jilin Fuel Ethanol Co.** <Unlisted> Jilin Fuel Ethanol Co. Ltd is the ethanol production unit in China and was formed by China National Petroleum Corp., Jilin Food Stuff (Group) and China Resources Corp.

- **Henan Tianguan Enterprise Group Co., Ltd** <Unlisted> is one of the five enterprises authorized by National Government to produce fuel ethanol, with a capacity to produce around 500,00 tones per year.

- **Anhui BBCA Biochemical Co** **<000930.SZ>** processes 3 million tons of corn per year, with fuel ethanol, citric acid, L-lactic acid, ethylene oxide, amino acids, fats, fruit juice, gluten meal, fiber feed and other products. For a detailed company profile, see Appendix A.

- **Guangxi COFCO Bio-Energy Co.** <Unlisted> is a subsidiary of COFCO and passed technical appraisal for its 200 000 tonnes per year cassava-based fuel ethanol project in April 2009.

Biodiesel

- **China Clean Energy** **<CCGY.OB>** China Clean Energy through its wholly-owned subsidiary, Fujian Zhongde Technology Co., Ltd. and Fujian Zhongde Energy Co., Ltd, is engaged in the development, manufacturing, and distribution of biodiesel fuel and specialty chemical products made from renewable resources. Since its inception, the Company has been engaged in the manufacture of high-quality specialty chemical products from renewable resources. Through its research and development efforts, the Company developed a proprietary process for refining biodiesel fuel from waste grease and certain vegetable oils.

Using this proprietary process, the Company began producing biodiesel in 2005 and commenced selling biodiesel commercially starting in December 2005. The Company has completed construction of its 100,000 tonnes biodiesel plant in Jiangyin in China's Fujian Province.

- **Gushan Environmental Energy Limited** **<GU.N>** is a biodiesel producer in China. The Company produces biodiesel and by-products of biodiesel production, including glycerine, plant asphalt, erucic acid and erucic amide. The Company sells its products in China to direct users, including marine vessel operators, petroleum wholesalers and individual retail gas stations. The Company primarily uses vegetable oil offal and used cooking oil to produce biodiesel. The Company operates five production facilities, located in Beijing, Shanghai, Sichuan, Hebei and Fujian, with an aggregate annual biodiesel production capacity was 340,000 tons. For a detailed company profile, see Appendix A.

- **China Biodiesel International Holding Co., Ltd** **<CBI.L>** is a renewable energy company focused on the research and development, production and marketing of biodiesel as a substitute for diesel or petrochemical chemicals. China Biodiesel has a couple of local production companies in Longyan Zhuoyue New Energy Development Co., Ltd. and Xiamen Zhuoyue Biomass Energy Co., Ltd., both of which locate in Fujian Province, South China, with an annual production of around 50,000 tonnes.

- **Hebei Zhenghe Biodiesel Co Ltd** <Unlisted> produces around 300,000 tonnes per year in Wuan city,Hebei province from waste edible oil,waste of pressed oil and jatropha.

- **Fujian Zuoyue New Energy Co.Ltd** <Unlisted> is a principal biodiesel producer in China with an operational capacity of 20000 tonnes/year.

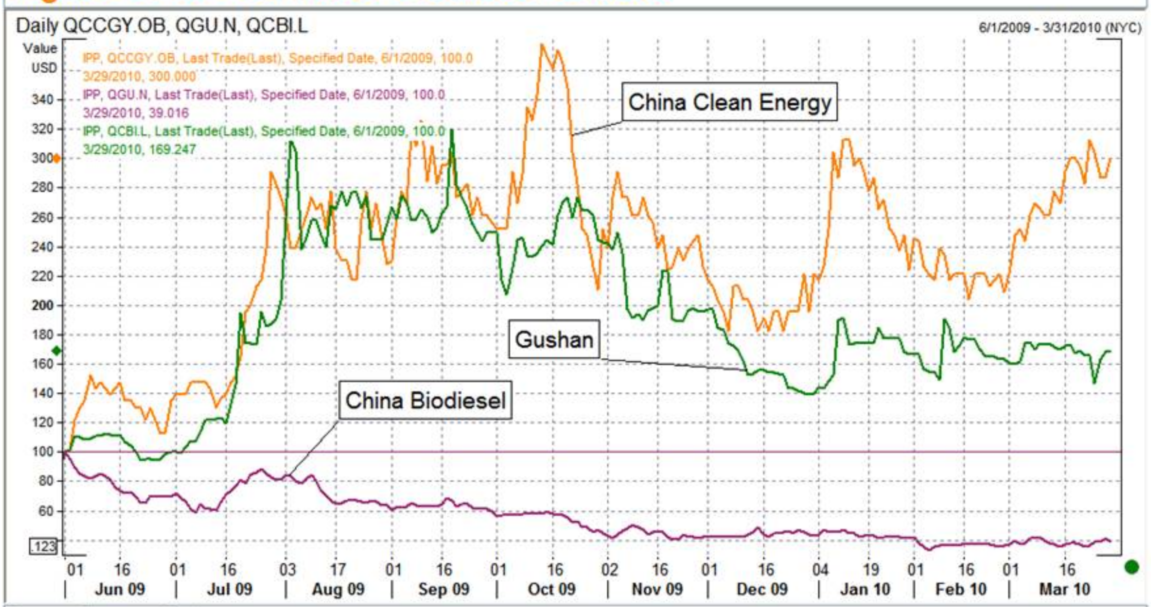
- **Wuxi Huahong Biofuel Company** <Unlisted> produces around 100,000 tonnes per year.

Algae

- **Guodian Power Company** **<600795.SS>** is one of the largest power producers in China. It signed a $10million deal with Israeli firm Seambiotic entering into a joint venture to commercialize the cultivation of microalgae using carbon dioxide captured from its power plants.

- **Shanghai Jun Ya Yan Technology Development Company** <Unlisted> has developed an agreement with PetroSun whereby it will provide $40 million (US) for the construction of an algae farm facility inside China and split profits with PetroSun, in exchange for PetroSun’s propriety technology and expertise.

Figure 6.10 - Chinese Biodiesel Stocks



Source: Thomson Reuters

6.3.5 Japan

Market Size & Growth

Japan has a biofuel target of 500,000 KL/year for Crude Oil equivalent by 2010. This is split into a target for ethanol of 210,000KL/year and bio-diesel of 290,000KL/year. A proposal in 2007, states that a target of 6 million KL/year can be achieved by 2030.

Drivers & Constraints

The “***Biomass Nippon Strategy***,” was unveiled by the government in December 2002 and updated in 2008. Given Japan’s limited agricultural resources, the focus was on cellulosic biofuel as the future for its biofuel production. Several ministries are involved in setting Japan’s bio-fuels policy: The Ministry of Economy, Trade and Industry (METI), the Ministry of Agriculture Forestry and Fisheries (MAFF), the Ministry of Environment (MOE), the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Ministry of Land, Infrastructure and Transport (MLIT), and the Ministry of Internal Affairs and Communications (MIC).

In February 2007, the Executive Committee on Biomass Nippon Strategy released a report titled “Boosting the Production of Biofuels in Japan.” The report presented to the Prime Minister states that Japan will be able to produce 6 million KL of biofuels by 2030.

In 2008 the government introduced tax incentives to encourage the use of bioethanol. If a fuel contains 3% bioethanol, the gas tax is lowered by ¥1.6 per liter (approximately USD .02) and is effective until March 31, 2013.

With respect to bio-diesel, the government decided that the blending ratio of Fatty Acid Methyl Ester (FAME) into diesel should be less than 5%, in order to ensure that the fuel meets safety and gas emissions standards for existing vehicles in the market.

Market Players & Competition

The major players in the biofuel sector in Japan are Mitsubishi Heavy Industries and Nippon Oil, working in private public partnerships with various agricultural co-operative across the country.

Ethanol

Japan has started a number of public private partnerships to promote the production of bioethanol. The two projects are:

Grain Based

- The public-private partnership is between Mitsubishi Corp. and Hokuren (the federation of agricultural cooperatives) in Shimuzucho, Hokkaido. These are expected to become the first commercially-viable ethanol plants in Japan with a planned annual production of 15,000 KL, which will be used to produce ETBE. A third facility in Obihiro City, Hokkaido is run by the Tokachi Foundation and is supported by prefectural and national funds. The foundation runs a very small still that converts Hokkaido-grown wheat into ethanol to fuel a single test vehicle. The equipment is all state of the art, expensive, and on a miniature scale. The Foundation says that this is a proof of concept project intended simply to see whether they could produce ethanol from wheat to fuel the vehicle.

- A public-private partnership is with Zen-noh in Niigata. It uses high yield rice grown specifically for biofuel production (800 kg/1000 m2 vs 500 kg/m2 for food use rice). The project began in 2006 using fallow land set aside in MAFF's acreage reduction plan. Early this year the facility has begun to produce 1000 kl of bioethanol. The ethanol is used as part of an E3 blend and started to be sold at 20 affiliated gas stations around Niigata prefecture this March.

- In addition, there are ten more ethanol facilities nationwide including one in Okinawa using sugar cane as the fuel stock. All those are small-scale built for bioethanol verification projects supported by the government.

Cellulose

- **Mitsubishi Heavy Industries** **<7011.T>** has constructed a bioethanol demonstration plant located in Hyogo Prefecture to produce ethanol for automobile fuel from soft cellulose vegetation, such as rice straw and wheat straw that do not compete with food supply. The plant was developed jointly with Hakutsuru Sake Brewing and Kansai Chemical. The company expects the biofuels produced could be sold at a price less than JPY90 (USD 1.04) per litre by the end of 2010.

- **Nippon Oil** **<5001.T>** is also leading a consortium of Japanese firms, including Mitsubishi Heavy, Toyota and others to develop low-cost cellulosic ethanol. The consortium, which also includes Toray Industries, Kajima and Sapporo Breweries subsidiary Sapporo Engineering, aims to produce 200m litres of bioethanol per year by March 2014 at a cost of JPY 40 (USD 0.44) per litre by 2015.

- **Biomass Energy Corporation** <Unlisted> is a technology leader in the field of Biomass to Liquid ("BTL") gasification. BME's technology enables the conversion of cellulose biomass (also known as inedible biomass) into green fuels such as liquefied bio-methanol without the participation of oxygen. Transcu is the major shareholder of the company.

Biodiesel

In May 2006, Nippon Oil Corporation <5001.T> and Toyota Motor Corporation announced that they jointly developed a palm oil-based bio-diesel that performs comparably to gasoline. They claim to have removed the oxygen from the palm oil, which would normally cause the fuel to degrade. Nippon Oil aims to develop a commercially viable bio-diesel by 2010.

- **Nippon Shokubai Co. Ltd** <Unlisted> has announced in September 2009, the development of a high-performance catalyst for manufacturing acrolein from glycerol obtained as a by-product from the manufacture of biodiesel fuel from vegetable oils. According to Nippon Shubakai, the acrylic acid from the new manufacturing method can reduce emission of carbon dioxide by about a third compared to the petroleum-sourced raw material. The company is to build a pilot plant for this technology in early 2011 at its site in Himeji, Japan where the company's acrylic acid plant is located.

6.3.6 South Korea

Market Size & Growth

There are 8 registered biodiesel facilities in Korea with a total production capacity of a little over 300,000 tons annually. MOCIE forecasts that biodiesel production will expand to 700,000 tons by 2012/13.

Production

Korea's Biodiesel Mid & Long Term Production Plan

Year	% Blend	KL	Tonnes
2007	0.5 %	90,000	79,200
2008	1.0 %	180,000	158,400
2009	1.5 %	270,000	237,600
2010E	2.0 %	360,000	316,800
2011E	2.5 %	450,000	396,000

Source: The Ministry of Knowledge and Economy (MKE)

Korea's Biodiesel Producers

Company Name Annual	Capacity (KL)	Feedstock
KAYA Energy Co., Ltd.	100,000	Soybean Oil & recycled cooking oil
Ecoenertech	33,000	Recycled cooking oil
Dansuk Industrial Co., Ltd.	60,000	Soybean oil
BND Energy	50,000	Soybean Oil & recycled cooking oil
3M Safety	48,000	Soybean oil
BDK	33,000	Soybean Oil & recycled cooking oil
Mudeung Bioenergy	6,000	Recycled cooking oil
Biodiesel Energy	9,000	Soybean oil
CNG	9,000	Recycled cooking oil
Samwoo Oil Chemical Co., Ltd.	12,000	Recycled cooking oil
Next Oil	99,000	Soybean oil
Enertech Inc.	80,000	Palm oil & Soybean oil
Bio Doil Korea	12,000	Soybean Oil & recycled cooking oil
SK Chemicals	34,000	Palm oil
Aekyung Petrochecmical Co., Ltd.	32,000	Soybean oil
BND Kunsan	50,000	Soybean Oil & recycled cooking oil
Total	667,000	

Source: The Ministry of Knowledge and Economy (MKE)

Drivers & Constraints

South Korea is planning to introduce a renewable fuel standard system, which would mandate the use of biofuels for vehicles, by 2013. Under the new system, the minimum proportion of biodiesel fuel contained in gasoline would grow to double digits. Currently petrol in Korea only contains 1.5% of vegetable oil or animal fat-based diesel fuel. If successful the move would be a breakthrough for the use of renewable energy in Korea.

When a pilot scheme was launched by the ***Ministry of Commerce, Industry and Energy*** (MOCIE) in 2002, to ensure that petrol contained 20% biodiesel fuel, it was met by strong opposition from oil refiners and carmakers regarding its quality. In 2007, the government had planned to raise the content ratio to 3% by 2012.

Market Players & Competition

Ethanol

- **Kumho Petrochemical** **<011780.KS>** and biotechnology firm Biosystems have signed an agreement to build a 125m-litres per year ethanol plant in South Jeolla Province. The USD 176m plant will be constucted in the city of Yeosu by 2013, with a 4000-litres per day pilot plant to be built by 2011.

Biodiesel

- **Next Oil Co. Ltd.** <Unlisted> plans to produce about 200 metric tons of biodiesel daily in the Philippines, the same processing capacity at its Korean facilities.

- **Enertech Inc.** <Unlisted> is a Biodiesel Manufacturer in Korea with annual capacity of 70,000 MT.

6.3.7 Taiwan

Market Size & Growth

Taiwan's annual motor vehicle demand for gasoline is 10.5 million KL and 4.5 million KL for diesel. Taiwan's demand for crude oil is met by imports and it imports 1.2 million barrels of crude oil a year.

Taiwan has set a compulsory goal to use B1 diesel starting July 2008 and B2 diesel in 2010. Taiwan has also set a goal to use E3 gasoline to replace MTBE in 2011. This equates to a demand for biodiesel is estimated at 45,000 KL for B1 diesel and 315,000 KL for E3 in 2011.

There are four biodiesel plants manufacturing biodiesel and there are several biodiesel plants are under construction.

While there is no domestic ethanol produced from feedstock, Taiwanese authorities support several bio-fuels research projects. They are considering ethanol produced from sugarcane, sweet potato and other biomass from agricultural wastes and the MOEA pilot scheme of 3,000T/year.

Drivers & Constraints

Small and fragmented land holdings in Taiwan greatly increase the cost of field crop production, harvest, and transport. This will make it difficult to develop a viable bio-fuels sector in Taiwan, without large subsidies. In-spite of these obstacles, Taiwan has developed a bio-fuels policy that requires certain levels of biofuel to be blended into existing gasoline and diesel supplies.

The demand for biodiesel is estimated at 45,000 KL for B1 diesel. However, Taiwan only produces 6,500 KL of biodiesel from recycled cooking oil. The rest demand must be sourced from domestically grown energy crops. Taiwan has selected soybean and sunflower as two major energy crops to grow on fallow rice paddy fields. Taiwan's ***Council of Agriculture*** (COA) provides supports to farmers per hectare NT$45,000 according to the current green payment to farmers who set aside their rice paddy for fallowing and oil seeds are sold to contracted biodiesel plants at NT$12 per kilogram according to current soybean import price level.

Market Players & Competition

No companies identified in this sector.

6.3.8 India

Market Size & Growth

Bioethanol

India is one of the worlds leading producers of sugarcane and sugar. The government is trying to encourage sugarcane juice/sugar molasses usage for ethanol production to diversify farmer's income stream. Current production is only around 50 million liters. However, production would need to increase to 1-2 million tonnes of ethanol to meet the new target.

Biodiesel

Bio-diesel production efforts are focused on using non-edible oils from plants such as Jatropha and other tree borne oilseeds. The focus is to encourage the use of wastelands and other unproductive land for the cultivation of these relatively hardy "new" bio-fuel crops. An estimated 55.3 million hectares are considered wasteland in India, which could be brought into productive use by raising bio-diesel crops.

There are about 20 large capacity plants (one to fifty tons per day) that produce bio-diesel from edible oil waste (unusable oil fractions), animal fat and non-edible oil with production estimates ranging anywhere between 100 to 200 million liters per year. However, production would need to increase to 10 million tonnes of biodiesel to meet the new target.

Drivers & Constraints

The Indian government is expected to approve the national biofuels policy in 2009 to target 20% blended biodiesel by 2017.

Ethanol

The commercial production and marketing of ethanol-blended gasoline started in January 2003, when the ***Ministry of Petroleum and Natural Gas*** launched the first phase of the ***Ethanol Blended Petrol*** (EBP) program that mandated blending of five percent ethanol in gasoline in nine states (out of a total of 29) and four union territories (UT) (out of a total of 6).

The second phase of the EBP program was announced in September 2006 that mandated 5% blending of ethanol with gasoline, subject to commercial viability in 20 states and eight Union territories. This involved the production of 1.4 billion liters of ethanol. However, as of April 2009 only 35% had been supplied.

The government had initially planned to launch the third stage of the EBP from October 1, 2008 to raise the percentage of the blend ratio. However, due to the short supply of feedstock, the government has deferred the implementation of the third phase of the EBP. Currently, the government does not allow use of imported ethanol for the EBP program as the focus is on developing domestic production capacities.

Biodiesel

In April 2003, the government launched a National Mission on Bio-diesel that identified Jatropha as the most suitable tree-borne oilseed for the production of bio-diesel, and focused on promoting plantations of Jatropha on "wastelands". The government's Planning Commission set an ambitious target of 11.2-13.4 million hectares to be planted with Jatropha by 2012, in order to produce sufficient bio-diesel to blend at 20% with petro-diesel.

New Policy

The National Bio-fuel Policy formulated by the Ministry of New and Renewable Energy has been announced on December 2009. Key features of the proposed new policy are:

- An indicative target of 20% blending of petrol and diesel with bio-fuels by 2017
- Promote biodiesel production from non-edible oilseeds in waste/degraded/marginal lands
- Discourage plantations in fertile, irrigated premium farm land
- Focus on domestic production of bio-diesel feed stock and not permit imports
- Recommend minimum support prices for bio-fuel crops like Jatropha and other non-edible oilseeds with provisions of periodic revisions
- Recommend a minimum purchase price for the purchase of ethanol based on the cost of production and import price. The biodiesel price will be based on the prevailing price of diesel
- Take steps to ensure unrestricted movement of bio-fuels within and outside states.
- Removal of taxes and duties on bio-diesel
- Set up of an inter-ministerial National Bio-fuel Coordination Committee under the Chairmanship of the Prime Minister and a Bio-fuel Steering Committee under the Chairmanship of the Cabinet Secretary for high level coordination and policy guidance or review on various aspects of bio-fuels development in India.

Market Players & Competition

- **Alfa Laval** **<ALFA.BO>** supplies a comprehensive range of equipment for the production of both ethanol and biodiesel.
- **Tree Oils India Ltd.** <Unlisted> is established to build up environment friendly and sustainable energy system based on plant sources, contribute to waste lands utilisation and rural women employment and promote ethics and self reliance. TOIL is primarily engaged in manufacture of Biodiesel from Non-Edible Tree Oils such as Jatropha and Pongamia.
- **Praj Industries** <Unlisted> is a global Indian company that provides offers process equipment & systems for bio-ethanol, bio-diesel, and brewery plants.

6.3.9 Singapore

Market Size & Growth

Singapore is an island state, with only 6 million inhabitants, with little or no land available to grow crops for biofuel. However, it plans to act as a refinery hub for Asia by refining palm oil and jatropha from neighbouring countries such as Indoniesia and Malaysia for export across the region and to Europe. With the Neste Oil production facility to open in 2010, this will take Singapore's biofuel production capacity to over 1 million tones per year.

Drivers & Constraints

Over the past few years, the focus in Singapore has been to kick-start biodiesel production for export. The country aims to produce higher quality biofuels and use alternative non-food feedstock, such as palm oil and jatropha.

Singapore is close to countries that provide the source of raw materials, thus simplifying the process of obtaining feedstock. In addition, the well-connected global shipping routes would facilitate export of the processed biofuels to the major European markets. Companies would also be able to benefit from the many free trade agreements Singapore has signed with our foreign partners.

Market Players & Competition

- **Neste Oil** **<NES1V.HE>** has already invested S$1.2 billion to establish the world's most advanced and largest commercial-scale biodiesel production facility in Singapore and is expected to commence operations in 2010. Finland's Neste Oil announced plan to build the world's largest biofuel plant with a design capacity of 800,000 tons per year in Singapore. Expected to be completed in 2010, the plant will rely on palm oil feedstock from Malaysia and Indonesia.

- **Continental BioEnergy** <Unlisted>, a Singapore company, opened a biodiesel plant in September 2006, with production capacity of 150,000 tons a year.

- **Peter Cremer** <Unlisted> is building a Singapore plant with a planned output of 200,000 tons a year.

- **JOil (S) Pte. Ltd** <Unlisted> engages in the production of jatropha seeds which produce 40% oil, used in diesel engines after crushing and processing. The company is based in Singapore. JOil (Singapore) Pte Ltd. operates as a subsidiary of Temasek Life Sciences Laboratory Limited.

- **Golden Agri-Resources Ltd** **<GAGR.SI> i**ncludes cultivating and harvesting oil palm trees, processing fresh fruit bunches (FFB) into crude palm oil (CPO) and palm kernel (PK), and refining CPO into industrial and consumer products, such as cooking oil, margarine and shortening. During the year ended December 31, 2008, the Company acquired five estates in Kalimantan with total planted area of 11,000 hectares. In September 2008, the Company, through its wholly owned subsidiary, Asia Palm Oil Investment Pte. Ltd. (APOI), acquired Eco Investment Limited (Eco Investment). In October 2009, it incorporated a wholly owned subsidiary, Sinar Mas Natural Resources (China) Investment Co., Ltd (SNC). In November 2009, the Company announced the incorporation of a wholly owned subsidiary, Easton Capital Resources Pte. Ltd. (ECR).

- **Wilmar International** **<WLIL.SI>** is engaged in providing management services to its subsidiary companies. The Company operates in four segments: merchandising and processing, consumer products, plantation and palm oil mills, and others. The merchandising and processing segment includes merchandising of palm oil and laurics-related products. The consumer products segment bottled oil business in the People's Republic of China, Vietnam and Indonesia. The plantation and palm oil mills segment is engaged in oil palm cultivation and milling. The other segment includes the business of manufacturing and distribution of fertiliser products and ship-catering services.

6.3.10 Indonesia

Market Size & Growth

Currently, there is only one producer which still actively produces biofuel, but the production is well below plant capacity. The installed capacity is approximately 1.5 MMT/year, but reportedly is operating at approximately 7,000 MT/month.

Biodiesel from Palm Oil was 20,750 MT in 2009 and produced 27,000MT of bioethanol from molasses. A total of 70,000MT of biodiesel was exported in 2009.

Drivers and Constraints

Biodiesel Blending Mandates

Sector	Jan 2009	Jan 2010	Jan 2015	Jan 2020	Jan 2025
Transportation (Public)	1%	2.5%	5%	10%	20%
Transportation (Private)	1%	3%	7%	10%	20%
Commercial & Industries	2.5%	5%	10%	15%	20%
Power plants	0.25%	1%	10%	15%	20%

Source: Regulation No. 32/2008 of Ministry of Energy and Mineral Resources

Bioethanol Blending Mandates

Sector	Jan 2009	Jan 2010	Jan 2015	Jan 2020	Jan 2025
Transportation (Public)	1%	3%	5%	10%	15%
Transportation (Private)	5%	7%	10%	12%	15%
Commercial & Industries	5%	7%	10%	12%	15%
Power plants					

Source: Regulation No. 32/2008 of Ministry of Energy and Mineral Resources

The use of biofuel in power plants as of December 2008 has reached 0.1%. Mandated levels within the Ministerial Decree are 0.25% in 2009; 1% by January 2010; 10% by January 2015; 15% by January 2020; and 20% by January 2025.

This would equate to roughly 4 to 4.5 million MT per year by 2025, from a current consumption of around 27,000 MT in 2009. This is unlikely to be achieved, unless there are incentives for producers to make a profit in producing biofuels.

Estimates on Biofuel Requirements

Sector	Usage (KL)	2010	2015	2020	2025
Industry	5,203,479		520,348	605,166	780,522
Electricity	3,309,124		330,912	496,369	661,825
Households	5,043,051				
Transportation	20,788,075		1,039,404	2,078,808	3,118,211
Total (KL)		**786,000**	**1,890,664**	**3,180,343**	**4,560,558**
Total (MT)		**691,682**	**1,663,790**	**2,733,108**	**3,919,250**

Source: Estimates

In response, the Indonesian government is planning to set aside USD 150m as subsidies for biofuels in 2010, which it hopes will raise production levels. The ministry of energy said the subsidies are necessary, as crude oil prices are rising, but production is not enough when biofuels becomes mandatory. The government plans to make it mandatory for a 1% bioethanol blend and up to a 5% biodiesel blends from 2010. It estimates that the country would need about 214m litres and 562m of biodiesel when the targets kick in – 786,000KL.

The subsidies will be given to state oil and gas company PT Pertamina, the sole distributor of subsidised fuels, via its pump stations, to help the company to purchase biofuels from the producers. The government said that it will wait until it has finalised a regulation that sets out the rules on the categories of fuels to be subsidised, before agreeing to the subsidy levels.

Market Players & Competition

- **Puri Usaha Kencana** <Unlisted> will cooperate with Sinopec to set up biofuel plants and to grow energy crops in Indonesia, with an investment of US$5 billion. The plants and plantations are set to be located in Indonesia's Papua and East Kalimantan regions, and will be used for extracting biodiesel from crude palm oil and jatropha curcas oil.

- **China National Offshore Oil Corporation** (CNOOC) signed a Memorandum of Understanding with the Indonesian government under which it intends to invest $5.5 billion in the development of the biofuel sector in Indonesia, announcing the establishment of 3 biodiesel processing plants in Kalimantan

- **Bronzeoak** plans to invest US$270 million to produce ethanol from sweet sorghum. Bronzeoak will cooperate with the Satria Group to build a factory and plantation in the regency of Belu and Central Timor in East Nusatenggara

- **The Sampoerna Group** plans to construct an ethanol plant in Wonogiri, Central Java.

Besides direct foreign investments, Indonesian (state-owned) Banks are to disburse 25 trillion rupiah (US$2.7 billion) in loans to finance local farmers that help the biofuel projects.

The ***Bandung Institute of Technology*** (ITB), ***Bogor Institute of Agriculture*** (IPB), the ***Research and Development Division*** of the ***Ministry of Energy and Mineral Resources*** are amongst the scientific institutions that signed the Memoranda of Understanding to support biofuels projects in Indonesia.

6.3.11 Malaysia

Market Size & Growth

Malaysia, with its large and growing palm oil industry, has the potential to play a major role in the world biofuel market. Malaysia is currently the world's number two producer, after Indonesia and remains the top exporter of palm oil.

Ethanol

Ethanol production is commercially insignificant in Malaysia. There is an opportunity for ethanol production from oil palm biomass but the technology is yet to be commercialized. Ethanol consumption is unlikely as retail gasoline prices are subsidized.

Biodiesel

According to the ***Malaysian Palm Oil Board's*** (MPOB), there are about 12 Bio-diesel plants, with a combined capacity is about 1.5 million tons. In 2008, bio-diesel output increased by only 5% due to high prices for feedstock. Post expects a 30% increase in 2009 as companies are cranking up their machines when the margins started to appear during the latter half of 2008.

Bio-diesel plants in Malaysia

Company	Location	Capacity (MT)
Carotino Sdn.Bhd	Pasir Gudang, Johor	
Malaysiavegetable Oil Refinery Sdn. Bhd.	Pasir Gudang, Johor	
PGEO Bioproducts Sdn. Bhd.	Pasir Gudang, Johor	
Vance Bioenergy Sdn. Bhd.	Pasir Gudang, Johor	
Mission Biotechnologies Sdn. Bhd.	Petaling Jaya, Selangor	
Carotech Bio-Fuel Sdn. Bhd.	Ipoh, Perak	
Lereno Sdn. Bhd.	Setiawan, Perak	
Golden Hope Biodiesel Sdn. Bhd.-	Carey Island Pulau Carey, Selangor	
Golden Hope Biodiesel Sdn. Bhd.-	Panglima Garang Teluk Panglima Garang, Selangor	390,000
Zoop Sdn. Bhd.	Shah Alam, Selangor	
Global Bio-Diesel Sdn. Bhd.	Lahad Datu, Sabah	
SPC Bio-diesel Sdn. Bhd.	Lahad Datu, Sabah	
	Total	1,500,000

Source: USDA

Another four plants with a combined capacity of 190,000 tons was expected to commence commercial production by the end of 2009.

Drivers & Constraints

Malaysia is one of the leading producers of Palm Oil, which is a main source of biodiesel for the European markets. The use of Palm Oil has been very contentious, with bans threatened on the import of biodiesel from Malaysian and Indonesia, due to the impact on the rainforest.

The ***Biofuel Industry Act*** passed in 2007 is the main driver for the development of the biofuel domestic industry.

Market Players & Competition

- **Golden Hope Biodiesel** <Unlisted> Golden Hope has 4 biodiesel plants producing a total of 390,000 tonnes. The plants include the plant at Teluk Panglima Garang, Banting which is operated by its wholly owned subsidiary Rubiatec Sdn Bhd; the plant at East Estate, Carey Island; the plant at Bintulu, Sarawak and a plant at Unimills in The Netherlands.

6.3.12 Thailand

Market Size & Growth

The Thai Government has licensed 45 manufacturing companies to produce ethanol, with a combined production capacity of around 12 million liters/day. Of this, 8.4 million liters are cassava-based ethanol from 24 plants and the balance comes from molasses/sugar-based ethanol (2.2 million liters/day) from 12 plants and tapioca/molasses-based ethanol (1.4 million liters/day) from 9 plants.

Summary of Ethanol Production in Thailand in 2008

Feedstock	Number of Plants	ML/day	Number of Plants Online	ML/day	% Utilization
Cassava	24	8.4			0%
Sugar Molasses	12	2.2	10	1.45	66%
Tapioca Molasses	9	1.4	1	0.15	11%
Total	45	12.0	11	1.6	13.3%

Source: USDA, Estimates

Projected Growth in Demand for Biofuels in Thailand

Biofuel	2008 (KL/year)	2010/11 (KL/year)
Ethanol	90,000	450,000
Biodiesel	31,000	492,000
Total	121,000	942,000
Total MT	104,000	810,000

Source: USDA, Estimates

However, only 11 plants had come online in 2008, with a production capacity of around 1.6 million liters/day, with only a total utilization of around 13%. Reduced capacity was mainly due to high prices of feedstock.

Summary of Ethanol Production Capacity in Thailand

Company	Location	Feedstock	Capacity (L/day)	Actual Production
Ponwilai	Ayudhaya	Molasses	25,000	-
Thai Alcohol	Nakornprathom	Molasses	200,000	104,381
Thai Agro	Supanburi	Molasses	150,000	109,842
Thai Nguan Ethanol	Khonkean	Tapioca	130,000	-
Khonkean Alcohol	Khonkean	Cane/Molasses	150,000	129,551
Thai Sugar Ethanol	Kanchanaburi	Cane/Molasses	100,000	102,520
Petro Green	Chaiyapoom	Cane/Molasses	200,000	162,757
K.I. Ethanol	Nakornratchasima	Cane/Molasses	100,000	89,029
Ekarat Pattana	Nakornsawan	Molasses	200,000	-
Thai Ruangruong Energy	Saraburi	Cane/Molasses	120,000	28,280
Petro Green	Kalasin	Cane/Molasses	200,000	160,653
E.C. Business Partners	Rayong	Tapioca	150,000	n/a
Fha-kwantip	Prajinburi	Tapioca	60,000	n/a
Ratchaburi Ethanol	Ratchaburi	Tapioca/Molasses	150,000	Q3-2008
E.S. Power	Srakaew	Cane/Molasses	150,000	Q3-2008
Srima Inter Products	Chachoengsao	Cane/Molasses	150,000	Q4-2008
Supthip	Lopburi	Tapioca	200,000	Q4-2008
P.S.C. Starch Products	Chonburi	Tapioca	150,000	Q2-2008
T.P.K Ethanol	Nakornratchasima	Tapioca	340,000	Q3-2008
Impress Technology	Chachoensao	Tapioca	200,000	Q4-2009
Boonanek	Nakornratchasima	Tapioca	350,000	Q2-2009
Double A Ethanol	Srakaew	Tapioca	500,000	Q1-2009
		Total	**3,975,000**	

Source: USDA

Biodiesel

At present, nine B100 biodiesel plants are operating at half of their production capacity of 2.19 liters/day. Although the current government policy on mandatory B2 production warrants sale quantities and prices to manufacturers, they are still concerned that CPO production could be a bottleneck for expanding.

Summary of Biodiesel Production Capacity in Thailand

Plant Production	Capacity (liters/day)
BangChak Petroleum Plc.	50,000
Bio Energy Plus Co.,Ltd.	100,000
Sun Tech Palm Oil Co.,Ltd.	200,000
Pathum Vegetable Oil Co.,Ltd.	300,000
Bangkok Alternative Energy Co.,Ltd.	200,000
Green Power Corporation Co.,Ltd.	200,000
A I Energy Co.,Ltd.	250,000
WeeraSuwan Co.,Ltd.	200,000
Thai Oleo	650,000
Total	**2,185,000**

Source: USDA

Drivers & Constraints

Ethanol

As of January 1, 2008, the Thai Government launched E20 gasoline following a surge in E10 gasoline sales in 2007. According to the Department of Alternative Energy Development and Efficiency, Ministry of Energy, E20 gasoline consumption is estimated at 0.25 million liters/day in 2008, and is forecast to increase to 1.23 million liters/day (450 million liters per year) or 5% of total gasoline consumption by 2011. Targets are expected to increase to 9 million liters/day by 2022.

Biodiesel

As of February 1, 2008 the Thai Government began to enforce compulsory production of B2 biodiesel throughout the country. The requirement has made a noticeable impact on demand for domestic palm oil, the only raw material for B100 biodiesel production at the moment. It is estimated that demand for crude palm oil and stearin (palm oil by-product) will be 492 million liters per year by 2010, as compared to only 31 million liters in 2006. Targets are expected to increase to 1.2 million liters/day by 2022.

Market Players & Competition

Ethanol

- **Thai Alcohol Co Ltd** <Unlisted> sells Ethanol locally to oil companies such as Petroleum Authority of Thailand Public Co., Ltd., Bang Chak Petroleum Public Co., Ltd., Thai Oil Public Co., Ltd., Shell Thailand Co., Ltd., Esso (Thailand) Public Co., Ltd., and Star Petroleum Co., Ltd. for blending with Benzene to produce Gasohol.

- **Double Ethanol Co Ltd** <Unlisted> invested 3.69 billion baht to produce ethanol with a capacity of 165 million liters/year, and bio gas of 13.6 million cubic meters/day at a plant located in 304 Industrial Estate in Prachinburi.

- **Bioethanol (Thailand) Co.,Ltd** invested 1.3 billion Baht in producing ethanol with a capacity of 72 million liters/year and organic fertilizers 21,600 tons/year at a plant located in Chonburi.

- **Thai Agro Energy Public Co., Ltd** <Unlisted> invested 1.76 billion Baht in ethanol production with an annual capacity of 66 million liters at a plant located in Suphanburi.

- **Power Agricutural Industry Co., Ltd** <Unlisted> invested 4.3 billion Baht in producing ethanol with a capacity of 231 million liters/year at a plant located in Ubolratchathani.

- **Boonanek Co.,Ltd**. <Unlisted> invested 5.38 billion Baht in producing ethanol with a capacity of 346.5 million litres/year at a plant located in Nakornratchasrima.

Biodiesel

- **Lam Soon Public Company Limited** **<LST.BK>** is a Thailand-based company. It is engaged in the production, distribution and wholesale of refined palm oil and related products under the brand names Yok and others. It manufactures extracted and refined products, including coconut and palm kernel, vegetable oils, margarine, shortening and specialty vegetable fats, and markets a variety of consumer products, such as fish sauce and soy sauce products. It operates a crushing mill and a palm oil refinery, and it has a production capacity of 700 tons a day. The Company's products are sold domestically, as well as exported to foreign countries. It has operations in Singapore, Malaysia, Thailand, Vietnam and Hong Kong. Lam Soon (Thailand) has two direct subsidiaries, United Palm Oil Industry Public Co. Ltd. and Universal Food Public Co., Ltd.

6.3.13 Philippines

Market Size & Growth

Ethanol

To date, there are only 2 ethanol production facilities in commercial operation. Both facilities have a combined annual production capacity of about 39 million liters. At the current mandated 5% ethanol blend, however, overall demand for bio-ethanol in 2009 is estimated at around 208 million liters. The Philippines has been importing bio-ethanol to meet the mandated bio-ethanol blend of 5%. However, as part of the ***Biofuel Act***, companies can only import ethanol for four years (through to 2013) and will need to source ethanol from domestic supplies. After 2013, the mandated percentage blend will be reduced to that level local production can only supply. The final blend percentage is to be decided by the ***National Bio-Fuels Board*** (NBB). The probability of this happening is high given the inadequate number of bio-ethanol extraction plants currently in operation or under construction.

Biodiesel

There are currently 12 bio-diesel plants capable of producing 395 million liters annually. At a 2% blend, an estimated 140 million liters of CME is required annually. The excess CME production capacity is indicative of the industry's potential as a CME exporter although this scenario will largely be determined by how oil prices behave relative to prices of CNO. The surplus capacity is also likely the basis for the ***Philippine Department of Energy*** (DOE)'s consideration of increasing the required bio-diesel blend to 3% from the present 2% by end of 2009. Domestic coconut oil refiners, on the other hand, are discussing with the Philippine government the possibility of promoting an even higher blend of 5% bio-diesel blend.

Market Drivers & Constraints

Ethanol

From February 2009, a 5% ethanol mandate will be implemented in the Philippines. At the moment, oil firms are importing ethanol to help meet the mandate, as there is no domestic operating plant. Chevron plans to buy ethanol from domestic sources when the first production plants start operating, starting from mid-2009

Most of the USD 20m will go towards making its terminals compatible with E10 ethanol. It is seeking to increase the number of stations that carry its E10 brand to 35 from 22 now. It hopes to increase this further to 400 retail stations by February. The company plans to invest more once the mandated blending ratio under the Biofuels Act of 2006 becomes higher.

Ethanol feedstock currently being investigated are sugarcane, sweet sorghum and cassava to increase domestic production.

Biodiesel

The Philippine ***Department of Energy*** (DOE) increased the biodiesel blend to 3% in February 2009, from the 2% originally planned. The DOE stated that the 13 biodiesel manufacturers could produce up to 326m liters, which is enough to cover the 3% blend.

Coco-methyl ester (CME) derived from coconut oil (CNO) is the feedstock currently used for Philippine bio-diesel production the country being the largest CNO producer in the world. The government has also announced plans to launch massive propagation and cultivation of jatropha covering around 2 million hectares of unproductive and idle public and private lands nationwide. This effort will produce about 5,600 million liters of bio-fuel in the next 10 to 12 years.

Market Players & Competition

- **National Development Co** <Unlisted> has signed a preliminary agreement with Toyota Tsusho to develop a biodiesel project in the Philippines in 2009, using jatropha.

6.3.14 Australia

Market Size & Growth

According to ABARE, total consumption of petroleum products for 2009 is estimated at 58,119 ML (million liters) and is projected to increase steadily to 61,463 ML in 2014. Automotive gasoline makes up about 55% of Australia's transport fuel demand while diesel represents about 45%.

Biofuels production capacity for 2009 is about 255 ML (split roughly into about 180 ML of ethanol and 75 ML of biodiesel) and is likely to increase to 365 ML in 2010.

Ethanol Production Facilities

Production facility/location	Principle feedstocks
Manildra Group - Nowra NSW	Waste wheat starch
CSR Distilleries – Sarina Qld	Molasses
Dalby Biorefinery	Grain

Source: ABARE

Biodiesel Production Facilities

Production facility/location	Principle feedstocks
Biodiesel Ind - Rutherford NSW	Tallow and used cooking oil
Biodiesel Producers Barnawatha	Tallow and used cooking oil
Smorgan Fuels – Laverton Vic	Tallow and used cooking oil
Eco-tech Biodiesel – Narangba Qld	Tallow and used cooking oil

Source: Post Estimate

Drivers & Constraints

While there is no national biofuel policy, the government has a broad range of policy instruments that affect the production of biofuels. These instruments include a production target, fuel taxes (excise), fuel quality standards, grants and labeling.

Both ethanol and biodiesel are currently free from excise taxes, currently applied to diesel and petrol. This exemption is made in the form of "production grants" which effectively provide a subsidy at the same rate per liter of fuel as the excise that would be levied – A$0.381 per liter. This scheme is due to commence scaling down in 2011/12 when the effective assistance rate will fall to A$0.234 and will continue to fall through 2015/16.

At a state level, New South Wales increased its volumetric mandatory inclusion policy for ethanol to legislation. Under this legislation, by 2011, the inclusion level of ethanol in petrol will be 10%. This will equate to roughly 120 ML of ethanol per year.

The state of Queensland has committed to a mandate of volumetric inclusion of 5% by 2011. Victoria and Western Australia have a biofuel "target" of 5% by 2010. The states of Tasmania, South Australia and the Northern Territory remain uncommitted.

Market Players & Competition

Ethanol

- **Manildra Group** <Unlisted> is one of the largest user of wheat for industrial purposes in Australia, processing 1 million tonnes of wheat per annum.

- **CSR Ethanol** **<CSR.AX>** is one of the major Australian producers of ethanol products, supplying over half of the domestic Food & Beverage and Industrial market as well as supplying the growing fuel market in Australia. CSR produces its ethanol (ethyl alcohol) by fermenting molasses, a by-product of sugar production. CSR Ethanol's Sarina Distillery in Queensland produces 60 million litres of ethanol per year.

- **Dalby Biorefinery** <Unlisted> is Queensland's first grain-to-ethanol production facility.

Biodiesel

- **Smorgen Fuels** <Unlisted> own and operate a 100 million litre biodiesel plant at Laverton North, Victoria Australia.

- **Eco-tech Biodiesel** <Unlisted> own and operation a plant that produces 30 million litres of bio diesel per year. The plant is located 35 kilometres north of Brisbane in Queensland

6.3.15 New Zealand

Market Size & Growth

Under the ***Biofuel Bill***, a 2.5% obligation by 2010 would require 158 ML of biofuel to be produced.

Drivers & Constraints

The Biofuels Bill required oil companies to sell a minimum percentage of biofuels from July 1, 2008. The mandatory requirement was set to start at 0.53% of energy rising to 3.4% in 2012. However, Parliament's Environment Select Committee, which reported back on the bill on June 23, 2008, recommended the obligation be cut to 2.5% by 2012

Market Players & Competition

- **Fonterra** **<xx>** is New Zealand's largest dairy cooperative and reportedly produces about 20 ML liters of whey-derived ethanol annually and sells around 10% of this as fuel. Currently, all of the ethanol sold by Gull, one of two retailers selling biofuels in New Zealand, is sourced from Fonterra. There is also biodiesel from tallow although there are reportedly some problems yet to be resolved with its behavior in cold temperatures.

- **Solid Energy** <Unlisted> is a major New Zealand energy company that is interested in producing biodiesel from rapeseed. Biodiesel New Zealand, which is a subsidiary of Solid Energy, produces fuel from two sources - used vegetable oil collected from restaurants and food processors throughout the country.

