Green Energy Roadmaps of Major Economies

An Overview of Low-Carbon Policy Frameworks of Major Economies

Prepared by Nitzan Goldberger and David Pumphrey[1]

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In the coming decades, significant breakthroughs in clean technologies are needed to tackle the looming threats of global climate change. Such technologies hold great potential, but in order to deploy enough low carbon energy technologies to alter the trajectory of greenhouse gas emissions, clean technology must become price competitive and efficient. In a 21st century global economy that is likely to face carbon constraints, countries with the greatest energy efficiency and greenest economy will have a competitive advantage over others.

While, clean energy technology is an essential part of mitigating the catastrophic effects of climate change, some now view greenhouse gas emissions mitigation not as an economic burden but rather as an opportunity. Solar panels and wind turbines have become the symbols of economic growth and prosperity and green jobs in this sector are seen as the way out of the

[1] Nitzan Goldberger is a Research Assistant and David Pumphrey is Deputy Director and Senior Fellow with the Energy and National Security Program at the Center for Strategic and International Studies.

recent global financial crisis. The emphasis on manufacturing is backed by a few key assumptions. The first is that manufacturing jobs tend to pay better.[1] The second is that studies have suggested that up to three quarters of the labor required for many renewable technologies are in the upstream part of the process, not the later stages of deployment and maintenance.[2]

There is great market opportunity in the clean technology sector. In 2008, $173 billion[3] was invested in clean energy globally, reaching $162 in 2009 despite the financial crisis. The industry is estimated to reach a value of $200 billion in 2010. Economic stimulus packages with green investment components have helped grow this market. Additionally, green mandates and regulations across the world are likely to increase demand for clean technology in the years ahead. According to a recent report by Roland Berger Strategy Consultants, the clean energy sector is estimated to grow to $2.3 trillion by 2020.[4] The eventual size of the clean energy market,however, will be determined by the strength of the greenhouse mitigation polices of the world's major emitters.

Countries spanning from Asia to Europe and the U.S. have set up public programs and regulations with the aim of becoming leaders of this fast expanding industry in addition to mitigating climate change. Each country has tried to nurture and advance certain targeted technologies, often struggling to strike the perfect balance without picking and choosing winners. The policies adopted are broad and range in effectiveness. The policy tools can be divided into the categories of direct and indirect policies: direct policies that subsidize or incentivize the production and component manufacturing of clean energy technologies and indirect policies that stimulate demand for clean energy.

There is much to learn from the success of previous technological booms. Those technological leaps were often brought about by government support for promising companies with low-interest loans, industry-wide R&D, government procurement, and subsidies for private firms to drive the purchase of advanced technologies. This same is happening in the clean technology sector, and China is leading the way.

This paper will explore green energy roadmaps and strategies of the world's leading players in this field:, China, the European Union, ,South Korea, and the United States. The specific technologies highlighted and explored are LED lighting, Carbon Capture and Storage (CCS), solar, wind, nuclear, smart grid, and nuclear power. The paper seeks to draw out key green policy guidelines and best practices. Each country has a different economic infrastructure and demand base, and therefore no two green roadmaps will look the same. Nonetheless, some best practices include creating a carbon price, government fiscal policies, renewable and energy efficiency standards and government investment in research and development (R&D).

China's Clean Energy vision

China's energy and climate change policies are animated by the country's growing energy needs to fuel its massive economic growth. While coal dominates its energy system, China has invested in a variety of low carbon energy sources, including renewable energy and nuclear power. China's investment in clean technology manufacturing and deployment is one of the largest in the world. The energy policy of the Chinese government covers both an effort to

increase access to a wide variety of supply and an effort to decrease demand by improving efficiency and energy intensity. Energy efficiency technology is a key focus area for the Chinese government. Figure 1 highlights key technology areas where China's investment has been directed between 2005 and 2009.

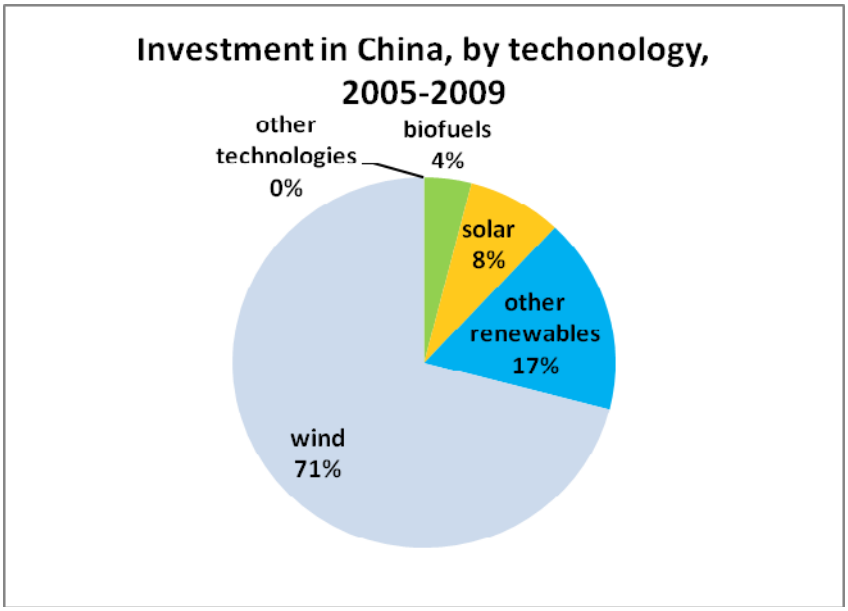
The 2006 11th Five Year Plan (2006-2010) includes mandates targeted at reducing energy intensity in the economy by 20% and a zero-carbon electricity standard of 15% by 2020, which includes energy generated through wind, solar, nuclear and hydro power. Just before the international climate summit at Copenhagen in December 2009, China announced a goal of achieving a 40-45% reduction in its greenhouse gas intensity by 2020.

China's most comprehensive technology roadmap was launched in January 2006. China's government published the Medium-to-Long-Term Science and Technology National Plan (S&T National Plan) outlining the government's plan for technological research and innovation out to 2020. Under the plan, the government outlines five strategic areas of focus, with a major emphasis on energy, water and environmental protection technologies. One of the themes that stands out in this plan is the country's desire to reduce its dependence on foreign technologies as well as increase domestic jobs in these five technology areas. The 863 & 973 programs provide the most well-known and biggest funding sources for clean technologies.

China's ambitious goal in the area of energy technology has been matched by a large financial investment. The government's stimulus fund was an additional boost to an already impressive investment record. Government R&D appropriations increased from $11 billion in 2001 to $26

billion in 2006. While in the past China has excelled in the global economy by staking out a competitive advantage in large-scale manufacturing and driving down costs, these government policies and massive investment approach may well lead China to being a key innovating country in the clean tech sector.

Figure 1



Source: Pew Charitable Trusts, *"Who's Winning the Clean Energy Race?" March 2010*

China green policies and incentives

Wind and solar

China's renewable energy policies are in large part animated by the 2005 Renewable Energy Law, which took effect in 2006 and was further amended in 2009. This renewable energy law created a renewable portfolio standard, feed-in tariff policies, and other incentives and mandates. The Act established the Renewable Energy Development Fund, which collects 0.4 cents/kwh and

added up to12-20 billion Yuan for 2009. This Act also requires the public utility to purchase all the renewable electricity.

With its target of installing 30 GW of wind by 2020 and a generous feed-in tariff program, China doubled its wind capacity in 2009.[5] In the wind sector, China set feed-in tariff levels of $75-89/MWh in August 2009.[6] In fact, wind has deployed at such rapid rates that many China analyst suggests that only about two-thirds of the wind turbines currently in operation are actually linked to the grid.

Until recently the Chinese government has imposed local content requirement on renewable energy projects. These "buy Chinese" provisions had required that 70 percent of the equipment needed for installed wind power plants be sourced domestically. Under U.S. and European pressure China dropped these requirements in November 2009. This does not mean, however, that U.S. and European manufacturers will soon flood the Chinese market. The Chinese manufacturers (in part because of subsidies, less expensive land and labor) are still making the cheapest, most competitive products. The 70% local content requirement was introduced in 2004 when most of turbines in the then very small Chinese market were imported. After five years, the domestic wind turbine manufacturing industry is now the world's largest, and no longer needs such policies.

For solar, programs like "Golden Sun" and "Solar Roofs" are encouraging demand by subsidizing up to 50 percent of project costs. The government restricted the Golden Sun subsidy to a total of 20 MW in solar projects for each province, which does put limit on scale for

developers. In addition to covering 50 percent of the cost, China's Ministry of Finance will also support projects by building any needed transmission and distribution infrastructure for utility scale projects. For off-grid projects in less populated areas, the ministry will pay 70% of the cost. The Golden Sun program has received some criticism for being a supply side program that will not be sufficient to boosting up demand for solar. In fact, China's solar deployment pales in comparison to the amount of solar manufacturing capacity in the country. Almost all of the solar components are exported to other markets. In order to trigger demand for solar in China, a feed-in tariff would be necessary.[7]

In response to wind FiTs, local Chinese governments in a few provinces have created FiT systems[8] for solar projects. For example, Ningxia province began a FiT program in April 2010 in which it committed $0.17 per kilowatt-hour for four projects. Starting in November 2009, Zhejiang began offering $0.10 per for kilowatt-hour for solar PV demonstration projects. Jiangsu Province set fixed solar FiT in June 2009. The Chinese government announced its intentions to set national tariff prices for solar in July 2010, but no steps have been taken as of yet to do so.

