ENERGY FROM WIND AND OCEAN

Source: energytechstocks.com

A NORTH-EAST ASIA MARKET STUDY

2010

Coordinated by:
Per Christer Lund
Innovation Norway Tokyo

Foreword

Innovation Norway is proud to present our report on market conditions for wind- and ocean- based renewable energy in North-East Asia. This report aims to give Norwegian companies - offering products and services in the value chain of renewable energy - an overview of market possibilities and limitations in the most relevant markets in Europe. We hope you will find the report a helpful tool in choosing the right market for your company.

Our colleagues in Innovation Norway's offices in North- East Asia have invested a substantial amount of time and effort in putting together this report, under the excellent supervision of Per Christer Lund in IN Tokyo, who has been in charge of receiving, adjusting and compiling the material.

Thank you!

Energetic regards,

Bergny Irene Dahl,

Sector Responsible

Innovation Norway Energy and Environment

bergny.irene.dahl@innovationnorway.no

Innovation Norway contributors to the report

Yoji Ishihara

Senior Advisor

Innovation Norway, Tokyo

Yoji.ishihara@innovationnorway.no

Ji Wu Zhang

Senior Advisor

Innovation Norway, Beijing

ji.wu.zhang@innovasjonnorge.no

Doo Seok Kim

Senior Advisor

Innovation Norway, Seoul

dooseok.kim@innovasjonnorge.no

Qin Shi

Senior Advisor

Innovation Norway, Shanghai

Qin.Shi@innovationnorway.no

Per Christer Lund

Counsellor, Science and Technology

Innovation Norway, Tokyo

perlu@innovationnorway.no

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1. Summary

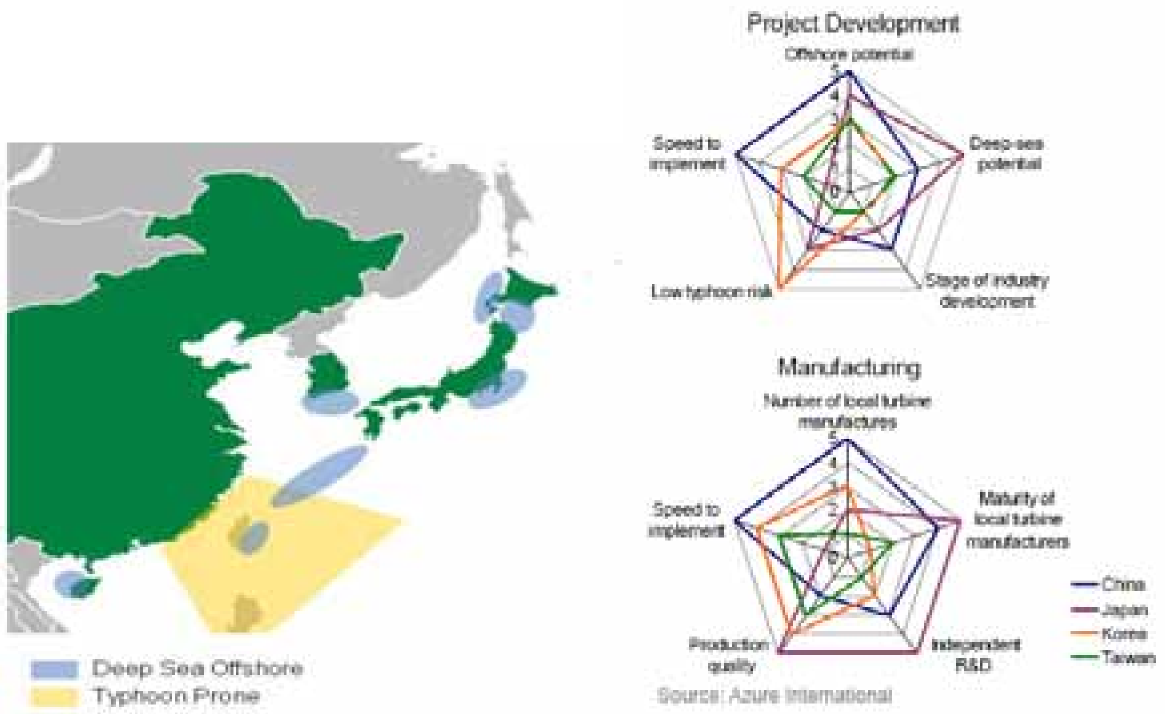
1.1. Renewable energy in NEA – Offshore wind[1]

Japan, Korea and Taiwan all have ambitious renewable energy goals and offshore wind is an attractive solution as all three countries have strong infrastructural and geographical barriers for development of onshore wind. China will likely be the production hub serving the regional and global market. Of these countries Japan has the highest potential for deep sea (+50m) offshore development with up to 245 GW and has already started conducting research in this area. Korea, while new to the market, has started to move quickly in developing an offshore wind industry and may be the first country in Asia to develop offshore wind projects in deeper waters (+30m).

It is likely that Japan will take the lead in applying deep sea offshore technology as most of the waters off the coast of Japan are very deep. In order for Japan to move forward, policies and incentives will have to be applied to make deep sea offshore wind development economically viable.

Korea may initiate the deep sea industry in Asia, as it started making efforts to develop its offshore industry.

Figure 1: Deep sea potential (left) and qualitative comparison between the countries in North-East Asia (NEA) [2]



[1] This section is largely extracted from *Azure International: China, Norway and Offshore Wind Development, WWF 2010*.

[2] ibid.

New policies have been implemented that will help spur on the growth of the wind industry across Asia.

Korea enacted a new renewable energy plan in 2008 and is looking to set a renewable portfolio standard by 2012. The Korean industry falls in the middle of the spectrum between the Chinese and Japanese industries. While overall net offshore development potential is lower, Korea implements faster than Japan and with higher quality than China. In addition, Korea has much less environmental risk due to typhoons

Japan, on the other hand, was early to implement a renewable energy policy and develop wind turbine technology, yet has only seen slow conservative market growth and is unlikely to meet its 2010 target for installed wind capacity. Regardless Japan has had long-term research in the offshore wind implementation and may still have growth.

China has the greatest potential for offshore development. Most of this offshore capacity is in shallow waters and the inter-tidal zone. China will likely develop these areas first before tapping into its deep sea zones.

Norwegian companies have already started to branch out into the broader Asian market. The DNV who has had a long-term established headquarter in China and recently opened a Sustainability Center, is branching out to establishing a port center in Korea which can support offshore wind; providing floating foundation training in Japan in early 2010 and establishing a center of excellence for ships and ports in Singapore.

Table 1: Deep sea offshore wind estimates for NEA and Norway[3].

Table 6: Deep Sea Offshore Wind Industry Overview (East Asia and Norway)

Country	Offshore pipeline	Policy support	Strengths	Weakness	Deep Sea Potential
China	13,675MW	Likely Supportive	Low cost High speed to implement High potential for offshore wind industry development Ambitions for large scale offshore wind	Developing experience Typhoon risk Quality gap compared to international companies	40GW
Japan	NA	Likely Supportive	Strong deep sea wind research and development Long term wind industry experience	Slow industry development	265GW
Korea	NA	Likely Supportive	High quality products due to experience in the technology and ship building industry Relatively quick to implement technology	Very limited experience in wind industry	25GW
Taiwan	~500MW	Supportive	Offshore wind feed-in tariff already in place	Very limited experience in wind industry High typhoon risk	limited
Norway	350MW	Limited	High quality offshore cluster and R&D, especially deep sea activities Increasing experience with large scale offshore wind projects in the North Sea	Weak domestic wind industry Domestic offshore wind market still not developed.	125GW

Source: Azure International

[3] The deep sea potential for Korea varies significantly between various sources; Azure's estimate is 25 GW, while the estimates from KIER and KEMCO are 7.9 GW and 17 GW respectively.

Table 2: Comparison of feed-in-tariffs.

Country	NOK/MWh offshore wind	NOK/MWh onshore wind
China	420-510	up to 1000
Korea	610	
Japan	640	not set

Table 3: Ernst& Young's Energy Wind Attractiveness Index, February 2010.

Rank[1]		Country	Wind index	Onshore wind	Offshore wind	Near-term wind
1	(1)	China	72	75	62	80
2	(2)	US[2]	71	75	58	85
3	(3)	Germany	66	64	69	50
4	(5)	UK	65	63	73	52
5	(4)	India	62	70	41	56
6	(6)	Spain	60	65	45	50
6	(6)	Canada	60	65	46	46
6	(8)	Italy	60	63	52	47
9	(8)	France	59	60	55	47
10	(10)	Ireland	58	58	58	40
11	(16)	Netherlands	54	52	58	37
11	(11)	Portugal	54	59	42	39
13	(12)	Greece	53	57	42	40
14	(13)	Sweden	52	52	53	35
15	(14)	Australia	51	54	41	40
16	(15)	Belgium	50	48	56	37
16	(16)	Poland	50	53	41	39
18	(18)	Norway	48	49	44	34
19	(18)	Denmark	47	44	56	34
20	(20)	New Zealand	46	50	35	32
21	(21)	Japan	45	47	38	27
22	(21)	Brazil	44	48	33	36
23	(23)	Turkey	42	45	35	32
23	(23)	South Africa	42	46	34	32
25	(25)	Czech	34	46		28
26	(26)	Finland	33	33	34	23
27	(27)	Austria	29	40		24

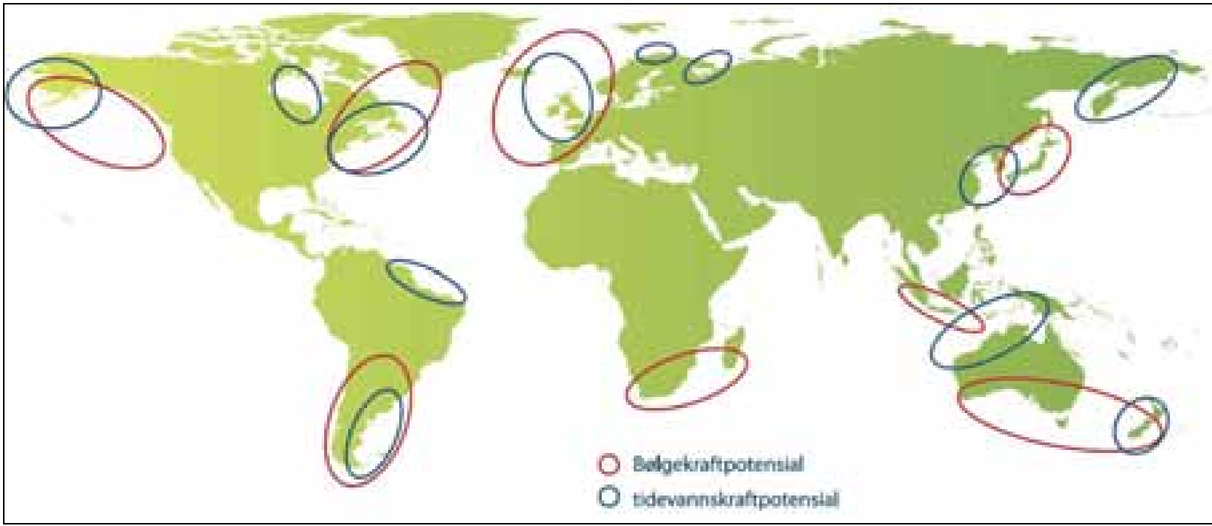
Source: Ernst & Young

1. Ranking in issue 23 long term wind index is shown in parenthesis.

2. This indicates US states with RPS and favorable renewable energy regimes.

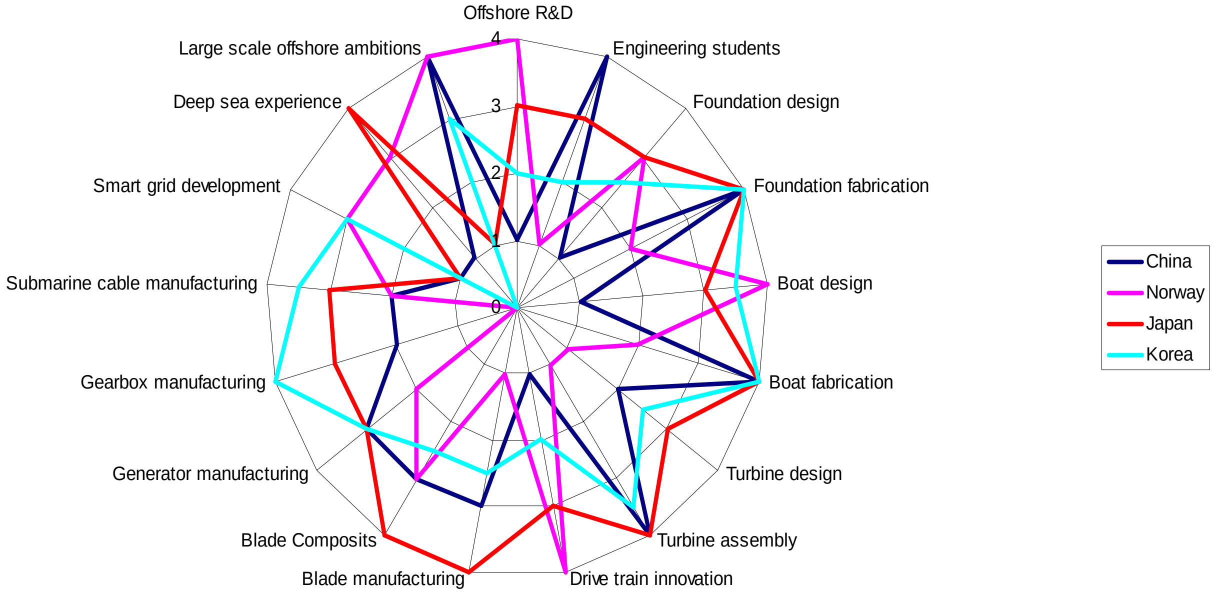
1.2. Renewable energy in NEA - Wave and Tidal

Figure 2: Major global tidal (blue) and wave (red) power potential regions.



The figure above illustrates the tidal power potential in Asia. The only significant, large scale region is on the south-east part of China, where some of the largest tidal power plants in the world are installed. There are some smaller wave and tidal projects in Korea and even less in Japan.

Figure 3: Comparison of Norwegian offshore wind power strengths vs. NEA countires.



1.3. Country-by-Country Summaries

China

China is currently ranked as number three in the world with 25,000 MW installed wind capacity. Just behind US and Germany, and is the world's fastest growing market for land based and offshore wind energy. There is increased incentive to develop offshore wind as coastal provinces must import up to 25% of their energy from surrounding provinces. China‟s national goals for wind installation are expected to increase to 100-150GW by 2020.

Wind energy

Considering the national policies, offshore wind energy resources, and market development, Azure[4] estimates that 30GW of offshore wind energy generation capacity is likely to be installed in China during the next decade with an expected market potential valued at 74 billion Euros.

This development presents huge opportunities for technology and engineering companies specializing in wind and offshore technologies. A substantial part of this market will be captured by domestic companies such as Chinese turbine and engineering companies, but there will also be substantial openings for international players, including Norwegian companies.

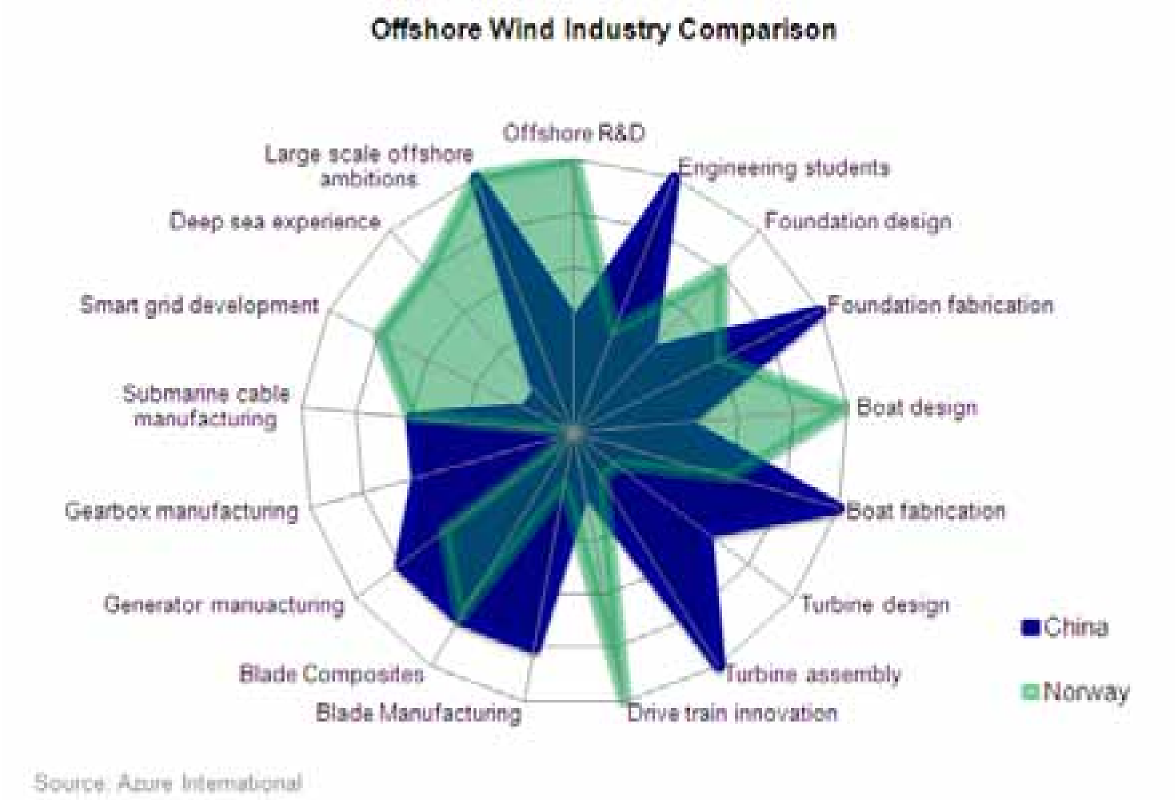
Areas of Norwegian strengths where there are Chinese needs include:

- offshore R&D
- foundation design
- boat design
- drive train innovation
- grid development and
- General ocean installation and service experience (especially deep sea).

The figure below illustrates the overlap between Norwegian expertise and current Chinese strengths.

[4] *Azure International: China, Norway and Offshore Wind Development, WWF 2010*

Figure 4: Offshore wind industry comparison – China and Norway



Ocean energy

China's tidal power reserves are estimated at 110 GW, of which 21 GW can be exploited and generate 58,000 GWh of power every year. China's R&D on wave energy started in 70s and later a number of experimental power conversion projects had been carried out mainly in Shanghai, Guangzhou, Dalian, Qingdao, Beijing and Tianjin. R&D had been focused rather on OWC (oscillating water column) in 80s and 90s but shifted to oscillating buoy and hydraulic converter since 2000 when OWC was proven inefficient and unstable.

It is not easy to identify clear market opportunities for Norwegian companies within the Chinese ocean energy market. A recommendation would be to interact with the leading academic and commercial players listed in section 2.3.

Japan

In Japan, renewable energy, including hydropower, represents around 6% of the total primary energy supply in 2005, and the maximum introduction of renewable energy in 2030 will be 11.6%. Wind and solar energy contribution is currently very small, but solar and PV especially is expected to grow substantially.

Most of the wind mills were installed onshore in Japan. There are 1,517 turbines installed as of March 31, 2009, and the total accumulated capacity is 1,854 MW, which is far below the government's target (3,000 MW by March 31, 2011). In fact, wind power contributes only 0.3% of the total electric power demand as of March 31, 2009.

The potential of wind is, however, substantial: 25 GW MW onshore; 18 GW shallow water and 38 GW deep water offshore. Offshore wind – floating installation at deep water – is especially attractive in a country with high population and very little available land and shallow water areas for wind parks.

Japan has had long-term involvement in the wind industry with Mitsubishi manufacturing wind turbines since 1980. Japan‟s local manufactures include Mitsubishi Heavy Industry (200 kW – 2.4 MW), Fuji Heavy Industry (2 MW), Japan Steel Works (2 MW), and Komai Tekko (300 kW). Mitsubishi has stopped selling its turbine in the local market and is focusing primarily on international markets.

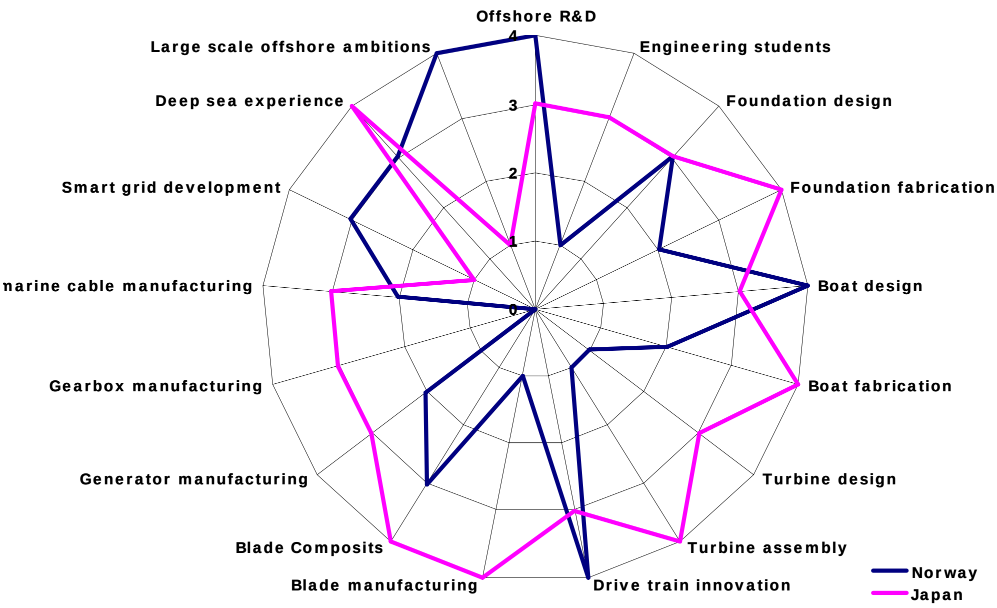
Given the facts that offshore wind/ocean energy market is still in early stage and that R&D work is required to make deep water offshore wind mills commercially viable, it will be recommended to form a partnership with Japanese companies like Ocean Power Technologies (USA) did or tie with Japanese researchers. Another option is to form a partnership with Japanese companies such as Mitsubishi Heavy Industries in the international market at first, which could lead Norwegian companies easily to the Japanese market when the market is willing, able and ready for offshore wind and ocean energy

- -25% CO2 emission from 1990 level
- FIT for renewable energy is proposed
- Cap-and-trade system is proposed
- Abundant deep water offshore resources
- Strength in maritime R&D
- Offshore wind mill has just started attracting attention.

The figure below indicates where Norwegian companies may have market opportunities or cooperation opportunities with Japanese companies:

- Offshore R&D
- Boat design
- Drive train innovation
- Smart grid development and advanced energy systems

Figure 5: Norway – Japan offshore wind comparison.