6.3.16 Summary of Companies in Biofuel Sector

Code	Compay Name	Market Cap (M Dollars)	PE ratio	Country	Sector
000930.SZ	Anhui BBCA Biochemical Co Ltd	$1,367.7	65.3	China	Health & Personal Care
CCGY.OB	China Clean Energy Inc	$21.7	N/A	China	Building Materials & Components
GU.N	Gushan Environmental Energy Ltd	$97.6	N/A	China	Ethanol
CBI.L	China Biodiesel International Hldg Co Ltd	$6.6	26.7	China	Chemicals
ALFA.BO	Alfa Laval India Ltd	$526.3	19.4	India	Machinery & Engineering
WLIL.SI	Wilmar International Ltd	$30,390.8	16.0	Singapore	Business & Public Services
GAGR.SI	Golden Agri-Resources Ltd	$4,882.0	7.7	Singapore	Misc. Materials & Commodities
LST.BK	Lam Soon Thailand Public Co Ltd	$89.3	9.6	Thailand	Food & Household Products
CSR.AX	CSR Ltd	$2,328.6	N/A	Australia	Industrial Components
Unlisted	Solid Energy	N/A	N/A	New Zealand	Biodiesel
Unlisted	Biomass Energy Corporation	N/A	N/A	Japan	Ethanol
Unlisted	Nippon Shokubai Co. Ltd	N/A	N/A	Japan	Biodiesel
Unlisted	Next Oil Co. Ltd.	N/A	N/A	South Korea	Biodiesel
Unlisted	Enertech Inc.	N/A	N/A	South Korea	Biodiesel
Unlisted	Continental BioEnergy	N/A	N/A	Singapore	Biodiesel
Unlisted	Peter Cremer	N/A	N/A	Singapore	Biodiesel
Unlisted	JOil (S) Pte. Ltd	N/A	N/A	Singapore	Biodiesel
Unlisted	Puri Usaha Kencana	N/A	N/A	Indonesia	Biodiesel
Unlisted	Golden Hope Biodiesel	N/A	N/A	Malaysia	Biodiesel
Unlisted	National Development Co	N/A	N/A	Philippines	Biodiesel
Unlisted	Thai Alcohol	N/A	N/A	Thailand	Ethanol
Unlisted	Thai Agro Energy Public Co	N/A	N/A	Thailand	Ethanol

Source: Thomson Reuters

6.4 Biomass

6.4.1 Background

Biomass combustion consists of burning material produce from plant material. At present, combustion of biomass falls into the main categories:

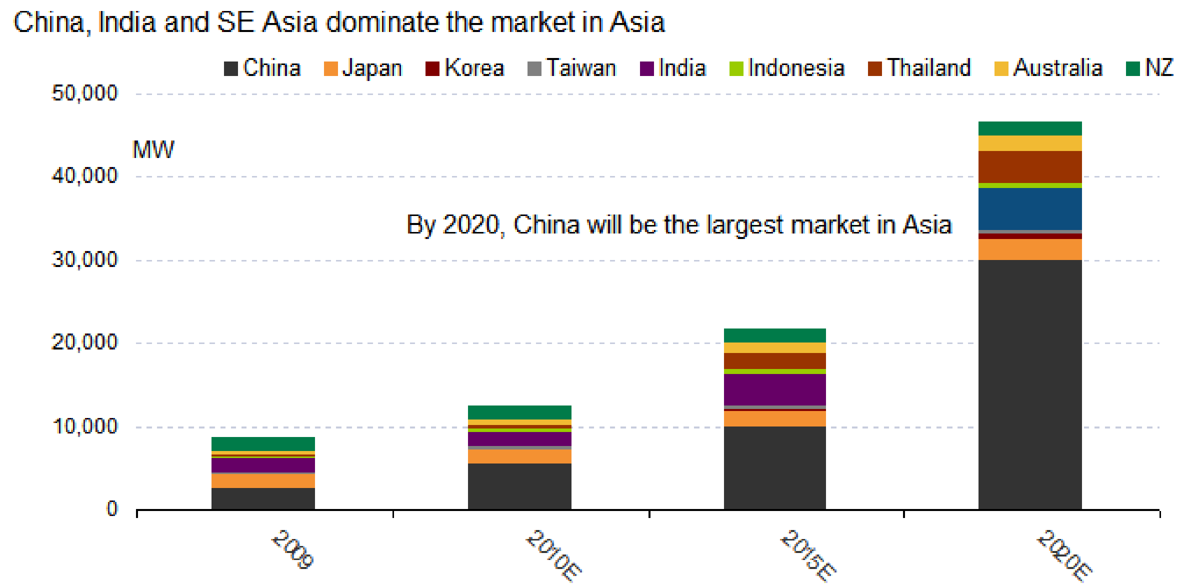
- **Co-firing** in modern coal power plants with efficiencies up to 45% is the most cost-effective biomass use for power generation. Due to feedstock availability issues, dedicated biomass plants for **combined heat & power (CHP)**, are typically of smaller size and lower electrical efficiency compared to coal plants (30%-34% using dry biomass, and around 22% for municipal solid waste). In cogeneration mode the total efficiency may reach 85%-90%.
- Biomass **integrated gasification** in gas-turbine plants (BIG/GT) is not yet commercial, but integrated gasification combined cycles (IGCC) using black-liquor (a by-product from the pulp & paper industry) are already in use.
- **Anaerobic digestion** to produce biogas is expanding in small, off-grid applications.
- **Bio-refineries** may open the door to combined, cost-effective production of bio-chemicals, electricity and biofuels.

6.4.2 Targets & Incentives

Biomass already makes up a part of the energy mix in countries like India. Biomass offer a consistent supply of fuel that is cost efficient and can complement the existing fuel mix, with no need for retro fitting.

China and India, Indonesia already produce a large amount of energy from biomass. Thailand has introduced its 15 year plan, with the majority of it focused on biomass.

Figure 6.11 Asia Pacific Biomass Sector



Source: IEA, Thomson Reuters, Government Publications

Asia Pacific Biomass Market (MW capacity)

Country	2009	2010E	2015E	2020E
China		5,500		30,000
Japan	1,630	1,630	1,750	2,530
S Korea	12		200	
Taiwan	380			
India		1,700	3,920	
Indonesia	302			810
Thailand	214			3,700
Australia	446			1,845
NZ	1,644	1,650	1,650	1,700

Source: EIA, Government Publications, Estimates

Cost of Generation

Because of widely varying feedstocks and conversion processes, it is difficult to identify typical costs for biomass energy. The most economical approach is to use local biomass to avoid costly, energy-consuming transportation. Pelletisation can facilitate transportation but not all biomass readily forms pellets. The incremental investment cost of biomass/coal co-fired power plants range from $50 to $250/kW. Where feedstock is available at little or no cost, co-firing can reduce the electricity generation cost to as low as $20/MWh. If biomass is available at costs between $3.0-$3.5/GJ, then the electricity generation cost is higher than for typical coal-based electricity ($30-$50/MWh). This is however the most competitive near-term option for using biomass in power generation. The cost of electricity from dedicated solid biomass plants depends on technology, feedstock quality and cost, regional location, and size of the plant. Large-size plants require biomass transportation over long distances.

Small size means higher investment cost per kW and lower electrical efficiency relative to coal plants. The capital cost of power plants with biomass gasification in the United States is about $2000-$3000/kW and generation cost is in the order of $90/MWh. Such plants may be cost-effective in CHP mode, if connected to district heating schemes. The cost of biomass combustion steam cycle and CHP plants can be lower, with $1000/kW as the cost target.

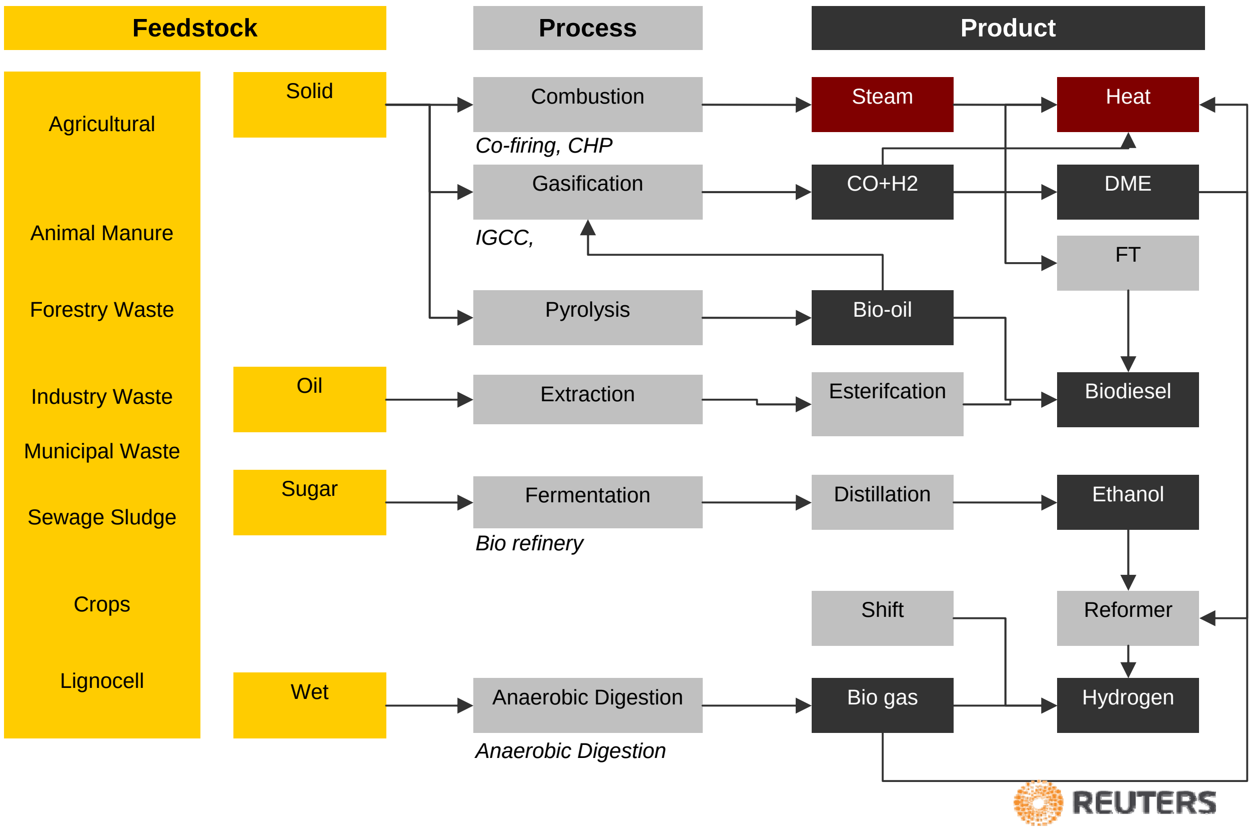
Assuming a delivered biomass price of $3/GJ, the generation costs from biomass gasification plants, even at higher efficiencies, are expected to be some $100-$130/MWh, more than twice the cost of fossil-fuel power plants. These costs may be significantly reduced by technology learning and then represent a low-cost option for renewable electricity.

CDM Projects

There are 593 projects in biomass in Asia, making it the third largest CDM sector after hydro and wind. India is the largest generator with 386 projects, followed by China (82) and then Malaysia (45) and Indonesia (23). Most of these projects are generated from agricultural residue.

6.4.3 Biomass Supply Chain

Figure 6.12 – Biomass Process



Co-firing

Biomass co-firing in modern, largescale coal power plants is efficient, cost-effective and requires moderate additional investment. In general, combustion efficiency of biomass can be 10% points lower than for coal at the same installation, but co-firing efficiency in large-scale coal plants (35%-45%) is higher than the efficiency of biomass-dedicated plants. In the case of co-combustion of up to 5%-10% of biomass (in energy terms) only minor changes in the handling equipment are needed and the boiler is not noticeably derated. For biomass exceeding 10% or if biomass and coal are burned separately, then changes in mills, burners and dryers are needed. In addition, coal ashes that are used to produce construction materials should not be contaminated with tar and alkali metals-rich ash from biomass. Many co-firing technology options have been demonstrated in several countries (Northern Europe, United States and Australia) in some 150 installations using different feedstock (wood biomass, residues and crops). Using low-cost local biomass, the incremental investment may have a short payback period (2 years), but low-quality biomass such as herbaceous crops and wet wood may produce tar and cause slagging and fouling that affects plant reliability and raises costs.

Combustion in dedicated power and CHP plants

Biomass can be burned to produce electricity and CHP via a steam turbine in dedicated power plants. The typical size of these plants is ten times smaller (from 1 to100 MW) than coal-fired plants because of the scarce availability of local feedstock and the high transportation cost. A few large-scale such plants are in operation. The small size roughly doubles the investment cost per kW and results in lower electrical efficiency compared to coal plants. Plant efficiency is around 30% depending on plant size. This technology is used to dispose of large amounts of residues and wastes (e.g bagasse). Using high-quality wood chips in modern CHP plants with maximum steam temperature of 540°C, electrical efficiency can reach 33%-34% (LHV), and up to 40% if operated in electricity-only mode. Fossil energy consumed for bio-power production using forestry and agriculture products can be as low as 2%-5% of the final energy produced. Based on life-cycle assessment, net carbon emissions per unit of electricity are less than 10% of the emissions from fossil fuel-based electricity.

When using ***Municipal Solid Waste*** (MSW), corrosion problems limit the steam temperature and reduce electrical efficiency to around 22%. New CHP plant designs using MSW are expected to reach 28%-30% electrical efficiency, and above 85%-90% overall efficiency in CHP mode if good matching is achieved between heat production and demand. Incineration of MSW is a mature technology. Emissions of pollutants and dioxin can be effectively controlled, but in many countries, incinerators face public acceptance issues and are seen as competing with waste recycling. MSW also offers net reduction of CO_2 emissions. MSW can generate some 600 kWh of electricity per tonne and emit net 220-440 kg CO_2 from the combustion of the fossil-derived materials (20-40% of MSW). The CO_2 emitted to generate 600 kWh from coal would be some 590 kg. Methane emissions from MSW in modern landfills would be between 50-100 kg/t (equivalent to 1150-2300 kg CO_2), 50% of which is collected and 50% is released in the atmosphere. Thus, electricity production from MSW offers a net emission saving between 725 and 1520 kg CO_2/t MSW. Saving is even higher for CHP.

Gasification

Biomass conversion into biogas can be either from fast thermo-chemical processes (e.g., pyrolysis) which can produce biogas and other fuels, with only 2%-4% of ash, or from slow anaerobic fermentation - which converts only a fraction (50%-60%) of feedstock but produces soil conditioners as a byproduct. The biogas can be used in combustion engines (10 kW to 10 MW) with efficiency of some 30%-35%; in gas turbines at higher efficiencies or in highly-efficient combined cycles. ***Biomass integrated gasification gas turbines*** (BIG/GT) are not yet in commercial use, but their economics is expected to improve. The ***first integrated gasification combined cycle*** (IGCC) running on 100% biomass (straw) has been successfully operated in Sweden. Technical issues appear to have been overcome. IGCC plants are already economically competitive in CHP mode using black-liquor from the pulp and paper industry as a feedstock. Other developments have brought ***Stirling engines*** and ***Organic Rankine Cycles*** (ORC) closer to the market whereas integrated gasification fuel cell plants (IGFC) still need significantly more R&D.

Anaerobic digestion, landfill gas

In the absence of air, organic matter such as animal manures, organic wastes and green energy crops can be converted by bacteria-induced fermentation into biogas (a 40%-75% methane-rich gas with CO_2 and a small amount of hydrogen sulphide and ammonia). Anaerobic digestion is also the basic process for landfill gas production from municipal green waste. It has significant potential, but it is characterised by relatively small plant size. Anaerobic digestion is increasingly used in small-size, rural and off-grid applications at the domestic and farm-scale. The rising cost of waste disposal may improve its economic attractiveness. In modern landfills, methane production ranges between 50 and 100 kg per tonne of MSW. In general, some 50% of such gas can be recovered and used for power and heat generation. After purification and upgrading, biogas can be used in heat plants, stationary engines, fed into the natural gas grid, or used as a transport fuel (compressed natural gas). Large-size plants using MSW, agricultural wastes and industrial organic wastes (large-scale co-digestion) need some 8000-9000 tonne MSW per year per MW of installed capacity. Some 200 such plants are in operation or under construction world wide using more than 5 million tones of MSW.

Bio-refineries and hydrogen

Bio-refineries can theoretically produce a variety of products such as biopolymers, liquid bio-fuels, biogas, electricity or hydrogen. Using proper feedstock and exploiting production synergies, bio-refineries could gain economic appeal. The pulp and paper industry as well as the food industry have processing plants already produce several products for different markets but energy carriers are not usually one of them. Hydrogen can be obtained from biomass in a number of ways, the most direct being reforming of bio-methane and bio-ethanol. Processes are well known but their efficiency and cost need to be improved.

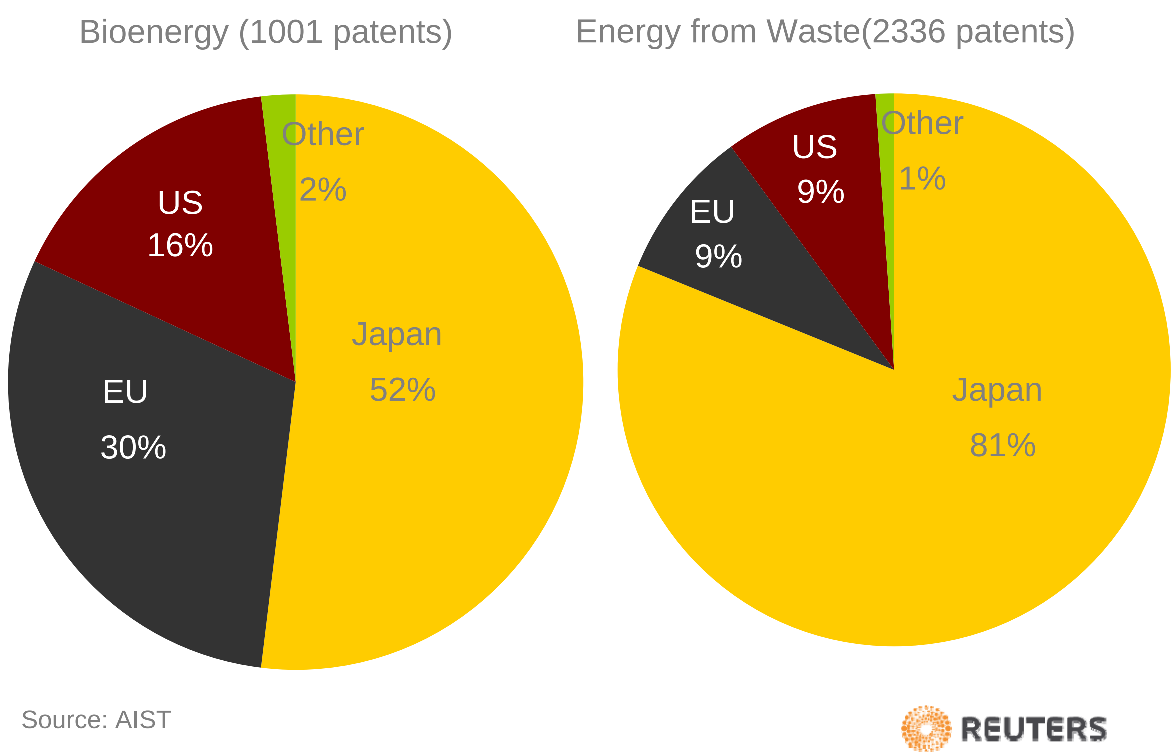
Potential Sources of Biomass Feedstock

Category of biomass residue	Main sources / biomass residues
Agriculture	All residues remaining in-situ from agriculture production, including straw from cereal production; animal manures; stalks from cotton, maize etc; stems & leaves from sugar beet, tobacco etc; prunings from vines, fruit trees etc. All residues produced as by-products from processing agriculture crops such as cotton processing; food canning; olive oil processing; meat processing; wine making
Forestry	All non-merchantable wood - small diameter roundwood, branches/brash, tops – left in-situ by thinning and harvesting operations. Includes short rotation forestry. All non-treated residues – chips, bark etc – from primary and secondary processing of wood: saw mills; furniture making; pulp and paper mills; fiber board mills
Energy Crops	Potential annual or perennial dedicated energy crops. Trees grown on short rotation coppice (willow, poplar etc); grasses etc (giant reed, switchgrass, miscanthus, cardoon, Spanish thistle artichoke).
Waste (Covered in Section 6.12)	Untreated wood residues excluding those from wood processing industry (eg. wood pallets and packaging, demolition wood). The organic fraction of waste from households, commerce, industry.
Sewage (Covered in Section 6.11)	Potential biogas production from sewage treatment

6.4.4 Research & Development

Japan led the number of patent filings in the biomass and Waste to Energy sectors from 1990 to 2000. However, recent analysis shows that China has increased the numbers of patents it has filed in this sector.

Figure 6.13 - Biomass R&D Patent Filings



6.4.5 China

Market Size & Growth

The size of the biomass market in China is around 480 million tons of oil equivalent (TOE), of which half (240 million tons of oil equivalent) is estimated to be from agriculture waste[36] . This equates to roughly 800 million tons of agricultural residues a year. 58% of this residue is discarded or burned in open fields, while less than 1% is used in power generation[37].

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[36] Research and Development on Biomass Energy in China, Wu Chuangzhi, Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences

[37] www.chinaeconomicreview.com

China has launched 19 biomass plants, with a further 10 planned in five leading grain-producing provinces to cut carbon dioxide emissions in electricity generation amid growing global concerns over greenhouse gas and climate change. The biomass plants are operatied by ***National Bio Energy*** (NBE), a Joint Venture between the State Grid and DP CleanTech.

China's installed capacity of bio-energy electricity is forecast to reach 5,500 MW by 2010, according to the country's 11th Five-Year Plan 2006 to 2010.

Drivers & Constraints

The Chinese "***Renewable Energy Act***" of 2006 represented a significant market driver that led to the construction of over 100 biomass electric power generation plants on a scale of 25MW or above. China has renewed its biomass target to 30GW by 2020. Constraints are access to the grid and supply of secure and reliable feedstock, with competition from other renewable energy types, such as cellulosic biofuel.

Market Players & Competition

- **National Bio Energy Limited** <Unlisted> A Joint Venture between DP CleanTech (formerly known as Dragon Power) and the State Grid. NBE has 19 power plants in operation and a further 10 under construction. By the end of 2010, it will have over 700MW on the grid. DP CleanTech acquired Danish straw-fired combustion specialists Bioener ApS of Denmark in September 2009.

- **Balama Nviro Limited** <Unlisted>, a Joint Venture between Vertus Technologies Limited and Balama Prima Engineering will roll out the Vertus technology for electricity generation from biomass waste - such as rice husks - and low grade, high contaminant coals in the energy-hungry Peoples' Republic of China.

- **Wuhan ecoWise Energy Co., Ltd** <Unlisted> is a joint venture between ecoWise Energy Pte Ltd and Wuhan Jiabao Sugar Co., Ltd. The company is in the midst of converting its current coal-fired power plant to a 25 MW biomass co-generation power plant running on a variety of biomass materials, using Vyncke's clean combustion technology.

- **China Energy Conservation Investment Corp** <Unlisted> is one of China's first operating straw-fired 24MW power station and burns 170,000-200,000 tons of straw and generate 132 GWh/yr.

6.4.6 Japan

Market Size & Growth

Incineration

Japan incinerates over 70% of its ***Municipal Solid Waste*** (MSW). It processes around 51 million tonnes per year through 1400 incinerators, generating around 1,630 MW in electricity. In addition, it incinerates processes around 412 million tonnes, with a 75% incineration rate. For more detail on process, see **Section 6.12.**

Agricultural Waste

The country produces about 24 million KL of biomass waste annually and about 5.5 million KL of unused biomass, including rice and wheat straw. The target for 2010 is 2.6 million KL in 2010[38]. With the target of 80% of waste biomass and 25% of unused biomass, it is expected that total capacity will increase to around 20.5 million KL (17.5 million tones).

Drivers & Constraints

The '***Biomass Nippon Strategy***' implemented in 2002 sets out the objective of using 80% of waste biomass and 25% of unused biomass for productive purposes by 2025.

As part of the Strategy, the government plans to launch 300 biomass towns by 2010[39]. Cellulosic biomass accounts for almost two thirds of biomass in Japan.

Market Players & Competition

- **Energy Advance** <Unlisted>, a subsidiary of Tokyo Gas Co., Ltd has installed 48 units and 56 MWe cogeneration plants in japan.

- **Chugai Ro Co. <1964.T>** has developed a forest biomass gasification pilot plant in Yamaguchi Prefecture, western Japan. The system also reuses combustion residue and waste heat from the gasification process, which makes it possible to get three times more energy from biomass than existing methods.

- **Nishinippon Environmental Energy Co** <Unlisted> has a 11.35MW power plant that uses 440 tonnes per day of chicken-litter in a stoker furnace, which has been in operation, since 2005

- **First Energy Service Company Ltd <9514.T>** operates a 10MW biomass power plant, which started operation in 2006. Wood fuel is secured from Iimori Mokuzai Co, a logging company, and annual consumption by the CFB boiler is expected to be about 90,000t.

6.4.7 South Korea

Market Size & Growth

The total amount of new and renewable energy generated in Korea is around 5.5 million tons of oil equivalent (TOE), of which waste energy including waste gas accounted for about 4 million TOE.

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[38] METI, 2007

[39] Biomass Nippon Strategy, MAFF, Japan

The ministry has gradually increased the government subsidies for waste to energy facility establishment and provided about 33 billion won of national budget for establishment of such facilities in local governments. It is expected the ministry will offer more government subsidies to increase the waste to energy distribution rate by 2010. As the results of its effort to expand power generation facilities from waste, it is scheduled to complete the construction work of an RDF manufacturing facility capable of producing 200 tons of RDF a year in the metropolitan areas in 2009, a biogasification facility capable of producing 98 tons of biogas per day in Dongdaemun-gu in Seoul, a sewage sludge desiccation facility capable of processing 450 tons per day in Suwon, and landfill gas facilities in Gumi and Masan. In addition, RDF manufacturing facilities and exclusive RDF boilers in 12 cities including Naju, and biogasification facilities and sewage sludge desiccation facilities in 8 landfill sites in the metropolitan areas are under construction or in the planning stage.

Korea has only one ***Refuse Driven Fuel*** (RDF) manufacturing facility (in Wonju in Gangwon province) and 34 RDF manufacturing facilities led by private sector companies. Although Biogasfication using food waste, sewage sludge and livestock manure has been partly processed in the livestock wastewater disposal facility in Paju Gyeonggi province, the Saenggok landfill site in Busan, and sewage disposal facilities in Dongrae-gu in Busan and Nam-gu in Ulsan.

Drivers & Constraints

The ministry of environment announced "***Waste Resources and Biomass Energy Utilization Initiatives***" in 2008 and was due to release its roadmap in 2009. As of 2007, the amounts of combustible wastes and organic wastes accounted for about 3.84 million tons and 7.85 million tons per year, respectively. However, only 1.5% (58,000 tons/year) of combustible waste, and 2% (160,000 tons/year) of organic waste were utilized as energy resources. In an effort to facilitate waste to energy policy, the ministry aims to achieve energy utilization of combustible waste (by 47% or 1.82 million tons/year) and of organic waste (by 26% or 2.04 million tons/year) by 2013. In addition, it plans to increase energy collecting rates-77% of residual thermal from middle and large-scale incinerators and 91% of landfill gas from waste landfill sites- by 2013.

Market Players & Competition

- **Kumho Petrochemical <011780.KS>** provides three categorized products: synthetic rubber, synthetic resins and fine chemicals. Synthetic rubber products include styrene butadiene rubber (SBR), thermoplastic elastomer, acryronitrile butadiene, polybutadiene rubber and other products, which are used for the manufacturing of tires, shoes, rubber hoses, belts and industrial rubber products. Kumho has constructed its second cogeneration plant in Yeosu in 2009.

- **Aquentium <AQNM.OB>** will build a waste-to-energy plant South Korea with capacity of processing 1,000 metric ton per day waste to energy. The company also has interests in non-chemical sanitation equipment, waste-to-energy technologies, water treatment, food safety, mining, alternative energy, building materials, affordable housing, re-deployable housing, and recycling.

6.4.8 Taiwan

Market Size & Growth

From 1991, the Taiwan government set up a long term plan for the construction of WTE plants. 21 WTE plants were to be constructed by the government by 2005. These WTE plants will process an estimated total of 18,615 metric tons of MSW per day (85% of the design capacity of 21,900 metric tons), amounting to about 7.2 million tons per year or 65% of the total MSW generated in 2005. These plants are expected to generate $1.85*10^6$ MWh of electricity per year. The surplus electricity generated will be result in annual revenue of about $47 million.

Drivers & Constraints

Market Players & Competition

- **Taiwan Cogeneration Corporation** **<8926.TW>** is a specialized cogeneration company, established in 1992 with a goal of assisting the industry by providing cogeneration technology to enhance energy efficiency, to result in lower energy cost, and to upgrade power supply in Taiwan. Taiwan Cogeneration obtained two permits from MOEA to invest in Fong Der Gas-fired Power Plant of Sun Ba Power Corporation and Chang Bin Gas-fired Power Plant of Star Energy Power Corporation.

- **Chung Hsin Electric & Machinery Mfg.** **<1513.TW>** is principally engaged in the manufacture and distribution of electrical power equipment, as well as the project contracting of construction works.

- **SINO Environmental Services Corp** <Unlisted> is a subsidiary of CTCI Corp. The main business focus is on the refuse incineration plant's operation and maintenance project which is the extension of the incineration EPC project of the mother company. It has won the refuse plants operation contracts of Hsintien, Shulin, Taoyuan, Maoli, Houli, Wuzu, Keelung, Tainan, and Tainan Science Park. The service capacity of SESC is summed up to 6,900 7,400 tons per day which represents 44% of the privatization market share in Taiwan.

- **Onyx Ta-Ho Environmental Services Co., Ltd** <Unlisted> was established as a joint-venture between Taiwan Cement Corporation (TCC) and Veolia Environmental Services and provides integrated waste management services for both local authorities and industrials. With its two subsidiaries - Onyx Ta-Ho Waste Clearance Co. and Onyx Ta-Ho Energy Recovery Co., Onyx Ta-Ho offers services such as waste incineration treatment, waste collection and recycling, waste transfer, liquid industrial waste treatment, fly ash treatment, drainage cleaning and MARPOL oil treatment.

- **Taiwan Sugar Corp** <Unlisted> has established an industrial safety and environmental protection department. At present, the operation includes an Examination and Analysis Center, two Municipal Waste Incineration Plants (in Gangshan and in Kanding), and several waste landfill sites, with which it created about NT$500,000,000 of revenue per year.

6.4.9 India

Market Size & Growth

Total installed capacity 148,265MW, with a projected growth of an additional 92,000MW over the next 10 years, with the potential power generation for biomass estimated to be 16,000MW.

Under the ***11th Plan*** period, the government aims to add 1,700MW capacity through biomass (500MW) and bagasse (1,200MW) cogeneration in states – Maharashtra, Uttar Pradesh, Tamil Nadu and Karnataka.

Sugar mills in Maharashtra, Uttar Pradesh, Tamil Nadu and Karnataka, Andhra Pradesh, Bihar, Gujarat, Punjab and Haryana has an estimated potential of 5,000MW surplus of power generation through bagasse based cogeneration[40]

Biomass/Co Generation Projects in India

Program	Commissioned Projects (MW)	Under Implementation (MW)
Bagasse Co-generation	109 (1048)	118 (1591)
Biomass Power	102 (704)	60 (578)
Total	21 (1752)	178 (2169)

Source:

Drivers & Constraints

Incentives for biomass projects include:

- Accelerated Depreciation 80% in first year (Boiler and Turbine).
- Income Tax Exemption for 10 years (under Section 80 1A).
- Concessional import duty; excise duty exemptions on equipments & components required for initial setting of the project.
- Sales tax exemption in some states.
- IREDA Provide Loan For Biomass Power / Cogeneration Projects.
- Capital subsidy
- Preferential Tariff in 14 States.

Market Players & Competition

There are around 10 domestic manufacturers that can producer gasifiers from a few KW-1 MW and have an annual production capacity and include:

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[40] Minister of State in the Ministry of New and Renewable Enegry

Manufacturers

- **BHEL** **<BHEL.BO>** is an engineering and manufacturing company in the energy-related and infrastructure sector. The Company caters to sectors, including to the power generation and transmission, industry, transportation, renewable energy and defense. BHEL manufactures a range of products and systems for thermal, nuclear, gas and hydro-based utility power plants. BHEL supplies steam turbines, generators, boilers and matching auxiliaries up to 800 MW ratings, including supercritical sets of 660/800 MW. BHEL also supplies circulating fluidised bed combustion (CFBC) boilers for thermal plants. BHEL manufactures 220/235/500/540 MW Nuclear turbine-generator sets.

- **Thermax** **<THMX.BO>** is a global solution provider in energy and environment engineering. It offers products and services in heating, cooling, waste heat recovery, captive power, water treatment and recycling, waste management and performance chemicals. The Company operates in two business segments: energy and environment. The products covered under the energy segment include boilers and heaters, absorption chillers/heat pumps and power plants. The products covered under the environment segment include air pollution control equipments/ systems, water and waste recycle plants, ion exchange resins and performance chemicals.

- **Walchangnagar** **<WALC.BO>** is an India-based company. The Company is engaged in heavy engineering, which includes engineering, fabrication and manufacturing of machinery for sugar plants, cement plants and boilers, heavy duty gears, mineral processing, defence and nuclear power business; foundry and machine shop-manufacturing of cast iron (CI) and spheroidal graphite iron (SGI) castings required by various industries and machining of components, and other non-reportable segment, includes units manufacturing pressure and temperature gauges and Infotech Services.

- **Texmaco** **<TEXM.BO>** is an India-based company. The Company operates in four business segments: heavy engineering division, steel foundry division, real estate and others. The Company has five factories on the outskirts of Kolkata. The Company's product portfolio includes railway freight cars, steel foundry, hydro-mechanical equipment and steel structures, process equipment, and agro machinery.

- **Cetnar Vessels** <Unlisted> makes boilers for Power Generation or for Steam Generation in Process Industries. It also makes Boiler Auxiliaries that include Fans, Electrostatic Precipitator, Cooling Towers, Fuel Handling Systems, and Water Treatment Systems. Cetnar Vessels makes biomass (Rice husk) fired BFB boiler and BFB boiler to fire gaseous fuel (Biogas).

- **Triveni Engineering** **<TREI.BO>** has co-generation plants in Western Uttar Pradesh state of India. These are used to produce two forms of useful energy simultaneously i.e. electric power and steam, with the surplus electric power being supplied to the power distribution companies. The company has an aggregate cogeneration capacity of 68 MW out of which approx. 43-45 MW of electricity is exported to the grid.

- **DLF Energy Systems** <Unlisted> is a manufacturer of aero derivative gas turbines (1-5MW) and Steam Turbine Generators.

Biomass Operator

All Green Energy <Unlisted> a 100% subsidiary of AllGreen Energy Pte Ltd, Singapore plans to set up 10 biomass based renewable energy projects in India by 2012 with each plant having a capacity of 6.5 MW each and first three plants to be set up in the Indian states of Karnataka, Tamil Nadu and Madhya Pradesh.

6.4.10 Singapore

Market Size & Growth

Singapore incinerates 90% of its Municipal Solid Waste through 4 incineration plants and generates roughly 980 kWh of energy, supplying roughly 2% of Singapore's electricity demand.

MSW incinerator capacities in Singapore

Plant	Capacity	Comment
Ulu Pandan	16MW	Closed in August 2009
Senoko	56MW	Acquired by Keppel
Tuas	46MW	
Tuas South	132MW	
Total	234MW	

Source: Waste Management Department, NEA

Drivers & Constraints

'Waste to Energy' projects in Singapore are focused on Municipal Solid Waste.

Market Players & Competition

- **Transcu Group <TRSU.SI >** acquired a 45% strategic stake in Japanese Biomass Technology Company, Biomass Energy Corporation (BME) for US$277k in April 2009.
- **ecoWise Holdings Limited < ECOW.SI>**, an integrated environmental solutions provider, announces that its joint-venture company, Wuhan ecoWise Energy Co., Ltd ("Wuhan ecoWise") has recently entered into an equipment procurement and supply contract for clean combustion technology with Belgian clean energy company, Vyncke Energietechniek NV ("Vyncke"), for its 25 MWH biomass co-generation plant in Wuhan Peoples' Republic of China.
- **ECO-IEE** <Unlisted> has three wholly-owned subsidiaries; ECO Special Waste Management Pte Ltd (ECO-SWM), ECO Resource Recovery Centre Pte Ltd (ECO-RRC) and ECO Energy Recovery System Pte Ltd (ECO-ERS). It provides third-party environmental laboratory services, consultancy services and conducts R&D programmes on waste treatment

processes and environmental technologies. It has a cogeneration plant has a turbine capacity of 0.53 MW and uses wood waste as fuel.

- **Bee Joo Industries Pte Ltd** <Unlisted> has a cogeneration plant has turbine capacity of 1.0 MW and uses wood waste and horticulture waste as fuel.

6.4.11 Indonesia

Market Size & Growth

Indonesia has a potential of 147 million tonnes of biomass per year. However to date only palm oil biomass project by Bronzeoak has been identified.

Drivers & Constraints

Biomass has a target of 180MW capacity by 2025.

Market Players & Competition

Bronzeoak Indonesia has a number of biomass plants in Indonesia.

6.4.12 Malaysia

Market Size & Growth

No plants have been identified.

Drivers & Constraints

No targets for biomass have been identified, although there is potential for biomass cogeneration from Palm Oil and agricultural waste.

Market Players & Competition

No companies in this sector have been identified.

6.4.13 Thailand

Market Size & Growth

Thailand has the potential to produce large amounts of power from biomass, such as sugar cane (bagasse) and agricultural waste (rice husks). It currently generates around 214MW via the ***Small Power Producer*** scheme, but this is expected to grow significantly, in order to meet its 2022 target of 3,700MW.

Drivers & Constraints

Thailand has made biomass central to its 15 year plan for renewables and expected to generate 3,700MW by 2022.

EGAT announced in 2009 to purchase electric from Small Power Producers (SPP) from waste and biomass, which should increase generation from biomass.

Market Players & Competition

- **Vichitbhan Group** <Unlisted> the country's leading palm-oil crushing comapny is investing almost Bt2 billion to set up biogas and biomass energy businesses, as well as a fertiliser plant

- **Thailand's Biomass Electricity Co., Ltd.** <Unlisted> to develop a 150 MW biomass firing power plant in Prachinburi, Thailand.

- **MPM Technologies** <Unlisted> has announced a partnership with SFO, Biofame Consulting Group, and V.C. Consultants to develop waste-to-energy projects in Thailand. It is anticipated that Srakaew (in Srakaew province, eastern Thailand) will house the first commercial project. This plant, a showcase facility, will be a reference site for the use of the Skygas technology in future projects specifically for the disposal of various waste streams, the recovery of renewable energy and alternative fuel from residual resources.

- **Clean Energy Development Company Thailand Ltd** <Unlisted> is a developer of the largest and first cassava root biogas project in Thailand.

- **AT Biopower Co Ltd** <Unlisted> has developed a Thermal Power Plant which takes Rice Husk as fuel and has a generating capacity of 22MW. The plant has no waste water discharge and uses electrostatic precipitator that detects 99.5% of particulates.

- **Mungcharoen Green Power Co Ltd** <Unlisted> is a large-scale rice husk-based power plant project developed, and operated by a group of local rice millers under a long-term 21-year power purchasing contract with Thailand's national power utility. It is located in Surin Province in the lower northeast of Thailand and has a 9.9 MW of installed capacity.

- **Advance Bio Power Co Ltd** <Unlisted> uses eucalyptus trees to make paper, and the waste wood, which cannot be used in paper production, is utilised as fuel to operate a steam-driven power plant. The power plant generates 9.5 MWh of which 8 MWh is exported to the national electricity supply company, EGAT.

Summary of Biomass Projects in Thailand

Location	Owner	Output (MWe)	Status	Primary fuel	Cofired fuel(s)
Bang Mun Nak, Pichit	AT Biopower Co Ltd	1 X 22 MW	2005		rice husk
Burirum, Buri Ram	Advance Bio Power Co Ltd	1 X 9.5 MW	2007		rice husk
CGC Plant, Nakhon Ratchasima	C Gigantic Carbon Co Ltd	1 X 2.76 MW CHP			coconut shell, wood
Roi Et	Electricity Generating Public Co Ltd	1 X 9.8 MW	2006		rice husk
Surin MGP, Prasart Surin	Mungcharoen Green Power Co Ltd	1 X 9.9 MW	2007		rice husk
Chiang Mai	Provincial Electricity Authority of Thailand	20		lignite	RDF

Source: USDA, Websites

6.4.14 Philippines

Market Size & Growth

Demonstration plants have been planned and aim to use the agricultural waste for cogeneration.

Drivers & Constraints

Although no target has been set, Biomass falls under the ***Philippines Energy Plan*** (PEP) and will contribute to the 20GW target by 2020.

Market Players & Competition

- **Phil-Korean Renewable Energy** <Unlisted> is planning to invest USD 71m to build a 30MW biomass project in Palawan that utilises wood chips for feedstock. Phil-Korean Renewable plans to start commercial operations by 2013. Electricity generated by the plant will be sold to the Palawan Electric Cooperative.

- **Clenergen** **<CRGEE.OB>** plans to develop a biomass demonstration project in the Philippines which will use bamboo as feedstock. The project will have up to 4MW of capacity Clenergen recently signed a memorandum of understanding with the Philippine Agricultural Development and Commercial to study the viability of a 5MW biomass projects.

6.4.15 Australia

Market Size & Growth

In Australia less than 5% of energy is generated using biomass fuels. Wood represents 2.4% of Australia's total primary energy consumption. About three quarters of the heat energy produced from wood is used in the residential sector. The remaining heat energy is used in making wood products, paper and in food industries. About 22% of Australian homes use wood for heating[41]. In 1997 bagasse represented about 2% of Australia's total primary energy consumption. The energy produced by burning it is used to power the sugar cane mills and the excess is sold to the local electricity company. The sugar mills in Queensland, NSW and WA had a combined maximum output of about 300 MW in 1997[42]. In 1997 the total capacity of power plants using landfill gas in Australia was about 72MW.

LFG

Landfill gas projects are a recent development in Australia, with the number growing to 29 at the beginning of 2004. For more on LFG, see **Section 6.12.**

Biogas

The use of sewage gas for electricity production is also increasing in Australia. In 1997 the installed sewage gas electricity generation capacity was about 7MW, which represented a 59% recovery of methane gas from wastewater treatment plants.This output is expected to treble to 20MW by 2010. For more on Biogas, see **Section 6.11.**

Biomass Potential in Australia

Feedstock	MW in 2020	Existing Generation (GWh)	Total in 2020 (GWh)	Long term potential (GWh)
Agricultural Waste	106	2	791	50,566
Energy Crops	29	0	218	534
Landfill Gas	251	772	1,880	3,420
Sewage	120	57	901	929
Sugar	831	1,200	3,165	7,800
Urban Waste	96	103	721	4,320
Forestry	412	438	2,948	5,060
Total	**1,845**	**2,572**	**10,624**	**72,629**

Source: Bioenergy Roadmap, Clean Energy Council

[41] DPIE, 1997

[42] DPIE 1997

Drivers & Constraints

The ***Renewable Energy Target*** (RET) is the main driver for renewable targets in Australia. Estimates from the ***Clean Energy Council*** suggest that electricity from biomass can account 4% of Australia's total by 2020 (11,000MWh per year)[43]

Market Players & Competition

- **EarthPower Technologies** <Unlisted> has a anaerobic digestion facility which will convert 82,000 tonnes per year into biogas.
- **Methanix** <Unlisted> has a 5,000 tonnes per year syngas demonstration plant in Darwin.

Operators

- **Stanwell Corporation** <Unlisted> owns and operates coal-fired thermal, wind, hydroelectric and bio-energy power generation facilities. The company owns and operates a portfolio of power stations, including coal-fired thermal as well as hydroelectric power stations. The company's thermal and hydro generating sites contributed more than 1,500 MW of electricity into Australia's national electricity market.

- **Ergon Energy** <Unlisted> is engaged in generating, distributing electricity and providing electricity related services to Queensland. The company serves 480,000 residential customers and 100,000 industrial and commercial customers spread over an area of one million square kilometers in the Queensland region. The electricity network of the company comprises of more than 150,000 kilometers of powerlines and one million power poles. It owns and operates 33 stand-alone power stations and 70,000 substations.

- **Delta Electricity** <Unlisted> is an electricity generation company. The company is engaged in the generation and production of electricity from coal, water, and biomass materials in Australia. It generates 12% of the electricity needed by consumers in South Australia, Queensland, New South Wales, Victoria and the ACT. It generates power from mini-hydro generators and co-firing biomass at Mt Piper near Lithgow and Chichester Dam in the upper Hunter Valley and its four coal-fired power stations located in New South Wales. These power stations include Mt. Piper and Wallerawang near Lithgow and Munmorah and Vales Point on the Central Coast. These stations have a combined generating capacity of 4,240MW. It sells electricity to energy retailers and industrial customers in South Australia, Queensland, New South Wales, Victoria, and the Australian Capital.

[43] Bioenergy Roadmap, Clean Energy Council

Summary of Biomass Projects in Australia

Location	Owner	Output (MWe)	% heat	Status	Primary fuel	Cofired fuel(s)
Collie	Western Power	1040	5% mass	Trial, now C&D stage	pulverised coal	plantation forest waste and green waste
Ipswich, SE Queensland	CS Energy	4 x 125	No	Trial	pulverised coal	wood waste
Lake Macquarie, Newcastle, New South Wales	Delta Electricity	2 x 660	<1% mass	Commercial	pulverised coal	wood waste
LIddell, New South Wales	Macquarie Generation	4 x 500	<1% mass	Commercial	pulverised coal	wood waste (sawdust, shavings)
Lithgow, New South Wales	Delta Electricity	2 x 660	No	Commercial	pulverised coal	wood waste (fresh sawdust)
Lithgow, New South Wales	Delta Electricity	2 x 500	<1% mass	Commercial	pulverised coal	wood waste (plantation sawmill residue and construction and demolition waste timber)
Rockhampton	Stanwell Corporation	4 x 350	No	Trial	pulverised coal	wood waste (sawdust and shavings)
Tarong	Tarong Energy	2 x 350	No	Trial	pulverised coal	wood waste
Isis Central Extension, Queenland	Ergon Energy Corp Ltd	1 x 25.5		Commercial, 2006		bagasse
Maryborough, Queensland	Maryborough Sugar	1 X 750 kW, 2 X 2 MW CHP		Commercial, 1972		bagasse
Rocky Point-3, Queenland	Stanwell Corp	1 X 30 MW CHP		Commercial, 2001		bagasse, wood
Suncoast Gold, Queensland	Ergon Energy Corp	1 X 1.5 MW CHP		2003		macadamian nut shells

6.4.16 New Zealand

Market Size & Growth

The main source of biomass heat and power generation comes from the wood processing sector in NZ.

Biomass power generation projection in New Zealand

Industry	MW	2005 (PJ)	2020 (PJ)	2030 (PJ)
Sawmill	348.5	9.53	14.38	13.68
Panel		9.5	11.76	11.18
Pulp & Paper	1,293	26.83	23.41	22.83
Total	1,641.5	45.86	49.55	47.69

Source: Assessment of Possible Renewable Energy Targets – Direct Use of Biomass, Energy Efficiency Conservation Authority, NZ

Drivers & Constraints

Market Players & Competition

- **Blue Mountain Lumber Energy** <Unlisted> has an energy centre consisting of a 10 MWth steam boiler fuelled by sawmill wood residues and a 1.4 MWe steam turbine generator which utilises surplus steam for electricity generation.

- **Mighty River Landfill** <Unlisted> is a New Zealand electricity generation and electricity retailing company. The company owns and operates the hydroelectric generating stations on the Waikato River as well as geothermal plants in the Taupo area, the combined cycle Southdown plant in south Auckland and the largely unused plant (Marsden A and Marsden B) at Marsden Point near Whangarei.

- **Brightwater Hog Feed System** <Unlisted> was designed originally for the large Blue Mountain Lumber sawmill site at Tapanui in Southland where a wide variety of sawmill wood and by-product residues are produced in the day-to-day mill operation. These residues include lumber off-cuts (green and dry), sawline screen "overs", bark, fillet sticks, wet and dry sawdust and general woodyard waste. In most situations, these difficult-to-handle materials, often tangled and multi-sized, are deemed to be too difficult to process and are usually dumped as waste at a significant cost. Installation of the Hog Feed system allows this "biomass waste" material to be converted into a valuable fuel resource.

- **Pan Pac Forest Products** <Unlisted> is located on the Whirinaki industrial site, 20 kilometres north of Napier and includes the management of cutting rights to over 30,000 hectares of plantation forests in Hawke's Bay at five forest locations.In 2007 Pan Pac became wholly owned by Oji Paper, one of the largest pulp and paper producers in Japan. Over 220,000 tonnes of thermo-mechanical wood pulp is produced annually and shipped to Japan's northern island of Hokkaido, where Oji Paper has a large paper manufacturing plant. Chip exports through the Port of Napier provide wood fibre for Oji Paper' kraft pulp and paper operations in Japan.