Smart Grid

China has most likely made the most significant investment in its grid infrastructure ever in 2009, although it is difficult to classify the investment as "smart grid" policies. By some estimates, over $160 billion of China's stimulus money went toward electric grid construction over the 2009-2010 period. Within the stimulus funds, there is also a clear allocation of $7.32 billion for developing of a national smart grid. Mandates that grid companies must build

interconnections for renewable projects have promoted the building out of the grid. China is currently working to create four smart grid power cities.

Nuclear

In the area of nuclear, China has set a medium and long-term National Plan for Nuclear Power Development. Under this plan, China will install 5-8 new nuclear power units each year, reaching a total installed nuclear capacity of 40 GW in 2015 and 80 GW in 2020. By 2020, nuclear will make up 5% of China's overall power generation. Some estimates suggest that the government has already bookmarked over $146 billion for nuclear energy in the next decade. Currently China has over 20 reactors (about 25.4 GW) under construction.

LED

The most noteworthy policy tool used by the Chinese government to promote the use and manufacturing of LED technology is its LED mandate. The National Development and Reform Commission and Ministry of Finance have set a goal to use an additional 150 million energy efficient lights by 2010. The Ministry of Finance provides LED subsidy of 33% for wholesale purchases and 50% for retail purchases of LED lighting.[9] Under the current five-year plan (2006-2010) and through the Ministry of Science and Technology, China is investing EUR36.7 million into LED. Funding from the National Solid State Lighting program is also helping to drive up LED efficacy.

There are several LED initiatives occurring on the local level in China, most notably in Shenzhen and Guangzhou. These two cities in the Guangdong province are not only the biggest production

centers for LED but are also spearheading LED incentives and policies in China. Guangdong administration installed 100,000 lights on 1,000 kilometers of highway, and Shenzhen has set aside about $14 million annually from 2009-2011to fund LED R&D, patent acquisition, industry standardization and marketing.

CCS

The Chinese Government has launched research programs into CCS technology through the National Basic Research Program and the National High Tech program. Construction has begun on China's first CCS project, being run by Shenhua Group, in Erdos in Inner Mongolia. The CCS project will begin a trial period at the end of 2010 and plans for the project estimate a reduction of 100,000 tons of CO2 emissions. Additionally, Huaneng Group has been moving forward on the GreenGen project, a IGCC plant incorporating CCS.

Europe's Clean Energy Vision

Europe has a long established clean technology sector, largely built up around a strong commitment to reducing greenhouse gas emissions. The EU's carbon policies brought about robust clean energy markets with a relatively consistent investment. Europe moved aggressively to set a carbon price through the Emissions Trading System (ETS). Further to the ETS, the EU has committed to carbon reduction of 20% by 2020 (against a 1990 baseline) and consideration is being given to raising this target to 30%. Europe has mandated a renewable energy standard of 20% of electricity by 2020. Each member state will be assigned a target to meet the European wide goal, but the policies to achieve these targets must be chosen by the country.

Until recently, Europe has been the world's main PV market, In 2008, Europe represented over 80% of the Global PV market. Much of this clean technology manufacturing capacity and R&D came from Germany, where there was a strong industrial base and a trained labor force equipped with such manufacturing. Denmark has made significant strides in increasing clean technology sales as well, and France has championed nuclear energy and is a leading manufacturer of nuclear technology.

Europe's clean technology vision is outlined in the Strategic Energy Technology Plan (SET-Plan), which covers six technology focus areas: wind, solar, bio-energy, nuclear fission, CCS and electricity grids. The SET-Plan signifies the most ambitious effort on the part of the European Union to put forward a coordinated policy framework for advancing clean technology innovation and deployment in order to meet the EU's ambitious carbon and renewable energy targets. However, there is no one strategy or approach to a clean industrial policy framework within Europe. Each member state is driven by its own economic and political agenda. A number of member states have stated their views regarding the proposed six industrial initiatives. Austria in particular has expressed strong reservations about the promotion of nuclear energy. France on the other hand is pushing to make sure its global leadership in nuclear technology is reflected in the plan and backed by the EU.

Europe‘s green stimulus might be considered small compared to the big stimulus projects in the United States, China, and Korea, but that is in large part because Europe has already invested heavily in renewable energy and efficiency and has a fairly advanced clean energy technology

manufacturing industry. The EU 27 put forward $11.3 billion in green stimulus allocation, while individual member countries announced additional green stimulus spending. Germany's stimulus package contained $8.4 billion for green investments, Italy provided $2.6 billion, and France provided $2.4 (see figure 2).[10] Of the total European Union stimulus, 64 percent is dedicated to energy issues (this figure is closer to 10 percent for EU plus member country stimulus in aggregate). The biggest focus in Europe is on building efficiency, with about a third of the green stimulus in Europe directed to those projects. Most of the money is distributed by individual EU member state stimulus plans. Over half of the European Union stimulus package is focused on carbon capture and storage and low carbon power generation.

Figure 2

Green stimulus allocations to sustainable energy, billion $		
EU-27	$	11.30
Germany		8.40
Italy		2.60
France		2.40
Spain		0.80
United Kingdom		0.30
Total	$	25.80

Source: Michael Mehling "Transforming Economies Through Green Investment," German Marshall Fund, 2010

EU green policies and incentives

Investments dedicated to R&D in the SET-Plan was EUR3.3 billion in 2007, with R&D investments dedicated to CCS, smart grids, biofuels, wind energy and PV around EUR300 million each. Almost 80% of the government investment under the SET-Plan is at national level. In 2009, the European Commission had approved a ramping up of investment even more in the clean technology sector as part of an economic package. The Commission put out a roadmap that

outlined $73 billion of investment over the next ten years, but that was not a budget appropriation. Instead, this figure is a goal and vision set forward by the Commission, much like a lot of its work in the clean technology sector. The budgetary implementation is determined by the states themselves. The Commission has already begun to distribute some of the funds, particularly in the area of CCS and wind deployment.

Solar

In the area of solar, the SET plan outlines the Solar Europe Industry Initiative (SEII). The initiative focuses on reducing the generation costs and outlines R&D priorities in the area of solar.

CCS and wind

Over EUR1.5 billion was committed for 15 CCS and offshore wind projects. The overall funds earmarked for the clean tech sector under the economic stimulus plan were EUR4 billion. If this program goes through the total installed capacity of all CCS power plants will be about 2.4GW. In addition to the stimulus package, in 2009 the European Investment Bank made available EUR17 billion in loans for climate related investments and projects.

Nuclear

The SET Plan included nuclear power as one of the non-fossil fuel technologies. Specifically, the Plan established the Sustainable Nuclear Fission Initiative to develop a new generation of reactor

(the Generation-IV reactor). The plan outlines R&D investment strategies and aims to reach commercial deployment of these reactors by 2040.

LED

One policy advanced by the European Commission that helps the deployment of LED lighting is the December 2008 decision to phase out incandescent light bulbs by 2012.

Clean Energy Policies at the Member State Level

The most important concrete actions to stimulate investment in clean energy technologies, especially wind and solar, have been taken at the individual member states. The following table (figure 3) shows the range of Feed in Tariffs adopted by European countries and as will be noted later these policies have proven to be effective. Germany and Spain have been particularly active in promoting renewable investment.

Figure 3

Feed in schemes in 2009 (€)/kwh[11]

	Wind onshore	**Wind offshore**	**Solar PV**
Austria	**.07**	**-**	**.29-.46**
Belgium	**-**	**-**	**-**
Czech Republic	**.11**	**-**	**.46**

Denmark	**.08**	**.08**	**-**
France	**.08**	**.31-.58**	**-**
Germany	**.05-.09**	**.13-.15**	**.29-.55**
Italy	**.30**	**.30**	**.36-.44**
Netherlands	**.12**	**.19**	**.46-.58**
Poland	**-**	**-**	**-**
Portugal	**.07**	**.07**	**.31-.45**
Spain	**.07**	**.07**	**.32-.34**
Sweden	**-**	**-**	**-**
United Kingdom	**Tariffs scheduled for 2010**		

Germany

Germany remained a clean energy manufacturing powerhouse and is one of the world's top countries for installed capacity, especially in the solar sector. Germany invested $4.3 billion in clean energy and was the leader in the solar sector in 2009. The main reason behind this success, aside from a long history of clean technology manufacturing and a government vision for clean energy, is the feed-in tariff program. However, the FiT program has faced significant challenges and cuts.

The program was created in 2004 with generous tariffs and a 20 year flat rate contract. Under the original system, rates paid to solar providers would decline 5 percent each year for rooftop solar and 6.5 percent for ground installations. This program created a boom in the solar market in Germany. However, as the rush to cash in on these new incentives overwhelmed the government, the program incentives were altered. After much negotiation and parliament approval, the German government in July 2010 cut the rates for rooftop PV by 16% and ground mounted solar by 15%.

Spain

Spain invested more than $10 billion in clean energy in 2009, with much of that funding going toward solar. Following Germany's example, Spain had created a feed-in tariff program with a national cap of 400MW intended to carry the industry from 2007 through 2010. Because the FiT rates were generous and the government carried the budgetary burden of funding the program, the market responded by flooding the Spanish solar sector. As a result, the government reduced the FiT incentives in 2009 and imposed a cap of 500 MW.[12] In August 2010, Spain's industry ministry announced further changes to the solar FiT. The Ministry cut subsidized electricity prices paid to new large, ground based PV power plants by 45%, while large roof PV projects were cut by 25%. Spain plans to cut its wind tariff premiums by 35%. [13]

While Europe does not have a local content requirement, there are a few interesting trends that indicate a growing trade and protectionist sentiment in the clean tech sector. For example, in Spain while there is no national or EU-wide mandate for domestic content in clean energy projects, some regional governments have taken it upon themselves to implement requirements

of up to 70% local manufacturing content. According to some estimates about three-quarters of Spain's installed wind farms are supported by domestic manufacturing.[14] On a more macro level, the European Union is debating what steps to take if a global climate accord does not materialize. In that case, there are some who propose putting up trade restrictions and tariffs to account for the carbon content of the products.