Source: Innovation Norway

Korea

Korea puts its best efforts on the utilization of new and renewable energy (NRE) to commodities using clean technology. As of the end of 2007 NRE supplied 65 TWh, or 2.37 % of total primary energy consumption of 2,790 TWh. Of the total supply of NRE, waste energy contributed the largest proportion at 77.0 percent, followed by hydro power with 13.9 percent, and wind with 1,4 %. The Korean government has announced an ambitious NRE plan of 11% share NRE within 2030, backed by about 61 billion Euros funding.

Wind energy

In case of wind generation, deployment was 1,000 GWh in 2007 and it will be increased up to 48,322 GWh in 2030. It means wind power generation will be increase average 18.1 percent every year and it shares 12.6 percent of total new and renewable energy.

The government has introduced substantial financial incentive programs, including competitive feed-in-tariffs for wind and ocean power; regional and government subsidy programs and tax and loan incentives.

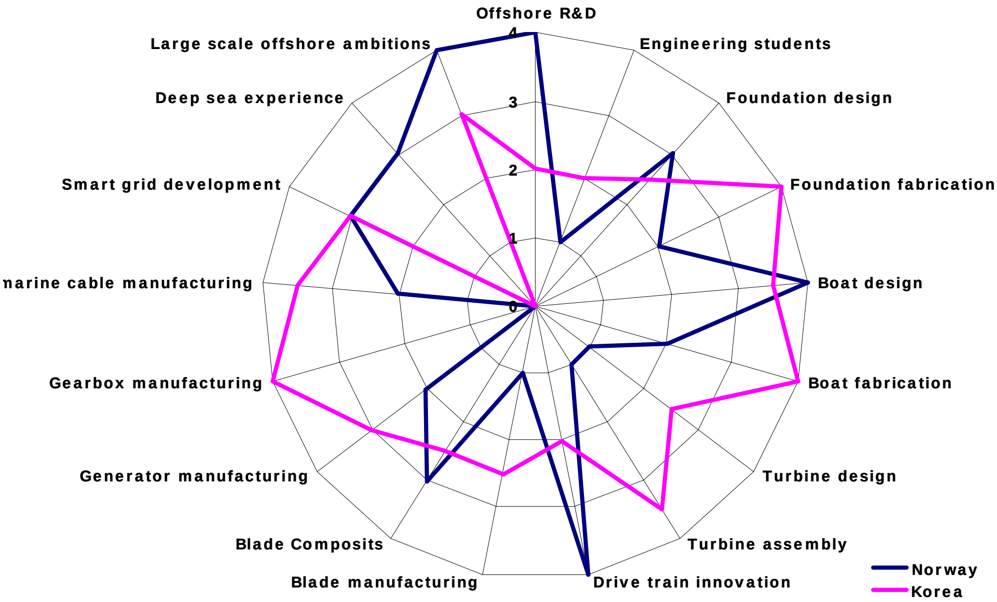
Korea has also ambition of becoming a major technology provider to the emerging wind markets in NEA and beyond. Among the key players in wind and ocean energy are diversified units from larger conglomerates, power companies and NRE companies. Especially large shipbuilding and construction companies are moving into the wind energy market for manufacturing, export, installation and management, with aims to become among the global top players in less than a decade from now. Among these, are Hyosung, Doosan, Samsung DSME, Hyundai and STX. The country is currently lagging behind on wind turbine technologies, and companies are therefore actively seeking international collaboration with e.g. Norwegian expertise on R&D.

Considering growing ambition on offshore wind project development, large sized offshore wind turbine system as well as new floating tower system for deep-sea will be warmly welcomed to collaborate with Norwegian players.

Opportunity areas for Norwegian companies include:

- Offshore R&D
- Foundation design
- Boat design
- Drive train innovation
- Blade composites
- Deep sea experience

Figure 6: Norway – Korea offshore wind comparison.



Source: Innovation Norway

Ocean energy

Korea has total 14 GW of ocean energy resource potential - Wave power has its potential of 6.5 GW, tidal power has 6.5 GW and tidal current has 1 GW. As of 2008 ocean energy was nothing in 2008 but dissemination target in 2030 is 18,000 GWh, average 49.6 percent of annual growth and 4.7 percent from total new and renewable energy.

Ocean energy was nothing in 2008 in Korea but dissemination target in 2030 is 18,000 GWh, average 49.6 percent of annual growth and 4.7 percent from total new and renewable energy.

Regarding ocean energy, Korea is currently pushing ahead with building four tidal power plants, all on the western coast. Most of tidal and tidal current projects are led by several leading engineering & construction (E&C) companies in Korea however core components (turbine) have been supplied from overseas VA Tech and Voith Hydro (local partner Renetec) so far. Therefore it is worth for Norwegian industrial players to start communication with Korean leading E&C companies to explore new business opportunity from local tidal and tidal current power projects.

Korean wave-force power generation is little behind on its development compared with development status of tidal and tidal current.

1.4. General notes

For convenience for Norwegian readers, local currencies are converted to Norwegian kroner (NOK) using the following exchange rates as of April 4, 2010:

- China: 1 RMB/yuan = 0.83 NOK
- Korea: 100 won = 0.50 NOK
- Japan: 100 yen = 6.20 NOK

2. China

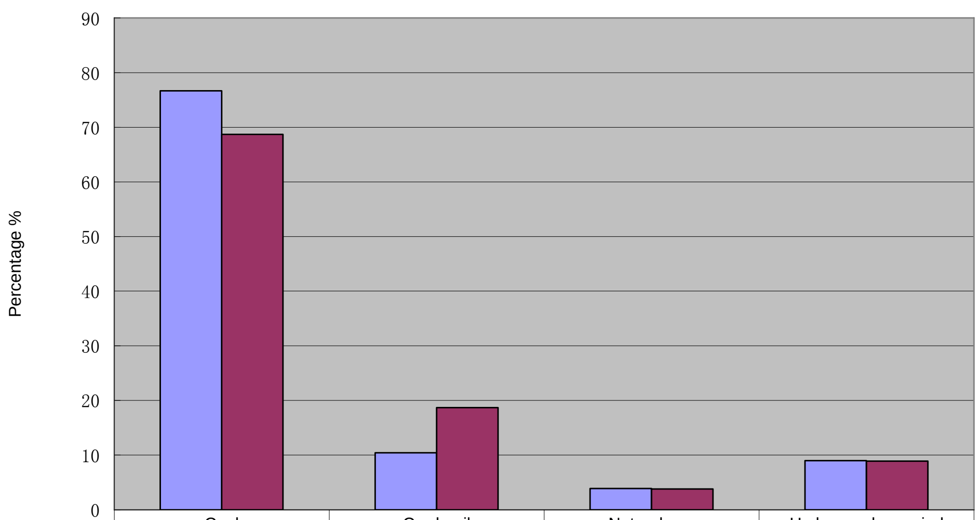
2.1. Energy supply and demand

Currently, China's energy portfolio consists mainly of domestic coal, oil and gas from domestic and foreign sources, and small quantities of hydro-power and uranium. China has also created a strategic petroleum reserve to secure emergency supplies of oil for temporary price and supply disruptions. Considering the growth of GDP and population in China, its total energy demand will keep going up in foresee decades.

By 2008, the compositions of energy production and consumption show a basic energy structure (diagram as below), and it will be more or less same in 2009 (to be officially published in June 2010). Despite many questions on Chinese statistic data from all over the world, the fact of too relying on coal and oil is un-doubtable.

Figure 7: Energy composition in China 2008

Compositions of energy production and consumption in China 2008



	Coal	Crude oil	Natural gas	Hydro, nuclear, wind
Production %	76.7	10.4	3.9	9
Consumption %	68.7	18.7	3.8	8.9

The total energy production and consumption in 2008 were 2.6 and 2.85 billion tons of standard coal energy (Chinese official statistic unit for energy).[5]

China energy strategy is diversification in order to reduce risk of relying almost exclusively on few supplying countries. Today, China is putting more emphasis on adjusting its energy structure with focus on renewable energy, wind power and nuclear power especially[6]. The available wind power resource in China is around 2,600 GW, China has installed wind power capacity 25 GW by 2009. Currently China has 11 nuclear power projects in operation, while other 21 new stations are under construction.

[5] Data source: China statistic annual book

[6] Source: Xinhua News Agency, an exclusive interview to Zhang Guobao, director of China's National Energy Administration, vice-minister of the National Development and Reform Commission Interview during annual session of National Committee of the Chinese People's Political Consultative Conference, March 2010-03-19

By 2009, China has played an important role and has contributed to the global renewable energy development by taking some important positions (shown in following diagrams)[7].

Table 1: Global ranking of renewable energy nations.

Wind Power	Hydro Power	Solar Power	
		(PV)	(CSP)
1. United States - 35,296 MW	1. China - 179,056 MW	1. Germany - 6526.00 MW	1. United States - 900.0 MW
2. Germany - 25,777 MW	2. Brazil - 81,955 MW	2. Spain - 5504.76 MW	2. Spain - 130.0 MW
3. China - 25,104 MW	3. United States - 78,054 MW	3. Japan - 2347.00 MW	3. Australia - 37.0 MW
4. Spain - 19,149 MW	4. Canada - 75,287 MW	4. United States - 1487.71 MW	4. Mexico - 25.0 MW
5. India - 10,925 MW	5. Russia - 46,756 MW	5. Italy - 908.59 MW	5. Algeria - 20.0 MW
6. Italy - 4,850 MW	6. India - 39,546 MW	6. Republic of Korea - 557.60 MW	6. Morocco - 20.0 MW
7. France - 4,492 MW	7. Norway - 29,317 MW	7. France - 253.42 MW	7. Italy - 5.0 MW
8. UK - 4,051 MW	8. Japan - 22,089 MW	8. China - 223.00 MW	8. N/A
9. Portugal - 3,535 MW	9. France - 20,850 MW	9. India - 223.00 MW	9. N/A
10. Canada - 3,319 MW	10. Sweden - 16,266 MW	10. Australia - 114.39 MW	10. N/A

Geothermal Power	Biogas Power	Biomass Power
1. United States - 3153.0 MW	1. Germany - 3,594 MW	1. United States - 9,391 MW
2. Philippines - 2195.3 MW	2. United Kingdom - 1,425 MW	2. Germany - 5,890 MW
3. Indonesia - 1132.0 MW	3. United States - 1,047 MW	3. Sweden - 4,522 MW
4. Mexico - 965.0 MW	4. Italy - 477 MW	4. Brazil - 3,970 MW
5. Italy - 810.0 MW	5. Australia - 427 MW	5. Japan - 2,834 MW
6. New Zealand - 577.0 MW	6. Spain - 194 MW	6. Netherlands - 2,531 MW
7. Japan - 535.0 MW	7. Netherlands - 130 MW	7. China - 2,381 MW
8. Kenya - 169.0 MW	8. France - 120 MW	8. Finland - 2,352 MW
9. Turkey - 83.0 MW	9. Canada - 117 MW	9. India - 2,117 MW
10. Russian - 81.0 MW	10. Sweden - 64 MW	10. Canada - 1,885 MW

However, the proportion of the renewable energy is still low – 9.9% of the total energy consumption in 2009 in China.

[7] Green Chip Stocks, March 12, 2010

To adjust the energy development pattern will be the top priority of national energy development blueprint and more efforts would be made in scientific research and development in the field. The national target for renewable energy development has actually been driven by the fast industry development. A most updated blueprint is expected be published in April 2010 after the annual session of the National People's Congress.

Following graphs give an overview shared by some officials and experts based on the draft plan presented to the State Council. By 2020, the portion of renewable energy in total energy matrix will be 15-20%. Nuclear, wind and solar power may take 15% of it, while bio-energy, geothermal, tidal and wave may take other 5%.[8]

Figure 8: Renewable energy contribution to total energy consumption in China.

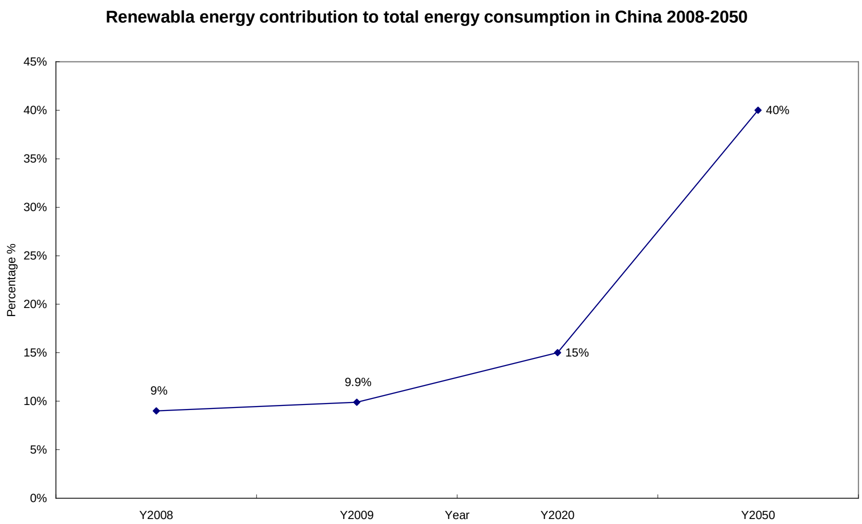
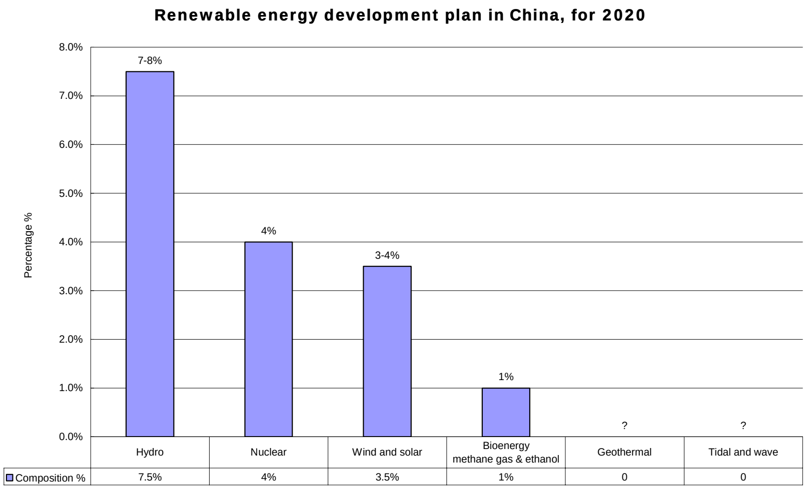


Figure 9: Renewable energy development plan in China for 2020.



Renewable energy contributes 15% of total energy consumption - national energy development plan by 2020.[9]

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[8] Sources: officials and experts interviewed and reported by media

[9] Mr. Meng Xiangan, vice president of China Renewable Energy Society, March 15 2010, remarks after the annual National People's Congress

2.2. Wind – status and future potential

Wind power industry in China has short history but developed fast. The industry framework is existing and being basically established.

Wind resource

Wind energy has the necessary resource basis mainly distributed in north, east and south coast of China. The total resource is between 700 GW and 1.2 TW onshore & offshore. Of this, 100-200 GW is potential of offshore.[10]

Established capacity

In 2009, China became the third largest wind energy provider worldwide (behind USA and Germany), with the installed wind power capacity reaching 25 GW at the end of 2009. According to the Global Wind Energy Council, the development of wind energy in China, in terms of scale and rhythm, is absolutely unparalleled in the world. Researchers from Harvard University and Tsinghua University have predicted that China could meet all electricity demands from wind power through 2030.

The national renewable energy development plan is going to be published sooner or later in 2010. Except the goal of establishing 100-150 GW wind capacity by 2020, this plan also emphasis to build 7 biggest national wind power bases in 6 provinces – Gansu, Xinjiang, Hebei, Jilin, Inner Mongolia and Jiangsu provinces. The capacity of each of these 7 bases will exceed 10 GW, and the total capacity of these 7 bases will be more than 126 GW.

Onshore wind power has been developed very fast and most of it has been taken by monopolized national and provincial state owned developers and local turbine manufacturers.

Offshore wind resource has not yet been exploited. But it is getting a hot issue driven by incentives of national renewable energy development plan, regulations, policies and the attractive potential market prospect. And it will be no doubt to bring more business opportunities to either local or foreign companies who own up-to-date technologies, products and services.

National government is organizing to start the first batch of offshore wind concession projects bidding by all top 5 power generation enterprises and developers in 11 coastal provinces.

Government

Both central government and local government encourage and support wind industry development. Although the State Energy Bureau is coordinator, many other ministries and/or authorities are involved in administration and regulation.

Law, regulation and policy

China has established a series laws, regulations and policies to encourage wind power development, especially during recent past years.

Finance & Investment

In addition to the strong financial and tax supports by central and local government, there are various venture capitals from both Chinese and foreign companies.

Developer

It is more or less monopolized by state owned companies. The top 5 state owned power companies are taking majority of wind farms. Provincial government supported provincial and regional developers take the rest of market share.[11]

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[10] China Wind Power Report 2008, Li Junfeng; Sun Yat-Sen University (ZhongShan University), refers to *Azure International: China, Norway and Offshore Wind Development, WWF 2010*

[11] China Wind Power Center

Manufacturer

By 2009, China already has 70-80 turbine manufacturers, more than 50 blade manufacturers, 100 tower manufacturers and more than thousand manufacturers producing other components & parts for this industry. However, there are only around 10 turbine manufacturers have capacity to produce turbine. And of these 10, only three can produce turbine in batches. Acquisition & merging will be an obvious trend within this manufacturing industry.

China can make 1.5 MW turbines in batches. R&D on 3 and 5 MW turbines has breakthrough and is going to be industrialized in batches soon.[12]

R&D / Technology

At present, Chinese established turbine manufacturer technology development mode is 32% local independent, 18% joint venture and 50% licensed transferring from foreign leading manufacturers.[13]

The quality and reliability of local independent developed turbines are challenging wind power developers and grid enterprises – operating efficiency is 7%, or even more lower than foreign leading manufacturers' products. Many products, installed in the already established 25 GW wind capacity, have actually no clarified industrial standards and no industrial certificates. This situation challenges feed-in power grid and its operation security actually[14].

National policy is clearly and strongly encourages industry to study and buy global leading technologies and to further develop Chinese ownerships of technologies. And such effort will sooner or later increase Chinese turbine manufacturers' market shares in not only China but also global market.

Meanwhile, China national government has organized a series R&D programs to support wind power industry. For instance, many Chinese academicians, engineering academicians and top wind industry economic scientists have participated in a national fundamental R&D Program (973 Program) to develop grid connection and/or regional direct supplying & utilizing wind power. 6 universities and academies have participated in this Program.

Supporting industries

As a well-known manufacturer for global market, China has established a huge and wide range fundamental industry that is no doubt supporting wind power industry development today.

Although the huge fundamental but monopolized power grid industry is challenging wind power development today, the situation is supposed to have obvious improvement benefited from national renewable energy regulations and incentive policies and blueprint in recent coming years.

International cooperation

Foreign turbine and components producers are actively taking certain market share by joining wind farm concession projects through JV and/or selling licensed technologies to Chinese counterparts.

Organizations & Services

Many organizations, including both local and foreign, have been established connecting to wind power industry in China. And theirs services are covering almost whole value chain of the wind power industry – from wind resource investigation to manufacturing, engineering & construction, operating & maintaining, education & training, information management, professional exhibitions, etc.

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[12] Shi Lishan, a senior official of State Energy Bureau, interviewed by Xinhua News Agency, January 4th, 2010

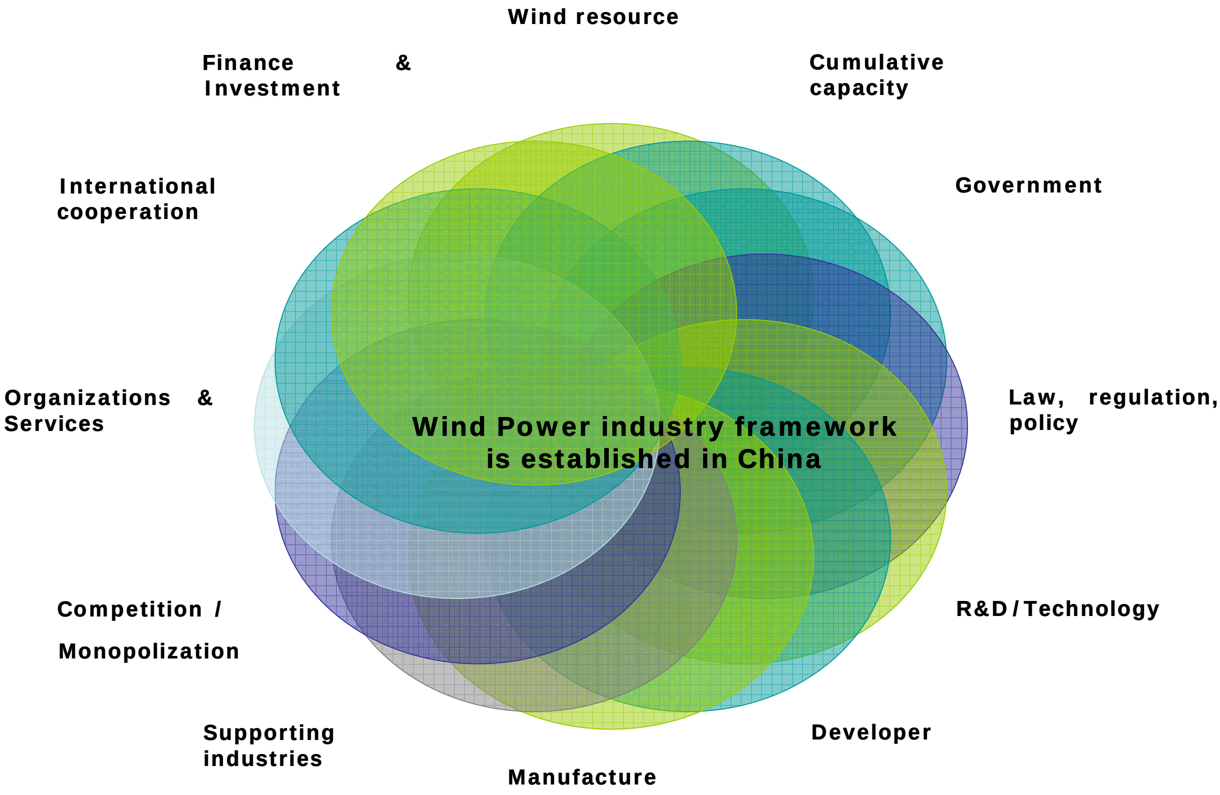
[13] *Azure International: China, Norway and Offshore Wind Development, WWF 2010*

[14] Yang Xiaosheng, the chief engineer of LongYuan, Speech for a wind seminar in Shanghai April 2009

Competition and/or monopolization

Both monopolization and competition situations are parallel within wind power industry. Wind resource investigation, wind farm/project developer are monopolized by state owned companies and/or organizations. But there are fierce competitions on technologies R&D, turbine and components manufacturing, installing, training and consulting services, etc.

Figure 10: Chinese power industry framework.