- **Pure Power** <Unlisted> uses wind and biomass to generate energy. It produces biofuels from feedstock and biomass sources and uses the waste streams of these processes, to produce a range of bioproducts such as resins, paints and plastics.

6.4.17 Summary of Companies in Biomass Sector

Code	Compay Name	Market Cap (M Dollars)	PE ratio	Country	Sector
1964.T	Chugai Ro Co Ltd	$261.0	23.2	Japan	Machinery & Engineering
9514.T	First Energy Service Co Ltd	$10.8	N/A	Japan	Utilities-Electrical & Gas
011780.KS	KUMHO PETROCHEMICAL CO., LTD.	$602.5	N/A	South Korea	Chemicals
8926.TW	Taiwan Cogeneration Corp	$277.0	9.1	Taiwan	Electrical & Electronics
THMX.BO	Thermax Ltd	$1,794.3	32.4	India	Machinery & Engineering
WALC.BO	Walchandnagar Industries Ltd	$198.0	37.8	India	Machinery & Engineering
TREI.BO	Triveni Engineering & Industries Ltd	$759.9	15.8	India	Machinery & Engineering
CRGEE.OB	Clenergen Corp	$54.8	N/A	USA	Metals - Non Ferrous
Unlisted	Thailand Biomass Electricity Co., Ltd.	N/A	N/A	Thailand	Biomass Operator
Unlisted	AT Biopower Co Ltd	N/A	N/A	Thailand	Biomass Operator
Unlisted	National Bio Energy Limited	N/A	N/A	China	Biomass Operator
Unlisted	Wuhan ecoWise Energy Co., Ltd	N/A	N/A	China	Biomass Operator
Unlisted	China Energy Conservation Investment Corp	N/A	N/A	China	Biomass Operator
Unlisted	Energy Advance	N/A	N/A	Japan	Biomass Operator

Source: Thomson Reuters

6.5 Hydro

6.5.1 Background

Hydroelectricity is going through a revival, as it is seen as key source of uninterrupted renewable power and key to countries achieving renewable targets. Hydro also makes up a largest portion of the renewables generation of power in New Zealand (55%), China (14%), India (16%) and Japan (8%). Hydroelectricity has also evolved from large scale infrastructure projects to also include smaller microhydro projects that can just be a few MW in size.

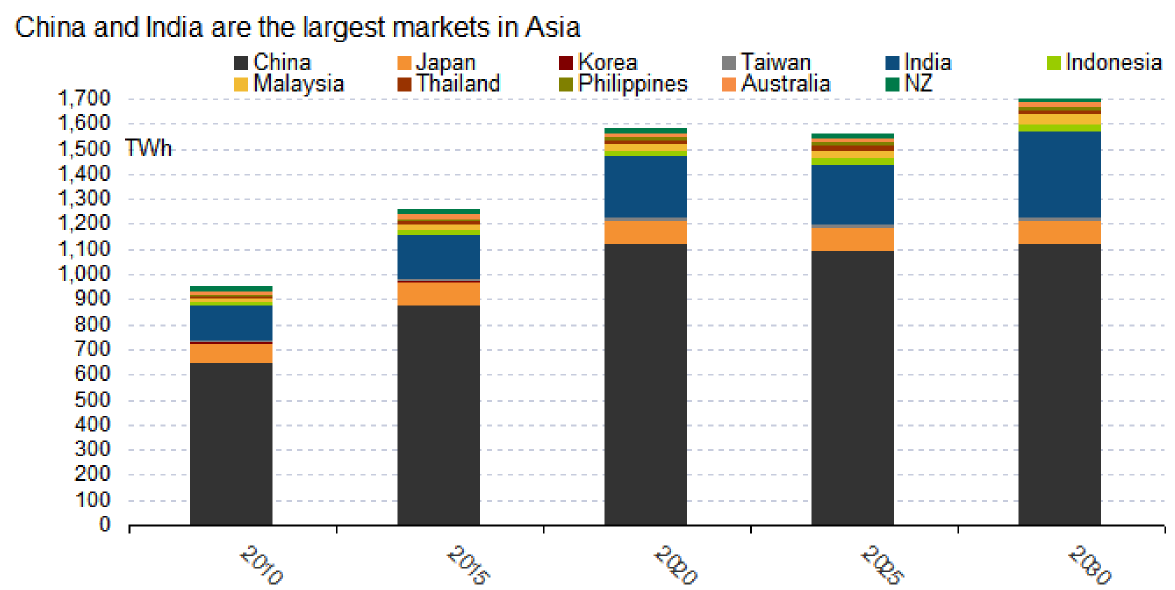
Asia Pacific is the key region for Hydroelectricity, with over 100GW to be added by 2020.

Another key driver for hydro in APR are the carbon credits generated from CDM projects. As of 2009, there were 1,194 Hydro projects in APR which accounted for a quarter of all CDM projects in the region. China alone had 918 hydro projects in the CDM pipeline.

6.5.2 Targets & Incentives

Hydroelectricity forms a major source of renewable energy, accounting for 14% of China's total power generation. Large hydro projects are driven by government targets, while the smaller micro hydro projects have been driven by CDM projects. China makes up over 65% of the total hydro production by 2030, mainly driven by large scale infrastructure projects, such as the Three Gorges Dam.

Figure 6.14 Asia Pacific Hydro Sector



Source: IEA, Thomson Reuters, Government Publications

Asia Pacific Hydro Market (MW capacity)

Country	2005	Construction	Planned	2020E
China	105,000	50,000	80,000	300,000
Japan	27,759	745	19,052	
S Korea	1,584			
Taiwan	1,910	447	440	
India	31,982	13,245	8,810	94,000 by 2027
Indonesia	3,221	135	802	
Malaysia	2,078	2,400	510	
Thailand	3,476			
Philippines	2,450		660	
Australia	7,670			
NZ	5,346	16	186	

Source: World Energy Council, EIA, Government Publications, Estimates

Costs of Generation

Estimates for cost of generation for hydro range from $40 to $60/MWh.

6.5.3 Hydroelectric Power Process

Hydro power plants vary enormously in size, from fractions of megawatts for some microhydro facilities to thousands of megawatts, such as the Three Gorges Dam in China. Most of the hydro power plants included in this report are “small” hydro facilities (typically less than 10 MW).

The main criteria for a hydro power installation are elevation and depth. From an elevated head, either natural or artificial, water can be diverted through a headrace (tunnel or tube) into a turbine coupled to a generator that converts the kinetic energy of falling water into electricity. The water is then discharged through a tailrace, usually through a tunnel or canal, back into the river at a lower level. The natural factors which affect hydro power potential are the quantity of water flow and the height of the head. Flow roughly relates to average annual precipitation and the head depends, basically, on topography.

Power capacity in a flow of water (Q cubic metre per second) is the flow of the water times the height or head (H) the water can fall.

Hydro power plants can generally be divided into three different categories depending on the type of head and the nature of the plant:

- ***High-head power plants*** are the most common and generally include a dam to store water at a higher elevation. These systems are commonly used in mountainous areas.
- ***Low-head hydroelectric plants*** generally use heads up to a few metres in elevation or simply function on the run of the river. Low-head systems are typically built along rivers.
- ***Multipurpose hydro power systems*** are generating facilities where the hydro power is subordinate to other activities like irrigation, industrial processes, drinking water supply or wastewater disposal. Electricity production is thus not the only objective of the plant but often a useful by-product.

The value of the hydro power produced often depends very much on the firm power which can be produced, which in turn depends on the possibilities to store water in the reservoir by the hydro power plant or in upstream reservoirs.

6.5.4 China

Market Size & Growth

According to the EIA, hydro accounts for 14-15% of China's power generation (105GW) and is expected to be a key source of renewable power in the future, with a target of 300GW by 2020. China accounts for 918 CDM projects in Hydro and is the largest single source of CDM projects for China.

The largest hydro project is the Three Gorges complex (18 200 MW), which is operated by China Yangtze <600900.SS> is gradually being brought into full operation by 2010.

The installed capacity of small hydropower in China is estimated to be about 30 GW. China has about 8 300 MW of pumped-storage capacity, with 7 600 MW under construction.

Other major hydro projects listed as under construction, with completion expected in the period 2009-2013, include:

Summary of Hydro Projects in China

Project	Capacity
Three Gorges Dam	18,200MW
Shuibuya	1 840 MW
Pubugou	3 600 MW
Longtan	5 400 MW
Xiloudu	1 500 MW
Laxiwa	4 200 MW
Xiaowan	4 200 MW
Goupitan	3 000 MW
Pumped Storage	7,600 MW
Total	49,450MW

Drivers & Constraints

China has put in place a 300GW target for hydro capacity by 2020 and will contributed around three quarters of the renewable target.

Market Players & Competition

- **China Yangtze <600900.SS>** generates and supplies hydropower to Central, South and East China. The company has a total consolidated installed capacity of 8,714MW from its two core assets, the Gezhouba Dam (3,114MW) and eight units of the Three Gorges project (5,600MW) and plans to acquire the remaining 18 units (12,600MW) from the parent company in the future. Yangtze has also acquired recent exposure to thermal generation, although the portfolio remains dominated by hydro.

- **China Power International <2380.HK>** acquired 63% of Wuling Power, which owns attributable hydropower capacity of 3.6GW. CPI's capacity mix will change from 100% coal to 19% hydro that will increase to around 21% by 2011.

6.5.5 Japan

Market Size & Growth

According the EIA, hydroelectricity accounts for around 8-9% of total power generation, with about 22GW capacity. The government revised it power generation mix in 2009, but kept hydro at 8-9% by 2020.

It expected that 745 MW of conventional hydro capacity was under construction in 2005. Most of the sites suitable for the installation of large-scale conventional hydroelectric plants have now been developed. The great majority of the larger hydro projects presently under construction or planned in Japan are pumped-storage schemes. It is reported that 7,520 MW of pumped storage was under construction. Developed small-hydro capacity at end-2005 was about 3.5 GW, equivalent to 12.5% of total hydro capacity. Capacity planned for construction totalled 106 MW, with a probable annual generation of 478 GWh.

Drivers & Constraints

Hydro is the largest contributor in the renewable energy. However, most of the large potential sites have already been developed and there is limited additional capacity.

Market Players & Competition

- **J-POWER <9513.T>** has a total hydro-generating capacity of 8,550 MW in 59 locations around Japan. To cope with increasing electric power demand and higher peak demand, the company has continued to build and operate mid-size hydroelectric power stations and large-scale pumped-storage power stations. Besides, entrusted by the Japanese government, J-POWER became the first company in the world to build and operate a 30 MW sea-water pumped-storage generation plant.

6.5.6 South Korea

Market Size & Growth

Based on EIA data, the capacity for Hydro is not expected to growth by 2030 and stay at around 1.6GW capacity.

Drivers & Constraints

Korea has embarked on a push to increase its share of renewable energy in its power generation. However, due to limited hydro potential, it will focus its efforts on other sectors.

Market Players & Competition

- **KHNP** <Unlisted> is the largest among the six power generating subsidiaries that separated from Korea Electric Power Corporation (KEPCO) in April 2001, accounting for approximately 25% of electricity producing facilities, hydro and nuclear combined. KHNP also operates nuclear power plants in Kori, Yonggwang, Ulchin and Wolsong, and several hydroelectric power generation facilities (536MW) in the Hangang system, providing approximately 40% of the national power supply.

6.5.7 Taiwan

Market Size & Growth

Taiwan generated around 1,911 MW from Hydro.

Drivers & Constraints

Hydro forms part of Taiwan's Energy Policy, which aims to increase contribution from renewable energy to 12.5% by 2035.

Market Players & Competition

Taipower is the vertically integrated utilty and operates existing hydro plants.

6.5.8 India

Hydro accounts for 16% of India's power generation and is seen as a key component of MNRE's targets. India has 150 Hydro projects in the CDM pipeline.

Market Size & Growth

India has around 34GW generated from hydroelectricity from 55 plants and accounts for 25% of total power generated. There is an expected increase of around 13GW under construction and further 8GW planned.

The largest hydro plants currently under construction are Subansiri Lower (2 000 MW), Parbati II (800 MW), Omkareshwar (520MW) and Teesta V (510 MW).

There are about 420 small-scale hydro plants in operation, with an aggregate installed capacity of about 1 423 MW, with a further 521 MW of smallscale capacity is under construction.

Drivers & Constraints

As part of the ***12th Five Year Plan*** (2012-17), the government has identified an additional 38,242MW to be added in that time period.

Based on the ***2005 Electricity Plan***, India, the government expects to increase hydro capacity to 94,000 MW by 2027[44]

Market Players & Competition

- **National Hydroelectric Power Corporation Ltd** **<NHPC.BO>** formerly National Hydroelectric Power Corporation Ltd., is a hydroelectric power generating company engaged in the planning, development and implementation of an integrated network of hydroelectric projects in India. NHPC also provides contract-based technical, management advisory and consultancy services to domestic and international clients. As of March 31, 2009, it had developed and constructed 13 hydroelectric power stations and its total installed capacity is 5,175MW. This includes two power stations with a combined capacity of 1,520MW, constructed and operated through its subsidiary, Narmada Hydroelectric Development Corporation. The Company and its subsidiary generated 16,582.72 million units and 2,368.45 million units of electricity, respectively during the fiscal year ended March 31, 2009. The company is engaged in the construction of 11 additional hydroelectric projects, as of March 31, 2009.

- **Malana Power Company Ltd** <Unlisted> has developed a hydroelectric plant in India. Water is collected at the plant's intake which consists of a barrage head regulator, a desilter, and a small concrete dam reservoir. Water is transferred via an underground headrace tunnel and steel surface penstock into the power house. Power is transmitted to the Bajaura connection point of Himachal Pradesh State via a high voltage transmission line built by the plant.

- **Jaiprakash Hydro-Power Limited** **(JHPL)** <Unlisted>, a part of the Jaypee Group owns and operates the 300 MW Baspa-II Hydroelectric Project at District Kinnaur in Himachal Pradesh.

- **S. Kumar Group** **<SKMO.NS>** has been commissioned to develop a 400MW Hydro Electric power station in Maheshwar.

6.5.9 Singapore

Market Size & Growth

Not applicable

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[44] India Central Electricity Authority

Drivers & Constraints

Not applicable

Market Players & Competition

Not applicable

6.5.10 Indonesia

Market Size & Growth

Hydro presently provides approximately 12% of Indonesia's electricity supply, with around 3.2GW of capacity. There is around 135 MW of hydroelectric generating capacity was under construction at end-2005 and 802 MW of additional hydro capacity is planned. Key Hydro electricity plants include:

Summary of Hydro Projects in Indonesia

Project	Capacity	Company	Operation
Balambano, South Sulawesi	2 X 70 MW	PT Inco	1999-2000
Cirata, West Java	8 X 126 MW	PT Pembangkitan Jawa Bali	1988-1998
Kotapanjang, Riau	3 X 38 MW	PT PLN	1998
Larona, South Sulawesi	3 X 65 MW	PT Inco	1977
Musi, South Sumatra	3 X 70 MW	PT PLN	2006
Saguling, West Java	4 X 178-MW	PT Indonesia Power	1986-1987
Sudirman, Central Java	3 X 61.5-MW	PT Indonesia Power	1988-1989

Drivers & Constraints

Indonesia has targeted Hydro, as a key resource to increase it share of renewable energy and set a target of 2.9GW by 2025. Mini Hydro is included in the Feed in Tariff (FIT) for renewable energy

Market Players & Competition

- **PLN** <Unlisted> is Indonesia's state-owned power utility. The company transmits and distributes electricity to 36 million residential, commercial, and industrial customers. Its 24,000 MW of generation capacity comes from its own power plants and is supplemented by independent power producers. The Indonesian government has ended Persero's power-supply monopoly to spark interest among independents to build more capacity for sale directly to consumers.

- **PT Inco** is an Indonesia-base nickel producer. The Company's main activities are the exploration and mining, processing, storage, transportation and marketing of nickel and associated products. The Company's production facility and mine are in Sorowako, Sulawesi, where it has a contract agreement until 2025.

6.5.11 Malaysia

Market Size & Growth

There is a substantial potential for hydro development, with a total technically feasible potential of about 123 TWh/yr, most of which is located in Sarawak (87 TWh/yr) and Sabah (20 TWh/yr). The major Hydro project in Malaysia is the 2 400 MW Bakun hydro project in Sarawak and the 300 MW plant at Ulu Terengganu a 210 MW scheme at Sungai and Pelus.

Summary of Hydro Projects in Malaysia

Project	Capacity	Company	Operation
Bakun	2,400 MW		
Hulu Terengganu	212MW	Tenaga Nasional	2013
Sungai	210MW	Tenaga Nasional	
Pelus	210MW	Tenaga Nasional	

Source: Company Reports

Drivers & Constraints

Hydro is a key sector for Malaysia and will account for most of Renewable Energy contribution, contributing about 17% of the total power generation.

Market Players & Competition

- Tenaga Nasional, the largest electricity utility company in Malaysia and is owned by the Government.

6.5.12 Thailand

Market Size & Growth

Thailand has around 3.5GW in Hydro capacity, but is not expected to increase capacity, as the focus in renewable energy will be on solar, wind and biomass.

Drivers & Constraints

There is no target set for hydro, as part of the ***15 Master Plan*** to raise the contribution of renewable energy to 20% and reduce its reliance on natural gas. Thailand does have a FiT for mini hydro to promote renewable energy from hydro, as part of the ***Small Power Producer*** (SPP) and ***Very Small Power Producer*** (VSPP) programs, although most projects are in biomass.

NEPC Proposed Feed in Tariffs in Thailand

Project Type (THB/kWh)	Current Adder	New Adder	Special Adder	Special Southern Adder
Minihydro 50-200 kW	0.40	0.80	1.00	1.00
Minihydro< 50kW	0.80	1.50	1.00	1.00

Source: NEPC

Market Players & Competition

- **Electricity Generating Authority of Thailand (EGAT)** <Unlisted> is Thailand's main electric power producer/wholesaler.
- **Ratchaburi Electricity** **<RATC.BK>** is an independent power producer (IPP) and has an installed capacity of 3,995 MW from its current commercial operating power plants, which represents about 13% of the installed capacity in Thailand.

6.5.13 Philippines

Market Size & Growth

The Philippines has about 2.4GW in installed capacity for hydro, making up around 15% of the total generation.

Drivers & Constraints

The main driver for hydro power will be the ***Renewable Energy Act*** that will produce a ***Renewable Portfolio Standard*** (RPS) that will be defined in 2010 and is expected to include a target hydro. A Feed-in-Tariff (FiT) will be finalized in 2010 and will incentivize the production of power from minihydro projects.

Market Players & Competition

- **EDC** **<EDC.PS>** is the leading generator of hydro power in the Philippines and accounts for 30% of the country's power generation. See Appendix A for more details.
- **Aboitiz** **<AP.PS>** is engaged in the power generation and distribution. The Company operates through two segments: power generation and distribution. Its subsidiaries include Hedcor Tamugan Inc., Hedcor Sibulan Inc., Cleanergy Inc., Hydro Electric Development Corp. and Mactan Enerzone Corporation. See Appendix A for more details.

6.5.14 Australia

Market Size & Growth

Australia has three large generators of hydroelectricity, with around 6-7GW of capacity and making up about 6% of Australia's total power capacity.

In addition, there are also prospects for increased contributions from mini-hydro projects. Private development of small-scale grid-connected hydro has been taking place in Australia since the mid-1980s, with the first significant project undertaken by Melbourne Water on the Thompson Dam.

Drivers & Constraints

Hydro has been identified as a renewable source, as part of the RET that aims to increase its renewable target to 20%. However, given Australia's limited hydro potential, it will be hard to significantly increase capacity.

Market Players & Competition

- **Snowy Hydro** <Unlisted> owns and operates the 3,800MW Snowy Mountains Scheme, an integrated water and hydro-electric power project located in Australia's Southern Alps. Snowy Hydro is jointly owned by the Commonwealth (13%), New South Wales (58%) and Victorian (29%) Governments.

- **AGL Energy <AGK.AX>** AGL has 16 operating hydroelectric stations across six hydro schemes. Upon completion of the Bogong expansion of the Kiewa scheme, AGL's total hydro capacity will be almost 800MW.

- **Hydro Tasmania** <Unlisted> is owned by the State of Tasmania. Hydro Tasmania's hydro-power scheme is an integrated system of 29 hydro power stations, numerous lakes and over 50 large dams and generates around 1,180MW capacity

6.5.15 New Zealand

Market Size & Growth

Hydroelectricity is the largest contributor to the electricity market generating around 5.3GW of power and make up 55-60% of the total power capacity. The main hydro projects are:

Summary of Hydro Projects in New Zealand

Project	Capacity
Tongariro Power Scheme	360MW
Waikato	1,052MW
Waitaki	873MW
Clutha River	765MW
Manapouri	850MW

Drivers & Constraints

The Energy Strategy set a target of generating 90% of New Zealand's electricity from renewable energy sources by 2025, with hydro making up the largest contribution, with over 50-60% of total power generation. However, the new government announced in 2009 that it is revising the Energy Strategy to focus on security of supply.

Market Players & Competition

- **Contact Energy** **<CEN.NZ>** focuses on the wholesale generation of electricity and the retail sale of electricity, natural gas and liquefied petroleum gas (LPG), and related services in New Zealand. The Company operates in two segments: retail and generation. The retail segment encompasses any activity that is associated with the Company's supply of energy and related services to end-user customers. The generation segment encompasses any activity that is associated with the Company's generation of electricity or steam and its sales to the wholesale electricity market.

6.5.16 Summary of Companies in Hydro Sector

Code	Compay Name	Market Cap (M Dollars)	PE ratio	Country	Sector
600900.SS	China Yangtze Power Co Ltd	$20,611.2	25.2	China	Utilities-Electrical & Gas
2380.HK	China Power International Development Ltd	$1,263.4	N/A	Hong Kong	Utilities-Electrical & Gas
9513.T	Electric Power Development Co Ltd	$5,628.0	15.7	Japan	Utilities-Electrical & Gas
NHPC.BO	National Hydroelectric Power Corp Ltd	$8,540.3	N/A	India	Utilities-Electrical & Gas
RATC.BK	Ratchaburi Electricity Generating Holding PCL	$1,638.0	7.9	Thailand	Utilities-Electrical & Gas
EDC.PS	Energy Development Corp	$2,354.1	N/A	Philippines	Utilities-Electrical & Gas
AP.PS	Aboitiz Power Corp	$1,945.0	17.8	Philippines	Utilities-Electrical & Gas
AGK.AX	AGL Energy Ltd	$6,203.5	53.8	Australia	Energy Sources
CEN.NZ	Contact Energy Ltd	$2,567.9	19.9	New Zealand	Utilities-Electrical & Gas
Unlisted	KHNP	N/A	N/A	South Korea	Hydro Utility

Source: Thomson Reuters

6.6 Wave & Tidal Technology

6.6.1 Background

Ocean technology is still a nascent market and not as developed as solar or wind technology. Australia and New Zealand lead the region with pilot programs in place. In most countries, ocean technology is not part of the renewable portfolio with any targets set or defined. This section falls into two main categories: Wave and Tidal.

6.6.2 Targets & Incentives

Wave and Tidal Technology is still a nascent sector, with most projects still in pilot phase. Cost of generation is still high and can be as high as $225/MWh, making it cost prohibitive, when compared with other renewables, although this cost is expected to fall rapidly, as standards are set and a leading technology emerges.

Summary of Tidal Projects in Asia Pacific

Country	Country	Mean tidal range (m)	Basin area (km2)	Installed capacity (MW)	Approximate annual output (TWh/ year)	Annual plant load factor (%)
Australia	Secure Bay (Derby)	7.0	140	1 480	2.9	22
	Walcott Inlet	7.0	260	2 800	5.4	22
India	Gulf of Kutch	5.0	170	900	1.6	22
	Gulf of Khambat	7.0	1 970	7 000	15.0	24
South Korea	Garolim	4.7	100	400	0.836	24
	Cheonsu	4.5	-	-	1.2	-

Source: World Energy Council

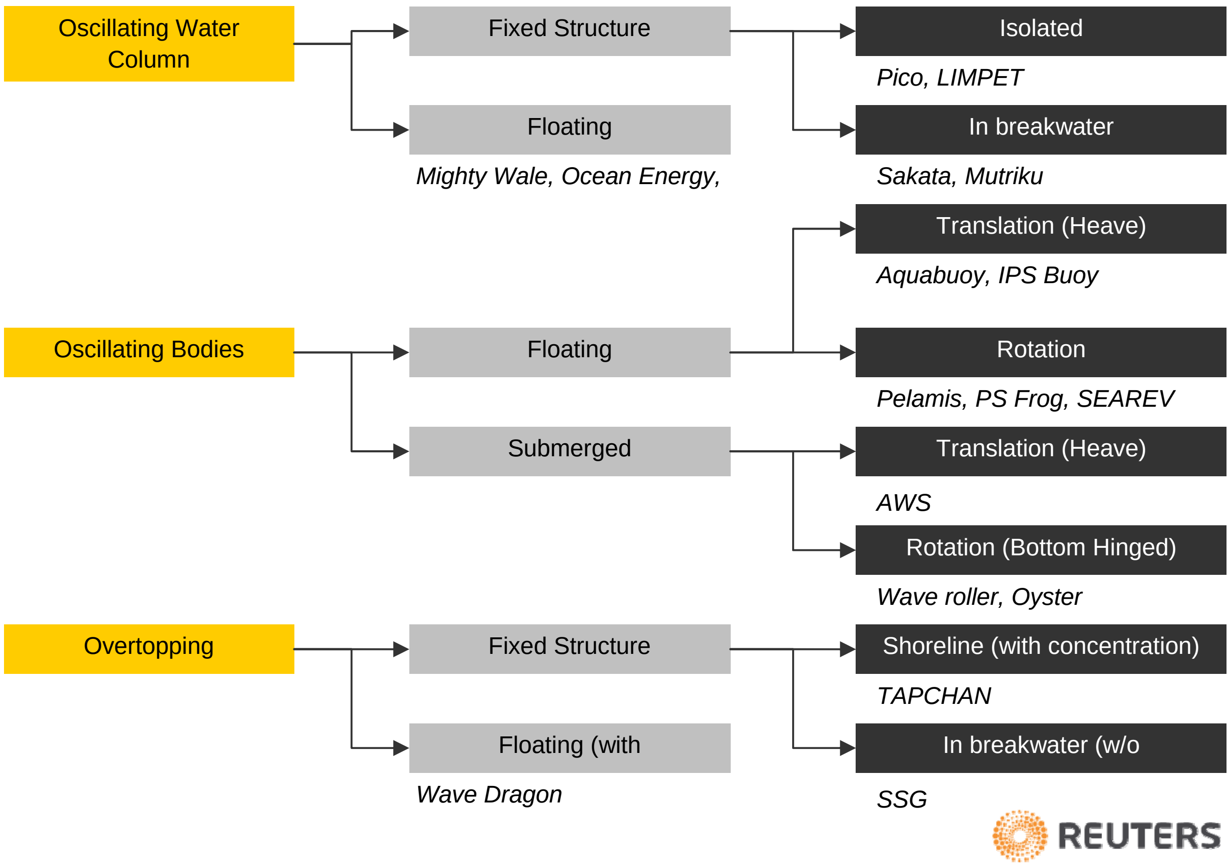
6.6.3 Wave & Tidal Process

Wave

Unlike large wind turbines, there is a wide variety of wave energy technologies, resulting from the different ways in which energy can be absorbed from the waves, and also depending on the water depth and the location (shoreline, near-shore, offshore).

Several methods have been proposed to classify wave energy systems, according to location, to working principle and to size (“point absorbers” versus “large” systems), with the lading technology, based around Oscillating Water Column (OWC).

Figure 6.15 – Wave Technologies



Tidal

There are two main leading technologies:

- ***Tidal Fences*** are effectively barrages which are deployed across the mouth of an estuary. The most advanced plan is for a scheme for a fence across the Dalupiri Passage between the islands of Dalpiri and Samar in the Philippines.
- ***Tidal turbines*** are the main alternative to the tidal fence. Tidal turbines function well where coastal currents run at 2-2.5 m/s. Tidal currents are both predictable and reliable, a feature which gives them an advantage over both wind and solar systems.

6.6.4 Research & Development

A specialty company, Ocean Power Technologies <OPTT.O> has the most inventions in this collection. Most of the other large companies are experts in turbine technology or are shipbuilders. Smaller entities include many specialty companies and think tanks.

There is a particular drop off in patent filings in Japan and this is again reflected in lack of government targets in this area.

The academic-government group is not completely dominated by Chinese institutions, but they are a strong presence among mostly Asian universities.

LARGER PRESENCE IN FIELD	06-08	97-08	% RECENT
GENERAL ELECTRIC CO	4	4	100
SHANGHAI JIUNENG ENERGY SCI & TECHNOLOGY	3	3	100
OCEAN POWER TECHNOLOGIES INC	9	22	41
MITSUBISHI ELECTRIC CORP	1	11	9
ENERCON - ALOYS WOBBEN	0	4	0
HITACHI LTD	0	3	0
ISHIKAWAJIMA HARIMA HEAVY IND	0	3	0

Source: Thomson Reuters Scientific

SMALLER PRESENCE IN FIELD	06-08	97-08	% RECENT
NEPTUNE ENERGY LTD	4	4	100
SAM AN CORP	3	3	100
SRI INT	3	3	100
MARINE CURRENT TURBINES LTD	2	3	67
RENERGYS GMBH	2	4	50
TOYO PLANT KK	1	3	33
WAVECREST LAB LLC	1	3	33
HYUNDAI HEAVY IND CO LTD	0	4	0

Source: Thomson Reuters Scientific

ACADEMIC – GOVERNMENT	06-08	97-08	% RECENT
CHINESE ACAD SCI ELECTRICAL ENG INST	3	3	100
UNIV TIANJIN	2	2	100
UNIV YAMAGUCHI	2	2	100
KOREA OCEAN RES & DEV INST	5	6	83
GUANGZHOU ENERGY INST RESOURCES	2	3	67
UNIV ZHEJIANG	2	3	67
UNIV SHANGHAI JIAOTONG	1	2	50
UNIV HEBEI AGRIC	1	2	50
UNIV INHA	0	4	0
KAIYO KAGAKU GIJUTSU CENT	0	2	0

Source: Thomson Reuters Scientific

6.6.5 China

Market Size & Growth

Wave

China's wave energy research has concentrated mainly on fixed and floating OWC devices. In 1995, the ***Guangzhou Institute of Energy Conversion*** of the Chinese Academy of Sciences successfully developed a symmetrical turbine wave-power generation device for navigation buoys rated at 60 W. Over 650 units have been deployed along the Chinese coast, with a few exported to Japan. Other wave energy projects in China include:

- ***Oscillating Water Column*** (OWC) at Shanwei in Guangdong province consisting of a two chambered device with a total width of 20 m, rated at 100 kW began operating in September 1999;
- ***kW Backward Bent Duct Buoy*** (a floating OWC with the opening to the OWC chamber pointing towards the land) in association with Japan;
- ***Shoreline pivoting flap device*** (Pendulor) developed by Tianjin Institute of Ocean Technology of the State Oceanic Administration;
- ***kW shoreline OWC*** was installed on Dawanshan Island (in the Pearl River estuary), which is being upgraded with a 20 kW turbine.

Tidal

The south-eastern coastal areas of Zhejiang, Fujian and Guangdong Provinces are considered to have substantial potential for tidal energy. Currently there are seven tidal power stations with a total capacity of 11 MW. It was announced in November 2006 that China had signed a joint venture with the Italian engineering company Ponte di Archimede International for the application of its patented Kobold turbine to a site in the Strait of Jintang, in the Zoushan Archipelago.

Drivers & Constraints

China has announced a renewable energy target of 20% by 2020. However, there are no defined capacity targets for wave and tidal technologies.

Market Players & Competition

Wave

- SDE Technology <Unlisted> has signed an agreement for selling sea wave power plants throughout China. Construction of the power plants will be financed by investors from Hong Kong and China.

- Chinese Academy of Sciences Guangzhou Institute of Energy Conversion recently completed a test on a pilot wave power system

Tidal

- Tidal Electric <Unlisted> signed an agreement with the Chinese Government in 2004 for a 300 MW Tidal Lagoon Project, near the near the mouth of the Yalu River.

- Harbin Engineering University developed a Tidal Power Plant (TPP) in 2006 in Daishan County of eastern China's Zhejiang province. The 40 kW tidal power station was also involved the Daishan Technology Bureau.

6.6.6 Japan

Market Size & Growth

Despite having low wave-power levels, extensive research on wave energy has been undertaken in Japan, which deployed one of the first wave-energy devices (the floating OWC, 'Kaimei'), followed by another floating OWC (the 'Mighty Whale' in 1989). Particular emphasis has been placed on the development of air turbines and on the construction and deployment of prototype devices (primarily OWCs), with numerous schemes having been built:

- a 40 kW OWC was deployed in 1983 on the shoreline structure at Sanze for research purposes. It has since been decommissioned;
- a five-chambered 60 kW OWC was built as part of the harbour wall at Sakata Port in 1989;
- 10 OWCs were installed in front of an existing breakwater at Kujukuri beach, Chiba Prefecture. The air emitted from each OWC was manifolded into a pressurised reservoir and used to drive a 30 kW turbine. This scheme was operational between 1988 and 1997;
- a 130 kW OWC was mounted in a breakwater in Fukushima Prefecture in 1996. This used rectifying valves to control the flow of air to and from the turbine;
- a floating OWC known as the Backward Bent Duct Buoy was deployed in Japan in 1987. This continues to be developed in co-operation with institutes in China and Ireland;
- the Pendulor wave energy device has been developed by the Muroran Institute of Technology. Wave action causes pendulum oscillations of a plate ('pendulor') at the

entrance to a box, this movement being used in conjunction with a hydraulic power take-off to generate electricity.

- The only significant wave-energy device currently being studied is an OWC deployed at Niigata in 2005.

Drivers & Constraints

The Government established the ***Basic Plan on Ocean Policy*** in March 2008, which acts as the guide for ocean policy for the next five years. The plan includes 12 government measures, including development and commercialisation of submarine resources such as methane hydrate, polymetallic sulphides, wave-power generation and tidal-power.

The ***New Energy and Industrial Technology Development Organization*** (NEDO) undertook a survey identifying existing and potential technology for ocean energy.

However, unlike wind or solar energy, ocean energy is not included in the ***New Energy Law***. As a result, there are no government targets or financial assistance for ocean energy and this will be a limiting factor, in the development of this technology in Japan.

Market Players & Competition

- **Ocean Power Technologies Inc** **<OPTT.O>** has signed an agreement in October 2009 with a consortium, including Mitsui Engineering and Shipbuilding Co Ltd (2766.T), to develop the first demonstration wave power station in Japan. The Japanese consortium also includes Idemitsu Kosan Co (5019.T), Japan's third-largest refiner, and Japan Wind Development Co Ltd (2766.T), which primarily develops and operates wind farms.

6.6.7 South Korea

Market Size & Growth

South Korea has developed two tidal projects: ***Sihwa Lake*** and ***Wando Hoenggan Water Way***.

It was announced in mid-2005 that the country's first tidal power plant was to be constructed at Sihwa-Lake, 25 km southwest of Seoul on the Water Resources Corporation acting as project developer. The artificial lake was created between 1987 and 1994 to provide water for agricultural purposes. A dam curtailing the tidal currents was constructed but the quality of the water deteriorated, becoming heavily polluted following a rise in local industry and a consequent increase in factory wastes.

A sophisticated plan has been formulated whereby the power plant will utilise the head between high tide on one side and the level of the lake on the other. The scheme will not only provide generation of electricity but also environmental improvements and tourist attractions. The Korean Energy Economics Institute reported in April 2007 that construction of the 254 MW plant will be completed by July 2008 and that annual power generation is expected to be in the region of 550 GWh. On completion Sihwa-Lake will be the world's largest tidal energy plant.

In May 2007 the city of Incheon announced that it had signed an MOU with Korea Midland Power Co. and Daewoo Engineering and Construction to build the Ganghwa tidal plant. At 812 MW, the 32-generator plant would overtake the Sihwa-Lake project to be the world's largest tidal scheme when the plant becomes operational – planned for 2015. A 7.8 km long dam will connect four islands: Ganghwa, Gyodong, Seokmo and Seogeom.

Drivers & Constraints

In order to encourage the development of tidal power and other renewable energy schemes, the South Korean government has introduced a target of boosting the proportion of renewable energy in the generation mix to 5% by 2011.

Market Players & Competition

Tidal

- **Korea Water Resource Corporation** <Unlisted> state owned KWRC is developing the 254MW Sihwa tidal power plant at Sihwa lake on Inchon bay. Funding of about US$250M is being provided by the government's new renewable energy fund and KOWACO. The system will comprise 12 units of 21 MW generators and an annual power generation is projected at 552 million kWh. Designed by the Korea Ocean Research & Development Institute. Costs are estimated at US $320 million with a price per kWh of US $0.09.

- **Korean Midland Power Co** <Unlisted> A collaboration between Lunar Energy and KOMIPO, and would create a 300-turbine field in the Wando Hoenggan Water Way off the South Korean coast by 2015, providing 300MW of renewable energy, enough to power 200,000 homes.

6.6.8 Taiwan

Market Size & Growth

Taiwan has proposed a demonstration project to promote marine energy and prove the viability of wave energy converters in Taiwanese waters, leading to further development and the installation of up to 75MW of capacity by 2025.

Drivers & Constraints

There are no defined Renewable Targets for Wave or Tidal Power, except for a 75MW target for 2025.

Market Players & Competition

Wave

- **Ocean Navitas** <Unlisted> Aegir Dynamo wave energy converter has been selected as the most suitable technology for development in Taiwanese waters for a demonstration project

6.6.9 India

Market Size & Growth

Wave

The Indian wave energy program started at the ***Institute of Technology*** (IIT) under the sponsorship of the ***Department of Ocean Development***. The ***National Institute of Ocean***

Technology (NIOT) succeeded IIT and continues to research wave energy including the ***Backward Bent Duct Buoy*** (a variant of the OWC design).

Tidal

The main potential sites for tidal power generation are the ***Gulf of Kutch***, the ***Gulf of Khambhat*** (Cambay) and the ***Gangetic delta*** in West Bengal. The tidal ranges of the Gulf of Kutch and the Gulf of Khambhat have a capacity of 900 and 7 000 MW, respectively. The ***West Bengal Renewable Energy Development Agency*** (WBREDA) prepared a project report (on behalf of the Ministry of Non-Conventional Energy Sources) for a 3.65 MW demonstration tidal power plant at ***Durgaduani Creek*** in the Sundarbans. In February 2007 the WBREDA stated that it had engaged the ***National Hydroelectric Power Corporation*** to implement the Rs 400 million (approximately US$ 10 million) project on a turnkey basis.

Drivers & Constraints

There are no defined targets for wave or tidal power generation, as part of the 5 year plan.

Market Players & Competition

Wave

- **National Institute of Ocean Technology, Chennai.** The institute is the technical arm of the Ministry of Earth Sciences, Government of India, working towards development and demonstration of field-scale models of ocean renewable energy devices. As a part of its mandate, NIOT has setup a 100 m^3/day island-based low-temperature thermal desalination plant at Kavaratti, India, in 2005 and demonstrated a 1 000 m^3/day experimental barge-mounted desalination plant off Chennai Coast, India, in 2007. Currently, work is underway to establish three island-based desalination plants in three remote islands in the Lakshadweep region of India, scheduled to be commissioned by June 2009. NIOT is also working on wave powered devices meant for remote islands.

Tidal

- **National Hydroelectric Power Corporation <NHPC.BO>** involved in the 3.65 MW demonstration tidal power plant at Durgaduani Creek in the Sundarbans.

6.6.10 Philippines

Market Size & Growth

Tidal

A tidal fence across the ***Dalupiri Passage*** between the islands of Dalpiri and Samar was proposed in 1997 between the Philippines Government and ***Blue Energy Engineering Company***. The site, on the south side of the San Bernardino Strait is expected to generate up to 2200 MW of peak power (with a base daily average of 1100 MW). However work stopped in 1998, due to the Asian Financial Crisis.

Drivers & Constraints

Philippines enacted the ***Renewable Energy Law*** in 2008 and expected to define renewable energy targets in 2010. However, it is unlikely that there will be any allocation of wave and tidal power, as part of the RPS.

Market Players & Competition

- **Blue Energy Company** <Unlisted> is a Canadian clean energy technology company commercializing a vertical axis hydro turbine capable of converting tidal currents into firm, renewable electricity.

6.6.11 Indonesia

Market Size & Growth

Indonesia has been indentified as a country with tidal power resources. However, there are no plans to develop any demonstration or pilot projects.

Drivers & Constraints

There are no renewable energy targets includes for marine and tidal power generation.

Market Players & Competition

Not applicable

6.6.12 Thailand

Market Size & Growth

No projects planned

Drivers & Constraints

There is no renewable energy target included for marine and tidal power generation.

Market Players & Competition

Not applicable

6.6.13 Malaysia

Market Size & Growth

No projects planned.

Drivers & Constraints

There is no renewable energy target included for marine and tidal power generation.

Market Players & Competition

Not applicable

6.6.10 Australia

Market Size & Growth

Australia has a number of projects in wave and tidal power, with a number of companies setting up pilot schemes. Key projects include:

Project	Capacity	Company	Technology
Port Kembla	500kW	Oceanlinx	Wave
Exmouth		Carnegie Wave	Wave
King Island		Bio Power	Wave
Philip Island	150kW	Atlantis	Wave
Secure Bay (Derby)	1 480MW	Derby Hydro Power	Tidal
Walcott Inlet	2 800MW		Tidal
Flinders Island		Bio Power	Tidal

Source: Company Publications

Drivers & Constraints

There are no specific programs or FiTs for Australia for ocean energy, but an expanded program has aimed at increasing the installed capacity of renewable energy within Australia, as part of the government's target of 20% for renewables. Australia leads the regions in companies and projects in this sector, with a number of projects rolled out including:

Market Players & Competition

Wave

- **Oceanlinx** <Unlisted> has a 500-kW demonstration wave energy project at Port Kembla and will be re-installed, along with full grid interconnection. Other Oceanlinx projects are planned for southern Australia. It incorporates a parabolic wave collector to focus waves over a wide area onto a central OWC (to compensate for the lower wave power levels near shore) and a novel variable-pitch turbine that has higher efficiencies than turbines normally used in OWCs. The project has been carried out with support from the Australian Greenhouse Office, under its Renewable Energy Commercialisation Programme.

- **Carnegie Wave Energy** **<CWE.AX>** is focused on developing and commercializing its CETO Wave Energy technology, which it developed a pilot project at its Fremantle Wave Energy facility. It also announced that it has been commissioned by the Commonwealth of Australia, via the Department of Defence (DoD), to assess the feasibility of utilising CETO wave energy technology to supply power to the Defence Communications Station Harold E Holt (HEH) at Exmouth in the North West of Western Australia.

- **Bio Power Systems** <Unlisted> continues to progress its proposed demonstration projects in Bass Strait via a wave energy facility (King Island) and a tidal energy facility (Flinders Island). Their bioWAVE™ wave energy conversion system is based on the swaying motion of sea plants in the presence of ocean waves. Their vertically mounted, waving fronds capture a wide range of incident wave energy without using a large rigid structure and can orientate themselves to the prevailing wave direction. Themotion is turned into electricity by their O-DRIVE™ generator, which uses a simple single-stage reciprocating gear mechanism, a direct-drive synchronous permanent magnet generator and high-inertia flywheel to produce smooth AC power. The key innovation is the ability of the system to avoid large loadings in extreme waves by lying flat on the sea bed.

- **Ocean Power Technologies <OPTT.O>** Ocean Power Technologies, Inc. is engaged in developing and commercializing systems that generate electricity by harnessing the renewable energy of ocean waves. The Company offers two types of products as part of the line of PowerBuoy systems, including a utility PowerBuoy system and an autonomous PowerBuoy system. The utility PowerBuoy system is capable of supplying electricity to a local or regional electric power grid. The autonomous PowerBuoy system is designed to generate power for use independent of the power grid in remote locations. The PowerBuoy system consists of a floating buoy-like device that is loosely moored to the seabed so that it can freely move up and down in response to the rising and falling of the waves, as well as a power take off device, an electrical generator, a power electronics system and control system, all of which are sealed in the unit. OPT achieved substantial milestones in 2Q, which should help solidify its market position going forward. Milestones include:

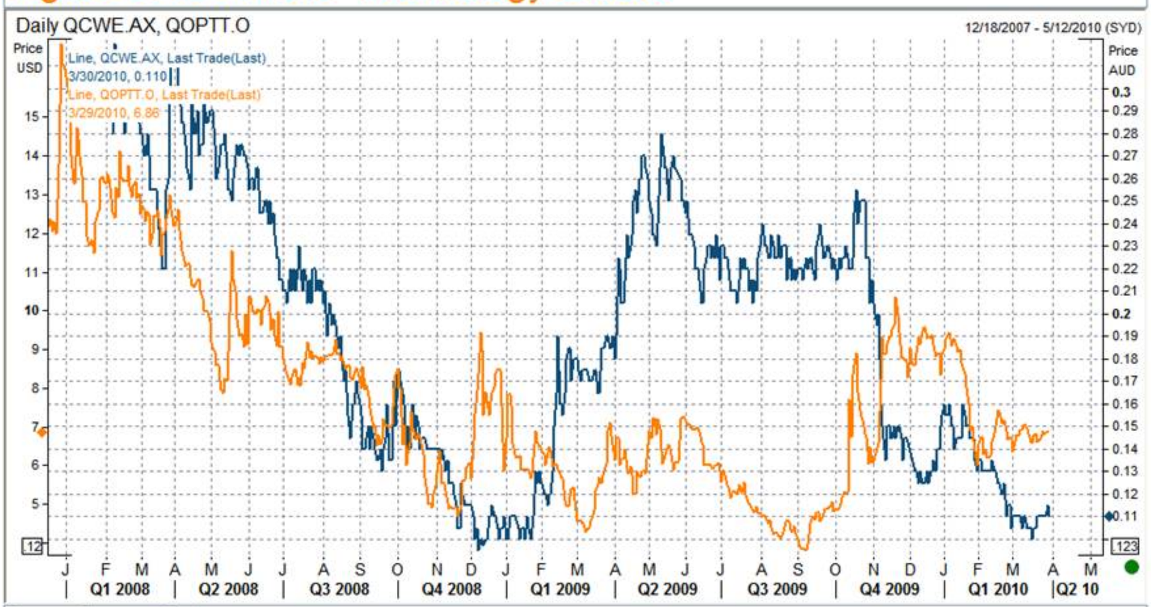
    - $66.5m grant from the Australian government;
    - Entering Japanese market;
    - continuing to build its relationship with partners (e.g. LMT)
    - diversifying its revenue base /broadening product applications (successful trial of OPT's Underwater Substation Pod, new Navy contract to provide a wave energy conversion system) and
    - on track to deploy its first PB150 in mid-CY 2010

- **Atlantis Resources Corporation** <Unlisted> installed a 150-kW tidal device at Phillip Island (south of Melbourne) during 2008.