Japan's Clean Energy Vision

Japan has established aggressive greenhouse gas reduction targets over the past two years. The "low carbon revolution" proposed by then Prime Minister Aso, in April 2009, aimed at supporting the economic growth and addressing climate change challenges through the installed capacity of solar power generation to increase by 20 times by 2020, "eco car" to make up half of the new vehicle sales by 2020, the use of energy efficient appliances, the development of low carbon emission transport system (through tax breaks/subsidy provision), the increased energy and mining supply/mineral security, and international cooperation on water treatment technology. In September of 2009, Prime Minister Hatoyama announced a target of reducing Japan's GHG emissions by 25% below 1990 levels by 2020. This target has been reiterated by Prime Minister Kan.

In December 2008, the Japanese government announced a $486 billion stimulus package with a very small carve out for green investment. The second stimulus package of $154 billion announced by Japan in April 2009 made a more significant investment in climate-related projects with more than 15% of the new package ($23.6 billion) going to clean technology. Solar and

energy efficiency promotion received the lion's share of the funding. Overall, Japan allocated $36 billion for investment in clear energy technologies, including $18.3 billion for energy efficiency and $3.7 billion for low-carbon vehicles.[15] Over the next five years, Japan plans on investing approximately $66 billion in clean energy technologies, of which $36 billion to support the deployment of clean energy and energy efficiency technologies and $30 billion to undertake clean technology R&D, with focus on solar energy, low-emission vehicles, and energy efficient technologies.[16]

Japan has identified 21 clean energy technologies to support from R&D to deployment phases.[17] For each of the selected technologies, the government has also developed a technology roadmap through 2050. [18] The government is focusing on CCS, solar PV, and nuclear power generation as key growth areas. In 2008, Japan spent $3.9 billion on R&D in the energy sector. The International Energy Agency's ranking of energy R&D places Japan just below the United States. The majority of these R&D funds went to nuclear (65%), with energy efficiency receiving 12%.[19]

Through effective policies in the past decade, Japan has been able to make leaps in the area of energy efficiency. Japan's Top Runner program sets extremely stringent and demanding efficiency standards for a range of Japanese products. The Japanese government plans to be 30% more efficient by 2030. Figure 4 was taken from the Outline of the Year 2010 Resources and Energy related Budget Proposal by the Ministry of Economy, Trade and Industry shows the proposed allocation in the 2011 budget for low carbon technologies and energy efficiency.

Figure 5 highlights the key technology areas where the Japanese government is focusing its investment.

Figure 4

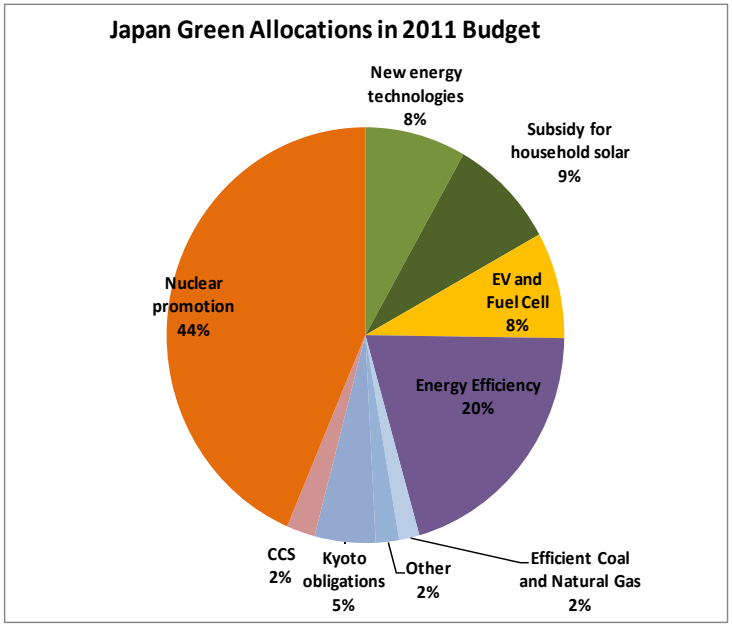
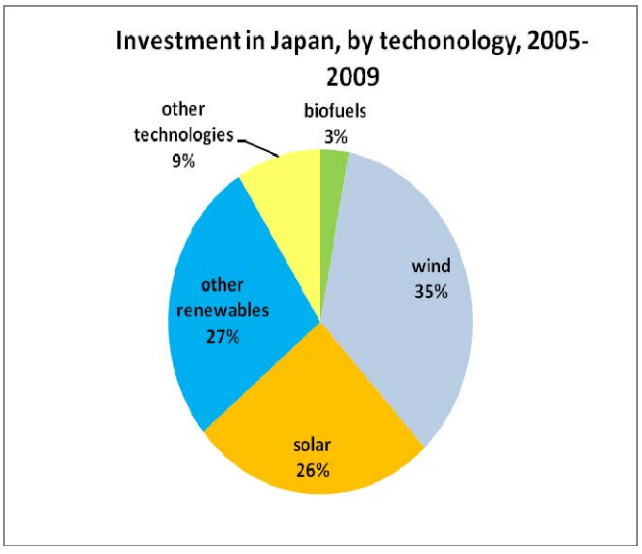


Figure 5



Source: Pew Charitable Trusts, *"Who's Winning the Clean Energy Race?" March 2010*

Japan green policies and incentives

Wind and Solar

Japan is a leader in the solar industry as a result of years of investment and promotion of solar manufacturing and deployment. The government had a very robust feed-in tariff program that has result in the installation of 1.7 GW of solar power. The feed-in tariff today applies only to residential solar installation. The government's FiT is considered a very successful case. It started in 1994 and was drawn down in 2003. In conjunction, the Ministry of Economy, Trade and Industry established the New Sunshine Project in order to boost the domestic solar industry by funding the industry all along the value chain, from research and development to demonstration and deployment. Other programs include the 5-Year Plan for Photovoltaic Power Generation Technology Research and Development and Residential PV System Dissemination Program. Japan now has a mandate to source 28 GW of its electricity capacity from solar by 2020. The Japanese government has established a similar mandate of 5 GW for wind by 2020.[20]

Nuclear

Japan is a leader in nuclear technology development and is home to many companies that export nuclear component and know-how to countries around the world. Japan's clean technology strategy focuses heavily on nuclear power and technology. The biggest tranche of Japan's R&D budget each year is allocated to nuclear energy. The Ministry of Economy, Trade and Industry has set a goal of reaching 61.5 GW in nuclear capacity by 2017 (compared to 47.5 GW today),

equivalent to 41% of the total generation (compared to 30% today). In June 2010, METI released a goal of bringing online 9 additional nuclear reactors by 2020 and 14 more by 2030. The plan also outlined a goal of 85% utilization rate for those plants by 2020 and 90% utilization rate by 2030.

LED

LED is one of the 21 technologies outlined in the Cool Earth program. Japan's Basic Energy Plan sets LED deployment targets, aiming for 100% high efficiency lighting penetration of such by 2020. Through METI, Japan has launched a five-year 2,642 million yen program to encourage and deploy LED. Under METI, NEDO has launched a project for LED as well.

CCS

Japan has taken a few steps to advance CCS technology and deployment. In 2008, the government set a goal of capturing and storing 100 million tons of CO2 annually by 2020. Under the Cool Earth initiative, Japan has committed to reducing the cost of capturing carbon by 75%.[21] METI is leading the effort to build out CCS facilities in Japan.

Smart Grid

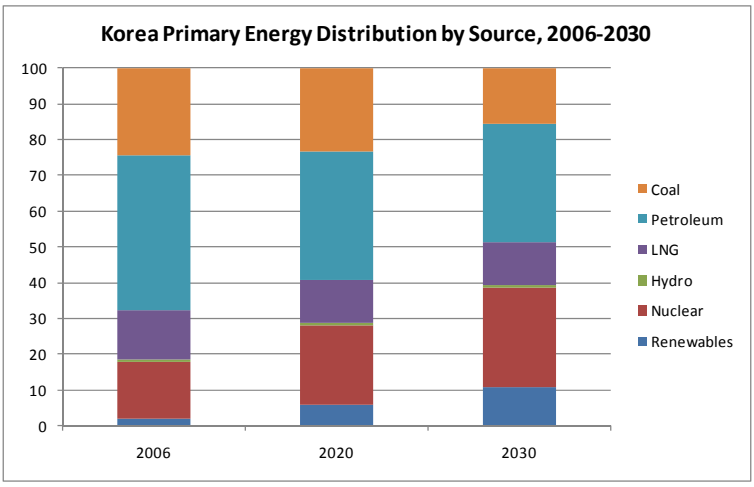
The Japanese government has invested a lot in making the country's grid system more efficient, with an estimated $100 billion already invested to upgrading plants and transmission. Large Japanese companies like Toshiba and Mitsubishi Heavy Industries have made investments in

smart grid projects overseas. The Japanese government is lobbying for Japanese smart grid standards to become international and for the country to become a leader in smart grid technology.[22]

Korea's Clean Energy Vision

The vision and agenda of Korea's green industrial policy is intimately linked to President Lee's vision for the country. President Lee has demonstrated an interest in taking a leadership role, starting with his 2008 speech on the 60th anniversary of the founding of Korea. One of the Korea government's main organizations responsible for turning these green policy visions into real progress is the Energy Management Corporation (KEMCO). KEMCO is a government-backed organization responsible for implementing the Korean government's energy efficiency and climate mitigation goals. The government has adopted a wide spectrum of policy tools to advance this green industrial agenda. The *First National Basic Energy Plan (2008-2030)* launched in August 2008 and aimed at increasing the share of renewables into Korea's energy mix to 11% by 2030 (figure 6 illustrates the Korean governments energy goals). Korea has stated a overall goal of lowering its greenhouse gas emissions by 30% the business as usual level in 2020 or about 4% below 2005 levels.

