The 2011 Inflection Point for Energy Markets Health, Safety, Security and the Environment

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Overview

— **Energy transitions are inherently lengthy but can be accelerated by material changes in economics, security, public sentiment and regulatory responses to human health, safety and the environment**. The world has been battered in 2011 by two very important events that could combine to create an inflection point in energy choices. First, we are currently experiencing an oil price shock reflecting both long-term supply/demand trends, as well as important security issues in the Middle East and North Africa. Second, the disaster at the Fukushima Daiichi nuclear plant in Japan has drawn attention to all of the human health and safety, and environmental issues surrounding nuclear energy, and dampened its outlook as a low carbon energy option.

— **The dual impact of the oil price shock and the Fukushima tragedy – coming on top of years of discussion of climate change and carbon emissions, and last year's oil spill in the Gulf of Mexico – are likely to mark 2011 as a key inflection point in the global energy mix and catalysts for a transition toward cleaner, sustainable and more secure energy sources**. In personal sentiment terms to voters, these represent the themes of **Health, Safety, Security and the Environment**. Policy makers and energy companies will be challenged to deal with these ongoing issues in coming years, and we believe that renewable energy and natural gas-fired generation will emerge as longer term winners.

— Renewed questions concerning nuclear energy deployment could lead to a view that coal seems more secure, cheaper and even safer and even healthier. But looking at all fuel sources from a wider perspective of health and safety, we believe that coal has many disadvantages. In our analysis, to fully "clean up" coal, its cost basis would be much higher. In the case of Germany, the response has been to close around one-third of its operating nuclear fleet (pending a safety review), as well as announcing it will likely accelerate closure of these and other nuclear plants. Although short term some increase in coal utilization is likely, the policy focus is to deploy greater renewables and gas-fired generation.

— Regarding oil security, even with an increase in non-conventional supply and supply from more politically stable regions, we believe this latest oil price shock will require governments to focus on transport systems and electrification, along with natural gas or biofuels. In a knock-on effect, electrification will then shift the focus onto the sustainability of the fuels powering the electric vehicle fleet.

— We believe that renewable energy will be a clear long term winner in most energy systems, a conclusion supported by many voter surveys conducted over the past few weeks. At the same time, we consider natural gas to be, at the very least, an important transition fuel, especially in those regions where it is considered secure.

— In many ways, the outlook boils down to a cost analysis. Can health, safety and the environmental issues present in fossil fuels be addressed by new technologies? The answer is likely "yes", but mostly at higher cost. Meanwhile, renewable energy costs should fall long-term due to increasing scale and technology developments. Security, however, is a thornier problem complicated by geography, natural resources and infrastructure. In our view though, security is more likely addressable by a move towards resource-specific forms of renewable energy, complemented by natural gas.

— For investors, we recommend a re-evaluation of investment holdings across the energy spectrum in light of these new realities. In terms of health, safety, security and the environment certain energy sectors are inherently more risky than others, and these risks (along with a company's operating history) should be taken into account when making energy investments and ensuring investment holdings conform to the targeted risk-return profile. The thesis that renewable energy and natural gas are the winning fuels of the future has been reinforced by recent events, and the reaction of the public, governments and markets to these events. In addition to risk exposure, investors should pay attention to the vast market opportunity these sectors present.

Introduction: Energy Markets and Health, Safety, Security and the Environment

There have been two major events affecting global energy markets so far in 2011. Firstly, the oil price rise as a result of unrest in the Middle East and strong 1Q11 global growth, and secondly the devastating earthquake and tsunami that hit Japan's north-east region on March 11th, 2011. Both these events have far-reaching and complex implications for energy policy in many countries and potentially for the future of the global energy industry. We believe the severity of the subsequent nuclear fallout has caused a fundamental shift in public perception with regard to how a nation prioritizes and values its population's health, safety, security, and natural environment when determining its current and future energy pathways. Radioactive contamination of the air, water and food in the region surrounding Fukushima's nuclear plant and farther afield has incited public fear not only in Japan, but in other nations around the globe. Nearly every country with existing nuclear plants has ordered a safety review of its facilities, and several countries have reduced or intend to reduce their reliance on nuclear power as a direct outcome of events currently unfolding in Japan. At the same time, in oil importing countries all around the world, the issue of secure supply has become yet again a key focus of discussion as consumers grip with the shock of high gasoline prices at the pump and the knock-on inflationary impact across a wide basket of goods and services, which will likely lead to downward estimates of global GDP growth expectations for 2011.

Given that health, safety and security are of paramount concern to individuals and by consequence their governments, it is inevitable that the entire energy spectrum is being further reframed in this light. It is with this perspective that DBCCA provides a comparative analysis of different fuel sources according to their health, safety, energy security and environmental risk. **It is apparent that, given the recent events at Fukushima, combined with increasing and volatile oil prices, we are at an inflection point with regard to future energy pathways.** As we explore in depth in this paper, we believe that natural gas and particularly renewables will be the winning fuels of the future, given the lower health, safety, security and environmental risks associated with these resources. The following analysis looks at current technologies and does not address how new technologies might be deployed to counter these risks – this is an issue that energy markets need to address in terms of regulation and/or changing technology costs, which is discussed at the end of this introduction.

- Firstly, we look at the basic risk factors that are present in each fuel and associated technology.
- We then look more closely at the impact of accidents on energy markets, in terms of frequency, severity and their industry impacts.
- We follow this with an overview of available data on mortality rates in different energy value chains.
- After a discussion of these issues, we provide a qualitative overview of these major risks, according to health, safety, security and the environment.
- Finally, we link this to the need to properly price these issues in fossil fuels, while renewable energy costs continue to fall.

Exhibit 1: Fuel Source Decision Matrix

	Oil	Coal	Nuclear	Gas	Renewables
Safety	− - Pipeline explosions - Rig explosions - Refinery explosions	− - Mining accidents - Sludge spills	− - Hydrogen explosions - Radiation burns / sickness - Nuclear meltdown	− - Pipeline explosions - LNG explosions	− - Hydro: floods / releases - Geothermal: EGS quakes
Health	− - Breathing disorders - Cancers	− - Breathing disorders -Cancers - Heavy metals	− - Radiation exposure - Cancers		− - Wind: vibration-health
Security	− - Limited supply (OPEC) - Price volatility - Military costs	+ - Relatively abundant	+ - Very limited feedstock − - Terrorist attack target	+ - Relatively abundant	+ -Wind/solar: very limited material feedstock
Environment	− - Oil spills – water/land - Particulates, SOX/NOX, carbon monoxide and carbon emissions - High water consumption	− - Particulates, metals, SOX/NOX, carbon emissions - Water/land contamination from mining and sludge spills - High water consumption	+ - Emissions free − - Radiation leaks - Large water usage - High water consumption - Spent fuel storage - Accident land sequestration	+ - Relatively low SOX/ NOX & carbon emissions − -Some water consumption -Methane leaks - Fracking – water contamination	+ - Low/zero emissions - Low water consumption (except hydro) − - Hydro: fish-kill, flooding - Wind: bird-kill - Solar: thin-film waste, solar thermal water use - Bioenergy: emissions, agricultural techniques (e.g. soil erosion)

Source: DBCCA Analysis

Fossil Fuels and Nuclear:

Oil / Petroleum: Oil ranks very high with regard to environmental concerns due to the large amounts of carbon and other emissions that occur during combustion of this fuel, combined with several "black swan" events, most notably the recent Deepwater Horizon oil spill in the Gulf of Mexico. Oil is also the fuel that causes the most energy security anxiety as so many countries are dependent on it for their energy requirements. In particular, the transportation sector is a very large consumer of energy around the world (particularly in the most developed economies[1]), and this sector tends to be highly dependent on oil-derived petroleum, with few or no substitutes available. Many countries are also reliant on oil as a key source of power generation, particularly island states and/or developing countries. Yet, a substantial portion of oil reserves are located in politically unstable regions, and 41% of oil production comes from members of the Organization of the Petroleum Exporting Countries (OPEC)[2]. With regard to human health and safety, oil is similarly a fuel of high concern due to the particulates, sulfur and nitrogen oxides, carbon monoxide (although these are fairly tightly regulated in developed economies) and greenhouse gases emitted during combustion, due to explosions at some oil rigs, and due to political violence against oil workers in some producing countries (for example, in the Niger Delta region in Nigeria).

Coal: Coal ranks very high with regard to health and environmental concerns due to the emissions of sulfur and nitrogen oxides, particulates, heavy metals and greenhouse gases from coal plants, and the resultant negative implications for human health and the environment. These effects are particularly apparent in countries with less

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[1] *In the US, for example, nearly 29% of energy consumption in 2009 was by the transportation sector. Source: "Total Energy Flow 2009", US Energy Information Administration*
[2] *Based on 2009 oil production statistics. Source: "BP Statistical Review of World Energy", BP, June 2010*

stringent air emissions standards. In China, for example, only 1% of the country's 560 million city dwellers breathe air considered safe by European Union standards according to a 2007 World Bank study[3]. Even in the US (which has relatively stringent air pollution rules), it is estimated that pollution from coal-fired power plants result in the premature deaths of more than 13,000 people a year[4]. Coal also ranks high with regard to safety risks, given the safety issues involved in storing highly contaminated coal ash or sludge[5] and also due to mining accidents, which are particularly prevalent in countries with less stringent mining safety regulations. Coal mining deaths have reduced to less than 50 per year in the US over the past two decades[6], but in China, for example, there were over 2,433 coal mining deaths in 2010 – China remains the country with the highest number of fatalities from coal mining in the world, despite a nearly 50% decline from 4,746 deaths in 2006[7]. Although coal ranks high with regard to human health and safety concerns, coal is not generally a fuel that engenders substantial energy security concerns as coal reserves are relatively abundant and tend to be located in politically stable countries – more than 38% of global reserves are located in the US and Australia, with a combined 340 years of future extraction capacity (at current rates of production).[8] Coal is also relatively risk-free to transport, as it is not an explosive fuel and does not carry the risk of spills (unlike oil, for example).

Natural Gas: Similarly to coal, there is an abundance of natural gas reserves in politically stable countries – particularly the US – with strong export potential. In Europe, reliance on gas for power generation is considered more risky due to geo-political concerns, given that Russia holds the vast majority of gas reserves in the region. However, the fuel is being increasingly transported between countries and regions in liquid form (Liquefied Natural Gas or LNG). Relative to other fossil fuels, natural gas is also not considered to be a particularly risky fuel source in terms of health or environmental concerns due to its relatively lower emissions of greenhouse gases (although this has recently been an issue of some debate[9]), and other pollutants, and established extraction procedures. In terms of safety, however, gas-induced explosions (e.g. pipeline leaks, LNG tank explosions) pose a significant risk element for natural gas as a fuel source – there has been an upward trend in frequency of gas-related accidents (per GW of generation) both in the European Union (EU) and in non-OECD (Organization for Economic Co-operation and Development) countries over the last thirty years. More recently, hydro-fracking processes for extraction of shale gas has also caused some environmental, health and safety concerns with regard to contamination of water resources and the creation of underground fissures, although these risks have not yet been fully evaluated[10].

Nuclear: This fuel is more difficult to rank, given that the probability of a nuclear accident is very low, but the health, safety, security (in terms of loss of power generation) and environmental and public acceptance implications are extremely severe and long-term, and are also extremely expensive to remedy (see later discussion of the economic costs of previous nuclear disasters). In the case of Fukushima or another major nuclear accident then, nuclear is very risky with regard to health and safety, security and the environment. By contrast, nuclear under a "business as usual" scenario is of medium-to-high risk with regard to health, safety and the environment – nuclear workers will experience some radiation exposure, there is a chance of an accident (minor or major), and the spent fuel is highly radioactive and difficult to dispose of, posing some environmental and security risks. In terms of security of domestic energy supply though, nuclear is viewed as a very attractive fuel source (particularly in countries with few natural fossil fuel resources) as it relies on very small quantities of uranium feedstock to produce electricity. This explains why nuclear has been so popular in countries with few domestic fossil energy resources, such as Japan and France.

Renewable Forms of Energy:

Hydro: There have been a few incidents of hydro dams being breached in recent decades, with some fatalities – the Banqiao dam failure in China in 1975 is the most infamous and deadly incident, with an estimated 30,000 people killed[11] as a result of heavy rainfall, poor communications and mismanagement. In addition, construction of large

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[3] As cited in "As China Roars, Pollution Reaches Deadly Extremes" New York Times, August 26, 2007
[4] "The Toll From Coal", Clean Air Task Force, September 2010
[5] There have been multiple incidents in recent years, where coal ash sludge has been improperly stored and has leaked out of its containment vessel, contaminating the surrounding area and causing substantial damage. For example, the 2008 Tennessee Valley Authority spill of over 1 billion gallons of coal ash sludge
[6] "Despite danger, US coal mining deaths are rare", AolNews, April 6, 2010
[7] "China's coal mine deaths fall 'but still remain high', People's Daily, February 28, 2011
[8] Coal data as of the end of 2009. "BP Statistical Review of World Energy", BP, June 2010
[9] Natural gas emits approximately 50% of the carbon emissions of coal-fired power. For discussion, please see "Comparing Life Cycle Greenhouse Gas Emissions from Natural Gas and Coal", DBCCA, March 15 2011
[10] The US EPA is currently conducting an in-depth assessment of the risks of hydro-fracking (particularly those related to water), but it is not expected to be completed until 2012
[11] "Comparing Nuclear Accident Risks with Those from Other Energy Sources", OECD Nuclear Energy Agency, 2010

dams (for example, the highly controversial Three Gorges Dam in China) has been criticized for population displacement and ecological damage for flooding very large areas – although this is far less of an issue with small hydro, which now accounts for the majority of new hydro build opportunities. Hydro is also associated with excessive water usage, preventing upstream movement of fish, and some fish-kill – the latter can occur if insufficient flow is maintained out of the dam (flow is regulated in the US, for example), and as a result of fish passing through a dam's turbines. In general though, if correctly designed, regulated, maintained and efficiently operated, hydro (particularly small hydro) should be a very low risk form of generation in terms of health, safety, security and the environment, given the simple technological design, the lack of feedstock required (once the dam is built), the fact that nearly all of the water "consumed" is actually being stored and then released, and the zero emissions from generation.

Wind: With regard to safety and security, wind ranks very low due to the negligible mortality rate involved in construction of wind components and wind farms, and the fact that once installed wind energy requires virtually no additional material inputs (apart from occasional replacement of components), minimizing any commodity price or import risk. The environmental impact of wind farms is also low, although there is some bird-kill associated with this technology – the US Fish and Wildlife Service estimates 440,000 birds are killed by wind blades each year in the US[12], and that this is likely to increase as the prevalence of wind farms increases. It should also be noted, however, that up to 500 million birds are killed each year by domestic cats in the US[13], giving an indication of the risk of wind blades relative to other bird-kill factors. In addition to bird-kill, some scientists have cited human health concerns for residents living in close proximity to wind farms, arguing that the constant vibrations can cause heart disease, tinnitus and sleep deprivation due to disruption or abnormal stimulation of the inner ear vestibular system.[14]

Solar: Solar energy ranks very low with regard to health, safety and energy security concerns for similar reasons as for wind. Once operating, solar is also a zero-emission source of energy, so the only environmental concerns are those associated with the manufacturing of solar photovoltaic (PV) wafers, cells and modules, and excessive water usage in the process of generating concentrated solar power (CSP or solar thermal). The latter can generally be overcome by installation of dry cooling systems at the CSP plant, with estimated water use reductions of up to 90%[15]. With regard to solar PV manufacturing, there are two dominant types of PV cells – thin-film and silicon. The process of producing electronic-grade silicon for solar cell production is fairly energy intensive, and cannot therefore be considered zero emissions. Of greater concern to some, however, is the waste product generated during thin-film solar production – cadmium telluride is one of several materials used to convert sunlight into electricity in thin film modules, and is a highly toxic metal. The argument against the use of cadmium in thin-film solar production is that the modules could potentially catch fire and release toxic substances, or that once the modules have outlived their useful life these substances could be released during disposal. However, cadmium is a byproduct of zinc mining and thus a waste material at the start, so advocates argue that thin-film modules are sequestering cadmium for at least 20 years (average lifetime of a solar module). In addition, thin-film solar companies have been working to develop recycling programs to re-use the cadmium removed from solar modules in nickel-cadmium batteries. The environmental risk of thin-film solar and CSP plants (without dry cooling plants) are thus issues of environmental concern and have been characterized as medium.

Bioenergy: Bioenergy covers a range of different forms of energy, including biomass and biogas power, and biofuels. With regard to the environment, biomass power is generally characterized as carbon-neutral as the feedstock is usually waste product (e.g. wood pellets) that would otherwise decay naturally and release carbon. There are, however, some other emissions including particulates, nitrogen and sulfur oxides – although these are considerably lower from biomass burning than fossil fuels[16]. Biogas generally reduces emissions as it involves capturing and generating power from methane emissions during the organic decomposition of animal or agricultural waste. Biofuels, in particular "first generation" biofuels (in the US, this is typically corn ethanol), have been the most controversial form of bioenergy with regard to the environment and security due to the huge quantities of water consumed in producing these fuels (see Exhibit 2), the relatively low energy return on energy invested (EROEI)[17], and as corn ethanol diverts a food-source (as opposed to a waste product) towards fuel production. These technologies are therefore ranked as medium with regard to environmental concerns. With regard to health, safety and energy security concerns, they are

[12] As cited by"Tweety Was Right: Cats are a Bird's No. 1 Enemy", New York Times, March 20, 2011
[13] American Bird Conservancy, as cited by "Tweety Was Right: Cats are a Bird's No. 1 Enemy", New York Times, March 20, 2011
[14] See, for example: "Are wind farms a health risk? US scientist identifies 'wind turbine syndrome'", The Independent, August 2, 2009
[15] "The trade-off between water and energy: CSP cooling systems dry out in California", WorldWatch Institute, December 31, 2010
[16] For example, modern woody biomass systems emit 1/6 the sulfur dioxide emissions of fuel oil. Source: "Air Emissions from Modern Wood Energy Systems", Biomass Energy Resource Center
[17] EROEI refers to the ratio of usable energy acquired from a particular energy resource to the amount of energy expended to obtain that energy resource

ranked as very low as there are negligible adverse health or safety effects from producing power or fuel from bioenergy, and the feedstock tends to be locally sourced.

Geothermal: Traditional geothermal technologies are touted for their provision of secure, baseload power, and the health and safety risks of geothermal drilling and operations are low. The only real concern with geothermal is associated with enhanced geothermal systems (EGS), a new "generation" of geothermal technologies whereby developers deliberately fracture hot rock formations with high-pressure water blasts to access geothermal heat. This process has been associated with some induced seismic activity – for example, an EGS project in Basel, Switzerland, caused a 3.4 magnitude earthquake in 2006, and was subsequently shut down by the Swiss authorities after studies determined the project would trigger earthquakes and cause millions of dollars of damages each year. And a California, US-based EGS project named AltaRock received considerable negative press coverage in 2009[18] due to perceived seismic risk from the project – the company commissioned an induced seismicity evaluation in an attempt to allay public safety concerns, but the project was subsequently called off anyway due to local concerns, combined with operational problems and cost over-runs.

Environmental Concerns of Different Fuel Sources: A Focus on Water

Despite the aforementioned concerns, it should be noted that relative to traditional fossil fuels the health, safety and environmental risks of renewable energy technologies are far less significant, and if a country has some or all of these natural resources, development of renewable energy can make a huge contribution to reducing that country's energy security concerns. An analysis of the water use of different types of energy in the US provides further support to the environmental benefits of renewable forms of energy (with the exception of first generation biofuels), as outlined in the below table.