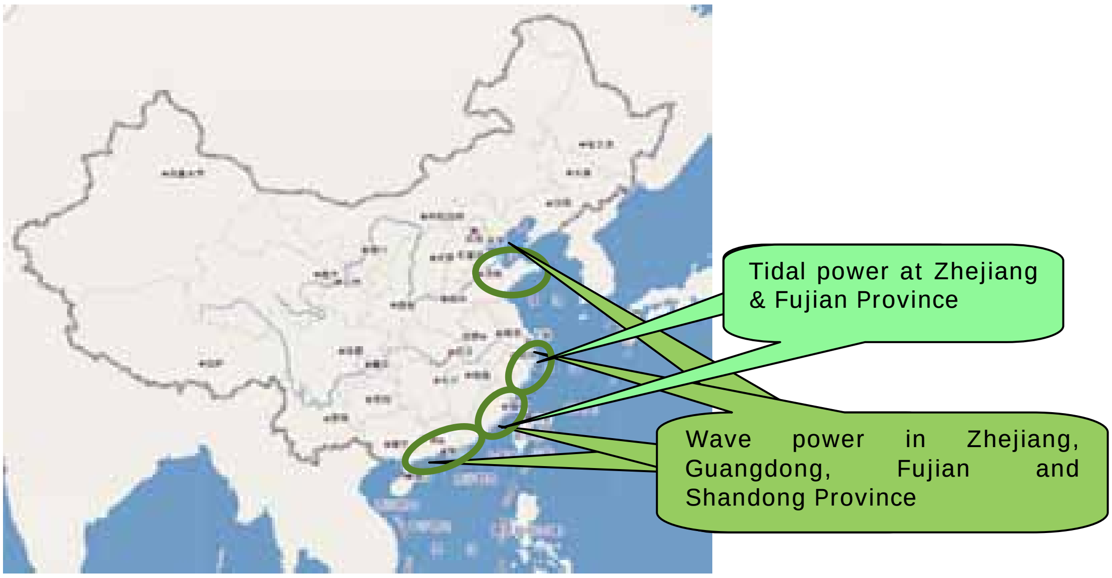
2.3. Wave and Tidal – status now and future potential

Wave and Tidal Energy Reserves

China has a long coastline of 18,000 km, which embraces 3 million km^2 ocean territory and 6500 islands.

China's tidal power reserves are estimated at 110 GW, of which 21 GW can be exploited and generate 58,000 GWh of power every year. Coast at Zhejiang and Fujian provinces accounts for 88% of total tidal power reserves. The average theoretical reserve of wave power is 12.9 GW. They are scattered along the coastline unevenly. Zhejiang, Guangdong, Fujian and Shandong province account for about 55% of total reserves.

Figure 11: Tidal and wave power locations off China.



R&D and Experimental Projects

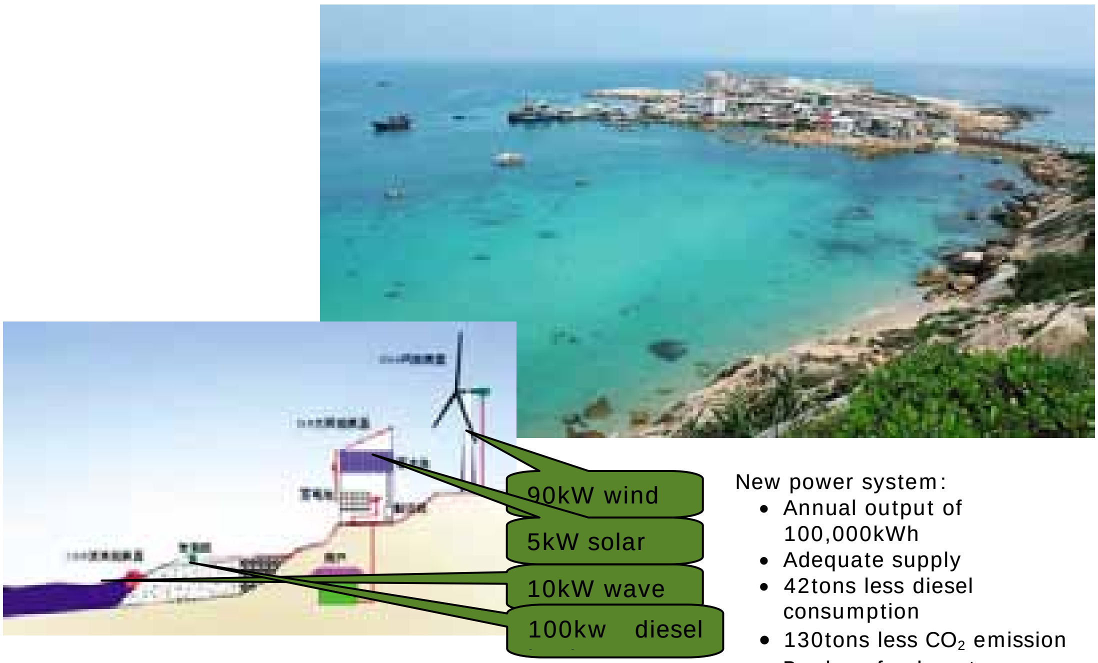
China started research on utilization of tidal energy in 50s. More than 40 small tidal power stations of dozen kilowatts were built by then and some of larger capacity constructed later in 70s. Unfortunately most of these tidal power stations became out of service due to wrong location, out-of-date technology, conflict service against local irrigation and navigation, or inconvenient use. While eight tidal power stations are left in service only three of them are in continuous operation, namely Jiangxia, Baishakou and Xingfuyang.

The Jiangxia tidal power generation plant is one of the largest tidal generation plants in China and an experiment facility of tidal generation. The plant locates at Jiangxia port at 16 kms southwest from Zhejiang's Wenling County. The power plant started its construction in 1972 as a Tidal Power Generation Research Project. After the last upgrade in 2009, the station now has 6 double direction bulb-type hydraulic generating units for a total installed capacity of 3.9 MW, ranking the third biggest in the world only after French Lance and Canadian Annapolis. It has generated 162 GWh since it started operating in 1986, of which 7.31 GWh output in 2009.

China's R&D on wave energy started in 70s and later a number of experimental power conversion projects had been carried out mainly in Shanghai, Guangzhou, Dalian, Qingdao, Beijing and Tianjin. R&D had been focused rather on OWC (oscillating water column) in 80s and 90s but shifted to oscillating buoy and hydraulic converter since 2000 when OWC was proven inefficient and unstable.

A milestone was seen in 2009 that an independent sustainable power plant, a combination of solar, wind and wave, was installed on Dan Gan Island, Zhuhai city, Guangdong Province. It's the first of such type in the world. The power plant will generate 100 MWh every year to ensure sufficient supply of electricity and fresh water to 300 habitants, and use the surplus to produce 10,000 tons fresh water annually. Construction is completed and the windmill started operation in 2009, and has proven economic performance with diesel backup in summer. Once solar and wave start operating, the system will run without backup of diesel generator or power net.

Figure 12: Dan Gan Island combined power plant project.



New power system:

- Annual output of 100,000kWh
- Adequate supply
- 42tons less diesel consumption
- 130tons less CO_2 emission
- Produce fresh water

Academic and Commercial Players

- **Guangzhou Institute of Energy Conversion (GIEC), Chinese Academy of Sciences**, *http://www.giec.cas.cn/*, was founded in 1978 and is affiliated to Chinese Academy of Sciences (CAS). The institute has 8 research groups covering solar, clean energy, biomass, solid wastes, industrial energy conservation, geothermal energy and etc. The Zhu Dan island project (on previous page) was headed by the Ocean Energy Lab of Guangzhou Institute of Energy Conversion.
- **The Second Institute of Oceanography, the State Oceanic Administration (SOA)**, *http://www.sio.org.cn/english/index.asp*, was established in 1966 and is affiliated to the State Oceanic Administration (SOA). It is mainly engaged in scientific research and technology development for oceanic environment and resources on China seas, oceans and polar regions.
- **National Ocean Technology Center (formerly the Marine Technology Research Institute), State Oceanic Administration (SOA),** *http://www.notc.gov.cn/*, was founded in 1965 as a non-profit organization of the state oceanic administration. The department of ocean energy technology is responsible for R&D on oceanic renewable energy.
- **The College of Power and Energy Engineering, Harbin Engineering University,** *http://www.hrbeu.edu.cn/*, was founded in 1953 as a branch of Harbin institute of military engineering, now has a focus on Thermal Power Engineering, Communication and Transportation, and Marine Engine Engineering. It designed Jiangxia, China's biggest tidal power station.
- **The College of Engineering, Ocean University of China (OUC),** *http://www.ouc.edu.cn/* is strong at harbour, channel and coastal engineering, naval architecture and ocean engineering.
- **Long Yuan Group,** a daughter company of China Guodian (Group) Corporation (one of major central government-owned enterprises), is one of the first companies to develop electricity power generation in China, and is now mainly engaged in investment and operation of renewable energies, including wind, solar, biomass, geothermal, and tidal power. As for tidal power, the company owns Chinese biggest tidal power plant, Jiangxia

Experimental Tidal Power Plant. Upcoming tidal power station projects will be one of 20 MW in Zhejiang Province (Jian Tiao Port) and one of 36 MW in Fujian Province. The company plans to complete tidal power station of total 100 MW by 2020.

- **China Huaneng Group,** as one of the key central government owned corporations in power industry, targets total generation capacity of 120 GW by 2020, 12% of Chinese total installation. Huaneng Power International Inc is a listed subsidiary of Huaneng Group, which owns a number of power plants all over China. Its ocean energy project is divided into 3 sub-projects, two offshore windmills of 500 MW each at Qidong and Rudong, one tidal power station of 35 MW at Rudong.

2.4. Energy price and tariffs

During 2005-2007, The 72 concession onshore wind power projects followed project rule to set down feed-in tariff.

In 2008, National government has approved a new wind power price at three levels: 0.51, 0.56 and 0.61 yuan (0.42, 0.47, 0.51NOK) per kWh. It was guidance implemented by all wind power projects.

In 2009, China set a fixed feed-in tariff for new onshore wind farms. The feed-in tariffs per kWh are set at 0.51 yuan (0.42NOK), 0.54 yuan (0.45NOK) , 0.58 yuan (0.48NOK) and 0.61 yuan (0.51NOK). These represent a significant premium on the average rate of 0.34 yuan (0.28NOK) per kWh paid to coal-fired electricity generators. However, the area of the 4 types wind power resources regions is not clarified. This situation leaves flexibility for negotiation among national government, provincial government, wind power developers and operators.

In reality for each project, provincial government normally also gives additional support based on national tariff as benchmark price.

Offshore wind power feed-in tariff is not set down yet. It is still in the formative stage according to offshore wind power development status. The first commercialized offshore wind project in Shanghai will be put into operation after May 2010. And it will help national government to work out a benchmark feed-in tariff soon for more up coming offshore wind projects.

For thorough details about wind power price and pricing mechanism in China, we refer to:

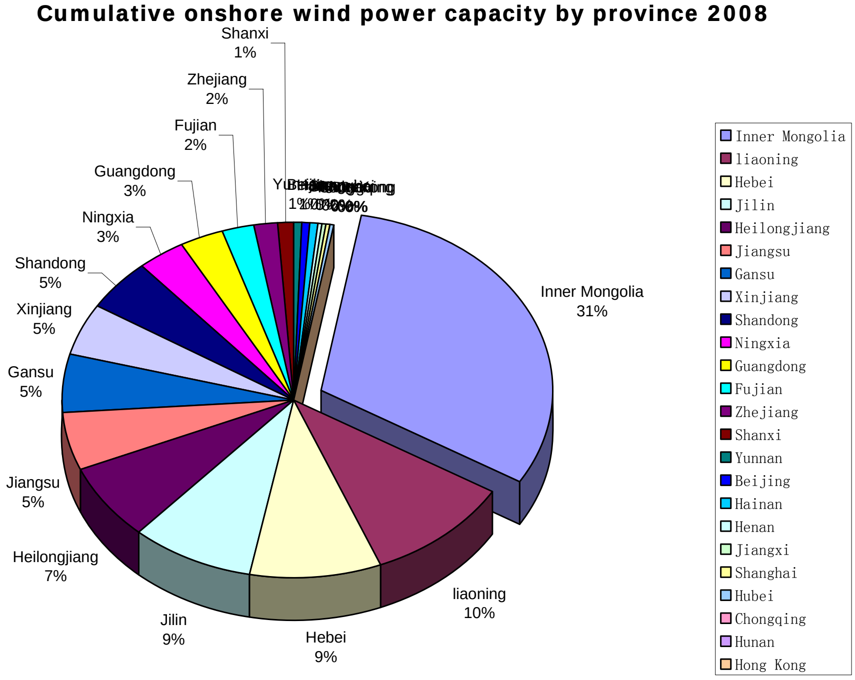
- China Wind Power Report 2008, written by WWF China and China Renewable Energy Industry Association. The report was funded by Norad.
- China Wind Power Report 2007, written by China Renewable Energy Industry Association and Global Wind Energy Council
- Danish-Chinese cooperated wind energy development program (2006-2009)
- China Greentech Report 2009

2.5. Relevant locations for offshore wind energy

The established onshore wind farms are mostly spreading in north and east areas, across from west to east, and from north to south along coastal provinces. Around 80% of cumulative onshore wind capacity is distributed in provinces in north China. Inner Mongolia is outstanding from following chart. Along coastal provinces, Shandong, Jiangsu and Guangdong take around another 13%. This is the basic structure although it may be a bit changed in 2009.[15]

[15] China New Energy Chamber of Commerce

Figure 13: Offshore wind capacity by province.



According to offshore wind resources, national development plan and developers' interests, two offshore areas administrated by Shandong and Jiangsu provinces will become major offshore wind bases soon.

China National Offshore Oil Corporation (CNOOC) has launched the first 1.5 MW offshore wind mill in Bohai Sea in 2007. It was a pilot project mostly contributed on R&D instead of commercialization.

The country's first pilot offshore wind farm started construction in 2008. The *Shanghai East Sea Bridge Offshore Wind Farm* has a total installed capacity of 100 MW, comprising 34 sets of 3 MW turbines from Sinovel, the country's largest wind turbine producer. It will go into operation before the inauguration of the World Expo Shanghai, which is scheduled for May 1st, 2010.

Shandong province

In 2010, China National Offshore Oil Corporation (CNOOC) is building construction an offshore wind farm in *Weihai*, east Shandong Province, which is scheduled to produce 1.1 GW in 10 years. The first stage will have 30 sets of 1.5 MW turbines producing 45 MW.

By March 2010, Datang Corporation, Guodian Corporation, Huaneng Group and Xiangdian (Shandong) Group have signed strategic cooperation agreements with provincial and regional government in Shandong for developing offshore wind power.

China Power Investment Corporation, Longyuan Electric and Huaneng New Energy have begun to study offshore wind farms in Shandong province as well.

Jiangsu province

It is reported that the generation capacity of offshore wind farms in Yancheng region is expected to reach 12.3 GW as the municipal government is stepping up efforts to facilitate the development of offshore wind projects in five counties and cities in Yancheng region.

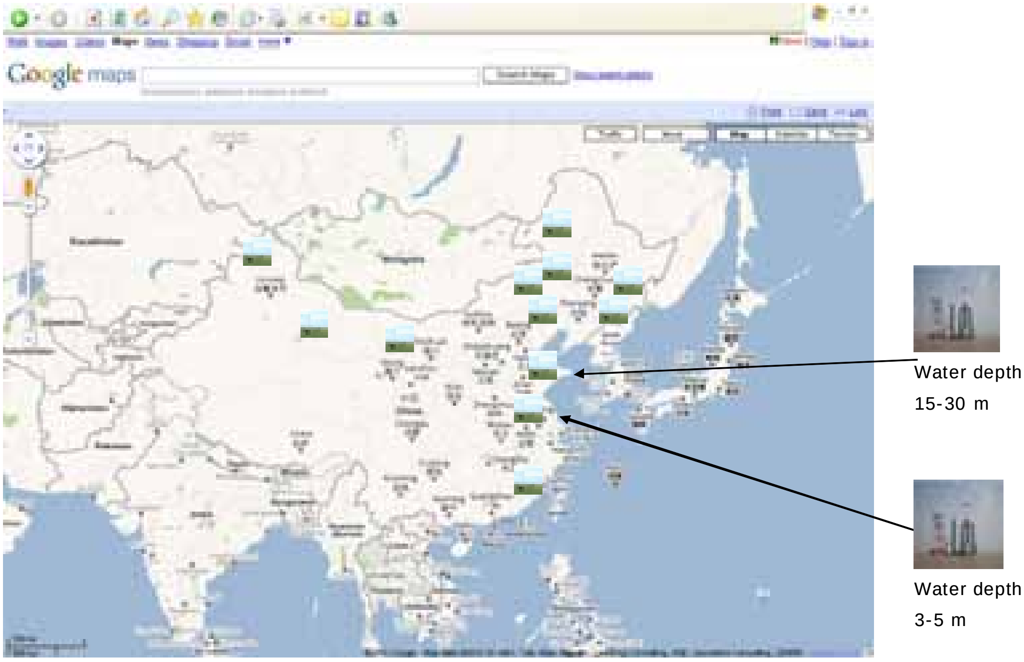
The first wind turbine was installed in an offshore wind farm on February 18th 2010 in Xiangshui County.

On February 2nd 2010, Shenhua Group Corporation announced it would start early phase works for the examination and approval of the third stage project of the *Dongtai Wind Farm* (a 300 MW offshore project, with 84 sets of 3.6 MW turbines from Shanghai Electric.) It has also started planning for the fourth stage 300 MW offshore project, scheduled to have 84 sets of 3.6 MW turbines from Shanghai Electric.

Other leading Chinese power developers, such as China Power Investment Corporation, Longyuan Electric and Huaneng New Energy, have also been attracted to the promising offshore wind power sector. They have begun to study offshore wind farms in *Dafeng and Rudong.*

Huarui Wind Power Technology Co., Ltd recently started construction on a wind power project in Yancheng that will have a capacity of 5 MW and will involve a total investment of RMB 1.5 billion. The project is expected to be completed by the end of 2010.

Figure 14: Onshore and offshore wind farms in China.



2.6. Political climate for renewable energy from ocean and wind

In general, Chinese political climate for wind power industry has been keeping improvement since 2005. Following series incentive laws, regulations, policies and national plan have been put into effect. It strongly supports wind power industry developed fast within few years.

2009:

- The Renewable Energy Law (Amendment)
- Corporate income tax policy for CDM Projects
- Wind power feed-in tariff policy
- VAT refund policy

2008:

- The Eleventh Five-Year Plan for renewable energy development
- China's policy and action against climate change
- Global Environment Facility Grant Projects Management
- Wind Power Generation Equipment Industrialization Special Fund Management
- High-tech Enterprise Designation Management
- Import tax policy on turbine and components
- National government gives subsidy, RMB 600 per KW, to qualified developer for its first 50 MW installed turbines after operation and feed-in grid.

2007:

- Implementation provision on promoting wind power
- Pricing renewable energy
- Development Plan
- Wind power construction and management
- Renewable energy additional price
- Technical requirements for grid connection

2006:

- Renewable energy law
- Energy conservation law
- New energy projects capital management
- Guidance catalogue for renewable energy
- Renewable energy pricing and cost
- Regulations on renewable energy generation
- Renewable energy development special fund management
- CDM Project Administration

The governance of wind power sector in China is anfractuous.

The difficulty of coordination among too many administrative bodies prolongs the development process. To establish a national energy coordinating committee of the State Council has been discussing for years. It is expected to help coordination considering state security, land and offshore layout and utilizations, power grid connection, etc.

In practice, political climate to foreign companies is NOT equal as to Chinese companies, especially state owned companies.

Although the mandatory rule of using not less than 70% of local made components and/or equipments applied in wind power concession projects has been released in 2009, another restricted regulation has been published in January 2010 - China has opened the door to domestic wind power companies to start developing the country's offshore resources – but has effectively shut it on international operators – with the release of regulations governing approval and ownership of offshore wind projects.

The new offshore regulation does not overtly prohibit foreign involvement in project development. But it does require foreign companies to enter into a Chinese-controlled joint venture and it limits equity ownership to less than 50%. In reality, most of the international developers cannot, or are not willing to, do a joint venture with Chinese partner.

In effect, there has been relatively little international participation in the onshore wind sector as well, due to policy barriers such as low tariff levels and a regulation requiring majority Chinese ownership to qualify for revenue from the Clean Development Mechanism (CDM), the UN-administered system for rewarding projects that reduce greenhouse gas emissions with carbon credits. Consequently, the 25 GW installed onshore capacity has been mostly developed by the 'big five' state-owned companies.

Political influence on grid connection is weak in practice. An in-depth reform to improve the monopolized power grid administration will be the only key actually. The national level feed-in tariffs for wind power industry will, theoretically, help to encourage wind industry development based on project performance and energy yield rather than installed capacity. Due to the instability of wind power, grid connection costs more on technologies, operation and management. It is more important to establish an effective incentive and/or competitive mechanism that can push power grid enterprises and its administrations proactively to accept wind power.

2.7. Incentives for developing and utilizing new technology

National wind power development plan gives a huge and attractive business opportunity to all parties involved in this industry. It covers whole value chain of this industry from wind resource investigation till to grid connection.

National technology development strategy encourages introducing and studying international up-to-date technologies. For long term consideration, National government has strong incentive to establish and develop new and advanced technologies with Chinese ownership of intellectual properties and patents. It is one important state strategy, and it is being implemented in all industries including wind power.

Finance & Tax policies are encouraging and supporting companies to import and develop new and advanced technologies and products.

Driven by *the global CDM mechanism* and the pressure of fulfilling government promise to reduce green-house gases, China will have a big challenging and critical role to play as its economy continues to grow at a staggering rate. Chinese government and industry have to seek for new technologies and products to develop and to utilize new & renewable energy resources.

The fierce competition status within manufacturing and service segments push companies to apply in new technologies and products to improve products and services quality.

As a global *technical difficulties and operation challenges of grid connection* for wind power, both wind power developers and grid corporations have no choice but to break present dilemma situation and apply in more and more new and advanced technologies to feed the installed huge amount of wind power capacity into power grid.

The fundamental driven force is *profit*. All wind power developers and producers are looking forward to having further strong national policy support to guarantee grid connection or to establish regional grid and 'direct-supply' model for wind power industry. It will strengthen wind power developers' incentives to further invest in developing and utilizing new and advanced technologies. Such incentives depended on national government coordination result between wind power industry and power grid industry.

Coal resource is limited and its price is getting higher and higher. It forces all power generating companies to invest more and more on new energy resources.

2.8. Key players

Governance

It is complicated and difficult coordination among too many administration bodies.

- State Energy Commission (coordinator future)
- State Electricity Regulatory Commission
- State Energy Bureau of National Department & Reform Commission
- Ministry of Finance
- Ministry of Sciences & Technology
- Ministry of Commerce
- Ministry of Industry and Information
- Ministry of Land & Resources
- State Oceanic Administration
- Fisheries authority of Ministry of Agriculture
- Military authorities/navy
- Maritime affairs authorities
- Ministry of Environment Protection

- State Administration for Industry and Commerce
- State Tax Administration
- National Standard Committee
- Provincial government and/or authorities

Wind resource investigation, data and software (CFD) development

It is monopolized by government organizations. However, foreign companies and organizations have chances to access into some projects through national level cooperation programs.