Tidal

- **Derby Hydro Power** <Unlisted> has put a proposal to construct a 50 MW tidal plant in the Derby region. The project received a $1 million grant through the Australian ***Greenhouse Office's Renewable Energy Commercialisation Program*** to further develop the project. The inlets would be connected via an artificial channel. By damming each inlet, differences in water levels in each basin could be controlled which would enable flow via the connecting channel. Power take-off would be achieved from a bank of turbines housed in a structure built in this channel.

Figure 6.16 - Wave Technology Stocks



Source: Thomson Reuters

6.6.11 New Zealand

Market Size & Growth

Project	Capacity	Company	Technology
Kaipara Harbour		Crest Energy Kaipara	Tidal
Cook Strait	1MW	Neptune Power	Tidal
Tory Channel	1MW	Energy Pacifica	Tidal

Source:

Drivers & Constraints

There are no national targets for deployments of marine energy projects. However, the recently published ***New Zealand Energy Strategy*** set a target of 90% of generation to come from renewable sources by 2025 (currently 65%). The New Zealand government announced the first award of funds from the ***Marine Energy Deployment Fund*** (MEDF). The fund aims to promote marine energy by offering NZD 2 million per year over the next four years for the deployment of prototypes in New Zealand waters. The first award – of NZD 1.85 million – was made to ***Crest Energy Kaipara Limited*** to assist in the deployment of three tidal turbines in New Zealand's largest harbour, the ***Kaipara Harbour***. The company plans to deploy up to 200 tidal turbines progressively over 10 years.

Market Players & Competition

Wave

- **Ocean Power Delivery** <Unlisted> is in talks with Auckland-based firm ***Power Generation Projects*** (PGP) and local manufacturers will soon be asked for quotes to build up to 140 machines.

Tidal

- **Crest Energy Kaipara Limited** <Unlisted> was granted consents and recommended the approval of two further consents to the Minister of Conservation in late August 2008. In early September 2008, four parties, including Crest Energy itself, appealed the consents, requiring a hearing in the Environment Court. Evidence was provided to the court in late 2008 and the hearings have been set down for mid-2009.

- **Neptune Power** <Unlisted> was granted non-notified consent by Greater Wellington Regional Council, allowing it to deploy a single 1-MW prototype tidal turbine in Cook Strait. A non-notified consent means that there were no public hearings and the consent was granted essentially to allow environmental monitoring of a single device deployment. Neptune Power has indicated that it intends to deploy the prototype in late 2009.

- **Energy Pacifica Limited** <Unlisted> is to deploy twenty 1-MW tidal turbines in Tory Channel indicated that it intended to submit resource consent applications before the end of 2008.

6.6.12 Summary of Companies involved in Wave/Tidal Technology

Code	Compay Name	Market Cap (M Dollars)	PE ratio	Country	Sector
CWE.AX	Carnegie Wave Energy Ltd	$54.8	N/A	Australia	Energy Sources
OPTT.O	Ocean Power Technologies Inc	$70.3	N/A	USA	Utilities-Electrical & Gas
NHPC.BO	National Hydroelectric Power Corp Ltd	$8,540.3	N/A	India	Utilities-Electrical & Gas
Unlisted	Atlantis Resources	N/A	N/A	Singapore	Tidal
Unlisted	Derby Hydro Power	N/A	N/A	Australia	Tidal
Unlisted	Oceanlinx	N/A	N/A	Australia	Wave
Unlisted	Bio Power Systems	N/A	N/A	Australia	Wave
Unlisted	Crest Energy	N/A	N/A	New Zealand	Wave
Unlisted	Neptune Power	N/A	N/A	New Zealand	Wave
Unlisted	Energy Pacifica	N/A	N/A	New Zealand	Wave
Unlisted	Korea Water Resource Corporation	N/A	N/A	South Korea	Tidal
Code	Compay Name	Market Cap (M Dollars)	PE ratio	Country	Sector

6.7 Geothermal

6.7.1 Background

Located on the "Ring of Fire", Asia Pacific has the largest potential natural resource for geothermal energy in countries including" Japan, New Zealand, Indonesia, Philippines and Papua New Guinea. In addition, with the advancement of new drilling techniques and ***Enhanced Geothermal Systems*** (EGS), countries such as Australia have started to commercialise their geothermal 'hot rock' resources.

Indonesia and Philippines have the largest installed geothermal capacity in the region. While Australia, seem to be leading the region in the new EGS space, with 9 companies launched on the ASX to exploit this resource. China and Korea also appear to be investigating their respective geothermal potential.

6.7.2 Targets & Incentives

Asia Pacific Geothermal Market (MW capacity)

Country	2007	2010E	2015E	2020E
China	28	28	28	28
Japan	535	535	535	535
S Korea	21	21	21	21
Taiwan	0	50		
India	0			
Australia	0.12			10,000GWh*
NZ	452			
Indonesia	992	1,900		9,500
Malaysia	0			
Thailand	0			
Philippines	1,970			

Source: GIA, EIA, Government Publications, Estimates

6.7.3 Geothermal Process and Technologies

Geothermal technology depends on the type and location of the natural resource. Since it is not practical to transport high-temperature steam over long distances by pipeline due to heat losses, most geothermal plants are built close to the resource. A geothermal system consists of three main elements: a heat source, a reservoir and a fluid. The heat source can be either a very-high-temperature (> 600°C) magmatic intrusion that has reached relatively shallow depths (5 to 10 km) or, as in certain low temperature systems, the Earth's normal temperature, which increases with depth. The heat source is natural, whereas the fluid and the reservoir can be introduced.

Geothermal power plants tend to be in the 20 MW to 60 MW range and the capacity of a single geothermal well usually ranges from 4 MW to 10 MW. Typical minimum well spacing of 200 m to 300 m is established to avoid interference. There are three main power plant technologies are being used to convert hydrothermal fluids to electricity. The type of conversion depends on the state of the fluid (steam or water) and on its temperature:

- ***Dry steam power plants*** use hydrothermal fluids primarily in the form of steam. The steam goes directly to a turbine, which drives a generator that produces electricity. This is the oldest type of geothermal power plant.

- ***Flash steam power plants*** use hydrothermal fluids above 175°C. The fluid is sprayed into a tank (separator) held at a much lower pressure than the fluid, causing some of the fluid to vaporise rapidly, or "flash" to steam. The steam then drives a turbine.

- ***Binary-cycle power plants*** use hot geothermal fluid (below 175°C) and a secondary (hence, "binary") fluid with a much lower boiling point than water – both passing through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to steam, which then drives the turbines. Since binary-cycle generation system makes moderate-temperature geothermal fluids usable for power generation, this is being explored in countries with lower temperature geothermal resources.

The total energy efficiency is around 10% for electricity production. Because geothermal power plants operate at relatively low temperatures compared to other power plants, they eject as much as 90% of the heat extracted from the ground into the environment. The minimum temperature for electricity generation is 90°C.

Despite the relatively low efficiency in power generation, geothermal does not suffer from intermittency issues and can operate 24 hours per day and thus provide base-load capacity.

A relatively new concept in geothermal power is "***Hot Dry Rock***" (HDR), also known as "***Hot Wet Rock***" (HWR), "***Hot Fractured Rock***" (HFR) and "***Enhanced Geothermal Systems***" (EGS). The basic concept is to increase the permeability of the natural fractures of the basement rocks, install a multi-well system, force the water to migrate through the fracture system ("reservoir") by using enhanced pumping and lifting devices and, finally, use the heat for power production. HDR is expected to contribute to further geothermal development in the decades to come and is the technology use for geothermal production in Australia.

6.7.4 China

Market Size & Growth

China only has around 30MW geothermal capacity in Tibet, at there main locations at Yangbajain (24MW), Langju (2MW) and 1 MW binary power station in Nagqu. There are also two small 300 kW plants are operating in Guangdong and Hunan.

There are not any targets for growth in geothermal capacity in China, as part of the 2020 target. However the following was proposed by the geothermal community in China:

- Accelerate the exploration and use of the deep reservoirs at Yangbajing. The objective would be to meet the electric needs of the Lhasa area.
- Develop the Yangyi Geothermal Field with a modern 10 MW-size power plant.
- Explore the deep reservoirs in the Naqu Field and expand the existing installed capacity.
- Establish a 3 - 5 MW pilot project at the Ruili Geothermal Field, followed by development of the Rehai Field with a 10 MW plant.
- Develop the fields around Litang in western Sichuan.

Drivers & Constraints

China's geothermal resources are limited to Tibet and Western China. There are not any targets for growth in geothermal capacity in China, as part of the 2020 target and this will limit capacity growth.

Market Players & Competition

No companies identified in this sector.

6.7.5 Japan

Market Size & Growth

Japan, as a volcanic country, is blessed with potential geothermal resources for development. However, the construction of geothermal power plants has been restricted, due to factors such as the restrictions in National Parks and hot spring (onsen) resort areas. Capacity stands at 534 MW and not projected to grow.

However, Mitsubishi Materials Corp., Kyushu Electric Power Co. and several other Japanese firms announced plans in 2009 to start developing geothermal power for the first time in nearly 20 years. Mitsubishi Materials and J-Power plan to collectively invest 40 billion yen ($433.9 million) to build a geothermal power plant in the Akita Prefecture in northern Japan to start operations in 2016. Mitsubishi currently owns two geothermal power plants while J-Power has one. A desire to build generate clean power is fueling the resurging interest in geothermal power. Tapping steam and hot water for generating electricity also could help the country meet its goals of cutting greenhouse gas emissions.

Drivers & Constraints

The "***Renewables Portfolio Standard Law***" was enacted in 2003, where geothermal energy was included as renewable energy in this law in 2006. However, there is no stand-alone geothermal legislation which defines geothermal resources, governs their use or development in Japan. Total capacity remains at about 534 MW.

Geothermal research at national universities (Kyushu and Tohoku) and AIST is supported by grants from the government. Other institutions that fund geothermal R&D are CERL in CRIEPI.

Market Players & Competition

While there is no proposal to increase geothermal capacity in Japan, Japans' turbines and generators still have 75% share in the world geothermal power plants and export to other markets, such as Indonesia and Philippines. Key manufacturers are MHI, these makers still continue to invest in these R&D fields

- **Fuji Electric Systems Co., Ltd <6654.T>** supplies turbines and generators as a single package for flash steam geothermal plants of 30 MW capacity.
- **Mitsubishi Heavy Industries <7011.T>** is involved in the design, manufacture, installation, and servicing of flash steam power plants.
- **Toshiba Corp <6502.T>** Its product range includes flash steam turbines, binary cycle power generating equipment, and the Super Rotor Package for geothermal turbine using its latest advanced technology.
- **Mitsubishi Materials <5711.T>** and **J-Power** plans to invest roughly 40 billion yen ($433.9 million) and construct a geothermal power plant in Yuzawa in Akita Prefecture, northern Japan.
- **Kyushu Electric Power <9508.T>** operates 5 geothermal power stations with a total capacity of 209,500kW, about 40% of Japan's total.

6.7.6 South Korea

Market Size & Growth

Though Korea's geothermal resources are characteristically low-temperature hot springs associated with localized, deep fractures, a high heat flow anomaly was recently discovered and is being investigated in the Pohang geothermal development program. Geothermal heat pump installations are accelerating, with the total heat produced about doubling every year.

Drivers & Constraints

The Korean Government provides support and incentives for renewables, with geothermal subsidies of about US$ 9.5 M paid in 2007. Korea's R&D activities are concentrated on exploration and exploitation of low-temperature geothermal water for district heating and characterization of geothermal resources.

Market Players & Competition

No companies identified

6.7.7 Taiwan

Market Size & Growth

Taiwan lies on major geological fault-lines along the Pacific Rim, and has abundant geothermal resources. A comprehensive exploration effort has indicated a total potential of up to 1 000 MW. However, most of the resources are located in remote areas or protected lands and that makes them difficult to develop.

Drivers & Constraints

The Government has set a target of 50 MW for 2010.

Market Players & Competition

Currently, a BOT project at Chin-Suei, I-Lan County is under development and is aimed at the integration of geothermal energy usage with recreational facilities. It is planned to construct a 5 MW plant by 2008.

6.7.8 India

Market Size & Growth

Not a focus for India

Drivers & Constraints

Geothermal is not a focus in India

Market Players & Competition

No companies identified in this sector.

6.7.9 Indonesia

Market Size & Growth

Indonesia is the third largest generator of geothermal power, after the US and Philippines.

Indonesia has focused its renewable policy on geothermal, small hydro and biomass. New geothermal regulations have removed Pertamina from its central role in steamfield development and passed that responsibility to the regions.

Indonesia launched its 10,000MW program to increase its use of geothermal, as a primary source of power generation. The Indonesian government said it is studying plans to merge the geothermal units of three state-owned firms - PT PLN, oil refiner PT Pertamina and gas firm PT

Perusahaan Gas Negara. However, there are plans to encourage foreign investment for IPP generation.

Drivers & Constraints

Indonesia announced the 10 000 MW Crash Program Phase II in 2008, which aims to increase renewable generating capacity, particularly from geothermal and hydropower. Targets have been set to boost the capacity of geothermal plants to 9.5 GW by 2025.

Market Players & Competition

- **PLN** <Unlisted> has been designated by the Indonesian government to construct 11 geothermal power plants with a total capacity 10,000 MW by 2014.

- **Star Energy** <Unlisted> through its subsidiary Magma Nusantara Ltd has developed the Wayang Windu power generation project, which is spread over 12,960 hectare of geothermal resources contract area producing 400 MW of electricity.

6.7.10 Malaysia

Market Size & Growth

Tawau, Sabah in Malaysia has an electricity generation potential of up to 67 MW from geothermal resources following the discovery of a geothermal site in Apas by a study by the ***Mineral and Geoscience Department***.

Drivers & Constraints

Under the ***Ninth Malaysia Plan*** the government had allocated RM1.5 million (US$ 420,000) for research on the site and it was hoped that drilling could start under the ***Tenth Malaysia Plan***.

Market Players & Competition

Geothermal is still in research and development stage and no companies have set up projects for commercialization of geothermal resources.

6.7.11 Philippines

Market Size & Growth

The Philippines has a total installed geothermal capacity of 1.9GW, secondl only to the US and is a central component of its comprehensive ***Renewable Energy Act***. .

The ***Philippine Department of Energy*** plans to offer investors four new areas for geothermal exploration. The areas are in ***Luzon*** and one is in ***Mindanao***. The government is keen to increase the capacity, and wants to invite foreign firms to play a more prominent role in the sector.

Drivers & Constraints

The Philippine government enacted the ***Renewable Energy*** (RE) Act in 2008 and is in the process of setting renewable energy targets in 2010 that will include Geothermal Energy.

Market Players & Competition

- **Energy Development Corporation** **<EDC.PS>** is the leading generator of geothermal power in the Philippines and accounts for 30% of the country's power generation. formerly PNOC Energy Development Corporation, is engaged in the exploration, development and operation of geothermal energy. It is also involved in geothermal drilling and consultancy services. EDC became a subsidiary of Red Vulcan Holdings Corporation on November 29, 2007, which is a wholly owned subsidiary of First Gen Corporation. The Company operates 12 geothermal steamfields in the five geothermal service contract areas: Leyte Geothermal Production Field, Southern Negros Geothermal Production Field, Bacon-Manito Geothermal Production Field, Mindanao Geothermal Production Field and No. Negros Geothermal Production Field. On November 17, 2008, EDC acquired 60% of First Gen Hydro Power Corporation (FG Hydro) from First Gen Corporation.

- **Chevron Geothermal Philippines Holding Inc.** <Unlisted>

- **Aboitiz** **<AP.PS>** operates through two segments: power generation and distribution. Its subsidiaries include Hedcor Tamugan Inc., Hedcor Sibulan Inc., Cleanergy Inc., Hydro Electric Development Corp. and Mactan Enerzone Corporation.

Figure 6.17

6.7.12 Thailand

Market Size & Growth

There are approximately 64 geothermal resources in Thailand, but major ones are in the north of the country, especially the geyser field at ***Fang District*** in Chiangmai Province. Survey on the potential of geothermal energy development at Fang District commenced in 1978, with technical assistance and experts from France later in 1981.

Drivers & Constraints

The main driver for renewable energy is Thailand's ***15 year Master plan***. However focus on renewable energy will be on hydro, biomass and biofuels.

Market Players & Competition

- **Electricity Generating Authority of Thailand (EGAT)** <Unlisted> is operating a 300-kW binary cycle geothermal power plant at Fang District, generating electricity at about 1.2 million kWh per year. EGAT produces more than 15,000 MW of electricity and buys another 10,600 MW from independent power producers. EGAT not only generates or buys most of the nation's power; it holds a monopoly on transmission to the distributors (Metropolitan Electricity Authority and Provincial Electricity Authority). The utility operates hydroelectric, thermal, and alternative power plants, and provides engineering, maintenance, and other energy-related services.

6.7.13 Australia

Market Size & Growth

Australia's potential electricity generating geothermal resources consist of ***Hot Sedimentary Aquifers*** (HSA), e.g. ***Hydrothermal Groundwater Resources***, and ***Hot Rock technologies*** (HR), including ***Hot Dry Rocks*** (HDR) and ***Hot Fractured Rocks*** (HFR). Geothermal generation in 2007 amounted to 1.8 GWh/yr from a 120 kW binary plant in Queensland. The total direct use installed capacity was about 130 MW.

Current investment to explore for, and demonstrate the potential of, geothermal energy for power generation in Australia is focused on:

- HR EGS plays in the ***South Australian Heat Flow Anomaly*** (SAHFA) and the eastern half of Tasmania, and

- HSA plays in the ***Otway and Gippsland Basins*** in the States of South Australia and Victoria

By the end of 2009, 33 companies applied for 277 licenses, with 9 Australian companies having reached a drilling phase in their geothermal projects. These 9 companies are listed on the ASX.

Through the expanded ***Renewable Energy Target*** (RET), the Australian government's goal is to have at least 20 per cent of Australia's electricity supply coming from renewable energy sources by 2020. This will provide a cross-subsidy to the renewable energy sector worth many billions of dollars. The Australian Government's modelling shows that by 2020, geothermal projects could take up one fifth of the target, or around 10,000 GWh.

Drivers & Constraints

The main driver for geothermal capacity expansion has been the RET target of 20% renewable energy target by 2020, with geothermal targeted as a key sector.

- ***South Australia*** **-** The Petroleum Act recently underwent a review and amendment process to be renamed the ***Petroleum and Geothermal Energy Act, 2000***. A paper outlining proposed amendments to the *Petroleum Act 2000* closed for public comment on 29 June 2007. The Petroleum (Miscellaneous) Amendment Bill 2008 was released in April 2008 for public consultation. The intended changes will increase the maximum size of geothermal licences to 3,000 km2 and lower licence fees. It is expected that the *Petroleum and Geothermal Energy Act, 2000* will be enacted in the near future.

- ***Victoria*** **-** The ***Geothermal Energy Resources Act*** (GER Act) was passed in April 2005 and the ***Regulatory Impact Statement and Geothermal Energy Resources Regulations, 2006*** came into effect during 2006.

- ***New South Wales*** **-** The ***Mining Act, 1992***, governing geothermal exploration in New South Wales is on its final review stage for a bill amendment. Currently geothermal exploration is considered as Group 8 -Geothermal Substances. Application for a Group 8 geothermal exploration licence requires the Minister's consent especially if it is under mineral allocation areas, usually within coal basins. In other areas of the state over the counter applications are still accepted. If successful, a maximum 5-year term is granted based on work program commitments.

- ***Queensland*** **-** The ***Geothermal Exploration Act 2004 and Geothermal Exploration Regulation 2005*** provides a competitive permit system to encourage and facilitate efficient and responsible exploration for the State's geothermal resources.

- ***Tasmania*** **-** Geothermal exploration and development has been covered for over a decade by the ***Mineral Resources Development Act*** (1995) (MRD Act) and using this tried legislation, exploration has been able to be conducted with little regulatory impediment or uncertainty.

- ***Western Australia*** **-** The West Australian (WA) ***Petroleum and Geothermal Energy Resources Act 1967*** (PGERA67) was proclaimed on 15 January 2008, providing legislative coverage for both conventional (hydrothermal) geothermal energy and hot dry rock geothermal energy.

- ***Northern Territory*** **-** The ***Northern Territory of Australia Geothermal Energy Act, 2009*** has been passed and assented to and is expected to come into operation in mid-August 2009. The NT Government is in the process of developing the Regulations, Forms and Guidelines prior to triggering the Act.

Market Players & Competition

- **Geodynamics** **<GDY.AX>** Geodynamics is Australia's largest geothermal company, with a specific focus on using enhanced geothermal systems (EGS) methods to extract heat from hot rocks. The company has raised some AUD$ 142 M in the 5 years to December 2007.

Efforts are focused in the Cooper Basin area in South Australia and three wells. Plans are to drill the fourth well, Jolokia. For a detailed company profile, see Appendix A.

- **Eden Energy Limited** **<EDE.AX>** Eden Energy is the second largest geothermal company listed on the ASX. Chowilla 1 was drilled to 512 m in the Renmark-Tararra Trough, in the Riverland of South Australia, 40 km northeast of Renmark. Chowilla-1 is located to establish geothermal resources in proximity to transmission lines running to Adelaide and Broken Hill.

- **Petratherm Limited** **<PTR.AX>** Petratherm has drilled two wells to establish thermal gradients down to about 600 m above exceptionally high heat producing granites in South Australia. In June 2006, the phase-2 drilling program at Paralana was successfully completed with the geothermal test well being extended to 1,807 m. Temperature logging of the well suggests a world class thermal resource is located at Paralana, with extrapolations indicating 200 ºC at a depth of 3,600 m within insulating sedimentary rocks that are predicted to be susceptible to fracture stimulation. Petratherm refers to this play concept as ***Heat Exchange Within Insulator*** (HEWI). High heat producing basement rocks are a prerequisite for high quality HEWI plays. Petratherm plans to create a HEWI system with the circulation of water between the two Paralana project wells to demonstrate hot rock EGS energy production from an initial small scale power plant that will supply up to 7.5 MW to a growing electricity market 10 km away at the Beverley Uranium Mine. This plan is the subject of a Memorandum of Understanding between Petratherm and the owners of the Beverley Mine, Heathgate Resources. An ASX-listed upstream oil and gas company (Beach Petroleum) has taken an equity position in the Paralana project. In November 2007, Petratherm signed a Letter of Intent for Ensign International Energy Services to secure a suitable rig and drill a deep Paralana well. Stimulation, flow testing and the drilling of a second well would follow, pending results of the first deep Paralana well.

- **Torrens Energy Limited** **<TEY.AX>** Torrens Energy drilled five wells of its nine well program in its Lake Torrens project area in late 2007. The aim of this program is to delineate heat flow trends as a precedent to locating deep proof-of-concept wells in proximity to the National Electricity Grid and power markets.

- **Geothermal Resources Limited** **<GHT.AX>** Geothermal Resources Limited is exploring a gravity low that could be a high heat producing granite associated with hot rock reservoirs predicted to be over 200 ºC at roughly 4,000 m depth in its Frome project area. Potential hot rock power markets for the Frome project are electricity consumers connected to the National Electricity Grid, some 120 km away at the township of Broken Hill. Pending further encouraging results from the shallow drilling in 2008 and rig availability, Geothermal Resources will then drill deeper wells in the Frome area.

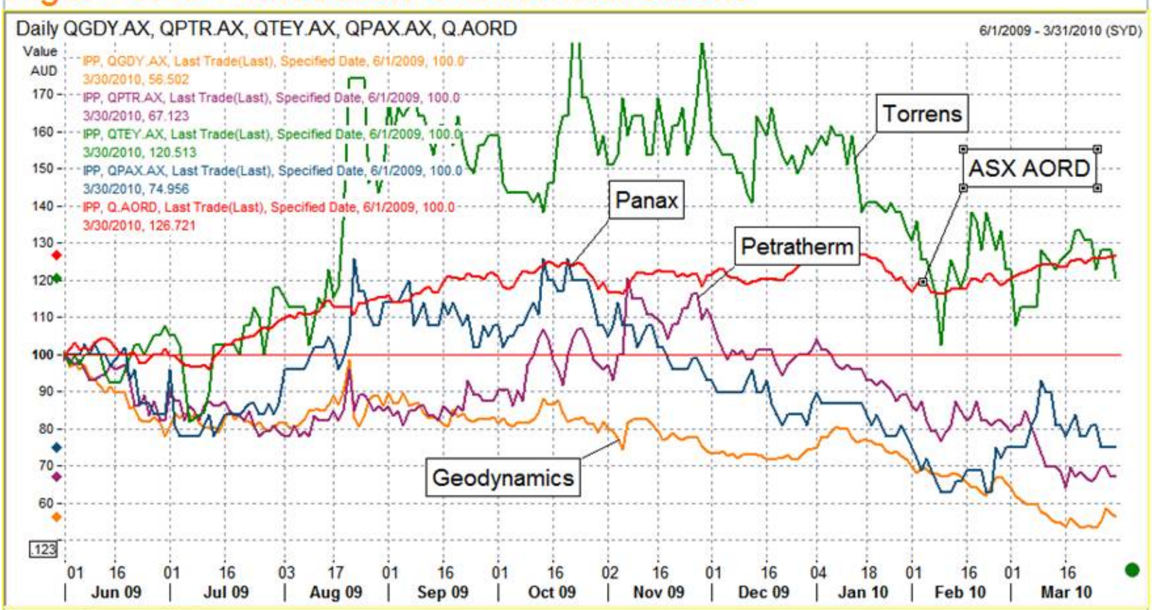
- **Greenearth Energy Limited** **<GRE.AX>** Greenearth is the operator of the Lakes Oil Geothermal Exploration Permits (GEPs) in the State of Victoria. Greenearth also has rom four additional wells: Hazelwood-1 and Boola Boola-2; Alberton-1; and Napier High-1 (in an application area for a Petroleum Retention Licence, will be drilled after the grant of the relevant PRL). Greenearth has retained rights to deepen, core and log Boola Boola-2 from depths below 1,715 m.

- **Panax Geothermal Limited <PAX.AX>** Scopenergy was acquired by Uranoz (an ASX-listed company changing its name to Panax Geothermal) in October 2007.

- **Green Rock Energy <GRK.AX>** Green Rock Energy Limited is a public listed company on the ASX and aims to explore, develop and produce geothermal energy from both hydrothermal systems and EGS for electricity and direct use. Green Rock held exploration licences for three major project areas in South Australia: Olympic Dam, Patchawarra and Upper Spencer Gulf. The company owns 100 % interest in an area at BHP Billiton's Olympic Dam mine, where hot granites at ~ 2 km depth have been located.

- **KUTh Energy Limited <KEN.AX>** KUTh Energy has a shallow drilling program of 33 wells in eastern Tasmania. The shallow drilling campaign, when completed, will allow systematic down-hole temperature measurements across all of its +14,000 km^2 of tenements, leading to a high quality heat flow map. The heat flow map will allow optimal location of holes initially to 1,500 m, and then deep production holes into the thermal basement.

Figure 6.18 - Australian Geothermal Stocks



Source: Thomson Reuters

6.7.14 New Zealand

Market Size & Growth

New Zealand is located has an abundance of natural geothermal resources and currently generates 452MW (5%) of its power from Geothermal and is expected to increase its capacity with the potential development of an additional 600 MW over the next few years. Contact Energy and Mighty River Power have stated that they each expect to spend about NZ$ 1 billion in developing geothermal resources over the next 10 years.

The NZ Government banned all new fossil fuel (non-renewable) power plants for the next 10 years in 2007 and Geothermal was recognised as a resource vital to New Zealand's future energy mix and is economically competitive at the current average wholesale electricity cost of about US$50/MWh and could double with the correct incentives in place.

However, there are no direct government incentives, in the form of renewable energy feed-in tariffs (FiT) or subsidies in New Zealand. Total capital costs of generation from new geothermal plants now average about NZ$ 3-4 M/MW installed. Drilling costs have increased significantly in recent years by about 50% to about NZ$ 4 M/2km for a deep well.

Geothermal comprises about 4.9 % of the national capacity. However, it generates 7.7 % of the total national electricity.

Summary of New Zealand Geothermal Power Projects

Geothermal System	Start Date	Capacity (MW)	Direct Use (MW)	Constructing (MW)	Planned (MW)
Wairakei	1958-2005	176			234-162
Poihipi	1996	55			
Tauhara Centennial	2007		100		23
Tauhara Expansion					220
Kawerau	1958	14	200	100	
Ka 24				10	
Ohaaki (104 MW_e)	1989	50			
Rotokawa	1997	35			132
Mokai	1999-2007	112			
Ngawha	1998	10		15	
Ngatamariki					80
Total		**452**	**300**	**125**	**527**

Source: GIA

Drivers & Constraints

New Zealand has the highest percentage of power generated from renewable energy in Asia Pacific and a number of regulations and policies that is supposed to drive that number up to 90% by 2025. However, a change in government in 2008 has forced a review of the Energy Strategy and may impact the projected growth in geothermal energy in New Zealand.

Market Players & Competition

Companies involved in Geothermal in NZ include:

- **Contact Energy <CEN.NZ>** is a diversified and integrated energy company, focusing on the wholesale generation of electricity and the retail sale of electricity, natural gas and liquefied petroleum gas (LPG), and related services in New Zealand. The Company operates in two segments: retail and generation. The retail segment encompasses any activity that is associated with the Company's supply of energy and related services to end-user customers. The generation segment encompasses any activity that is associated with the Company's generation of electricity or steam and its sales to the wholesale electricity market. It also includes all activities in relation to the gas storage facility at the Ahuroa reservoir, including the cushion gas required to enable the field to be used for storage.

6.7.15 Summary of Companies involved in Geothermal

Code	Compay Name	Market Cap (M Dollars)	PE ratio	Country	Sector
9508.T	Kyushu Electric Power Co Inc	$10,584.7	13.0	Japan	Utilities-Electrical & Gas
6654.T	FUJI ELECTRIC INDUSTRY CO LTD	$63.9	22.4	Japan	Electronic Components & Instruments
7011.T	Mitsubishi Heavy Industries Ltd	$13,117.9	1238.5	Japan	Machinery & Engineering
GDY.AX	Geodynamics Ltd	$163.7	N/A	Australia	Energy Sources
PAX.AX	Panax Geothermal Ltd	$39.7	N/A	Australia	Energy Sources
PTR.AX	Petratherm Ltd	$21.4	N/A	Australia	Energy Sources
TEY.AX	Torrens Energy Ltd	$13.4	N/A	Australia	Utilities-Electrical & Gas
WAS.AX	Wasabi Energy Ltd	$22.3	N/A	Australia	Utilities-Electrical & Gas
GHT.AX	Geothermal Resources Ltd	$9.3	N/A	Australia	Energy Sources
GRK.AX	Green Rock Energy Ltd	$7.0	N/A	Australia	Metals - Non Ferrous
HRL.AX	Hot Rock Ltd	$8.5	N/A	Australia	Utilities-Electrical & Gas
KEN.AX	KUTh Energy Ltd	$6.2	N/A	Australia	Energy Sources
GER.AX	Greenearth Energy Ltd	$9.7	N/A	Australia	Energy Sources
EDC.PS	Energy Development Corp	$2,354.1	N/A	Philippines	Utilities-Electrical & Gas
AP.PS	Aboitiz Power Corp	$1,945.0	17.8	Philippines	Utilities-Electrical & Gas

Source: Thomson Reuters

6.8 Smart Grid

6.8.1 Background

The term “Smart Grid” refers to a system that incorporates information and communications technology into every aspect of electricity generation, delivery and consumption to improve reliability and service, and reduce costs and improve efficiency. The driver for a smart grid is the need to feed in and manage the intermittent renewable energy from multiple sources, such as wind and solar energy.

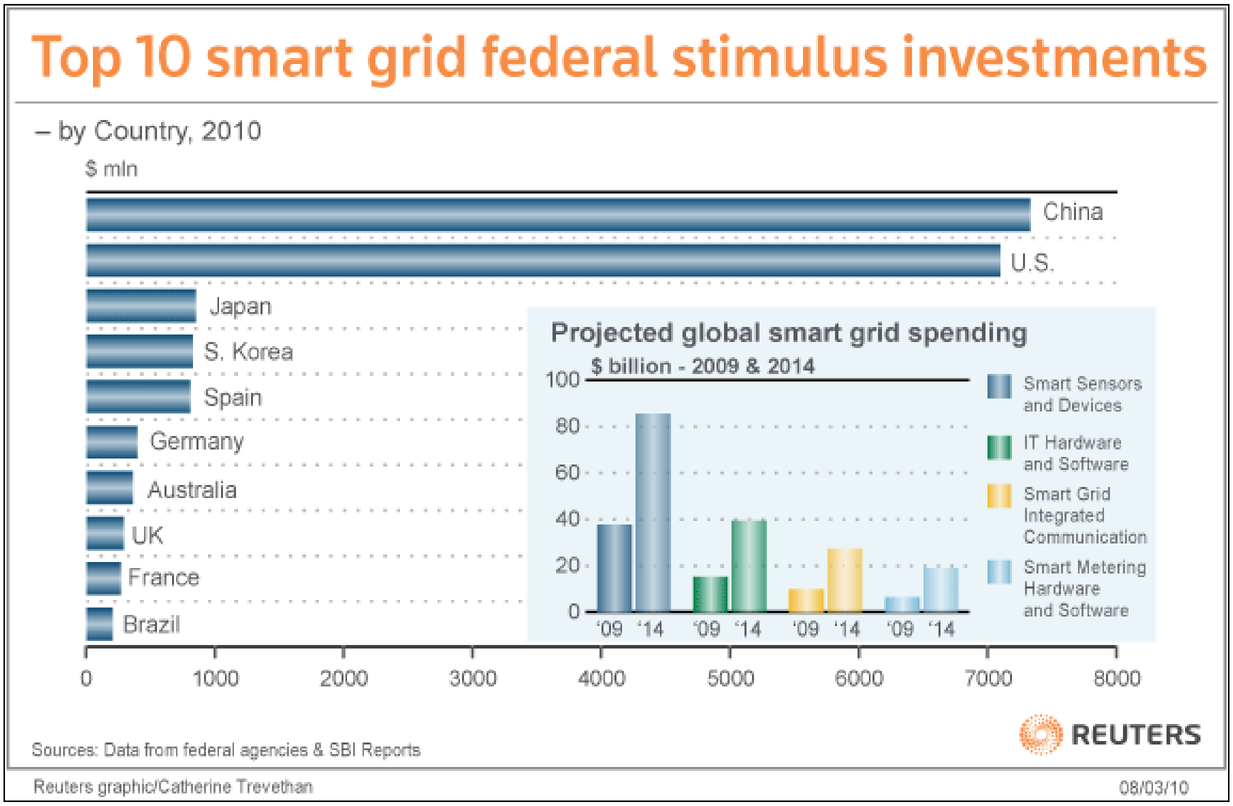
Countries across APR have embraced the concept of Smart Grid and recognize that it is a key component of fulfilling the various renewable energy targets. There have been a number of recent announcements from China, Japan, South Korea, Taiwan, Australia, New Zealand looking to take the lead in smart grid technology.

China, Japan, South Korea and Taiwan have targeted this sector and companies in their electronics sector see this as an extension to the electronics and solar businesses.

6.8.2 Targets & Incentives

A number of recent announcement have been made by countries across Asia Pacific, in a bid to take a lead in this growing market, with China, Japan and South Korea investing about $9 billion in 2010.

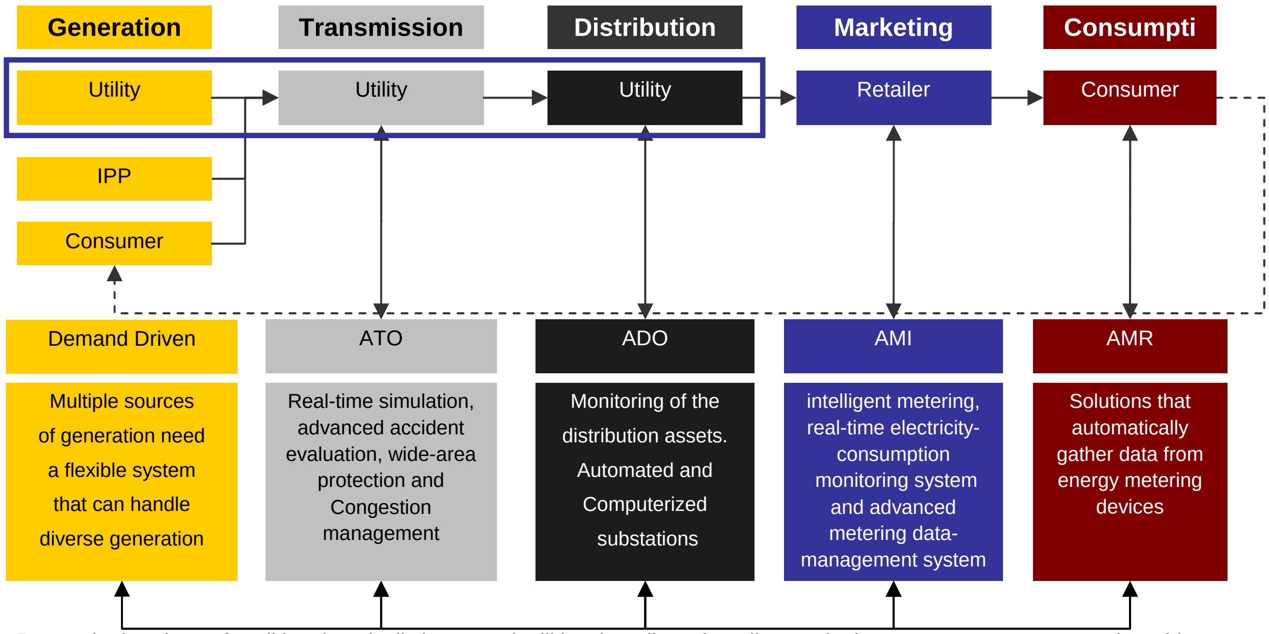
- ***China*** has announced a investment in its grid system, that will include smart grid technology
- ***Japan*** has launched a number of demonstration projects via NEDO and Japanese companies are looking to target the US market
- ***South Korea*** has started work on its pilot scheme in Jeju Island and also targeting other countries with its smart grid technology
- ***Taiwan*** has targeted a pilot scheme and Taiwanese companies
- ***Singapore*** has started a pilot scheme in 2009
- ***Australia*** has a launched a 100m government fund to set up a smart grid scheme. There are also State projects in Victoria, NSW and Western Australia.
- ***New Zealand*** is in the second phase of its smart grid upgrade



6.8.3 Smart Grid Process

The existing power generation system has not really changed, since its invention in the late 19th century. Grids are essentially a central driven supply driven one way so that it generates and supplies power to a community, based on estimates of past demand requirements. The break up of the traditional vertically integrated utility, along with the introduction of new generating sources (IPPs and end consumers), along with separate retailers, means that there is a need for a more integrated and flexible grid that can cater for the drastic changes in both supply and demand. This new "***intelligent system***" is commonly referred to as the smart grid. There are five basic components required in a new smart grid system.

Figure 6.20 – Smart Grid



Due to the break up of traditional vertically integrated utilities that allowed retailers and other power generators onto the grid,
There is a need for an integrated, flexible system to manage the changes in both supply and demand

REUTERS

Advanced transmission operations (ATO)

ATO includes real-time simulation, advanced accident evaluation, wide-area protection and congestion management. It can decrease the blackout risk of large-scale grids and connect intermittent power supply onto the grid. ***Wide Area Management System*** (WAMS) – Integrated system that monitors and controls elements of the electrical power grid to ensure availability and improve reliability and efficiency of the network

Advanced distribution operations (ADO)

ADO will adopt the visible monitoring of the distribution assets. ADO can be self healing based on ***Distribution Fast Simulation and Modelling*** (DFSM). While the primary grid is shut down, the distributed power generation will supply power to key account.

A ***Digital Substation*** is one that is automated and computerized, providing greater transparency, higher reliability and efficiency of operations.

Advanced metering infrastructure (AMI)

AMI includes intelligent metering, real-time electricity-consumption monitoring system and advanced metering data-management system. Advanced Metering Infrastructure (AMI) measures, collects, stores and analyzes utility usage, such as electricity, gas or water usage; is a broader concept than AMR-IP based solution.

IP-Based Automatic Meter Reading (AMR-IP)

Solutions that automatically gather data from energy metering devices and transmit to a central processing facility where billing is handled and consumption patterns are analyzed Real-Time

Information Processing. They enable real time communication between core nodes in the electric network, including customer premise, and allow better management of demand, improved reliability and flexibility of the network.

6.8.4 China

Market Size & Growth

On May 21, 2009, China has announced a framework for Smart Grid deployment with investment that could reach Rmb1tn over the next 10 years, with around Rmb200bn for State Grid in the coming five years from 2010-14. Smart metering (AMR) has already kicked off with an Rmb80bn budget for the next five years, with ***Heilongjiang*** being a trial province. The smart grid should improve transmission and distribution efficiency under State Grid's strong network and facilitate renewable-energy expansion.

Drivers & Constraints

As part of its current 5-year plan, China is building a ***Wide Area Monitoring system*** (WAMS) and by 2012 plans to have ***Phasor Measurment Unit*** (PMU) sensors at all generators of 300 MW and above, and all substations of 500 kilovolts and above.

Power generated from and solar and wind sources are intermittent and will require a more advanced power-grid system. Under China's latest renewable-energy plan, wind power capacity and solar energy capacity will reach 100GW and 30GW respectively by 2020, which will make a combined 8% of total capacity by 2020 and require and active system to manage potential imbalances.

Market Players & Competition

Key players that should benefit from the Smart Grid investment in China include:

- **Wasion** **<3393.HK>** Wasion is a leader in China's electronic-power-meter market, with a leading market share in the electronic power meters, single-phase electronic power meters and in data-collection terminals and power-management system. It also sells water, gas and heat meters. The major customers are ***State Grid Corporation of China*** (SGCC) and ***China Southern Power Grid*** (CSG). These core state-owned enterprises are closely related to national energy security and the economy. They are responsible for building and operating power grids to provide a secure and reliable power supply. Wasion also acquired water, gas and heat-meter companies, and is positioning itself as an integrated meter and data-collection system provider. The company is expected to benefit from the governments plan to invest in smart grid technology. For a detailed company profile, see Appendix A.

- **Sieyuan Electric** **<002028.SZ>** Sieyuan Electric Co., Ltd. is a China-based company primarily engaged in research, development, manufacture and sale of power transmission, distribution and monitoring equipment. The Company provides protection devices for power automation, high-voltage switches, high-voltage transducers, capacitors, reactors, power electronics products and power controlling products, among others. It distributes its products principally in domestic market. For a detailed company profile, see Appendix A.

- **JiangSu YongDing** **<600105.SS>** JiangSu YongDing Company Limited is principally engaged in the manufacture and sale of optical cables, electric cables and communication equipment. The Company primarily provides layer-stranding cables, central beam tube cables, ribbon optical fiber cables, power optical cables and soft cables, among others. The Company primarily distributes its products mainly in China’s domestic market.

- **NARI Technology Development** **<600406.SS>** NARI Technology Development Limited Company is principally engaged in the development, manufacture and sale of software and hardware products serving the power industry, as well as the provision of system integration services. The Company mainly offers products of power grid dispatching automation, integrated substation automation, rural power network automation, industrial process control automation, rail transportation automation, protection automation, electricity market operating system and distribution automation. For a detailed company profile, see Appendix A.

- **Guodian Nanjing Automation** **<600268.SS>** Guodian Nanjing Automation Co. is principally engaged in the development and production of power automation equipment. The Company's major products include protection and automation equipment for power grids and power plants, water conservancy and hydropower protection equipment and industrial automation protection equipment. Through its four branches, the Company provides solutions for digital substations, power grid relay protection systems, substation automation systems, power grid automation systems, digital power plants, energy-saving and emission-reduction projects, water treatment, hydropower station integrated automation systems, water conservancy automation, industrial automation, rail transportation automation and information technology, among others. The Company also offers intelligent electric equipment, photoelectric mutual inductors and high/low voltage distribution series.

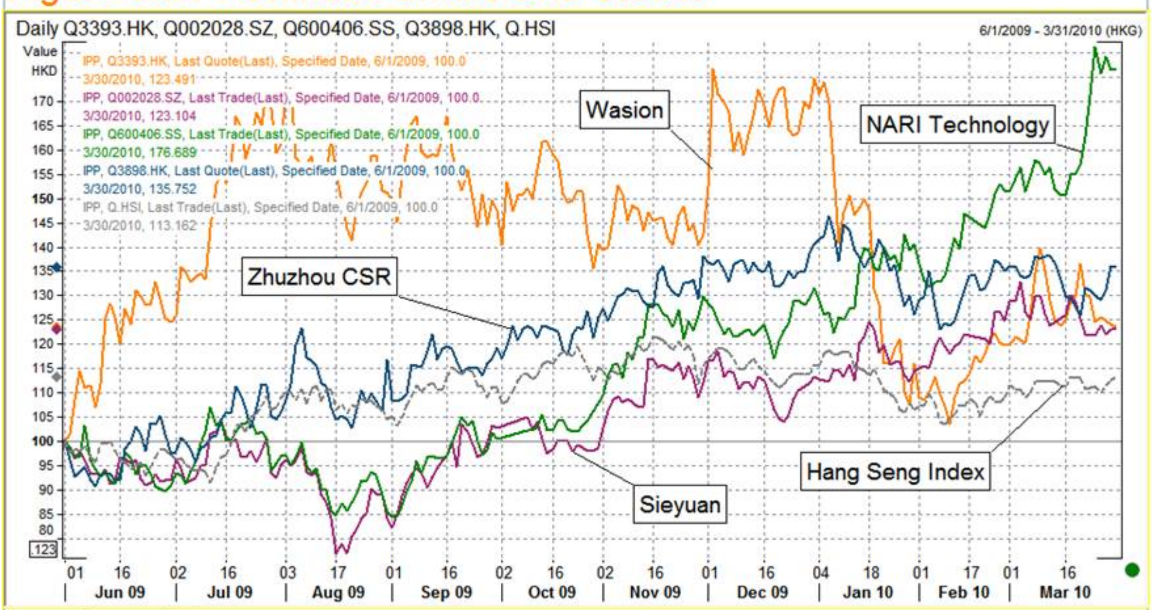
- **XJ Electric** **<000400.SZ>** XJ Electric Co., Ltd is a China-based company principally engaged in research, development, manufacture and sale of automation, protection and controlling products for electric power systems. The Company provides electric network scheduling automation equipment, electric distribution network automation equipment, substation automation equipment, power station automation equipment, railway power supplying automation equipment, network security and stabilization controlling equipment, power management information systems, technology supporting systems for power market, relay protection and automation controlling equipment, relays, electronic measuring instruments, medium-voltage switches and switch cabinets, as well as transformers and combined substations. It distributes its products primarily in domestic market. For a detailed company profile, see Appendix A.