Exhibit 2: Water Consumption by Energy Type in the US

Energy Type	Approximate Total Water Consumed (m^3/MWh)
Solar	0.001
Wind	0.001
Gas	1
Coal	2
Nuclear	2.5
Oil/Petroleum	4
Hydro	68
Biofuel (1st Generation)	178

Note: Based on water consumed for production/extraction of raw materials; water consumed for refining fuel; water consumed at energy plant; and average totals by plant type. For wind/solar, water consumption is primarily for maintenance (i.e. cleaning).
Source: "Linking Water, Energy and Climate Change: A proposed water and energy policy initiative for the UN Climate Change Conference, COP15, in Copenhagen 2009", DHI, Draft Concept Note, January 2008

[18] *See, for example, "Deep in bedrock, clean energy and quake fears", New York Times, June 23, 2009*

A Focus on Frequency of Severe Accidents by Fuel Source

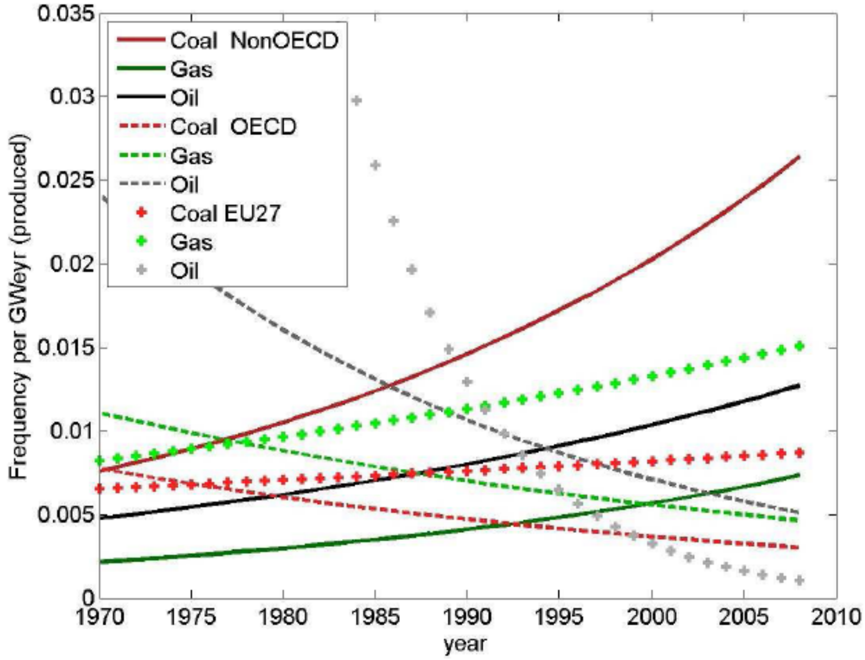
"Accidents in the energy sector comprise a substantial share of all technological disasters. Furthermore, they are a major concern in the context of energy security and critical infrastructure protection. The consequences of such accidents cover a wide range from impacts on human health and ecosystems to economic losses or the disruption of energy supplies. A clear understanding of the risks involved in the production of energy thus forms an important input for decision makers and other stakeholders."[19]

In recognition of the fact severe accidents in the energy sector have been identified as one of the main contributors to man-made disasters, in 1998 the Paul Scherrer Institut (PSI) established a comprehensive database on severe accident risks in fossil fuels, hydro and nuclear throughout the energy chain from raw material extraction to waste disposal[20]. The Energy-Related Severe Accident Database (ENSAD) uses seven criteria to define a "severe accident", with only one criterion having to be met for the accident to be included in the database.[21] A 2010 PSI paper entitled "Comparative Analysis of Severe Accident Risk in the Fossil Energy Chains" outlines the results of a recent update of the ENSAD database (for the EU project SECURE), which focuses on the 1970 to 2008 timeframe, with the following key findings.

- Over the period since 1970 there has been a clear trend to lower frequencies of severe accidents in OECD countries in all fossil fuel energy chains – both in absolute terms and if the number of accidents normalized to produced or consumed energy.
- The opposite trend is occurring in non-OECD countries, where the number of severe accidents has been rising since 1970 across all fossil energy chains, in terms of the total number of accidents per year as well as in the number of accidents normalized to produced or consumed energy[22].
- In EU-27 countries, the trend is more mixed, with a very considerable decline in oil-related accidents (a far steeper decline than in non-OECD countries), but a gradual increase in gas and coal-related accidents over the same time period – in contrast to OECD countries as a whole, where all accidents have decreased since 1970.
- For example: a minimum of 10 and a maximum of greater than 20 severe accidents occurred in the oil industry in non-OECD countries each year in the 2000 – 2008 period, as opposed to a total of only 3 severe accidents over the same 9-year period in EU-27 countries.
- These findings are outlined in Exhibit 3 below.

[19] *"Comparative Analysis of Severe Accident Risk in the Fossil Energy Chains", Eckle, P. & Burghen, P., Paul-Scherrer Institut, 2010*
[20] *"ENSAD Overview", Paul Scherrer Institut*
[21] *Criteria: (i) at least 5 fatalities, or (ii) at least 10 injured, or (iii) at least 200 evacuees, or (iv) extensive ban on consumption of food, or (v) release of hydrocarbons exceeding 10,000 t, or (vi) enforced clean-up of land and water over an area of at least 25 km^2, or (vii) economic loss of at least \$5 million (USD 2000)*
[22] *Note that this upward trend is occurring even with the exclusion of China from the coal dataset, as the country has such a history of frequent and severe coal mining accidents it would otherwise skew the data*

Exhibit 3: Trend in Severe Fossil Fuel Accidents by Fuel Source



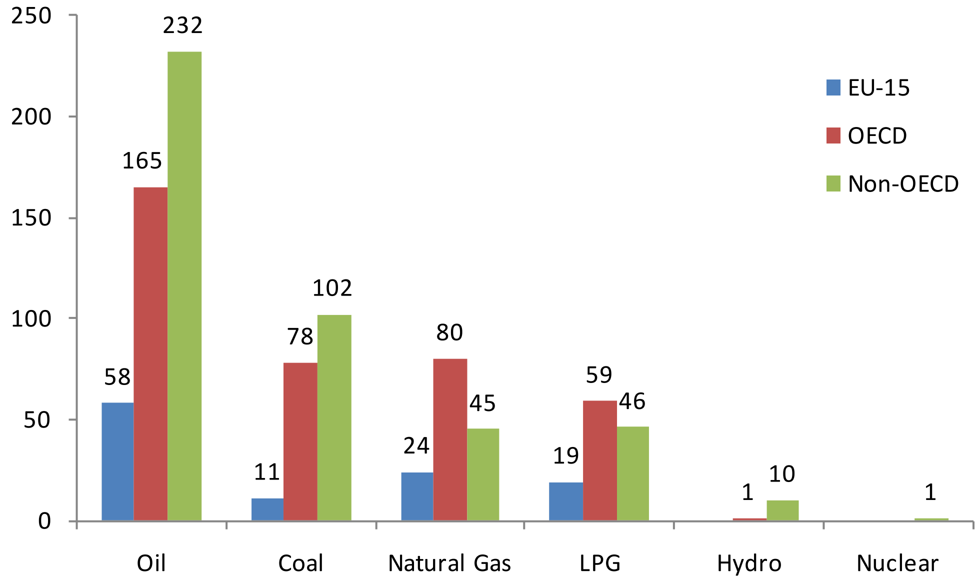
Note: Exponential trend fitted to accident frequency normalized to produced energy
Source: "Comparative Analysis of Severe Accident Risk in the Fossil Energy Chains", Eckle, P. & Burghen, P., Paul-Scherrer Institut, 2010

Evidently there is quite significant variation in terms of the absolute frequency of accidents, the trend in frequency of accidents, and the "problem" fuel sources between Europe, OECD and non-OECD countries. An earlier (2004) ENSAD study for the EU Project "New Elements for the Assessment of External Costs from Energy Technologies" (NewExt) further supports this conclusion, and also includes nuclear and hydro energy chains in its severe accident assessment, although it only covers the period 1969 to 2000. The key findings for this study, covering all energy-related accidents with 5 immediate fatalities or greater, are as follows:

- In all countries (OECD, non-OECD and EU-15), oil had the highest frequency of severe accidents and the highest number of fatalities (if the Banqiao dam failure is excluded).
- The coal industry experienced the second highest frequency of accidents in non-OECD countries, while this position is occupied by the natural gas industry in OECD countries and the EU-15.
- Liquefied Petroleum Gas (LPG) accounted for the next highest portion frequency of severe accidents across all geographies.
- In terms of frequency, hydro accounted for the second lowest number of severe accidents, with nuclear coming in last with only 1 accident (Chernobyl) included in the analysis[23].
- Exhibit 4 below demonstrates these trends across geographies.

[23] *The study only included severe accidents with 5 fatalities or greater, and therefore Three Mile Island nuclear accident does not qualify*

Exhibit 4: Number of Severe Accidents in EU-15, OECD and Non-OECD Countries, 1969 - 2000



Note: These numbers do not sum to the global totals because they "double-count" EU-15 countries that are also in the OECD. For coal, the above chart also excludes China as this skews the data to such a degree.
Source: "New Elements for the Assessment of External Costs from Energy Technologies", Final Report to European Commission, 2004

It should be noted that as the above table only classifies a severe accident as one with five immediate fatalities or greater, Three Mile Island is not included in the analysis and there is no consideration of long-term fatalities resulting from either nuclear accident. However, if the severity of an accident is measured by the highest number of evacuees then Three Mile Island and Chernobyl are rated as the third and sixth most severe accidents over the 1969 to 2000 timeframe, with 200,000 and 135,000 evacuees, respectively[24]. Of even greater significance, if the severity is rated according to the highest monetary damages, Chernobyl and Three Mile Island are the most severe energy-related accidents to have occurred globally over this timeframe – with the NewExt report estimating costs of $372.3 billion and $6.0 billion, respectively (valued in USD 2000)[25]. Estimates for the cost of Fukushima are still undecided, but are expected to be in the hundreds of billions of dollars (valued in USD 2010).

Industry Impacts of Accidents by Fuel Source

Evidently, although the frequency with which severe accident occur generally shows a small variation from year to year, the severity distribution exhibits a large spread between frequent but less severe accidents and very rare but potentially disastrous accidents[26]. This level of severity also varies by industry, as outlined below:

Nuclear: Nuclear industry accidents (e.g. hydrogen explosions, nuclear meltdowns), although relatively rare, are potentially inordinately severe in terms of health, safety, security and environmental implications, with extremely large potential loss of life and environmental contamination (particularly over the long term), and loss of baseload power. Severe nuclear accidents are also hugely expensive (disabled plants, replacement power costs, continuous cooling, long-term clean-up of radioactive contamination, and compensation) and disruptive to entire industries. Examples of severe and disruptive nuclear accidents include: Fukushima (2011), Chernobyl (1986), and Three Mile Island (1979).

Oil: Oil industry accidents (e.g. offshore oil spills, petroleum pipeline leaks, refinery explosions) are potentially very severe in terms of health, safety, security and environmental risks, with very large potential loss of life and environmental contamination as well as being very costly (disabled rigs / ships, clean-up of oil spills, and compensation) and disruptive to entire industries. Examples of severe and disruptive oil accidents are numerous and

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[24] *"New Elements for the Assessment of External Costs from Energy Technologies", Final Report to European Commission, 2004*
[25] *"New Elements for the Assessment of External Costs from Energy Technologies", Final Report to European Commission, 2004*
[26] *"Comparative Analysis of Severe Accident Risk in the Fossil Energy Chains", Eckle, P. & Burghen, P., Paul-Scherrer Institut, 2010*

include the following: BP Deepwater Horizon oil spill (2010), BP Texas City refinery explosion (2005), Exxon Valdez oil spill (1989), Shell Oil refinery explosion (1988), Piper Alpha oil rig explosion (1988), Union Oil refinery explosion (1984), Ixtoc I oil spill (1979), Amoco Cadiz oil spill (1978), and Torrey Canyon oil spill (1967).

Coal: Coal industry accidents (e.g. mine explosions, coal sludge spills) are potentially very severe in terms of health, safety and environmental risks (less so security risks as they do not typically occur at the point of generation), with very large potential loss of life, as well as being costly (interrupted or halted production, clean-up and worker compensation). Examples of severe coal accidents are numerous and include the following: Massey Upper Big Branch Mine explosion (2010), Copiapo mine collapse (2010), TVA Coal ash spill (2008), Crandall Canyone Mine collapse (2007), Aracoma Alma Mine fire (2006), Sunjiwan mine disaster (2005), Martin County coal ash spill (2000), Springhill mining explosion / earthquake (1956/1958), and Benxihu colliery coal dust explosion (1942).

Gas: Gas industry accidents (e.g. pipeline leaks / explosions, LNG tank explosions, power plant explosions) are potentially very severe in terms of health and safety risks, with significant potential loss of life and economic consequences. In terms of security and environmental risks, the impacts of a gas accident tend to be less severe as the fuel is less polluting and explosions occur more frequently in the distribution as opposed to generation stage of the energy chain. Examples of severe gas accidents include: Pennsylvania pipeline explosion (2011), San Bruno pipeline explosion (2010), Connecticut Keen Energy Systems power plant explosion (2010), Skikda LNG liquefaction plant explosion (2004), Danaciobasi LNG explosion (1980), Cleveland East Ohio LNG explosion (1944), and New London gas leak explosion (1937).

Hydro: Hydro industry accidents (e.g. dam breaches, power station floods) have been relatively rare, but are potentially severe in terms of safety, security and environmental risks, with large potential loss of life, and loss of baseload power. Examples of severe hydro accidents include: Sayano-Shushenskaya hydro accident (2009) and Banqia dam failure (1975)

Wind, Solar and Bioenergy: there is little evidence or reason to believe there is severe accident potential for these industries, and there are no historic examples of severe accidents.

As a result of this variation in the level of severity of an accident, the **impacts of these severe accidents on future industry development** also varies considerably by fuel source:

Nuclear: A severe nuclear power accident has typically caused full national reviews of future deployment of this technology, with significant impacts on development of the industry, and substantially higher costs.

Oil: Oil industry accidents have led to regulatory changes in oil production and transportation, and can impede regional exploration, production and transportation.

Gas: Similarly to oil, gas industry accidents have prompted regulatory changes, and in some cases, impeded regional industry development.

Coal: Coal industry accidents have also prompted regulatory changes, but unlike oil (and to a lesser extent, gas) have not typically slowed overall production.

Hydro: Hydro industry accidents have prompted some regulatory changes, but have not slowed industry development.

Health and Safety Risks of Different Fuel Sources: Analysis of Mortality Rates

Another metric that has been used in this overall context of health and safety is the mortality rate of different energy fuel sources. Data is hard to find and not always transparent. Next Big Future, which provides coverage of science and technology with “high potential for disruption”, and “analysis of plans, policies and technology to enable radical improvements”[27], provides a much cited analysis of deaths per TWh by energy source. Recognizing a “growing need

[27] *www.thenextbigfuture.com*

for accurate data on the number of, and associated damage from, natural catastrophes and man-made accidents", in 2010 the OECD Nuclear Energy Agency (OECD NEA) conducted a comparative analysis of severe accident risks in the energy sector in the report: "Comparing Nuclear Accident Risks with Those from Other Energy Sources" (obviously, prior to Fukushima). Included in this analysis are accidents and risks that occurred in the full energy value chains of fossil fuels, hydro and nuclear in the period 1969 – 2000, separated out by OECD and non-OECD countries. The findings of these analyses are outlined in the table below. Where the absolute numbers are expressed differently in these studies, the relative rankings, where available, are consistent.

Exhibit 5: Mortality Rate of Different Energy Fuel Sources

Fuel	Geography	Deaths per TWh (Next Big Future) Global (unless indicated otherwise)	Deaths per GW (OECD Nuclear Energy Agency)	
			OECD	Non-OECD
Oil		36	0.132	0.897
Liquefied Petroleum Gas		No data	1.957	14.896
Coal	Global	161	0.597[28]	
	China[29]	278	6.169	
	USA	15	0.157	0.597
Natural Gas		4	0.085	0.111
Nuclear ??		0.04[30]	0.048[31]	
Hydro		1.4[32]	0.003	10.285[33]
Wind		0.15	No data	
Solar (rooftop)		0.44	No data	
Bioenergy		12	No data	

Sources: Next Big Future, "Comparing Nuclear Accident Risks with Those from Other Energy Sources", OECD Nuclear Energy Agency, 2010

These data sets further support the thesis that oil, liquefied petroleum gas (LPG) and coal have far greater human health and safety risks than renewables (with the exception of hydro – as a result of the extreme Banqiao dam failure in 1975 -, and bioenergy), and to a slightly lesser extent, natural gas. With certain fuels it is more difficult to estimate attributable deaths due to the long-term impacts of the negative environmental externalities of energy generation from that fuel. This is particularly true in the case of coal and oil, which emit considerable pollutants that can be difficult to directly relate to mortality rates, and which do not currently factor in the effect of greenhouse gas emissions on potential current and future mortality rates.

In the case of nuclear, determining mortality rates is also extremely difficult, given the very long-term effects of a nuclear disaster – cancers as a result of radiation exposure can take decades to materialize, and it can be difficult to

[28] *Global, excluding China*
[29] *Data for 1994 – 1999 only*
[30] *Includes an estimated 4,000 deaths from Chernobyl, estimated over 2005 to 2030 period, with assumed generation of 112,000 TWh over the same period*
[31] *Only includes immediate fatalities*
[32] *Includes China's Banqiao dam failure, which killed an estimated 30,000 people in 1975*
[33] *Includes China's Banqiao dam failure, which killed an estimated 30,000 people in 1975*

directly attribute these to a specific case of radiation exposure. A 2005 study by the International Atomic Energy Agency and the World Health Organization, for example, estimated 50 direct deaths and 4,000 premature deaths as a result of the Chernobyl nuclear disaster.[34] As Amory Lovins points out in his recent editorial in the Huffington Post[35], this analysis overlooked vast quantities of Slavic-language literature and data on the topic. A subsequent study, published in the Annals of the New York Academy of Sciences in 2010, argues that as a result these statistics were vastly underestimated as the study lacked sufficient geographical scope and detailed facts concerning the consequences of the disaster. By including these additional countries, the report concludes that the Chernobyl fallout reached four continents, with a death toll now in excess of a million, plus a half trillion dollars worth of economic damage.[36]

"Radioactive contamination from the Chernobyl meltdown spread over 40% of Europe and wide territories in Asia, Northern Africa, and North America. Nearly 400 million people resided in territories that were contaminated with radioactivity at a level higher than 4 kBq/m^2 from April to July 1986. Nearly 5 million people still live with dangerous levels of radioactive contamination in Belarus, Ukraine, and European Russia… There is no reasonable explanation for the fact that the International Atomic Energy Agency and the World Health Organization have completely neglected the consequences of radioactive contamination in other countries, which received more than 50% of the Chernobyl radionuclides, and addressed concerns only in Belarus, Ukraine, and European Russia."[37]

Pulling it All Together: Risk Matrix

Exhibit 6 below sets out our matrix for looking at the key fuel sources in the electricity market against the criteria of health, safety, security and the environment, in terms of risk. These overall risk ratings are driven by the preceding considerations, but are not a quantitative, but rather a qualitative synthesis.

Exhibit 6: DBCCA Comparative Analysis of Different Energy Fuel Sources: Health, Safety, Security and Environmental Concerns Based on Current Technology

Fuel	Health Concerns	Safety Concerns	Energy Security Concerns	Environmental Concerns
Oil / Petroleum	High	High	Very High	Very High
Coal	Very High	High	Low	Very High
Nuclear	Medium	High	Low	Medium
Natural Gas	Low	High	Medium / Low	Medium
Hydro	Very Low	Medium	Very Low	Low
Bioenergy	Very Low	Low	Very Low	Medium
Geothermal	Very Low	Low	Very Low	Low
Wind	Low	Very Low	Very Low	Very Low
Solar	Very Low	Very Low	Very Low	Low

Source: DBCCA Analysis

[34] "Chernobyl: the true scale of the accident", World Health Organization, September 2005
[35] With Nuclear Power, 'No Acts of God Can Be Permitted'", Amory Lovins, HuffPost Green, March 18 2011
[36] As cited in "With Nuclear Power, 'No Acts of God Can Be Permitted'", Amory Lovins, HuffPost Green, March 18 2011
[37] "Chernobyl: Consequences of the Catastrophe for People and the Environment", Yablokov, A., Nesterneko, V. and Nesterenko, A., Annals of the New York Academy of Sciences Volume 1181

With Current Technology, Secure Coal Supplies are not a Healthy or Safe Way to Fill a Power Gap

One obvious response to the issues with nuclear generation is to deploy more secure coal, which some argue is safer than nuclear and is a baseload replacement. Certainly in the very short-term any plant closures in nuclear will have to be replaced by gas or coal until renewables increase their share. As we have seen, gas is preferable over coal in terms of health, safety and the environment, and for many countries is a secure resource. Therefore, we believe that over the medium to longer term, many countries will look to fill any gaps in energy supply due to concerns about nuclear with gas and renewables.

In terms of the 2011 oil price shock, the most significant area for reduction of demand (as we discuss further in "Section 1: Oil and the Middle East in 2011") is through transportation – the development of an electrified vehicle fleet, or substitution of diesel with compressed natural gas (CNG) in short-haul heavy duty vehicle fleets such as garbage trucks and buses. With electric vehicles, the choice of fuel for electricity production once again becomes the key point and the same health, safety, security and environmental considerations will have to be (re-)visited.