- National renewable energy research institute
- National electric power research institute
- China water & electricity engineering consulting (group) co. ltd.
- China meteorological administration
- China wind power association
- Risoe National Laboratory, Demark
- Garrad Hassan & Partners Ltd, UK
- Long Yuan Electric Power Group Corp.
- Regional and provincial reconnaissance & design academies/institutes

Wind farm developer

This segment is monopolized, especially by top 5 state owned power generation enterprises. Some foreign companies take very limited wind farm ownership through joint venture with Chinese companies.

All top 5 state-owned power developers are actively invested in wind power industry. They are taking the majority of onshore wind power already.

- Guodian Corporation www.cgdc.com.cn (Long Yuan Electric Power Group is holding the majority of onshore wind market share on behalf of Guodian)
- Datang Corporation www.china-cdt.com
- Huaneng New Energy Industrial Co. Ltd. www.hpi.com.cn
- China Power Investment Corporation www.zdt.com.cn
- Huadian Corporation www.chd.com.cn

In addition, other developers as below are also active and get strong support from national and provincial government.

- China Nuclear Group (Guangdong)
- State Develop & Investment Corporation
- China Energy Saving & Investment Corporation
- Guohua New Energy Investment
- China Three Gorges Project Corporation http://www.ctgpc.com
- Xiangdian (Xiangtan) Wind Energy Co., Ltd www.xemc-wind.com

Provincial government strongly supported theirs own major developers, such as Hebei Provincial Construction Corporation Group and other similar group companies in Inner Mongolia, Shandong, Jiangsu provinces, etc.

Although present main offshore wind farm developers are not as many as onshore wind, none of ‘top 5’ state-owned power developers and producers actually will give up this market. So far, following developers step ahead than others.

- Guodian Group http://www.cgdc.com.cn and its daughter company Longyuan Power Group Company http://www.clypg.com.cn

- China National Offshore Oil Corporation www.cnooc.com
- China Three Gorges Project Corporation http://www.ctgpc.com
- Bao Li Hua (Guangdong) New Energy Stock Co. Ltd www.baolihua.com.cn

Turbine and components manufacture

This is a fierce competitive segment, involving various Chinese and foreign manufacturers.

Turbine manufacturers

Main turbine manufacturers for onshore wind farms in China are listed in the following table. By the end of 2008, Chinese and Chinese-foreign joint venture manufacturers take 62% of cumulative turbine market share, and foreign companies take 38%. Theirs market share has been changed a bit in 2009, but the basic structure and main players are stable.

Table 1: Turbine manufacturers operating in China

Chinese and JV manufacturer	Capacity (MW)	Percentage of cumulative capacity	Foreign manufacturer	Capacity (MW)	Percentage of cumulative capacity
Goldwind	2,629	21.63%	Gamesa	1,552	12.77%
Sinovel	2,157	17.75%	Vestas	1,455	11.97%
DEC	1,290	10.61%	GE	637	5.25%
Windey	330	2.72%	Suzlon	347	2.86%
CASC-Acciona	250	2.06%	Nordex	328	2.71%
Sewind	201	1.66%	Others	325	2.68%
Mingyang	175	1.44%	**Total**	**4,646**	**38.23%**
XEMC	128	1.05%			
New Unite	82	0.68%			
BEIZHONG	60	0.49%			
Others	202	1.66%			
Total	**7,506**	**61.76%**			

Five Chinese turbine manufacturers are most actively focusing on offshore wind power[16].

- **Sinovel Windtec Co., Ltd.** www.sinovel.com an early starter, began to develop offshore wind turbines in 2006. It has focused on developing 3 MW and 5 MW offshore wind turbines. In April 2009, work began to install its 3 MW wind turbines in the Shanghai East Sea Bridge Offshore Wind Farm. In January 2010, Sinovel started construction of a 5 MW offshore turbine production base in Yancheng, Jiangsu Province. Sinovel had finished designing the 5 MW turbines and will produce the first sample turbine at the end of 2010.
- **Goldwind (Xinjiang) Science & Technology Co., Ltd** www.goldwind.cn China's second largest wind turbine producer is expected to complete construction of a production base for offshore turbines in Dafeng, Jiangsu Province, in October 2010. In 3-5 years, theirs annual production capacity will be 800 - 1,000 sets of turbines.
- **Dongfang Steam Turbine Works Co. Ltd** www.dfstw.com
- **Shanghai Electric Wind Power Co., Ltd.** www.shanghai-electric.com

[16] For details, we refer to: The annual report 2010 published by China New Energy Chamber of Commerce; and *Azure International: China, Norway and Offshore Wind Development, WWF 2010*

- **Xiangdian (Xiangtan) Wind Energy Co., Ltd.** www.xemc-wind.com

Foreign companies are staring at offshore wind turbine market in China as well.

- **Siemens** are considering setting up an offshore turbine plant in Weihai, Shandong Province. It also established a blade manufacture in Shanghai invested RMB 500 million in 2009 (416MNOK). And its yearly production capacity is expected to be 500 MW.
- Vestas has intensified market research and exploration of the Chinese offshore wind power market. It has set up an offshore wind power office in Shanghai dedicated to develop Chinese offshore wind power business. It also established a manufacturing base in Tianjin city mainly producing V80 turbines that have been successfully applied in offshore wind farms in Europe.

Major blade manufacturer

35 domestic and joint venture manufactures account for 83% market share which mainly includes:

- ZhongHang Huiteng Wind Power Equipment Co., Ltd
- Zhongfu Lianzhong Composites Group Co., Ltd
- SHFRP, ChangQian Group
- Tianjin Dongqi Wind Turbine Blade Engineering Co., Ltd
- Baoding HuaYi Wind Turbine Blade R&D Co., Ltd
- Sinoma Science and Technology Co., Ltd
- Tianjin XinFeng Energy
- Jiangsu Miracle Logistics System Engineering Co., Ltd
- Guangdong MingYang Electric
- Changzheng Electric
- State Joint Power
- Tianwei Group
- Shanghai Aeolon Wind Energy Technology Development Co., Ltd
- GCL-Power
- Hanwei Energy

6 foreign-funded enterprises account for 17% market share, mainly include:

- LM (based in Tianjin city close to Beijing)
- Vestas (based in Tianjin city close to Beijing)
- Gamesa (based in Tianjin city close to Beijing)
- Suzlon (based in Tianjin city close to Beijing)
- Nordex (based in Dongying city close to Beijing)
- TPI (based in Taicang city close to Shanghai).
- Major gear box manufacturers Competition is fierce.
- Dalian Heavy Industries Electro Mechanical Power Co., Ltd
- Chongqing Gearbox Co., Ltd
- Nanjing High-Speed & Accurate Gear Group Co., Ltd
- China National Erzhong Group Co., Ltd
- Hangzhou Advance Gearbox Group Co., Ltd
- Jake (Germany)

Major generator manufacturers

Competition is strong.

- Tianyuan Electrical Machinery Co., Ltd
- Yongji Electric Equipment Co., Ltd
- Zhuzhou CSR Electric Motor Co., Ltd
- Nanjing Turbine & Electric Machinery (Group) Co., Ltd
- Sichuan Dongfeng Electric
- Shanghai Nanyang Group
- Shanghai Electric, Lanzhou Electric
- Xiangtan Electric Manufacturing Corporation Ltd
- VEM (Germany)

Major manufacturers of control systems

There are not many competitors dependent on technology.

- Goldwind
- Windtec (Austria)
- Mita (Denmark)
- SEG (Germany)

Major converter manufacturers

There are not many competitors, but it is technology competition.

- ABB (Beijing)
- VERTECO (Finland)
- Windtec (Austria)

Service organizations

It gives lot of business opportunities to both Chinese and foreign companies.

- China Wind Power Center (CWPC) – a valuable information source
- Institute of New Energy under China Electric Power Research Institute purchases turbine power test equipment with the funding of Sino-German cooperation project. It helps to establish power curve measurement capability.
- China Classification Society has the capability in the authentication of gearboxes, generators and other components.
- China National Certification Center has issued certificates on turbine design and evaluation.
- Germanischer Lloyd, certification and training
- DNV, certification and training
- China Renewable Energy Industries Association (CREIA) www.creia.net
- China Wind Power Association
- Nanjing Aviation University
- Tsinghua University
- China Academy of Sciences
- Northeast University

- Military Chemical Academy
- Jiangsu Provincial Economy Academy
- China Electrician Technology Society
- China Machinery Industrial Union
- Shanghai GreenTech Engineering Co., Ltd
- China Power International Corporation
- China Shipbuilding Industry Corporation, its daughter companies based in Chongqing city, and its affiliated research institutes that are specialized on offshore R&D, engineering & construction, submerging, etc
- Shanghai Investigation and Design Institute
- Zhongtian Technologies Submarine Optic Fiber Cable Co. Ltd
- China Communications Construction Company Third Harbour Engineering Co., Ltd.
- China Hydropower Engineering Consulting Group Corporation
- China Meteorological Association
- China Offshore Oil Engineering Corporation
- China National Petroleum Offshore Engineering

Major grid enterprise

Two monopolies are controlling more than 95% of the grid in China.

- State Grid
- State Grid (South)
- News and articles published by various media

2.9. Market entry

Foreign companies have to face the fact of monopolized ownerships market structure

Wind resource investigation and wind farm projects.

They are normally carried out by Chinese especially state owned companies or organizations. Such requirement is to protect state geographic and oceanic data considering state security.

In practice, a series criteria and preferential policies weight scale towards Chinese national and/or provincial state owned developers. Consequently, the 25 GW installed onshore capacity has been mostly developed by the top 5 state-owned companies. In fact, all these five jumbos are already in talks with key coastal provincial authorities to secure prime locations.

A new published offshore regulation does not overtly prohibit foreign involvement in project development. But it does require foreign companies to enter into a Chinese-controlled joint venture and it limits equity ownership to less than 50%. In reality, most of the international developers cannot, or are not willing to, do a joint venture with Chinese partner.

Chinese Premier emphasized that China does need new and high-tech technology.

Both Chinese government and wind power industry do have strong demand on new and advanced technologies. Although China has established wind power manufacturing industry, most of technologies have been introduced through licensed agreement and JV cooperation with international players.

Of the 25 GW already installed onshore capacity actually proves quite a lot of quality and technical problems during operation. International turbine, equipment and service providers still have business opportunities, especially the offshore wind development in the coming years. With proven products already installed in Europe, wind turbine manufacturers such as Vestas and Siemens are preparing entry into offshore wind development in China.

However, foreign technology providers MUST consider China national technology development strategy. In short term, China encourages introducing advanced core technologies. The long term strategy is to develop own patented innovative technologies based on benchmark technologies provided by foreign companies today. This is a CHALLENGE, not only to wind power industry, but also a similar intellectual property issue to nuclear industry, spaceflight industry, aeroplane manufacturing and express train & railway manufacturing industries etc.

Foreign companies have many business opportunities in service segment

Services

Considering short and quick development history, wind power industry in China has found a framework ONLY so far. The strong political incentives, the quick established onshore wind capacity and the incentive towards upcoming offshore wind power development brings service opportunities towards international players with proven technologies, products, onshore and offshore experiences and expertise. For instance,

- Offshore engineering
- Offshore R&D and know-how
- Education & Training
- Offshore wind resource database analysis & management software
- Information management
- Operation management
- Technology & products test and certification
- Industrial technology and products standard

Opportunities and/or recommendations are shown as following diagram[17]

[17] China Greentech Report 2009

Figure 15: Wind industry opportunities in China.

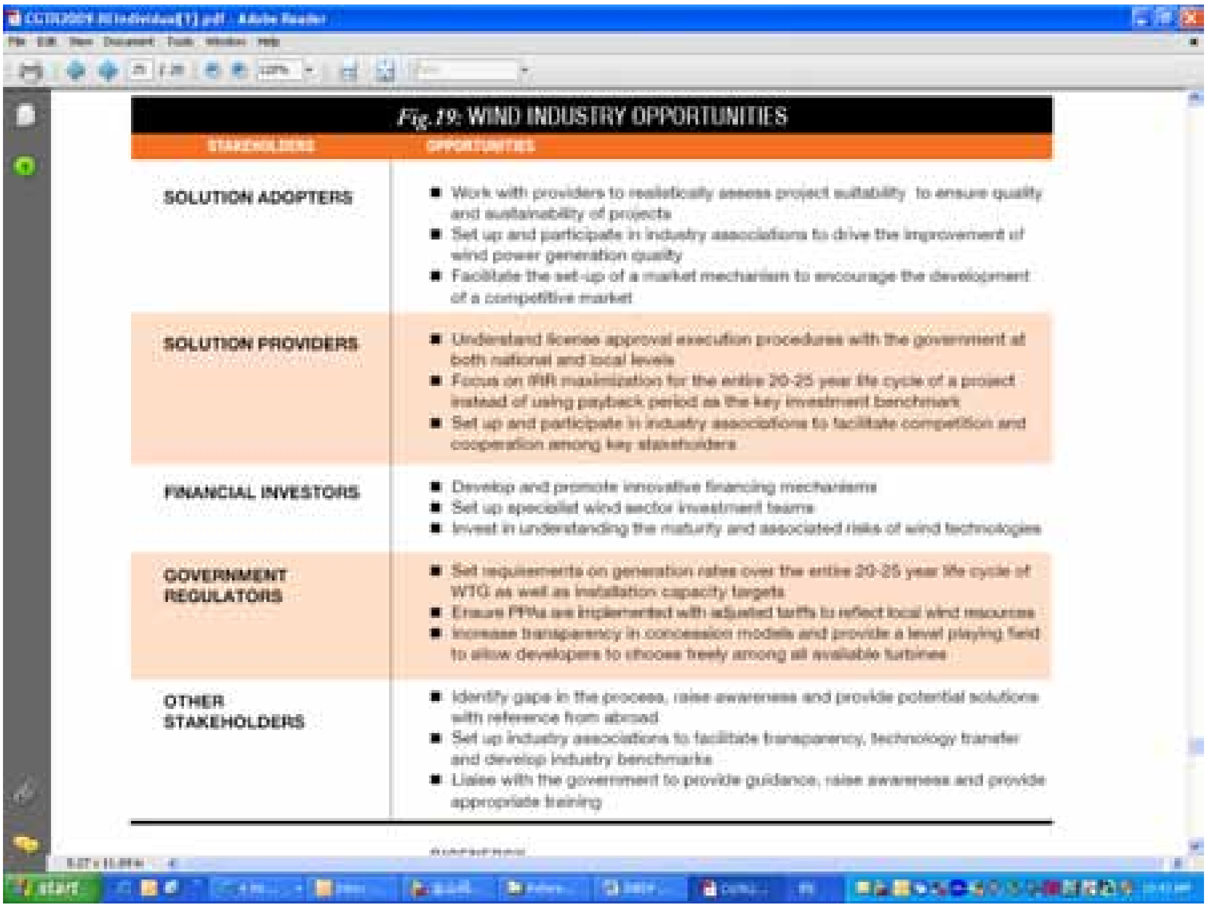


Fig.19: WIND INDUSTRY OPPORTUNITIES

STAKEHOLDERS	OPPORTUNITIES
SOLUTION ADOPTERS	■ Work with providers to realistically assess project suitability to ensure quality and sustainability of projects ■ Set up and participate in industry associations to drive the improvement of wind power generation quality ■ Facilitate the set-up of a market mechanism to encourage the development of a competitive market
SOLUTION PROVIDERS	■ Understand license approval execution procedures with the government at both national and local levels ■ Focus on IRR maximization for the entire 20-25 year life cycle of a project instead of using payback period as the key investment benchmark ■ Set up and participate in industry associations to facilitate competition and cooperation among key stakeholders
FINANCIAL INVESTORS	■ Develop and promote innovative financing mechanisms ■ Set up specialist wind sector investment teams ■ Invest in understanding the maturity and associated risks of wind technologies
GOVERNMENT REGULATORS	■ Set requirements on generation rates over the entire 20-25 year life cycle of WTG as well as installation capacity targets ■ Ensure PPAs are implemented with adjusted tariffs to reflect local wind resources ■ Increase transparency in concession models and provide a level playing field to allow developers to choose freely among all available turbines
OTHER STAKEHOLDERS	■ Identify gaps in the process, raise awareness and provide potential solutions with reference from abroad ■ Set up industry associations to facilitate transparency, technology transfer and develop industry benchmarks ■ Liaise with the government to provide guidance, raise awareness and provide appropriate training

Foreign companies or organizations are possible to access in niche part of monopolized projects based on research cooperation. And such cooperation mostly involved in national and/or provincial governmental organizations. Few national level cooperation examples are as below.

China Wind Power Research and Training Project (CWPP), March 2005 – February 2010 Federal Ministry for Economic Cooperation and Development, Germany is government sponsor. Deutsche Gesellschaft für Technische Zusammenarbeit, which is German Development Cooperation, is an implementation agency.

The China Renewable Energy Scale-Up Program (CRESP) has been developed by Chinese national government in cooperation with the World Bank and the Global Environment Facility to provide assistance with the implementation of a renewable energy policy development and investment program.

The Danish-Chinese Wind Energy Development Programme (WED) is a bilateral development programme with its overall objective to help China improve technological and management capacity in wind power development, and to assist local authorities in their preparation of wind energy development plans. The programme represents an innovative approach to the delivery of bilateral technical assistance. The bearing idea behind this programme is to convey to China the experience from achieving a record high wind energy penetration in Denmark.

Wind Environment Research & Training Center (WERT-Center) Government sponsor is Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, Germany and Deutsche

Gesellschaft für Technische Zusammenarbeit, which is German Development Cooperation is implementing agency.

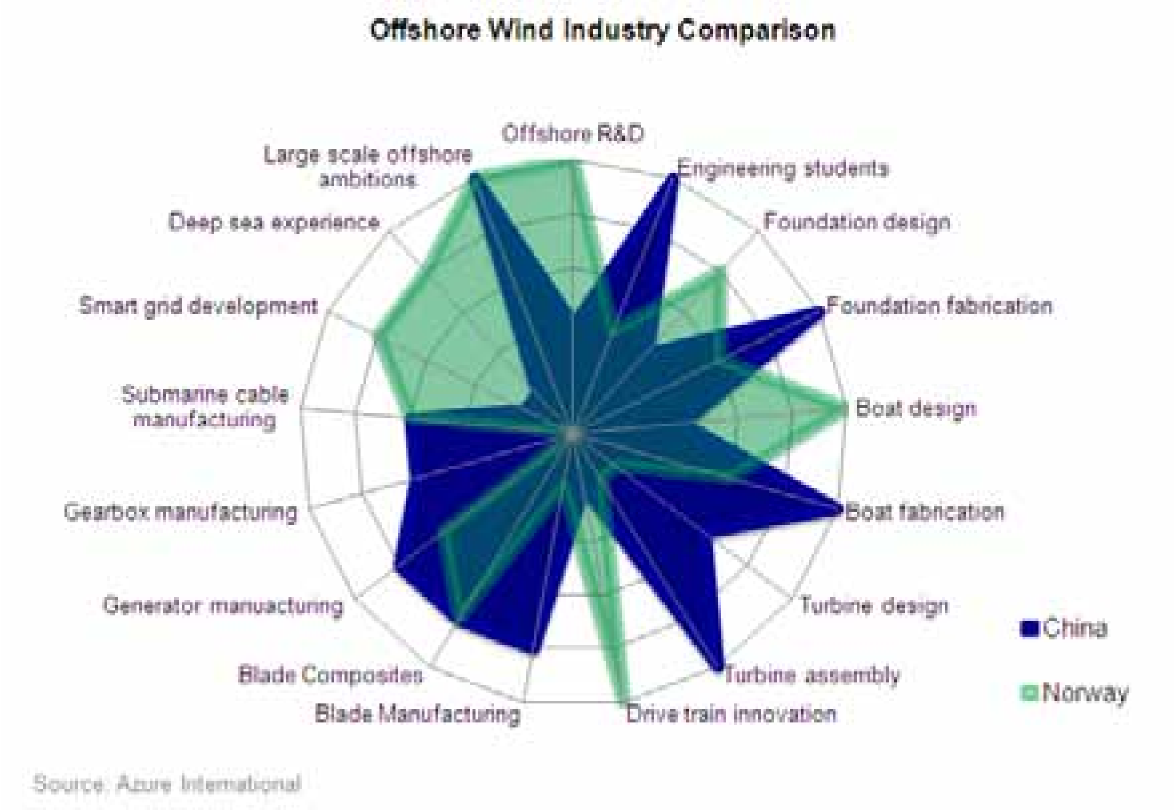
USA has established a research cooperation project with Chinese national energy research institute since early of 1990s. Through this project, USA has access in dialogue directly with Chinese national energy authority.[18]

2.10. Recommendations

This chapter is extracted from the recent report from Azure International[19].

The offshore wind industry in China is moving at a quick pace, and it will not slow down to wait for partners to collaborate. As the industry is just now at a formative stage, there is still time to engage and participate. By the time governmental regulations are in place in the next few years the industry will likely be in full swing.

As an emerging offshore wind market China presents huge possibilities for an offshore cluster looking to realize its potential. The size of the Chinese market means that companies who are able to position themselves to play a significant role in this market are likely to become important global players in the industry.



Norwegian and Chinese industry characteristics are complementary in a number of interesting ways (ref. diagram above).

[18] China Wind Power Center

[19] *Azure International: China, Norway and Offshore Wind Development, WWF 2010*

- Areas of Norwegian strengths where there are Chinese needs include: offshore R&D, foundation design, boat design, drive train innovation, grid development and general ocean installation and service experience (especially deep sea).
- Areas of Chinese strengths where there are potential Norwegian needs are: turbine design and assembly, fabrication (of foundations, boats, blades, generators, gearboxes) and a huge pool of engineering students.

Norway clearly has a niche with potential to secure a significant role for Norwegian companies in the emerging Chinese offshore wind market. An estimated 74 billion Euros will be invested in developing the market over the next decade, of which 30% may be available to foreign players. Of this Norway could capture an estimated 10%, applying standard offshore project breakdown and accounting for the technical strengths of Norwegian companies, Norway has the potential to secure and estimated 930 million Euros over the next decade.

Norway is presently behind countries like Denmark and Germany in developing relationships and cooperation with wind energy stakeholders in China, see number of companies in the figure below. Still, Norway's main strengths are different from these countries whose main ambition is to develop and sell turbines. This still leaves an opportunity for Norway if a concerted effort were made, actively supported by the Norwegian government, and led by Norwegian companies with financial muscle and a willingness to engage long-term. (Note that Scottish offshore companies, which have similar strengths as the Norwegian offshore cluster, are already engaging the emerging Chinese offshore wind market actively.)

Competing wind industry clusters in China's market

The fact that Norway has a limited number of domestic turbine manufacturers (Scanwind now owned by GE and Sway AS piloting the development of a 10 MW turbine supported by Enova) advantageously positions Norway as a strategic partner with China in offshore wind technical development. Some of the big Norwegian companies with international ambitions could invite a Chinese turbine producer to set up a joint company in Norway, focusing on large scale deployment of offshore wind turbines for the European and global market.

Recommendations

To realize the potential for offshore wind engagement in China, the Norwegian Government, offshore wind cluster, and key companies must develop a shared vision about how to strategically approach China and the broader Asian market, using the strengths of the cluster to build on existing relationships.

Norwegian companies should tap into the offshore wind industry in China, which has similar potential to the North Sea.