- **Rongxin Power** **<002123.SZ>** Rongxin Power Electronic Co., Ltd. is primarily engaged in the design and manufacture of energy-saving and high-power electric and electronic equipment. The Company's offerings are static var compensators (SVCs), smart gas emission devices (MABZs), power filters, high-voltage frequency converters (HVCs), variable frequency starters (VFSs) and static var generators (SVGs). The Company distributes its products within the domestic market and to overseas markets.

- **Dongfang Electronic** **<000682SZ>** Dongfang Electronics Co.,Ltd, formerly Yantai Dongfang Electronics Information Industry Co., Ltd., is principally engaged in the development, production and distribution of electrical and industrial automation controlling systems. The Company primarily provides electricity dispatch automation systems, power protection and transformation integrated automation systems, power distribution automation systems, information management systems, electricity bill measurement systems, traction power supplying automation systems of electric railways, as well as cable and wire products.

- **Zhuzhou CSR Times Electric Co Ltd** **<3898.HK>** is engaged in the sale and manufacture of train-borne electrical systems and electrical components. The Company is also engaged in the manufacture and sale of electrical systems and components relating to locomotive and rolling stock. The Company supplies a range of on-board electrical systems, including train power converters, auxiliary power supply equipment and control systems, train operation safety equipment and electrical control systems for large railway maintenance vehicles. The Company also produces electrical components, including power semiconductor devices, sensors and related products and other products for its own raw material requirements, and to sell to third parties.

Figure 6.21 - Chinese Smart Grid Stocks



Source: Thomson Reuters

6.8.5 Japan

Market Size & Growth

The Japanese government and companies are making a renewed push into smart grid technology, in a bid to catch up with US. While projects in Japan are still in R&D stage, Japanese companies have started to target the US market, with a project in New Mexico.

Drivers & Constraints

The government decided to launch a verification test for the next generation transmission network - the smart grid in 2009. Through the test, Japan aims to establish technology for securing power system stability in preparation for the massive introduction of new energy sources such as photovoltaic power. The verification test will be carried out on an isolated island in cooperation with electric utilities in order to determine whether the smart grid can be introduced to the power system in Japan.

Public Sector

NEDO has started four microgrid demonstration projects at Aomori, Aichi, Miyagi and Kyoto Prefectures under its ***Regional Power Grid with Renewable Energy Resources Project*** in 2003.

- ***Aomori Project in Hachinohe***. The project includes PV and biomass, are used to supply electricity and heat. The microgrid serves seven City of Hachinohe buildings. These facilities are interconnected through a 6-kV, 5.4-km duplicate distribution line, with the whole system connected to the commercial grid at a single PCC.

- ***Aichi Project near the Central Japan Airport****.* This project supplies a Tokoname City office building and a sewage plant via a private distribution line. Its main feature is a combination of fuel cells supplied by energy from biogas, wood waste and plastic bottles.

- ***Kyoto Project at Kyotango***. This project called the ***Kyoto Eco Energy Project*** is run by the municipal government of Kyotango City. An energy control center communicates with the DERs by internet protocol over the legacy telecom network to balance demand and supply, and energy is fed into the legacy distribution system.

- ***Sendai Advanced Regional Electricity Network Program.*** NEDO also sponsors a multiple PQR service demonstration which was completed in October 2006. The purpose of this research is to demonstrate multiple simultaneous PQR supply, as may be requested by a range of customers.

Private Sector

In addition to the government-sponsored projects, significant private sector research activities are also in progress.

Shimizu Corporation, with the cooperation of the University of Tokyo, is developing a microgrid control system using a test microgrid at its research center in Tokyo.

Tokyo Gas also aims to establish distributed energy networks including microgrids within its service territory. Tokyo Gas is developing an integrated ***Distributed Energy Resources*** (DER) control system based on simulation studies and experiments at its test facility in Yokohama.

In addition, Japanese firms, including ***Toshiba, Kyocera, Shimizu, Tokyo Gas Co.,*** and ***MHI***, will spend $33.4 million on a smart grid project in Los Alamos and Albuquerque, New Mexico. Toshiba says it will install a 1-megawatt storage battery at the Los Alamos site, while Kyocera and Sharp will test smart home, energy management and load control technology. The Yomiuri

Shimbun reported that METI will try to get the International electrotechnical Commission to adopt 26 Japanese standards to serve as global standards for the smart grid.

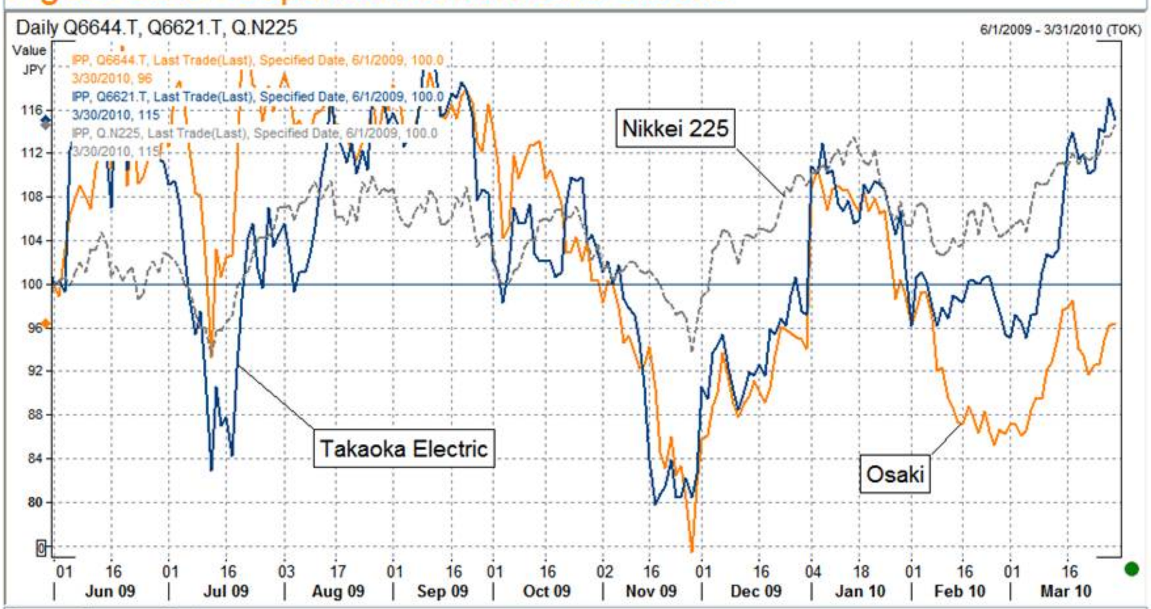
Market Players & Competition

- **Osaki Electric Co** **<6644.T>** operates in three business segments. The Measurement and Control Equipment segment manufactures and sells electric meters, current limiters, monitor and control equipment, time switches, optical-communications-related equipment, automatic meter reading (AMR) systems and equipment, switchboards and distribution switchboards. For a detailed company profile, see Appendix A.

- **Kikusui Electronics** <Unlisted> is mainly engaged in the manufacture and sale of electronic applied equipment. The Company develops, manufactures and sells power electronics equipment including power supply controllers, electronic loads and battery testers, alternating current (AC) power supplies, as well as test and measurement instruments including harmonics and flicker testers, jitter meters, signal generators and digital multi-meters.

- **Takaoka Electric Manufacturing** **<6621.T>** operates in two business segments. The Electric Equipment Materials segment is engaged in the manufacture, sale and repair of power transformers for electricity distribution and receiving, pole transformers, terrestrial transformers, reactors, switches, electric supervision and control systems and environmental systems,

Figure 6.22 - Japanese Smart Grid Stocks



Source: Thomson Reuters

6.8.6 South Korea

Market Size & Growth

South Korea hopes to become the world's first country with a nationwide smart grid by 2030. It has poured KRW35 bn (USD 28.2 m) into smart grid research and development every year since 2005, with over KRW250 bn (USD 201m) to be used by 2012.

In a further statement in January 2010 by the ***Ministry of Knowledge Economy*** (MKE), South Korea will spend about 27.5 trillion won ($24bn) by 2030 building smart electricity grids.The private sector is expected to invest 24.8 trillion won, with the government meeting the 2.7 trillion won shortfall.

Drivers & Constraints

Korea's MKE expects the nationwide smart grid to reduce the country's power consumption by 3%. By transmitting electricity to consumers during non-peak hours, Korean utilities are expected to reduce greenhouse gas emissions by 41m tonnes and cut fossil fuel imports by USD 10bn. Consumers will also benefit by enjoying an average 15% decrease in their electricity bills.

South Korea has begun construction of its first smart grid pilot project on ***Jeju Island***. The project, scheduled to be completed in 2013, will benefit 6,000 households on the resort island. The Jeju system will have facilities to allow the full use of electric cars, a network to harness clean energy, and electric services and grids that can enhance energy conservation. AMRs will also tell users when electricity prices are cheapest during the day so they can recharge home appliances and cars at less cost. The government said it will provide KRW58 bn (USD 46.5 m), or roughly half of the construction cost, with the rest coming from the private sector.

Market Players & Competition

- **LS Industrial Systems** **<010120.KS>** offers power transmission and distribution equipment, automation and control systems, and industrial equipment and systems. The Company's power transmission and distribution equipment includes low-, medium- and high-voltage equipment, measuring and protection equipment, switchgears and transformers. Its automation and control systems consist of programmable logic controller (PLC) products, inverters, automation solutions and intelligent transportation systems (ITSs).

- **NURI Telecom** <Unlisted> NURI Telecom is a provider of AMI solutions that allow two-way, realtime communication with customers. Around half-million meters were deployed with AiMiR System throughout Asia and Europe.

6.8.7 Taiwan

Market Size & Growth

Taiwan's biggest power company, telecoms operator and IT firms are designing metering and communication systems to link air conditioners and lighting systems with computers and mobile phones.

According to the government's ***Industrial Technology Research Institute*,** more than five million smart meters will be installed at a cost of NT$50bn ($1.5bn), over the next 5 years.

Drivers & Constraints

Taiwan is putting in place a smart meter policy to build up its domestic market and target the international smart metering market, estimated to be 30 million meters, over the next 30 years.

Market Players & Competition

Manufacturing

Many of Taiwan's electronic companies have targeted smart grid and include:

- **Fortune Electric Co., Ltd <1519.TW>** is engaged in manufacture and sale of electrical equipment. The Company provides transformers, electric switchboards, distributor devices and other products. The Company also involves in provision of contract engineering services. It distributes its products in domestic and overseas markets.

- **Allis Electric Corp. <1514.TW>** is principally engaged in manufacturing power distribution and switching components and equipment. The Company provides its products under four categories: switchboards, such as high and low voltage switchboards, motor control centers and switch boxes; transformers, including reactors, potential transformers and current transformers; industrial, communication and electronic switches, such as chargers, rectifiers, un-interruptible power supply systems, switchable direct current power supply, as well as power transmission and distribution apparatus, such as oil switch, vacuum switches and others.

- **Luxe Co., Ltd. <1529.TW>** is a Taiwan-based company engaged in design, manufacture and installation of switchboards and other electrical appliances. The Company provides switchboards, including high voltage and low voltage switchboards, motor control centers, relays-meters, generator parallel control panels and switchboards for ships, among others; transformers, including low voltage transformers, outdoor transformers, current transformers and voltage transformers; electrical appliances, including breakers, cutouts, resistors and high voltage direct current power supplies, as well as monitoring network products such as remote terminal units (RTUs), supervisory control and data acquisition systems (SCADAs) and management information systems (MISs). The Company also involves in construction and installation of electrical engineering projects, such as wind power generation projects, electric power substation projects and turnkey projects of thermal and electric power cogeneration

Utility

- Taiwan Power, the island's utility, will launch a small-scale research study of less than 100 homes, which will be rapidly expanded to tens of thousands of homes in the next two to three years.

6.8.8 India

Market Size & Growth

North Delhi Power Limited (NDPL) is building a smart grid in India with GE Energy's ***PowerOn Outage Management System***.

Drivers & Constraints

There is no government mandate to invest in Smart Grid Technology in India, with the major push from private sector projects. At present NDPL is the leading utility in the smart grid, with its project with GE Energy.

Market Players & Competition

Utilities

- **North Delhi Power Ltd** <Unlisted>

6.8.9 Singapore

Market Size & Growth

Singapore has a small market and is positioning itself as a regional hubfor companies to set up a test bed and target larger markets across the region.

Drivers & Constraints

Singapore wants to set itself up as a Clean Technology Hub and test bed for Asia and has targeted Smart Grid, as a key sector for investment. It has launched a pilot scheme via the EMA.

Market Players & Competition

- The Energy Market Authority (EMA) has initiated the Electricity Vending System (EVS) pilot, where selected households can monitor their real-time electricity consumption using smart meters. The pilot program involves 1,000 households in the ***Marine Parade*** and West Coast areas will run till December. Through the EVS, participating users can also select electricity packages from a retailer of their choice.

6.8.10 Indonesia

Market Size & Growth

The Indonesian Utility market is essentially dominated by one large government vertically integrated utility, Perusahaan Listrik Negara (PLN) and thus any smart grid technology would need to be driven by PLN.

Drivers & Constraints

There are no investment plans for the Smart Grid in Indonesia.

Market Players & Competition

- PLN. At present there does not appear to be any smart grid investment planned by PLN

6.8.11 Malaysia

Market Size & Growth

The Malaysian Utility market is essentially dominated by one large government vertically integrated utility, Tenaga Nasional Berhad on the peninsula and Sabah Electricity for Sabah State and Sarawak Electricity Supply Corporation for Sarawak State. These utilities will be responsible for driving any smart grid technology upgrades.

Drivers & Constraints

There are no investment plans for the Smart Grid in Malaysia. CIRED Malaysia, Malaysian National Committee of CIGRE and IEE Power & Energy Society have raised awareness of the Smart Grid in Malaysia.

Market Players & Competition

- ***Malaysian Resources Corporation Berhad*** *(MRCB)* has signed an MoU with Cisco and Datacraft to provide smart grid and real estate technology to its new Kuala Lumpur developments

6.8.12 Philippines

Market Size & Growth

The Philippines Utility market is essentially dominated by a few large government vertically integrated utilities, namely: National Power Corporation, MERALCO and National Grid Corporation of the Philippines. These utilities will be responsible for driving any smart grid technology upgrades.

Drivers & Constraints

There are no investment plans for the Smart Grid in Philippines. However, a number of the utilities, notably PNOC and Meralco are investigating smart grid technologies with Kepco and Siemans, respectively.

Market Players & Competition

Utilities

- ***Philippine National Oil Company***. Kepco is planning to incorporate smart grid technology in expanding in the Philippine wind and hydro power plant projects. Kepco has partnered with state-run Philippine National Oil Company-Renewable Corp. for the investment opportunities in the renewable energy.

- ***Manila Electric Co.*** (Meralco), the largest power distributor in the Philippines, is seeking ways to improve operational performance. Meralco president and CEO Jose de Jesus said that Siemens' smart grid solution would allow for improved performance at the utility.

6.8.13 Thailand

Market Size & Growth

The Thai Utility market is essentially dominated by a few large government vertically integrated utilities, namely: ***Electricity Generating Authority of Thailand*** (EGAT), ***Metropolitan Electricity Authority*** (MEA) and ***Provincial Electricity Authority*** (PEA). These utilities will be responsible for driving any smart grid technology upgrades.

Drivers & Constraints

There are no investment plans for the Smart Grid in Thailand.

Market Players & Competition

There are no companies identified in Thailand in this sector.

6.8.14 Australia

Market Size & Growth

The Australian Utility Market is split into 3 markets: the ***National Electricity Market*** (NEM); the ***Wholesale Electricity Market*** (WEM) for Western Australia; and the ***Darwin and Katherine Interconnected System*** (DKIS) servicing the Northern Territory.

- NEM was established by the disaggregation of the government vertically integrated system and supplies electricity to 6 states: ACT, NSW, Queenland, Victoria, South Australia and Tasmania and accounts for around 200 GWh per year, over 90% of the total power generation

- WEM was established by the restructuring of Western Power Corporation, into four corporations: Synergy; Horizon Power; Verve Energy and Western Power and accounts for around 16.5 GWh per year.

- DKIS is dominated by the government owned Power and Water corporations and accounts for less than 2 GWh per year

Drivers & Constraints

The key driver for smart grid technology is the ***Renewable Energy Target*** (RET), which will require utilities to generate 20% of its power from Renewable Energy. In order for utilities to manage this potentially huge change in supply and demand, a smart grid will need to help manage these imbalances.

Government Project

The Australian Government has committed to investing $100m in smart grids. In October 2009, it asked for proposals to initiate a study into the technology. The study is expected to increase customer awareness and engagement in energy usage and establish distributed demand management and distributed generation management. Within Australia the adoption of smart grids is hindered by a lack of service level obligations on electricity distribution businesses to connect distributed generation devices in a timely fashion. Submissions from industry consortia will be assessed by an independent panel and the successful consortium announced by Government in 2010.

State Projects

In addition, there are state projects including:

- ***Victoria***. Victoria's smart grid plan, as announced by energy and resources Minister Peter Batchelor in 2009, will give 2.5 million Victorians the ability to monitor their own energy use and allow utilities to read, connect or disconnect meters remotely and respond faster to power outages. UED and Jemena are rolling out smart meters, with a further three utilities expected to roll out similar technologies.

- ***New South Wales***. The University of Sydney and Energy Australia have signed an agreement on 26 May 2009 a $5 million partnership to lead smart grid development in Australia. The NSW Government launched a Smart Village in Newington in 2009, where appliances can be switched on and off remotely using an iPhone, people can get around on plug in electric scooters and energy costs and carbon emissions are graphed in near real-time.

- ***Western Australia***. Western Power, the ***Smart Grid-Advanced Meter*** Infrastructure pilot itself forms part of the federal government's A$73.5 million Perth Solar City project.

Market Players & Competition

- ***United Energy Distribution*** (UED) Victorian power utilities UED and ***Jemena*** have selected ***Silver Spring Networks*** to roll out smart meters to over a million Victorian homes in 2009. UED provides power to 660,000 people in South-East Melbourne and on the Mornington Peninsula.

- ***Jemena*** is also part of the smart meter roll out project .Jemena serves 320,000 more in North and Inner-West Melbourne.

- ***Country Energy*** has built an ***Intelligent Network*** (IN) Demonstration Center to showcase the benefits of a smart grid through real examples such as energy storage and vehicle to grid.

- ***CSIRO***. The Intelligent Grid Research Program is an Australian collaboration between the CSIRO and five universities investigating technologies and practices to make our electricity networks smart, greener and more efficient.

6.8.15 New Zealand

Market Size & Growth

The New Zealand electricity market was deregulated in 1996, under the formal Electricity Rules and Regulations and is overseen by the market regulator, the Electricity Commission.

There are 5 generators in New Zealand: Meridian, Genesis, Mighty River Power, Contact, and TrustPower and they account for about 95% of New Zealand's electricity.

Ther are 12 retailers in New Zealand: Bay of Plenty Electricity, Bosco Connect, Contact Energy, Energy Direct NZ, Genesis Energy, King Country Energy, Mercury Energy, Meridian Energy, Nova Energy, Powershop, Simply Energy, and Trust Power.

Drivers & Constraints

The key driver for the smart grid upgrade is the 90% renewable energy target by 2025, as part of its ***Energy Plan*** in 2007.

Market Players & Competition

- GE Energy announced in July 2009 that the first phase of an advanced smart grid system has been implemented in New Zealand. GE is working with Orion New Zealand Limited, an electricity distribution network supplying 190,000 homes and businesses in the country, on the project

- **Meridian Energy** <Unlisted> introduced the usage of smart meters in the Central Hawkes Bay area with over 1000 households participating. By late 2006, over 6,300 smart meters had been installed as part of the initial trial. On June 28, 2007 the first roll-out began for households in Christchurch and there are plans to install over 112,000 smart meters by January 2009. The smart meters are made by Christchurch based company Arc Innovations, a wholly-owned subsidiary of Meridian Energy.

6.8.16 Summary of Companies involved in Smart Grid

Code	Company Name	Market Cap (M Dollars)	PE Ratio	Country	Segment
600406.SS	NARI Technology Development Ltd Co	$2,153.1	69.4	China	Machinery & Engineering
600268.SS	Guodian Nanjing Automation Co Ltd	$735.2	56.2	China	Electrical & Electronics
000400.SZ	XJ Electric Co Ltd	$1,501.3	78.7	China	Utilities-Electrical & Gas
002123.SZ	Rongxin Power Electronic Co Ltd	$1,379.3	48.6	China	Machinery & Engineering
000682.SZ	Dongfang Electronics Co Ltd	$828.3	312.8	China	Electronic Components & Instruments
3393.HK	Wasion Group Ltd	$721.1	16.2	Hong Kong	Electrical & Electronics
600105.SS	Jiangsu Yongding Co Ltd	$497.5	39.4	China	Misc. Materials & Commodities
002028.SZ	Sieyuan Electric Co Ltd	$1,969.8	29.2	China	Electronic Components & Instruments
3898.HK	Zhuzhou CSR Times Electric Co Ltd	$2,017.2	31.6	China	Machinery & Engineering
6644.T	Osaki Electric Co Ltd	$354.5	53.7	Japan	Electronic Components & Instruments
6621.T	Takaoka Electric Mfg Co Ltd	$375.1	N/A	Japan	Electrical & Electronics

010120.KS	LS INDUSTRIAL SYSTEMS CO LTD	$2,141.3	13.9	South Korea	Electrical & Electronics
1519.TW	Fortune Electric Co Ltd	$217.9	13.2	Taiwan	Electrical & Electronics
1514.TW	Allis Electric Co Ltd	$77.7	N/A	Taiwan	Electrical & Electronics
1529.TW	Luxe Co Ltd	$24.6	N/A	Taiwan	Electronic Components & Instruments

Source: Thomson Reuters

6.9 Carbon Capture and Storage

6.9.1 Background

With coal still as the primary source of fossil fuel for power generation, with over 70% generation for China and Australia and accounting for 40% of the total carbon emitted, ***Carbon Dioxide Capture and Storage*** (CCS) is seen as the best short term way to retrofit existing coal fired power stations to store and capture this large and growing source for carbon dioxide.

Based on an IEA Study, Asia Pacific is expected to account for the majority of CSS projects by 2050, with 950 projects in China and India alone.

Australia is trying to position itself as a global leader in CCS and already has 15 projects in Australia. The Coal21 Fund has set aside $1 billion to fund and commercialise CCS by 2015.

For the rest of Asia, there are 2 feasibility projects in Japan and 3 in China. There are also plans for feasibility studies in South Korea and Taiwan, while India is taking a more cautious approach.

6.9.2 Targets & Incentives

The IEA study[45] on CCS has projected that Asia Pacific will account for a majority of CCS projects by 2050.

[45] CCS Deployment Requirements in the IEA BLUE Map Scenario

IEA CCS Project Projections from 2010 to 2050

Region	No. Projects in 2020	No. Projects in 2050	Additional Cost 2010-2020 ($bln)	Additional Cost 2010-2050 ($bln)	Total investment 2010-2020	Total investment 2010-2050
OECD Pacific	7	280	5.9	645	14.1	530
China & India	21	950	7.6	1315	19.0	1170
Non-OECD	29	1260	9.7	1625	19.8	1765
World Total	100	3400	54	5810	130	5070

Source: IEA CCS Deployment Requirements in IEA BLUE Map Scenario

Power generation is expected to account for 55% of the worldwide total for CCS by 2050, of which coal fired power stations will account for 29GW (90%) n 2020 and 734GW (64%) of the total power generation.

IEA CCS Projects in Power Generation

Region	No. Projects in 2020	CCS Capacity in 2020 (GW)	Captured 2020 (Mt CO_2/year)	No. Projects in 2050	CCS Capacity in 2050 (GW)	Captured 2050 (Mt CO_2/year)
OECD Pacific	2	1.3	9	150	85	510
China & India	6	2.5	13	465	365	1785
Non-OECD	4	1.6	6	610	400	1725
World Total	38	22	131	1670	1140	5510

Source: IEA CCS Deployment Requirements in IEA BLUE Map Scenario

A country review of CCS shows that Australia the regional leader in this sector, with projects in China and Japan.

- China has four feasibility projects
- Japan formed a consortium of 24 companies to investigate feasibility of CCS. 3 projects are underway
- South Korea working on R&D projects to reduce cost to under $30/t$CO_2$
- India is still very cautious about CCS and has not started on a pilot scheme
- Indonesia has undertaken a feasibility study to assess the potential of CSS
- Australia has 15 projects funded by various institutions from COAL21 and CSIRO
-

Current CCS Inventory and Potential in Asia Pacific

Country	Projects	Potential
China	4	
Japan	3	150 billion tonnes
South Korea	0	
Taiwan	1 by 2012	50MW by 2025
India	0	3.7-4.6 Gt CO_2
Indonesia	0	
Australia	15	

Source: Coal21, CSIRO, Company Websites

Additional Cost of CCS

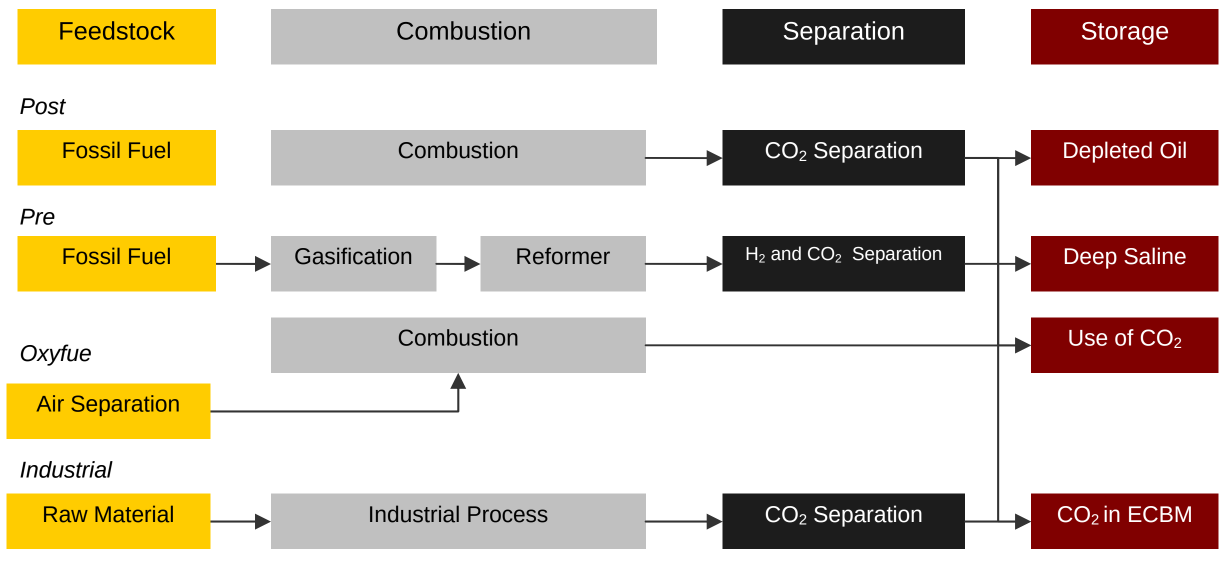
Country	Additional Cost of CCS $/tCO$_2$	Comment
IPCC	$15-75	
Japan	$66	
South Korea	$55	
Australia	$35	

Source: IPCC, CSIRO

6.9.3 CCS Process

CCS is a process consisting of the separation of CO_2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere.

Figure 6.23 – CCS



Source:

There are three main types of CO_2 capture systems:

- ***Post-combustion*** capture of CO_2 in power plants is economically feasible under specific conditions. It is used to capture CO_2 from part of the flue gases from a number of existing power plants. Separation of CO_2 in the natural gas processing industry, which uses similar technology, operates in a mature market.
- ***Pre-combustion*** is used in fertilizer manufacturing and in hydrogen production. The initial fuel conversion steps of pre-combustion are more elaborate and costly; the higher concentrations of CO_2 in the gas stream and the higher pressure make the separation easier.
- ***Oxyfuel*** combustion is in the demonstration phase and uses high purity oxygen. This results in high CO_2 concentrations in the gas stream and, hence, in easier separation of CO_2 and in increased energy requirements in the separation of oxygen from air.

Storage of CO_2 uses many of the technologies used in the oil and gas business. There are four main types of storage:

- Injection of CO_2 in depleted oil and gas reserves
- Injection of CO_2 in saline formations
- The combination of CO_2 storage with Enhanced Oil Recovery (EOR)

- The combination of CO_2 storage with Enhanced Coal Bed Methane Recovery (ECBM)

6.9.4 China

Market Size & Growth

Coal still accounts for around 70-80% of China's power generation. While, China has set 20% renewable energy target by 2020, coal will still be the primary source of power generation and CCS is seen as a key technology for reducing the carbon emissions generated from coal fired power stations.

Drivers & Constraints

At present, there are a only a few feasibility projects underway to test the technical and economic viability of CCS.

The ***Ministry of Science & Technology*** (MOST) has been working the ***Guide for CCS science and technology development development***, which was expected to be issued in the mid 2009.

Market Players & Competition

The feasibility projects in China include:

- **PetroChina** *<xx>*. Carried out China's s first project of CO_2 storage and usage (EOR) at Jilin Oil Field from 2006, with the injection of CO_2 into 10 wells. The investment was RMB200 million
- **China Huaneng Group** *<xx>* constructed the first demonstration post-combustion capture (PCC) project in Beijing Thermal Power plant with 3000 t CO_2/year. CSIRO and the Thermal Power Research Institute (TPRI) are partners in the project.
- **GreenGen Limited** <Unlisted> *i*s a consortium of 8 chinese companies and is a new build IGCC power plant with CCS capability. It planned to be operational by 2015.
- ***UK-China Near Zero Emissions Coal Project (NZEC) Project*** set to be operational by 2014.

6.9.5 Japan

Market Size & Growth

Japan CCS said in a statement it aims to conduct feasibility studies for the government in an attempt toward realizing Japan's goal to capture and store 100 million tonnes of CO_2 per year from 2020. METI official said there was potential to store 150 billion tonnes of CO_2 in Japan. Feasibility projects in Japan include:

- Feasibility Study on a Total System from Electric Power Generation to CO_2 Storage, as a part of the "***Innovative Zero Emission Coal Gasification Electric Power Project***" funded by NEDO
- Development of Assessment Technologies for a Deep Aquifer appropriate for ***Demonstration as a part of Research and Development of Underground Storage Technology for Carbon Dioxide***, funded by MET

- Nagoaka Project funded by Research Institute of Innovative Technology for the Earth (RITE). The project injected 10,200 tCO_2 into an aquifer.

Drivers & Constraints

The constraints for Japan are the limited suitable sites are far away from large emission sources and projected cost for CCS in Japan ($66/$tCO_2$) are much higher than IPCC estimates.

Market Players & Competition

- **CCS Co Limited** <Unlisted> A grouping of 24 Japanese firms, including 11 utilities five oil refiners, four engineering firms, two oil and gas developers, one steelmaker and one chemical firm will work with government on feasibility studies for CCS projects.

6.9.6 South Korea

Market Size & Growth

There is limited storage capacity in South Korea, which is estimated to be 0.5 $GtCO_2$

Drivers & Constraints

Korean government is actively involved in international cooperation and development of technologies. However, South Korea has limited storage capability and the costs are still too high and need to drive capture cost down from $55/$tCO_2$ to less than 30tCO_2$

Market Players & Competition

No companies identified

6.9.7 Taiwan

Market Size & Growth

Unlike Japan and South Korea, Taiwan seems to have great CCS potential because thick Tertiary to Quaternary sediments are distributed all along west coast.

Drivers & Constraints

A pilot scale demonstration for CO_2 geologic sequestration in Taiwan is scheduled to start in 2012, with commercialization of a 50MW planned for 2025.

Market Players & Competition

There are no companies identified in CCS in Taiwan

6.9.8 India

Market Size & Growth

Coal will be the main fuel for power generation for the next 20 to 30 years in India and is expected to account for over 60% of the total power generation mix and rising to around 950 GWh by 2030 and over 140 GW in capacity.

Preliminary studies indicate that potential storage sites are located in the ***Gangetic, Brahmaputra*** and ***Indus*** river plains, and along the immediate offshore regions on the ***Arabian Sea*** and ***Bay of Bengal***.

An assessment [46] of potential for geological storage in India suggests that CO_2 storage in coal seams is likely to be constrained since these coal reserves can be easily mined and used as fuel. Taking this into consideration, the calculated storage potential countrywide was found to be more of the order of 345 Mt CO_2 in the major coalfields, where none have the capacity to store more than 100 Mt CO_2, and only eight of the fields can store more than 10 Mt CO_2. For oil and gas reservoirs, the authors calculated the total storage capacity to be between 3.7 and 4.6 Gt CO_2.

Drivers & Constraints

While coal will be the main fuel for power, India is still very cautious about CCS and has not started on a pilot scheme

Market Players & Competition

- Australia's EESTech <Unlisted> has signed a joint venture agreement with India's ***Aryan Clean Coal Technologies*** to install three 10MW hybrid coal gas technology plants valued at USD 60m. The two firms had announced in October last year that they plan to invest in a JV and have now formally inked the deal valuing nearly USD 60m. The HCGT systems will be developed over the next five years and the power generated will be sold to the coalmine companies. Any surplus electricity will be sold to the national grid. EESTech's technology uses waste coal and ventilated air methane from underground coalmines to produce energy.

6.9.9 Singapore

Market Size & Growth

There are no planned CCS projects in Singapore.

Drivers & Constraints

Singapore does not have any plans for CCS.

Market Players & Competition

No companies involved in CCS in Singapore.

6.9.10 Indonesia

Market Size & Growth

Indonesia has a high potential for CSS, with large sedimentary basins located in the archipelago. A feasibility study was undertaken in 2007 by Shell, but no further plans have been put in place to develop CCS project further.

Drivers & Constraints

A feasibility study was undertaken in 2007 by Shell to assess the potential of CCS in Indonesia.

Market Players & Competition

There are currently no demonstration projects in Indonesia.

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[46] 2008 IEAGHG Assessment

6.9.11 Malaysia

Market Size & Growth

There are no planned CCS projects in Malaysia.

Drivers & Constraints

Malaysia does not have any plans for CCS in its Energy Plan.

Market Players & Competition

No companies involved in CCS in Malaysia.

6.9.12 Philippines

Market Size & Growth

The Philippines has a high potential for CSS, with large sedimentary basins located in the archipelago.

Drivers & Constraints

There are currently no plans for CCS, as part of the RE Act or any targets or investments in place for demonstration projects.

Market Players & Competition

There are no companies involved in CCS in Philippines.

6.9.13 Thailand

Market Size & Growth

The market potential for CCS in Thailand has not been assessed.

Drivers & Constraints

There are currently no plans for CCS, as part of the Energy Master Plan or investments in place for demonstration projects. However, CCS is being considered, as an option to reduce Carbon Emissions.

Market Players & Competition

There are currently no companies involved in CCS in Thailand.

6.9.14 Australia

Market Size & Growth

Australia is a global leader in CCS technology and the government and coal industry are investing over $1 billion and there are already 15 projects sponsored by various institutions, such as CSIRO, Coal21 and CO2CRC, as highlighted in the Table below.

In addition, the storage potential for CCS in Australia is the largest in Asia Pacific at 700 $GtCO_2$

Summary of existing CCS projects in Australia

Project	Capacity	Timeframe
ZeroGen Project I	120MW, 75% capture	2012
ZeroGen Project II	450MW, 90% capture	2017
Coolimba	2x200MW	2012
Otway Project	100,000 tonnes	2008
Mulgrave		
Loy Yang	1,000 tonnes per year	
Hazelwood	10,000–20,000 tonnes per year	
Munmorah	100,000 tonnes per year	2013
Tarong PCC Project.	1,500 tonnes per year	
Callide Oxyfuel Project		2011
Gorgon	3.3 million tonnes per year	2015
Moomba		2010
HRL IDGCC Project	400MW	
Latrobe Valley		
FuturGas Project		2016

Source: CSIRO, Company Reports

A number of domestic and international CCS initiatives are currently underway, including:

Coal21 Program

The Australian Coal Association's Coal21 Program – a partnership between the coal and electricity industries, governments, researchers and unions to investigate a variety of technologies, including CCS to reduce or eliminate greenhouse gas emissions from coal production and coal-fired power generation.

- ***ZeroGen Project***. The project will develop a demonstration-scale 120 MW IGCC power plant with CCS. The facility is due to begin operations in late 2012 and will capture up to 75% of

CO_2. Some of the CO_2 will be transported by road tankers for partial sequestration in deep underground reservoirs in the ***Northern Denison Trough***, approximately 220km west of the plant. To facilitate more rapid uptake of the technology at commercial scale, ZeroGen will concurrently develop a large-scale 450 MW IGCC power plant with CCS. Due for deployment in 2017, the facility is expected to capture up to 90% of CO_2. Its location will be at a site in Queensland to be determined by a feasibility study. ZeroGen Pty Ltd is currently supported by the Queensland Government and the coal industry's COAL21 Fund.

- The NSW Government has undertaken a series of studies to assess the potential for geosequestration of CO_2 in deep saline formations and coal seams in NSW. Both storage assessment initiatives are financially supported under the Australian coal industry's COAL21 Fund.

Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC)

The Global Carbon Capture and Storage Initiative, ***National Low Emissions Coal Initiative*** (NLECI) ***and Cooperative Research Centre for Greenhouse Gas Technologies*** (CO2CRC), to provide a forum for international collaboration and develop a technology roadmap for both capture and geological storage of carbon dioxide.

- **Coolimba Power Project.** Construction of Aviva Corporation Ltd's 2x200MW coal-fired base-load power stations is proposed to be completed by 2012. The plant will be built ready for conversion to CO_2 capture. Sequestration sites are being sought for the storage with the involvement of CO2CRC and ARC Energy.

- ***The Otway Project****.* The CO2CRC Otway Project is Australia's most advanced CO_2 storage project. Launched in April 2008, the project involves the extraction, compression and transport and storage of 100,000 tonnes of naturally occurring CO_2. The CO_2 is being stored in a depleted natural gas reservoir two km below the earth's surface.

- ***Mulgrave Pre-Combustion Capture Project****, Victoria*. CO_2 emissions will be captured from HRL's research gasifier in Mulgrave in a pilot-scale capture project by CO2CRC. The capture technologies will be evaluated to identify which are the most cost effective for use in a coal gasification power plant. Partners include CO2CRC and HRL with funding from the Victorian Government.

- ***Loy Yang***. A CSIRO mobile pilot PCC facility has begun operation at Loy Yang and will capture around 1000 tonnes of CO_2 each year. Partners in this project include International Power, Loy Yang Power, CO2CRC, CSIRO and Process Group with funding from the Victorian government.

- ***Hazelwood***. Work is underway on a facility at Hazelwood that will capture and chemically sequester CO_2 at a rate of 10,000 – 20,000 tonnes each year, with capture to commence late 2008. CO2CRC will use that plant to test a range of solvent and process changes. Using two other rigs, CO2CRC will test adsorbent and membrane post-combustion techniques

CSIRO Flagship Program

- ***Munmorah Power Station***. CSIRO's Energy Transformed Flagship is working with Delta Electricity to test post-combustion capture at a pilot plant they have built at the *Munmorah Power Station*. The Flagship's goal is to provide proof of the post-combustion concept, evaluation of various CO_2 absorbents, assistance in the scale up to demonstration and commercial plants, and provide the science underpinnings for future policy options for CO_2 capture. It is hoped the Munmorah project will provide the foundation for a $150 million post-combustion CCS demonstration project in NSW, planned for operation by 2013, capturing up to 100,000 tonnes of CO_2 each year.

- ***Tarong PCC Project***. CSIRO and Tarong Energy will install a post-combustion capture pilot plant using an amine-based solvent at Tarong Power Station near Kingaroy, Queensland. The pilot plant will capture 1500 tonnes of CO_2 each year over a two-year research program beginning in 2009

The projects will need to prove the viability of the technology by 2011 with the aim of storing between two and five megatons of CO_2 per year from coal-fired power plants.

The Flagship projects, jointly funded by the Australian black coal industry, state and federal governments, are part of several initiatives to protect the country's domestic coal industry. Coal is Australia's largest export earner, but mainly exports high quality coal for coking, while it uses low grade coal for its domestic power generation.

The Australian government has announced details of the commercial release of 10 offshore areas designated specifically for the assessment of their carbon storage potential.

The initial release areas are located across five offshore basins adjacent to Victoria, South Australia, Western Australia and the Northern Territory. The assessment areas being released have been identified as having the best potential in terms of geological suitability and current industry needs and are underpinned by technical data from Geoscience Australia.

Regulations and guidelines to support the new legislation are under development and will be finalised in the third quarter of 2009. The acreage release bidding will remain open until two months after the completion of the regulations.

Other CSS Projects in Australia

- ***The Callide Oxyfuel Project*** will demonstrate CCS using oxyfuel combustion, combined with carbon storage. The Oxyfuel boiler is scheduled to be operational in the ***Callide A power plant*** by 2011. The project team is assessing potential carbon storage sites to the west of the power plant and plans to select the final location. The CO_2 will be transported in road tankers. The project is headed by CS Energy Ltd in conjunction with an international team of partners, including IHI Corporation (Japan), J-Power (Japan), Mitsui & Company (Japan) Schlumberger Oilfields Australia and Xstrata Coal.

- ***Geological storage site assessments****, Queensland and New South Wales*. The Queensland State Government through the Geological Survey of Queensland has developed, in conjunction with the coal industry and the Commonwealth Government, the ***Carbon***

Geostorage Initiative (CGI) to identify and assess potential sites for safe, long-term CO_2 storage in Queensland. Mapping work is currently underway for regional assessment of basin storage potential.

- ***Gorgon CO_2 Injection Project***. Chevron (operator), Shell and Exxon are planning a major sequestration project linked to the Gorgon LNG Project. The separated CO_2 will be injected under Barrow Island to a depth of about 2.3km, with injection of 3.3 million tonnes of CO_2 per year. A total of 125 million tonnes will be injected over the life of the project. The construction phase is planned to commence in late 2009 and take about five years. A data well has been drilled and a major study of the subsurface is underway.

- ***Moomba Carbon Storage Project***. This project is currently at the early feasibility stage, with the objective of establishing a regional carbon storage hub in the Cooper Basin. The first phase, will involve the capture of CO_2 from existing gas processing facilities and injecting one million tonnes of CO_2 commencing in 2010, to re-pressure oil reservoirs for EOR. Partners in this project include Santos and Origin.

- ***HRL IDGCC Project***, *Victoria*. A proposed 400MW power generation plant in Victoria will involve integrated drying gasification combined-cycle (IDGCC) using brown coal. Partners include HRL Technology and Harbin.

- ***Latrobe Valley Post-Combustion Capture Projects***, *Victoria*. These projects involve retrofit of pilot scale post-combustion CO_2 capture plants.

- ***FuturGas Project***, *South Australia.* Hybrid Energy Australia is researching the development of the carbon dioxide storage component of the FuturGas Project – an energy conversion development involving the gasification of lignite to syngas for the production of synfuels. It is proposed that the CO_2 captured post-gasification will be stored in the Otway Basin to the south of the lignite resources. A feasibility study and an environmental impact study will be completed by 2011. It is hoped the project will become operational by 2016.

Drivers & Constraints

Australia is the world's largest coal exporter and relies on coal, as it primary source of fuel for power generation and has targeted CCS technologies, as a way to reduce its carbon emissions and meet its green house gas targets.

Under the A$4.5 billion ***Clean Energy Initiative***, the Government will provide A$2.4 billion to support investment in large scale integrated CCS projects in Australia. The target is to create 1000 MW of low emission fossil fuel generation. Australia has established the ***Global Carbon Capture and Storage Institute*** (GCCSI) with the aim of accelerating the global development and deployment of Carbon Capture and Storage technology.

The Australian Government is contributing up to A$100 million per annum to fund the operations of the GCCSI, which has the mandate is to foster a global portfolio of commercial-scale flagship demonstration projects.

In addition, Australia has introduced legislation allowing offshore geological storage and is undertaking a commercial release of offshore exploration areas for greenhouse gas storage assessment.

The ***Offshore Petroleum and Greenhouse Gas Storage Act, 2006*** (which came into effect in November 2008) provides a system of access and property rights for the geological storage of greenhouse gas in offshore waters under Commonwealth jurisdiction. Ten offshore areas have been offered by the Government.

Market Players & Competition

Australia is the largest coal exporter in the world and also generates over 70% of its power from coal and has the highest percentage of power generated out of all the developed nations, so has a vested interest in reducing carbon emissions from its existing coal fired power stations. It has a number of government funded pilot schemes in place, in addition to the large potential CCS at the Gorgon Gas Field. Key Players include:

CCS

- Mitsubishi Heavy Industries <7011.T> and Mitsubishi Corporation <8058.T> have signed an agreement with Australia's ZeroGen to develop a combined cycle power generation plant integrated with a carbon capture and storage facility.

Clean Coal

- **White Energy** **<WEC.AX>** White Energy Limited is an Australia-based company. The principal activities of the Company consisted of ongoing development/exploitation of the binderless coal briquetting technology and evaluation of the mining exploration assets. The business segments of the Company are coal technology, mining and unallocated. The coal technology segment includes license to technology developed by Commonwealth Scientific & Industrial Research Organization (Australia) (CSIRO), which processes poor-quality coal into a higher-quality product. For a detailed company profile, see Appendix A.

- **Environmental Clean Technologies** **<ESI.AX>** is a clean coal company that dewaters brown coal to produce a black coal substitute via its Coldry process. Coldry process produces pellets that can be stored, transported and is of equal energy value than black coal. Coldry works by initiating a chemical reaction to expel water from lignite and sub-bituminous coal. The pellets are used in electricity generation in black or brown coal power stations and coal-to-oil applications.

- **EESTech** <Unlisted> is engaged in promoting the commercialization of its three primary products: a hybrid coal and gas turbine (HCGT) power plant, Carbon Capture and Storage (CCS) and the JetWater System (JWS) to markets in Australia, People's Republic of China, South America, the United Arab Emirates and the United States. In December 2007, the Company announced the acquisition of Carbon Capture and Storage (CCS) technology from Canadian company, HTC Purenergy.

6.9.15 New Zealand

Market Size & Growth

There are no planned CCS projects in New Zealand.

Drivers & Constraints

The Ministry of Economic Development (MED) is the lead agency in developing CCS policy for New Zealand. MED has a work programme in development to ensure that CCS remains an option for New Zealand.