In the Long Run, It's about Costs

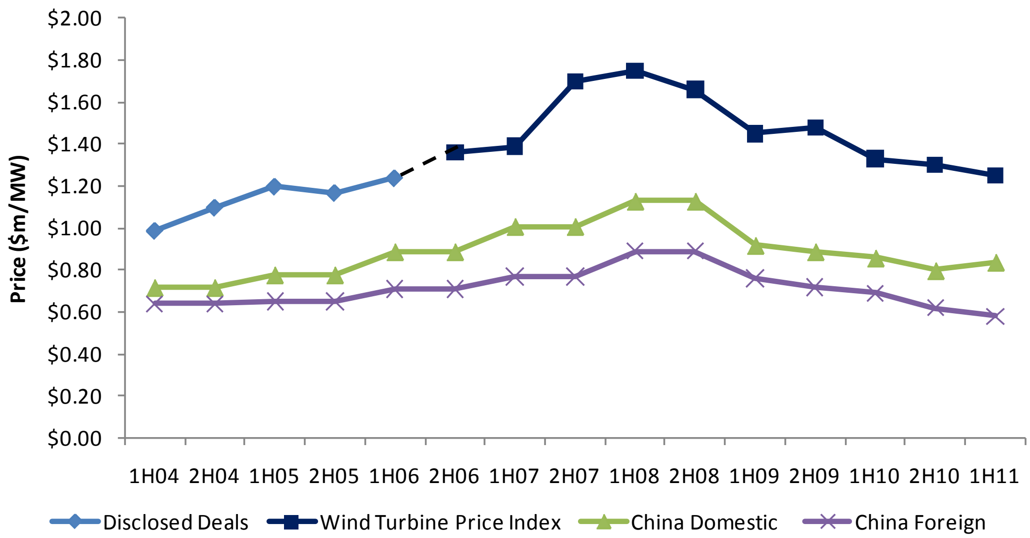
In some ways the fuel source decision matrix can be boiled down to cost – fossil fuels and nuclear need to price externalities while renewables costs are falling as they achieve greater scale.

As previously indicated, our analysis has focused more on the current technologies using these fuels. Arguably, for some of these it might be possible to address health, safety and environmental issues by upgrading to new technologies, for instance: (i) coal: installation of scrubbers, better cooling towers, carbon capture and storage and (ii) nuclear: even more heavily-engineered and protected plants, more secure backup power. This draws renewed attention to the issue of reflecting the true costs of fuel resources, or the so-called health, safety and environmental externalities associated with these forms of power generation.

At the same time as these (usually costly) technology upgrades are considered for traditional fossil fuels, technology and scale is bringing down the costs of renewable energy sources. As depicted in Exhibit 7 below, global wind turbine prices have declined considerably, while global installed wind capacity has more than doubled from 94 GW at the end of 2007 to 194 GW at the end of 2010[38] - this trend is expected to accelerate as lower-cost Chinese wind turbines gain a stronger foothold in the international wind market. Similarly, solar PV system costs have declined precipitously since 2008, and are expected to continue this decline for the next several years (see Exhibit 8). In addition to these technology and scale-driven cost reductions, we believe a renewed focus on health, safety, security and the environment here will cause further cost adjustments such that gas and renewables will win out eventually.

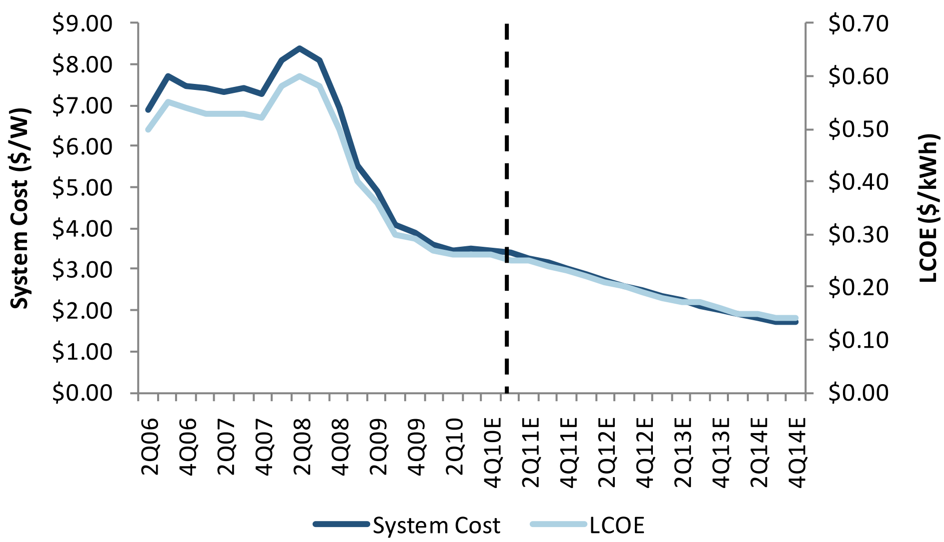
[38] *Global Wind Energy Council*

Exhibit 7: Wind Turbine Prices Have Compressed Since 2008



Source: "Coming to America? New Asian Turbine Exports to the United States", Bloomberg New Energy Finance, April 21, 2011; Global Wind Energy Council

Exhibit 8: Low Cost Solar PV Producer Pricing Trends, 2006A – 2014E

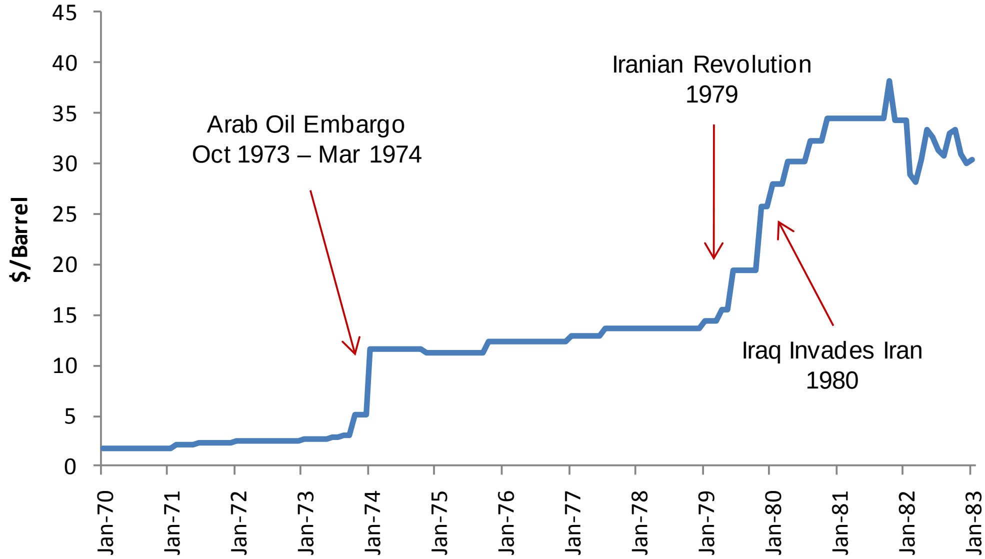


Source: EIA, NREL, Jefferies, DBCCA Analysis

Section 1: Oil and the Middle East in 2011

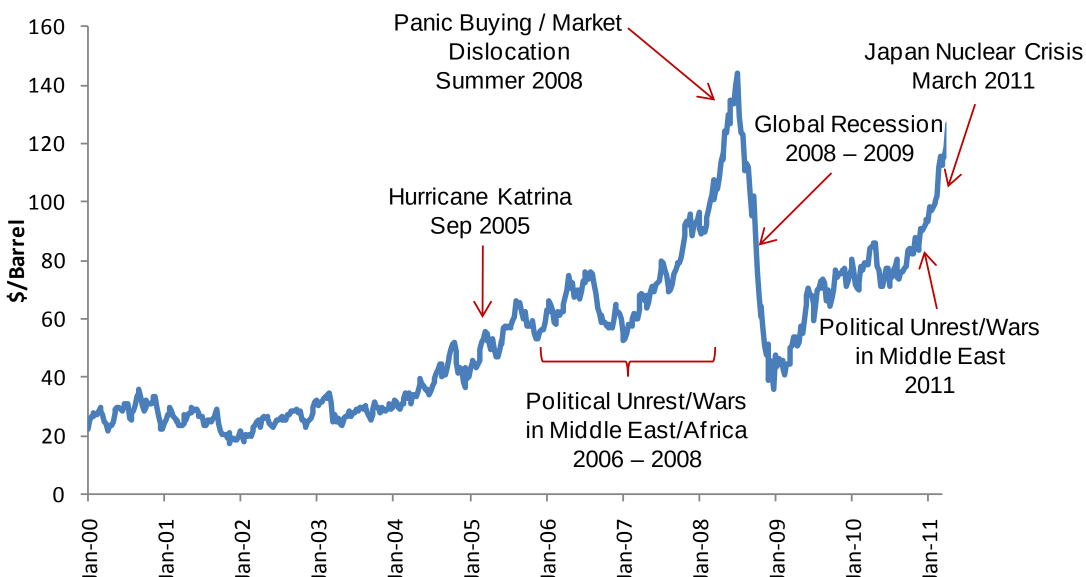
The oil price shock of 2011 has reflected shifting global supply-demand dynamics, driven by a growth in global oil demand and tighter supply, political instability in the Middle East, and Japan's nuclear crisis.

Exhibit 1.1: Oil Shocks of 1970s



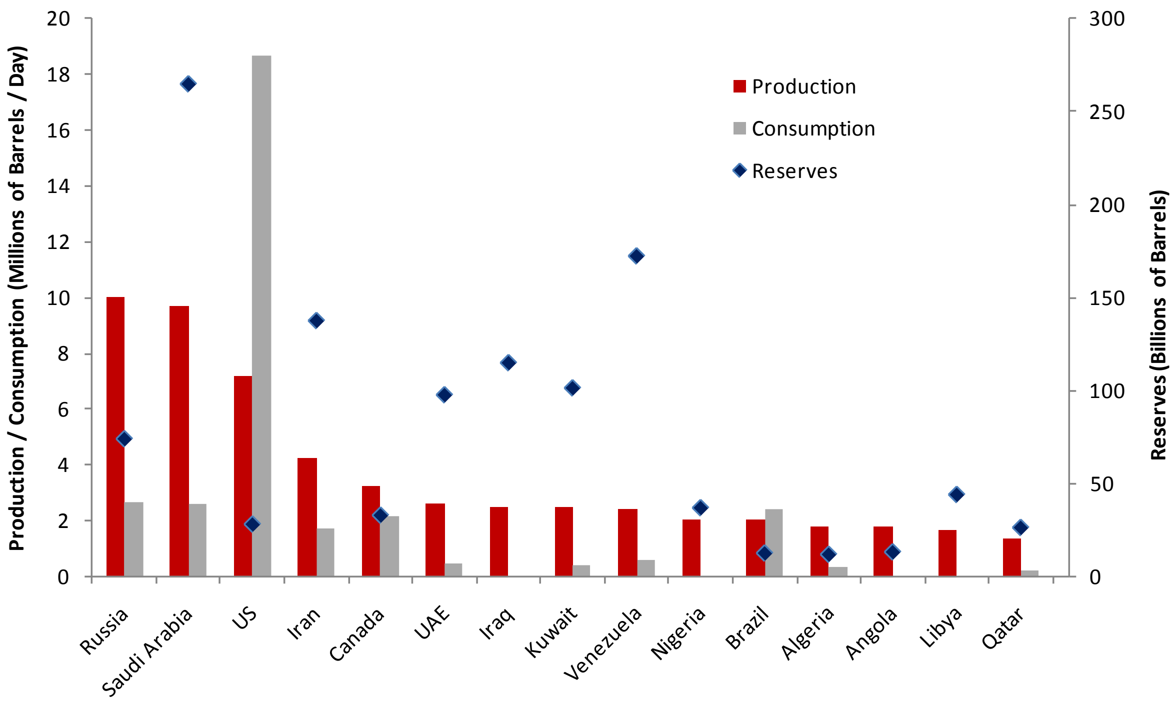
Source: Bloomberg Arabian Gulf Arab Light Crude Spot

Exhibit 1.2: Oil Shocks of 2008 and 2011



Source: Bloomberg Brent Crude Spot

Exhibit 1.3: Substantial Global Oil Reserves are Located in the Middle East

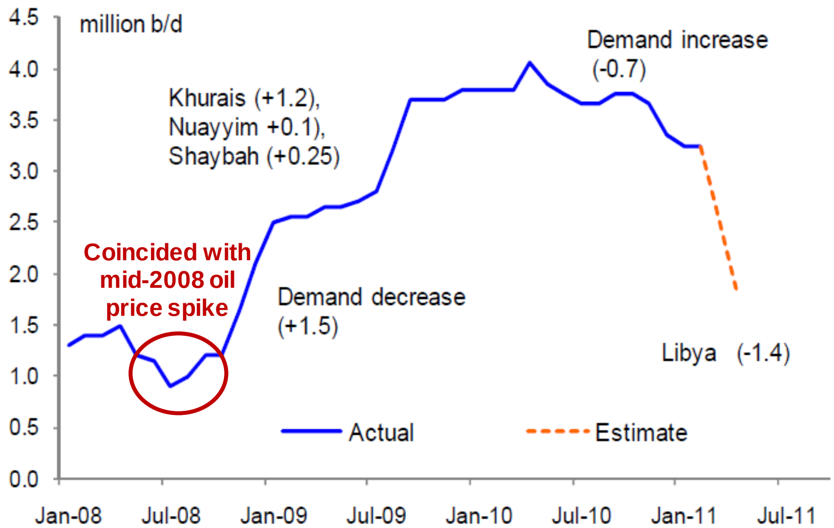


Source: "BP Statistical Review of World Energy", BP, June 2010

- World oil demand has grown considerably since the global recession of 2008 and 2009, from 84.1 million barrels/day of demand in 2009 to 87.9 million barrels/day in 2010 and 89.4 million barrels/day in 2011[39]. The global economic outlook supports continued robust oil demand, particularly from fast growing countries such as China, India and Brazil.
- Simultaneous to demand growth, global oil supply from many OPEC countries is currently constrained due to severe political instability occurring in several large oil producing countries in the Middle East and Africa, in particular Libya[40], which is a producer of light, sweet crude that requires less refining. OPEC's capacity growth is also constrained as it is dependent on stability in Iraq and elsewhere in the Middle East and North Africa (MENA) region.
- This, combined with restrictions on offshore oil exploration and production in the US as a result of the May 2010 Deepwater Horizon oil spill, has considerably reduced Saudi Arabian spare oil capacity (from approximately 4 million barrels/day in mid-2010 to 2 million barrels/day at the end of March 2010[41]) and tightened the global oil balance.

[39] *"International Energy Outlook 2010", Energy Information Administration, May 2010; "Oil Market Report", International Energy Agency, March 15, 2011*
[40] *Libya typical exports 200 thousand barrels/day (kb/d), and due to its civil war is not currently exporting any oil. "Oil Market Report", International Energy Agency, March 15, 2011*
[41] *"Commodities Quarterly", Deutsche Bank, March 30, 2011*

Exhibit 1.4: Saudi Spare Oil Capacity, 2008 to 2011E

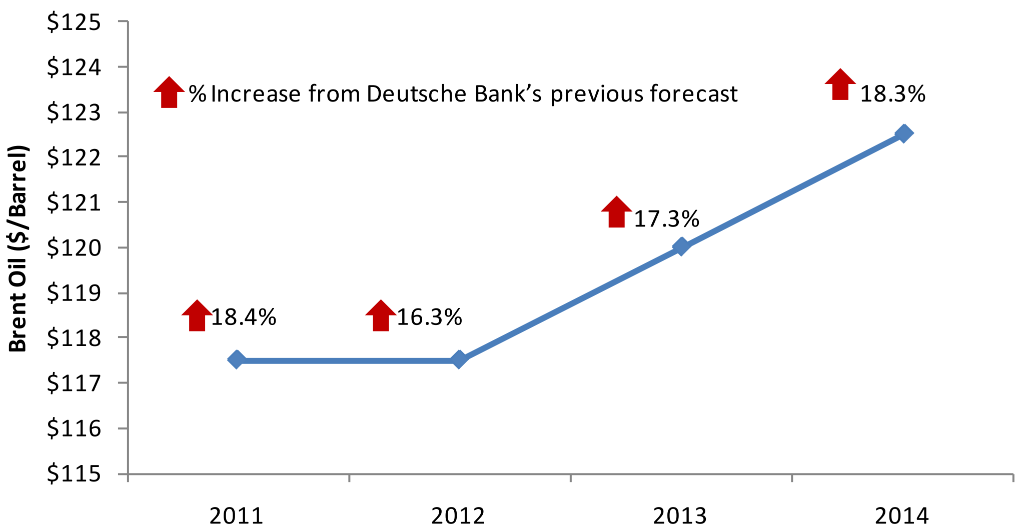


Source: "Commodities Quarterly", Deutsche Bank, March 30 2011

- As a result of these changing market fundamentals oil prices have increased considerably in 2011, particularly in the Asia Pacific region where there is robust oil demand growth, predominantly from China.
- The earthquake and tsunami in Japan on March 11th has significant further implications for the global oil balance as the country lost considerable oil refining capacity[42] and a large portion of its installed power base during the crisis.
- As a result, in the short-term Japan is expected to boost refined oil imports to counter the loss of refining capacity and also to enable increased use of low-sulfur fuel oil for power generation to offset the loss of nuclear power generation[43].
- The combination of these events has led to considerable increases and volatility in global oil prices, and industry analysts are growing increasingly bullish on oil, revising their price forecasts upward in recent months. Deutsche Bank, for example, has increased its forecast for oil prices out to 2015 from $100 - $105 in early 2011, to $115 - $125 / barrel at the end of March: ***"Converging financial, fundamental and geopolitical trends suggest that oil prices will be well supported with risk to the upside. We have raised our forecast prices accordingly. We expect crude oil prices to average well above USD 100/bbl in 2011, with Brent prices ranging between USD 115 – 215/bbl out to 2015."*** [44]

[42] *Japan's oil refining capacity was reduced by a very substantial 36% immediately following the crisis, with two refineries on fire and five shut down. As Japan's capacity utilization of refineries averaged 77% in 2010 (capacity has exceeded demand for some time), the 36% reduction leaves the country with a shortage of supply. Source: "Quake impact: oil refining industry capacity down 36%", Bank of America Merrill Lynch, March 14 2011*
[43] *For example, analysts are forecasting a 2.9% increase in previous oil demand forecasts for Japan. "Japan's quake: Implications for the oil balance", Deutsche Bank, March 18, 2011*
[44] *"Commodities Quarterly", Deutsche Bank, March 30, 2011*

Exhibit 1.5: Brent Oil Price Forecast

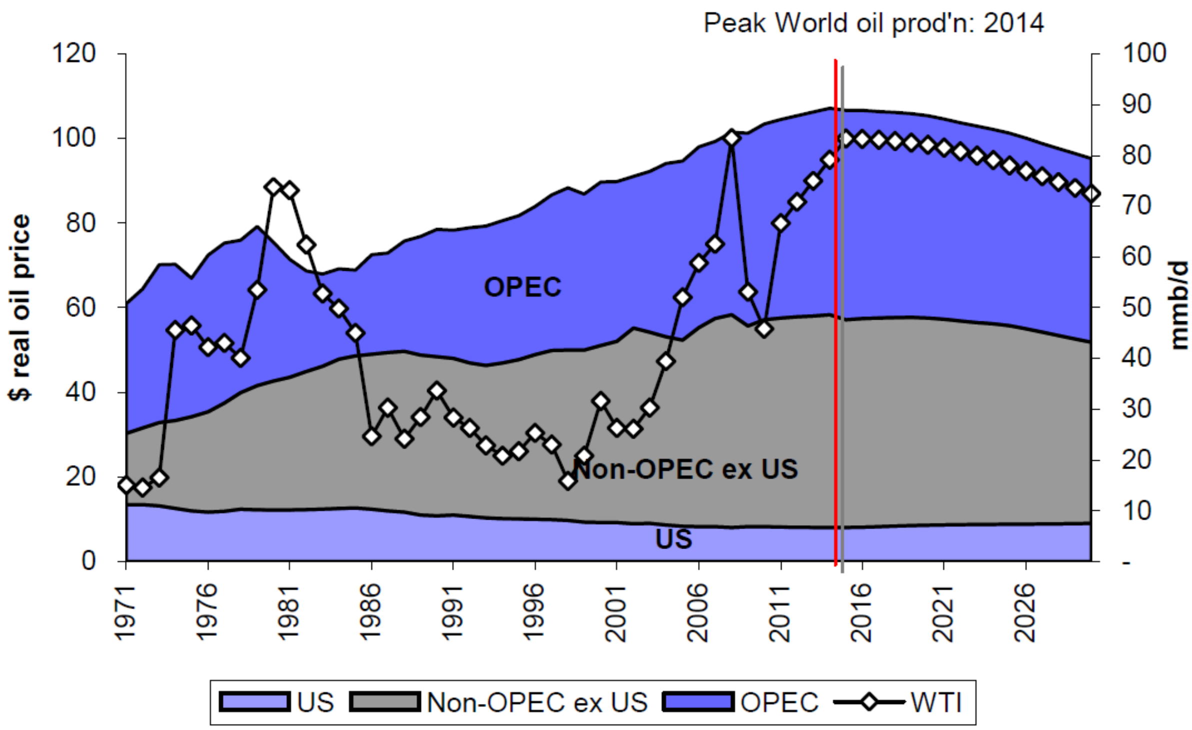


Source: "Commodities Weekly", Deutsche Bank, April 15, 2011

- In an October 2009 report on "The Peak Oil Market", Deutsche Bank predicted continued oil price volatility in the medium-term, and a price crisis in 2016 (forecasted at $175 per barrel) due to government-created distortions preventing oil supply from responding to rising prices. This distortion theory for peak oil differs from the geological constraint theory, by arguing that deep uncertainty in supply and demand, partly as a result of lack of clear legislation/regulation, will disincentivize private sector oil supply investment and lead to peak oil supply in 2016. This price spike will drive an emphasis on efficiency, and in particular, the emergence of "a powerful disruptive technology": the electric vehicle. As a result, US and then global oil demand will fall once the high efficiency fleet hits critical mass, a trend that will be exacerbated by cheaper natural gas: ***"This is the end of the 20th Century of Oil; we are entering the 21st Century of Electricity. We expect high volatility in both fuels as the baton is passed. Once the peak oil market is reached and demand begins its decline, there will be a real need for OPEC to reverse its strategy of under-supply, and pursue market share & lower prices."***[45]