Figure 6



Source: Korea Ministry of Environment website

The second is an economic stimulus package referred to as the "Green New Deal." In January 2009, South Korea launched a stimulus program of $38 billion, of which an unprecedented 81% went to green investments. This included $17 billion for clean energy technologies.[23] The second stimulus, announced in July 2009, was rolled out under the framework of the *Five Year Green Growth Plan*. Under this stimulus, the government committed to spending $83.6 billion over the next five years, $22.3 of which will be directed to advancing green industries.

Lastly, the government has placed a significant emphasis on research and development, best highlighted under the *Third Basic Plan for New and Renewable Energy (NRE) Technology Development and Deployment*. The government plans to significantly boost energy R&D spending over the next five years, committing approximately $6.6 billion (or $1.3 billion per year) on clean energy R&D to advance 27 core green technologies including LED technology, solar, and hybrid vehicles.

This green growth plan aims to double Korea's current energy R&D investment, which stood at $595 million in 2008.[24] According to the International Energy Agency, the Korean government's spending on R&D in the energy sector has grown by approximately 16% a year over the last four years. By expanding R&D funding for technologies such as LEDs, solar batteries, and hybrid cars, Korea aims to raise its international market share of clean tech products to 8%.[25] A recent report surveying the OECD international patent database assessed that South Korean companies ranked 12th in the world for clean technology patents, highlighting that South Korean companies filed around 2.5% of the 700 renewable energy patent applications in 2005.[26]

Preferential financing to small clean technology business will amount to approximately $900 million by 2013 and the Korean Development Bank will also establish a $237 million fund to support R&D activities of private sector green industries.[27] This plan also includes $5.6 billion in loan guarantees in 2013 (currently at $2.2 billion) and export financing of green products of $2.3 billion in 2013.[28] This effort is backed by a complementary bank lending stimulus. Shinhan Bank has started to give prime interest rates to environment-friendly companies from April this year. The State-run Korea Development Bank and Export-Import Bank of Korea have planned to invest 1 trillion won ($860 million) and 840 billion won ($730 million) in the industry this year, respectively.[29]

Korea green policies and incentives

Wind and Solar

The government has declared renewable energy targets of 2.25GW installed wind generation and 1.3GW of solar. By far the most significant policy to advance those goals is its FiT program, although changes to the program have slowed down wind and solar deployment. The Korean government FiT program is intended to incentivize the production of solar and wind power. Wind projects are eligible to receive a FiT of $.09 per kWh for the first 15 years of plant operation. The FiT rateis set to decline at a rate of 2% per year until 2012, when the FiT program is slated to end. Solar feed-in tariffs are set at 8 times the average cost of residential electricity.[30] The FiT program has had problems taking off, in part because of the way it was designed. South Korea's feed-in tariff is unique in that the government pays for the program. In most feed-in tariff systems the burden of the FiT is pushed down to the ratepayer. This has created a significant budgetary stress, and forced the government to decrease in the cap for solar feed-in tariff rates in 2008.

When the program was originally introduced in 2002, the incentives were capped at a total accumulated capacity of 20 MW. By 2007, the cap was raised to 100. In 2008, the cap was raised even further to 500 MW.[31] The Ministry of Knowledge Economy reduced the subsidies for renewable energy sources, limiting the subsidy coverage to 50 MW in 2009, 70 MW in 2010 and 80 MW in 2011.[32] The government's decision to decrease the overall cap for solar feed-in tariffs was also driven by another rationale. Realizing that the majority of the clean technology components being used for the renewable energy production were being imported from overseas, the country wanted to set up a policy approach that would encourage and nurture domestic clean tech manufacturing.[33] When the government announced the passage of the renewable portfolio standard, officials made it clear that the current feed-in tariff policy would only remain in place

until the RPS went into effect in 2012.[34] The main reasoning behind this government decision was based on the notion that a renewable energy standard would generate enough incentive for investment in solar and wind energy. The government was forced into this decision in large part because it was becoming burdened by the public funding required to continue the feed-in tariff program.

The government does provide subsidized loans to help renewable project developers finance wind and solar projects. Government subsidies of up to 70% of a renewable energy project (including demonstration projects) are also available.[35] The government has also offered to compensate banks if they take on the risk of financing renewable energy projects.[36]

Smart Grid

Korea launched the "Smart Grid Roadmap" in 2009, which outlines a strategy for building a national smart grid by 2030. Through the stimulus, Korea allocated for smart grid is about $6.2 billion for smart grid R&D and $18 billion for building infrastructure.[37] The initial target for investment is the country's smart grid pilot project on the island of Jeju. The country has picked 10 companies along with KEPCO to build out the infrastructure.[38] The stimulus plan also allocated $65 million toward a smart grid pilot project 2011. South Korea has signed cooperative agreements with the United States to collaborate on the development of smart grid technologies.[39] Additionally, Korea's national utility company has committed to spending a portion of its $2.36 billion budget for clean energy R&D on smart grid technology.[40]

Nuclear

Korea's emphasis on nuclear technology can be identified in the percentage allocated to the technology in the government's overall R&D investment in clean technologies. In 2008, of the $595 million invested in energy R&D, over 40% of that investment went to nuclear power, while renewable energy and energy efficiency made up the second and third largest tranches.[41] The government's 5 Year Green Growth Plan outlines plans to promote nuclear power in the country's energy supply, from 24% in 2009 to 32% in 2020. To meet this goal, the Korean government has committed to invest in the building of 10 domestic reactors by 2030 in the country (not including the 8 under construction). Further, Korea is a growing exporter of nuclear power plant technology, recently beating out France and Japan for a contract in the UAE, increasing its international profile.[42] Following this sale, the Korean Government declared that its plans to increase exports of nuclear power technology to become a leading supplier of nuclear technology along with the United States and France.[43] This includes the operation, maintenance and repair of reactors, which helps Korea maintain an active, skilled workforce in the nuclear industry.

LED

In 2008, Korea announced the LED lights 15/30 Dissemination Project. Under this project, the Korea government intends on distributing LED technology to make up 30% of the country's lights by 2015.The Korean government is focusing on LED technology as a key strategic area for its clean industrial policy. The market for LEDs has excellent growth potential, with analysts like Strategies Unlimited predicting annual growth rates of 20% over the next five years. Korea

has the potential of becoming a leading world manufacturer of LED technologies, and government incentives are aimed at making that a reality. The Korean government has mandated the conversion of one million light bulbs to LED technology and plans to replace all incandescent light bulbs at public facilities with LEDs by 2012. In February 2010, the government announced a plan to invest $47 million to promote LED products. This investment plan will most likely come in the form of consumer subsidies covering up to 50% of installing LED lighting, and a 10% tax credit option of businesses that do the same.[44]

CCS

In October 2009, the Korean government established a carbon capture and sequestration (CCS) research and development program that will fund pilot projects. Total investment will amount to $85.5 million by 2013 on R&D. In addition, the government will set up a consortium to finance a 500MW pilot power plant by 2015. The nationalized Korea Electric Power Corp (KEPCO) will be given $1.1 billion in funding through 2020 for CCS R&D and implementation.[45]

U.S. Vision

The Obama administration has set a target of reducing greenhouse gas emissions by 17% below 2005 levels. The vision for greening the economy has become intimately linked with the financial crisis and the need to create jobs. Policy makers in the U.S. believe that promoting a clean technology sector will make the United States competitive in the 21st century, and this view is predicated on the notion that the clean technology sector will become a significant market. Mitigating climate change and jobs are inherently linked, as Secretary Chu highlighted when he

noted, "The world urgently needs to move toward clean energy technologies, and the United States has the opportunity to lead in this new industrial revolution. Today's awards will create new jobs and jumpstart the industries we need to both solve the energy problem and ensure America's future competitiveness."[46] The clean energy legislation and debate in the United States is based on a need to promote clean technology manufacturing, and competition from countries leading the way, such as China and the European countries, is a big focus.

The Climate Change Technology Program (CCTP) created during the George W. Bush administration was intended to provide a comprehensive technology initiative for the United States government, but the initiative's profile was lowered when the Obama administration came into office. Aside from the CCTP, the U.S. has pursued clean energy technology primarily in an ad hoc fashion. Incentives such as the production tax credit and investment tax credit have been brought up for consideration year-on-year without any permanence. This provided investors in renewable energy with little policy certainty, since tax credits could not be guaranteed in the future and therefore posed risk to their projects. The stimulus package extended the incentives by three years but will soon be up again for reconsideration. Comprehensive energy legislation that makes these incentives into law would provide the necessary policy signal. The green components of the American Reconstruction and Reinvestment Act (ARRA), the stimulus package passed by Congress in February 2009 marked the largest investment in clean technology by the United States. Aside from directly funding clean technology deployment and manufacturing, the stimulus package also invested in clean tech R&D. However, the programs and incentives were not necessarily part of a grand vision and strategy.

The Obama administration did release "A Framework for Revitalizing American Manufacturing" in December 2009, in which the administration outlined an industrial policy catered towards advancing the clean tech manufacturing sector. The Obama administration's focus on manufacturing jobs or "green jobs" is easily seen in this document. For example, the document boasts that, "Hourly total compensation in the manufacturing sector averages more than $32.00, approximately 22 percent higher than average compensation in service industries." The framework outlines an ambitious agenda to promote the clean tech sector in the United States, including heavy investment in research and development (R&D), access to capital, and public investment in infrastructure.