- The work program is focused on the near term goal of ensuring that an appropriate legislative and regulatory framework is in place to regulate CCS should it be deployed in New Zealand, and to allow for proactive investment decisions.
- Another early priority of the work programme is to better understand New Zealand's capacity to actually store CO_2 in geological structures. Research is currently underway to assess New Zealand's geological storage options.

Market Players & Competition

There are currently no companies involved in CCS in New Zealand.

6.9.16 Summary of Companies

Code	Company Name	Market Cap (M Dollars)	PE Ratio	Country	Segment
WEC.AX	White Energy Company Ltd	$542.6	N/A	Australia	Metals - Non Ferrous
Unlisted	GreenGen Limited	N/A	N/A	China	CCS
Unlisted	EESTech	N/A	N/A	Australia	CCS
Unlisted	CCS Co Limited	N/A	N/A	Japan	CCS

6.10 Nuclear

6.10.1 Background

There are now 439 nuclear reactors in operation around the world in over 30 countries, providing almost 16% of the world's electricity. However, due to public perception, growth in the sector had slowed in the 1990s. As nuclear power only emits a small amount of greenhouse gases, it is undergoing a revival and is seen as a major source of non fossil fuel power and the only present day source that can provide reliable, cost effective base load power that can offer a viable alternative to coal.

New reactor designs (Generation IV) are in progress, with 6 leading designs recommended by the ***Generation IV International Forum*** (GIF). In addition, APR countries are embracing nuclear power generation and lead a new wave of reactor installations, particularly in China and India, but also plans for reactors in Indonesia, Vietnam, Malaysia, and Thailand.

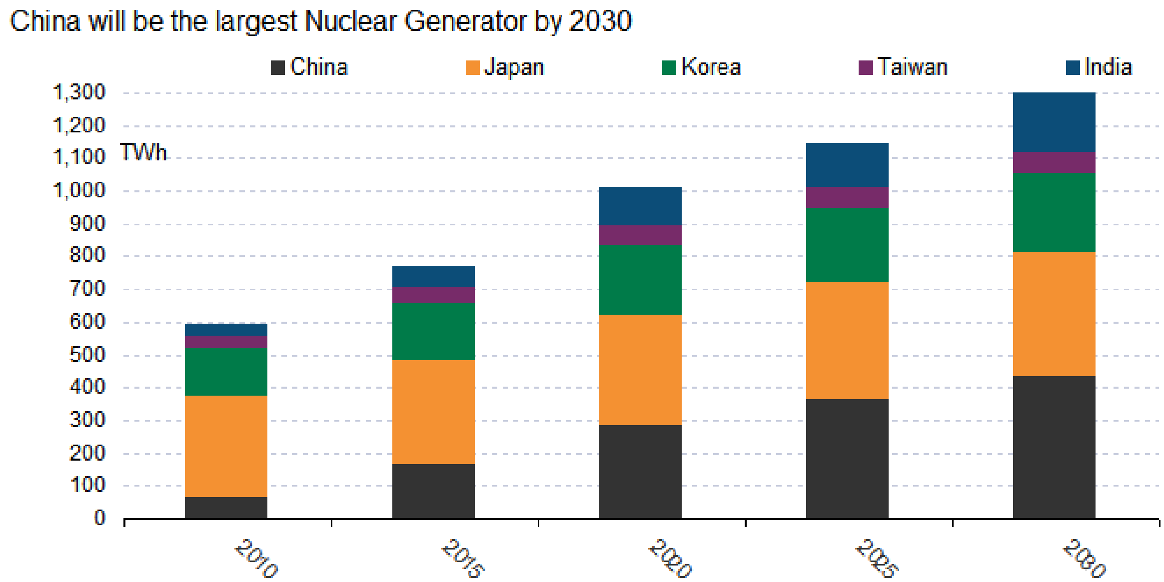
Japan is home to two of the three leading nuclear reactor companies – Westinghouse-Toshiba and GE-Hitachi – and has proposed to boost its share of nuclear power to 44% by 2030.

South Korea has embarked on a large nuclear power generation program through ***Korea Nuclear Hydro Power*** (KNHP) and expected to increase generation to 243 billion kWh by 2030.

India is looking to lead the next generation of nuclear reactors with its expertise in thorium fuel, coupled with the largest reserves of thorium globally. While China, also plans to increase it share of nuclear reactors to increase its share of non fossil fuel in its power generation mix.

6.10.2 Targets & Incentives

Figure 6.24 Asia Pacific Nuclear Sector



Source: IEA, Thomson Reuters, Government Publications

REUTERS

- ***China*** - is set to increase its nuclear capacity by six times to 60GW and then a further substantial increase to 160 GW by 2030
- ***Japan*** - A METI plan called for an increase in nuclear power generation by a further 30% (13 GW) with the addition of 9 to 12 new nuclear plants.
- ***South Korea*** - The government stated that South Korea should develop its nuclear industry into one of the top five in the world, with about 60% of electricity from nuclear by 2035.
- ***Taiwan*** - Taiwan has 6 nuclear power stations in operation and considering the addition of another 6 more plants.
- ***India*** - expects to have 20GW nuclear capacity by 2020.

Total Installed capacity (MW)

Country	Nuclear electricity generation, 2007 (billion kWh)	Number of reactors in operation*	Nuclear generating capacity* MW	Proposed Capacity MW
China	59.3	11	8,587	60,000MW by 2020
Japan	267.0	55	47,577	65,000MW by 2020
South Korea	136.6	20	17,533	26,000MW by 2020
Taiwan		6	5,700	Additional 6 reactors
India	15.8	17	3,779	20,000MW by 2020
Singapore	0	0	0	Feasibility Study
Indonesia	0	0	0	4,800MW by 2025
Malaysia	0	0	0	0
Philippines	0	0	0	600MW by 2025
Thailand	0	0	0	2,000MW by 2020
Vietnam	0	0	0	4,000MW by 2025
Australia	0	0	0	0
New Zealand	0	0	0	0

Source: WNA, IEA, EIA, Government Publications

6.10.3 Nuclear Process and Supply Chain

The nuclear supply chain can be broken several sections. A huge amount of R&D work goes into reactor designs, which is now consolidated into a small number of players who can sell throughout the world. Capital costs of nuclear plants are relatively high by comparison with rival technologies and building on time and on budget is essential. This involves many local subcontractors but there are a number of major international companies involved in this area. The nuclear fuel cycle, from uranium mining to waste disposal, has a number of specialist activities, each of which are carried out by a limited number of companies worldwide. More in the background are a number of technology, equipment and service companies, who provide a range of specialized products and services to all areas of the industry. Finally, there is a group of electricity utilities for whom nuclear plants represent a significant share of their generating capacity.

Figure 6.25 – Nuclear Supply Chain

	Mining	Nuclear Fuel	Reactors	Construction	Operation	Disposal
China		China Uranium	CNNC, SNPTC	Local Providers	CGNPC, CPIC,	China Uranium
Japan		JNFL, MNFL	Hitachi, Toshiba, MHI	JSW, MHI	TEPCO, KEPCO,	JNFL, MFL
Korea		KNFC, KAERI	KNHP	Local Providers	KHNP	KNFC
Taiwan		Imported	Imported	Taipower	Taipower	Taipower
India	Uranium Corp	Uranium Corp	NPCIL	L&T, HCC	NPCIL, NTPC	Uranium Corp
Australia	BHP, Rio Tinto,	BHP, Rio Tinto				

Source: Company Reports, Thomson REUTERS

Mining

Uranium is not scarce, as a resource with over 2 million tonnes mined. Unlike oil, proven reserves exist in stable countries, such as Australia and Canada.

Since 2003, uranium prices have risen sharply, driven by the surge in commodity prices, encouraging a growth in exploration by new uranium companies, adding to the established market participants such as Cameco, Rio Tinto, Areva, BHP Billiton and Kazatomprom. Few of these will ever enter the production phase, but some such as Paladin and Uranium One are already doing so and will participate in a likely production boom over the next few years.

Nuclear Fuel

Nuclear fuel is loaded into new nuclear reactors in the form of fuel assemblies. These will stay in the reactor for about 3 years until the reactivity declines to the extent that replacement is warranted. Light Water Reactors (LWRs), comprising 90% of today's reactors, were traditionally shut down once per year (an "outage") when one third of the fuel would be replaced, but many reactors today have longer operating cycles, with outages only every 18 or 24 months. After discharge from the reactor, used nuclear fuel is cooled for several years in large ponds of water. Thereafter there are essentially two options – either reprocessing the used fuel, to separate uranium and plutonium which may be re-introduced into the nuclear fuel cycle, or storing the used fuel for longer before sending it to a deep geological repository.

The "front end" of the nuclear fuel cycle comprises the stages up to fuel fabrication, where the fuel assemblies are prepared. The "back end" is the route followed by the used fuel, which can include reprocessed uranium and plutonium re-entering the front end. Uranium production is the starting point of the front end and it goes through stage of conversion and enrichment (at least for LWRs – ***Pressurised Heavy Water Reactors*** (PHWRs) run on natural uranium) before fuel fabrication.

Conversion is an intermediate step in the nuclear fuel cycle, where uranium is converted from oxide to fluoride form for the enrichment stage (which requires uranium to be in a gaseous form). It is carried out in a few specialist plants throughout the world. LWRs require the U-235 isotope of uranium to be increased from the natural 0.7% to 3-5%. This is a major, technically complex, step in the cycle and has historically accounted for slightly more of the fuel cost than uranium supply itself.

Fuel fabrication is a specialized service to reactor operators, rather than a homogeneous commodity like uranium, conversion and enrichment. As such, it takes place at a greater number of suppliers worldwide, in many cases national suppliers such as CNNC in China, JNFL in Japan and KNFC in South Korea close to the reactor location.

Reactors

Nearly 90% of existing reactors are ***Light Water Reactors*** (LWRs) of which there are two main groups, ***Pressurized Water Reactors*** (PWRs) and ***Boiling Water Reactors*** (BWRs). All of the currently operating 104 US reactors, for example, are of these two types. The most significant alternative design is the pressurised heavy water reactor (PHWR) of which the ***CANada Deuterium Uranium*** (CANDU) design is the best known. With one exception, all of the new reactors being offered today fall into these types.

The marketing of new major reactors has today become concentrated in a few major companies: Areva, GE-Hitachi and Westinghouse-Toshiba are the three majors, and are at the centre of the proposals to build new reactors both the United States and United Kingdom. Atomstroyexport of Russia, AECL of Canada and KOPEC of Korea are also competing for major reactor contracts, having established reputations with the nuclear programs in their own countries and the Middle East.

Construction

Construction of new nuclear reactors are major civil engineering projects, inline with other capital investment projects in other sectors. A nuclear project can be sub-divided into two parts:

- Nuclear island (accounting for about 60% of the cost); and
- Non-nuclear part (the remaining 40%).

Contracts for new nuclear plants are usually divided into the two parts with the major specialist reactor vendors (above) competing for the nuclear island part and the remainder the subject of bids from a wider range of companies. Nuclear plants are thermal generating units, as much as coal-, oil- and gas-fired units, and the non-nuclear part of the plant, largely the turbine generating set and a lot of pipework, is much the same as with these.

The nuclear island requires a significant amount of concrete work for strength and radiation protection and the installation of major components such a reactor pressure vessels and steam generators. These items for the latest reactors require very large steel forgings and more basic components must be of top quality, certified as “nuclear grade”. In terms of the construction process, some of the latest reactor designs allow for a much greater degree of modular construction with standardized major components being brought to the site from factories some distance away. This represents a reaction against the past practice of building “singleton” reactors bit-by-bit onsite, which proved to delay progress and harm project economics.

Estimates of costs of new reactor projects suffer from the lack of experience of these in the Western world since the 1980s. Nevertheless, experience of building in East Asia suggests that the construction phase, from first concrete to connection to the power grid, can be accomplished in 4 years and at all-in cost of $2-3 billion for a 1000 MWe reactor, scaled up for a larger model.

Operators

Operators are the domestic utility companies and are a much more fragmented group of companies, when compared with the mining and reactor sector. Companies include TEPCO, Japan’s largest utility and Korea’s KNHP.

Next Generation Reactors (Generation IV)

Countries are already working on the next generation of nuclear reactors (GIF – Generation IV) and have short listed 6 new designs. There is currently a race to establish the next standard for the industry, with different countries promoting technologies that will give their own domestic industry a crucial advantage.

Issues with the new generation reactors include the high temperatures and condition required to operate, as the materials do not yet exist to withstand these condition over a long time of at least 5 years.

SFR – Sodium-Cooled Fast Reactor System

The Sodium-Cooled Fast Reactor (SFR) system features a fast-neutron spectrum and a closed fuel cycle for efficient conversion of fertile uranium and management of actinides. A full actinide recycle fuel cycle is envisioned with two options. The SFR system can use existing nuclear waste and thus re-use spent fuel. This technology is the furthest developed and is estimated to be deployable by 2015.

VHTR – Very-High-Temperature Reactor System

The Very-High-Temperature Reactor (VHTR) system uses a thermal neutron spectrum and a once-through uranium cycle. The VHTR system has coolant outlet temperatures above 1000°C. It is intended to be a high-efficiency system that can supply process heat to a broad spectrum of high temperature and energy-intensive processes. The system may incorporate electricity generation equipment to meet cogeneration needs. The system also has the flexibility to adopt U/Pu fuel cycles and offer enhanced waste minimization. One current drawback is that it requires significant advances in fuel performance and high temperature materials currently not available. Additional R&D will include high-temperature alloys, fiber-reinforced ceramics or composite materials, and zirconium-carbide fuel coatings. The VHTR system is estimated to be deployable by 2020.

GFR – Gas-Cooled Fast Reactor System

The Gas-Cooled Fast Reactor (GFR) system features a fast-neutron spectrum and closed fuel cycle for efficient conversion of fertile uranium and management of actinides. The fuel cycle facilities can minimize transportation of nuclear materials and will be based on either advanced aqueous, pyrometallurgical, or other dry processing options. Several fuel forms are being considered for their potential to operate at very high temperatures and to ensure an excellent retention of fission products: composite ceramic fuel, advanced fuel particles, or ceramic clad elements of actinide compounds. Core configurations are being considered based on pin- or plate-based fuel assemblies or prismatic blocks. Given its R&D needs for fuel and recycling technology development, the GFR is not expected to be deployable until 2025.

LFR – Lead-Cooled Fast Reactor System

The Lead-Cooled Fast Reactor (LFR) system features a fast-neutron spectrum and a closed fuel cycle for efficient conversion of fertile uranium and management of actinides. The system uses a lead or lead/bismuth eutectic liquid-metalcooled reactor. The fuel is metal or nitride-based, containing fertile uranium and transuranics. The most advanced of these is the Pb/Bi battery, which employs a small size core with a very long (10–30 year) core life. The reactor module is designed to be factory-fabricated and then transported to the plant site, reducing risk of nuclear proliferation. The reactor is cooled by natural convection and sized between 120–400 MWth, with a reactor outlet coolant temperature of 550°C, possibly ranging up to 800°C, depending upon the success of the materials R&D. The system is specifically designed for distributed generation of electricity and other energy products, including hydrogen and potable water. Given its R&D needs for fuel, materials, and corrosion control, the LFR system is estimated to be deployable by 2025.

SCWR – Supercritical-Water-Cooled Reactor System

The Supercritical-Water-Cooled Reactor (SCWR) system features two fuel cycle options. Both options use a high-temperature, high-pressure, water-cooled reactor that operates above the thermodynamic critical point of water (22.1 MPa, 374°C) to achieve a thermal efficiency approaching 44%. The fuel cycle for the thermal option is a once-through uranium cycle. The fast-spectrum option uses central fuel cycle facilities based on advanced aqueous processing for actinide recycle. The fast-spectrum option depends upon the materials' R&D success to support a fast-spectrum reactor. In either option, the reference plant has a 1700-MW power level, an operating pressure of 25 MPa, and a reactor outlet temperature of 550°C. Passive safety features similar to those of the simplified boiling water reactor are incorporated. Owing to the low density of supercritical water, additional moderator is added to thermalize the core in the thermal option. The benefits of the SCWR system are high thermal efficiency and plant simplification. Given its R&D needs in materials compatibility, the SCWR system is estimated to be deployable by 2025.

MSR – Molten Salt Reactor System

The Molten Salt Reactor (MSR) differs from other designs in that it uses a molten mixture of liquid sodium, zirconium, and uranium fluorides. The molten salt fuel flows through graphite core channels, producing a thermal spectrum. The heat generated in the molten salt is transferred to a secondary coolant system through an intermediate heat exchanger, and then through another heat exchanger to the power conversion system. This design benefits by allowing the addition of actinide feeds with variable composition by varying the rate of feed addition. There is no need for fuel fabrication. Given its R&D needs for system development, the MSR is estimated to be deployable by 2025.

Liquid Fluoride Thorium Reactor (LFTR)

One variant of the MSR technology that is gaining traction is the use of Thorium, as a substitute for Uranium. Thorium can be used within existing reactors and mixed with the existing uranium. Thorium is advantageous, as it is readily available, cheaper, more efficient and does not have harmful waste products, such as plutonium. India is looking at this technology closely, as it is also has one of the largest reserves of Thorium globally.

6.10.4 China

Market Size & Growth

China has 11 nuclear power reactors in commercial operation with a further 20 under construction. Based on renewed statements, China is set to increase its nuclear capacity by six times to 60GW and then a further substantial increase to 160 GW by 2030, making it the leader in Nuclear Capacity globally.

Plant	Province	MWe gross	Reactor model	Project control	Construction start	Operation
Lingao Phase II units 1&2	Guangdong	2x1080	CPR-1000	CGNPC	12/05, 5/06	12/10, 8/11
Qinshan Phase II units 3&4	Zhejiang	2x650	CNP-600	CNNC	4/06, 1/07	2011, 2012
Hongyanhe units 1-4	Liaoning	4x1080	CPR-1000	CGNPC	8/07, 4/08, 3/09, 8/09	10/12, 2014
Ningde units 1-4	Fujian	4x1080	CPR-1000	CGNPC	2/08, 11/08, 1/10, 15/7/10	12/12 - 2015
Fuqing units 1&2	Fujian	2x1080	CPR-1000	CNNC	11/08, 6/09	10/13, 8/14
Yangjiang units 1-4	Guangdong	4x1080	CPR-1000	CGNPC	12/08, 8/09, 15/7/10, 15/3/11	8/13 - 2016
Fangjiashan units 1&2	Zhejiang	2x1080	CPR-1000	CNNC	12/08, 7/09	12/13, 10/14
Sanmen units 1&2	Zhejiang	2x1250	AP1000	CNNC	3/09, 12/09	11/13, 9/14
Haiyang units 1&2	Shandong	2x1250	AP1000	CPI	9/09, 31/7/10	5/14, 3/15
Taishan units 1&2	Guangdong	2x1700	EPR	CGNPC	10/09, 1/7/10	12/13, 11/14
Shandong Shidaowan	Shandong	210	HTR-PM	Huaneng	1/10?	2013 or 2014
Fangchenggang/Hongsha units 1&2	Guangxi	2x1080	CPR-1000	CGNPC	early 2010	2014, ?

Fuqing units 3-6	Fujian	4x1080	CPR-1000	CNNC	2010, ?	
Changjiang units 1&2	Hainan	2x650	CNP-600	CNNC or Huaneng	First half 2010	2014, 2015
Tianwan units 3&4	Jiangsu	2x1060	VVER-1000 (AES-91)	CNNC	10/2010	
Hongshiding (Rushan) units 1&2	Shandong	2x1080	CPR-1000	CNEC/CNNC	Deferred from 2009?	2015
Ningde units 5&6	Fujian	2x1080	CPR-1000	CGNPC		
Dafan, Xianning units 1&2	Hubei	2x1250	AP1000	CGNPC	late 2010	
Xiaomoshan (Jiulongshan) units 1&2	Hunan	2x1250	AP1000	CPI	2010?	4/2015-2018
Taohuajiang units 1-4	Hunan	4x1250	AP1000	CNNC	9/2010	2015
Pengze units 1&2	Jiangxi	2x1250	AP1000	CPI	2010	2013-14
Haiyang units 3&4	Shandong	2x1250	AP1000	CPI	2010?	
Tianwan units 5&6	Jiangsu	2x1200	VVER-1200	CNNC	10/2010	
Wuhu units 1&2	Anhui	2x1250	AP1000	CGNPC	12/2011	8/2016
Total: 57		63,130 MWe				

Source: WNA

Drivers & Constraints

In June 2008, the ***China Electrical Council*** projected 60 GWe of nuclear capacity by 2020, which was an increase from 50GW proposed by the ***State Energy Bureau*** (SEB) in 2008 and the 40 GW target proposed by the NDRC in 2007. In addition, a further statement from the ***State Council*** in 2009 is considering raising the 2020 target to 86 GW installed.

Market Players & Competition

Nuclear Fuel

China has ordered mineral refiners to reserve Thorium for future nuclear generation plans.

- ***China (Nuclear International) Uranium Corporation*** is responsible for CNNC's uranium exploration domestically. In December 2006, China Nuclear International Uranium Corporation, or simply China Uranium Corporation (Sino-Uranium or SinoU), was set up by CNNC to acquire uranium resources internationally, as well as undertaking exploration, development and uranium production abroad.[1] It is setting up a mine in Niger and is investigating prospects elsewhere.

- ***CNNC Overseas Uranium Holding*** <Unlisted> A wholly owned Hong Kong subsidiary of SinoU is CNNC Overseas Uranium Holding Ltd, which in mid-2008 bought a 75% interest in United Metals Holdings, a listed Hong Kong company and changed its name to CNNC International Ltd. This has bought prospects in Mongolia, and in February 2009 made a takeover bid for Khan Resources Inc, with major Mongolian assets.

- ***China Jianzhong Nuclear Fuel Co Ltd*** is a CNNC subsidiary and its main PWR fuel fabricator, at Yibin in Sichuan. China North Nuclear Fuel China North Nuclear Fuel Co Ltd is a CNNC subsidiary set up in 1998 to run a fuel fabrication plant at Baotou in Inner Mongolia. A joint venture centred on it is being formed to progress research on thorium fuel cycle.

- ***China Baotau Nuclear Fuel***. CNNC Baotou Nuclear Fuel Co Ltd was set up at the end of 2008 by SNPTC and the two CNNC fuel companies to make fuel for AP1000 reactors in Inner Mongolia.

- ***CGNPC Uranium Resource Co Ltd* (CGNPC-URC)** is a CGNPC entity responsible for mining and purchase of uranium resources, both domestic and imported. A related CGNPC subsidiary set up in 2007, Sino-Kazakhstan Uranium Resources Investment Co, has invested in two Kazakh uranium mines managed by Semizbai-U joint venture, following approval from NDRC. CGNPC-URC has also embarked upon a joint venture (Uz-China Uran LLC) with Uzbekistan's Goskomgeo focused on black shales in the Navoi region of Uzbekistan. Within China, in November 2008 CGNPC Uranium (Xinjiang) Co. Ltd., a JV between CGNPC-URC and Xinjiang Geology and Mineral Resources Bureau, was established.

- ***China Uranium Development Co Ltd* (CUD)** is an investment vehicle of CGNPC-URC buying equity in overseas uranium resources, notably by a 70% takeover of Australian uranium exploration company Energy Metals Limited.

Reactor Design and Construction

China has targeted nuclear energy as a key part of its energy policy. As with other strategic sectors, such as Wind and Solar, it has focused on the development of its domestic industry:

- PWRs will be the mainstream but not sole reactor type.
- Nuclear fuel assemblies are fabricated and supplied indigenously.
- Domestic manufacturing of plant and equipment will be maximised, with self-reliance in design and project management.
- Technology transfer through Joint Venture with international companies

China has entered into a number of Joint Ventures to obtain key IP foreign partners and become self-sufficient in reactor design and construction.

- ***China National Nuclear Corporation*** (CNNC, www.cnnc.com.cn) controls most nuclear sector business including R&D, engineering design, uranium exploration and mining, enrichment, fuel fabrication, reprocessing and waste disposal. It is the major investor in all nuclear plants in China. Established by the State Council in 1988 as a self-supporting economic entity, it "combines military production with civilian production, taking nuclear industry as the basis while developing nuclear power and promoting a diversified economy." It has numerous subsidiaries, including CNNC International Ltd (www.cnncintl.com), which is listed in Hong Kong. CNNC designed and built Qinshan Phases I and II, and controls the full Qinshan power plant. It has a payroll of about 1,000,000 and owns shares in many of the nuclear power generation projects. In particular it is a champion of local designs.

- ***State Nuclear Power Technology Corporation*** (SNPTC, www.snptc.com.cn) was set up in 2004 to take charge of technology selection for new plants being bid from overseas. This is through its Preparatory Office which draws expertise from other organizations such as CGNPC. SNPTC is directly under China's State Council and closely connected with it. Early in 2007, SNERDI was removed from CNNC control and assigned to it as an R&D arm, boosting its stature considerably. Westinghouse announced in 2008 that it was working with SNPTC and Shanghai Nuclear Engineering Research & Design Institute (SNERDI) to jointly develop a reactor, based of its AP1000 design.

- ***China Power Investment Corporation*** (CPI, www.cpicorp.com.cn), is one of five state-owned power generation holding companies formed from the State Power Corporation in 2002 and inheriting all its nuclear capacity. It is a major power generator (controlling 54 GWe at the end of 2009, including only 1351 MWe nuclear) and is the largest state-owned power holding company with nuclear assets. It was at the forefront of discussions on plants for the 11th Five-Year Plan (2006-10). CPI owns 19 operating power plants above 1000MWe each, a majority of Shandong Haiyang nuclear power project, 45% of Liaoning Hongyanhe nuclear power project phase I, and holds minority shares in five nuclear power plants in operation, and three under construction. It is carrying out preparation for nuclear power projects in Guangxi, Liaoning, Hunan, Jilin and Chongqing.

- ***China Guangdong Nuclear Power*** (CGNPC, www.cgnpc.com.cn). CGNPC comprises some 20 companies with gross assets of RMB 133 billion and net assets of RMB 41 billion. CGNPC is responsible for Daya Bay, Ling Ao, Yangjiang, Hongyanhe and Ningde power stations, as well as further projects in the province and outside it. CGNPC was established in 1994 and is 45% owned by the provincial government (via China Guangdong Nuclear Power Group), 45% by CNNC and 10% by CPI. Despite its relative independence it claims so be "under the supervision of the State-owned Assets Supervision and Administration Commission of the State Council." There is 25% Hong Kong equity in the Daya Bay plant. Areva and CGNPC announced establishment of an engineering joint venture as a technology transfer vehicle for development EPR and other PWR plants in China.

- ***China Huaneng Group*** <Unlisted> (CHNG, www.chng.com.cn) is one of China's major generators, formed in 1988 when the State Power Ministry was broken up, and it has about 50 GWe in operation, none of it nuclear. In 2005 it set up a subsidiary, **Huaneng Nuclear**

Power Development Co Ltd to handle nuclear power projects, initially two projects in Shandong province. It has formed links with both CNNC and CGNPC. It is an independent state-owned but incorporated business entity focused on power generation. It aims to have 80 GWe installed by 2010 and 120 GWe by 2020.

- ***Huaneng International Power Development Corporation*** (HIPDC) is a sino-foreign JV company owned 57% by China Huaneng Group and set up to develop, construct and operate power plants in China. HIPDC controls **Huaneng Power International** (HPI), a sino-foreign joint stock company incorporated in China, with a 42% shareholding in it. HPI is the country's largest listed generator. China Huaneng Group also has a 9% direct shareholding in HPI, which develops, constructs, operates and manages large-scale power plants in China nationwide.

- The ***China Zhongyuan Engineering Corporation*** is involved with constructing a 300 MWe PWR unit (CNP-300) at Chasma in Pakistan – a twin to that already commissioned in 2000 and similar to Qinshan 1 – China's first indigenously-designed (by SNERDI) nuclear power plant. Qinshan phase 2 is CNP-600, a scaled-up two-loop version of the same.

6.10.5 Japan

Market Size & Growth

Japan's plan to cut greenhouse gas emissions is expected to boost the nation's share of electricity from nuclear power to 44% from 31% now, a government estimate shows.

As part of METI Cool Earth 50 energy innovative technology plan in 2008, the Japan Atomic Energy Agency (JAEA) has modelled a 54% reduction in CO_2 emissions (from 2000 levels) by 2050 leading on to a 90% reduction by 2100. This would lead to nuclear energy contributing about 60% of primary energy in 2100.

Proposed Nuclear Reactors in Japan

Reactor	Type	Capacity MW	Utility	start * construction	start * operation
Ohma 1	ABWR	1383	EPDC/ J-Power	mid 2010	11/2014
Fukushima I - 7	ABWR	1380	Tepco	4/2010	10/2015
Fukushima I - 8	ABWR	1380	Tepco	4/2011?	10/2016
Higashidori 1 Tepco	ABWR	1385	Tepco	11/2009	3/2017
Tsuruga 3	APWR	1538	JAPC	10/2010	2016
Tsuruga 4	APWR	1538	JAPC	10/2011	2017
Kaminoseki 1	ABWR	1373	Chugoku	6/2012	3/2018
Sendai 3	APWR	1590	Kyushu	2013	2019
Higashidori 2 Tepco	ABWR	1385	Tepco	2014?	2019 or later
Hamaoka 6	ABWR	1380	Chubu	2015	2020
Higashidori 2 Tohoku	ABWR	1385	Tohoku	2016	2020 or later
Namie-odaka	BWR	825?	Tohoku	2017	3/2021
Kaminoseki 2	ABWR	1373	Chugoku	2018	2022
Total (13)		17,915 MWe			
Monju	Prototype FBR	246	JAEA	operated 1994-95, awaiting restart	

Source: WNA

Drivers & Constraints

In March 2002 the government announced that it would focus on nuclear energy to achieve greenhouse gas emission reduction goals and submitted a 10-year energy plan to METI. The plan called for an increase in nuclear power generation by about 30% (13,000 MW), with the addition of 9 to 12 new nuclear plants by 2011. However, due to the safety fears and shut of nuclear plants, Japan has not increased it nuclear power capacity at 53 reactors (46,236 MW). There are an additional 3 plants (3300 MW) under construction and a further 13 plants (17,915 MW) planned.

In July 2005 the Atomic Energy Commission reaffirmed policy directions for nuclear power with a 30-40% share target for nuclear power in total generation after 2030.

Market Players & Competition

Nuclear Fuel

- **Japan Nuclear Fuel Ltd (JNFL)** operates a commercial enrichment plant at Rokkasho. This began operation in 1992 using indigenous technology. It has been testing a lead cascade of its new Shingata design, and expects to re-equip the plant with this, starting in April 2010, and with the new equipment to come on line in September 2011. JNFL's shareholders are the power utilities.

- **Mitsubishi Nuclear Fuel Co Ltd** operates a 440 tU/yr fuel fabrication facility, which started up in 1972 and has had majority shareholding by Mitsubishi Materials Corporation (MMC). In April 2009 this was restructured as a comprehensive nuclear fuel fabrication company to supply Japanese customers with uranium fuel assemblies for pressurized water reactors (PWR), boiling water reactors (BWR) and high-temperature gas-cooled reactors (HTR), as well as MOX fuel assemblies. It will also provide related services, including uranium reconversion from 2014.

- **Nuclear Fuel Industries (NFI)** operates two fuel fabrication plants which have operated from 1976 and 1980 respectively. Kumatori (284 tU/yr) produces PWR and BWR fuel, Tokai (200 tU/yr capacity) is also set up to produce HTR and FNR fuel. NFI is also involved in a project to design MOX fuel for Areva to manufacture for Japanese power plants. In 2009 Westinghouse bought the 52% share of NFI owned by Furukawa and Sumitomo for $100 million.

Reactor Design and Construction

- **GE-Hitachi** <Unlisted> develops advanced light water reactors (LWR) and offers products and services used by operators of boiling water reactor (BWR) and pressurized water reactor (PWR) nuclear power plants to improve efficiency and boost output. Products and services include steam turbines designed for nuclear applications, new and refurbished parts, nuclear fuel, inspection and reactor modifications and modernization, plant performance software, and instrumentation such as in-core and ex-core sensors, gamma thermometers, probes, and radiation monitors. GEH serves more than half of the US's active nuclear reactor operators and almost a third of the nation's operators for reactor supplies.

- **Westinghouse** <Unlisted> provides design work and start-up help for new nuclear power plants and makes many of the components. Westinghouse Electric manufactures and supplies the commercial fuel products needed to run the plants, and it offers training, engineering, maintenance, and quality management services. The firm also has research and technology operations. Its customers include utilities and industrial companies worldwide. Westinghouse Electric, which is owned by Japan-based conglomerate Toshiba, estimates that almost 50% of nuclear power plants around the world and about 60% of US plants are based on the company's technology.

- **Mitsubishi Heavy Industries (MHI)**. In April 2007 the government selected MHI as the core company to develop a new generation of FBRs. This was backed by government ministries, the Japan Atomic Energy Agency (JAEA) and the Federation of Electric Power Companies of Japan. These are concerned to accelerate the development of a world-leading FBR by Japan.

MHI has been actively engaged in FBR development since the 1960s as a significant part of its nuclear power business.

- **Japan Steel Works (JSW)** The main company producing the heavy forgings required for nuclear power plants spent 40 billion Yen ($330 million) from 2007 to increase capacity in advance of orders expected from both China and the USA. Japan Steel Works (JSW) has production and research bases in Hiroshima, Yokohama and Muroran. The Muroran centre, in Hokkaido, hosts the heavy steel works and research laboratory relevant to power generation. Muroran manufactures reactor pressure vessels, steam generator components, generator & turbine rotor shafts, clad steel plates and turbine casings for nuclear power plants. JSW has been manufacturing forgings for nuclear plant components to US Nuclear Regulatory Commission standards since 1974, and around 130 JSW reactor pressure vessels are used around the world - more than one third of the total.

Utilities

- **J-Power,** is preparing to build its **Ohma** nuclear plant - 1383 MWe Advanced Boiling Water Reactor (ABWR) - in Aomori prefecture. Construction of unit 1 was due to start in August 2007 for commissioning in 2012, but was delayed by more stringent seismic criteria, and then delayed again in 2008

6.10.6 South Korea

Market Size & Growth

South Korea has embarked on a large nuclear power generation program through ***Korea Nuclear Hydro Power*** (KNHP) and expected to increase generation to 243 billion kWh.

South Korean energy policy has been driven by considerations of energy security and the need to minimise dependence on current imports. Policy is to continue to have nuclear power as a major element of electricity production.

After drawing on Westinghouse and Framatome (now Areva) technology for its first eight PWR units, and Combustion Engineering (which became part of Westinghouse) for two more, the Korean Standard Nuclear Power Plant (KSNP) became a recognised design, and evolved a little to KSNP+. In 2005 the KSNP/KSNP+ was rebranded as **OPR-1000** (Optimised Power Reactor) apparently for Asian markets, particularly Indonesia and Vietnam. Six operating units and four under construction are now designated OPR-1000.

The ***Ministry of Education, Science & Technology***'s third comprehensive nuclear energy development plan, for 2007-11, projected that South Korea should develop its nuclear industry into one of the top five in the world, with about 60% of electricity from nuclear by 2035.

Proposed Nuclear Power Plants in South Korea

Reactor	Type	Net capacity	Start construction	Commercial operation
Shin Kori 1	OPR-1000	1000 MWe	June 2006	12/2010
Shin Kori 2	OPR-1000	1000 MWe	June 2007	12/2011
Shin Wolsong 1	OPR-1000	1000 MWe	November 2007	3/2012
Shin Wolsong 2	OPR-1000	1000 MWe	September 2008	1/2013
Shin Kori 3	APR-1400	1350 MWe	October 2008	9/2013
Shin Kori 4	APR-1400	1350 MWe	September 2009	9/2014
Shin Ulchin 1	APR-1400	1350 MWe	March 2011	12/2015
Shin Ulchin 2	APR-1400	1350 MWe	March 2012	12/2016
Shin Kori 5	APR-1400	1350 MWe	8/2014	12/2018
Shin Kori 6	APR-1400	1350 MWe	8/2015	12/2019
Shin Wolsong 3	APR-1400	1350 MWe		6/2020
Shin Wolsong 4	APR-1400	1350 MWe		6/2021
Total 12		**14,800 MWe**		

Source: WNA

Drivers & Constraints

The MKE declared in January 2010 that it aimed to achieve exports of 80 nuclear power reactors worth $400 billion by 2030, in the course of becoming the world's third largest supplier of nuclear technology, with a 20% share of the world market, behind the USA and France or Russia.

Market Players & Competition

Nuclear Fuel

- ***Korea Atomic Energy Research Institute*** (KAERI) has developed both PWR and Candu fuel technology

- ***Korea Nuclear Fuel Company*** (KNFC) have supplied PWR fuel since 1990 and Candu PHWR fuel (unenriched) since 1987. KNFC has capacity of 550 t/yr for PWR fuel and 700 t/yr for Candu PHWR fuel, and supplies all KHNP's needs.

Reactor Design and Construction

- **KHNP** <Unlisted> is the largest among the six power generating subsidiaries that separated from Korea Electric Power Corporation (KEPCO) in April 2001, accounting for approximately 25% of electricity producing facilities, hydro and nuclear combined. KHNP also operates nuclear power plants in Kori, Yonggwang, Ulchin and Wolsong.

6.10.7 Taiwan

Market Size & Growth

Taiwan has 6 nuclear power stations in operation. Nuclear power has been a significant part of the electricity supply for two decades and now provides one quarter of base-load power and 17% overall, though nuclear comprises only 11% of 46 GWe installed capacity.

In May 2009 Taipower was examining the prospects for six more reactors, starting with a pair at an established site to be on line about 2020, though more recently it has projected one further unit beyond Lungmen 1&2 being on line by 2025.

Drivers & Constraints

Nuclear Power is seen as a cost effective alternative to other fuel sources and will form a key component of its power generation mix.

Market Players & Competition

- Taipower operates all 6 existing nuclear power stations and will be responsible for operating the new proposed plants.

6.10.8 India

Market Size & Growth

India has a streamlined nuclear power program and expects to have 20,000 MW nuclear capacities on line by 2020. It aims to supply 25% of electricity from nuclear power by 2050. It currently has 27 reactors built, with 3,800MW in capacity.

India is also one of the largest sources of Thorium globally and will be best place to utilise the raw material that it has domestically and become less reliant on Uranium.

Proposed Nuclear Reactors

Reactor	Type	MWe net, each	Project control	Commercial operation due	Safeguards status
Kaiga 4	PHWR	202 MWe	NPCIL	3/2010	
Rajasthan 6	PHWR	202 MWe	NPCIL	2/2010	Oct 2009 under new agreement
Kudankulam 1	PWR (VVER)	950 MWe	NPCIL	9/2010	item-specific
Kudankulam 2	PWR (VVER)	950 MWe	NPCIL	3/2011	item-specific
Kalpakkam PFBR	FBR	470 MWe	Bhavini	9/2011	-
Total (5)		2774 MWe			

Source: WNA

New Energy Parks

Nuclear Power Corporation of India (NPCIL) intends to set up "***Nuclear Energy Parks***" with a capacity of up to 10,000 MW at a single location. By 2032, 40-45 GW would be provided from 5 parks. Proposed new energy parks include:

- ***Kudankulam*** in Tamil Nadu, with a capacity of 6800 MW.
- ***Jaitapur*** in Maharashtra, with a capcity of 9600 MW.
- ***Haripur*** in West Bengal: to host four further Russian VVER-1200 units, with a capacity of 4800 MW.
- ***Markandi*** (Pati Sonapur) in Orissa with plans for up to 6000 MW of PWR capacity.
- ***Kumharia*** in Haryana, a proposal for a 2800 MW nuclear power plant and the site is apparently earmarked for four indigenous 700 MW PHWR units.
- ***Bargi*** in Madhya Pradesh is also designated for two indigenous 700 MW PHWR units.
- ***Mithi Virdi*** (or Chayamithi Virdi) in Gujarat: to host US technology (Westinghouse AP1000).
- ***Kovvada*** in Andhra Pradesh: to host US technology (GE Hitachi ESBWR - possibly ABWR).

The AEC has also mentioned possible new nuclear power plants in Bihar and Jharkhand.

Drivers & Constraints

The ***Indian Atomic Energy Commission*** (AEC) is the main policy body. The target since about 2004 has been for nuclear power to provide 20 GW by 2020. Late in 2008 NPCIL projected 22 GW on line by 2015, and a 50 GW of nuclear power operating by 2050. In June 2009 NPCIL said it aimed for 63 GW nuclear by 2032, including 40 GW of PWR capacity and 7 GW of new PHWR capacity. The AEC however envisages some 500 GWe nuclear on line by 2060, and has since speculated that the amount might be higher still: 600-700 GWe by 2050, providing half of all electricity.

Next Generation Reactors - Thorium

With a large reserve of thorium, India has targeted thorium for large-scale energy production to reduce its reliance on imported uranium. The plan will be in three stages:

- ***Pressurised Heavy Water Reactors*** (PHWRs) fuelled by natural uranium, plus light water reactors, producing plutonium.

- ***Fast Breeder Reactors*** (FBRs) using plutonium-based fuel to breed U-233 from thorium. The blanket around the core will have uranium as well as thorium, so that further plutonium (particularly Pu-239) is produced as well as the U-233.

- ***Advanced Heavy Water Reactors*** burn the U-233 and this plutonium with thorium, getting about 75% of their power from the thorium. The used fuel will then be reprocessed to recover fissile materials for recycling.

Market Players & Competition

Nuclear Fuel

- Mining and processing of uranium is carried out by ***Uranium Corporation of India Ltd***, a subsidiary of the Department of Atomic Energy (DAE), at Jaduguda and Bhatin (since 1967), Narwapahar (since 1995) and Turamdih (since 2002) - all in Jharkhand near Calcutta. All are underground, the last two being modern.
- India has reserves of 290,000 tonnes of thorium - about one quarter of the world total, and these are intended to fuel its nuclear power program longer-term

Design and Operation

- **Nuclear Power Corporation of India Ltd (NPCIL)** <Unlisted> is responsible for design, construction, commissioning and operation of thermal nuclear power plants. At the start of 2010 it said it had enough cash on hand for 10,000 MWe of new plant. Its funding model is 70% equity and 30% debt financing.

- **National Thermal Power Corporation (NTPC)** <Unlisted> is India's largest power company and has proposed building a 2000 MWe nuclear power plant to be in operation by 2017. It would be the utility's first nuclear plant and also the first conventional nuclear plant not built by the government-owned NPCIL. This proposal has now become a joint venture with NPCIL holding 51%, and possibly extending to multiple projects utilising imported technology. NTPC says it aims by 2014 to have demonstrated progress in "setting up nuclear power generation capacity", and that the initial "planned nuclear portfolio of 2000 MW by 2017" may be greater. NTPC, now 89.5% government-owned, is planning to increase its total installed capacity from 30 to 50 GWe by 2012 (72% of it coal) and 75 GW by 2017. It is also forming joint ventures in heavy engineering.

Construction

- ***Larsen & Toubro*** (L&T) announced in July 2008 that it was preparing to venture into international markets for supply of heavy engineering components for nuclear reactors.

- ***Reliance Power*** (RPower), NPCIL, and BHEL said that they plan to invest over US$ 50 billion in the next five years to expand their manufacturing base in the nuclear energy sector. BHEL plans to spend $7.5 billion in two years building plants to supply components for reactors of 1,600 MWe. It also plans to set up a 50-50 venture with NPCIL that will supply turbines for nuclear plants of 700 MWe, 1,000 MWe and 1,600 MWe and will seek overseas partners to provide technology for these enterprises

- ***Hindustan Construction Co.*** (HCC) has built more than half of India's nuclear power capacity, notably all 6 phases of the ***Rajasthan Atomic Power Project*** and also Kudankulam. It specializes in prestressed containment structures for reactor buildings. In September 2009 it formed a joint venture with UK-based engineering and project management firm AMEC PLC to undertake consulting services and nuclear power plant construction. HCC has an order backlog worth 10.5 billion rupees ($220 million) for nuclear projects from NPCIL and expects six nuclear reactors to be tendered by the end of 2010.

6.10.9 Singapore

Market Size & Growth
There are currently no nuclear plants in commercial use in Singapore.

Drivers & Constraints
Singapore has undertaken a feasibility study on nuclear power as part its study on energy security.

Market Players & Competition

There are no companies identifed in this sector in Singapore.

6.10.10 Indonesia

Market Size & Growth
Plans are to call tenders in 2008 for two 1000 MWe units, ***Muria 1 & 2***, leading to a decision in 2010, with construction starting soon after and commercial operation from 2016 and 2017. Tenders for ***Muria units 3 & 4*** are expected to be called for in 2016, for operation from 2023. The government has said that it has $8 billion earmarked for four nuclear plants of total 6 GWe to be in operation by 2025. Under current plans it aims to meet 2% of power demand from nuclear by 2017. There is also proposed a small power and desalination plant for ***Madura***, using the S. Korean SMART reactor.

Drivers & Constraints
A 2001 power generation strategy showed that introduction of a nuclear plant on the Java-Bali grid would be possible in 2016 for 2 GWe rising to 6-7 GWe in 2025, using proven 1000 MWe technology with 85% capacity factor and investment cost $2000/kWe. Late in 2003 ***National Atomic Energy Agency*** (BATAN) narrowed the choice of plant to a South Korean 1000 MWe pressurised water reactor.

Under the ***2006 Law on Nuclear Reactors*** the project may be given to an IPP to build and operate, on one of three sites on the central north coast of Java. Plans were to call tenders in 2008 for two 1000 MWe units, Muria 1 & 2, leading to decision in 2010 with construction starting soon after and commercial operation from 2016 and 2017, but this schedule has slipped. Tenders for Muria units 3 & 4 were expected to be called for in 2016, for operation from 2023.

The government has said that it has $8 billion earmarked for four nuclear plants of total 6 GWe to be in operation by 2025. Under current plans it aims to meet 2% of power demand from nuclear by 2017. It is anticipated that nuclear generation cost would be about 4 cents/kWh (US) compared with 7 c/kWh for oil and gas.

Market Players & Competition
In July 2007 KHNP signed a memorandum of understanding with Indonesia's PT Medco Energi Internasional to progress a feasibility study on building two 1000 MWe OPR-1000 units from KHNP at a cost of US$ 3 billion. The Indonesian government earlier confirmed in principle

approval of four 1000 MWe units on the Muria peninsula, 450 km east of Jakarta in central Java, with a view to commissioning in 2016

In addition, BATAN has undertaken a pre-feasibility study for a small Korean SMART reactor for power and desalination on Madura. However, this awaits the building of a reference plant in Korea. Also the province of Gorontalo on Sulawesi is reported to be considering a floating nuclear power plant from Russia, and late in 2007 a cooperation agreement with Japan was signed, envisaging its help in building and operating nuclear power plants.