- Strategically position to engage in the offshore wind industry in China and the deep sea offshore wind industry in broader East Asia, through presence at relevant forums and exhibitions, developing relationships and (pilot) projects.
- Norwegian companies with relevant existing contacts should actively develop these with a focus on strategic offshore wind cooperation. This especially applies to Statoil which has a long relationship with CNOOC (China National Offshore Oil Exploration) which is developing a 3 GW offshore wind pipeline.
- Leverage China's strong onshore wind and offshore supply chain to meet the needs of large scale growth in the North Sea and the broader Asian market.
- Continue to develop relationships with Korea and Japan through deep sea offshore wind training and position to be prepared for these markets when their development accelerates.

3. Japan

3.1. Energy supply and demand

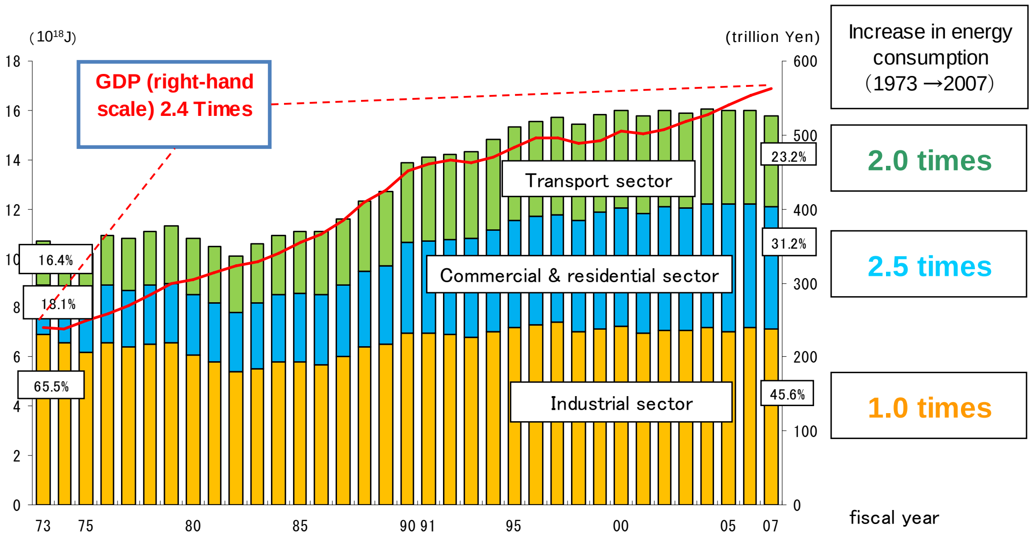
The GDP in Japan has increased by 2.4 times from fiscal year 1973 to 2007 while energy consumption in the industrial sector has remained roughly around the same level after the oil crises. In contrast, in the commercial and residential sector as well as the transport sector, the amount of energy consumption has sharply increased.

Industrial sector accounts for 45.6% of the energy consumption in fiscal year 2007, and manufacturing industry accounts for around 90% of the industrial sector. Energy consumption in manufacturing industry increased very slightly, despite of the fact its economic scale more than doubled after the first oil crisis in 1973. This is because energy efficiency (energy intensity) in manufacturing sector was significantly improved by 1980s.

The commercial (offices, hotels, stores, etc.) & residential (home) sector consumes energy more than double in 2007, compared to the level in 1973. Due to changes in national lifestyle in pursuit of convenience and comfort, energy consumption at home has increased while the increase in the total floor area of offices and retail stores, increase in air-conditioning/lighting equipment/IT equipment boosted energy consumption in the commercial sector.

The transport sector, comprising the passenger service (passenger cars, busses, etc.) and cargo services, consumes twice the energy, compared to the level in 1973. The passenger service represents 61% of the total transport sector, and the cargo service represents 39%, while they were 40% and 60% respectively in 1965.

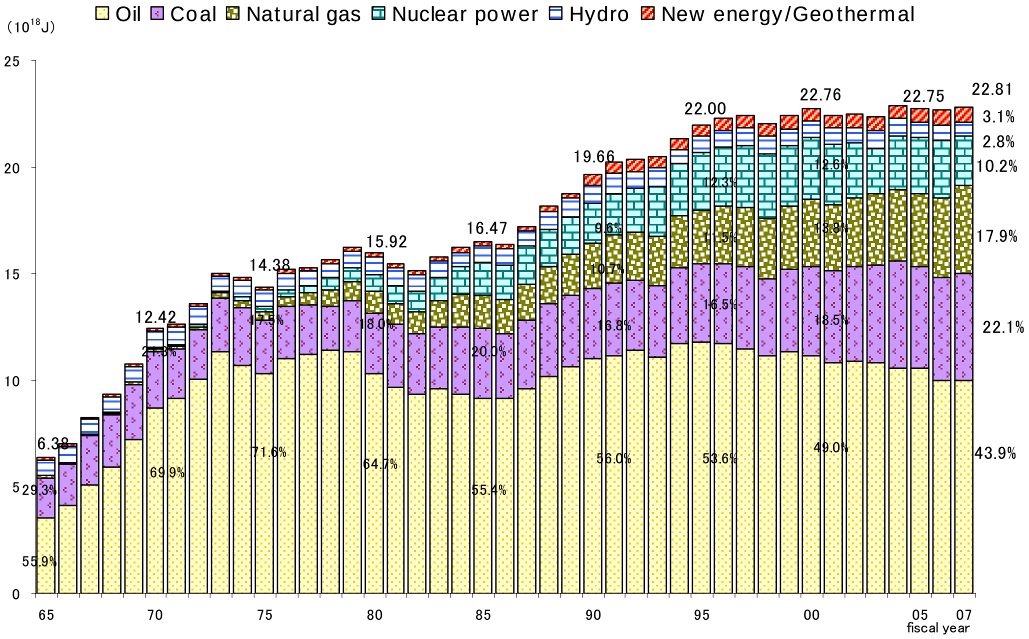
Figure 16: Trends in energy consumption and GDP in Japan[20]



Before the oil crises, oil supplied more than 70% of Japan's energy needs. Then after the oil crises, Japan tried to reduce its dependence on oil through the introduction of natural gas, nuclear power and overseas coal, and its dependence was reduced to 44% in 2007.

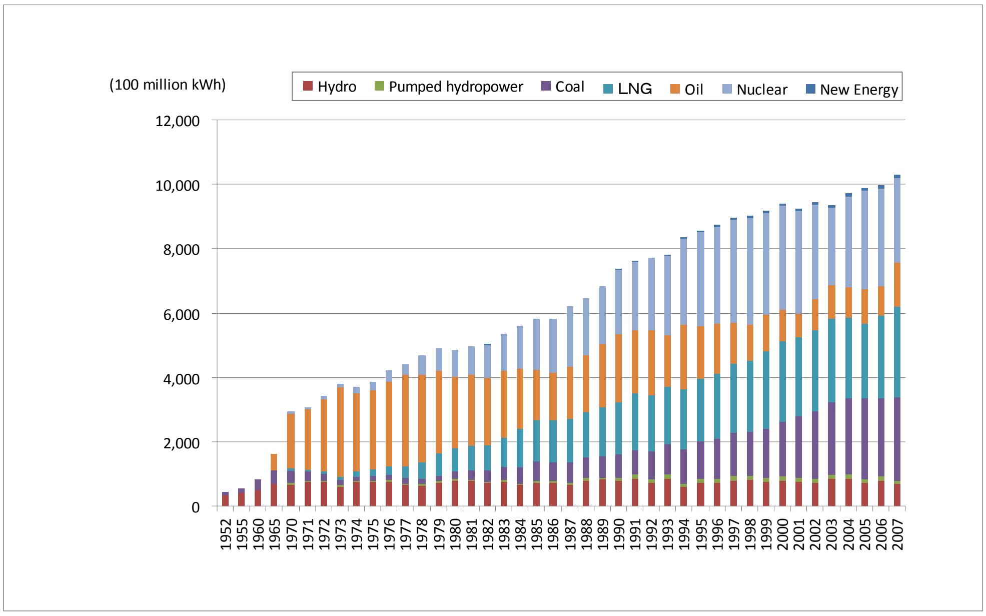
[20] Comprehensive Energy Statistics (Agency for Natural Resources and Energy), Annual National Account Bulletin (Cabinet Office), Handbook of Energy and Economic Statistics (Institute of Energy Economics, Japan)

Figure 17: Trends in Japan's primary energy supply[21]



In the electric power generation sector, the transition from the use of oil to nuclear power, coal and natural gas has made significant progress, and in fiscal year 2007, nuclear power, coal and natural gas represents 25.6%, 25.3% and 27.4% respectively. The capacity of the 10 regional electric power companies were 238 GW in 2007, and the total generated electric power exceeded 1,000 TWh.

Figure 18: Trends in generated amount of electric power[22]



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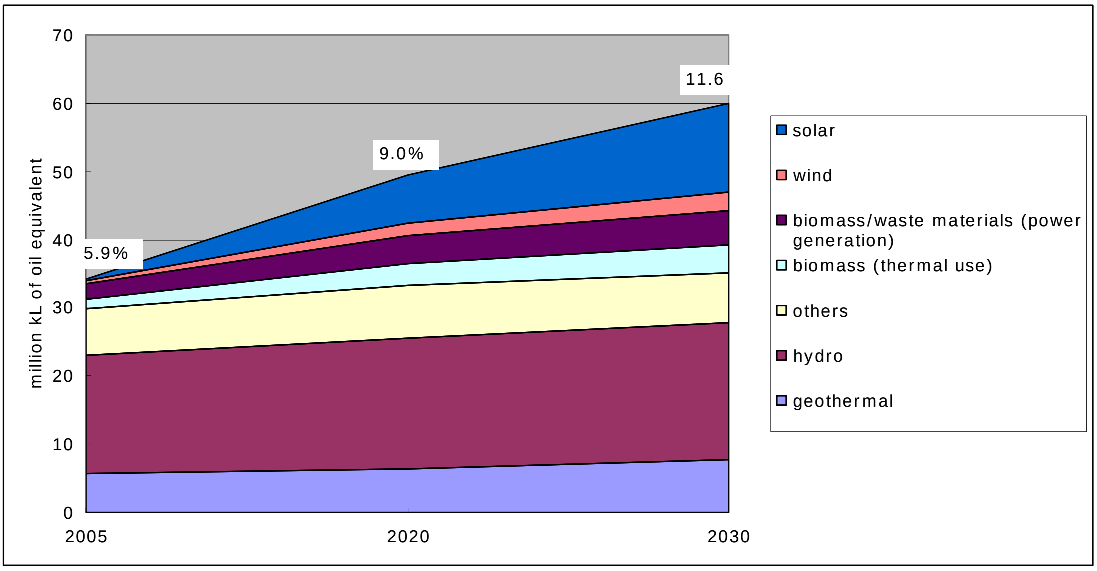
[21] Comprehensive Energy Statistics (Agency for Natural Resources and Energy)

[22] Outline of electric power development (Agency for Natural Resources and Energy)

Renewable energy, including hydropower, represents around 6% of the total primary energy supply in 2005, and the maximum introduction of renewable energy in 2030 will be 11.6%, according to METI's long-term energy demand and supply outlook.

Figure 19: Max. introduction of renewable energy[23]



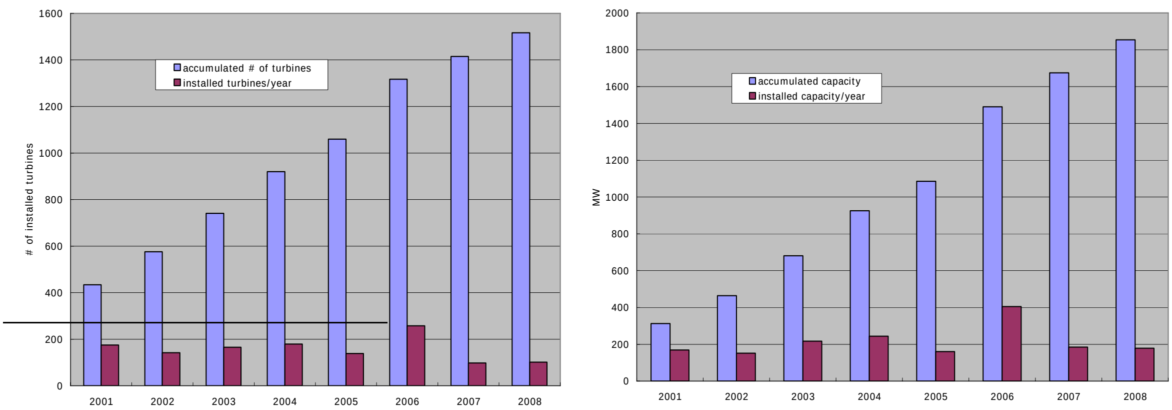
3.2. Wind – status and future potential

Status

The first wind farm (20 MW) in Japan was built in 1999 by Eurus Energy Tomamae, and it comprises of 20 units of 1 MW turbine. Since then, wind farms' capacity has becoming larger, and 3 MW turbines are used now. There are 5 wind farms that exceed 50 MW in Japan, and the largest wind farm have 78 MW capacity, comprising of 26 units of 3 MW turbines, which is operated by Eurus Energy Shin-Izumo.

Most of the wind mills were installed onshore in Japan. There are 1,517 turbines installed as of March 31, 2009, and the total accumulated capacity is 1,854 MW, which is far below the government's target (3,000 MW by March 31, 2011). In fact, wind power contributes only 0.3% of the total electric power demand as of March 31, 2009.

Figure 20: Number of turbines and capacity[24]



[23] Long-term energy demand and supply outlook (METI)

[24] Natural Energy White Paper (WPDA/JWPA)

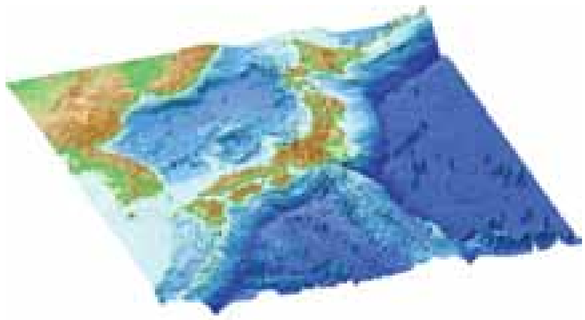
Potential

Wind Power Developer Association (WPDA) and Japan Wind Power Association (JWPA) estimated potential wind resources in Japan in March 2008 as follows.

Table 2: Wind energy potential in Japan.

	Onshore	**Offshore (fixed-bottom wind turbine)**	**Offshore (floating wind turbine)**
Potential	25,000 MW	18,000 MW	38,000 MW
Average wind speed at 60 m height	≥ 6m/sec	≥ 7m/sec	≥ 7m/sec
Turbine size	2 MW	2 MW	2 MW
Water depth	N/A	0 – 30 m	30 – 300 m
Distance from land	N/A	50 km	50 km

Given the limited land space in Japan and the following facts, offshore wind power, especially floating type, can attract more attention in the future.



- Japan ranks the 6th in the world in the size of EEZ (exclusive economic zone).
- Japan is surrounded by deep and steep slope of sea bottom, which is ideal for floating wind turbines.
- Competence in shipbuilding and maritime structure

3.3. Wave – status now and future potential

The coast lines in Japan stretch as long as 34,386 km, and the total wave energy potential approaching these cost lines amount to 36 GW. Therefore, Japan is one of the richest countries in wave energy resource.

Wave energy in Japan[25]

[25] PARI report, #654

INNOVATION NORWAY

Japanese government sponsored large scale wave energy projects such as Kaimei (ship type floating wave energy conversion plant: 1978 – 1986) and Mighty Whale (floating type wave energy conversion plant: 1989 – 2003); however, the government lost interest in wave energy now. Consequently no large scale wave energy projects are implemented.

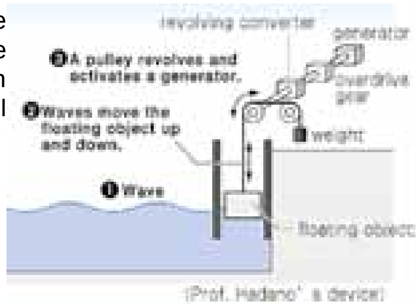
The following are examples of wave energy projects implemented now in Japan.

Ocean Power Technologies signed agreement with a consortium of three Japanese companies (**Idemitsu Kosan, Mitsui Engineering & Shipbuilding, Japan Wind Development**) on Oct 8, 2009 to develop a demonstration wave power station in Japan. The 3 Japanese companies plan to build a wave power station (20 MW) on the Pacific coast by 2012.

Prof. Hiroshi Kanki of Kobe University started research of a floating wave-power generating system using gyro moment about 10 years ago. His idea is now being tested by **Gyrodynamics Co., Ltd,** and the company is planning to launch it in the market this year. It was confirmed that the system has higher efficiency than conventional OWC wave power generation systems and sufficient reliability for actual application.

Figure 21: No.3 prototype system of wave power generation system using gyro moment (45 kW)[26]

Prof. Kesayoshi Hadano, the Graduate School of Science and Engineering at Yamaguchi University, has invented a new device, a cylindrical object made of iron that is suspended by wire and floats on the water. The object is moved vertically by the waves, activating the wire which moves a roller. The roller revolves in only one direction so it can generate power more efficiently than conventional methods.



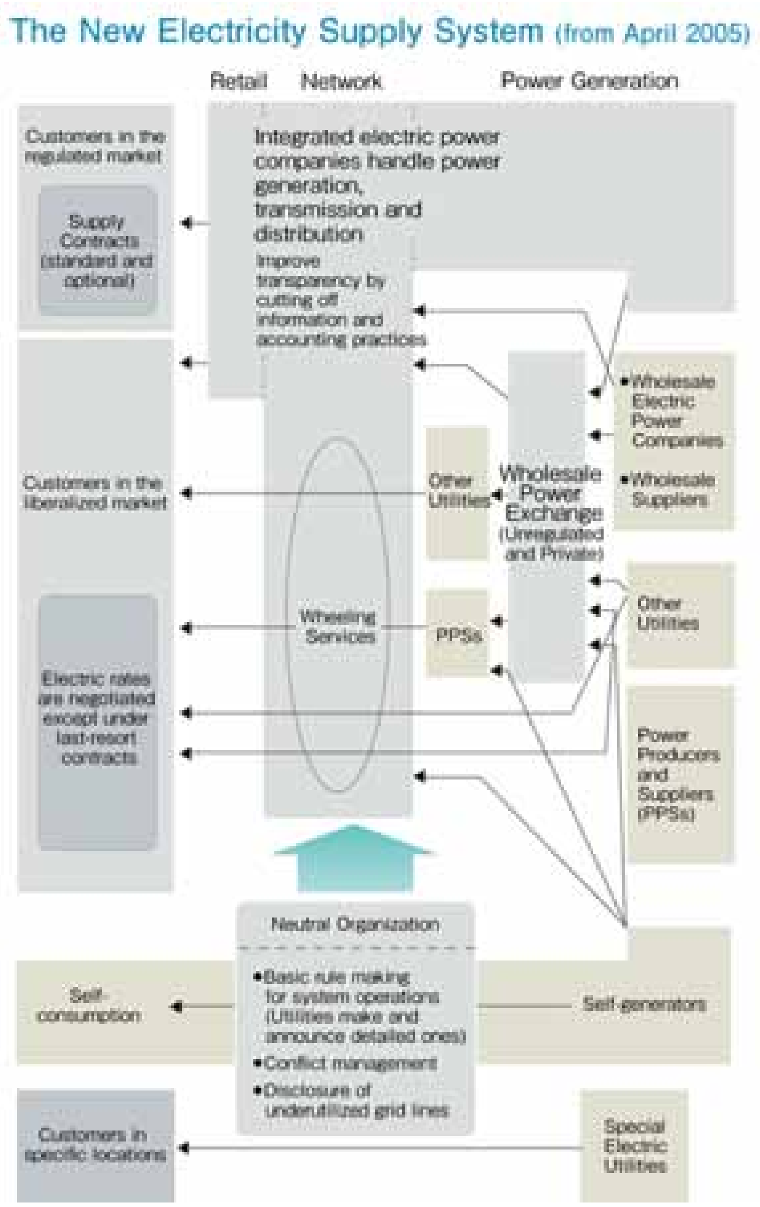
He plans to test the method at the mouth of Kiso river, Japan[27].

[26] http://www.youtube.com/user/Diginfonews#p/search/3/P4J1phu60lw

[27] Source: Chugoku Shimbun

3.4. Energy price and tariffs

Electric market[28]

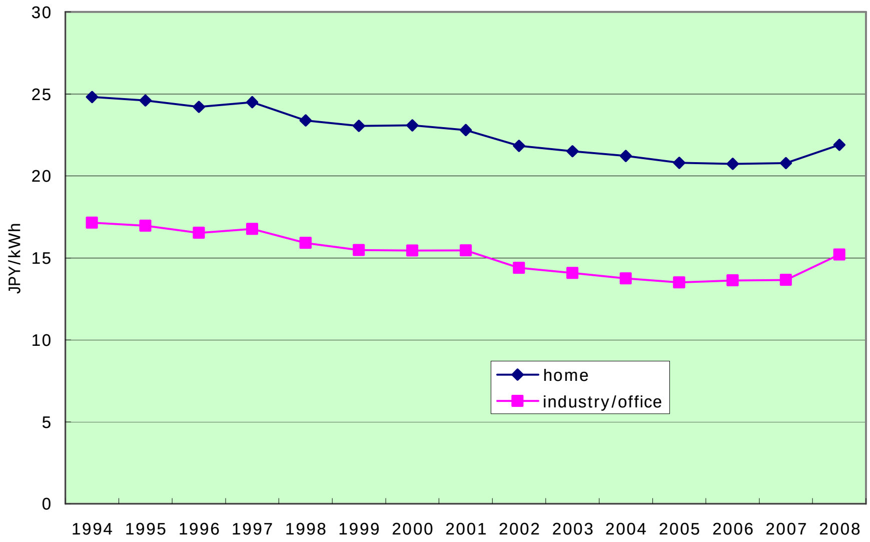


The 10 regional electric power companies used to undertake power generation, transmission and distribution. In 1995, the Electricity Enterprises Law was amended, and since then the electricity market has been gradually liberalized. Today, the scope of liberalization is expanded to all high-voltage users whose demand exceeds 50 kW, covering more than 60% of the total demand of electric power. However, the grid and the 10 regional electric power companies are not separated yet, and the trading volume of the electricity market represents mere 0.4% of the total sales of electric power.

Electric power rate decreased by 1.5% annually from FY 1994 to FY 2007 since the amendment of the Electricity Enterprises Law. Electric power rate in FY 2008 was up due to a rapid hike in fuel price.

[28] The Federation of Electric Power Companies of Japan

Figure 22: Transition of Electric Power Rate[29]



Support for electricity produced from wind turbines

Although there are government supports for the investment in wind power business, there are virtually no support for electricity produced from wind power (the operation of wind power business). Japanese RPS system imposes an obligation of electricity retailers such as electric power companies and PPSs to use "a certain amount" of electricity from new energy (solar, wind, biomass, medium/small hydro power, geothermal), but "a certain amount" is only 1.35% of the total supplied electricity in case of FY 2010. In addition, when electricity retailers use more than the mandatory amount of electricity from new energy, they can carry forward the excess amount to the following year. This "banking" system gives price pressure to the electricity from wind in the market.