U.S. Green policies and incentives

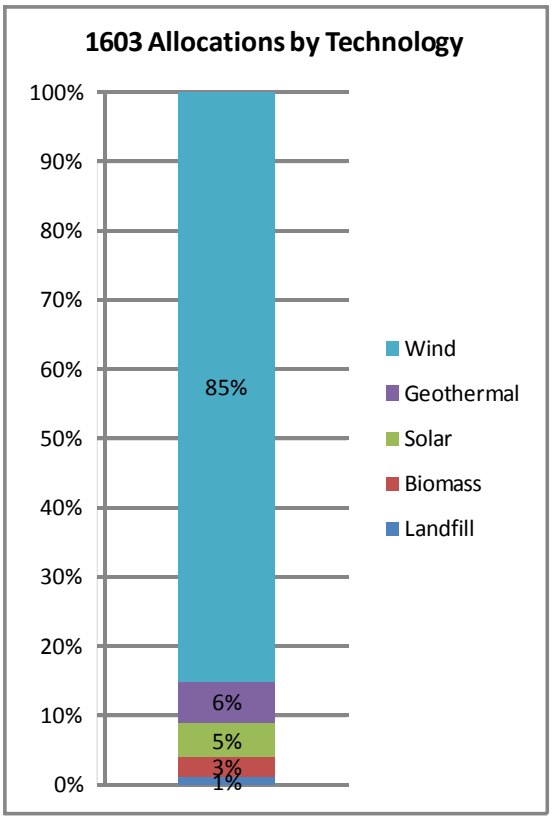
The American stimulus package serves as the most significant source of support for clean energy technology. Climate change and energy legislation continues to stall in Congress, largely as a result of the financial and economic crisis and the strain a price on carbon would put on the US economy. A recent last ditch effort by Democratic leaders in both the House and Senate to pass energy legislation before the midterm elections in November failed and even other initiatives such as legislation related to the Gulf oil spill bill and an RES seem unlikely to be passed..

Wind and Solar

Prior to the stimulus bill, wind and solar projects were eligible for a production tax credit (PTC) and an investment tax credit (ITC). These energy producers were able to tap into a growing tax equity market in order to take advantage of these policies. The biggest problem with the ITC and PTC were that they were extended a few years at a time, leaving investors and developers with

little policy certainty. The second problem arose with the financial crisis, when big banks that had taken advantage of the tax incentives by teaming up with wind and solar developers were hit by the financial crisis and no longer had any need for tax equity instruments.

Figure 7



Source: Recovery.gov, Department of Energy, May 2010

The stimulus package extended the ITC and PTC for solar and wind (to 2012 and 2013, respectively) but it also created the very popular 1603 program (see figure 7). This program allowed renewable energy projects to receive a 30% cash grant in lieu of tax credit. This program ended up attracting much attention and much controversy, in large part because of the boon it provided to foreign renewable energy firms. For example, when the DOE and Treasury

distributed a $1 billion tranche of these funds to support renewable energy projects in the United States, over 90% of the funding went to wind projects. Of those wind projects, 77 percent of the funding went to foreign companies. The European firm Ibedrola won 57 percent of the total wind funding, in large part because the company had the most shovel-ready projects. This raised alarm in Congress about the loss of jobs, with some calling to establish local content requirements and other trade/protectionist barriers.[2]

Another program used by the DOE to promote renewable energy is the 1703 loan guarantee program. This program was created under the Energy Policy Act of 2005 but was enhanced and strengthened through the stimulus package. The loan guarantee program has had a slow start and is only now starting to be used by renewable energy projects.

Almost all of the methods employed by the US government to promote and deploy renewable energy are through the stimulus funds. This is an expensive method of nurturing a nascent industry, however, continuing such programs over the long term or in large enough sums to ramp up economies of scale will prove difficult. With the majority of U.S. stimulus funding awarded in 2010 and 2011, and no national renewable energy standards or carbon price in place, the renewable energy industry's viability in the United States will face a significant challenge.

Smart Grid

Approximately $15 billion was allocated through the stimulus package toward smart grid investments and transmission improvements. This is a significantly larger amount than was invested by the government before the stimulus, but there is no indication that funding levels will

[2] Calculated based on data from DOE and Treasury Web site listing awardees for the 1603 cash grant program.

continue at this level once the ARRA money has run out. Since it is estimated that just digitizing the grid will cost up to $400-500 billion, the stimulus funds are a good start but nowhere near adequate for getting the entire job done. Another problem for the grid is the shovel-ready requirement, since it takes between 7 and 10 years to cite a new transmission line. Funding is therefore most likely to be directed to fixing existing lines. The stimulus funds have been used to support grants to 100 smart grid projects across the US, totaling about $3.4 billion.

Local resistance to smart metering and smart grid pilot programs has already started. This push back may become a significant obstacle in future deployment of smart grid technologies in the United States. Maryland's experiment with smart meters could be a bellwether case for smart grid in the United States. In June 2010, the Public Service Commission of Maryland rejected implementation of a metering system proposed by the local utility because of ratepayer concerns about rate increases and overall higher costs because of tiered pricing.

Nuclear

The Energy Policy Act of 2005 provided $18.5 billion in loan guarantees for nuclear power projects as well as other financial incentives. However, only about half of this amount has been was awarded for one project because of political and bureaucratic hurdles in moving forward. The Obama administration is seeking an additional $36 billion in loan guarantee authority that could provide crucial support. Industry officials do not believe that the loan guarantee program is sufficient in keeping the United States in a competitive position in the global nuclear technology market. Investment in nuclear R&D has dwindled in the past decade.

LED

The 2007 Energy Independence and Security Act created a mandate that will essentially require the phase out incandescent light bulbs by 2014 with the first year starting at 2012. In January 2010, the DOE distributed $37 million in funds to support LED projects under the Solid State Lighting Program. The funding supported 17 projects that encompass core research, product development, and domestic manufacturing. The budgets for 2009, 2010, and 2011 contain funding for R&D and deployment of solid state lighting. In 2009, the Emerging Technologies subprogram seeks to develop cost-effective technologies (e.g., lighting, windows, and space heating and cooling) for residential and commercial buildings received $39.5 million, and in 2010 the subprogram received $20.7 million.

CCS

CCS has received considerable attention in the United States. There are several initiatives underway to advance that technology. The DOE 2008 and 2009 budget channeled money toward developing CCS technologies. The 2008 budget allocated $500 million and the 2009 budget allocated $700 million. The stimulus package was the most significant investment in CCS, with $3.4 billion allocated toward advancing the technology. The funding covers research and development and carbon capture demonstration projects. The US government has four main programs to support the development of CCS: the Regional Carbon Sequestration Partnerships, the Clean Coal Power Initiative, the Carbon Sequestration Program, and the Gasification Technologies Program. Demonstration projects are being funded in both power generation and

industrial sectors with about $1.4 billion devoted to power project and $1.5 billion to industrial projects. The Regional Carbon Sequestration Partnerships Program, which is designed to study possible sequestration sites, is the most comprehensive collaborative private sector-industry-government effort underway in the United States tasked with coordinating CCS in the country. A program created in 2003 by the DOE called the FutureGen program has faced challenges in lifting off the ground. The FutureGen project was originally intended to be a first-of-its-kind full sized coal-fueled, near-zero emissions power plant integrated with CCS technology. This original proposal encountered serious financial difficulties and the Department of Energy recently announced a new concept which will involve repowering an existing small coal power plant which can be outfitted with CCs technology. The Federal share will be $1 billion. The total investment by public and private resources for CCS demonstration projects could be a high as $13 billion if all projects mature as designed.

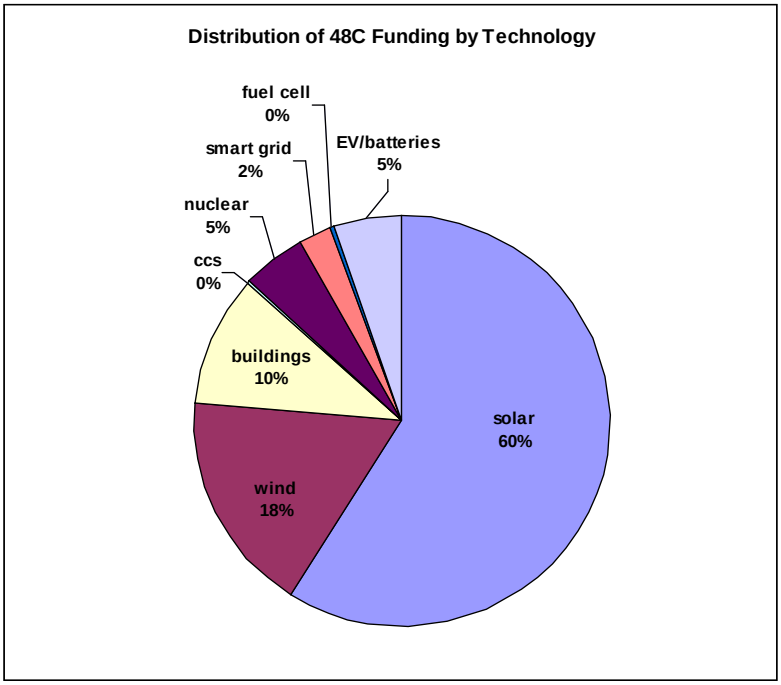
Manufacturing

The most targeted effort toward increasing domestic manufacturing of clean technology is the 48C advanced energy manufacturing tax credit which was built into the stimulus package**.** 48C supports the building and equipping of new, expanded, or re tooled factories that manufacture the products needed to power the green economy. The program covers a wide array of clean energy technologies, including renewable energy, energy efficiency, advanced transportation, and advanced transmission. The Recovery Act included $2.3 billion in tax credits that will support over $7.5 billion in total capital investment.