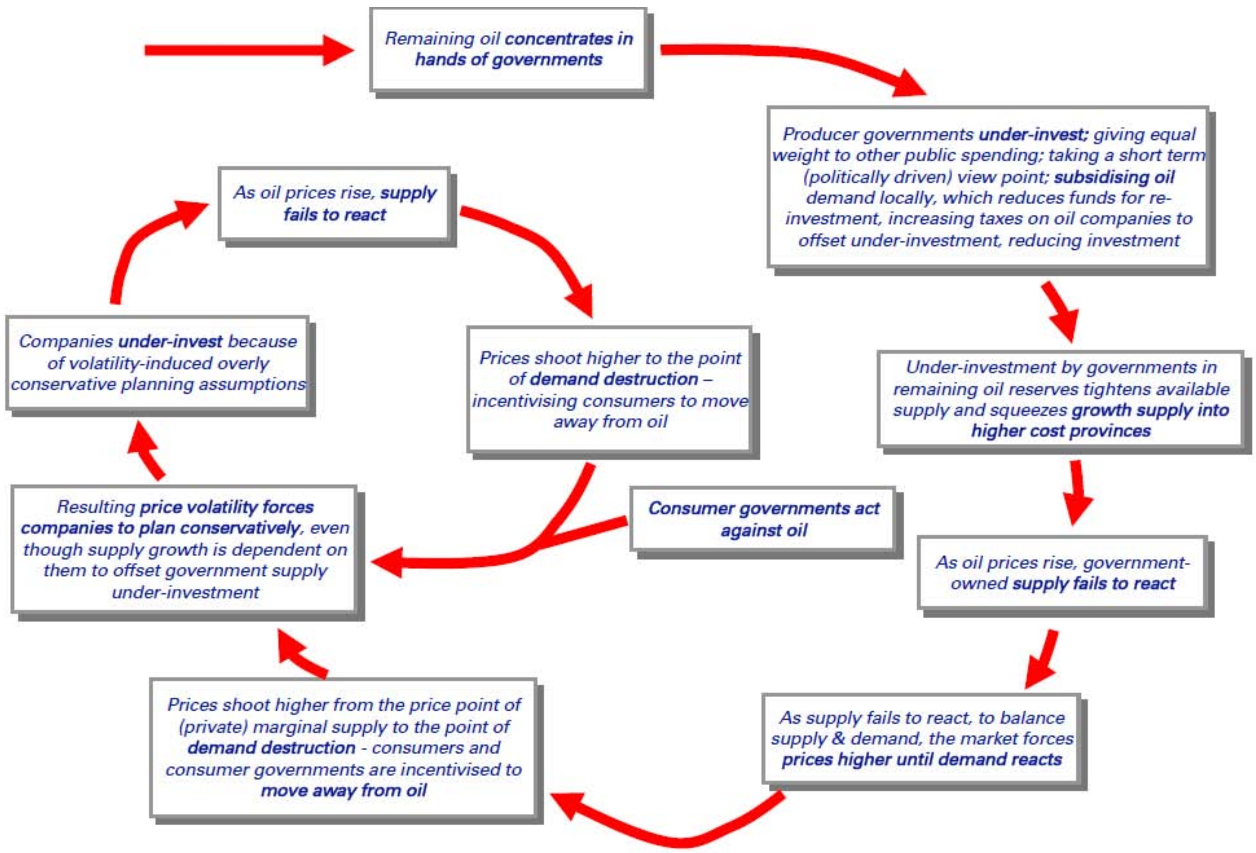
[45] *"The Peak Oil Market", Deutsche Bank, October 4, 2009*

Exhibit 1.6: Peak World Oil Market Coincides with Peak Oil Price at $100/Barrel (real USD 2008)



Source: "The Peak Oil Market", Deutsche Bank, October 4, 2009

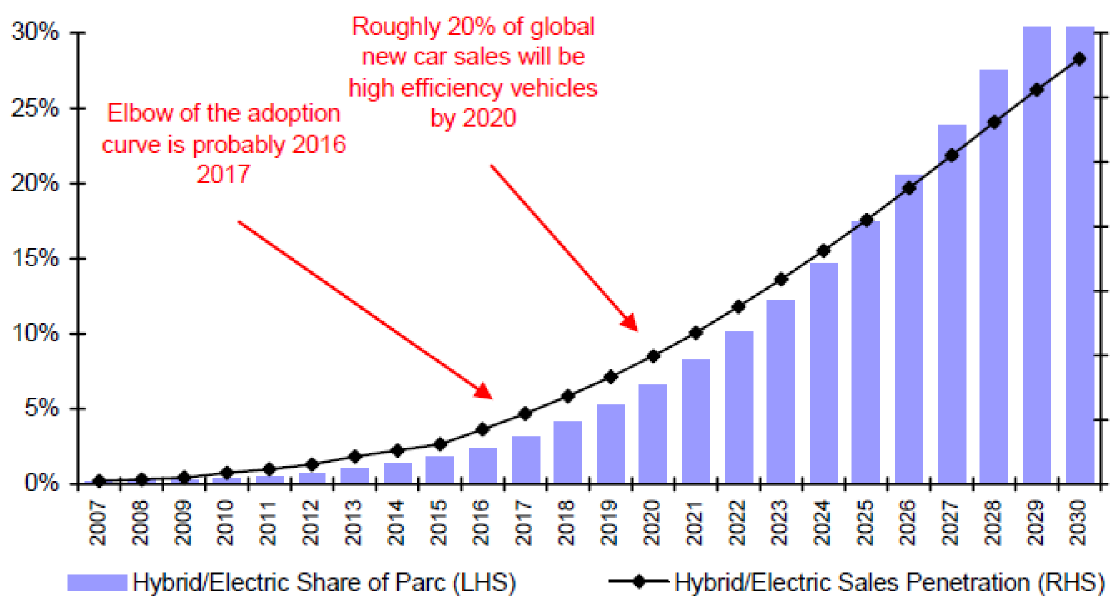
Exhibit 1.7: The Oil Under-Investment Cycle



Source: "The Peak Oil Market", Deutsche Bank, October 4, 2009

- Evidently, it is the near-term price volatility and expected price spike within the next five years that is expected to be the catalyst – inflection point – to the development of the electric vehicle fleet and increased drive to efficiency.
- Those national governments that provide domestic oil consumption subsidies will also experience higher costs for relying on oil as an energy source.

Exhibit 1.8: Estimated Hybrid/Electric Share of Vehicle Sales and Fleet ("Parc"), 2007 to 2030



Source: "The Peak Oil Market", Deutsche Bank, October 4, 2009

- There has been growing investor interest in electric vehicle-related stocks (manufacturers and value chain companies) recently due to growing expectations that the global transportation industry is likely to shift away from dependence on an oil-based transportation fleet.
- Development of an electrified transportation sector requires build-out of additional power generating capacity and a focus on ensuring this new capacity is both secure and sustainable, and complements existing power resources.
- Natural gas and renewables, both of which are useful for supplementing electricity supply at peak times (particularly gas and solar) will likely be the favored additional power resources.
- Natural gas or biofuels (in particular, sugar ethanol or advanced biofuels) are also an option to diversify the transportation fleet and reduce reliance on foreign oil.

The need to shift away from oil and toward clean energy, greater efficiency and electrification of the vehicle fleet has been increasingly emphasized and supported by national governments in recent months. This is evident in recent policy statements and initiatives – for example, President Obama's March 30th release of his "Blueprint for a Secure Energy Future", which provides a roadmap toward US energy security. Two parts of Obama's three-part strategy focus on vehicle electrification and efficiency, and clean energy (the other emphasizes domestic energy production), demonstrating the government's commitment to this course of action in the face of rising oil prices: ***"volatile gasoline prices reinforce the need for innovation that will make it easier and more affordable for consumers to buy more advanced and fuel-efficient vehicles, use alternative means of transportation, weatherize their homes and workplaces, and in doing so, save money and protect the environment."*** Second, the White House emphasizes the need for the US to lead "the world in clean energy" by ***"creating markets for innovative clean***

technologies that are ready to deploy, and by funding cutting-edge research to produce the next generation of technologies."[46]

China has similarly announced substantial policy support for clean energy, efficiency and electric vehicles, as is evident in the recent Draft 12th Five Year Plan – for example. China's national target of half a million electric vehicles by the end of 2015. For more detail, please see our recently published note: "12th Five Year Plan – *Chinese Leadership Towards a Low Carbon Economy.*"[47]

Evidently, this fourth oil price shock is causing many countries to once again focus on energy security. The price rise is to some extent part of longer term supply and demand conditions. The price change itself will, in our view, usher in changes, particularly in the vehicle fleet, that will start reducing oil demand. As recent policy initiatives demonstrate, governments around the world are working to encourage this.

[46] *"Blueprint for a Secure Energy Future", The White House, March 30, 2011*
[47] *http://www.dbcca.com/dbcca/EN/investment-research/investment_research_2366.jsp*

Section 2: Japan and Nuclear, 2011

What Happened?

The other major energy market development of 2011 has centered on Japan. On March 11, 2011 the largest earthquake in recorded history to strike Japan triggered a tsunami with waves of up to 33 feet in height. The tsunami wreaked havoc on the country's energy infrastructure and triggered an industrial accident at the Fukushima nuclear facility, which has been a headline grabbing incident and has exerted a large influence on global policy and the global energy markets.

The earthquake was ~13% more powerful than the plant was designed and engineered to withstand, according to the Japan Atomic Industrial Forum.[48] The six units at the facility – only four of which were operational at the time – were able to weather the earthquake only to be hit by a giant tsunami, which crippled the backup generators, and shut down the plant's vital cooling system, causing 3 of the 6 reactors to move out of control. Although the plant itself withstood earthquake and tsunami, the root cause of the problems appears to be design and engineering oversight: (i) the facility was reliant on electric powered pumps to cool its reactors in the event of an emergency, with only a limited battery life[49] (i.e. there was no long-term contingency plan for a failure in the backup power system; (ii) Japanese nuclear regulatory and contingency planning did not take into consideration the probability of such a large tsunami, which inundated the backup diesel generators; and (iii) the plant was storing its spent fuel on site in cooling pools, rather than storing it offsite or in dry casks, a process that occurs in many countries due to the political issues surrounding nuclear waste disposal.

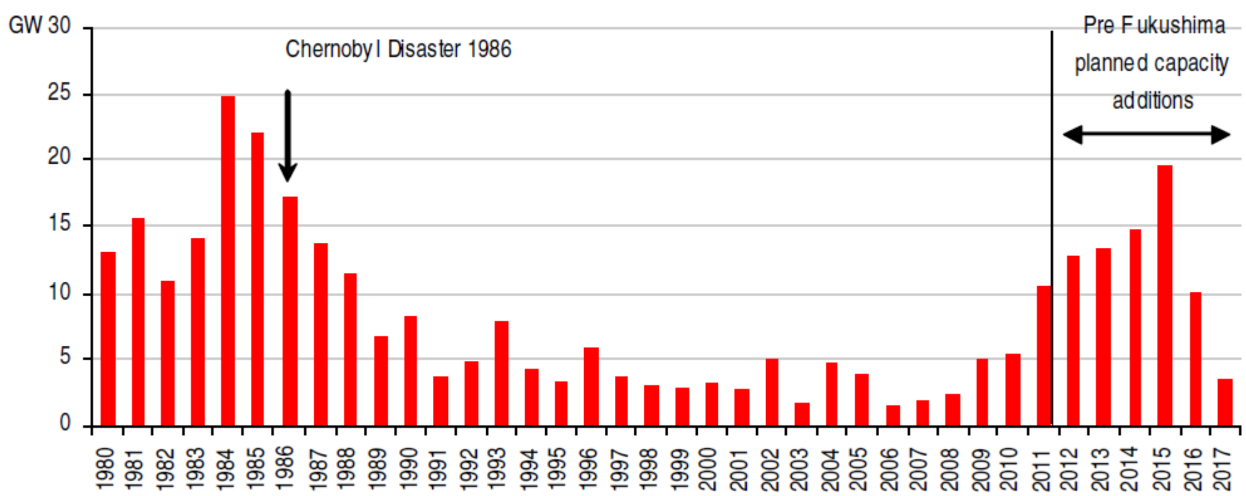
The severity rating of Fukushima has been increased several times since March 11th, and on April 12th was rated at a Level 7 or "major accident" on the International Atomic Energy Agency's scale, the same rating as Chernobyl and two levels higher than Three Mile Island. Officials said the increase (from a Level 5) was due to the fact "the impact of radiation leaks has been widespread from the air, vegetables, tap water and the ocean."[50] However, we will not know for sometime the full ecosystem impacts and degree of contamination from the disaster and the feedback loop effects on other parts of the economy and energy value chain.

Global Nuclear "Renaissance" Under Threat: Health, Safety Security and Environmental Implications

As Exhibits 2.1 and 2.2 below show, prior to Fukushima, net nuclear capacity additions were expected to increase, reversing a downward trend since Chernobyl in 1986. Chernobyl had a deep impact on popular and government views of nuclear energy, and substantially affected the next 20 years of new nuclear build plans. However, in recent years there was something of a global nuclear "renaissance" occurring, with many countries re-considering nuclear as a clean, secure baseload power option. However, the significant pipeline of new nuclear capacity both under construction and planned are now in jeopardy in many countries around the world – many planned plants are expected to experience substantial delays or even abandonment. In addition, there is now an increased closure risk for many older nuclear plants, particularly in Europe and Japan. Again, this illustrates that following an accident or event, new nuclear power construction comes under serious question.

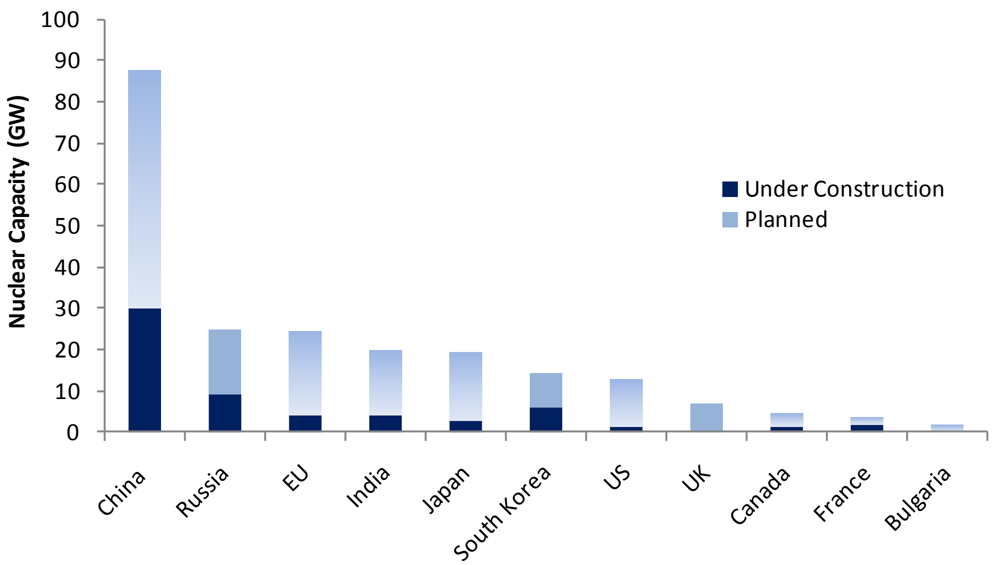
[48] *Nuclear Energy Institute, 2011*
[49] *"Experts assess risks of crisis", Wall Street Journal, March 17, 2011*
[50] *"Japan's Fukushima disaster on par with Chernobyl", E&E News, April 12, 2011*

Exhibit 2.1: "Before Fukushima Net Nuclear Capacity Additions were on Track to Pick Up"



Source: "Fukushima: Entering the next phase", HSBC, April 14 2011

Exhibit 2.2: Nuclear Plants under Construction or Planned



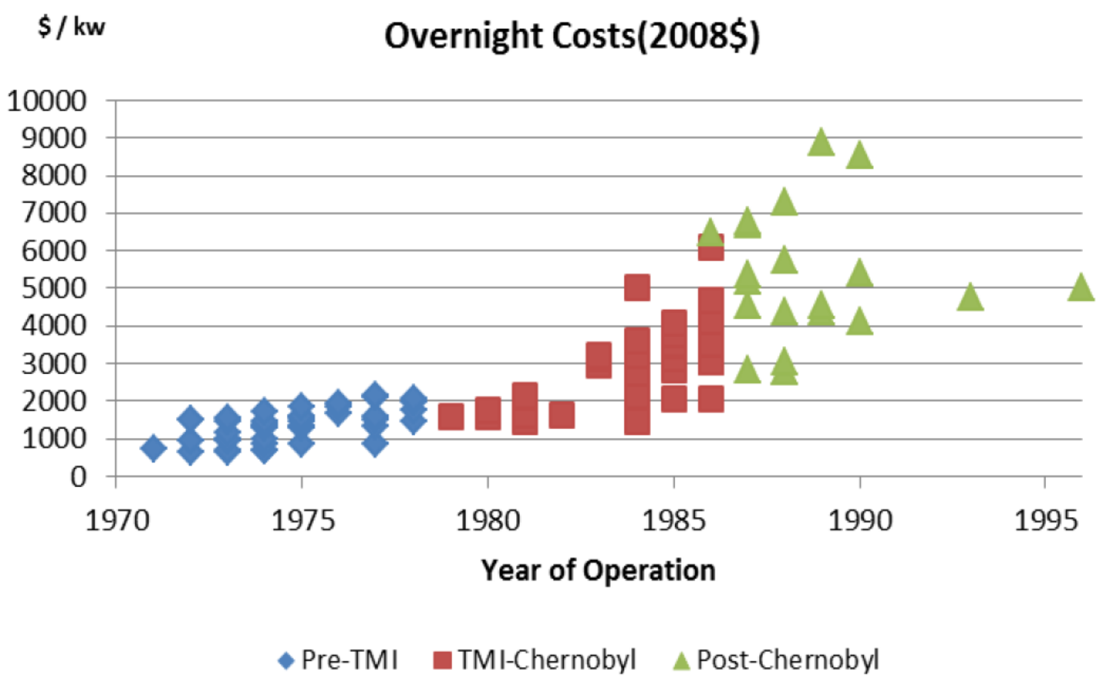
Note: Planned plants are indicated in gradient pale blue if delays/cancellations likely; or solid pale blue if no delays/cancellations expected
Source: "Fukushima: Entering the next phase", HSBC, April 14, 2011

- As of the beginning of March, 2011, there was a total of 64,074 GW of nuclear capacity under construction, and 178,117 GW of capacity planned, 56% of which was located in China, Russia and the EU[51].
- In addition to plants in the planning or construction phases, a large number of countries globally were also considering nuclear as a solution to both energy security and climate change concerns.

[51] *"Fukushima: Entering the next phase", HSBC, April 14, 2011*

- However, the tragic events in Japan have caused policy makers, regulators, vested stakeholders and investors to reassess the probability weighted risks and implications of current electricity generation and energy portfolios.
- In particular, there will now be heightened attention focused on risks to current plants and what future energy options and regulatory changes seem most feasible, secure and prudent from human health and safety, risk, and energy security perspectives.
- Costs are also correlated with health and safety issues, and nuclear costs are consequently very difficult to estimate.