The price of wind power electricity to electricity retailers is as follows (pr. kWh)[30]

Fiscal year	2003	2004	2005	2006	2007	2008
Wind	11.8 Yen 0.73NOK	11.6 Yen 0.72NOK	11.0 Yen 0.68NOK	10.7 Yen 0.66NOK	10.4 Yen 0.64NOK	10.4 Yen 0.64NOK

3.5. Relevant locations for offshore wind energy

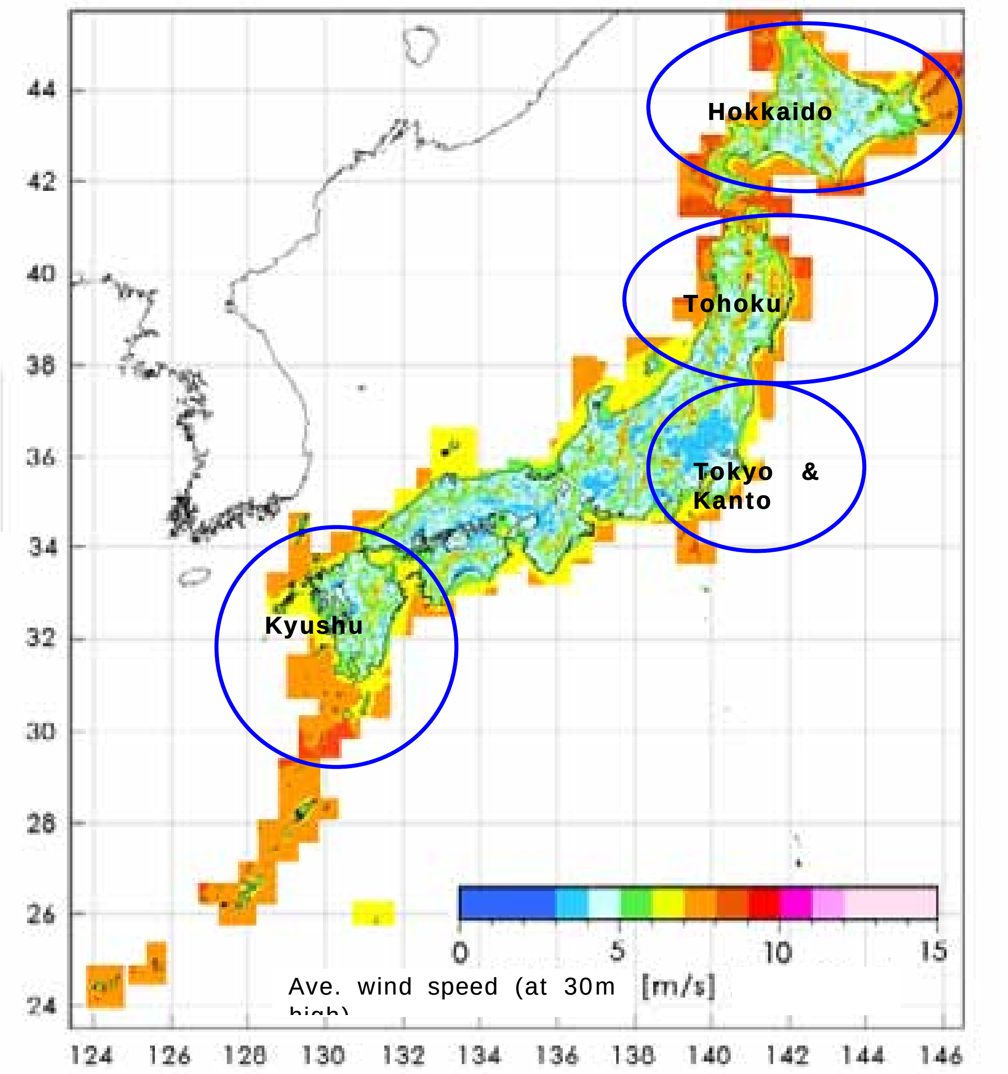
According to an estimation of Prof. Takeshi Ishihara of Univ. of Tokyo, 30% of the total electric power supplied by Tokyo Electric Power (TEPCO) can be generated by offshore wind farms along Kanto coast line. Although Hokkaido, Tohoku and Kyushu are the areas where wind conditions are good, these areas are far away from the market (Tokyo and neighbouring Kanto area). Off the coast of Kanto area, the wind conditions are stable and strong enough.

Univ, of Tokyo and TEPCO is now collecting wind data off the coast of Shoshi, Chiba to exploit more offshore wind power in the future.

[29] METI

[30] Agency of Natural Resources and Engergy

Figure 23: Wind map of Japan[31]



3.6. Political climate for renewable energy from ocean and wind

Political climate for renewable energy has changed dramatically since the Democratic Party took power in 2009. Prime Minister Yukio Hatoyama has set a goal for Japan to cut CO2 emissions by 25% by 2020 from 1990 levels. The Cabinet endorsed a climate change and environment draft bill on March 12, 2010, and it lays out the basic structure to shift to a more green economy. There are 3 major objectives in this draft bill as follows.

- Establishing a domestic cap-and-trade policy
- Introducing an environment tax
- Expanding the FIT program to include all renewable energy.

Both industry and labor unions are against the cap-and-trade policy, so the bill sets the emission caps using absolute quantity but also consider intensity targets as well.

[31] NEDO

Japan has already started a FIT based on the surplus electricity generated by PV. However, this bill will introduce a FIT based on total electricity generated by renewable energy, including wind power. Japanese Ministry of Economy, Trade and Industry (METI) is now drafting a FIT system so that the operation of electric power from renewable energy can be supported financially. METI is planning to enforce a FIT as early as in 2011.

3.7. Incentives for developing and utilizing new technology

NEDO is a prime organization that supports development and utilization of new technology in ocean energy. They have been funding R&D projects in this field since 2007 (until March 2012). This fiscal year, they will fund 2482 million JPY for the following projects.

R&D on next generation wind power generation

- AIST,
- Itochu Techno-Solutions
- JEMA

R&D on ocean thermal energy conversion

- Institute of Ocean Energy
- Saga Univ.

R&D on power generation by use of generation elements absorbing kinetic energy such as tidal power and wave power.

- Hiroshima Univ
- Ehime Univ

R&D on conversion of energy generated from wave devouring propulsion system

- Tokai Univ

Establishment of the offshore wind conditions observation system

- Univ. of Tokyo
- TEPCO,
- J-Power,
- Port and Airport Research Institute,
- Itochu Techno-Solutions

Research on utilization of current energy by current power generation system

- Univ. of Tokyo

Experimental study of offshore wind power system

3.8. Key players

Although the market in Japan is still small, some of Japanese companies show its presence in the international market. Mitsubishi Heavy Industries, the largest wind turbine manufacturers in Japan, has singed a MOU with the UK Dept for Business, Innovation and Skills in Feb 2010 to receive 30 million pounds in subsidies for the development of a large offshore windmill. Eurus Energy, the largest Japan and world leading wind power generation company, is engaged in wind power generation business in Europe, US and Asia. R&D in maritime including deep sea water has a long tradition in Japan. Some of them have proposed offshore wind farm concept.

Large scale wind turbine manufacturers

- Mitsubishi Heavy Industries, Ltd.: http://www.mhi.co.jp/en/index.html
- Japan Steel Works, Ltd.: http://www.jsw.co.jp/en/index.html
- Fuji Heavy Industries Ltd: http://www.fhi.co.jp/english/

- Komai Tekko Inc.: http://www.komai.co.jp/index.html (Japanese only)

Small scale wind turbine manufacturers

- Zephyr Corp.: http://www.zephyreco.co.jp/en/
- Nakanishi Metal Works Co., Ltd.: http://www.nasudenki.co.jp/
- MECARO Co., Ltd.: http://www.mecaro.jp/eng/index.html

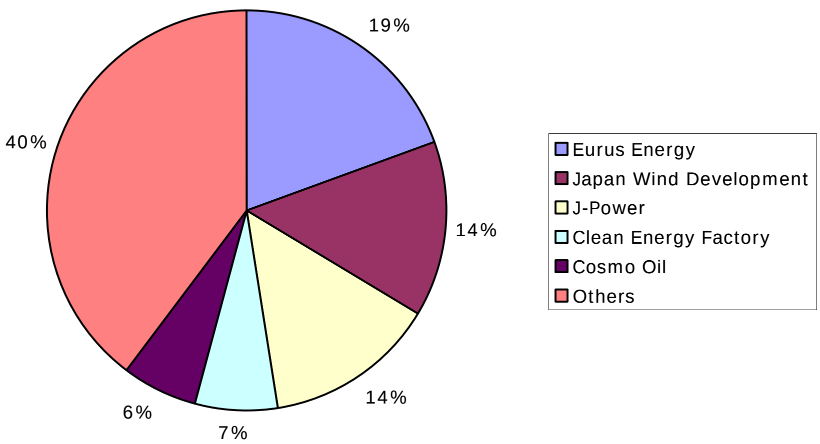
Blades manufacturers

- Japan Steel Works, Ltd.: http://www.jsw.co.jp/en/index.html

Generator manufacturers

- Hitachi Ltd.: http://hitachi.com/
- Toshiba Corp.: http://www.toshiba.co.jp/index.htm
- Meidensha Corp.: http://www.meidensha.co.jp/epages/top/index.html
- Sinfonia Technology Co., Ltd.: http://www.sinfo-t.jp/eng/index_a.htm

Figure 24: Market share of wind-generated power (FY 2008)[32]



Wind power developers

- Eurus Energy: http://www.eurus-energy.com/english/index.html
- Japan Wind Development Co., Ltd.: http://www.jwd.co.jp/english/
- J-Power EPDC: http://www.jpower.co.jp/english/index.html
- Clean Energy Factory Co., Ltd.: http://www.cef.co.jp/e/index.html
- Cosmo Oil Co., Ltd.: http://www.cosmo-oil.co.jp/eng/index.html

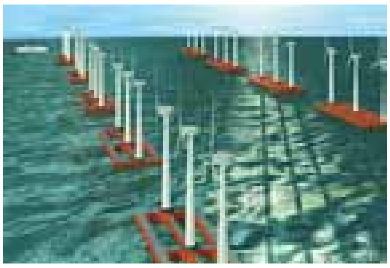
R&D

- Univ. of Tokyo: http://www.u-tokyo.ac.jp/index_e.html
- National Institute for Environmental Studies: http://www.nies.go.jp/index.html
- National Maritime Research Institute: http://www.nmri.go.jp/index_e.html

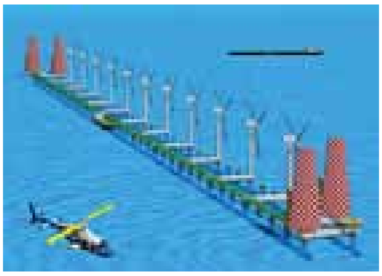
[32] Nikkei

- Institute of Ocean Energy: http://www.ioes.saga-u.ac.jp/english/index_e.html
- JAMSTEC: http://www.jamstec.go.jp/e/index.html

Figure 25: Concept models



National Maritime Research Institute



National Institute for Environmental Studies

Univ. of Tokyo/TEPCO

3.9. Market entry

There are following opportunities and risks when entering Japanese offshore wind and ocean energy market. Given the facts that offshore wind/ocean energy market is still in early stage and that R&D work is required to make deep water offshore wind mills commercially viable, it will be recommended to form a partnership with Japanese companies like Ocean Power Technologies (USA) did or tie with Japanese researchers. Another option is to form a partnership with Japanese companies such as Mitsubishi Heavy Industries in the international market at first, which could lead Norwegian companies easily to the Japanese market when the market is willing, able and ready for offshore wind and ocean energy

Opportunities

- -25% CO_2 emission from 1990 level
- FIT for renewable energy is proposed
- Cap-and-trade system is proposed
- Abundant deep water offshore resources
- Strength in maritime R&D
- Offshore wind mill has just started attracting attention

Risks

- Strong lobby against the introduction of FIT/Cap-and-trade from the industry/labor union
- Grid connection capacity between electric power companies is much smaller, compared to the generating capacity of these companies
- Current RPS gives price pressure to electric power rate from renewable energy
- Extreme climate conditions such as typhoon and lightening

4. South Korea

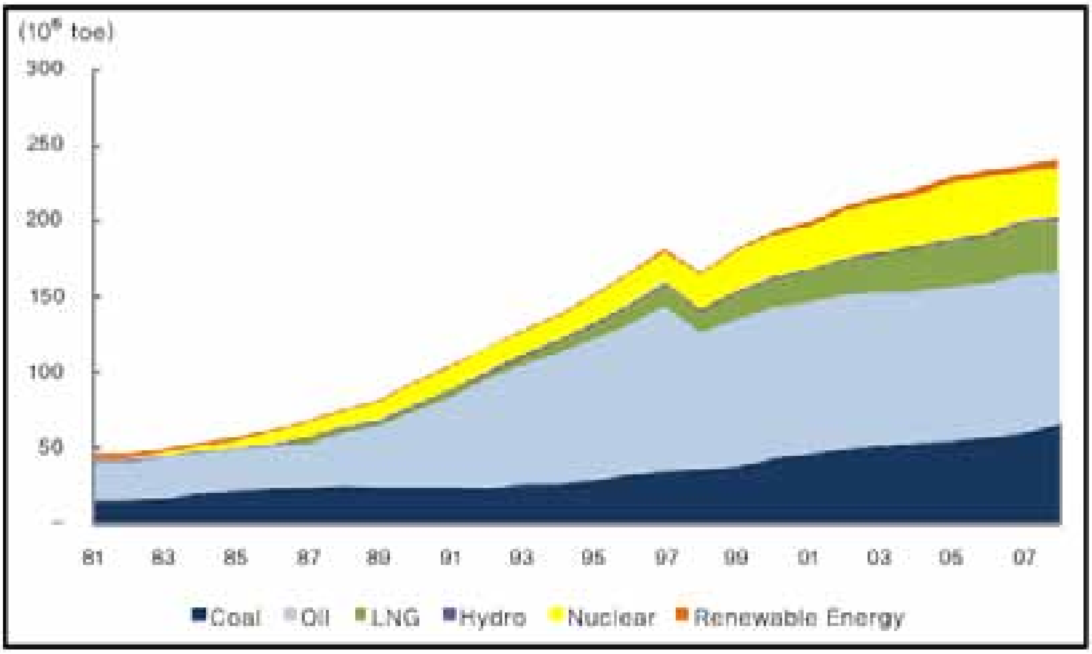
4.1. Energy supply and demand

Because of rapid economic growth propelled by the heavy and chemical industries, Korea's energy consumption has increased sharply since the mid-1970s. Total primary energy consumption, which stood at 43.9 million tons of oil equivalent (TOE) or 510 TWh[33] in 1980, increased more than five-fold to 240.7 million TOE (2,790 TWh) in 2008, to rank Korea as the tenth-largest energy-consuming country in the world. Energy consumption per capita also increased rapidly from 13,000 kWh in 1980 to 57,600 kWh in 2008.

With poor indigenous energy resources, Korea has to rely almost entirely on imports to meet its domestic energy needs. In 2008, the dependency rate on imported energy, including nuclear energy, was 96.4 percent, and its cost amounted to US$ 94.9 billion, which accounted for 26.6 percent of total inbound shipments. Korean energy resources are limited to low-quality anthracite, which accounted for less than 1 percent of total primary energy supply.

Demand for oil has been growing since 1970s, except immediately after the two oil crisis of 1973 and 1979. Coal supply has increased at an annual average rate of 5.1 percent for the seven years in the new millennium, but the main use of domestic anthracite has shifted dramatically from residential heating to power generation. Gas was introduced in 1986 in the form of LNG imports and accounted for 13 percent of the final energy consumption.

Figure 26: Energy Consumption[34]



Korea puts its best efforts on the utilization of new and renewable energy (NRE) to commodities using clean technology. As of the end of 2007 NRE supplied 65 TWh, or 2.37 percent of total primary energy consumption of 2,790 TWh. Of the total supply of NRE, waste energy contributed the largest proportion at 77.0 percent, followed by hydro power with 13.9 percent,

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[33] TOE is the most common energy unit used in Korea. However, for consistency and convenience for Norwegian readers, we'll use watt-hour and derived units. The conversion factor is: 1 TOE = 11.630 MWh

[34] Yearbook of Energy Statistics 2009 by Korea Energy Economic Institute (KEEI)

and other types of energy with a 9.1 percent share. However it is currently solar and wind based energy that is experiencing the largest relative growth.

In 2007 wind energy supplied 953 GWh, up 35 percent from 2006. It also increased relative to other NRE sources to 1.43 percent of the total NRE supply in 2007, up from 1.15 percent in 2006.

Table 3: Status of deployment by sources (unit: GWh)[35]

	Source	Solar thermal	PV	Bio	Wind	Hydro	Fuel cell	Waste energy	Geo-thermal	Total
2006	Supply	384	93	3,186	698	10,083	23	46,229	100	60,766
	Share (%)	0.63	0.15	5.25	1.15	16.59	0.04	76.08	0.11	100
2007	Supply	337	174	4,303	953	9,083	23	50,229	127	65,232
	Share (%)	0.52	0.27	6.59	1.43	13.92	0.03	77	0.19	100
Fluctuation	Supply	-46	81	1,116	244	-1,000	0	4,000	58	4,465
	Increase Rate (%)	-13.7	87.5	35	35	-10.08	0	8.6	1.2	7.9

In December 2008, the 3rd Basic Plan for NRE Technology Development and Deployment was established to set the medium-long term target for NRE development and deployment and to provide action plans and basic strategies to achieve it. The 3rd Basic Plan focuses on harnessing the NRE industries as a new growth engine for the Korean economy through fostering their economy.

Table 4: NRE deployment prospects[36]

	2008	2010	2015	2020	2030
Primary Energy (TWh)	2,872	2,942	3,140	3,338	3,489
NRE (TWh)	74	88	136	203	384
Share of NRE	2.58%	2.98%	4.33%	6.08%	11.0%

According to the Plan, the NRE share of primary energy supply will account 4.3 percent in 2015, 6.1 percent in 2020 and 11.0 percent in 2030. With the increase rate of marine energy, geothermal, solar thermal and wind energy is projected to be high, waste and hydro energy is turn downward.

4.2. Wind – status and future potential

Wind power generation has increased rapidly since the introduction of a Feed-in-Tariff (FiT) system. However, wind projects see more frequent delays and suspensions compared to other parts of the world. A major reason for this is popular protests.

[35] KEMCO (Korea Energy Management Corporation)

[36] KEMCO

One study has estimated the resource potential for Korea at 12.5 GW,[37] of which onshore capacity is 4.6 GW and offshore capacity 7.9 GW. However KEMCO believes the practical reserves are 27 GW, of which 10 GW are onshore and 17 GW offshore.

At the end of 2008 total installed capacity of wind power system reached 232.4 MW, up from 196.1 MW in 2007 for commercial power generation. Wind energy facilities are installed all around on the mainland and the island Jeju (aka. Cheju) but the main installation capacity, however, is concentrated in the Gangwon and Gyeongsan Provinces to the northeast and southeast, as well as on the island Jeju south of the mainland. In other words there are few and only minor wind farms in the Jella Provinces in the south-western part of Korea at this moment.

Table 5: Current wind farms in Korea[38]

Name	location	Capacity (kW)	Wind turbine
Haengwon	Jeju Island	1,200 (600x2)	VESTAS
		1,545 (660x2, 225x1)	VESTAS
		1,500 (750x2)	NEG-MICON
		1,320 (660x2)	VESTAS
		2,250 (750x3)	NEG-MICON
		1,980 (660x3)	VESTAS
		9,795 (15 units)	
Ulleungdo	Ulleung Island	600 (600x1)	VESTAS
Phohang	Gyeongsang	660 (660x1)	VESTAS
Jeonbook	Kunsan, Jeolla	1,500 (750x2)	NEG-MICON
		1,500 (750x2)	NEG-MICON
		1,500 (750x2)	NEG-MICON
		3,400 (850x4)	VESTAS
		7,900 (10 units)	
Hankyung	Jeju Island	6,000 (1,500x4)	NEG-MICON
		15,000 (3,000x5)	VESTAS
		21,000 (9 units)	
Daegwanryung	Pyeongchang , Gangwon	2,640 (660x4)	VESTAS
Maebongsan	Taebaek, Gangwon	1,700 (850x2)	VESTAS
		2,550 (850x3)	VESTAS
		2,550 (850x3)	GAMESA
		6,800 (8 units)	
Yongduk	Gyeongsang	11,550 (1,650x7)	

[37] The study by Hyun-Goo Kim at the Wind Energy Research Center, Korea Institute of Energy Research "Onshore/Offshore Wind Resource Potential of South Korea" applies the definitions of the World Energy Council of theoretical, geographical, technical and implementation potential; each category representing a narrower potential than the former. URL: http://www.ewec2009proceedings.info/allfiles2/30_EWEC2009presentation.pdf

[38] Source: Energy Journal as of December 2009

		8,250 (1,650x5) 19,800 (1,650x12)	NEG-MICON
		39,600 (24 units)	
Gangwon	Pyeongchang, Gangwon	28,000 (2,000x14) 20,000 (2,000x10) 50,000 (2,000x25)	VESTAS
		98,000 (49 units)	
Shinchang	Jeju Island	1,700 (850x2)	VESTAS
Yangyang	Yangyang, Gangwon	3,000 (1,500x2)	ACCIONA
Gori	Busan	750 (750x1)	UNISON
Taegisan	Gangwon	40,000 (2,000x20)	VESTAS
TOTAL		232,445 kW (146 UNITS)	

So far most of wind turbine generators have been imported from overseas suppliers such as Vestas, NEG-Micon, and Acciona. However several Korean wind turbine systems have been recently developed up to 3 MW system and they are under evaluating through filed demonstration at local sites. It is evident that Korea will be independent for wind turbine technology soon. Please refer to its major achievement on the development of wind turbine system.

Table 6: History of developing wind turbine technology[39]

750 kW	Commercialization of gearless and gearless wind turbine generator	Unison, Hyosung
1~2 MW	Field test of 2 MW gear type wind turbine generator	Unison, Hyosung
	Developing 2 MW gearless wind turbine generator	Hyundai Rotem
	Commercialization of 1.5 MW gear type wind turbine generator	Hanjin Industrial
	Exporting 1.65 MW/2.5 MW wind turbine generator	Hyundai Heavy Industries
	Exporting 2.5 MW wind turbine generator	Samsung Heavy Industries
	M&A of Harakosan Europe	STX Wind Power
	M&A DeWind	DSME
3 MW	Developing offshore wind turbine generator (2006~2009) and field demonstration in 2010	Doosan Heavy Industries
5 MW	Start development (2008~2012)	Hyosung

[39] Source: Energy Journal as of December 2009

In order to facilitate newly developed Korean technology on wind turbine system, the Presidential Committee on Green Growth, the highest level for the low carbon green growth agenda, plans a 40 MW wind farm project in the Saemangeum tidal flat by 2014. Its intention is to test the commercial viability of wind turbines based on new technologies by local companies.[40]

Regarding offshore wind farm development in Korea, several agreement, MoU and projects are under discussion. According to the industry, North Jeolla Province with POSCO E&C is under feasibility study for developing 100 MW offshore wind farm (5 MW x 20 units), located 20km^2 away from Gochang in the South Jeolla Province. Estimated budget is reported roughly 500 billion Korean won and the contruction wil be carried during 2011 to 2115.