This program has generated far more interest than anticipated. DOE and Treasury received

significantly more technically acceptable applications than the sources to fund. Instead of turning down worthy applicants who are willing to invest private resources to build and equip factories that manufacture clean energy products in America, on December 16, 2009 the Administration announced its support for expanding the program by up to $5 billion. This funding will go to shovel ready projects that will create tens of thousands of new construction and manufacturing jobs and continue America's emerging leadership in manufacturing the clean energy products of the future. Figure 8 illustrates the technology focus areas for the program. As the graph shows, a large portion of the 48C credits went to solar.

Figure 8



Source: Department of Energy/Recovery, "President Obama Awards $2.3 billion for New Clean-Tech Manufacturing Jobs," July 2010

Federal versus state incentives

There have been a few recent successes in bringing clean technology manufacturing to the United States. For a company, bringing component production and assembly closer to market is compelling. Significantly cheaper labor, land costs and capital availiblity in other countries, particularly Asia, and a lack of demand for renewable energy generation in the U.S. market have preventing this from happening. On a federal level, manufacturing incentives such as the 48C through the stimulus are a great way of changing the calculus for companies like Tesla Motors, SunPower and other clean tech companies. SunPower has just recently announced the opening of a plant in Milpitas, California, to assemble solar panels, although the solar cells themselves will still be produced in the Philippines. Aside from being able to apply for the 48C, SunPower is eligible for up to $24 million in Department of Energy funding under Solar Energy Technologies Program designed to drive down the cost of solar manufacturing. This agreement was initiated in 2007 under a program intended to promote solar technology improvements along the value chain in order to reduce solar cost.

While the company attributes the decision on federal assistance, state level policies and incentives are largely responsible for this move. A California program introduced by Governor Arnold Schwarzenegger will exempt SunPower from sales tax. California's ambitious renewable portfolio standard of 33% provides confidence in future demand for solar.[47] In 2009, an agreement was made with Tesla Motors and the California Alternative Energy and Advanced

Transportation Financing Authority to give them exemption from paying sales tax on the equipment they purchase to produce zero-emissions vehicles.[48]

While Department of Energy and U.S. stimulus incentives provide opportunities for research and development in clean technology as well as investment in clean energy production and manufacturing capacity, the state level incentives are often just as effective. In a vacuum of federal action on climate change and energy policy, state level policies have in many ways led the way. Approximately 30 states have instituted RPS programs. State Renewable Portfolio Standards have started a bottom-up approach to incentivize renewable energy generation across the United States. While state RPS programs have provided a certain level of policy stability and demand for renewable energy, there is a good argument to be made for a federal RES program, if devised correctly. State governors feeling political pressure and public backlash may opt to roll back RPS policies, something a federal RES would be able to prevent.

The RPS programs have created the beginnings of a Renewable Energy Certificate (REC) market. Energy projects can depend on an additional cash flow for the project from selling the RECs, which are the environmental attributes related to 1 megawatt of renewable energy generated. Green certificates and RECs might not seem to boost development as much as feed-in tariffs do, but they help ensure that capital is efficiently allocated towards the most cost-effective renewable energy projects available.

Lessons learned for policy makers

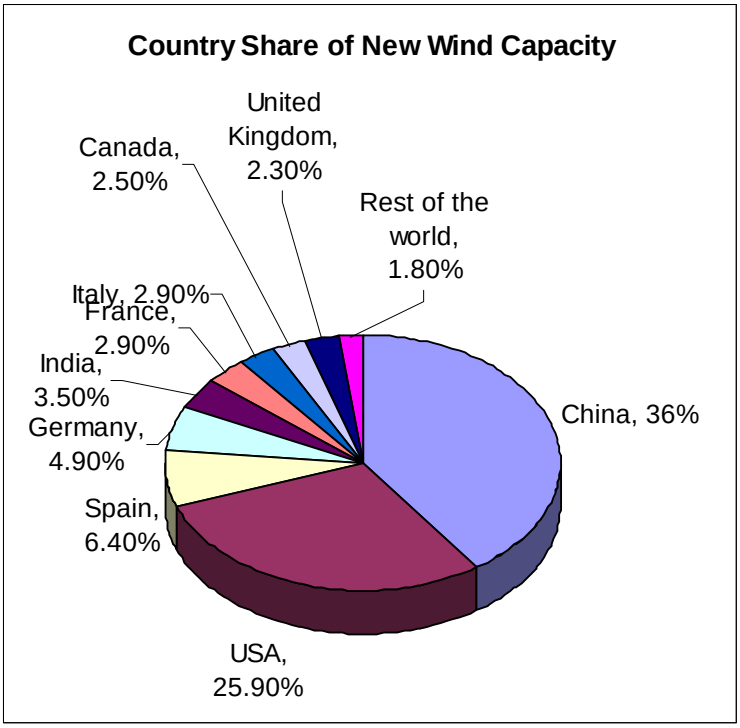
Results: global installed capacity and manufacturing

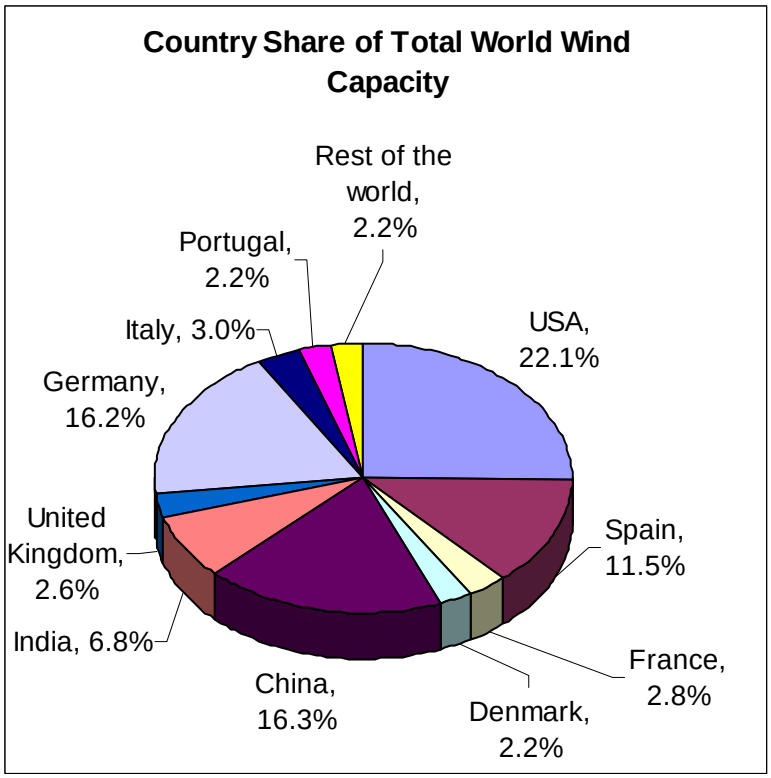
The most obvious area to focus on when assessing the results of clean technology promotion policies across the globe is in sales of clean technology products. A recent report by WWF and Roland Berger Strategy Consultants attempted to rank countries in terms of global clean energy technology product sales. For the year 2008 the United States was ranked 2nd, Japan ranked 3rd and China ranked 4th. However, when weighed according to GDP, China came in 6th while the United States trailed at 19th place. A Pew Charitable Trusts report titled, "Who's Winning the Clean Energy Race?" used data from New Energy Finance to determine that in 2009 China has surpassed the United States in overall clean energy finance and investment, reaching $34.6 billion. The United States came in second with $18.6 billion. The breakdown in investment by technology demonstrates that a majority of that money has been directed to wind projects, and to a smaller extent solar projects. The U.S. clean technology industry exported about $7.7 billion in products and services between 2004 and 2008, compared to China's $22.7 billion and Germany's $19.6 billion.[49]

Other metrics for measuring policy success could be deployed clean technology, manufacturing capacity and green jobs. China and the United States have the largest markets for wind, with the two countries accounting for 61.9% of additional wind capacity. Following behind them are Spain, Germany, India, France and Italy (see figures 9 and 10 below).[50] The global PV market is led by Europe, which has almost 16 GW of installed capacity in 2009 (or 70% of the world installed PV power at the end of 2009). Japan comes in second with 2.6 GW and the US comes in third with 1.6 GW. In 2009, China made a dash for solar PV installations, bringing the

country into the top ten category for world PV markets.[51] Figure 11 below shows global solar deployment by country.

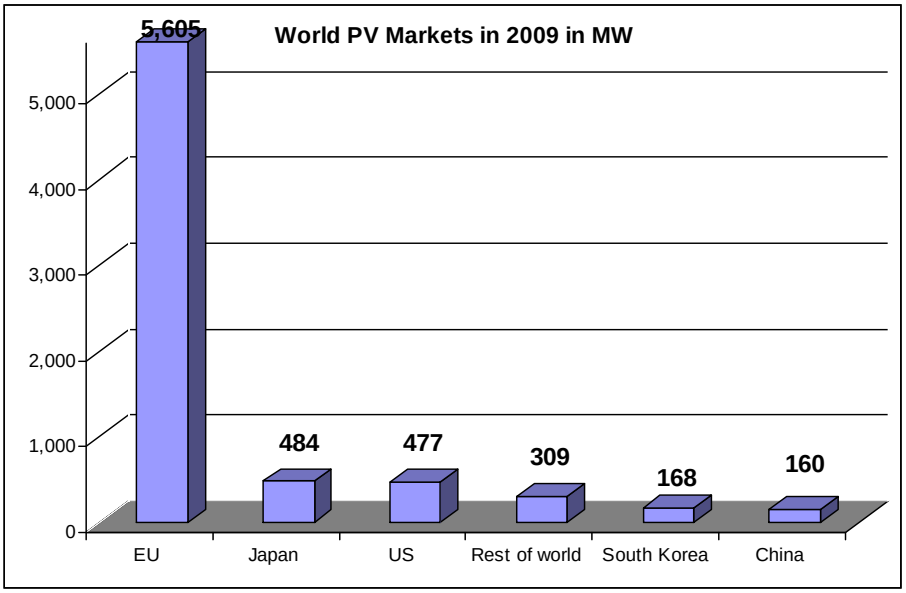
Figures 9 and 10





Source: World Wind Energy Association Report 2009

Figure 11



Source: Source: EPIA, Global Markets Outlook for Photovoltaics until 2014, May 2010

The clean jobs table below as well as the absence of data for other renewable energy sources, CCS, LED and smart grid deployment in the countries covered in this paper is indicative of the small scale of these technologies. Solar and wind have dominated the clean technology sector and therefore drawing conclusions about best policy methods to promote them is much clearer than with CCS, LED and clean technology. Figure 12 provides some color to distribution of jobs by country and technology.