Exhibit 2.3: Empirical Evidence of Nuclear Incidents and Increased Cost

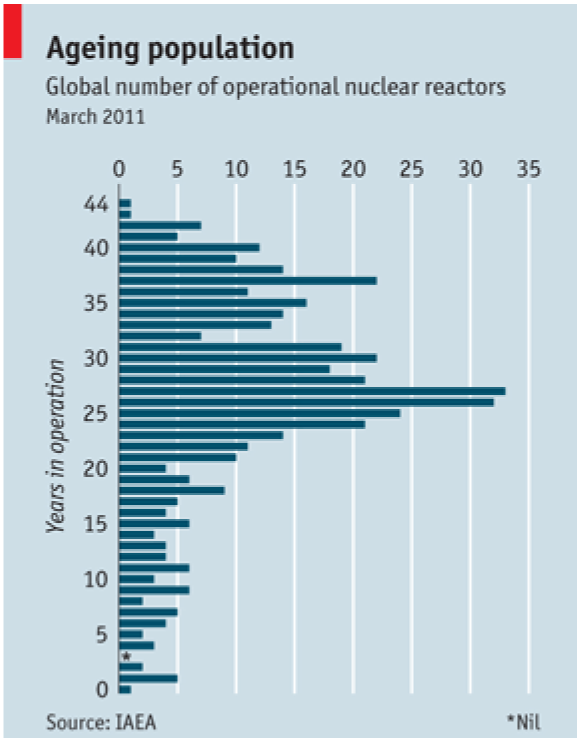


Note: "Overnight Costs" is a simplified method of referring to the costs of a construction project (usually a power plant) if no interest was incurred during construction, as if the project was completed "overnight" (i.e. it does not account for the time value or interest payments of an investment)
Source: "Nuclear Economics after Fukushima", Testimony of Dr. Mark Cooper before the Standing Committee on Natural Resources, House of Commons, Ottawa, Canada, March 24, 2011

- As is evident in Exhibit 2.3 above there is, however, empirical evidence that costs for nuclear reactors built after Three Mile Island (1979) were 95% higher than before, and construction costs increased another 89% after Chernobyl (1986). Given this historic experience, it is probable that the already high costs of nuclear will further increase in order to meet new design requirements for improved safety.
- Dr Mark Cooper, Senior Fellow for Economic Analysis, Institute for Energy and the Environment, Vermont Law School: ***"The high risk, cost, and long lead times of nuclear, combined with the rich portfolio of alternative resources available to meet electricity needs at much lower cost and risk for decades, means that the idea of a nuclear renaissance never made economic sense. The idea that a renaissance would involve construction of large numbers of reactors in a short period of time was particularly problematic from both the economic and safety points of view. There was no reason for the government to put taxpayers and ratepayers at risk by***

overriding the judgment of the capital markets, and there is less reason today. The economic analysis that was used to create the myth of the "nuclear renaissance" vastly underestimated the economic cost of nuclear reactors and totally ignored the societal impacts of nuclear reactors. The economics of nuclear reactors was bad and economics will likely be dealt another blow by the Fukushima incident."[52]

Exhibit 2.4: Ageing Global Population of Nuclear Plants



Source: "Nuclear power: When the steam clears", The Economist, March 24, 2011

- The global nuclear fleet currently accounts for 14% of the world's electricity supply, but it is an aging fleet – with a median age of about 27 years and a typical design life of 40, many are now near retirement. This fleet will require replacement if nuclear is to remain a key part of the global electricity mix. However, post Fukushima, costs may now be prohibitively high for new nuclear build, particularly in regions with low natural gas prices**.**
- We believe that moments in history, such as now, can provide important lessons with respect to infrastructure stability / fragility and appropriate regulatory oversight, and can serve as catalysts to ensure a safer and more secure energy future. In turn, the political response and consequences of that action can also lead to demonstrable changes in public and regulatory sentiment that drive investment behavior and capital allocation decisions.
- **Consequently, we expect over the next 12 to 18 months there will be a global shift in attitude to account for heightened concerns around energy security, safety and human health. We expect this shift in attitude to accrue to the benefit of natural gas and renewables, at the expense of nuclear and coal.**

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[52] "Nuclear Economics after Fukushima", Testimony of Dr. Mark Cooper before the Standing Committee on Natural Resources, House of Commons, Ottawa, Canada, March 24, 2011

The Policy Response to Nuclear So Far

The global nuclear power industry's mantra that ***"an accident somewhere, is an accident anywhere"*** has played out over the past few weeks with a dramatic reassessment of nuclear energy policy and safety across the globe from China to Europe to the US. The general thrust of the response has been to slow the pace of nuclear development, put more scrutiny on older plants seeking 10 to 20 year life extensions, and draw attention to less risky and cleaner sources of energy such as renewables and natural gas. Below we recap the more significant announcements that have happened thus far.

Fallout from Fukushima Daiichi: Regional Policy Response Varied

- **Germany**: March 15, 2011, German Chancellor Angela Merkel ordered all older nuclear reactors built pre-1980 to be temporarily taken offline for a three month period to undergo a safety review after the explosions in the reactors in Japan. As the 7 reactors accounted for approximately one-third of Germany's operating nuclear capacity (7 GW out of 20 GW of total operating nuclear capacity)[53] this has had an immediate upward impact on month-ahead German power prices, which had been in a downward trend since 2008 German public sentiment and policy on nuclear energy has been inconsistent over the years: first mandating a total shutdown, then consenting to life-cycle extensions in an agreement in 2010, and now once again deciding on a permanent long-term shift away from nuclear power. On April 12th the German government announced a six-point draft plan that "after the catastrophe in Japan, we will accelerate the fundamental conversion of our energy supply"[54]. While increased use of coal might be necessary in the short term, this plan intends to accelerate Germany's shift from nuclear power to renewable energy and increased energy efficiency, with baseload power being met by new gas-fired power plants. It argues for the provision of EUR 5 billion to increase offshore wined program, EUR 2 billion to improve building energy efficiency, and EUR 1 billion of additional funding to an energy and climate fund set up in January. It also demands an "offensive" to designate new areas for onshore wind parks and plan the construction of "electricity highways" to bring renewable power from northern Germany (high wind resource region) to industrial areas in the south.
- **China**: March 17, 2011, China temporarily stopped approving new nuclear power projects. ***"Approvals of new plants will be suspended, including those in the pre-development phase, until safety and improved long-term development plans are cleared"***, said China's State Council.[55] China has since announced its nuclear freeze will last until the beginning of 2012 while new safety codes and a new Atomic Energy Law are completed, and it has simultaneously considering doubling its 2015 solar target from 5 GW to 10 GW. As the most important player in the global energy markets and the country with the largest nuclear build program underway (25 out of 62 nuclear plants under construction are located in China, with expected capacity of 170 GW by 2030[56]), China's actions caught the market off guard. However, given the vast scale of China's nuclear ambitions and need for secure, domestic baseload power to meet rapidly growing demand, there is still a big question as to how likely it is that China will materially alter its nuclear build program to a greater degree than already announced. Instead, a shift to more advanced nuclear technologies is likely.
- **Russia**: Prime Minister Vladimir Putin said his government won't revise its own ambitious nuclear program of building new nuclear power reactors but it has ordered safety inspections at Russian nuclear facilities and will "draw conclusions from what's going on in Japan."[57]

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[53] *Data source: "Fukushima: Entering the next phase", HSBC, April 14, 2011*
[54] *"Germany Plans Faster Nuclear Exit", Wall Street Journal, April 12, 2011*
[55] *"China Halts Nuclear Approvals; Asia on Alert for Japan Radiation", Bloomberg News, March 16, 2011*
[56] *Bloomberg New Energy Finance, March 2011*
[57] *"Switzerland halts nuclear plants", Fuel Fix, March 14, 2011*

- **India**: India is another country with vast nuclear expansion plans – the country intends to expand to 63 GW of nuclear by 2032 from present capacity of 4.4 GW[58]. India's response to the Japan crisis has been somewhat muted relative to the global response, with the government implying the radioactivity threat of Fukushima has been exaggerated. The government has, however, announced that it will subject its reactors to greater stress-testing to ensure they are capable of withstanding earthquake shocks. In addition, delays are likely at some plants due to public protests – for example, the 10 GW Jaitapur plant in the state of Maharashtra. Given the government's growing interest and support for renewables, it is expected that wind and particularly solar may be used to fulfill at least part of any nuclear "gap".
- **France:** Having initially indicated the situation at Fukushima was overblown, on March 24th French Prime Minister François Fillon requested the country's nuclear-safety agency Autorité de Sureté Nucléaire to conduct an audit of France's 19 nuclear plants and 58 nuclear reactors. Plants will be audited one by one, with the aim to specifically detect any issue that could be linked to potential floods, power outages, seismic activity or a drop in reactor cooling, as well as to assess the handling process of potential accidents. However, given that France relies on nuclear for approximately 80% of its power generation, it is unlikely the country will be taking any significant steps against nuclear unless substantial domestic safety risks emerge.
- **Switzerland**: Switzerland is one of the world's most nuclear dependent countries, relying on nuclear energy for ~40% of its electricity supply. The government had been undecided about its commitment to incremental nuclear capacity additions, and did not have any nuclear capacity under construction prior to Fukushima. On March 14, 2011 the Swiss Energy Ministry suspended plans to build and replace nuclear plants, making any new nuclear build even more unlikely.
- **United States**: The US currently has the world's largest installed nuclear base (104 reactors at 65 nuclear plants, and >100 GW of installed capacity), but has not approved a new nuclear power plant in over thirty years. Prior to events in Japan, there were indications of a small nuclear "renaissance" occurring in the US with strong government support for new nuclear plants, partly to meet President Obama's goal of 80% clean energy by 2035 (for example, the federally funded nuclear loan guarantee program). However, the events of Fukushima have had a damaging impact on the fragile bipartisan consensus surrounding nuclear[59], and on March 17th the President ordered a safety review of the country's nuclear power plants. Accordingly, on March 21st the Nuclear Regulatory Commission (NRC) announced a "quick look" 90-day review of nuclear reactors in the US to determine whether stronger oversight is needed in the wake of the Japan crisis, with an interim review due to be submitted to the commission within 30 days. This investigation has subsequently been criticized for a lack of transparency and insufficient scope – for example, in a publicly disclosed letter to the Chairman of the NRC, Senator Markey states that *"the NRC has decided to keep the results of most of these investigations secret, and their scope and depth may be severely constrained. As such, they may not provide the sort of information needed to adequately assess, let alone remedy, the safety of US nuclear facilities."*[60] Of note, the Nuclear Regulatory Commission (NRC) had already required significant security enhancements and contingency improvements after the 9/11 terrorist attacks, making the US nuclear power fleet among the most hardened and secure infrastructure in the US. As a result of this, potential closures are likely to be moderate in the US, although states may well implement even more stringent standards than was already occurring, requiring older plants to close sooner than previously expected – the Oyster Creek nuclear plant in New Jersey, for example, is now closing in 2019 (10 years earlier than licensed) in an agreement between the plants owner (Exelon)

[58] *Bloomberg New Energy Finance, March 2011*
[59] *"US Nuclear Industry Faces New Uncertainty", New York Times, March 13, 2011*
[60] *Letter to the Honorable Greg Jaczko from Senator Edward J. Markey, Congress of the United States, April 15, 2011*

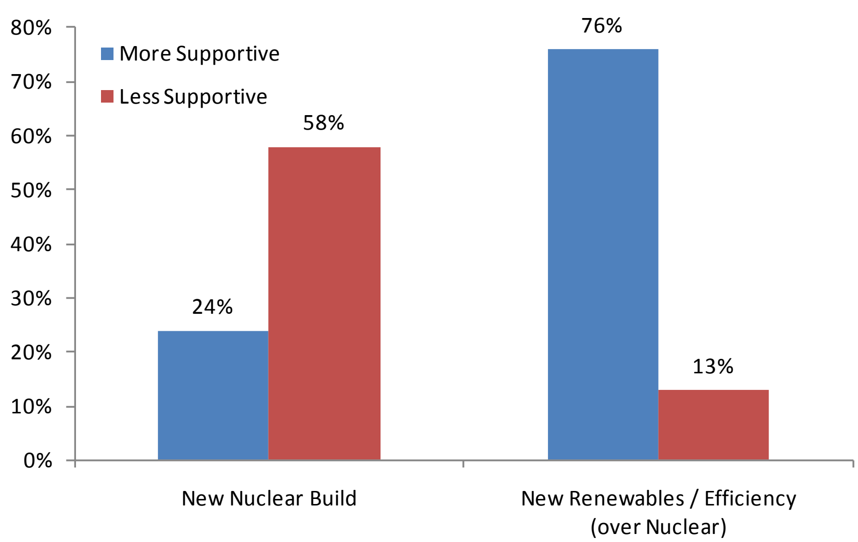
and the State of New Jersey to avoid installing new cooling towers at the plant, which would have rendered the plant non-economically viable.

Section 3: What are Voters Saying?

The Japanese nuclear crisis has caused a shift in global public opinion against nuclear and toward other clean forms of energy – particularly renewables. This response has been more marked in some countries than in others, and has more often than not reflected the country's political response to the crisis. Below we recap the more significant attitudinal shifts that have happened thus far.

- **United States:** According to a March 22nd poll by CBS, 50% of Americans disapprove of building new nuclear plants, a 16 point increase from a 34% disapproval rating in 2008[61]. An ORC International Poll taken on March 16th for the Civil Society Institute shows the very immediate attitudinal shift that has occurred, with 58% of Americans less supportive of expanding nuclear in the US than they were a month ago – only 46% of Americans would now support more nuclear reactors in the US (and 44% now oppose), down from a Gallup poll in March 2010 showing 62% support for nuclear. Interestingly, even more Americans (53%) would support a total ban on new nuclear construction in the US if increased energy efficiency and renewable technologies (such as wind and solar) could meet near term energy needs. This shows a strong shift away from nuclear and towards renewables, with 76% of Americans now more supportive than a month ago to using clean renewable energy resources and efficiency as an alternative to nuclear in the US.

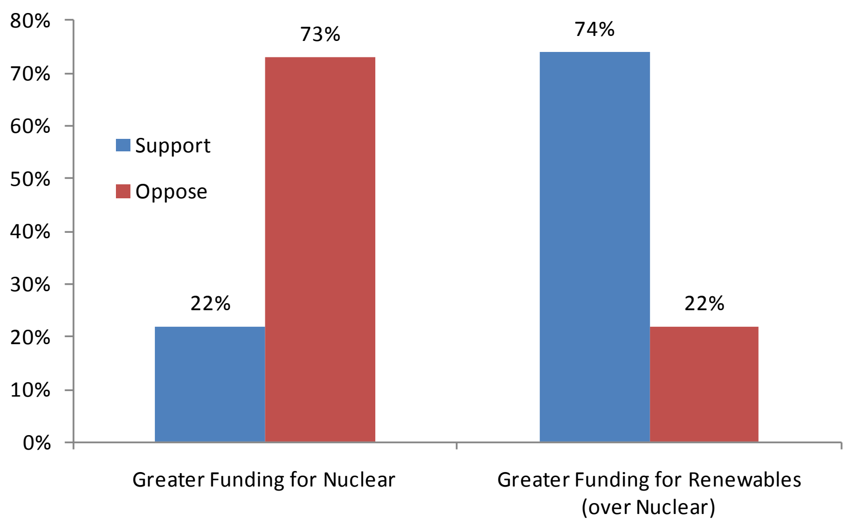
Exhibit 3.1: Diminishing Support for New Build Nuclear and Growing Support for Renewables



Note: Totals do not add to 100% as some respondents answered "no change" or "don't know"
Source: "After Fukushima: American Attitudes About Nuclear Power Policy Questions, ORC International Survey Conducted for the Civil Society Institute, March 22, 2011

[61] *"Building More Nuclear Power Plants", CBS News Poll analysis by the CBS News Polling Unit, March 22, 2011*

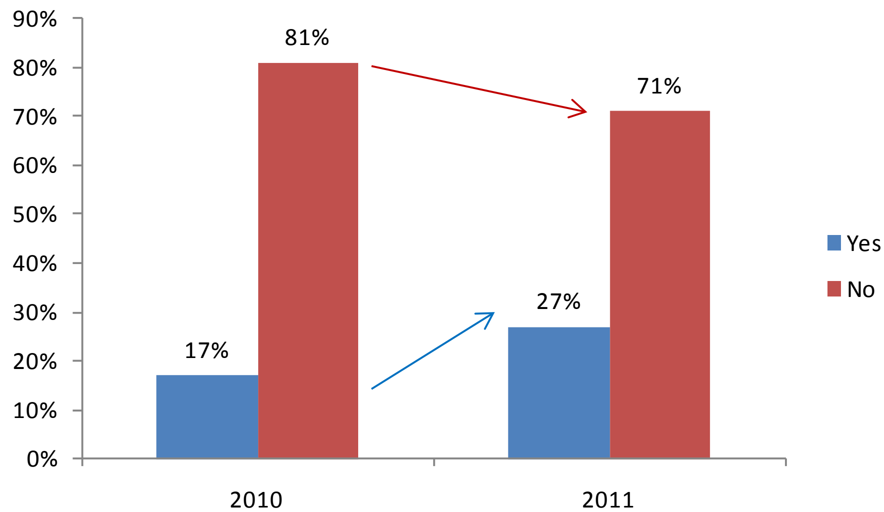
Exhibit 3.2: Greater Funding for Renewables Receives Broad Support



Note: Totals do not add to 100% as some respondents answered "no change" or "don't know"
Source: "After Fukushima: American Attitudes About Nuclear Power Policy Questions, ORC International Survey Conducted for the Civil Society Institute, March 22, 2011

- **Germany:** Immediately prior to Chancellor Merkel's announcement to suspend generation at seven of Germany's oldest nuclear reactors (all those operating prior to 1980), opinion polls showed resounding popular sentiment in support of closing the plants – an Infratest Poll for ARD television found 72% of respondents supported closure of the plants, and a very substantial 80% opposed Merkel's earlier decision (in September 2010) to extend the use of nuclear power by an average of 12 years past the previous phase-out date of about 2022. The German population clearly harbors serious nuclear safety concerns, with 70% of Germans believing a similarly serious accident was possible in a domestic nuclear power plant. Another poll, commissioned by Stern Magazine, found that 17% of Germans believed energy security could be achieved without nuclear in 2010, while a more significant 27% believed this was the case in March 2011. Interestingly, a majority (63%) of those polled believed Germany should abandon nuclear completely either immediately (11%) or within 5 years (52%), and 71% of Germans were willing to pay an additional EUR 10 – 20 on their monthly electricity bill to see this happen. There have also been serious political ramifications for the current governing party, the Christian Democratic Union (CDP), as it had extended the lifetime of several older nuclear plants in 2010, and made a quick policy reversal on this decision immediately following Fukushima. 82% of those polled agreed with the government's decision to close these plants, but 71% believed the government closed the plants for political (i.e. electoral) gain rather than due to concerns for the German population. Largely as a result of this skepticism and general dissatisfaction with the government's approach to nuclear, the staunchly anti-nuclear Green party received triple the votes in Rhineland-Palatinate and more than double the votes in Baden-Wurttemberg on March 27th, 2011, relative to 2006 state elections, placing the party in control of a state government for the first time. In another outward indication of the strong post-Fukushima anti-nuclear sentiment among the German public, an estimated 100,000 people to the streets in hundreds of towns and cities across the country on 14th March calling for an end to the country's nuclear power program, and on March 26th the largest anti-nuclear demonstration ever held in Germany took place under the slogan ***"heed Fukushima – shut off all nuclear plants."***

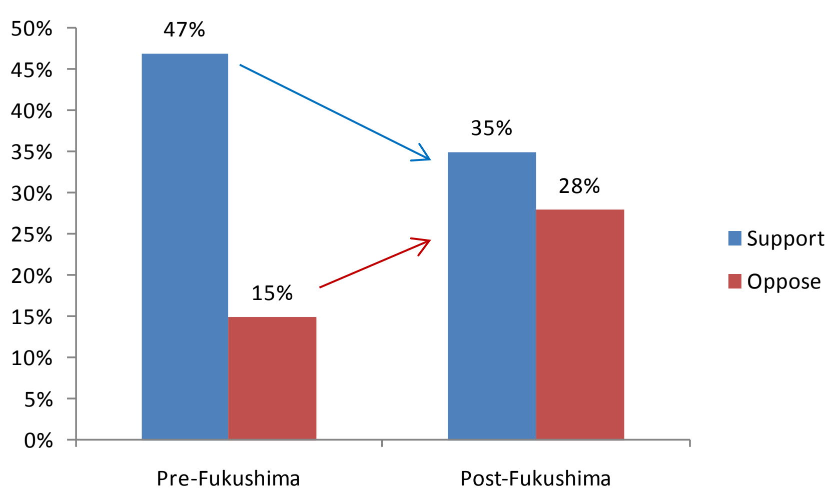
Exhibit 3.3: Can Germany Achieve Energy Security Without Nuclear?



Note: Totals do not add to 100% as some respondents answered "don't know"
Source: "Opinions on Nuclear Energy", Stern Magazine, March 14, 2011

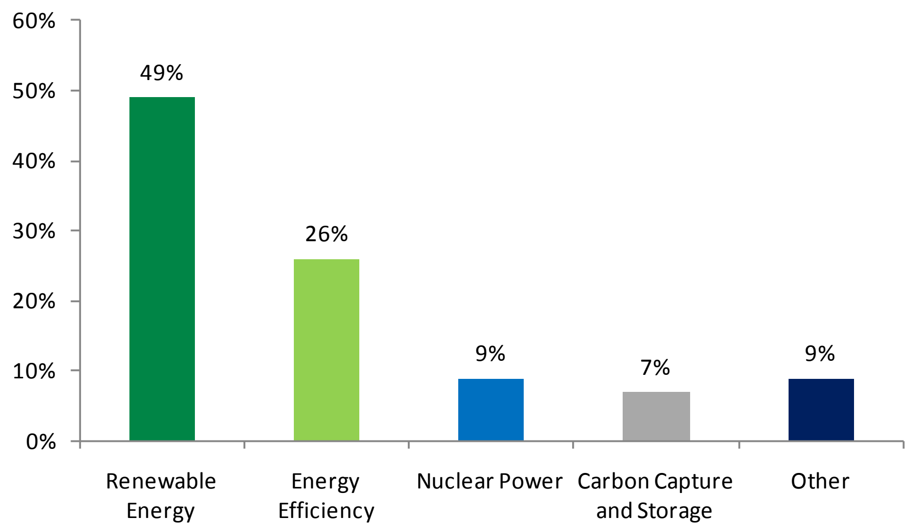
- **United Kingdom:** A Friends of the Earth Poll completed on March 20th found support for nuclear has dropped by 12 points following the crisis in Japan, relative to a similar poll conducted in 2008, 2009 and 2010. Of those polled, 37% said that they were now more likely to oppose the building of new nuclear power in the UK and 44% said that they were worried about the safety of UK nuclear power plants. There was also a very clear indication of public support for UK investment in renewable energy and energy efficiency measures over nuclear – 75% of respondents supported more investment in renewables and efficiency, relative to only 9% in support of nuclear power.