The Japanese and Indonesian governments signed a cooperation agreement in November 2007 relating to assistance to be provided for the preparation, planning, and promotion of Indonesia's nuclear power development and assistance for public relations activities.

6.10.11 Malaysia

Market Size & Growth

There are currently no nuclear plants in commercial use in Malaysia.

Drivers & Constraints

A comprehensive energy policy study including consideration of nuclear power will be completed before 2010. The state-owned utility TNB is tentatively in favour of nuclear power and in August 2006 the Malaysian Nuclear Licensing Board said that plans for nuclear power after 2020 should be brought forward and two reactors built much sooner.

Market Players & Competition

There are currently no nuclear plants in commercial use in Malaysia.

6.10.12 Philippines

Market Size & Growth

There are currently no nuclear plants in commercial use in the Philippines.

Drivers & Constraints

In 2007 the ***Philippines Department of Energy*** (DOE) set up a project to study the development of nuclear energy, in the context of an overall energy plan for the country. Nuclear energy would be considered in order to reduce the country's dependency on imported oil and coal. In its 2008 update of the National Energy Plan, 600 MWe was projected to be in operation by 2025, with further 600 MWe increments in 2027, 2030 and 2034 to give 2400 MWe.

Market Players & Competition

There are currently no nuclear plants in commercial use in the Philippines.

6.10.13 Thailand

Market Size & Growth

Interest by Thailand in nuclear power was revived by a forecast growth in electricity demand of 7% per year for the next twenty years. About 70% of electricity is from natural gas. Capacity requirement in 2016 is forecast at 48 GWe.

Drivers & Constraints

In June 2007 the Energy Minister announced that it would proceed with plans to build a 4000 MWe nuclear power plant, and has budgeted funds to 2011 for preparatory work. Construction will commence in 2015, to operate from 2020.

Thailand is currently investigating the potential for nuclear power by 2020, as part its 15 year Masterplan.

Market Players & Competition

Thailand has had an operating research reactor since 1977 and a larger one is under construction.

In November 2009 EGAT and CLP Holdings Ltd signed an agreement with China Guangdong Nuclear Power Corporation regarding nuclear power development.

6.10.14 Australia

Market Size & Growth

While Australia has the largest Uranium resources in the world, accounting for around a quarter of the world’s reserves (1.24 million tonnes), there are currently no nuclear plants in commercial use in Australia.

About 96% of Australia's ***Economically Demonstrated Resources*** (EDR) are within six deposits: Olympic Dam, Ranger, Jabiluka, Koongarra, Kintyre and Yeelirrie.

Drivers & Constraints

In December 2006 the report of the Prime Minster's expert taskforce considering nuclear power was released. It said nuclear power would be 20-50% more expensive than coal-fired power and (with renewables) it would only be competitive if "low to moderate" costs are imposed on carbon emissions (A$ 15-40 - US$ 12-30 - per tonne CO2). "Nuclear power is the least-cost low-emission technology that can provide base-load power" and has low life cycle impacts environmentally.

The report said that the first nuclear plants could be running in 15 years, and looking beyond that, 25 reactors at coastal sites might be supplying one third of Australia's (doubled) electricity demand by 2050.

In April 2007 the Prime Minister announced that the government would proceed to open the way for nuclear power in Australia by setting up a nuclear regulatory regime and removing any regulatory obstacles which might unreasonably stand in the way of building nuclear power plants. Australia would also apply to join the ***Generation IV International Forum***, which is developing advanced reactor designs for deployment about 2025. However, with a change of government late in 2007 the move towards nuclear power was halted.

Market Players & Competition

Nuclear Fuel

- **Paladin** **<PDN.AX>** is a Uranium Mining company and its projects include Langer Heinrich Project, Kayelekera Project, Bigrlyi Project, Angela Uranium Project, Manyingee Project and Oobagooma Project. The Langer Heinrich Project is located in the Namib Desert, 80 kilometers east of the seaport of Walvis Bay and about 40 kilometers south-east of Rossing uranium mine (Rossing Project). The Kayelekera Project is located in northern Malawi, 52 kilometers west of the provincial town of Karonga. The Company's subsidiaries include Paladin Finance Pty Ltd, Northern Territory Uranium Pty Ltd, Paladin (Africa) Ltd, Mount Isa Uranium Pty Ltd, Langer Heinrich Uranium (Pty) Ltd, Paladin Energy Minerals NL and Paladin Nuclear Ltd. In April 2009, Paladin Energy Limited completed the compulsory acquisition of 97% interest in Fusion Resources Limited. For a detailed company profile, see Appendix A.

- **Enery Metals Limited** **<EME.AX>** is engaged in uranium exploration. The Company has nine projects located in the Northern Territory (NT) and Western Australia covering over 4,000square kilometers. The Ngalia Regional project comprises 10, 100% owned exploration licenses (total area 2,840square kilometers) located in the Ngalia Basin, between 180 and 350 kilometer northwest of Alice Springs in the Northern Territory. The Bigrlyi Project comprises 10 granted exploration retention licenses located approximately 350 kilometer northwest of Alice Springs. The Macallan project is an exploration license application (ELA27333), located 460 kilometer northwest of Alice Springs and 140 kilometer from the advanced Bigrlyi project. The Company holds 100% interest in NT Energy Pty Ltd. The Company holds 53.74% interest in Bigrlyi Joint Venture.

Design and Construction

Australia only has two research nuclear reactors:

- ***High Flux Australian Reactor*** (HIFAR), was for many years the only operating nuclear reactor in Australia. It was used for materials research, to produce radioactive materials for medicine and industry and to irradiate silicon for the high performance computer industry.

- ***Open Pool Australian Lightwater reactor*** (OPAL), the new research reactor is is a 20 MW open pool design using low-enriched fuel (less than 20% enriched).

6.10.15 New Zealand

Market Size & Growth

There are currently no nuclear plants in commercial use in New Zealand.

Drivers & Constraints

In 1968 the national power plan first identified the likely need for nuclear power in NZ a decade or more ahead, since readily-developed hydro-electric sites had been utilised. However, a further report in 1978 said that there was no immediate need for NZ to embark upon a nuclear power program, but suggested that early in 21st century "a significant nuclear programme should be economically possible."

Market Players & Competition

There are currently no nuclear plants in commercial use in New Zealand.

6.10.16 Summary of Companies

Code	Company Name	Market Cap (M Dollars)	PE Ratio	Country	Segment
PDN.AX	Paladin Energy Ltd	$2,621.8	N/A	Australia	Metals - Non Ferrous
EME.AX	Energy Metals Ltd	$66.9	N/A	Australia	Metals - Non Ferrous
Unlisted	China National Nuclear Corporation	N/A	N/A	China	Nuclear Fuel
Unlisted	Japan Nuclear Fuel	N/A	N/A	Japan	Nuclear Fuel
Unlisted	GE-Hitachi	N/A	N/A	Japan	Reactor Design
Unlisted	Westinghouse	N/A	N/A	Japan	Reactor Design
Unlisted	KHNP	N/A	N/A	South Korea	Nuclear Utility

6.11 Wastewater

6.11.1 Background

This section primarily looks at waste water treatment and water re-use, rather than water supply. In addition, the use of wastewater streams to generate biogas that can be used to generate power that overlaps with landfill gas generation in **Section 6.11**.

6.11.2 Targets & Incentives

- ***China*** - The ***Ministry of Construction*** required that by 2010, the municipal wastewater treatment rate should not be lower than 70%, and all cities and counties should establish or plan to establish centralized wastewater treatment facilities.

- ***Japan*** - Japan's wastewater facilities services only around 70% of the population. Japan is increasing its power generation from biogas with over 40 plants installed and more than 350 sewage treatment plants working with anaerobic digestion facilities in place.

- ***South Korea*** – South Korea is in the process of upgrading its wastewater systems to include tertiary treastment. There are around 400 treatment plants, with around 30 new plants constructed every year

6.11.3 Wastewater Process

Wastewater Treatment

Water treatment technology is gradually shifting from traditional filter and settlement processes to membrane processing. Primary treatment involves separation, coagulation, flocculation and settlement of material. This stage is followed by a secondary stage involving filtration through sand beds or activated carbon to absorb chemical contaminants.

Water processing membranes are resin membranes with tiny perforations that range in size between micrometres (or millionths of a metre) to nanometres (billionths of a metre). The dimensions of the perforations allow them to filter out impurities under pressure, and increase the purity of the water. There are four main types of membrane, which are used in response to different applications:

- ***Reverse Osmosis*** (RO), used in the desalination process;
- ***Nano Filtration*** (NF);
- ***Ultra Filtration*** (UF); and
- ***Microporous Filtration*** (MF)

After potable water has been filtered, it then typically goes through a tertiary stage of disinfection. There are three methods of disinfection used in the potable water industry:

- ***Ozonation*** is a process of adding ozone to the water supply, whereby disease-causing microbes, including Giardia and Cryptosporidium, are deactivated.
- ***Ultraviolet*** takes place as water flows through an irradiation chamber. Micro-organisms in the water are inactivated when the UV light is absorbed. This damages their nucleic acid, thereby preventing the microbe from replicating and infecting a host.
- ***Chlorine*** is a disinfectant added to drinking water to reduce or eliminate microorganisms, such as bacteria and viruses. Chlorine remains the most commonly used drinking water disinfectant, used in more than 90% of the world's drinking water either as the primary source of disinfection or as a secondary disinfection after an ozone or ultraviolet primary disinfection.

Re-used Water

Since much of the recycled water will not be clean enough to drink, re-used water can be used for agricultural purposes (which is the main user of water) with relatively little purification compared with desalinated water (where the salt has to be extracted), which requires extensive purification.

There are two types of water that can be re-used:

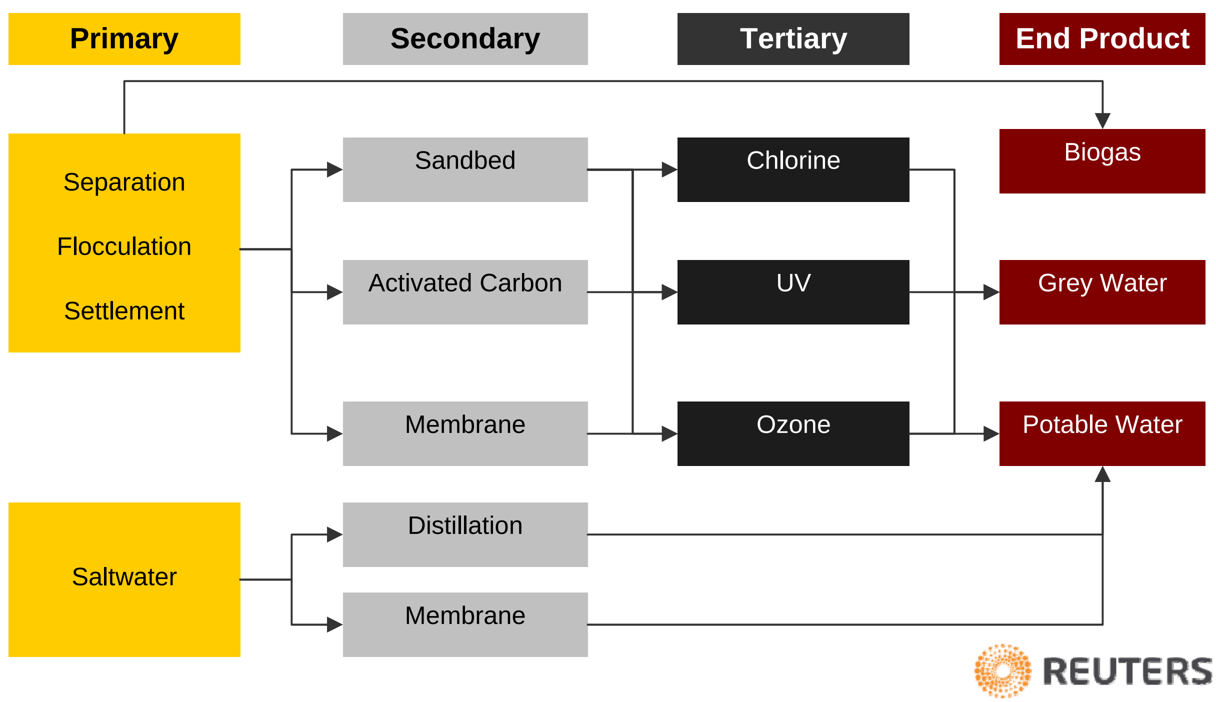
- Grey water is non-industrial wastewater generated from domestic processes. The US EPA defines grey water as non-drinkable water that can be reused for irrigation, flushing toilets, and other purposes. Grey water can be used immediately or treated and stored. It is distinct from black water, which contains more polluting chemical and biological contaminants.

- Reclaimed (or recycled) water is former wastewater that has been treated to remove solids and certain impurities. It is often only intended for non-potable uses (e.g., irrigation, dust control, fire suppression); but with more advanced treatment, it can be for potable reuse.

Biogas

Biogas is created from the anaerobic digestion of biodegradable matters, such as wastewater, which produces methan and used to generated electricity.

Figure 6.26 – Wastewater & Desalination Process



6.11.4 Research & Development

Research of 180,000 patent filings in the wastewater sector undertaken by Thomson Reuters (from 1985 to 2008) showed that Japan was the global leader, followed by USA and Germany. China ranked 6th with 18,278 patent documents[47].

Assignee analysis of water pollution and treatment patents applied in China showed that individual inventers contribute a significantly higher proportion of patent applications (54%), with Universities and enterprises accounting for 19% each, while research institutes only accounted for 8% of patents filed. Further analysis of the top 20 assignees indicates that the Chinese universities (15 out of 20). Further

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[47] Patent Activity on Water Pollution and Treatment in China – a Scientometric Perspective, Institute of Scientific and Technical of Information of China, Beijing, 100038, P.R.China. Thomson Reuters, Beijing,100190, P.R.China, ISTIC-Thomson Reuters Joint Lab for Scientometrics Research

investigation, showed that there was little collaboration among enterprises, universities, and research institutes are found.

The top 20 patent assignees for wastewater in China

Rank	Patent Assignee	No Patents
1	Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences 184	184
2	Tsinghua University	157
3	Harbin Institute of Technology	151
4	China Petroleum & Chemical Corporation	149
5	Nanjing University	128
6	Zhejiang University	113
7	Shanghai Jiao Tong University	89
8	South China University of Technology	88
9	Tongji University	84
10	Shanghai Wansen Water treatment Co.,Ltd	78
11	Tianjin University	65
12	Dalian University of Technology	43
13	Nankai University	38
14	Dalian Institute of Chemical Physics, Chinese Academy of Sciences	32
15	15 Shandong University	30
16	The Institute of Applied Ecology, Chinese Academy of Sciences	29
17	Southeast University	29
18	Sun Yat-sen university	27
19	Sichuan university	27
20	University of Science and Technology Beijing	27

Source: Thomson Reuters Scientific

6.11.5 China

Market Size & Growth

Wastewater

In early 2006, the ***Ministry of Construction*** required that by 2010, the municipal wastewater treatment rate should not be lower than 70%, and all cities and counties should establish or plan to establish centralized wastewater treatment facilities. Water remains one of the major focuses of the ***11th Five-Year Plan*** (2006-2010) environmental protection plan. While stepping up efforts to increase and improve municipal wastewater treatment facilities, China will begin to levy sewage treatment fees throughout the country in the coming five years.

China generated 57.2 billion tons of wastewater in 2008; municipal wastewater and industrial wastewater account for 58% and 42% respectively.

Investment in Municipal Wastewater Treatment Plants

Year	Budget ($ billion)	Number of Plants	Capacity (Mm3/day)
2001-2008	1.17	78	3.785
2009-2013	0.77	57	2.905
Total	1.94	135	6.690

Source: PRC State Environmental Protection Administration

China is likely to be a major market with the development of wastewater treatment capacity and continued water shortages in the north east. Beijing already recycles 60% of its wastewater but recently announced (April 2009) a three-point plan that includes RMB 35bn (US$5.13bn) of investment in water and wastewater infrastructure between 2009 and 2013. The plan includes increasing charges for recycled water (these have remained unchanged since being fixed at $0.15/m^3 in 2003) and specific goals to ensure that 100% of wastewater is eventually recycled. It is now required, for example, that newly developed residential buildings in Beijing with construction areas over 30,000 m^2 build on-site wastewater reuse facilities.

Biogas

China has also included biogas treatment technologies, such as anaerobic-aerobic activated sludge process. Examples of projects include The wastewater treatment plant in ***Shandong*** and ***Baoan District Wastewater Treatment Plant*** in Guangdong.

MSW and food waste biogas plants currently under consideration in China

Location	Start	Feedstock	Technology Developer	Capacity mt/a	€	Comments
Beijing Dong Cun Taihu Coun.	2007	Restaurant- & MSW,manure	Linde Valorga Biomax	0.2	Inv.18m Fee13.5/t	Feasibility 2005, CDM
Beijing	till 2010	Restaurant- &. MSW, ..				9 plants anticipated
Shanghai Jinshan	2008	MSW, BMW		0.22	Inv. 32m	Ppublic tender
Shanghai Putuo, Shanghai	2007	Municipal wet waste	Valorga Biomax	0.18 to 0.29	Inv.30m Fee17/t	Feasibility 2005, CDM PDD1/06
Guangzhou Likeng (Guandong)	2007	Municipal wet waste	Valorga Biomax	0.36	Inv.32m	Preparation
Changsha Huiming (Hunan)	2005	MSW		0.73	Inv.11m	Biogas power plant
Mianyang (Sichuan)	2002	MSW	Tunnel type	0.25 AD: 3600t/a		AD as pilot project
Yingkou (Liaoning)	2007	MSW, SS	Tsinghua Tongfang	0.27	Inv.20m	
Shenyang (Liaoning)	2010	BMW (source separation)	Wet AD recommended	0.12 to 0.20	Inv.12m Fee >6/t	Prefeasibility-study

Based on the 'National Biogas Construction Plan of the MOA 2003,[48] the small-scale urban household biogas digesters were built and supported in the south western rural areas of China In 2003 8m units were in use, which grew to about 10% of the rural population in 2005, producing

[48] National Biogas Construction Plan of the MOA 2003

5.5bn nm^3/a biogas from 15m units. It is projected that 56m digesters will be in operation by 2020 and 20bn nm^3/a of biogas will be produced for decentralised energy supply (cooking, lightning).

Drivers & Constraints

Wastewater

China has stepped up its efforts to improve the regulatory framework for modern wastewater management. A range of regulatory and economic instruments are used, such as charging users for water services. However, local enforcement remains weak in many regions.

The ***11th Five Year Plan***, the Chinese Government has set a target of 1.35% of GDP to be invested in “environmental protection”, which includes wastewater treatment. Continued investment in this sector is expected to continue into the ***12th Five-Year Plan*** (2011-2015). China has also stipulated relevant policies to encourage private and foreign investment in wastewater treatment facilities. Key wastewater treatment projects in China include:

- ***South-to-North Water Diversion Project***. The construction of the South-to-North Water Diversion Project will create a large water supply and wastewater treatment market. USD1.93 billion is the planned investment for the construction of municipal wastewater treatment plants. These projects are located in Jiangsu, Shandong, Hebei, Tianjin, Anhui and Henan Provinces.
- ***Three Gorges Watershed Area***. As part of the Three Gorges Project, wastewater treatment projects will be implemented in Hubei, Sichuan, Guizhou, Yunnan Provinces and Chongqing Municipality. China plans to build 20 more sewage disposal plants in the Three Gorges Reservoir area in central Hubei Province on the Yangtze River to further improve water quality in the reservoir. These projects will be built in Zigui, Xingshan, Badong, Yuan'an, Enshi and Lichuan counties in the reservoir area.
- ***Beijing 2008 Olympic Games***. Nine wastewater treatment plants, 1000 km long wastewater main pipelines, nine wastewater reclamation and reuse facilities, and four sludge digesting facilities were constructed for a total investment will be USD1.45 billion.

Biogas

China’s ***2003-2010 National Rural Biogas Construction Plan*** is to increase biogas-using households by a further 31 million to a total of 50 million, so the rate of use would reach 20% of total rural households.

Market Players & Competition

Wastewater

- **Epure** <Unlisted> is a water and water-treatment EPC company predominantly operating in China. The company also owns Beijing Hi Standard, a manufacturer of waste-water treatment equipment. Epure has said it is looking to diversify its earnings stream further by acquiring BOT and BOO projects in China, as well as expanding into the Middle Eastern EPC market. To this end, Epure has acquired seven BOT water and waste treatment plants in China. Epure also signed a Letter of Intent to design and build a 72,000 tpd waste water treatment facility in Saudi Arabia, the company's first venture outside China. Epure should in our view be a key beneficiary of the growing demand for water in China. We maintain a Neutral rating on the stock.

- **Pan Asia Environmental Protection Group Limited <0556.HK>** together with its subsidiaries, is engaged in the sale of pipes, water treatment and flue gas treatment products and equipment, as well as undertaking of environmental protection (EP) construction engineering projects and provision of EP-related professional services. The Company operates in three segments: sale of EP products and equipment, EP construction engineering projects, and the provision of professional services. The sale of EP products and equipment segment is responsible for selling pipes, and water and flue gas treatment products and equipment. The water treatment systems of the Company are used mainly to process industrial and urban wastewater. Its flue gas treatment systems are used to remove waste gases generated in an array of industrial processes.

Biogas

- ***Hongzhi Alcohol Corporation*** located in Mianzhu, Sichuan Province which is the largest alcohol factory in south-western China, uses its industrial organic wastewater, sewage and dregs to produce biogas. The city of Mianzhu treats 98 per cent of municipal sewage including wastewater from hospitals through digesters with a total capacity of 10,000 m^3.

- ***Chenming Paper Co.*** which generates 300 tons of sludge a day is adding its own start up biogas program using pulp wastes. The same goes for intensive animal husbandry on many large or medium size livestock and poultry farms in the suburbs of cities.

6.11.6 Japan

Market Size & Growth

Wastewater

As of March 2006, Japan's wastewater facilities serviced 69% of the population. Of the remainder, 12% of households used septic tanks and 19% had no access to sanitation. To improve this, the sector's first priority is to expand the wastewater treatment system in rural areas.

Production of Water Pollution Control Equipment

Millions of Dollars	2004	2005	2006
Industrial wastewater treatment	608	613	678
Sewage water treatment	1,989	1,703	1,303
Human waste treatment	379	324	268
Sewage sludge treatment	1,107	809	581

Source: Japanese Society of Industrial Machinery Manufacturers

Biogas

Japan is increasing the amount of biogas plants with a high speed. Power generation from stockfarming waste, sewage sludge, food waste and biomass is in 2007 increased to over 40 plants, build and under construction with a electric power generation over 9 million kWh. More then 350 sewage treatment plants working with anaerobic digestion facilities of the sludge, with more plants developing power generation facilities from 30 today and 100 million kWh per year.

Drivers & Constraints

Japan has two sets of legislation that deals with wastewater:

- The ***Water Pollution Control Law*** (WPCL) designates facilities that emit hazardous wastewater as Specified Facilities
- The Sewage Law refers to those same facilities as Specified Business Premises.

Market Players & Competition

Pump

- **Ebara** **<6361.T>** The pump business is Ebara's core business segment and it has historically delivered a very stable revenue stream. The environment-related business at Ebara also offers significant exposure to the water sector. Two thirds of Ebara's business is focused on Japan.

- **Kurita Water Industries** **<6370.T>** Business is focused on the sale of ultra pure water production systems (used for cleaning in the semiconductor and FPD manufacturing processes) and water treatment systems for industrial uses. Kurita also operates maintenance/service divisions to support these systems. Growth in equipment sales may slow (it has averaged annual growth of 17% over the past five years), but we expect the service businesses (which account for 70% of total FY 2009 revenue) to bounce back when facility operation rates and capex in semiconductor/FPD manufacturing-related companies recover. Growing demand for desalination plants, water recycling and water treatment systems and chemicals should continue to support Kurita's business.

- **Tsurumi Manufacturing Co., Ltd.** **<6351.T>** is a Japan-based company principally engaged in the manufacture, purchase, sale, leasing and repair of various water pumps, as well as the provision of post-sale services. The Company is also involved in businesses related to machinery equipment installation, civil engineering, electrical work, piping work, water utility construction, cleaning facility construction and steel structure work, as well as the leasing of fixed assets, which include real estates, machinery, office equipment and automobiles. The Company has 10 subsidiaries and one associated company in Japan, Hong Kong, Singapore, the United States, Taiwan, China and Thailand.

- **China Boqi Environmental Solutions Technology** **<1412.T>** is a holding company engaged in the provision of environmental services in China, through its subsidiaries. The Company is active in three business segments. The Flue Gas Desulfurization (FGD) segment is engaged in the design, construction, installment and the provision of after-sales services of desulphurization systems for the treatment of sulfur oxide in flue gas, denitration systems for the treatment of nitrogen oxides, and internal desulphurization systems for boilers. The Solid Waste Processing segment is engaged in the investment, construction and operation of waste treatment power plants and others. The Others segment is engaged in the design, construction, installment and the provision of after-sales services of treatment systems for power plants, industry and domestic wastewater, as well as residual heat power generation facilities.

Membrane Technology

- **Nitto Denko <6988.T>** Nitto Denko aims to expand the water business alongside its mainstay LCD film division. It has increased its RO membrane capacity by 1.6 times. With further expansion of this plant in due course, the company says it aims to boost sales in its water segment to ¥100bn over the next ten years by strengthening RO-peripheral technologies and the repair/maintenance business.

- **Mitsubishi Rayon Co., Ltd <3404.T>** is a leader in membrane technology for the wasterwater business

- **Toray Industries, Inc. <3402.T>** has an Environment and Engineering segment offers functional film and machines, as well as materials for housing, construction and civil works for the wastewater industry.

Engineering Procurement and Construction (EPC)

- **Kubota Corporation <6326.T>** is mainly engaged in the manufacture farm equipment, and producer of pipes, principally ductile iron pipes, and related equipment for water supply and other utilities. In addition, the Company manufactures and sells other items, such as engines, construction machinery, industrial castings, industrial machinery, environmental control plants.

- **Tsukishima Kikai Co., Ltd. <6332.T>** See **Section 6.12**

- **Suido Kiko Kaisha, Ltd., <6403.Q>** mainly engaged in the water treatment business. The Company is engaged in the manufacture, installation and sale of water treatment machinery and equipment. The Company's products include the water treatment process equipment, such as coagulation sedimentation treatment equipment, filtration equipment, chemicals injectors, water treatment chemicals, seawater desalination units, wastewater treatment equipment, measurement equipment and valves; the sewage treatment units for sewage treatment, advanced sewage treatment and agricultural community sewerage treatment, as well as the environment engineering products, such as industrial water and industrial wastewater treatment products and wastewater recycling systems.

6.11.7 South Korea

Market Size & Growth

Korea’s water and waste water market is estimated to be worth USD 10 billion and is steadily growing, according to the Korean MOE. In 2009, the government spent an estimated USD 2.1 billion on water management projects. This accounts for 60% of the entire environmental market, which is assessed at about USD 3.4 billion.

Companies and local communities operate the sewage services, including wastewater reclamation-and-reuse systems, drainage facilities, and sewage processing plants. Currently, there are 403 municipal sewage treatment factories nationwide, and the Korean government constructs over 30 new sewage treatment plants every year.

Drivers & Constraints

The Korean government improved environmental regulations and in the process upgradied existing sewage treatment plants to install tertiary processes such as activated carbon filtering and advanced disinfection processes. For these purposes, the Korean government allocated a budget of USD 1.2 billion in 2008.

Market Players & Competition

- **Samyang Water and Sewage** <Unlisted> is one of Korea`s first engineeringfirms in the water purification and sewage treatment industry.

- **Hyosung Ebara** <Unlisted> is a joint venture with Ebara and is the leading centrifugal pump manufacturer in South Korea.

Biogas

- Scandinavian Biogas is investing about 10 million euros ($13.8 million) to upgrade a wastewater treatment plant in Ulsan and will soon start accepting food and other waste for processing into biogas

6.11.8 Taiwan

Market Size & Growth

During the 1980s, the Taiwan authorities began the planning and construction of municipal water treatment facilities and the ***Taipei Metropolitan Sewage Treatment System Development Project*** was initiated to increase Taiwans's sewage treatment rate from 43% in 2008 to over 60% by 2014.

Drivers & Constraints

Market Players & Competition

No companies identified

6.11.9 India

Market Size & Growth

It is estimated the total market is worth more than US$1 billion, divided about one-third for water provisioning, one third for municipal water treatment and one-third for industrial water treatment.

Drivers & Constraints

The key pieces of legislation driving India's wastewater treatment markets are:

- ***Water (Prevention and Control of Pollution) Act, 1974***,
- ***Water (Prevention and Control of Pollution) Cess Act, 1977***, and
- ***Environment (Protection) Act, 1986***

The Indian water treatment equipment industry is reasonably well established and cost-competitive. Locally fabricated equipment is about 30% cheaper than imported equivalents, but Indian firms have limited capabilities in designing technologies for larger scale water treatment plants. The water treatment market is moving from chemical treatment and demineralization technologies to greater use of membrane technology.

Market Players & Competition

- **Jain Irrigation** **<JAIR.BO>** is the leading manufacturer of ***Micro-Irrigation Systems*** (MIS) in India with a market share of 50% in drip and 35% in sprinkler irrigation. Management expects the company to retain these market shares going forward and benefit from the rising implementation of MIS. It expects the micro-irrigation business to be the key growth driver and account for more than 50% of the company's revenue (by 2012) (from 40% currently). According to management, a higher contribution from micro-irrigation would also boost margins, as this is the most profitable segment (EBITDA margins of 25–30%).

6.11.10 Singapore

Market Size & Growth

Due to Singapore's limited market size, Singapore serves as a testbed for the region and is the regional headquarters for a number of wastewater companies.

Drivers & Constraints

The Singapore Government committed US$219 million over five years to promote R&D to sustain the Republic's competitive edge in the global market, and to position Singapore as an R&D base for environment and water solutions.

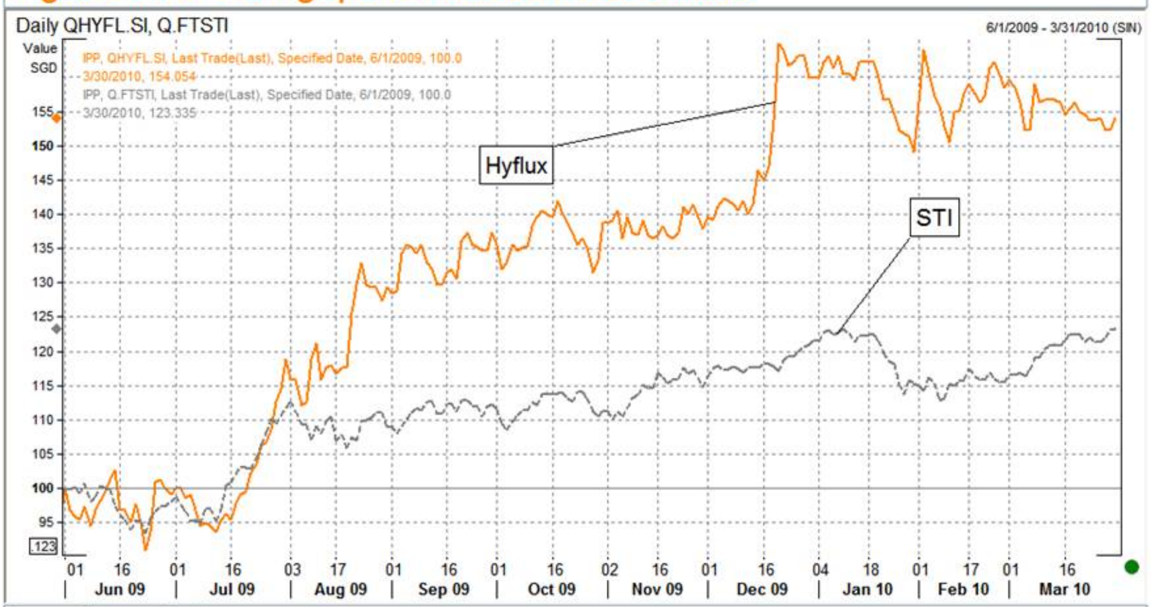
Singapore is home to over 50 water companies including major international players like GE Water, Siemens Water, Nitto Denko, and Black &Veatch. Homegrown firms such as Hyflux, Keppel and SemCorp have also set up water treatment plants in many overseas markets including China and the Middle East. With the development of major national water projects such as NEWater (recycled water), the Deep Tunnel Sewerage System (DTSS), desalination and rainfall storage like the Marina Barrage, Singapore is becoming increasingly independent when it comes to water. The aim of the Singapore Government is to increase value-added contribution from the water sector from US$0.3 billion (0.3% of GDP) in 2003 to US$1.1 billion (0.6% of GDP) by 2015.

Market Players & Competition

- **Hyflux** **<HYFL.SI>** develops and operates membrane-based water treatment, recycling, waste water treatment and seawater desalination plants. The company has extended its geographical footprint from China (38% of 2008 revenues) to the Middle East and North Africa (MENA) (60% of 2008 revenues). Hyflux is looking to build on its success on RO desalination plant wins in Algeria (200,000 m^3/day at Souk Tleta and 500,000 m^3/day at Magtaa) by targeting further projects in MENA. In June 2009, the company signed a Memorandum of Agreement with the commercial arm of the Libyan Ministry of Utilities to develop two desalination plants with a combined capacity of 900,000 m^3/day. For a detailed company profile, see Appendix A.

- **Sinomem Technology Limited** <Unlisted> develops advanced membrane materials and processes employed for water and wastewater treatment and environment-friendly production processes in various industries, such as pharmaceutical, nutriceutical, food and beverage. It operates in four divisions: membrane process and engineering, which is engaged in polymer membranes manufacturing, membrane-based process and development, engineering design, equipment fabrication, system integration, onsite installation and commissioning, and after-sales technical support; nutraceutical production and trading, which is engaged in the production of gibberellin, xanthan gum and sorbitol, and trading in nutraceutical products, including vitamins; waste water treatment, which provides waste water treatment services to the municipal and industrial users under build-operate-transfer or transfer-operate-transfer arrangements, and trading of equipment, which is engagade in the trading of stainless steel and glucose products.

Figure 6.27 - Singapore Wastewater Stocks



Source: Thomson Reuters

6.11.11 Indonesia

Market Size & Growth

There is an estimate 55% coverage of wastewater in Indonesia, with no clear government policy to increase this coverage.[49]

Drivers & Constraints

The key pieces of legislation driving Indonesia's wastewater treatment markets are:

[49] Domestic Wastewater Services and Facilities in Indonesia: Policy and Regulation Role, **Dwina Roosmini and Suphia Rahmawati**

- Law 32 in 2004, devolves the responsibility of the domestic wastewater management to the local government at provincial level as well as city level.
- Development of Institutional Based Water Supply and Environmental Sanitation (2004), by National Development Board
- National Action Plan in Wastewater (2003), by Ministry of Public Work

Market Players & Competition

Japan, China and Korea dominate the machinery and equipment market. Local companies control the construction services market.

6.11.12 Malaysia

Market Size & Growth

Malaysian imports of water and wastewater equipment in 2005 were around U.S. $878 million, an increase of 7% compared to 2004. In 2005, the U.S. had the second largest market share of 20% and its primary foreign competitor is Japan with a market share of 31%. A significant major emerging competitor is China that has a 19% market share.

Over U.S. $395 million has been allocated for improvement of the sewage systems in the country. Indah Water Konsortium (a wholly-owned company of the Ministry of Finance Inc.) is responsible for providing technical expertise and project management to projects that cover refurbishment of existing public sewerage treatment plants, public sewerage pipes network, pumping stations, and central sludge facilities throughout the country.

Drivers & Constraints

The key pieces of legislation driving Malaysia's wastewater treatment markets is the **Sewerage Services Act 1993**

Market Players & Competition

- **Gamuda** **<GAMU.KL>** Water accounted for 12% of revenue in 2008. Gamuda should benefit from the Malaysian government's plans to increase infrastructure spending. The group holds the concession for the largest water treatment plant (held by associate, SPLASH) in Malaysia, but is finalising the sale of this asset for RM632m (31sen per Gamuda share) by end 2009. Management has said it intends to return a substantial portion of the proceeds as special dividends if the deal is successfully completed and the group could also realise a RM100m–150m exceptional gain on the divestment.

6.11.13 Philippines

Market Size & Growth

The Philippine market for water and wastewater treatment products and equipment is projected to grow 10-15% per year over the next three years, from about $73million in 2004[50].

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[50] US Commercial Service, Wasterwater Market in the Philippines

Drivers & Constraints

The ***Clean Water Act*** was enacted in 2004, with Implementing Rules and Regulations issued in May 2005. Provisions of Clean Water Act that will open commercial opportunities include:

- Preparation of a National Program on Sewerage and Septage Management
- Mandatory connection to sewerage systems of all subdivisions, condominiums, commercial centers, hotels, sports and recreational facilities, hospitals, market places, public buildings and other similar establishments within five years following the enactment of the law
- Wastewater Charge covering all sources of wastewater discharges, including effluent from wastewater treatment plants, sewage treatment plants and discharges from water treatment facilities
- Discharge Permits that will be required from owners or operators of facilities that discharge regulated effluents. As part of the permitting procedure, DENR encourages the adoption of waste minimization and water treatment technologies when such technologies are deemed cost effective.
- Creation of the ***National Water Quality Management Fund*** and ***Area Water Quality Management Fund***. The funds can be used to purchase equipment for water quality monitoring, reporting or management.
- Fiscal and non-fiscal incentives to industrial wastewater treatment projects and/or adoption of water pollution control technology, cleaner production and waste minimization.

Market Players & Competition

- **Metropolitan Waterworks and Sewerage System (MWSS)** has jurisdiction, supervision and control over the waterworks and sewerage systems in Metro Manila and nearby cities.
- **Manila Water Company (MWC)** is responsible for the design and construction of North and South Septage Treatment Plants and Facilities in Quezon City and Taguig City. These projects are part of the International Bank for Reconstruction and Development/International Development Assistance's (IBRD/IDA) $64 million Manila Third Sewerage Project.

6.11.14 Thailand

Market Size & Growth

The current total market size for wastewater treatment is estimated at about $1.533 billion USD, with an average growth rate of about 10% per year (government sector $613 million USD, private sector $920 million USD). In general, construction and engineering services costs are 85% of the project with the remaining 15% for equipment. Thus, the market for wastewater treatment equipment is about $230 million USD. The wastewater treatment market is expected to continue growing by an average of 10% for the next few years due to improved economic performances from the real estate, industrial and agriculture sectors. The growth will be enhanced by the government initiative to build the 3 largest water treatment plants in Bangkok and 15 medium plants in other provinces.

The majority of the equipment used by the water and wastewater treatment sector is sourced from Japan, Europe, ASEAN, the U.S. and China. Total imports of water and wastewater treatment equipment in 2007 were an estimated $161 million USD. Japan had the largest market share of 30.9%, followed by Europe (18.5%), ASEAN (10.6%), the U.S. (10.2%), China (14.4%), and other (15.4%).

Wastewater treatment in Thailand is divided into two areas:

The government sector had provided a budget of about $2.6 million USD for 95 wastewater treatment projects in Thailand for the last few years (7 projects in Bangkok with budget of $633 million, 1 project in Samutprakarn province with budget of $333 and 87 projects in other provinces of $1.634 billion) The ***Bangkok Metropolitan Administrative*** (BMA), which looks after the Bangkok capital, has three new projects to finish with in the next few years. The projects are in Bangsue, Klongtoey,and Thonburi areas.

The ***Pollution Control Department*** of the Ministry of Natural Resource and Environment is supervising and allocating the budget of $1.6 billion for 87 wastewater treatment projects in other municipal areas. Presently, 75 projects were finished. Only 12 projects are under construction. According to the Pollution Control Department, Thai government will provide a budget of $37 million for 3 new municipal wastewater treatment projects in 2008.

The market size for the private sector is about $920 million USD. Growth is driven by economic performance and booming direct foreign investment, especially in export-oriented industries.

Drivers & Constraints

Under the “Enhancement and Conservation of National Environmental Quality Act 1992”, the Pollution Control Department (PCD), the Office of Natural Resources and Environmental Policy and Planning (ONEP) and the Department of Environmental Quality Promotion (DEQP) under the Ministry of Natural Resources and Environment (MONRE) are responsible for wastewater management by undertaking national and regional water quality management policy and planning, raising public awareness concerning water conservation and facilitating local authorities for their responsibilities of their own wastewater management.

Market Players & Competition

6.11.15 Australia

Market Size & Growth

Australia spends an estimated USD4.2 billion on the water and wastewater treatment sector. Direct purchases of capital equipment accounts for 30% of total spending.

Drivers & Constraints

Total annual capital expenditure by the Australian water utilities has nearly tripled over the past three years. Driven by a government-led program, total water and sewerage capital expenditure is projected by the Construction Forecasting Council to increase a further 60% over the next nine years. Southern Australia clearly has more of a problem with its water resource than with its network; hence the construction of desalination and recycling plants is absorbing the bulk of the capital expenditure.

Market Players & Competition

Water and wastewater treatment plants are operated by the regional government, such as Sydney Waster and Melbourne Water

- Sydney Water aims to increase water recycling to 12% by 2015 and increase desalination plants for NSW
- Melbourne Water Melbourne produces approximately 330,000 million litres of sewage a year and Melbourne Water is responsible for the wastewater treatment

6.11.16 New Zealand

Market Size & Growth

- Approximately 1.5 billion litres of domestic wastewater is discharged into the environment daily[51].

Drivers & Constraints

The key pieces of legislation driving New Zealand's wastewater treatment markets are:

- The New Zealand Waste Strategy includes a target requiring all substandard wastewater treatment plants to be upgraded, closed or replaced by December 2020.
- The Ministry for the Environment partners with Water New Zealand to develop initiatives which improve the country's environmental performance in the area of wastewater.

Market Players & Competition

New Zealand opened a wastewater algae to bio-crude oil demonstration project in 2009. The project uses NIWA's scientific expertise on advanced wastewater treatment and algal production pond technology with Solray's bio-crude oil conversion technology and is hosted by Christchurch City Council at the Christchurch Wastewater Treatment Plant.

[51] Ministry of the Environment

6.11.17 Summary of Companies

Code	Company Name	Market Cap (M Dollars)	PE Ratio	Country	Segment
0556.HK	Pan Asia Environmental Protection Group Ltd	$162.9	35.2	Hong Kong	Machinery & Engineering
6361.T	EBARA CORP	$2,168.2	N/A	Japan	Machinery & Engineering
6370.T	Kurita Water Industries Ltd	$3,633.7	19.7	Japan	Machinery & Engineering
6351.T	TSURUMI MANUFACTURING CO LTD	$182.8	26.6	Japan	Machinery & Engineering
1412.T	China Boqi Environmental Solutions Technology (Holding) Co Ltd	$81.4	N/A	China	Energy Equipment & Services
6988.T	NITTO DENKO CORP	$6,871.8	15.0	Japan	Misc. Materials & Commodities
6326.T	KUBOTA CORP	$11,695.4	32.1	Japan	Metals - Steel
6403.Q	SUIDO KIKO KAISHA LTD	$36.9	N/A	Japan	Machinery & Engineering
JAIR.BO	Jain Irrigation Systems Ltd	$1,650.1	43.8	India	Misc. Materials & Commodities
HYFL.SI	Hyflux Ltd	$1,324.2	70.7	Singapore	Business & Public Services

Source : Thomson Reuters

6.12 Waste

6.12.1 Background

This section will focus primarily on ***Municipal Solid Waste Incineration*** (MSWI) and ***Landfill Gas*** (LFG) to generate power. Incineration, in the form of ***Waste-to-Energy*** (WTE) is making a comeback, as costs for landfilling and power generation increase, outweighs the potential environmental risks of releasing contaminants into the air. This is particularly relevant in Northern Asia (China, Japan, Korea and Taiwan), as urbanization combines the increase in Municipal Waste with the lack of space for disposal. MSWI has not been adopted in India and SE Asia, as both economics and climate do not favour incineration over other alternatives.

Other options include introducing MSW into the wastewater stream to produce biogas, which is covered in **Section 6.11**.

6.12.2 Targets & Incentives

- ***China*** - The ***Ministry of Construction*** aims to raise the share of China's incinerated MSW from around 1% in 2002 to 30% by 2030. There are currently only 19 MSWI in China

- ***Japan*** has over a 70% rate of incineration of MSW and has the highest rate of major economies (excluding Singapore) and has over 1,700 MSWI in operation.
- ***South Korea*** is renewing its policy towards WTE projects and is in the process of setting up “Energy and Environment towns” to increase incineration rate to 77% by 2013.
- ***Taiwan*** has 21 MSWI in operation and processes around 7.7 milion tonners per year.
- ***India*** does not focus on MSWI, due to high cost and suitability of Indian MSW for incineration.
- ***Singapore*** has the highest rate of incineration in APR, incinerating 90% of its MSW.
- ***South East Asia*** has not embraced MSWI due to high cost and suitability of MSW for incineration
- ***New Zealand*** does not have any MSWI, due to issues with environemtal concerns on release of airbourne contaminants

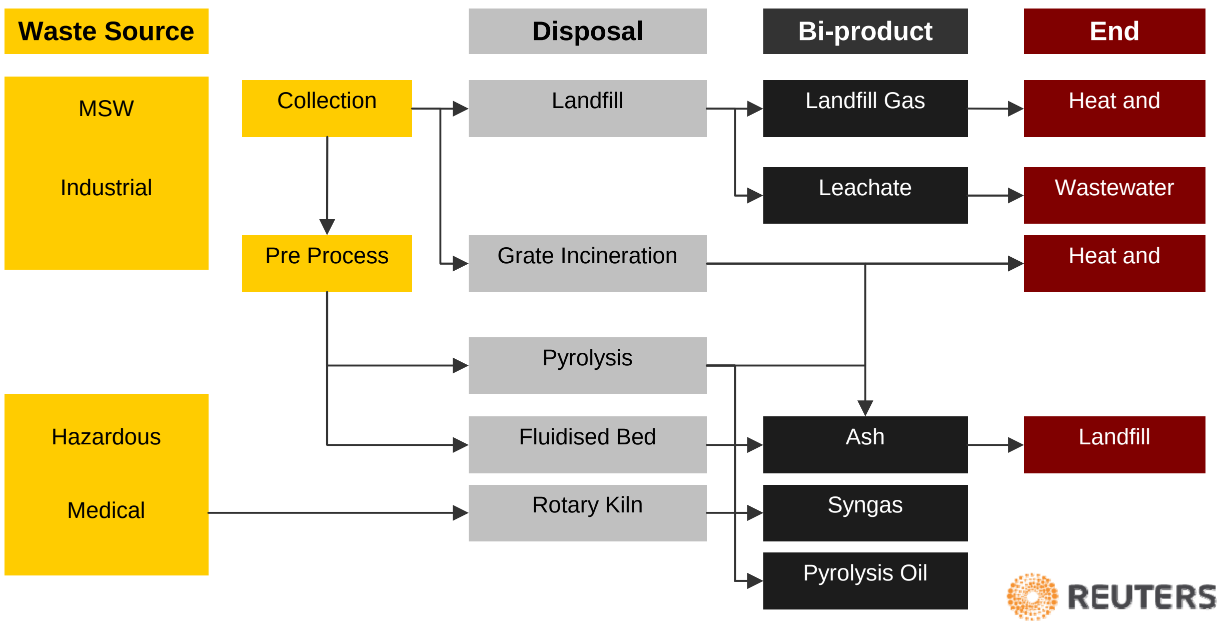
Total MSWI and capacity

Country	Number of MSWI in operation	Capacity (MW)	Number of Proposed MSWI	Proposed Capacity
China	19			
Japan	1717	1060MW		
South Korea				
Taiwan	21			
India				
Singapore	4	234MW		
Indonesia				
Malaysia				
Philippines	0	0	0	0
Thailand	3			
Australia				
New Zealand	0	0	0	0

Source: Government Publication and Estimates

6.12.3 Waste Process

Figure 6.28 – Waste Disposal



Incinerators

The incineration of rubbish has evolved in a number of different ways for different needs over the past hundred years. Mass burn grate incinerators dominate the US and European markets for WTE plants. However, they are not well suited to either smaller plants or the low-heat/high-moisture rubbish found across most developing countries. Pyrolitic and fluidised bed incinerators have moved in to fill up the gap. Pricey, but more efficient, rotary kiln furnaces are used to treat hazardous and medical waste. The heat produced by an incinerator can be used to generate steam, which is either used directly for heat or to drive a turbine to produce electricity.