Taean Offshore Wind Co. made an agreement with a local government to build 97 MW offshore wind farm (3.6 MW x 27 units) by 2012 in front of Taean-Gun[41] in the West of Korean peninsular. Estimated budget is reported roughly 400 billion Korean won (2 billion NOK).

Incheon City entered into an agreement with Hanhwa E&C to build 99 MW offshore wind farm (3 MW x 33 units) by 2012, located 5km away from Muwee Island in the West of Korean peninsular. Estimated budget is reported roughly 500 billion Korean won (2.5 billion NOK).

And POSCO E&C also got an investment agreement with 5 cities in South Jeolla Province to build large and long term offshore wind farms which plan to have installation capacity of total 600 MW by 2015. Total 2.5 trillion Korean won (12.5 billion NOK) will be invested for the project and the wind farms will be located at the South West Sea which belongs to South Jella Province.

In front of Jeju island, Korea Hydro and Nuclear Power (KHNP) announced to develop 30 MW offshore wind farm located 300~1000m away from Jeju island in cooperation with Doosan Heavy Industries and NCE.

4.3. Ocean– status now and future potential

It was reported that Korea had total 14 GW of ocean energy resource potential - Wave power has its potential of 6.5 GW, tidal power has 6.5 GW and tidal current has 1 GW. [42] The difference between a tidal power and a tidal current power is that the latter has no dams and can be operated 24 hours a day and also one of the advantages of having tidal current power plants is they have less of an impact on marine ecosystems.

Since 2000, KORDI (Korea Ocean Research Development Institute) has been focusing on developing technology for practical application on tidal energy (barrage), tidal current energy (1 MW pilot plant) and wave energy (500 kW pilot plant).

As for wave-force generation, Korea is under construction for the first 500 kW pilot wave generation plant located at 500m away from Jeju Island. The project is managed by KORDI with a budget of 10.5 billion Korean won (52.4 million NOK). The plant will be installed by 2011 at sea and all necessary test and evaluation will be executed by 2012.

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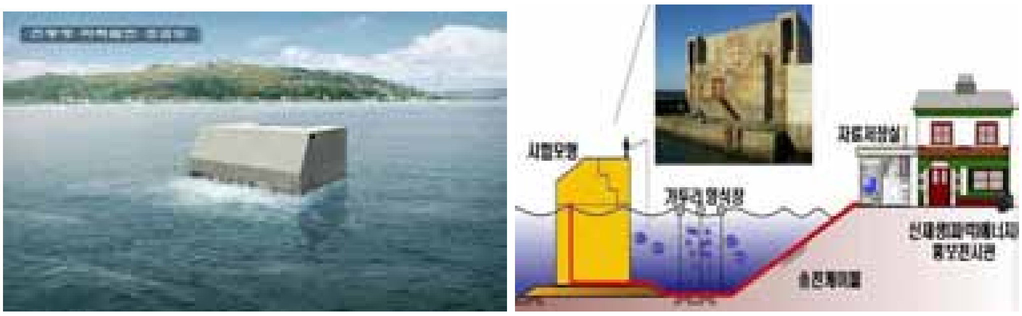
[40] Lee Ho-jeong (2009). New wind farms, subsidies planned. JoongAng Daily, 25 August 2009. URL: http://joongangdaily.joins.com/article/view.asp?aid=2909200

[41] Taean-Gun stands for Taean County in Korea

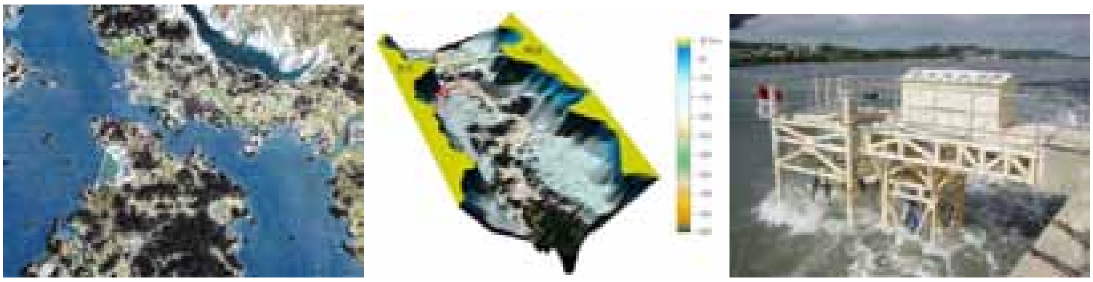
[42] According to the information on *Ocean Energy RD&D Strategy* published by KEMCO on November 2007.

Figure 27: Wave-force pilot plant (500 kW)[43]



Recently 1 MW demonstration tidal current power plant opened at Uldolmok, Jindo Island, South Jeolla Province in May 2009 using maximum 11 knots of sea current. The tidal current power plant at Uldolmok is based on locally developed triple helical turbine technologies and construction lasted from April 2005 to May 2009 at a cost of US$9.9 mil.[44] Hyundai C&E was the main constructor, Hyundai Heavy Industries developed the generators, and mechanical equipment was manufactured by Iljin Electric.

Figure 28: Uldolmok Tidal Current Power Plant (1 MW, experimental)[45]



Jindo is a meeting point of two-way tides coming from the South Sea and the West Sea. Korea East-West Power (EWP) has further plan to build commercial tidal power plant (90 MW) in two other locations in 2013, which would allow the company to produce an additional 400 MW per day.

[43] Image source: Jeju Province

[44] Moon Gwang-lip (2009). Korea opens its first tidal power-generating plant. JoongAng Daily, 15 May 2009. URL: http://joongangdaily.joins.com/article/view.asp?aid=2904861

[45] Source & image: Tidal and Tidal Current Power Study in Korea issued by Coastal Engineering Research Department of KORDI (May 2006)

Figure 29: Uldolmok Tidal Current Power Plant (Commercial)

There have also been talks about another tidal current project on Changjuk and Maenggol areas near by Jindo Island in the Southern Jeolla Province. The provincial government together with German Voith Hydro, KHNP, POSCO E&C and Renetec had plans for a joint venture to evaluate the feasibility of a 600 MW plant.

In February 2010, Renetec had opening ceremony to build 400 MW tidal current park on the Changjuk and Maenggol. A pilot station (110 kW) would be installed on the site in March this year and it will go through demonstration and finally 400MW commercial station will be constructed until 2018. A generator which was developed by German Voith Hydro is gearless type of horizontal axis rotor and subsea structure has been localized by Renetec. Construction and installation will be done by POSCO E&C for the project.

Every country has different environmental, geographical benefits. The western coastal area of the Korean Peninsula, where the difference between the ebb and flow of tides is great, and it is a favourable location to develop tidal power plants[46].

At present there are comparatively huge plans for tidal power in Korea and the first commercial operation of a tidal power plant may start already in 2010. It seems that many of the key components for construction of tidal power plants in Korea are currently being provided by non-Korean subcontractors.

During 2007 to 2009, no less than four plans for the world's largest tidal power plant were announced in Korea; first the Lake Sihwa project was announced at 254 MW,[47] shortly afterwards the 520 MW Garolim Bay project, the 812 MW plans for Ganghwa Island[48] and the 1,320 MW Incheon Bay project. The developers for the four tidal power plants are K-Water for Siwha, Korea Western Power (WP) for Garolim, Korea Midland Power (KOMIPO) for Ganghwa and Korea Hydro & Nuclear Power (KHNP) for Incheon Bay.

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[46] Said by park Jin-Soo, Senior Researcher of the Coastal Engineering and Ocean Energy Research Department of KORDI

[47] While the smallest of the four projects, Sihwa is perhaps the most significant in being not only the first, but also being the site for plans for wind power generators with a capacity of 1,500 kW in total.

[48] In former documents the Ganghwa project is also seen referred to as Seongmo (Seokmo) Island, Seongmo being one of the many islands in the Ganghwa district.

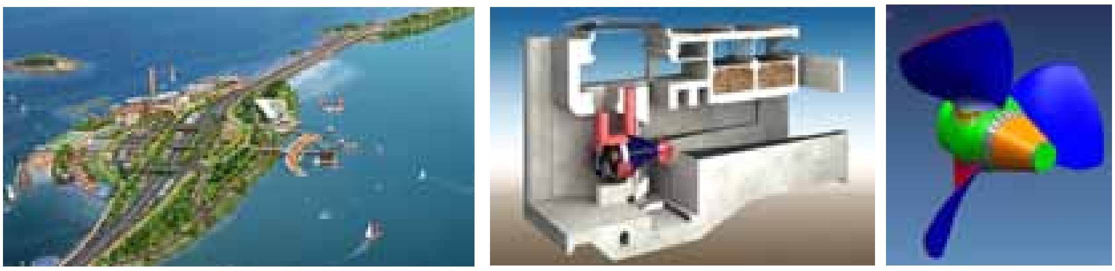
The power plant at Lake Sihwa is expected to be completed in August 2010 with a capacity of 254 MW. The Korean company Daewoo C&E is the main contractor for the project. Sihwa's turbines are manufactured by VA Tech Hydro, based in Austria. The Austrian company has agreed to transfer its turbine technology to Korea.

When completed, the Sihwa plant would help the country reduce carbon emissions by 315,000 tons, according to engineers. The plant was registered as a clean development mechanism project with the United Nations in 2006.

Table 7: Outline of Lake Sihwa tidal project[49]

Purpose	Power generation and improve water quality inside of the lake
Main tidal range	5.6 m
Spring tidal range	7.8 m
Barrage length	12.7 km
Basin area	43 km^2
Generation method	One-way during flood tide
Installed capacity	254 MW (horizontal axial bulb units)
Estimated annual output	553 GWh
Construction cost	350 M$

Figure 30: Lake Sihwa tidal power plant[50 51]



The Garolim Bay project originated from Korea tidal power study executed by both KORDI and Canadian Shawinigan in 1978. After dealing 10 sites in Korean west coast, Garolim was proposed as the 1st place. After the basic study in 1978, 3 times of feasibility study was performed again on Garolim site by French Sogreah, Chinese CSTC and KORDI.

Now the Garolim has met fierce opposition from local residents, fishermen, and environmental lobbies claiming its low economic benefits and negative impacts on the environment. The project has been approved by the Ministry of Land, Transportation and Maritime Affairs.[52] Progress is at a slightly slower pace than envisioned in 2007 and while construction start is described as elastic it is planned completed by December 2014.

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[49] *Tidal and Tidal Current Power Study in Korea* issued by Coastal Engineering Research Department of KORDI (May 2006)

[50] Image Copyright: Daewoo

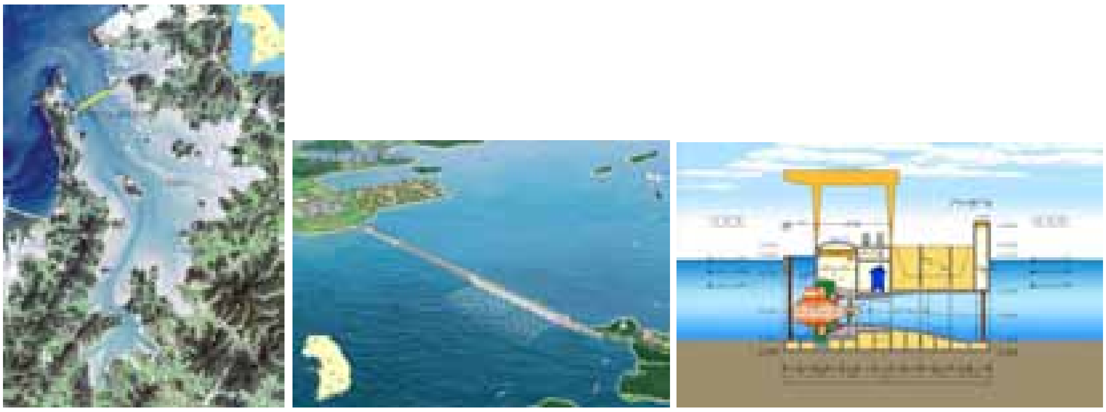
[51] Korea.net; International Water Power & Dam Construction Online; Edaily, 26 March 2009 "(희망+)(SOC는 힘!)대우건설 "바닷물로 전기를 만들다""

[52] Yonhap News. 가로림조력발전소 건립 구체화 전망. 4 February 2010. URL: http://www.yonhapnews.co.kr/local/2010/02/03/0807000000AKR20100203141100063.HTML; 전기신문 16 November 2009. 가로림조력발전소 건설 '탄력', p12.

Table 8: Outline of Garolim Bay tidal project[53]

Purpose	Power generation
Mean tidal range	4.7 m
Spring tidal range	6.6 m
Barrage length	2.0 km
Basin area	45.5 km^2
Generation method	One-way during ebb tide
Installed capacity	520 MW (horizontal axial bulb / pit unit with step-up gear)
Estimated annual output	880 GWh
Construction cost	1,000 M$

Figure 31: The Garolim Bay tidal power plant[54]



The Ganghwa project involves the construction of a tidal bank linking four islands near Ganghwa Island stretching for 7,795 meters and the installation of 32 power generators to generate 812 MW. The project is to be completed in 2015. The tidal power plant will be able to supply 8.4 percent of the power consumed in Incheon.

The difference in the ebb and flow among Ganghwa, Gyodong, Seokmo and Seogeum Islands has recorded an annual average of 5.5 meters with a maximum of 7.68 meters.

A project developer is Korea Midland Power (KOMIPO) and Daewoo E&C is responsible for its construction. The Construction costs are estimated at US$ 1.90 bn.[55]

[53] *Tidal and Tidal Current Power Study in Korea* issued by Coastal Engineering Research Department of KORDI (May 2006)

[54] Source & image: Tidal and Tidal Current Power Study in Korea issued by Coastal Engineering Research Department of KORDI (May 2006)

[55] Korea.net (2007). Korea to build world's largest tidal power station on Ganghwa Island. Korea.net, 4 May 2007. URL: ttp://www.korea.net/news/news/NewsView.asp?serial_no=20070504009&part=102&SearchDay=

Figure 32: Ganghwa tidal power plant [56]

In mid-2009 the end of a four year feasibility study also showed potential for a 1,320 MW plant at Incheon Bay, located in Gyeonggi Province.[57] Finally a MoU for the project was signed between Korea Hydro & Nuclear Power (KHNP) and GS Construction in January 2010.[58] The 1,320 MW (30 MW x 44 units), which is five times bigger than Sihwa tidal power plant will be able to satisfy 60 percent of household electricity consumption in Incheon, Korea's third largest city, 80 km west of the capital Seoul. Construction start is planned for 2011 and it will be finished in 2017.

Table 9: Outline of Incheon Bay tidal project[59]

Purpose	Power generation
Mean tidal range	5.3 m
Spring tidal range	7.3 m
Barrage length	20 km
Basin area	106 km^2
Generation method	One-way during ebb tide
Installed capacity	1,320 MW (horizontal axial bulb / pit unit with step-up gear)
Estimated annual output	1,800 GWh
Construction cost	2,500 M$

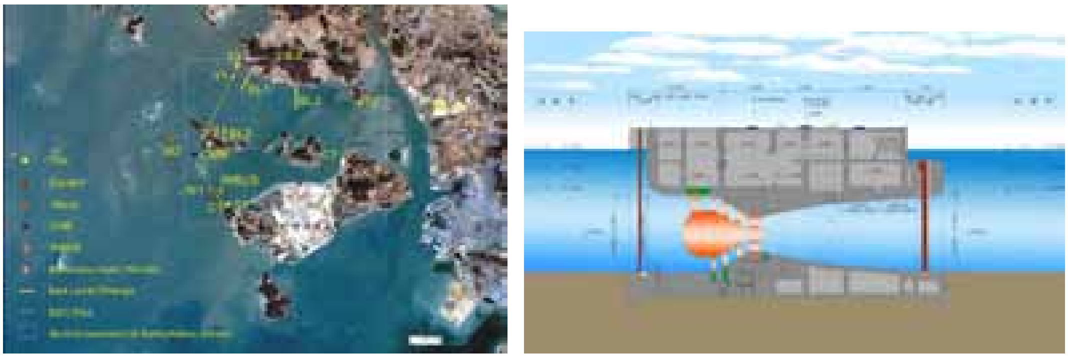
[56] Image source: Ganghwa County

[57] Kim Sun-ha & Moon Gwang-lip (2009). Tidal plant to power Incheon. JoongAng Daily, 14 July 2009. URL: http://joongangdaily.joins.com/article/view.asp?aid=2907377

[58] Yonhap News. Chosun Ilbo 20 January 2010. GS MOU. URL: http://news.chosun.com/site/data/html_dir/2010/01/20/2010012000760.html

[59] *Tidal and Tidal Current Power Study in Korea* issued by Coastal Engineering Research Department of KORDI (May 2006)

Figure 33: Incheon Bay tidal power plant[60]



The best potential for tidal power has been located in the central parts of the rias coast to the west and the bays in Gyeonggi Province in the northwest. And the best potential for tidal current has been located in south west of coast belongs to Jella Province. A map shows potential sites for them.

Figure 34: Map of potential sites for ocean energy[61]

4.4. Energy price and tariffs

The Korean power market is a national market with no international linkages. Price is not determined by a full market mechanism, but set in a cost-based pool (see below). Providers of electricity from NRE sources are eligible for various support schemes (see other section) as well as Feed-in-Tariffs (FiT). Importantly, the RPS (see below) as opposed to the FiT scheme is a non-market mechanism to introduce and disseminate the use of NRE.

[60] Source: Ocean Energy Development in Korea (November 2006) and Tidal and Tidal Current Power Study in Korea (May 2006), both issued by KORDI

[61] Source: Korea Ocean Research & Development Institute (2006)

Power in Korea is provided by a state controlled utility, the Korea Electric Power Corporation (KEPCO), which is the only power purchaser and has a transmission and distribution monopoly.[62] There are six publicly listed power generation companies (GenCos), which were separated from KEPCO in 2001, but in which KEPCO maintains a 100 percent stake:

- Korea South-East Power Co., Ltd. (KOSEP)
- Korea Midland Power Co., Ltd. (KOMIPO)
- Korea Western Power Co., Ltd. (WP)
- Korea Southern Power Co., Ltd. (KOSPO)
- Korea East-West Power Co., Ltd. (EWP)
- Korea Hydro & Nuclear Power Co., Ltd. (KHNP)

In addition, there are also private GenCos, such as POSCO E&C, Daelim, SK Construction, POSCO Power, GS Power, GS EPS, DOP Service, Hyundai Green Power. The private GenCos account for 10 to 15 percent of power generation. In 2008 there were a total of 302 generators, up from ten a decade earlier.[63]

The electricity market price is supposed to reflect the actual cost of generation, or its marginal product, which is called the system marginal price (SMP). Additionally, a capacity payment (CP) is paid to all power generators who have made themselves available for selling on the market, even if no power is dispatched. The system is called the cost-based pool (CBP), and can be regarded as an early stage in the transition to a competitive market system. After the initial opening of the power market in 2001 by the separation of the six publicly listed GenCos, further liberalisation has halted. By the original plan, price-setting is eventually to be done by a supply/demand and bidding system in a wholesale market. The average price for electricity on 2008 was **122.63 won/kWh (0.61NOK/kWh)**. Price is seasonal, with prices in fall, winter and spring 15-20 percent lower than during the summer months.[64] For information about the FiT applicable for wind and ocean power see below.

4.5. Relevant locations for offshore wind energy

The first three maritime wind power generators were completed in late 2009, in Ansan City, outside of Seoul. There are currently plans for 290 more generators in the same area.[65]

The Korean government is currently in the process of drawing up a roadmap for an offshore wind programme. Initially the aim is to build a wind farm with a capacity of around 100 MW off the west coast.[66]

The best and ideal potential areas, according to wind resource map below, for offshore wind farm should be located to the south and around the island of Jeju. However those areas are relatively deep-sea comparing to shallow West Sea. Therefore current offshore wind projects are focused on developing shallow sea water areas on the West of Korean peninsular.

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[62] Additionally, KEPCO is an international commercial actor for power generation, distribution and transmission, as well as consultancy and human resources training. Source: KEPCO website, URL: http://www.kepco.co.kr/

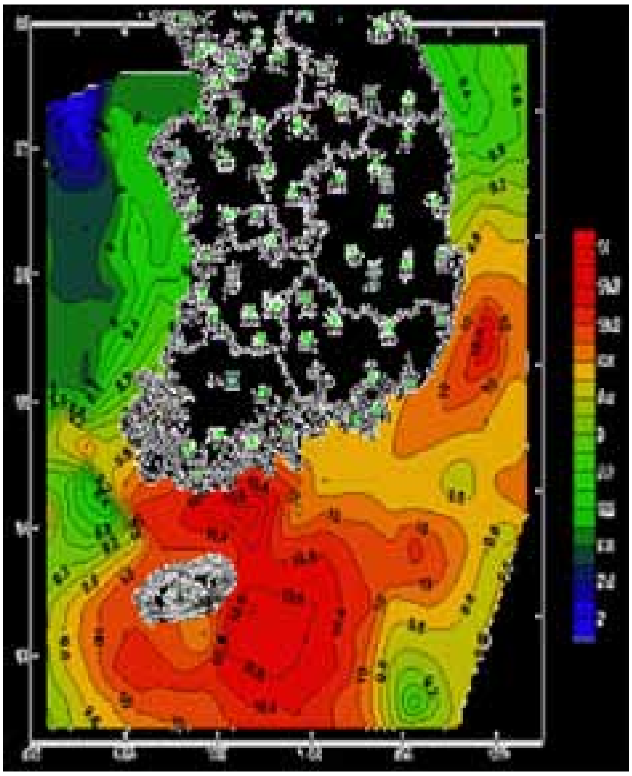
[63] A substantial number of these were solar PV power generators. KPX, the Korea Power Exchange, reports as many as 182 new power generators in 2008 within solar PV.