Exhibit 3.4: Change in UK Support for Nuclear Pre and Post-Fukushima



Source: Friends of the Earth Survey completed by GfK NOP, March 18 – 20, 2011

Exhibit 3.5: Substantial UK Popular Support for Clean Technologies over Nuclear and Fossil Fuels



Source: Friends of the Earth Survey completed by GfK NOP, March 18 – 20, 2011

- **France:** The shift in public sentiment against nuclear has not been as pronounced in France as in many other European countries, probably because the country is so heavily dependent on this technology for its power supply (80% of France's power comes from nuclear generation, and this has generally been publically accepted). Nonetheless, a poll commissioned by power producer EDF on March 16th found that 42% of those polled were in favor of dropping nuclear and 70% said that they believed a nuclear accident such as Fukushima could happen in France. A poll for Europe Ecologie Les Verts on March 17th found a slim majority of the population thought France should stop its nuclear program gradually over the next 25 to 30 years, while 19% wanted the nuclear program stopped immediately, and 30% thought the program should be continued and new plants constructed[62]. These findings suggest a general attitude of concern regarding France's nuclear program, but not the sort of dramatic opposition to nuclear that has been occurring in countries such as Germany.
- **Switzerland:** According to a poll carried out by Swiss newspapers Le Matin Dimanche and SonntagsZeitung following Japan's disaster, a very substantial 77% called for a shutdown of nuclear reactors in the medium-term while 10% sought an immediate closure of Switzerland's nuclear plants.
- **Sweden:** Based on a poll conducted by daily Dagens Nyheter support for nuclear energy in Sweden dropped sharply in the wake of Japan's crisis. 36% of respondents now favor the phase out of nuclear power, compared to 15% that wanted to do so in 2008.
- **Lithuania:** A poll for Lithuanian magazine Veidas released April 4th showed 88% of Lithuanians, traditionally supportive of nuclear power, now oppose plans to build a new power plant — an increase of 47% since January 2011. Some 42% of those polled said the Fukushima Dai-ichi disaster had made them change their minds. Lithuania was one of the world's most nuclear-energy dependent countries before it closed its Soviet-era plant in Ignalina in 2009, but the country has since developed substantial nuclear ambitions

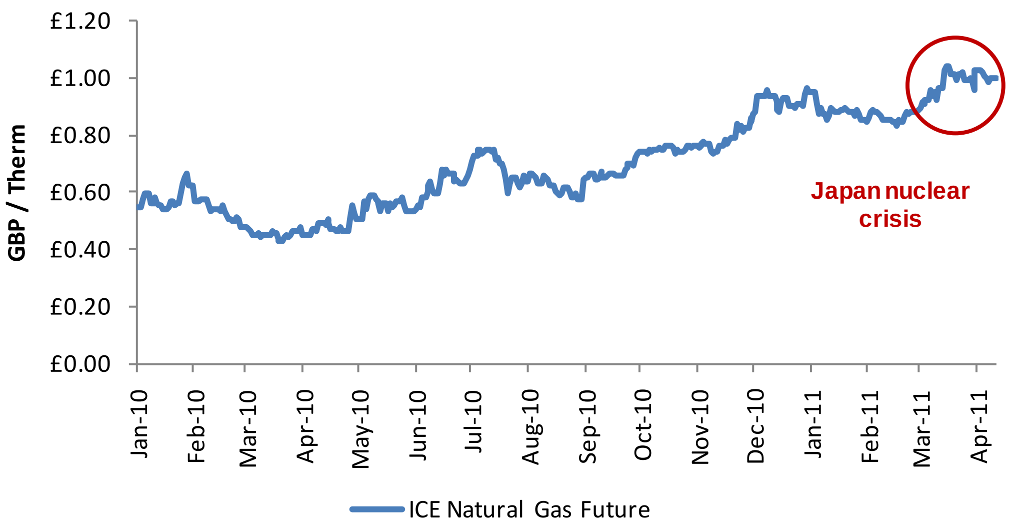
[62] *"Les Français et le nucléaire", Ifop for Europe Ecologies Les Verts, March 17, 2011*

Section 4: What are the Financial Markets Saying?

As an indicator of what investors think, market pricing of key elements of the global power markets and related corporations have shown the following:

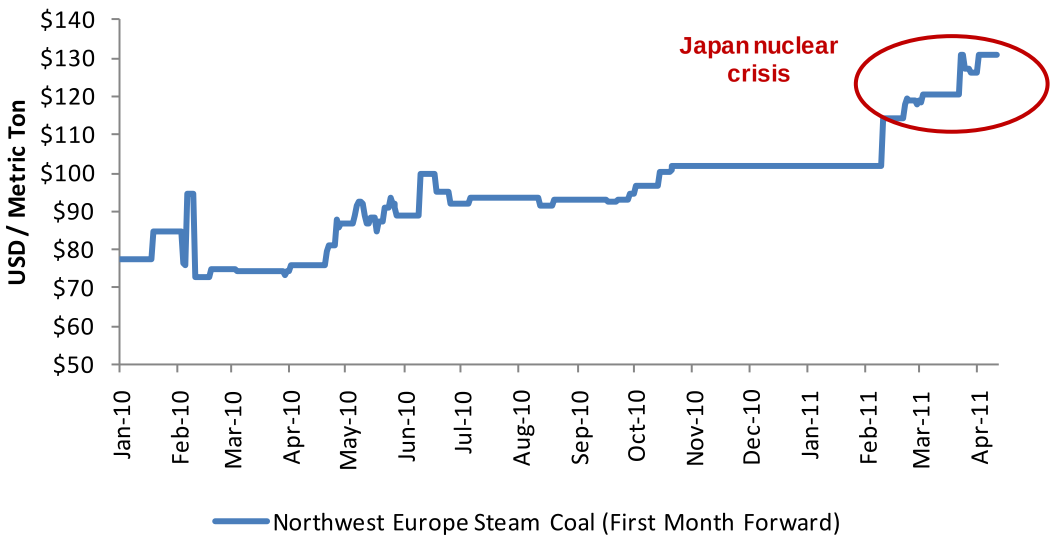
- Liquefied natural gas (LNG) and thermal coal prices are on the increase as nuclear supplies appear more constrained. Increased utilization in the near term is expected in Europe and Japan, in particular, to plug the gap in suspended or lost nuclear power generation. Japan is already a substantial LNG importer and it is expected that it will draw upon both Qatar and a diverse base of Pacific Basin sources, thereby drawing some supply away from Europe.
- Renewable energy stocks have seen some relative performance improvement as the sector appears increasingly attractive due to the relative health, safety, security and environmental benefits of these technologies – as well as their relatively minimal exposure to commodity price risk. Wind stocks, in particular, have responded positively to recent developments.
- Since the onset of the Japanese crisis, the correlation between oil prices and renewables stocks has tightened up.
- As expected, nuclear companies have been negatively affected by the events in Japan. Existing health, safety and environmental concerns regarding nuclear have been heightened, and the industry is also bracing itself for substantial cost increases as regulations of nuclear power facilities are heightened in countries all over the world.

Exhibit 4.1: Europe Natural Gas Futures Rise



Source: Intercontinental Exchange (ICE) Bloomberg

Exhibit 4.2: Steam Coal Prices Increase as Capacity Utilization Increases

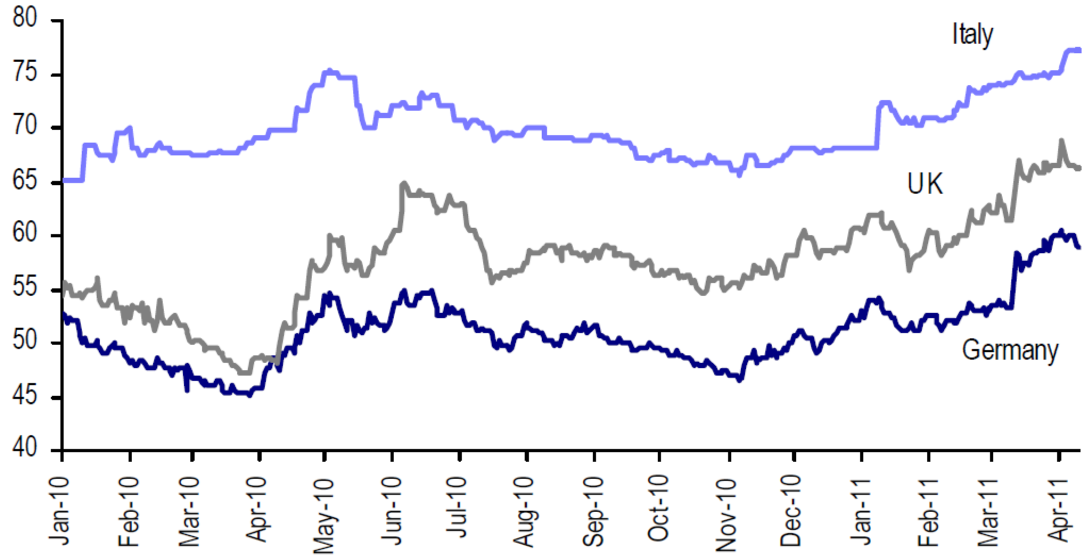


Source: Bloomberg

- Exhibits 4.1 and 4.2 demonstrate the upward impact of Fukushima on forward gas and coal prices in Europe. These fuel prices had already been on the rise in 2011, responding to rising oil prices as a result of unrest in the Middle East combined with growing demand, and Fukushima has accelerated this trend.
- Electricity prices have also increased as a result of events in Fukushima and an increase in fuel commodity prices (see Exhibit 4.3). This is evident in Europe, and particularly Germany, where approximately one-third of the country's operating nuclear power capacity was taken offline in the immediate aftermath of the nuclear disaster in Japan, pending a safety review of all plants constructed pre-1980.
- The nuclear crisis and its policy impacts in Europe also positively impacted EU ETS carbon prices, as is evident in Exhibit 4.4 below. A higher carbon price as coal utilization increases in the short term further supports the gas thesis over the medium to longer term due to its lower carbon emissions – the increased cost of coal generation (in terms of carbon allowances) is expected to make gas-fired generation more cost competitive with coal, particularly in Europe[63].

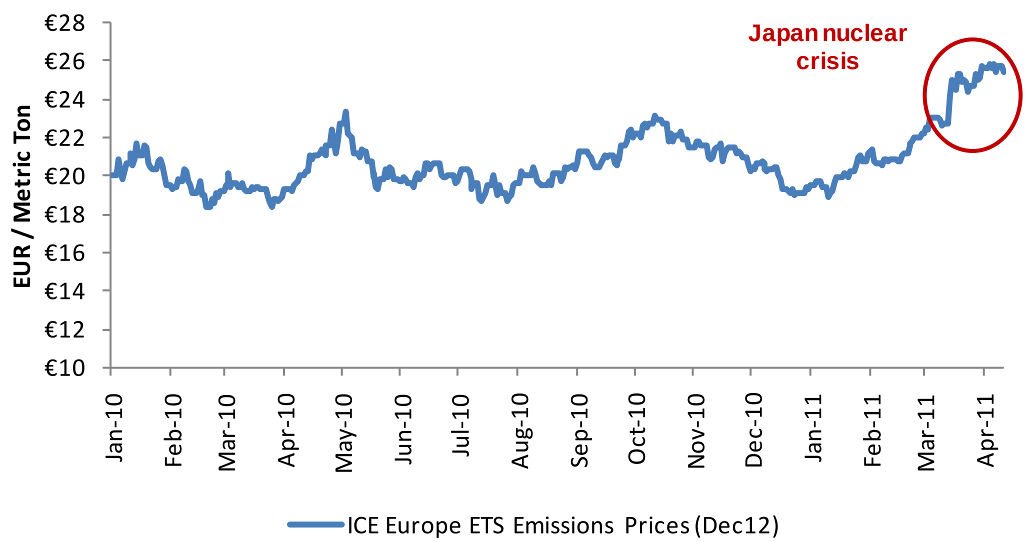
[63] *See, for example, "EU Energy Markets: Thunders in the Index", Deutsche Bank, March 22, 2011*

Exhibit 4.3: European Power Prices on the Rise (EUR/MWh)



Source: "Oil & input costs: More than just a spike?", UBS, April 20 2011

Exhibit 4.4: EU ETS Carbon Prices Increase Substantially

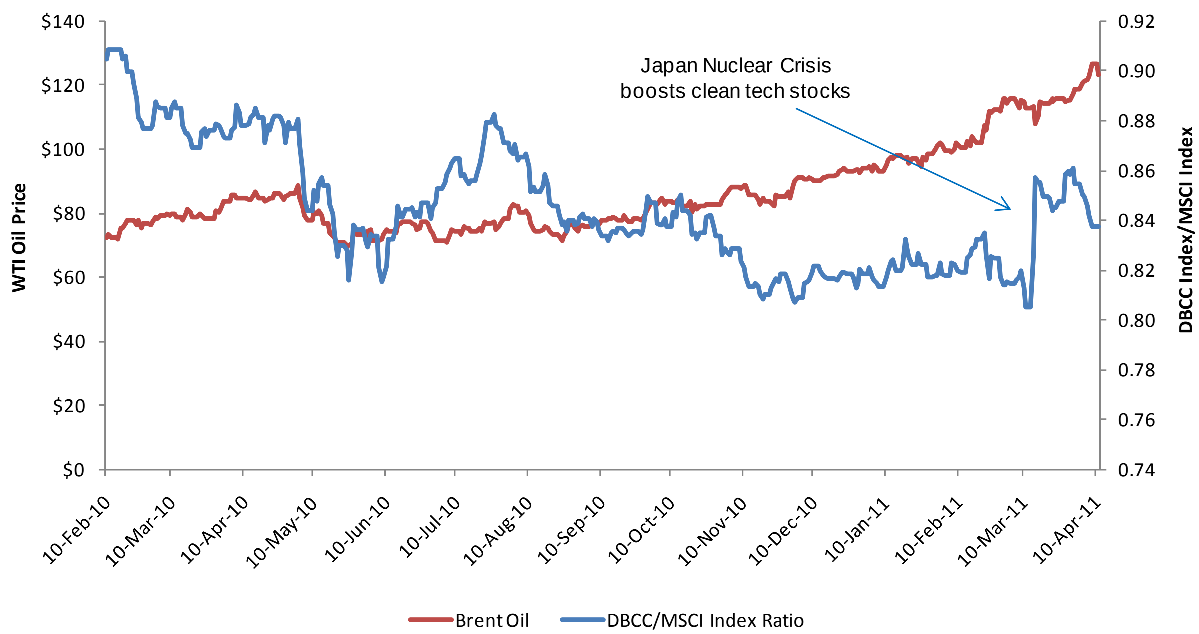


Source: Bloomberg

- Another outcome of events in Fukushima has been the relative improvement in performance of clean technology stocks, as investors expect an increase in the deployment of renewables in many countries, given the expected shift away from carbon-free nuclear generation. An increased correlation between clean technology stocks and oil prices is also observed.

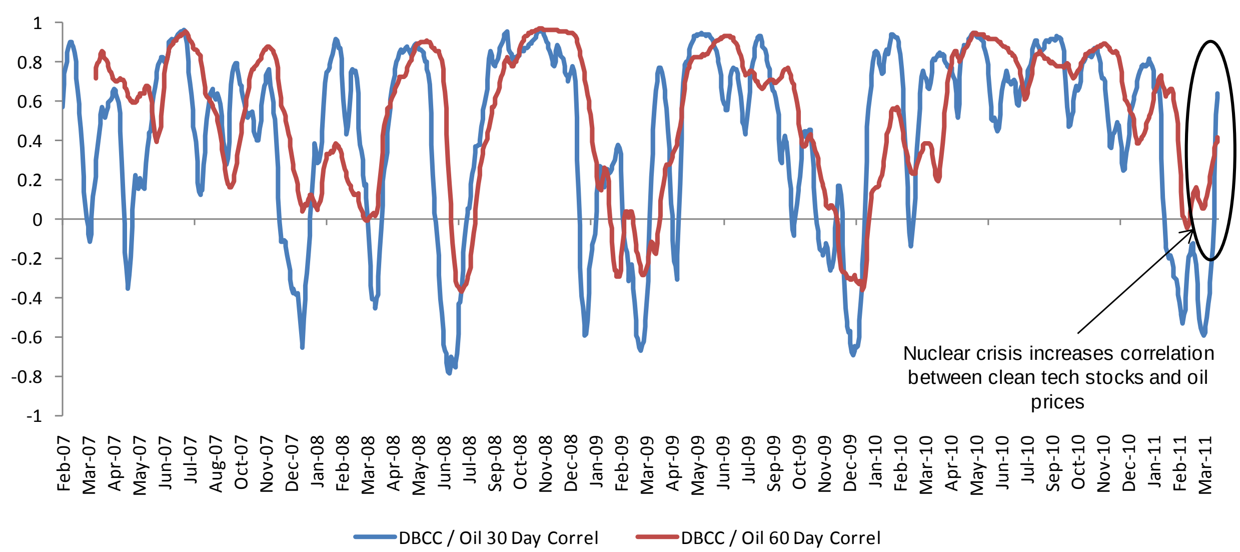
- The nuclear industry has simultaneously experienced a drop in investor interest as prospects for the industry have declined somewhat and these stocks are viewed as more risky.