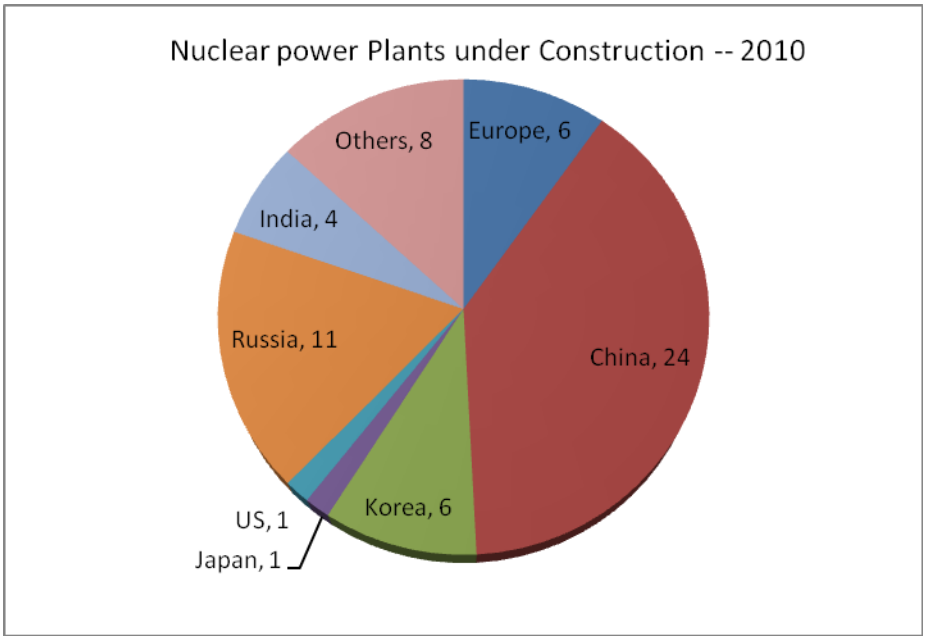
Figure 12

Jobs in Renewable Energy (2009)		
Global		National breakdown estimates
Biofuels	1,500,000.00	Brazil 730,000 for sure cane and ethanol production
Wind power	500,000.00	Germany 100,000; United States 85,000; Spain 42,000; Denmark 22,000; India 10,000
Solar hot water	300,000.00	China 250,000
Solar PV	300,000.00	Germany 70,000; Spain 26,000; United States 7,000
Biomass power	-	Germany 110,000; United States 66,000; Spain 5,000
Hydropower	-	Europe 20,000; United States 8,000; Spain 7,000
Geothermal	-	Germany 9,000; United States 9,000
Solar thermal power	2,000.00	Spain 1,000; United States 1,000
Total	**3,000,000.00**	
Source: REN21, Renewables 2010 Global Status Report		

For Nuclear power one indicator of jobs being created is the number of power plants under construction. The equipment for nuclear power plants can be sourced in international markets so it is difficult to estimate the manufacturing jobs associated with these new power plants. The construction of the plants will normally involve local labor as well as services and can result in significant employment opportunities. As the following table shows (figure 13), China is by far

the leader in the construction of new nuclear power plants. More than one-third of the plants under construction are being built in China.

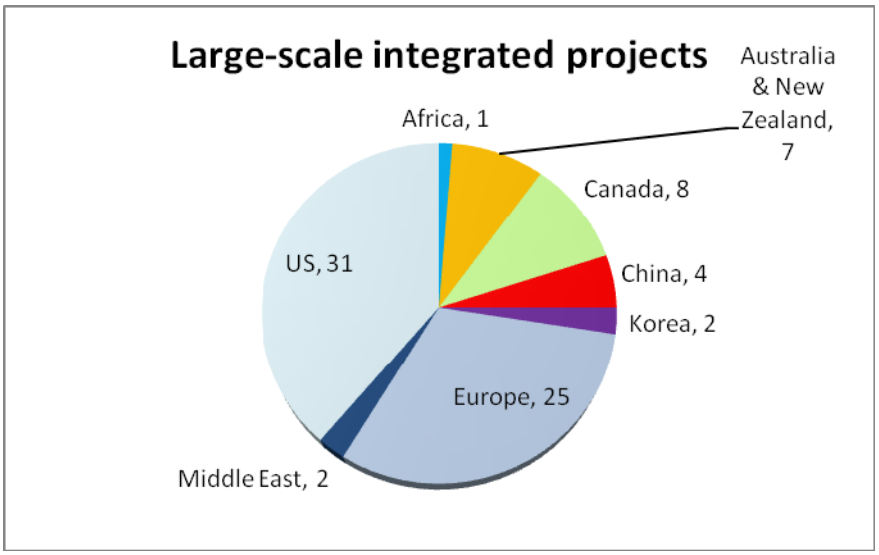
Figure 13



Source: European Nuclear Society, www.euroneuclear.org. Accessed 8/8/10

For CCS projects the Global CCS Institute has issued a report on the status of large scale integrated projects. For 2010, they have identified 80 large scale projects around the world. For this survey large scale integrated projects are defined as projects that cover the full cycle of carbon capture and sequestration at level greater that one million tons of CO_2 per year. As the figure below the United States and Europe dominate the active large CCS demonstration projects with 70% of all projects (see figure 14). Whether this leadership in CCS demonstration projects will translate into significant employment will be determined by the eventual resolution of the technical and economic constraints facing this technology.

Figure 14



Source: Global CCS Institute, *The Status of CCS Project, Interim Report 2010.*

Best Practices

Below is an overview of the policy mechanisms employed by each country outlined in the paper. The previous section outlined results in terms of renewable energy deployment, clean tech manufacturing capacity and green jobs. The correlation between the results and these policies is not definitive and direct, but rather a tool by which to assess what may be an effective policy.

Comparison of Policies to Accelerate Investment in Low Carbon Energy Technologies

Technology	United States	China	Japan	Korea	Europe*
Solar	Production tax credit, investment tax credit, cash grant, loan guarantee, manufacturing tax credit, R&D	Renewable electricity standard, R&D programs	Residential feed-in tariff (large scale FiT expired), capacity target	Feed-in tariff, renewable electricity standard	Carbon price,renewable electricity standard, feed-in tariffs, R&D
Wind	Production tax credit, investment tax credit, cash grant, loan guarantee, manufacturing tax credit, R&D	Renewable electricity standard, feed-in tariff, VAT incentives	Capacity traget	Feed-in tariff, renewable electricity standard	Renewable Electricity Standard, feed-in tariffs, carbon price, R&D
Smart Grid	Stimulus funding, R&D	Government investment	Pilot projects	Stimulus funding	Pilot program, R&D investment
Nuclear	Loan guarantee	Nuclear energy targets, included in RES	Nuclear energy target, R&D investment	Stimulus funding, nuclear electricity target, R&D investment	Carbon price, R&D
CCS	Stimulus funding and budget for demonstration projects	Funding for demonstration projects	CCS goal	R&D funding	Funding for demonstration projects
LED	R&D, phase out mandate	LED goal, government subsidy	LED phase out mandate, R&D	LED deployment target	LED phase out mandate
*Not all European members employ these policies. Please review Europe section for more details.					

Defining which policies have been successful in bringing about these investments can prove quite difficult. How do we define success? The story changes drastically depending on whether you define the success in terms of economic or environmental gains. The two are not always complimentary. If your metrics are reducing GHG emissions at the fastest rate and for the cheapest amount, few of these case studies succeed. If the costs of deploying clean technology

are not as important as ensuring the creation of a domestic clean technology manufacturing sector that will provide employment, the conclusion changes.

Many reports have been written attempting to define best practices. A recent Center for American Progress report titled "Out of the Running?" suggested the basic elements of a successful clean energy generation and manufacturing policy framework includes (1) government investment in R&D, (2) a demand inducing mechanism such as a renewable energy standard, and (3) investment in the necessary infrastructure to enable renewable energy. However, no two countries are the same, making it hard to apply the success of a country like China to the United States or Korea. Germany's successful transition to becoming a clean technology manufacturing giant was in large part dependent on a well-trained labor force and carbon policies in Europe. China's success has only in part been pushed by a domestic market. In fact, almost all of the solar panels manufactured in China are intended for export. China's success, contrary to the European example, is determined by its manufacturing prowess and cheap labor and capital costs. While there is clear reasoning for building up domestic demand in order to drive manufacturing, there are a few exceptions where countries have managed to export their products by driving down the costs. You can focus on exports instead of domestic demand if your product is price competitive.

Furthermore, not all countries will be able to determine and implement a grand strategy to advance its domestic clean technology sector. For example, China's centralized political system, for example, has been particularly helpful in moving wind energy into the market place and increasing the country's share of global PV manufacturing. This is in large part because of the

country's ability to build out enabling infrastructure with limited permitting procedures and to ensure financial stimulus for clean technology companies. Countries where political action is required from the legislative bodies, as is the case in the United States, a presidential vision such as Obama's manufacturing framework document can meet resistance in Congress. The Europeans have met similar issues. While the Commission can outline roadmaps and clean technology goals, it is largely up to individual countries to decide what kind of incentive to put in place.