[64] Cho Jin-su (2010). Electricity Price to Go Up to Summer Level. Korea Times, 17 January 2010. URL: http://www.koreatimes.co.kr/www/news/biz/2010/01/123_59174.html

[65] KBS World (2009). Wind Power Generators Built on Sea. KBS World, 31 December 2009. URL: http://world.kbs.co.kr/english/news/news_Ec_detail.htm?No=69278

[66] Power-gen worldwide (2010). South Korea eyes 1 GW offshore wind farm expansion. Power-gen worldwide, 9 February 2010. URL: http://www.powergenworldwide.com/index/display/articledisplay/7905520648/articles/powergenworldwide/renewables/wind/2010/02/south-korea_eyes_1.html

Figure 35: Offshore wind potential in Korea



Offshore Wind Project List

- 100 MW offshore wind farm (5 MW x 20 units) by 2015, located 20 km away from Gochang, in the South West of Korean peninsular.
- 97 MW offshore wind farm (3.6 MW x 27 units) by 2012 in front of Taean-Gun in the West of Korean peninsular.
- 99 MW offshore wind farm (3 MW x 33 units) by 2012 located 5 km away from Muwee Island in the West of Korean peninsular.
- 600 MW offshore wind farm in South West by 2015.
- 30 MW offshore wind farm located 300~1000m away from Jeju island

4.6. Political climate for renewable energy from ocean and wind

The major political fundament for emphasis on renewable energy is embedded into and is part of the major strategic political vision for future national development, titled "low carbon, green growth." The vision calls for "…all-out investment to shift the energy paradigm…" Due to its time of announcement – the President's speech to the nation on the jointly held 63rd anniversary of liberation and 60th anniversary of the founding of the republic – it is to be regarded as a political commitment similar to a government declaration. Having received significant international attention, the UN has praised the plan for being a "major attempt to fundamentally transform the country's growth paradigm."[67]

[67] Associated Press. http://www.chinapost.com.tw/business/asia/korea/2009/09/23/225875/S-Korean.htm

The overarching basis for renewable energy development is the 1st Basic Plan of National Energy (2008-2030).[68] The plan calls for an energy mix based on considerations of environment, efficiency and security. This is a markedly change from the two previous long term plans that only partly deals with efficiency and not with environment.[69] Importantly it also calls for more use of new and renewable energy to the level of 11 percent of the energy mix, as well as improving energy efficiency by 46 percent, by 2030.[70] The plan also touches on industrial policy by envisioning the birth of energy-related businesses as new growth industries for the Korean economy.

The "3rd basic plan for NRE technology development and deployment" develops on the 1st Basic Plan and targets NRE to supply 4.3 percent of the energy supply in 2015, 6.1 percent in 2020 and 11 percent in 2030.[71] Furthermore, this goal has received legislative backing entering into force in 2012; by law each and every power firm will be obligated to produce at least 11 percent of its electricity from renewable sources by 2030. This is also referred to as the Renewable Portfolio Standard (RPS). Due to the introduction of the RPS companies like Doosan expect a sharp growth in renewable energy after 2012.[72] In 2009-2011 nine state-run energy companies will invest US$ 2.6 bn in RNE, up from US$ 525.3 mil in 2006-2008.[73]

Currently, as under the Kyoto protocol, Korea is a non-Annex I member meaning it can apply for recognition of CDM (Clean Development Mechanism) projects. There is an uncertainty about what will happen to the Kyoto regime in the future, but there seems to be a consciousness that further carbon mitigation contributions must be NAMA and not offsets.[74]

The development of at least four main drivers for pursuing green technology will largely impact the political climate for renewable energy.

First, Korea's energy dependence is sought diversified and reduced. Second, and related, Korea seeks better energy security, which it believes it may obtain through domestic NRE sources. Third, the growth and development potential of semiconductors, consumer electronics, automobiles and shipbuilding seems to have reached a point where it is unable to provide for further high and sustained growth for the Korean economy at large. Both the government and business sector are looking for new areas to develop international competitiveness.

Fourth, the international climate for dealing with climate change impacts Korea as a G20 member with great aspirations for its geopolitical and regional status. Last, there is a growing domestic emphasis on better life quality and environment. In addition, the recent financial turmoil spurred Korea into action by spending more than any other nation relative to its GDP on green public works.

[68] Office of the Prime Minister, Ministry of Strategy and Finance, Ministry of Engineering, Science and Technology, Ministry of Foreign Affairs and Trade, Ministry of Knowledge Economy, Ministry of Environment & Ministry of Land Transportation and Maritime Affairs (2008). 제 1 차 국가에너지기본계획 2008 ~ 2030 [1st Basic Plan for National Energy (2008-2030)]; Blue-Ocean Content & Strategy (2009). National Basic Energy Plan, Korea (2008-2030). URL: http://www.energykorea.or.kr/pdf/2008_0102/090105-Basic_Energy.pdf.

[69] Although being called the 1st Basic Plan, it is preceded by the 1st and 2nd National Energy Plans for 1997-2006 and 2003-2012. A long-term energy plan every 5 years is a constitutional demand.

[70] Many of the goals in the 1st Basic Plan have been reiterated, developed into new plans and legally binding targets.

[71] The business as usual scenario suggests 3.6 per cent, 4.2 per cent and 5.7 per cent for 2015, 2020 and 2030 respectively.

[72] Song, Jung-a (2009). Doosan focuses energy on renewables. FT.com, 16 November 2009. URL: http://www.ft.com/cms/s/0/01de428e-d2d8-11de-af63-00144feabdc0.html

[73] Including the six public GenCos and KEPCO this includes the Korea District Heating Corporation and the Korea Water Resources Corporation.

[74] Nationally Appropriate Mitigation Action (NAMA) was introduced at the Bali COP of the UNFCCC and are understood as emission reduction actions.

4.7. Incentives for developing and utilizing new technology

There are various incentives and/or enforcements to utilize new technology for NRE and achieve a deployment ratio for NRE of 11 percent of the total primary energy supply by 2030.[75]

Renewable Portfolio Agreement (RPA): An investment agreement for NRE between the government and energy public energy providers. It is likely to be overtaken completely by the introduction of the RPS (see below).

Feed-in-Tariff (FiT): As described above the government operates a Feed-in-Tariff for NRE. However, in each October starting in 2009 it will gradually be reduced by a factor of 2 percent annually in the case for wind energy.[76] The maximum level applicable for support has been set at 50 MW for fuel cells 500 MW PV solar and 1,000 MW for wind power. However, the FiT is in many ways to be complemented and eventually superseded by the Renewable Portfolio Standard (RPS). Contrary to the FiT, which is a market mechanism, the RPS mandates the level of usage of NRE sources at a minimum of 12 percent by 2030.

The FiT for a grid connected wind generator with a capacity of more than 10 kW is 107.29 KRW/kWh. The wind energy FiT is guaranteed for 15 years. At the introduction in 2002 a limit was set at 250 MW, later expanded to 1,000 MW, and given on a first-come first-served basis.[77] The FiT for ocean (tidal) power depends on the tidal range and the presence of an embankment. The FiT rates are detailed in the table below:

Table 10: Feed-in-Tariff for wind and ocean

	Capacity	Classification			Price /kWh
Wind	> 10 kW				107.29 won 0.54NOK
Ocean (tidal)[78]	> 50 MW	Tidal range	> 8.5 m	Embankment	62.81 won 0.31NOK
				No embankment	76.63 won 0.38NOK
			< 8.5 m	Embankment	75.59 won 0.38NOK
				No embankment	90.50 won 0.45NOK

Voluntary Agreement (AV): A company may submit detailed plans for energy consumption and GHG emission reductions in return for low interest rate loans, tax incentives and technical support.

[75] The Business-as-Usual scenario forecasts the NRE share of the total primary energy supply in 2030 at 5.7 per cent.

[76] Korea Electric Power Times (2009). "풍력발전산업이야 말로 진정한 新성장동력" 24 May 2009. URL: http://www.epnews.co.kr/news/articleView.html?idxno=19169

[77] 그린데일리 (2009). [그린용어] 발전차액지원제도 3 March 2009. URL: http://www.greendaily.co.kr/news/articleView.html?idxno=2606

[78] The FiT for ocean is specified as tidal in the FiT scheme.

Clean Development Mechanism (CDM): Under the Kyoto Protocol, Korea as a non-Annex I signatory to the UNFCCC, carbon reduction projects may be registered as CDM projects and work towards offsets in Annex-I countries.

Government subsidy programs: To help the creation of an initial market two government subsidy programs are set up for products developed domestically; the exhibition deployment subsidy and the general deployment subsidy. The former is to help onto the market products and systems already proven through demonstration. A subsidy of up to 80 percent of installation costs for NRE is provided. The general program receives an installation subsidy up to 60 percent and is for already commercialized products and system. In 2008 wind power systems equal to 54 MW received either of these subsidies.

Regional subsidy program: In support of various regional projects, the government will support infrastructure development, such as education and public awareness, up to 100 percent and NRE system installation at up to 70 percent.

1 million green homes program*:* Originally the 100,000 solar-roof deployment program, private residences, larger apartment houses and public rental houses may receive a subsidy for installing NRE systems. The main target in the basic plan is to develop and deploy smaller PV systems, but after the redefinition of the program small wind has also been included as eligible for subsidy.

Tax and loan incentives: Up to 20 percent of investments in installations for NRE are tax deductible. The government provides loans both for installation of NRE systems and their operation. The loan may be as much as up to 90 percent for smaller companies and 50 percent for larger companies. Also, there is a three year tax audit exemption from the first profitable year for businesses in alternative energy (2,503 businesses in 2008)

Environmental Venture Fund*:* Support for promising venture companies. The Korea Institute for Environmental Science & Technology (KIEST) operates the Environmental Technology Business Incubator (ETBI) to assist companies developing new technologies.

Green procurement*:* A campaign to encourage public agencies to purchase environmentally-friendly products and services. There are also requirements for public organizations to make energy saving efforts.

Additionally the government has introduced an energy conservation day, environmental technology award, and other ways of awarding businesses in the NRE field.

4.8. Key players

Among the key players in wind and ocean energy are diversified units from larger conglomerates, power companies and NRE companies. Especially large shipbuilding and construction companies are moving into the wind energy market for manufacturing, export, installation and management, with aims to become among the global top players in less than a decade from now. Among these, are Hyosung, Doosan, Samsung DSME, Hyundai and STX. [79]

In early 2010 **Hyosung Power & Industrial Systems Performance Group** concluded a US$ 39.8bn deal to become the first Korean exporter of components for wind generation plants, in this case 1.65 MW wind turbine gearboxes.[80] Last year, in 2009, it also became the first Korean manufacturer to receive DEWI-OCC certification for its 750 kW and 2 MW wind power systems. Hyosung aims to become one of the world's top three wind turbine gearbox providers and has been put in charge of the "National Offshore 5-Megawatt Project," a government-led project aiming at having more wind power equipment produced locally.

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[79] A list of some non-market actors such as government controlled organizations may be found in the OECD report "Eco-Innovation Policies in the Republic of Korea" by Xavier Leflavie. URL: http://www.oecd.org/dataoecd/27/16/42876970.pdf.

[80] Kim Hyun-cheol (2010). Hyosung to Export Wind Power Parts. Korea Times 5 January 2010. URL: http://www.koreatimes.co.kr/www/news/biz/2010/01/123_58458.html

Doosan Heavy Industries, Korea's biggest power plant and equipment maker, is also counting on wind power investments and hopes to commercialize a 3 MW wind power generation system, called WinDS 3000, during 2010.[81] To enter the US and European markets Doosan has spent US$ 670 mil to acquire Czech turbine maker Skoda Power. The acquisition made Doosan the fourth largest power-plant equipment maker globally. It hopes to generate more than US$ 860 mil in sales annually by 2020.[82] By 2020 Doosan aims to become one of the global top 10 players in the wind power industry.

Among the shipbuilders **Samsung Heavy Industries** became the first international exporter as it has started delivering 2.5 MW generators to Cielo, a US-based company. By gradually increasing employees by 1,000 per cent and expanding manufacturing capacity to 800 units per year it aims to become one of the world's top 7 wind turbine makers by 2015. In 2010 it plans to produce 200 turbine units at a capacity of 2.5 to 5 MW each.[83] It has established a sales branch in Houston, Texas, and plans to open more soon both in the US and in Germany.

Daewoo Shipbuilding & Marine Engineering (DSME) acquired DeWind for US$ 49.5 mil in 2009 to further tap into foreign markets.[84] By investing US$ 70 mil in new product development it hopes to gain a stronghold in the North American market. It is also mulling an option of constructing an equipment plant in China.[85] By 2020 it hopes to have become the third largest wind power equipment maker with a global market share of 15 percent.[86]

Hyundai Heavy Industries has invested US$ 91 mil in a wind turbine plant in Gunsan, North Jeolla Province. The plan opened in October 2009 with an annual capacity of 600 MW. It will supply 30 generators for a 50 MW wind project in Pakistan worth about a US$ 52.7~70.2 mil[87] and has also been contracted to provide six 1.65 MW turbines to US-based Wave Wind. Hyundai and Wave Wind are also jointly looking into a 100 MW capacity wind turbine project.[88]

STX Shipbuilding acquired Dutch Harakosan Europe B.V. in a US$ 20 mil deal in 2009 and renamed it STX Windpower. In the process it received licenses on three different wind power designs and a R&D centre on wind energy in the Netherlands. It has received an order for six wind power facilities from Romania. It seeks to focus on offshore wind energy and become a top ten global players by 2015 and US$ 1.2 bn in sales.[89] Synergies with the STX Group's STX Engine, STX Enpaco and STX Energy may also create new business opportunities.

Korean actors are also active in overseas installations. **Korea Electric Power Corporation** (KEPCO) has completed wind energy projects in China, such as Gansu Province (99 MW) and

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[81] Kim Hyun-cheol (2010). Doosan Heavy Industries Eyeing Eco Businesses. Korea Times, 24 November 2009. URL: http://www.koreatimes.co.kr/www/news/biz/2009/11/127_56096.html

[82] Song Jung-a (2009). Doosan focuses energy on renewables. Financial Times, 16 November 2009. URL: http://www.ft.com/cms/s/0/01de428e-d2d8-11de-af63-00144feabdc0.html

[83] Lee Sun-young (2009). Beleaguered shipyards turn to wind power. Korea Herald, 15 October 2009. URL: http://www.koreaherald.co.kr/NEWKHSITE/data/html_dir/2009/10/15/200910150062.asp

[84] DeWind website. URL: http://www.dewind.de/services-en/index.htm.

[85] Reuters (2009). Daewoo Shipbuilding considers China wind power plant. Reuters, 27 Nvember 2009. URL: http://www.reuters.com/article/idUSTRE5AQ2L620091127.

[86] Kim Hyun-cheol (2009). Wind Power New Growth Engine for Shipbuilders. Korea Times, 30 November 2009. URL: http://www.koreatimes.co.kr/www/news/biz/2010/01/123_56409.html

[87] Kim Hyun-cheol (2010). HHI to Supply Wind Power Generators to Pakistan. Korea Times, 22 January 2010. URL: http://www.koreatimes.co.kr/www/news/biz/2010/01/123_59534.html

[88] Lee Sun-young (2009). Beleaguered shipyards turn to wind power. Korea Herald, 15 October 2009. URL: http://www.koreaherald.co.kr/NEWKHSITE/data/html_dir/2009/10/15/200910150062.asp

[89] SustainableBusiness.com (2009). STX Heavy Acquires Netherlands Wind Turbine Firm. SustainableBusiness, 8 April 2009. URL: http://www.sustainablebusiness.com/index.cfm/go/news.display/id/18636

Inner Mongolia (647 MW).[90] Most notably of late is perhaps the contract for developing a 2.5 GW wind + solar cluster in Ontario, Canada, won by a consortium led by Samsung C&E and includes KEPCO and Hanjin. The installation is to be done by 2016 and a fifth of the capacity instalment to be ready by 2012.[91] The consortium will invest a total of US$6bn.[92] Producers of wind energy equipment are listed in the below table:

Table 11: Producers of wind energy equipment

* Wind turbine generator

Company	Description
Hyosung Corporation	750kW, gear type 2MW, gear type: under proof test operation
Unison Co.	750kW, gearless type 2MW, gearless type: under proof test operation
Hyundai Heavy Industries	5/3.6MW offshore type & 2.5MW onshore type: tech inducement and development
Doosan Heavy Industries	3MW offshore type development
Samsung Heavy Industries	2.5MW: tech inducement and development
Hanjin Industrial	1.5MW: under proof test operation

*Parts manufacturers (wind power)

Company	Description
Taewoong	Products: The world largest manufacturer of forgings and rolled rings for wind turbine such as forged main shafts, tower flanges, inner and out rings for yaw bearing and pitch bearings. Major customers: Vestas, GE, Siemens, Enercon
Hyosung Heavy Industries	Products: Transformer, switchgear, generator, control system, towers Major customers: Ebara, Hansin Energy
Dongkuk S&C	Products: Towers Major customers: Vestas, Enercon, Gamesa
CS Wind	Products: Towers Major customers: Vestas, Siemens
Hyundai Heavy Industries	Products: Generator, transformer, switchgear, control system Major customers: GE, Mitsubishi
Korea Tech	Products: Molded materials such as rotor hub, bed plates Major customers: GE (under negotiation)

***Players in Ocean Energy**

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[90] Kim Hyun-cheol (2010). Power Up!!! Korea Times, 27 November 2008. UUL: http://www.koreatimes.co.kr/www/news/biz/2010/01/263_35179.html; KEPCO 2009 Annual Report.

[91] Christian Oliver (2010). S Korea invest $6bn in power project. Financial Times, 22 January 2010. URL: http://www.ft.com/cms/s/0/9cd5f2ba-072a-11df-a9b7-00144feabdc0.html

[92] 변국영 (2010). 세계 최대 풍력·태양광 클러스터 수주. The Korea Energy News, 22 January 2010. URL: http://www.koenergy.co.kr/news/articleView.html?idxno=50503

Company	Description
Harting Korea Ltd.	Products: Electric connectors, network cable harness, power controller
Renetec Co., Ltd.	Products: Tidal current generator, offshore structure In cooperation with Voith Hydro (Germany)
Hyundai Heavy Industries	Products: generator
Iljin Electric	Products: power transmission
KORDI	R&D (Korea Ocean and Research Development Institute)
BSR	Ocean engineering

Other players include Korea New and Renewable Energy Association (KNREA),[93] the most significant membership organization for businesses in the NRE field and affiliated with KEMCO, as well as the GenCos listed earlier.

4.9. Market entry

To conclude, Korea is seeing an explosive interest in the dissemination and commercial exploitation of new and renewable energy sources.

In case of wind generation, deployment was 1,000 GWh in 2007 and it will be increased up to 48,322 GWh in 2030. It means wind power generation will be increase average 18.1 percent every year and it shares 12.6 percent of total new and renewable energy. Ocean energy was nothing in 2008 in Korea but dissemination target in 2030 is 18,000 GWh, average 49.6 percent of annual growth and 4.7 percent from total new and renewable energy.

[93] Formerly Korea Alternative Energy Association

Table 12: NRE deployment forecasts [unit: thousand TOE, %]

	2008	2010	2015	2020	2030	Growth ratio
Solar heat	33 (0.5)	40 (0.5)	63 (0.5)	342 (2.0)	1,882 (5.7)	20.0
Photovoltaic	59 (0.9)	138 (1.8)	313 (2.7)	552 (3.2)	1,364 (4.1)	15.3
Wind	106 (1.7)	220 (2.9)	1,084 (9.2)	2,035 (11.6)	4,155 (12.6)	18.1
Biomass	518 (8.1)	987 (13.0)	2,210 (18.8)	4,211 (24.0)	10,357 (31.4)	14.6
Hydro	946 (14.9)	972 (12.8)	1,071 (9.1)	1,165 (6.6)	1,447 (4.4)	1.9
Geo thermal	9 (0.1)	43 (0.6)	280 (2.4)	544 (3.1)	1,261 (3.8)	25.5
Ocean	0 (0.0)	70 (0.9)	393 (3.3)	907 (5.2)	1,540 (4.7)	49.6
Waste	4,688 (73.7)	5,097 (67.4)	6,316 (53.8)	7,764 (44.3)	11,021 (33.4)	4.0
Sum	6,360	7,566	11,731	17,520	33,027	7.8
Ratio	2.58%	2.98%	4.33%	6.08%	11.0%	

( ): ratio of occupancy, %

Korean wind power technology is in the commercialization stage through own technology development or in cooperation with foreign technology. In terms of core wind turbine technology, the country is, acknowledged, lagging behind the most advanced countries. However the technology development has recently been dramatically speeding up when large conglomerates entered into this market.

However it will be a weak point that Korean onshore wind power market itself is relatively small. Therefore most of local players are much more focused on developing offshore projects in Korea or overseas markets. So far total 926 MW offshore wind farms are planned in Korea.

As for offshore wind energy, Korea is very beginning stage of development. Doosan is the first runner developed own 3 MW wind turbine system to be install on its first offshore demonstration site near by Jeju Island.

However most of local players do not have proper technology on offshore wind turbine system while they are planning offshore wind farm projects in the West and South West. Please refer to the projects described on the article 5.5 relevant locations for offshore wind energy.

Considering growing ambition on offshore wind project development, large sized offshore wind turbine system as well as new floating tower system for deep-sea will be warmly welcomed to collaborate with Norwegian players.

Among the ocean energies, Korea is currently pushing ahead with building four tidal power plants, all on the western coast. Among them, three are in Gyeonggi Province - Sihwa, Incheon and Ganghwa - while one is in South Chungcheong Province - Garolim. Total installation capacity will be 2,906 MW for tidal power generation. The government began to promote these projects in the early 2000s as part of its effort to reduce carbon emissions and dependence on imported oil.

Regarding tidal current energy, Korea is now operating first 1 MW pilot plant at Uldolmok and plans to build a 90 MW tidal power plant at Uldolmok by 2013 and a 400 MW tidal power plant at both Changjuk and Maenggol by for commercial power generation in 2018.

Most of tidal and tidal current projects are led by several leading engineering & construction (E&C) companies in Korea however core components (turbine) have been supplied from overseas VA Tech and Voith Hydro (local partner Renetec) so far. Therefore it is worth for Norwegian industrial players to start communication with Korean leading E&C companies to explore new business opportunity from local tidal and tidal current power projects.

Korean wave-force power generation is little behind on its development compared with development status of tidal and tidal current. So far a national institute – KORDI is building a first pilot plant (500 kW) in front of Jeju Island.

Since potential of wave power resource is estimated 6.5 GW as same as that of tidal in Korea, it seems there will be more feasibility study to define the best places in Korea. Therefore mutual collaboration on the feasibility study on wave power will be welcomed.

ACRONYMS

AV	Voluntary Agreement
BPE	Basic Plan of Long-Term Supply and Demand
CBP	Cost-based pool
CDM	Clean Development Mechanism
COP	Conference of the Parties
CP	Capacity payment
DEWI-OCC	DEWI Offshore and Certification Centre
DSME	Daewoo Shipbuilding & Marine Engineering
ETBI	Environmental Technnology Business Incubator
EWP	Korea East-West Power Co., Ltd.
FiT	Feed-in-Tariff
GDP	Gross Domestic Product
GenCo	Generation company
KEMCO	Korea Energy Management Corporation
KEPCO	Korea Electricity Power Corporation
KHNHP	Korea Hydro & Nuclear Power Co., Ltd.
KIEST	Korea Institute for Environmental Science & Technology
KNREA	Korea New and Renewable Energy Association
KOMIPO	Korea Midland Power Co., Ltd.
KOSEP	Korea South-East Power Co., Ltd
KOSPO	Korea Southern Power Co., Ltd.
KRW	Korean won (the currency of the Republic of Korea)
MW	Megawatt
MWh	Megawatt hour
NAMA	Nationally Appropriate Mitigation Action
NRE	New and renewable energy
PV	Photovoltaic
RPA	Renewable Portfolio Agreement
RPS	Renewable Portfolio Standard
SMP	System marginal price
tCO2	Tonne of CO2
tCO2eq	Tonne of CO2 equivalent
TOE	Tonne of oil equivalent
TPES	Total primary energy supply
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WP	Korea Western Power Co., Ltd.

List of figures

INNOVATION NORWAY