Exhibit 4.5: Out-Performance of DBCC Clean Technology Index relative to MSCI Index vs. Oil Prices



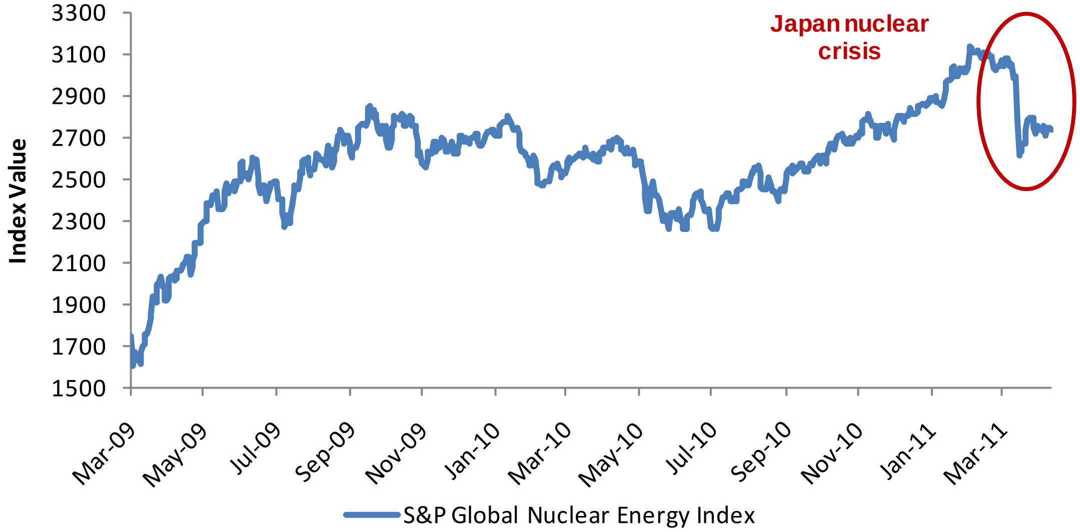
Source: Bloomberg

Exhibit 4.6: Rolling Correlation Analysis of DBCC Index and Oil Prices



Source: Bloomberg

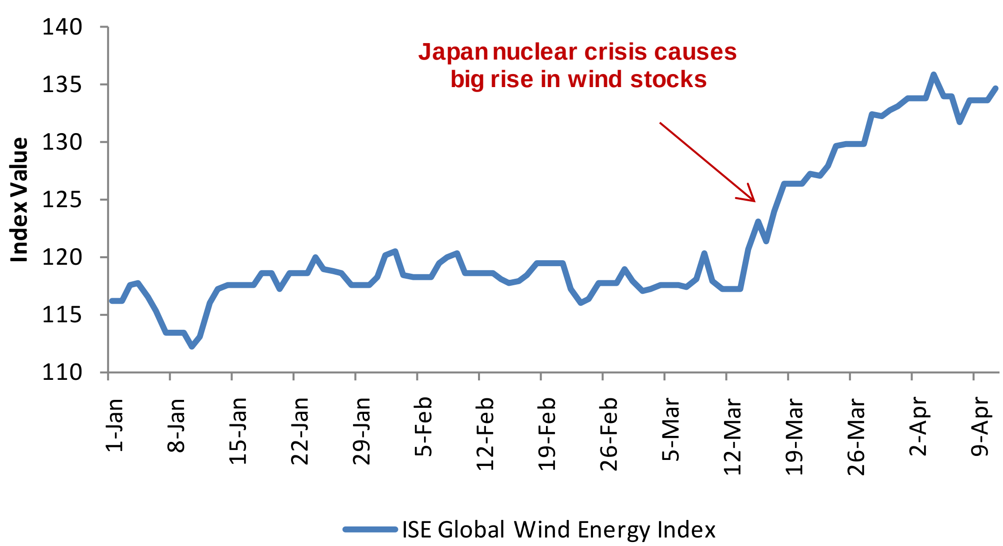
Exhibit 4.7: Nuclear Industry Suffers Setback



Source: Bloomberg

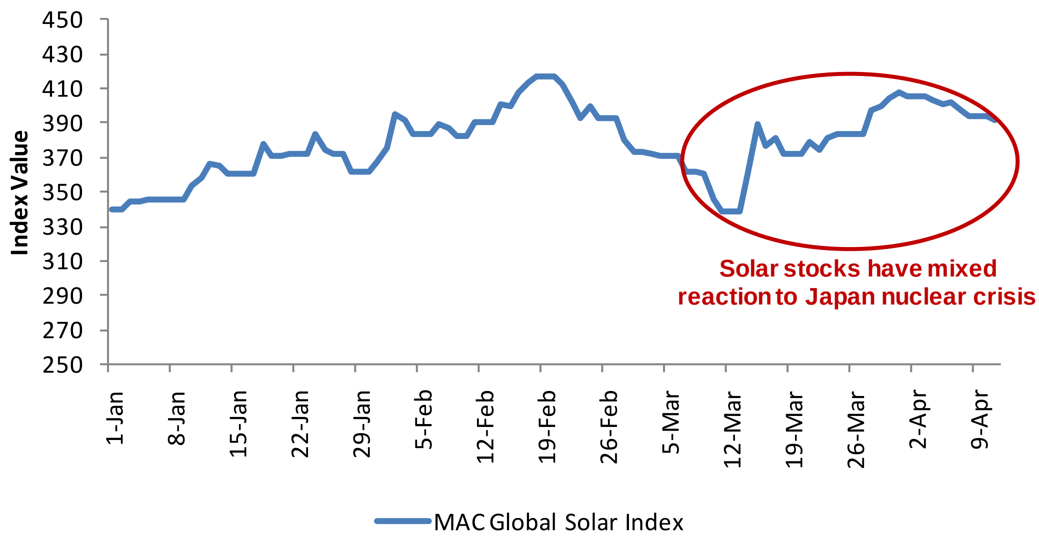
- Wind energy stocks have reacted very positively to events in Fukushima, with greater than a 10% increase in the ISE Global Wind Energy Index from March 11th to April 19th.
- Solar, by contrast, has had a far more mixed reaction, with some market fluctuation since Fukushima, as represented by the MAC Global Solar Index.

Exhibit 4.8: Wind Energy Stocks React Positively to Crisis



Source: Bloomberg

Exhibit 4.9: Solar Energy Stocks Have Mixed Reaction



Source: Bloomberg

Section 5: Renewable Energy Investment: A Winner

Before the oil and nuclear crises of 2011, the momentum towards renewable energy was growing across much of the world, evident in government support for this industry via direct (for example, feed in tariffs) or indirect (for example, carbon reduction targets) policy mechanisms.

Commitments to tackle climate change and reduce emissions are noticeably different by region and country. At the national level, Asia and Europe continue to experience the greatest momentum, while the United States (with some limited state exceptions) has yet to adopt federal emissions reductions targets, standards and incentives and therefore experiences less momentum.

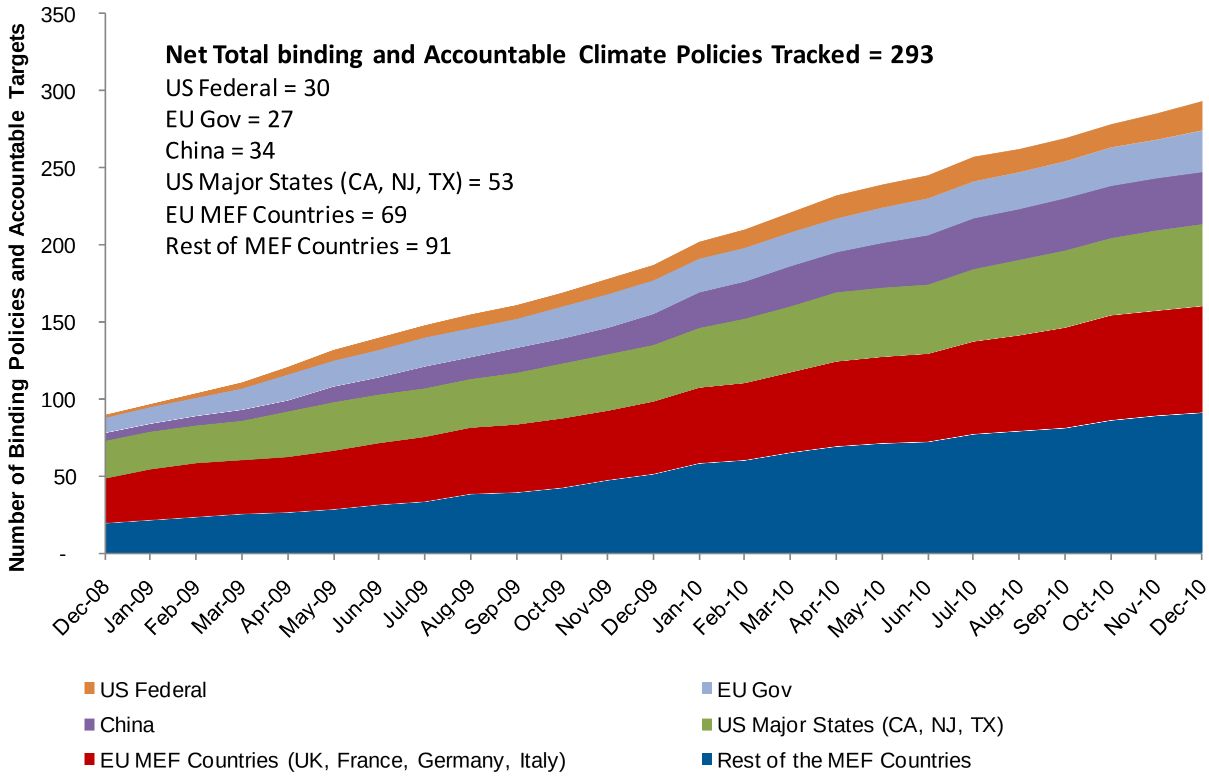
Historically, we have tracked the momentum of climate policy announcements since June, 2008, which depicted the momentum of binding legislation, aspirations and policy proposals. While momentum surrounding these policy types has been significant over the past two years, we believe it is useful to focus solely on the core fundamental legislation moving climate change markets.

As a result, we have tracked 293 net binding and accountable climate policies (which while not legally binding, are significant statements of intended action) for the Major Economies Forum (MEF), overarching EU government and major US states (California, New Jersey, Texas) made from June 2008 to December 2010 – as demonstrated Exhibit 5.1 below. The figures show continued strong momentum on a global scale, with Europe overall a core backbone, China strong, the US Federal level lagging, but key US states moving forward. These include emission reduction targets, mandates and standards and supporting policies such as feed-in tariffs and tax credits.

Key findings:

- The US, China and EU comprise the biggest share of total policies tracked (69%). The EU is still a leading driver of climate policy action, with the EU government and EU MEF countries comprising 33% of the total.
- When looking at both federal policies and major state policies for CA, NJ and Texas, the US comprises 25% of total policies. It is important to note that the US tally is primarily comprised of state-level policy actions, which we believe cannot be ignored. This confirms that the US has to rely on a state-level policy approach to mitigate climate change.
- China comprises 12% of the total policy count. The number of national climate policies in China is twice as large as that of the US at the federal level. China is a strong emerging policy leader in mitigation policy, with significant weight and magnitude to its policies, especially its supporting incentives.

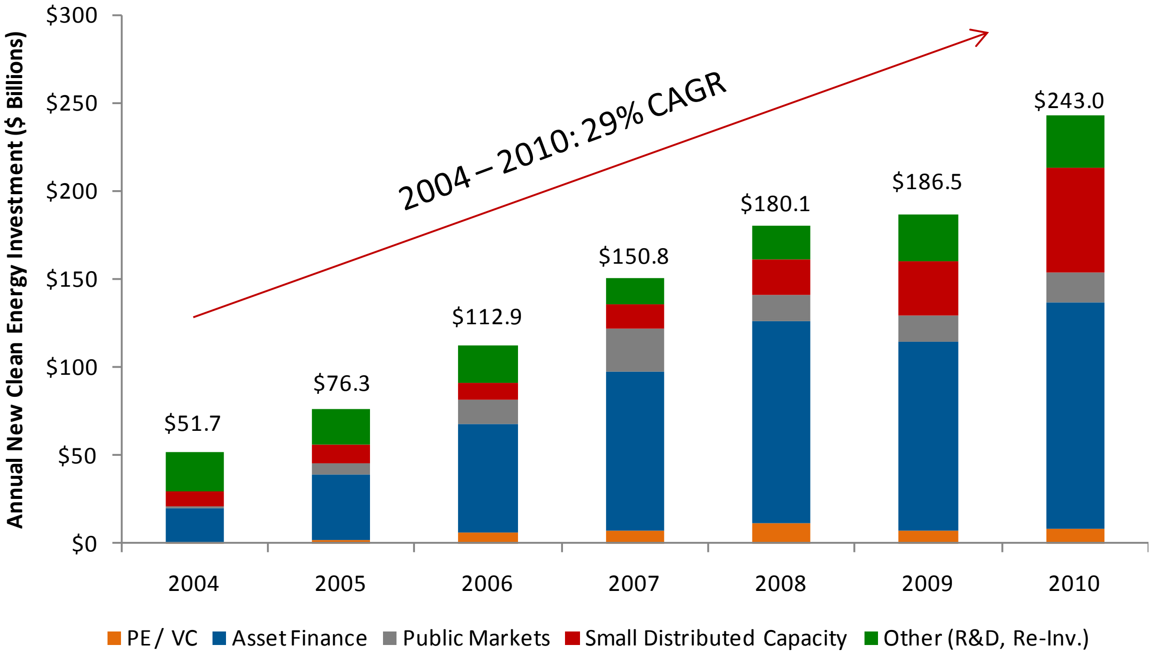
Exhibit 5.1: Cumulative Binding and Accountable Climate Policies Tracked for MEF Countries, EU Government and Major US States



Note: The number of net policies represents the difference between positive & negative policies.
Source: DBCCA analysis, 2011.

As a reflection and result of this policy momentum, total global new investment in clean energy has increased year-on-year since 2004, and in 2010 increased over all asset classes, reaching a record $243 billion[64].

Exhibit 5.2: Annual New Clean Energy Investment by Asset Class



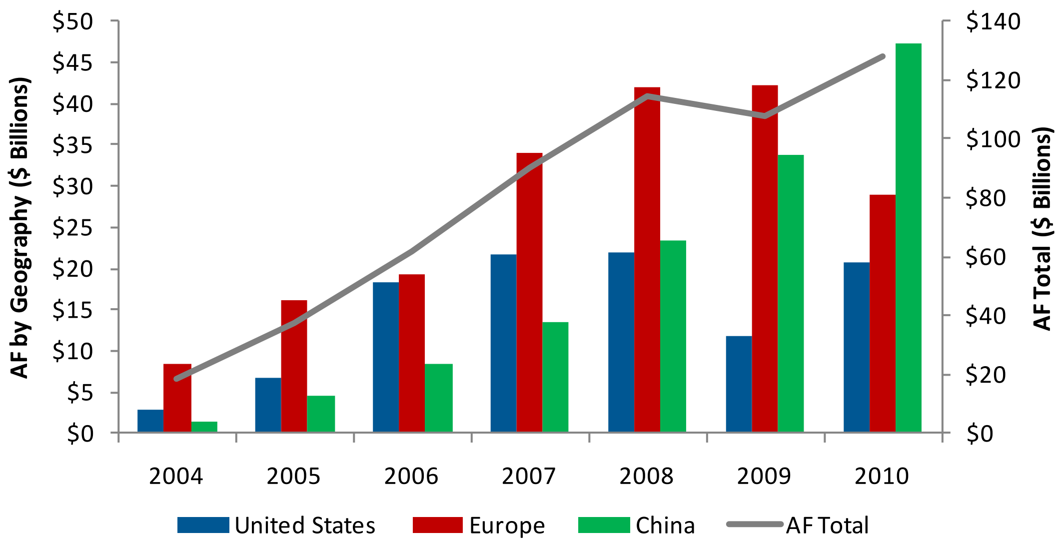
Source: Bloomberg New Energy Finance

A geographical breakdown of these investments by asset class further reinforces the growth story, and demonstrates the key regional trends in investment.

- There has been a very substantial growth in investment in China, and something of a shift away from Europe and the US as the centers of clean energy investing. This is particularly evident in asset financing statistics (see Exhibit 5.3 below).
- Clean energy private investment is still dominated by the US, as is evident from recent VC / PE investing trends (see Exhibit 5.4 below).
- In terms of small distributed capacity (SDC), this type of investment is still dominated by Europe, which saw a very substantial jump in 2010 (see Exhibit 5.5 below).

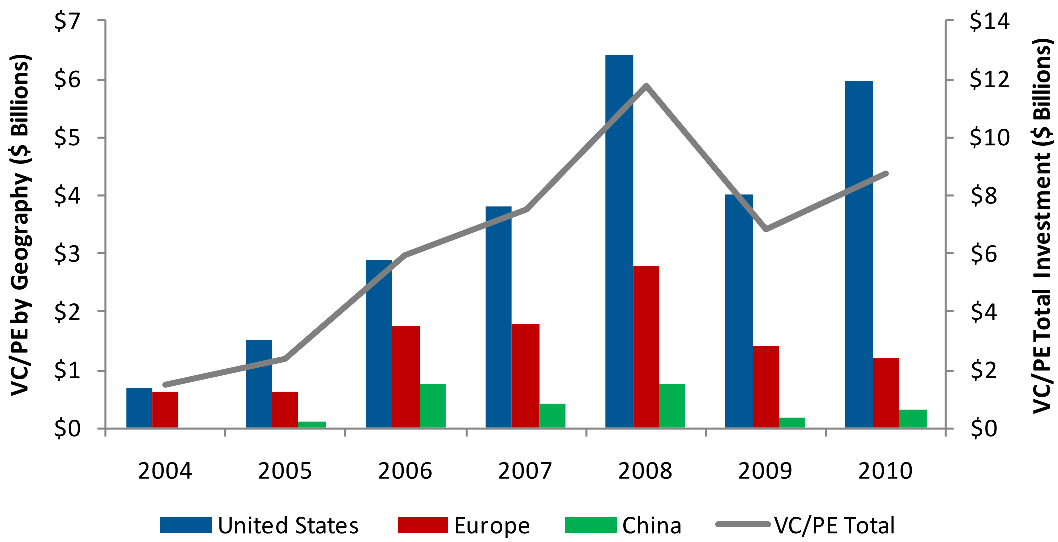
[64] *Bloomberg New Energy Finance*

Exhibit 5.3: Asset Finance Investment Breakdown by Geography



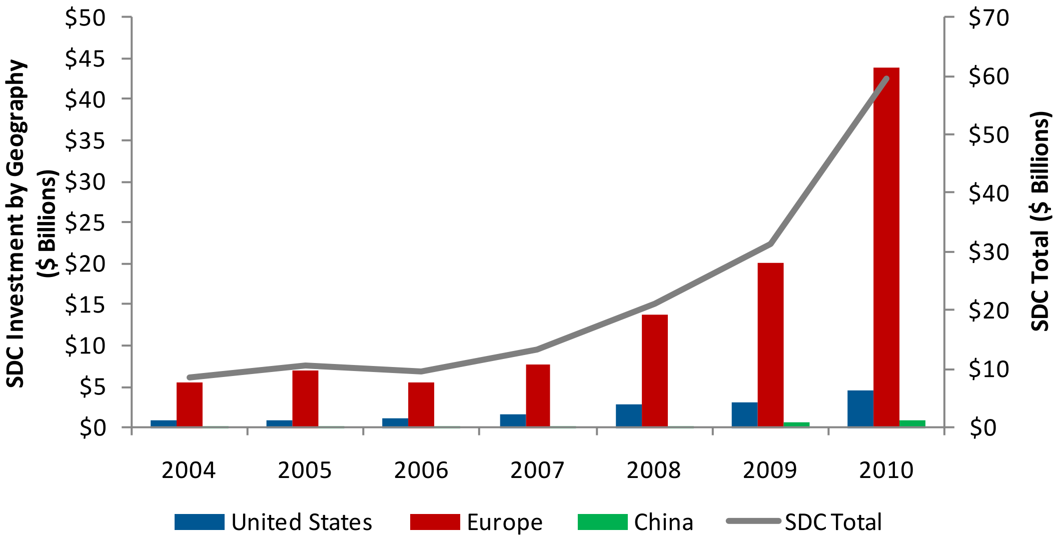
Source: Bloomberg New Energy Finance

Exhibit 5.4: VC / PE Investment Breakdown by Geography



Source: Bloomberg New Energy Finance

Exhibit 5.5: SDC Investment Breakdown by Geography



Source: Bloomberg New Energy Finance

With regard to public markets, in data calculated by Renaissance Capital, initial public offerings (IPOs) for clean energy firms have rebounded off the lows experienced during the credit crisis, although they have not yet regained their pre-crisis highs.

- Of note, 29 of 75 deals in the past 5 years have been in Asia, with a larger number of firms choosing to list in the region recently. 85% of deals by market value in 2010 IPO'd in Asia, and 53% of deals by market value were in China or Hong Kong.

Exhibit 5.6: Public Market Clean Tech Deals Return in 2010

Year	Number of Clean Tech IPOs (>$100mm)	Total Proceeds ($bn)
2006	15	$4.8
2007	26	$12.9
2008	6	$3.8
2009	4	$2.9
2010	24	$9.0
TOTAL	**75**	**$33.4**

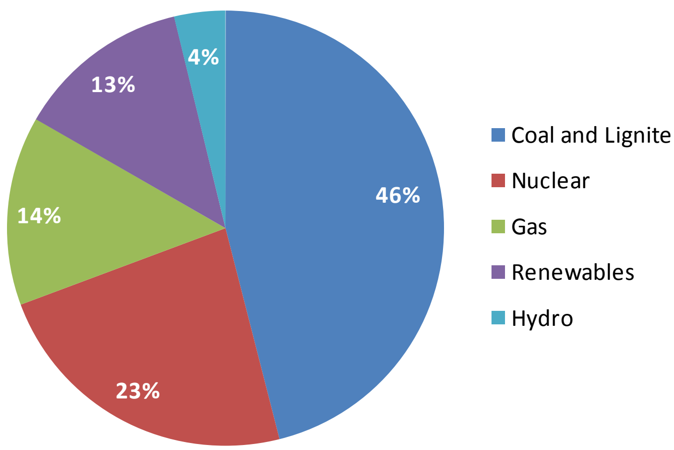
Source: Renaissance Capital

Germany – A Case Study of Successful Renewables Deployment, Further Strengthened by Recent Events

Germany has been a particularly early adopter of supporting climate policy mechanisms such as feed-in tariffs, which are an integral underpinning of any prosperous green economy.

- Germany clearly represents an example of how renewables and jobs can be scaled-up, while reducing policy risk, for other countries around the world, including the US.
- The main policy mechanism supporting Germany's renewable energy sector has been the feed-in tariff, which provides certainty of long-term cash flow to projects. In the passage of the German EEG in 2000 and since updated in 2009, Germany established a feed-in tariff (FiT) regime that supports the EU mandated goal of 20% renewable energy as a share of electricity by 2020. In addition, Germany has set an accountable target to achieve 80% of its electricity power from renewables by 2050, even with a full retirement of its nuclear fleet[65].
- Germany's FiT system embodies transparency, longevity, certainty and consistency (TLC) for investors: standard offer, transparent contracts with up to 20 years of longevity, with guaranteed certain payment streams and to ensure "right pricing" for electricity consumers, a tariff degression over time to match all reductions in technology costs, with an end target of grid parity with fossil fuels.
- There have been tangible benefits resulting from Germany's feed-in tariff and other climate legislation. Germany has experienced a rapid increase in solar PV installations, with a record surge in 2010 (7.4 GW of capacity was installed[66]), while $/watt costs fell dramatically.
- The additional benefit of Germany's renewable energy policies has been the creation of nearly 340,000 jobs, a two-fold increase from the number of green jobs in 2004)[67]. By 2020, the German government aims to create 500,000 new jobs in the renewable energy sector.