- ***Grate incinerator technology*.** Grate incinerators dominate the Waste to Energy market in most developed markets. They are suitable for burning MSW and industrial waste. Examples of this technology are the "***Martin grate***" and "***Dusseldorf grate***". A modification of this technology is the Danish "***Volund incineration***" method where an additional rotary furnace is added to the grate. Grate incinerators are the easiest type to scale, and new installations in the US and Europe average up to 3,000 tonnes per day. When energy content falls below 6,000 kJ/kg, grate incinerators require additional fuel – either coal or oil, to keep the fire going. This limits their usefulness in APR, where the moisture is higher than European and US markets.

- ***Pyrolytic incinerator technology*.** Pyrolytic incinerators are favoured in developing APR, as they do not require extra fuel except for ignition. They can be applied in both medical and municipal waste areas. Waste remains in the pyrolytic incinerator for an extended period of time to ensure full combustion. It controls burning in a static status devoid of oxygen and reduces slag and fume discharge. The application of pyrolysis to waste management has steadily gained acceptance along with other advanced waste-treatment technologies. Pyrolysis can also be used as a form of thermal treatment to reduce waste volumes and produce fuels in gaseous form (syngas), liquid form (pyrolysis oil) and ash. The gases are burnt to produce heat, which is normally then used to make electricity. The ash is reused as building material or sent to landfills. No extra heat or fuel source is required except for starting the process. These systems are not as robust as grate incinerators for raw solid waste and work better if the waste is pre-processed.

- ***Fluidised bed combustion*.** With this method of incineration, the grate is replaced by a bed of limestone or sand. It is used by many Japanese combustion systems with small daily capacities. China has also vigorously pursued this technology, with a local variety developed by the Academy of Sciences and Zhejiang University. Fluidised bed combustion has proven more suitable for the treatment of high moisture content of Chinese MSW, than foreign developed technologies. It is more convenient to add auxiliary fuels such as coal or oil to fluidised bed reactors, making them more amenable to the low-heat value of China's waste. They are also better suited to moist (organic) waste than grate incinerators.

- ***Rotary kiln incinerator technology*.** This is the most common choice for medical and solid hazardous waste, particularly in APR. Chinese law mandates that most solid hazardous waste be disposed of in rotary kiln incinerators. The waste is burnt in a rotating oven. It features mechanical feeding, temperature controlled ignition, a high level of automation and easy operation. Both global and domestic Chinese producers include advanced fume processing equipment including fast-cool semi-dry acid separator, activated carbon powder blowers, dust collection bags (to prevent secondary air pollution) and sludge drains.

Landfill Gas

Previously, Landfill Gas was seen as a pollutant and flared on site. In recent years, there has been a move to convert this gas either into Natural Gas (through purification) or convert it to energy.

6.12.4 China

Market Size & Growth

Total quantities of ***Municipal Solid Waste*** (MSW), ***Industrial Solid Waste*** (ISW), and ***Hazardous Waste*** (HW) in 2002 were 136.5 million tons, 945 million tons, and 10 million tons, respectively. In 2002, the quantity of MSW disposed of was 74.04 million tons, 89.30% of which was landfilled, 3.72% was incinerated, and 6.98% was composted. There are currently 651 disposal facilities for MSW in China.

The number of MSW landfill sites (2000 to 2007)

Year	2000	2001	2002	2003	2004	2005	2006	2007
Landfill sites	484	571	528	457	444	365	324	366
landfill quantity(million tons)	64.2	78.4	74.04	72.55	78.48	81.08	78.73	94.38

Source: China Urban Construction Design & Research Institute

Incinerators

China currently operates 19 municipal waste incinerators (MWI) with a total daily capacity of approximately 7,000 tons (December 2002). This is about 2% of all the MSW being produced in China. Most of these systems are grate technology.

Landfill Gas

Number	Province /City	Project Name	Generator (kW)	Other	Start up year
1	Zhejiang	Tianziling Landfill-Site Hangzhou City	1940		1998
2	Guangdong	Datianshan Landfill-Site Gaungzhou	3000		1999
3	Jiangsu	Shuige Landfill-Site Nanjing City	2520		2002
4	Shandong	Xiaojianxi Landfill-site Qingdao City	500 m3/h	Only Flare	2003
5	Shanxi	Jiangcungou Landfill-Ste Xian City	3900		2003
6	Anhui	Maanshan City Landfill Site	200 m3/h	Flare And To Incinerate Hospital Waste	2004
7	Jiangsu	Taohuashan Landfill-Site Wuxi City	1940		2004
8	Beijing	Ashuwei Landfill-Site	2700	Flare Only In 2004	2004/2007
9	Beijing	Beishengshu Landfill-Site	1000		2004
10	Guangdong	Xingfeng Landfill-Site Guangzhou City	2000		2004
11	Hunan	Qiaoyi Landfill Changsha City	2100		2005
12	Hubei	Erfeishan Landfill-Site	1200		2005

13	Beijing	Anding Landfill	750 m3/h	To Evaporate Leachate	2005
14	Jiangsu	Tianjinwa Landfill-Site Nanjing City	1030	2005	14
15	Shandong	Weihai City Landfill-Site	800 m3/h	Only Flare	
16	Shandong	Jinan Landfill-Site Jinan City	1400		2006
17	Liaoning	Yangeryue Landfill-Site Anshan City	500 m3/h	To Truck Fuel	2007
18	Guangdong	Shenzhen Xiaping Landfill-Site Shenzhen City	3500	Also to Truck Fuel	2007
19	Anhui	Liuan City Landfill-Site	200 m3/h	Only Flare	2007
20	Jiangsu	Huaian City Landfill-Site	200 m3/h	Only Flare	2007
21	Beijing	Liulitun Landfill-Site	800 m3/h	Only Flare	2007
22	Beijing	Gaoantun Landfill-site	1500 m3/h	Flare	2007
23	Zhejiang	Ningbo Landfill-Site	200 m3/h	Only Flare	2007
24	Jiangxi	Maiyuan Landfill-Site Nanchang City	4500		2008
25	Fujian	Hongmiaoling Landfill Fuzhou City	2000		2008
26	Tianjin	Shuangkou Landfill-siteTianjin City	1380		2008
27	Liaoning	Laohuchong Shenyang City	2000		2008
28	Shanghai	Laogang Landfill-Cite	2500		2008

Source: China Urban Construction Design & Research Institute

Drivers & Constraints

According to the ***Standard for Pollution Control on the Landfill Site of MSW*** (GB16889-2008), the LFG recovery facilities and flare should be installed when the landfill design capacity are more than 2.5 millions ton and the landfill body depth are more than 20 metres ,and for small scale landfill the flare or measures to reduce methane emissions should be also used.

Incinerators

China has incinerators in cities like Shenzhen and Leshan. The Shenzhen incinerator was purchased second-hand from Hong Kong, which decided it could not be retrofitted to meet anti-pollution standards. However, it has also proven too expensive for Shenzhen to run. Nevertheless, Beihai, Shenyang, Guangzhou, Beijing and Shanghai have all begun constructing pilot plants with foreign assistance. Although the MSW is still not that suitable for incineration, it is quickly improving, and engineers want to gain operational knowledge for the future.

Landfill Gas

Regarding biogas generation from MSW the authorities will give a high priority to landfill gas recovery CDM projects, especially for landfills closing soon, and which will produce high gas yields, before there is large scale recycling to remove the landfill gas creating organic materials. Their aim is to follow the success in many industrialised countries which routinely utilize the energy from landfill gas. Energy from waste schemes form part of the 2020 overall biomass electrification target of 30 GW.

Market Players & Competition

- **Zhong Hui** <Unlisted> Zhong Hui is a Singapore-based investment holding company. Its wholly owned subsidiaries include Zhonghui Environmental Conservation, an investment holding company engaged ain the provision of management services, and Shaanxi Zhonghui Environmental Conservation (SZECC), which is engaged in the design, sale, research, installation and construction of integrated domestic treatment systems. On 29 December 2006, the company announced that Shaanxi Zhonghui Environmental Conservation had entered into a framework agreement with Guang Tai Industry (Guang Tai) and its shareholders for the acquisition of a 51% interest in Baoji Zhong Cheng Machine Tooling (Baoji ZC Group) from Guang Tai and its existing shareholders. In January 2006, SZECC entered into an agreement with Linfen City Construction Bureau to build, install and operate a 1,200t/day solid waste incineration plant.

- **Eguard Resources Development** **<000826.SS>** Eguard Resources Development, a Chinese company established in 1993, invests in and develops urban water supply and wastewater treatment. It is also involved in the design, construction and integration of solid-waste treatment equipment, as well as the provision of related technical services. The company's major businesses include civil waste water-treatment, tapwater supply, solid-waste treatment and the provision of related technology services, as well as solid-waste-treatment system and equipment integration. The company is headquartered in Yichang, Hubei Province, China. As of end-2006, it had five major subsidiaries/associates.

- **Shenzhen Dongjiang Environmental** **<8230.HK>** Shenzhen Dongjiang Environmental is engaged in the processing and sale of recycled products, the provision of waste-treatment services, the trading of chemical products, the construction of environmental-protection systems and consultancy. Its recycled products and waste-treatment services segment produces and sells recycled products, and provides waste-collection and treatment services. The environmental-protection systems segment engages in construction contract work as a main contractor or subcontractor, primarily in respect to environmental-protection systems. In addition to the consultancy segment, the trading segment handles sales of chemical products. Last year, it acquired a 40.2% interest in Shenzhen Huizhou Dongjiang Environmental Technologies.

6.12.5 Japan

Market Size & Growth

According to the Japan MOE 2004 Report, the remaining capacity of the final disposal sites is 152.61 million m^3 and the remaining life time is less than 6 years.

Incineration

There are 1717 combustion plants in Japan of total capacity of 193,000 tons per day; of these, 1130 plants (64.2%) are Waste-to-Energy (WTE) plants and 215 plants (12.5%) generate a total of 1060 MW. Approximately 75 % of the gross amount of MSW that Japan generates annually is incinerated providing an estimated 2.5 million kW of electricity with an aimed 4 million kW is expected for generation in 2010.

Landfill Gas

In 2002, the volume of landfilled MSW and industrial wastes are 9 million metric tons and 40 million metric tons, respectively. Methane emission source is organic wastes composed of food waste, paper waste, waste textile and woodchip. The volume of methane emission from landfill sites is 3.7 million metric tons (CO2 equivalent) in 2002.

Drivers & Constraints

In order to tackle the challenges normally encountered by waste generation in Japan, “integrated waste management” the 3Rs method (Reduce, Reuse, and Recycle) is employed as the best and most preferable ways to address solid waste and the treatment of waste is usually performed based on the "Waste Disposal and Public Cleansing Law."(MOE, 2008).

LFG recovery is not common in Japan, because organic wastes are usually reduced through mid-disposal such as incineration.

Market Players & Competition

- **Hitachi Zosen** **<7004.T>** Hitachi Zosen is a Japan-based manufacturer engaged in four business segments. The environment and plant segment produces refuse-incineration plants, industrial-waste-treatment plants, biomass-energy systems, water and sludge-treatment plants and others. The machinery and processing machinery segment supplies iron-making, forging, wind-driven, food processing, pharmaceutical, plastic-processing, and precision machines, and power-generating units. The steel and construction segment supplies bridges, doors for water gates, steel chimneys, steel pipes, marine engineering equipment, shield machines and civil-engineering equipment. The others segment provides electronic and control, high-accuracy-positioning and disaster-prevention systems, and is engaged in the wholesale of electric power. Headquartered in Osaka, the company has 83 subsidiaries and 15 associated companies. For a detailed company profile, see **Appendix A**.

- **Tsukishima Kikai <6332.T>** Tsukishima Kikai is a Japan-based plant engineering company. Along with its subsidiaries and associated companies, the company has two business segments. The water environment segment is engaged in the operation, management and repair of singular machinery such as water-filter plants, sewerage-treatment plants, spinning dryers, dryers and incinerators, as well as water-filter and sewage-treatment facilities. Its industrial segment is engaged in the general- and industrial-waste treatment for singular machinery, such as food-manufacturing plants, chemical plants, biomassethanol plants, vacuum-technology-applied plants, dryers, separators, and gas holders, as well as liquid-waste-disposal facilities and solid-waste-disposal facilities, among others. Headquartered in Tokyo, Tsukishima Kikai has 12 subsidiaries and two associated companies. For a detailed company profile, see Appendix A.

- **Takuma <6013.T>** is a Japan-based manufacturing company. The Company has four business segments. The Domestic Environment Energy segment is engaged in the design, construction, sale, operation and maintenance of general waste treatment plants, resource recovery plants, sewage disposal plants, sludge incineration plants, biomass electric generation plants and generation gas turbine systems. This segment is also involved in the waste treatment business. The Overseas Environment and Energy segment provides waste power generation plants and biomass power generation plants. The Civilian Heat Energy segment offers miniature through-flow boilers and vacuum hot-water supply heaters. The Others segment is involved in the sale and maintenance of impregnating equipment, air conditioning facilities and facilities for semiconductor industry.

Figure 6.29 - Japanese Waste Stocks

Source: Thomson Reuters

6.12.6 South Korea

Market Size & Growth

In October 2008, as a part of the method to achieve the national vision of "***Low Carbon, Green Growth***," the ministry of environment announced "***Waste Resources and Biomass Energy Utilization Initiatives***", and has strived to establish a wide range of measures with the publication of the implemented road map in July 2009. As part of the plan it proposes to increase energy collection rates to 77% of residual thermal energy from incinerators and 91% of landfill gas from waste landfill sites by 2013.

Incineration

As of 2007, the amounts of combustible wastes and organic wastes accounted for about 3.84 million tons and 7.85 million tons per year, respectively. However, only 1.5% (58,000 tons/year) of combustible waste, and 2% (160,000 tons/year) of organic waste were utilized as energy resources. In an effort to facilitate waste to energy policy, the ministry aims to achieve energy utilization of combustible waste (by 47% or 1.82 million tons/year) and of organic waste (by 26% or 2.04 million tons/year) by 2013.

Landfill Gas

There are 238 landfill sites in operation, with 17 LFG projects installed in Korea, generating capacity of just over 80 MW.

Drivers & Constraints

The Government is in the process of improving its ***Waste to Energy Legislation***, in an effort to increase the contribution of Waste to Energy projects.

In addition, with the ban of ocean dumping of organic waste starting 2012, the MOE as part of its sewage sludge to energy strategy plans to expand the provisions regarding the use and method of waste utilization in the Waste Control Act, so as to allow coal power plants to use sewage sludge as fuel.

The MOE is conductinga feasibility study in the establishment of 6 "***Environmental and Energy towns***" in: Gangwon & North Chungcheong province (Wonju), Jeju province (Jeju Special Self-Governing Province), Daejeon & South Chungcheong province (Daejeon), Daegu & North Gyeongsang province (Daegu), and Gwangju & North Jeolla province (Gwangju).

Market Players & Competition

- **Insun Environmental New Technology Co.** **< Unlisted>** is a Korea-based company engaged in environmental engineering. Its technologies prevent the dilapidation of natural land and promote the conservation of natural resources by regenerating construction waste and removing pollution sources. The Company's principal activities include intermediate treatment of construction waste, reclamation and incineration of waste, as well as the demolition of scaffoldings and structures. It also produces regenerated aggregates from treated construction waste.

- **Daewoo Engineering & Construction.** Hitachi Zosen Corporation worked with Daewoo for the construction of a stoker-type incinerator (2 furnaces at 100 tons per day totaling 200 tons per day) for Ikusan City in Korea.

- **Korea Power Engineering Company, Inc.** **(KOPEC)** and SCS Engineers (SCS) constructed a 50MW LFG project at the Sudokwon Landfill

6.12.7 Taiwan

Market Size & Growth

Incineration
There are 21 municipal solid waste incinerators (MSWI) with a total yearly treatment capacity of 7.72 million tons in service in Taiwan.

Landfill Gas
Taiwan disposes of 35,379 tonnes of MSW daily in local landfills.

Drivers & Constraints
Since 1990, the ***Environmental Protection Administration*** (EPA) created a series of MSWI construction projects to build one incinerator for each city or county to address the waste problems in Taiwan.

Market Players & Competition
- **China Ecotek** **<1535.TW>** China Ecotek, headquartered in Taiwan, is engaged in environment-protection and mechanical-engineering projects, while also operating recycling factories and machinery maintenance. The company's businesses also include biochemical medicine plant construction projects, power-plant installation and maintenance projects. Last year, mechanical-engineering projects accounted for 48% of total revenue, followed by recycling factories and machinery maintenance (29%) and environment-protection projects (20%). The company distributes its products to southern, central, northern and eastern Taiwan. As of end-2006, the company had three wholly-owned subsidiaries, including CEC International and CEC Development.

- **SINO Environmental Services Corp** <Unlisted> is a subsidiary of CTCI Corp. The main business focus is on the refuse incineration plant's operation and maintenance project which is the extension of the incineration EPC project of the mother company. It has won the refuse plants operation contracts of Hsintien, Shulin, Taoyuan, Maoli, Houli, Wuzu, Keelung, Tainan, and Tainan Science Park. The service capacity of SESC is summed up to 6,900 7,400 tons per day which represents 44% of the privatization market share in Taiwan.

- **Onyx Ta-Ho Environmental Services Co., Ltd** <Unlisted> was established as a joint-venture between Taiwan Cement Corporation (TCC) and Veolia Environmental Services and provides integrated waste management services for both local authorities and industrials. With its two subsidiaries - Onyx Ta-Ho Waste Clearance Co. and Onyx Ta-Ho Energy Recovery Co., Onyx Ta-Ho offers services such as waste incineration treatment, waste collection and recycling, waste transfer, liquid industrial waste treatment, fly ash treatment, drainage cleaning and MARPOL oil treatment.

- **Taiwan Sugar Corp** <Unlisted> has established an industrial safety and environmental protection department. At present, the operation includes an Examination and Analysis Center, two Municipal Waste Incineration Plants (in Gangshan and in Kanding), and several waste landfill sites, with which it created about NT$500,000,000 of revenue per year.

6.12.8 India

Market Size & Growth

In India, most MSW are still disposed of in open sites, with little management or prospects for incineration or LFG. There are a number of pilot projects

- ***Vijayawada***, launched a WTE plant to generate electricity from MSW. This was the first plant in the country to be set up with financial assistance from the United Nations Development Programme (UNDP) and the MNES. The capacity o the power plant is 6 MW and is aimed to process 500 MT of MSW per day.

- The cities of ***Hyderabad*** and ***Secundrabad*** producing around 2200 MT of waste every day Setup a WTE plant in 1999 based on the RDF Technology (IPE, 2006). Located next to the Ganghamguda municipal land dump (20 acres), which receives 1300 MT of garbage every day from Hyderabad city. It was set up by the Andhra Pradesh Technology Development & Promotion Centre (APTDC) and Selco International Ltd.

Incineration

Due to the high capital cost for MSWI, there is not a policy in place to use incinerators in India. In addition, it is thought that Indian MSW is not suitable for Incineration.

Landfill Gas

There are a number of CDM projects using LFG gas to generate carbon credits in India.

Drivers & Constraints

The key pieces of legislation driving India's Waste Management markets are:

- ***Municipal Solid Waste (MSW) Management Rules 2000***, which came into effect from January 2004
- In addition, there are ***Municipal Corporation Acts*** by different states such as ***the Delhi Municipal Corporation Act 1959***, ***Uttar PradeshMunicipal Corporation Act 1959*** and ***Karnataka Municipal Corporation Act 1976***.

Market Players & Competition

- **Selco International Ltd** <Unlisted> SELCO International Limited is a Public Limited Company and the core business focus is energy recovery from Municipal Solid Waste (MSW) Management in India.

6.12.9 Singapore

Market Size & Growth

Incineration

Singapore incinerates 90% of its Municipal Solid Waste through 4 incineration plants and generates roughly 980 kWh of energy, supplying roughly 2% of Singapore's electricity demand.

Plant	Capacity	Comment
Ulu Pandan	16MW	Closed in August 2009
Senoko	56MW	Acquired by Keppel
Tuas	46MW	
Tuas South	132MW	
Total	234MW	

Source: Waste Management Department, NEA

Drivers & Constraints

The key pieces of legislation driving Singapore's Waste Management markets are:

- The law on waste is contained in the ***Environmental Public Health Act*** (EPHA) and its subsidiary laws, including the regulations relating to General Waste Collection and Toxic Industrial Waste.

Market Players & Competition

- **Keppel Seghers** <Unlisted> , a unit of Singapore's Keppel Integrated Engineering, has secured a USD 12.5m contract to provide technology to a waste-to-energy plant in Guanzhuang, Tianjin. The contract, is for the expansion of an existing 17MW plant that was commissioned in 2008. When commissioned in 2012, the project is expected to consume 1,000 tonnes of municipal waste per day. It is the third waste-to-energy contract that Keppel has announced this year. Keppel said that it currently takes up 60% of the market share of Chinese imported waste-to-energy solutions.

- **Sembcorp Environment Pte. Ltd.** <Unlisted> **is** a wholly owned subsidiary of SembCorp Industries Ltd. and has developed waste to energy projects across Asia under CDM.

6.12.10 Indonesia

Market Size & Growth

Surabaya, Indonesia has an imported incinerator that can only operate at two-thirds of its designed capacity, because the waste needs to be dried onsite for five days so it will burn. Even without air pollution control mechanisms, the cost of incinerating the waste in this instance is roughly ten times greater than the cost of sanitary landfilling in other Indonesian cities. In addition, there are a number of new Waste to Energy projects that are funded by CDM credits.

Waste to Energy Projects

- PT. Bioenergi Surya Persada & YCBI, Malang: MSW to Energy 17,000 T/Year
- PT. Bioenergi Surya Persada & YCBI, Surabaya: MSW to Energy 30,000 T/Year
- PT. Navigat Organik Energi Indonesia, Bali: MSW to Energy 2 x 10 MW:500,000 T/Year

Drivers & Constraints

National Regulation regarding to Municipal Waste Management has not been set up

Market Players & Competition

- **Navigat Organic Energi Indonesia** <Unlisted> has constructed a "GALFAD® (GAsification, LandFill gas and Anaerobic Digestion)" plant at the TPA Suwung1 landfill site in Bali, which will treat and recover energy from MSW.
- **PT Asia Biogas** Indonesia is a subsidiary of Asia BioGas Company, the largest biogas systems developer and operator in SE Asia.

6.12.11 Malaysia

Market Size & Growth

Disposal of solid waste is done almost solely through landfill method. There are about 177 disposal sites in Peninsular Malaysia. In most cases, open dumping is being practised and takes place at about 50% of the total landfills.

Incineration

The government had also spent RM17million to purchase 7 mini-incinerators with a capacity of 5 to 20 ton/day to be operated in the resort islands in Langkawi, Labuan, Tioman and Pangkor.

Landfill Gas

Drivers & Constraints

The key pieces of legislation driving Malaysia's Waste Management market is the ***Solid Waste and Public Cleansing Management Bill 2007.***

Market Players & Competition

- **CMTS Van Sommeren International** <Unlisted> provides MSW recycling technologies. Technology include the supply of turnkey incineration plants to treat hospital waste with plant size ranging from 10 to 50 tons per day, tunnel composting of green waste, SDF power plant for electricity generation

6.12.12 Philippines

Market Size & Growth

Incineration

There are no MSWI in the Philippines

Landfill Gas

There are around 15 LFG projects in the Philippines.

Drivers & Constraints

The Philippines has banned incineration, as part of the ***Clean Air Act***, which has put restrictions on incineration. Landfill Gas Projects have been driven by CDM credits, with a number of projects approved in the Philippines.

Market Players & Competition

- **Philippine Bio Sciences Company, Inc.** **(PhilBIO)** <Unlisted> is the largest biogas engineering company in the Philippines, with more than 35 Biogas Energy Plant digesters successfully installed.

- **Reclaim Resources Limited** <Unlisted> has signed a £12 million contract with a local authority in the Philippines to supply and install its 'clean' Vantage Waste Processor (VWP) that transforms MSW into biomass before converting it into a range of energy resources, including electricity and bio-ethanol.

6.12.13 Thailand

Market Size & Growth

MSW in Thailand has increased steadily during the last decade. About 38,000 ton/day of refuse was collected across the country in 2002.

In 2004 there were 425 disposal sites (95 landfills; 330 open dumps) in Thailand and an estimated methane emission of 115.4 Gg/year was generated based on this practice. It has been estimated that the anticipated methane emission in Thailand will rise from 115.4 Gg/year to 118.5 Gg/year if the largest open dumpsites in provinces with no existing landfill are upgraded to sanitary landfill; and it will increase to 193.5 Gg/year if the existing sanitary landfill is upgraded to integrated waste management facilities.

Incineration

There are currently only 3 MSWI in Thailand.

Landfill Gas

There are about 10 potential LFG projects in Thailand, with a potential of 18MW in power generation capacity, The largest two projects are Kampangsean and Ratchathewa Landfills.

Drivers & Constraints

MSW Management falls under the local municipal government.The key pieces of legislation driving Thailand's Waste Management markets are:

- ***Public Health Act. B.E.2535 (1992)***
- ***Enhancement and Conservation of National Environmental Quality Act. B.E.2535 (1992)***
- ***Municipality Act. B.E.2496 (1953)***

Market Players & Competition

- **CleanTHAI** <Unlisted> develops waste-to-energy biogas projects. CleanTHAI's portfolio of biogas plants include Thailand's largest Biogas Energy Plant, the Korat Waste to Energy Plant, and one of Thailand's largest ethanol plants, Thai Agro Energy.

6.12.14 Australia

Market Size & Growth

Incineration

Landfill Gas

There are 37 LFG power generation projects (around 9 % of total renewable energy generators), with a combined capacity of approximately 105 MW. In 2001/2002, LFG projects contributed 416 gigawatt hours (GWh) of electricity generation.

The largest operational LFG installation at 13 MW capacity, is the Energy Developments Limited <ENE.AX>, ***Lucas Heights II Landfill Gas Plant*** at Lucas Heights in New South Wales, 23 kilometres south west of Sydney. A larger LFG generator is under construction – a bioreactor located in a disused open-cut mine located at Woodlawn NSW (250 km south-west of Sydney). It will receive up to 500,000 tonnes of residual waste per annum, and the generation capacity will be 25 MW via gas turbines.

Drivers & Constraints

The key pieces of legislation driving Australia's Waste Management markets are:

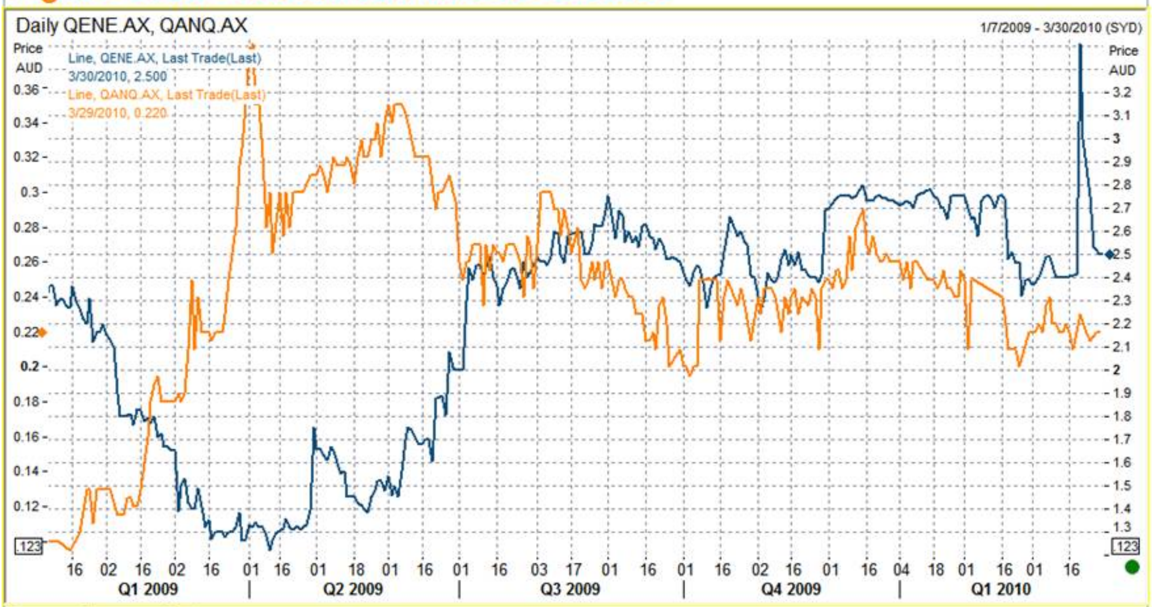
- ***The Health Act 1911*** is the primary Act dealing with all matters relating to public health, includes many aspects of municipal waste management.
- There are additional State legislation, such as Western Australia's ***Waste Avoidance and Resource Recovery*** (WARR) Bill

Market Players & Competition

- **Energy Developments Limited** **<ENE.AX>** is engaged in the development and operation of power generation projects that includes the use of MSW and Landfill Gas to generate electricity.

- **Anaeco** **<ANQ.AX>** The Company's principal business activity is the development and commercialization of a process for the treatment of organic municipal solid waste (DiCOM System).

Figure 6.30 - Australian Waste Stocks



Source: Thomson Reuters

6.12.15 New Zealand

Market Size & Growth

Incineration

New Zealand does not have any MSW Incinerators.

Landfill Gas

There are around 100 landfills in New Zealand, with some LFG to energy projects in operation.

Drivers & Constraints

The key piece of legislation driving New Zealand's Waste Management markets is the ***Waste Minimisation Act*** provides a levy on landfill waste, mandatory waste reporting, clarifies the role of territorial authorities with respect to waste minimisation, and sets up a Waste Advisory Board.

Market Players & Competition

- **Waste Solutions Ltd** designs Anaerobic Digestion (AD) facilities for over 30 years.

- **Envirowaste** was the first operator in New Zealand to generate electricity from methane gas produced by waste in landfills. The landfill gas to energy (LFGTE) plants operated by

EnviroWaste at Greenmount and Rosedale landfills in Auckland produce a peak of 10MW of electricity

6.12.16 Summary of Companies

Code	Company Name	Market Cap (M Dollars)	PE Ratio	Country	Segment
8230.HK	Shenzhen Dongjiang Environmental Co Ltd	$392.0	53.2	China	Business & Public Services
7004.T	Hitachi Zosen Corp	$1,199.4	8.3	Japan	Machinery & Engineering
6332.T	TSUKISHIMA KIKAI CO LTD	$310.8	N/A	Japan	Machinery & Engineering
1535.TW	China Ecotek Corp	$160.7	13.8	Taiwan	Machinery & Engineering
ENE.AX	Energy Developments Ltd	$348.5	30.8	Australia	Utilities-Electrical & Gas
ANQ.AX	AnaeCo Ltd	$33.3	N/A	Australia	Energy Sources
Unlitsted	Zhong Hui	N/A	N/A	China	Incineration
Unlisted	Keppel Seghers	N/A	N/A	Singapore	Waste Handling
Unlisted	Sembcorp Environment Pte. Ltd.	N/A	N/A	Singapore	Waste Handling
Unlisted	CMTS Van Sommeren International	N/A	N/A	Malaysia	Incineration
Unlisted	Philippine Bio Sciences Company	N/A	N/A	Philippines	LFG
8230.HK	Shenzhen Dongjiang Environmental Co Ltd	$392.0	53.2	China	Business & Public Services

Source: Thomson Reuters

7 SUMMARY OF KEY OPPORTUNITIES

7.1 Integration of Government Policy and Industry

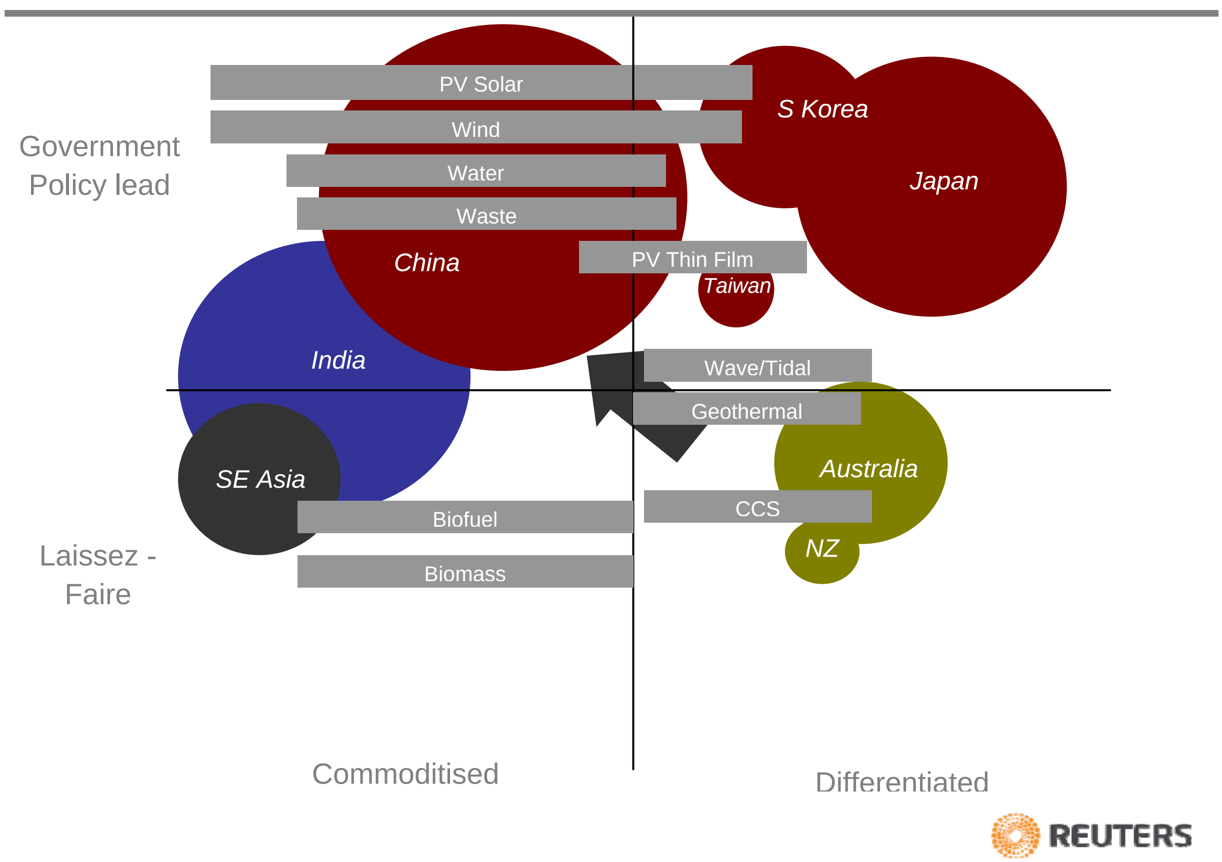
APR economies are suited to Clean Technology, in terms of integrating government policy with industry. Japan, South Korea and China have institutionalized this process by selecting key industrial sectors for the economy and working at building up first the domestic industry, through government incentives and protectionism that will grow and then export and compete on the global markets, through high quality and low cost.

China has already taken the lead in the PV Solar and Wind markets, in the space of 2 to 3 years and is expected to dominate these markets.

This 'statement of intent' is further re-enforced by the level of investment, R&D and patent filings that China, Japan, South Korea and Taiwan have filed in key sectors of solar, wind and water sectors to protect it investment.

This is also backed up by aggressive Renewable Energy Targets, Feed in Tariffs and cheap finance to promote the development of a domestic industry, particularly in PV Solar and Wind.

Figure 7.1 – Key Sectors



7.2 Infrastructure

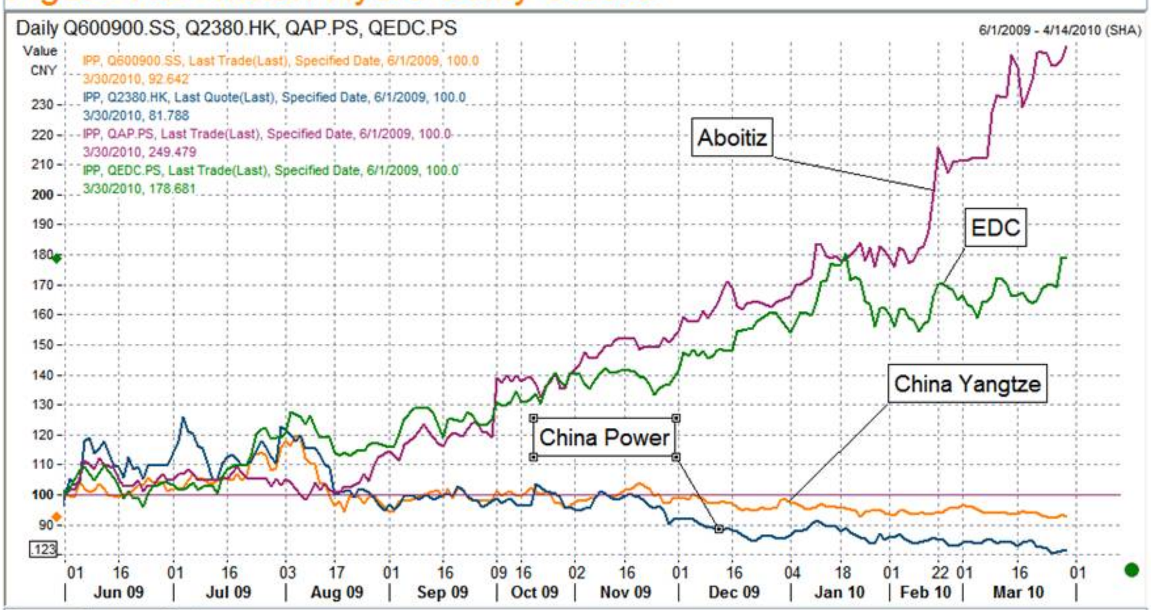
Most of investment in Clean Technology in Developing countries in APR is focused on large scale infrastructure projects, such as Hydro, Nuclear and Biomass co-generation projects, rather than small scale projects. Unlike the US and Europe, the APR is installing new infrastructure.

These projects will have the largest impact on Renewable Energy Targets, with Hydro (accouting for 14%) and Nuclear (8-9%) the two largest sectors. Wastewater and Waste to Energy and Biomass Projects also fall in this category.

Hydro

China Yangtze <600900.SS> and China Power International <2380.HK> are Chinese Utilities that have large exposure to Hydro. China Yangtze operates the Three Gorges Dam, which is the largest Hydro project globally. Other Hydro Utilities include: National Hydroelectirc Power Corporation <NHPC.BO> in India and EDC <EDC.PS> and Aboitiz <AS.PS> in the Philippines.

Figure 7.2 - Asian Hydro Utility Stocks



Source: Thomson Reuters

Nuclear

Japan, China, South Korea and India have embraced Nuclear Power and have all these countries have embarked on ambitious nuclear power programs. South Korea will have the the highest nuclear power contribution to its power generation mix, while China will have the largest capacity by 2030.

Key companies involved in Nuclear power include: China National Nuclear Corporation (CNNC), Korea Nuclear Hydro Power (KNHP), GE Hitachi, Westinghouse Toshiba, Nuclear Power Corporation of India (NPCIL). All companies are unlisted and controlled by government agencies.

The only listed companies are Uranium mines in Australia, that include: Paladin <PDN.AX> and Energy Metals <ENE.AX>.

Biomass

Biomass and cogeneration is a large contributor to renewable energy targets in China, India and South East Asia and all countries plan to use agricultural waste as feedstock. Key companies in this space include: National Bio Energy Limited in China and All Green energy in India.

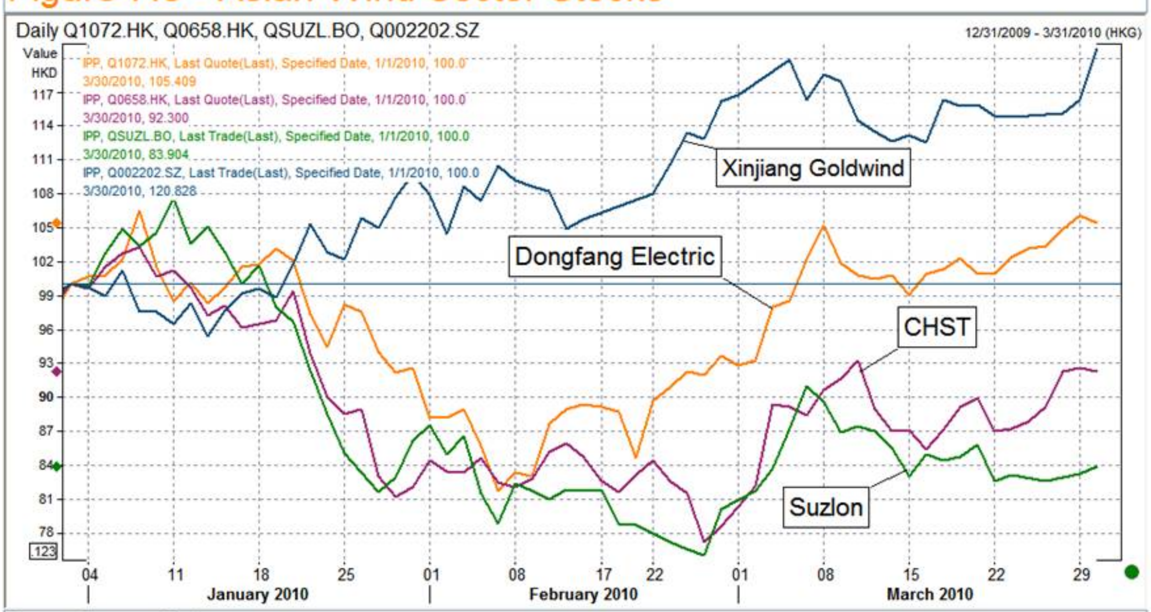
7.3 Commoditised Sectors

Wind and PV Solar have become commoditised and those countries that have high quality manufacturing and can reduce marginal costs will be those that compete. As with the electronics industry and heavy manufacturing – countries like Japan, Korea and Taiwan will be able to differentiate, through their high level of R&D and high quality manufacturing. China will be the main beneficiary of this commoditization, as it assimilates the technology and builds up its own domestic industry and look to expand globally.

Wind

China dominates this sector, around 70 companies set up in China. Leading Chinese Companies include: Xinhjiang Goldwind, Dongfang Electric and China High Speed Transmission. Suzlon is the leading global wind manufacturer in Asia.

Figure 7.3 - Asian Wind Sector Stocks



Source: Thomson Reuters

PV Solar

China, Japan, South Korea and Taiwan dominate the PV Solar sector. There are over 70 companies in China alone and China has a cost advantage over other countries and are leaders in the Cell and Module Manufacturing. Japan and South Korea have concentrate on feedstock, which is hard to manufacture and also focusing on PV thin film. Leading companies include Suntech, Solargiga and Trina Solar in China. Japan has Tokyuyama and Osaka Titanium in the feedstock space and Sharp, Kyocera in cell and module manufacturing.

7.4 Innovation

Beyond, Wind, Solar and Biomass, countries such as Australia and New Zealnd lead in new sectors, such as Wave/Tidal, Geothermal and CCS.

Geothermal

Japanese companies still dominate the manufacturing of turbines, with companies such as Fuji Electric and MHI. However, the domestic industry is small and most are exported to Philippines and Indonesia.

EDC and Aboitiz in the Philippines are the leading Geothermal Utilities in the region. While Australia leads the way in new 'Hot Rock" geothermal technology, with around 9 companies listed in the ASX.

Wave/Tidal

While still not commercially viable, Australia and New Zealand lead the way in Wave and Tidal technologies in the region. Key companies include Carnegie Wave <CWE.AX>, Atlantis Resources, Oceanlinx and Bio Power Systems.

Smart Grid

China, Japan, South Korea and Australia have set aside substantial investments to set up a smart grid in their respective countries. China alone is expected to invest over $7 billion to upgrade its infrastructure.

CCS

Even with aggressive new Renewable Targets, the region is still expected to generate over 70% of its power from fossil fuels by 2030, primarily from coal. CCS is seen as a way to mitigate this impact and most of the CCS projects are expected in APR by 2050.

Australia is the leader in CCS and has 15 projects underway, funded by the Coal Industry and Government Agencies, such as CSIRO. Japan has formed a company called CCS Ltd, which is consortium of utility companies.

7.5 Conclusions

The APR will be the largest Energy Market and Clean Technology Market in the world, by 2030. Countries within the APR are already gearing up for the impact of Climate Change by setting aggressive renewable targets. Clean Technology is seen as a growth industry that generates jobs, while reducing carbon emissions and energy security in the process. What is surprising is the speed of change, the emergence of organic innovation and the level of investment set aside by governments to ensure that countries become world leaders in this space.

For APR, Clean Technology is simply building new power capacity to keep up with growth. The largest contributors to renewable energy will be Hydro, followed by Nuclear Power. Renewable Energy will only account for 4% of total power generation by 2030.

Even with all these proposed targets, power generated from fossil fuels will still account for over 70% of the power generation mix by 2030. Other mitigation measures, such as energy efficiency will need to be included into projections to reduce the overall energy consumption in the APR.

This Handbook has focused primarily on renewable energy for power generation and focus on energy effiicieny will need to be included in the next version of the Handbook.