The reports also emphasize gaining control of the value chain for each clean technology. This reasoning raises some questions. For example, what other technological sectors have demonstrated that innovation only occurs with control of the value chain? There are clear advantages to a company-level control of all the stages of clean technology manufacturing, because of the obvious benefits to economies of scale, but not necessarily on a country-level. If you are looking for country domination of the value chain then you are giving up on a certain level of global market efficiency that comes with a global company's domination of the value chain.

Feed-in tariffs

Many of the countries who have had success in the clean energy deployment results have implemented feed-in tariff programs. These FiT programs could very well be behind the success in the country's growth in wind and solar, however the full picture has yet to come about. Many European countries, including Spain and Germany outlined in this paper, as well as Korea, have

made alterations and gone back on their commitments and FiT guidelines in the past year or two. The implications for their domestic clean energy market and ability to attract investor interest in the future will probably be undermined by these moves. We will have to wait and see what the outcome is before being able to fully assess the efficacy of a FiT program. Other programs currently being considered in the place of FiTs is a reverse auction method like the one used in Brazil for wind projects. The main concern with reverse auction bidding is that a company may underbid and face difficulty in delivering its promised project to the government at the price they originally offered.

China's method of determining the offering price of feed-in tariffs could be useful for other governments seeking to implement a feed-in tariff. Between 2004 and 2009, China provided incentives for wind companies through a concession-based bidding process. Over those five years, the government was able to determine to the best of their ability the market forces behind wind development in their country and set a feed-in tariff price accordingly. The same process is now underway for solar power. This is one way of overcoming the problems government face of having limited information on the market. Again, a concern for the concession bidding process is that a company mail underbid and fail to deliver on its commitments.

In terms of a good model for a feed-in tariff program, many argue that Germany has developed the best type of program. Under Germany's feed-in tariff program, the ratepayer (not the taxpayer) carries the burden of the renewable energy costs. This way, if a government faces tightened economic conditions and shrinking budgets, the FiT program will not suffer. Additionally, the FiT is set at 20 years and declines throughout the period in a predictable

manner, building into the program the reduced costs of the technology and components. Every year the government determines the initial FiT rate based on market conditions, ensuring that the FiT price is just the right price to support the industry. A recent report by NREL on feed-in tariff best practices recommends a new kind of FiT program for the US to adopt. One of the designs highlighted in the report is a floating FiT that sets "caps" and payment "floors" and allows the market prices to dictate the program.

The most important concern for a government in devising its clean technology policies is to determine where a technology is in its lifecycle. The maturity of a technology will determine what the policy instruments need to be. R&D investment is particularly useful when an innovative technology is in its infancy. As the technology develops, subsidies are a useful policy tool to ramp up production and reduce prices. Once a technology is in its deployment phase, auctions or feed-in tariffs can be used to push the technology into the market. Once a technology is mature, a carbon price may be necessary to make the technology competitive in the marketplace without government support.

Opponents of feed-in tariffs highlight obvious challenges that accompany the program, particularly the difficulty of setting the right price without burdening the ratepayer or the taxpayer too much. Making unplanned changes to FiT prices, particularly ones that apply retroactively, are considered extremely destabilizing for industry and investment flows. In the US in particular, support for a FiT program has been more muted partly due to the division of authority between state and federal regulators. The REC market that has been growing around mandatory RPS programs on the state level (especially if an RES on a federal level is instituted)

could act as a substitute instrument to promote renewable energy deployment. However, industry finds this cash flow helpful but less predictable than a feed-in tariff and tends to prefer that latter rather than the former.

While this paper highlighted policies that advance R&D, infrastructure, manufacturing and domestic demand for clean tech products across the globe's leading clean tech players, not one example stands out as having a perfect vision and policy framework in place. In most of these cases clean technology incentives are done in an ad hoc fashion. Establishing a technology specific strategic plan that coordinates all these policy mechanisms across the key technologies is a crucial step in building out a country's clean tech manufacturing capacity, and ensures that public funds are not wasted. The most important takeaway from all of these best practices is stability and consistency. Changes to these programs are inevitable and encouraged, but it must be done in a way that is clearly outlined and sends the appropriate signals to industry.

Footnotes

[1] http://www.whitehouse.gov/blog/09/02/27/The-case-for-green-jobs/
[2] http://thebreakthrough.org/blog/2010/04/clean_energy_jobs_can_be_shipp_1.shtml
[3] Bloomberg New Energy Finance, UNEP Report 2010 (http://sefi.unep.org/english/globaltrends22010.html)
[4] "Clean Economy, Living Planet," Roland Berger Strategy Consultants and World Wildlife Fund November 2009.
[5] "Who's Winning the Clean Energy Race?" Pew Charitable Trusts March 2010, page 19.
[6] "Joined at the hip: the US-China clean energy relationship," Bloomberg New Energy Finance May 2010, page 8.
[7] http://www.rechargenews.com/energy/solar/article199163.ece
[8] Fulton, Mark. "FiTs Adjust while Delivering Scale in 2010" Deutsche Bank 29 July 2010, page 22.
[9]http://online.wsj.com/article/SB10001424052748703961204575280473851819084.html?mod=WSJ_latestheadlines
[10] Mehling, Michael. "Transforming Economies Through Green Investment: Needs, Progress, and Policies" German Marshall Fund of the United States January 2010.
[11] "EU's Policies for Developing and Deploying Six Green Energy Technologies," Georg Erdmann, EWC/KEEI conference presentation
[12] http://www.ft.com/cms/s/0/3a7ac61c-7ee0-11df-8398-00144feabdc0.html
[13] http://www.pv-tech.org/news/_a/spain_feed-in_tariff_cuts_new_phot35654654_plants_to_be_chopped_by_up_to_45/?utm_source=Feeds&utm_campaign=News+Feed&utm_medium=rss
[14] "Out of the Running?" Center for American Progress March 2010, page 20.
[15] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009, p.74.
[16] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009, p.74.
[17] Ministry of Economy, Trade and Industry, Cool Earth Innovative Energy Technology Program, March 2008, www.meti.go.jp/english/newtopics/data/pdf/031320CoolEarth.pdf
[18] Government of Japan Cabinet Office, Environment & Energy Technology Roadmap and Diffusion Scenario, www8.cao.go.jp/cstp/english/doc/low_carbon_tec_plan/ref_roadmap1.pdf
[19] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009, page 24.
[20] "Case Studies in American Innovation A New Look at Government Involvement in Technological Development," The Breakthrough Institute page 24.
[21] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009, page 77.
[22] http://earth2tech.com/2010/02/01/the-new-smart-grid-players-korea-japan-china-oh-my/
[23] Atkinson, Rob. "Rising Tigers, Sleeping Giant," *The Breakthrough Institute and The Information Technology and Innovation Foundation*, November 2009.
[24] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation, November 2009.
[25] The Electric Power Information System, Korea's Presidential Commission on Green Growth report
[26] "Who's Winning the Clean Energy Race?" Pew Charitable Trusts March 2010.
[27] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009.
[28] Peace, Johanna. "South Korea to Invest $85b in Green New Deal," 7 July 2009.
[29] http://www.koreatimes.co.kr/www/news/biz/2010/02/283_49962.html
[30] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009.
[31] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009.
[32] "Renewable energy faces investment crisis in S.Korea," The Hankyoreh 11 March 2010
[33] "South Korea Taps Germany to Help Grow Its Solar Industry," Inside Renewable World 29 April 2009.
[34] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009 <http://thebreakthrough.org/blog/2009/11/asia_beats_us_31.shtml>

[35] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009
[36] Paek, Kil-Nam, Seung-Young Chung and Chinwha Chung, "Wind Power in Korea," 21 October 2009 <http://www.evwind.es/noticias.php?id_not=1851>
[37] http://peakenergy.blogspot.com/2010/03/south-korea-sets-2030-target-for-fully.html
[38] http://earth2tech.com/2010/03/29/the-billions-of-dollars-behind-koreas-smart-grid/
[39] "South Korea Sets 2030 Target for Fully Integrated Smart Grid," Peak Energy website, 19 March 2010 <http://peakenergy.blogspot.com/2010/03/south-korea-sets-2030-target-for-fully.html>
[40] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009 <http://thebreakthrough.org/blog/2009/11/asia_beats_us_31.shtml>
[41] Atkinson, Rob. "Rising Tigers, Sleeping Giant," The Breakthrough Institute and The Information Technology and Innovation Foundation November 2009, page 27
[42] http://online.wsj.com/article/SB10001424052748704538404574537471395577650.html
[43] Nuclear Power in South Korea, http://world-nuclear.org/info/inf81.html, updated 3/18/2010
[44] http://www.powerint.com/blog/mrgreen/korea-makes-new-push-led-lighting
[45] http://www.businessgreen.com/business-green/news/2251371/south-korea-spend-85m-ccs
[46] http://www.greenforall.org/blog/obama-announces-2.3-billion-tax-credit-for-clean-energy-jobs
[47] Kahn, Debra. "SunPower to build Silicon Valley manufacturing plant" E&E News 23 April 2010.
[48] http://www.allbusiness.com/legal/tax-law-sales-tax/13743636-1.html
[49] According to the office of bill sponsor Rep. Doris Matsui (D-Calif.)
[50] World Wind Energy Association Report 2009," World Wind Energy Association March 2010, page 8.
[51] "Global Market Outlook for Photovoltaic Until 2014," European Photovoltaic Industry Association May 2010.