Exhibit 5.7: Germany's Power Generation Mix, 2010



Source: "CO2 Fuel Mix and Prices", Citi, March 24, 2011

[65] *The actual date of full retirement is currently under discussion by the German government. In 2002, 2022 was cited as the target; this was subsequently revised by Merkel to allow for nuclear operations to 2035, and is again being revised in the wake of Fukushima*

[66] *"Germany installed 7.4 GW of PV in 2010", Renewables International March 22, 2011*

[67] *This covers direct employment in production, operation, maintenance and fuel provision as well as indirect employment in other sectors induced by the demand from the RE industry. The biomass sector has attracted the most jobs, followed by wind and solar. Source: "Renewably Employed! Short and long-term impacts of the expansion of renewable energy on the German labor market", Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, September 2010*

Germany is the only country (other than Japan) to have immediately closed several nuclear reactors in response to the events at Fukushima in Japan.

- The German government enacted an immediate clampdown on nuclear following the crisis – a shutdown of seven older plants for at least three months, and an unconditional safety review of all nuclear plants.
- Nuclear accounts for over 23% of Germany's power generation[68], and the recent shutdowns account for approximately one-third of Germany's operating nuclear capacity.
- Although coal is still the primary fuel used to generate power in Germany, the country has a long history of political commitment and robust policy support for renewables and consequently a well developed renewable energy sector, particularly its solar industry.
- Given the increasing costs of coal generation in Germany (due to increasingly stringent environmental regulations and a price on carbon, which recognize health, safety and the environment), Germany will not want to substantially increase coal capacity over the longer term – although it may have to increase capacity utilization at existing coal plants to boost generation in the short term.
- Germany has very ambitious renewable energy and climate mandates and targets, with a mandated EU goal of 20% renewable energy as a share of electricity by 2020 and an independently developed target to achieve 80% of its electricity power from renewables by 2050.
- Prior to the events of 2011, Deutsche Bank expected net capacity additions out to 2014 as a small increase in coal capacity, a run-off in gas and oil, but a very substantial increase in renewables (see Exhibit 5.8 below).

Exhibit 5.8: Deutsche Bank Base-Case Annual Net Change in Germany's Gross Power Generation Capacity by Source, 2010 – 2014

	2010	2011	2012	2013	2014	TOTAL
Lignite	0	+2,220	-642	-1,018	-1,355	**-795**
Coal	+750	-322	+1,885	+2,104	-1,926	**+2,491**
Gas	+1,906	+1,038	-3,357	-909	-2,088	**-5,486**
Oil	0	0	-94	-386	-1,264	**-1,744**
Renewables	+6,985	+5,597	+4,684	+4,803	+5,016	**+27,085**
TOTAL	**+9,641**	**+6,457**	**+2,476**	**+4,594**	**-1,617**	**+21,551**

Source: "German Power: The Time is Out of Joint", Deutsche Bank, November 17, 2010

- On April 12th the German government reinforced its commitment to renewables by announcing in a six-point draft plan that "after the catastrophe in Japan, we will accelerate the fundamental conversion of our energy supply". The plan intends to hasten Germany's shift from nuclear power to renewable energy and increased energy efficiency, with baseload power being met by new gas-fired power plants. It argues for the provision of EUR 5 billion to increase offshore wind program, EUR 2 billion to improve building energy efficiency, and EUR 1 billion of additional funding to an energy and climate fund set up in January. It also demands an "offensive" to designate new areas for onshore wind parks and plan the construction of "electricity highways" to bring renewable power from northern Germany (high wind resource region) to industrial areas in the south.
- On April 15th the federal and state government representatives held a meeting to discuss coordination of Germany's rapid transition away from nuclear and toward greater deployment of renewables: ***"We want to exit from nuclear power generation as soon as possible and make the transition to***

[68] *"CO2 Fuel Mix and Prices", Citi, March 24 2011*

renewable energy sources faster," stated Chancellor Merkel after a meeting between federal and state governments on April 15th.[69] She announced the government will make a decision by mid-June regarding how long the country's 17 nuclear power reactors are allowed to remain online, and it is expected Germany will be completely independent of nuclear power by 2022 (at the latest), as opposed to the 2032 – 2035 timeframe outlined by Chancellor Merkel in 2010.

- Having said this, there may well be the need for Germany to source coal-based power either internally or externally in the short-term.

[69] *"Merkel: Nuclear exit 'as soon as possible'", UPI, April 15 2011*

Section 6: The Role of Natural Gas: A US Case Study

This section is based on our 2010 report *"Natural Gas and Renewables: A Secure Low Energy Plan for the United States"*[70], which argues that, in addition to renewables, natural gas should also be a "transition fuel" of choice, given its more advantageous health, safety and environmental qualities. In the case of the US, this is augmented by security and, importantly, cost factors. John Rowe, the Chairman and CEO of Exelon Corp, the largest unregulated nuclear energy company in the US, stated in a key note address at the American Enterprise Institute on March 14 that: ***"a new natural gas combined cycle plant costs less than half of a new coal plant, even without carbon sequestration, and something like a sixth of the cost of a new nuclear plant. So natural gas is queen right now," by which he means it will be "the dominant source of energy for electricity at the margin" for the foreseeable future.***[71]

US Coal and Gas Historic Analogs (Energy Policy Changes)

Coal fell to its lowest percentage of market share in the early 1970's when it had about 17% of the total US electricity market while natural gas's share of the market was 32%. However, in 1978, the US passed the Fuel Use Act, which prohibited the use of natural gas in new power facilities. Consequently, by 1986, coal's share had increased to 23% and natural gas had declined to 23%.[72] Coal's share of electricity peaked in 1997 at about 53% and is now declining while gas's share is increasing. And based on forthcoming regulatory changes from the US Environmental Protection Agency (EPA) directed at Hazardous Air Pollutants (HAPs) we expect gas to continue to gain share at a steady clip at coal's expense, with gas increasing to 30% of total electricity supply by 2020 and coal's share decreasing to 34%, as shown in Exhibit 6.1. Our assumptions below were prepared late in 2010, and so our forecast for nuclear share is now looking on the high side and is under review.

[70] *http://www.dbcca.com/dbcca/EN/investment-research/investment_research_2358.jsp*
[71] *http://www.aei.org/article/103323*
[72] *Energy Information Agency Monthly Energy Review and Energy Statistic Sourcebook*

Exhibit 6.1: DBCCA Electricity Supply Mix Forecast

US Electricity Supply (% total kWh)	2005A	2009A	2020E	2030E	Comment
Coal traditional	50%	47%	34%	21%	Reduced to meet emissions target and comply with EPA regulation
Coal CCS	0%	0%	0%	1%	Limited deployment 2020-2030 with government R&D support
Natural gas	19%	23%	30%	35%	Coal to gas fuel switch, underutilized assets, strong new build
Natural gas CCS	0%	0%	0%	0%	No deployment, assume that gas CCS is viable post 2030 and cheaper $/MWh than coal
Petroleum	3%	0%	0%	0%	No additions; existing capital stock remains for reliability but hardly used
Nuclear (now under review)	19%	20%	21%	23%	Modest gains from nuclear steam generation "uprates" and limited new builds
Wind and solar (intermittent)	0%	2%	9%	14%	Large capacity additions; transmission and dispatchability limit growth vs potential
Baseload renewables (geothermal & hydro)	7%	8%	6%	6%	Share decreases modestly as only very limited new builds
Total	**100%**	**100%**	**100%**	**100%**	
Renewables share total (intermittent and baseload)	9%	10%	15%	20%	Doubling of share 2010 to 2030 due to wind and solar additions to meet RPS
Electricity Demand (kWh)	4,055	3,784	3,978	4,181	0.5% CAGR growth due to energy efficiency and operational improvements
CO2 emissions (mn metric tons)	2,397	2,200	1,691	1,347	Emissions reduced substantially due to the coal to gas fuel switch and build-up in renewables
% CO2 emissions reduction vs. 2005		**-8%**	**-29%**	**-44%**	

Source: DBCCA analysis 2010

We believe that in 2020 when investors look back at the 2011 and 2012 time period with the benefit of hindsight, it will be evident that there was indeed a measurable "tipping point" in favor of natural gas and renewables. This will be at the expense of coal over the longer term, and nuclear energy, which have higher costs and higher risks as illustrated in Exhibit 6.2 below (and in Exhibit 6 previously).

Exhibit 6.2: Evaluating the Power Sector Energy Mix Options

Fuel	CO2 Abatement Potential	Capex Financing Requirement	2020 Deployment Limitations	2030 Deployment Limitations	DBCCA Feasibility Assessment
Renewable Power – Wind	High	High	Moderate	Moderate	High
Renewable Power – Solar	High	High	Moderate	Moderate	High
Renewable Power – Other	High	High	Moderate	Moderate	High
Nuclear	High	High	High	Moderate	Moderate / Low
Coal	Low	High	High	High	Low
Fossil Fuel Switching (Coal to Gas)	Moderate	Low	Low	Low	High

Note: "Other" includes hydro, geothermal and biomass
Source: DBCCA analysis 2010

The fundamental investment case that we made in 2010, arguing that natural gas and renewable generation in parallel represent a secure low carbon future energy plan for the United States, has now been incrementally bolstered even more with nuclear energy tarnished and sentiment in flux. To recap, our investment thesis hinges at its core on what is economically, politically and environmentally feasible – with best practices – and is rooted in an in-depth analysis of the US energy sector. We now believe there will be heightened regulatory and political pressure to accelerate the retirement of older nuclear units on top of the sizable pressure that certain units already face with respect to cooling water intake regulation and potentially expensive retrofits.[73] Moreover, new nuclear units continued to be challenged by their high upfront capital costs in a low gas price environment as illustrated in Exhibit 6.3 below.

[73] *Mark Fulton and Nils Mellquist, Natural Gas and Renewables: A Secure Low Carbon Energy Plan for the United States*

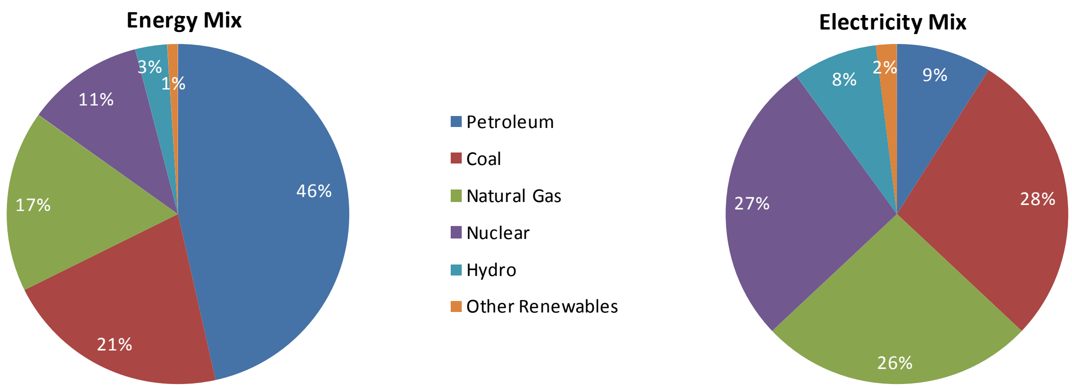
Exhibit 6.3: Total Costs – Which Reflect Risks – Favor Gas and Renewables

Fuel Source	LCOE ($/kWh)	Other Cash Costs ($/kWh)	Fully Loaded Cash Cost ($/kWh)	DBCCA Comment
Old Coal ($3.00 /mmBtu)	0.04 - 0.06	0.02 - 0.03	0.06 - 0.09	Retrofit costs required to be EPA compliant; only newer and more efficient coal plants are likely to be upgraded; no carbon price assumed
New Coal ($3/mmBtu)	0.07 - 0.09	0.03 - 0.05	0.10 - 0.14	EPA regulation on multiple pollutants pending; compliance costs uncertain; almost impossible to get air permit because of unknown Best Available Control Technology (BACT) for CO_2 retrofit could add incremental 30 – 50% to the capital cost; no carbon price assumed
Old Gas ($6/mmBtu)	0.05 - 0.07	0.01	0.06 - 0.08	Older gas plants were designed to run as baseload and often lack digital instrumentation; to pair with renewables new instrumentation and fast start optimization may be required; economics improve substantially with $4 - $5/mmBtu gas
New Gas ($6/mmBtu)	0.06 - 0.08	0.00 - 0.02	0.06 - 1.00	An estimated 50 GW of gas assets are co-located next to inefficient coal plants; replacing additional coal with gas could require substantial gas pipeline additions
Old Nuclear	0.07 - 0.09	0.04	0.11 - 0.13	Cooling water retrofits and steam turbine replacements may be necessary for lifecycle extensions
New Nuclear	0.12 - 0.14	??	??	New nuclear requires loan guarantees; massive scale-up from 2020 – 2030 would require substantial government support and a long-term storage option for spent fuel; fully loaded costs hard to measure, particularly given regulatory uncertainty post-Fukushima
Wind	0.09 - 0.11	0.03	0.12 - 0.14	The best on-shore wind resources are far from the major cities that constitute demand and therefore require substantial transmission and fossil backup because wind often blows at night when demand is low; revitalization of under-utilized gas plants may diminish the need for as much transmission capacity additions
Solar	0.22 - 0.30	0.02	0.24 - 0.32	The best solar CSP sites are in the desert far from load centers, requiring incremental transmission; however, solar is peak-coincident and therefore at scale can displace expensive and inefficient fossil generation, particularly if located close to the load; there is a merit order effect that could be beneficial for rate-payers in that large solar additions would diminish the need for dispatching expensive, high variable cost fossil peaking generation

Note: For coal/gas fully loaded cash cost refers to new build, scrubbed EPA compliant plants
Source: DBCCA Analysis, 2010

Section 7: The Energy Challenge for Japan

Exhibit 7.1: Japan's Primary Energy Supply and Electricity Generation by Source



Source: Energy Information Administration, US

Japan has very limited domestic reserves of oil, natural gas and coal, and as a result is a substantial importer of these fossil fuels

- Japan has only 44 million barrels of oil reserves[74] and consequently produces only a very negligible amount of oil, yet it is the third largest consumer of oil globally (after the U.S. and China), consuming 4.4 million barrels of oil per day in 2010[75] - as a result, Japan has long been a huge net importer of oil and relies on countries in the Middle East for more than 77% of its imports[76].
- Similarly to oil, Japan has only negligible domestic reserves of natural gas (738 Bcf) and produced only 181 Bcf in 2009, yet is a heavy consumer of gas (consumes 5.5 Bcf/day), utilizing the resource for 26% of its electricity generation[77]. As a result, Japan relies on liquefied natural gas (LNG) imports for virtually all of its natural gas needs, and is one of the largest LNG importers in the world – the country accounted for approximately 36% of global LNG imports in 2009[78].
- Japan relies on coal for 28% of its power supply, and imports 100% of its coal supply as domestic coal production was discontinued in 2002[79]. Japan has only 355 million tonnes of proven coal reserves, less than 0.05% of total global coal reserves.[80]
- Political and economic concerns over the country's high dependence on imported fossil fuels has led Japan to introduce policies to reduce domestic energy consumption (for example, Japan's 2006 New National Energy Strategy emphasized increased energy conservation and efficiency) – Japan has been successful in reducing oil consumption, which has fallen by 21% from 2000 to 2010[81].

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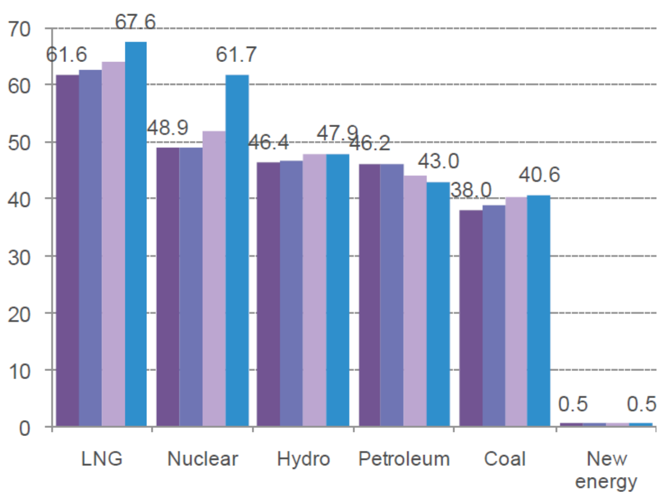
[74] As of January 2011. The Oil and Gas Journal, 2011. Note: Japan's accessible reserves are concentrated along the country's western coastline. Although there is likely to be significant potential offshore oil and gas reserves, particularly in the East China Sea, development of these reserves has not occurred to date due to competing territorial claims with China
[75] Energy Information Administration, 2011
[76] Japan's crude oil imports were from the following countries in 2009: Saudi Arabia (27%), UAE (20%), Qatar (12%), Kuwait (9%), Iran (9%), Russia (3%), and ROW (20%). Source: Energy Information Administration, US
[77] Energy Information Administration, 2011
[78] Energy Information Administration, 2011
[79] Energy Information Administration, 2011
[80] Data as of the end of 2009. "BP Statistical Review of World Energy 2010", BP, June 2010
[81] From 5.6 million barrels per day in 2000. Source: "BP Statistical Review of World Energy", BP, June 2010

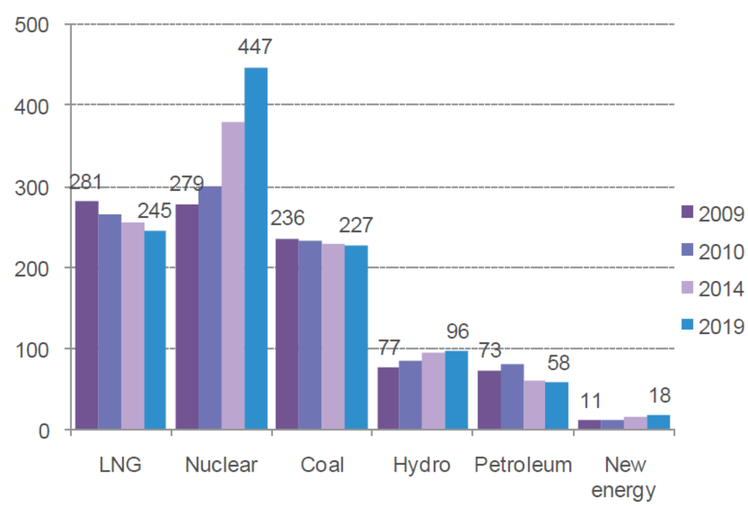
- Since the 1960s, the government has also taken steps to secure energy by supporting Japanese companies in overseas exploration and production of oil and gas[82], securing long term supply contracts, and promoting domestic stockpiling (particularly of oil).
- Japan also sought energy independence through the development of a substantial amount of domestic nuclear energy – Japan has been a global leader in nuclear energy, ranking third globally (behind the US and France) in terms of installed nuclear capacity. Prior to the events of March 11th Japan had 54 operating nuclear reactors and a total installed capacity of 49 GW, with nuclear accounting for 27% of the country's power supply.
- With regard to clean energy, although Japan has abundant wind, solar, biomass and geothermal resources, it has not been an international leader in any of these technologies except solar PV. Instead, the country has targeted clean technology exports, while relying on nuclear power and fossil fuel imports for its own electricity generation.
- As Exhibit 7.2 below shows, Japan intended to continue this energy strategy over the next decade, with only a very marginal increase in "new energy" expected.

Exhibit 7.2: Japan's "Electricity Supply Plan of 2010"

Planned Total Capacity in Japan by 2019 (GW)



Planned Total Electricity Supply in Japan by 2019 (TWh)



Source: "Electricity Supply Plan of 2010", Ministry of Economy, Trade and Industry, March 31, 2010, as cited in Bloomberg New Energy Finance, March 2011

[82] *Since 1967 Japan has sought to promote domestic and overseas oil exploration and production, with the establishment of the Japan National Oil Corporation (JNOC). Today, Japan has an established oil sector, with state-run Japan Oil, Gas and Metals National Corporation (JOGMEC) assisting Japanese companies in overseas oil exploration and production, and the leading Japanese upstream energy companies (e.g. Inpex; Japan Petroleum Exploration Company) hold stakes in multiple oil and gas projects all over the world.*

Japan's nuclear ambitions are now under threat: the country is likely to remain increasingly dependent on net imports of fossil energy resources, and may choose to mitigate this risk by expanding its renewable energy plans.

- The recent earthquake and tsunami have substantially reduced Japan's domestic power generating capacity (to 37 GW), with four nuclear plants, six coal-fired plants and 11 oil-fired power plants initially shut down, equating to up to 20% of the total generating capacity of the affected region's dominant utility (the Tokyo Electric Power Company), or an estimated 11% of percent of Japan's total power.[83]
- Nuclear had been presented as the national solution to climate change and energy security in Japan's Electricity Supply Plan of 2010, with the country planning to remain increasingly reliant on nuclear energy over the next decade – Japan had intentions to build-out its nuclear capacity from 48.9 GW in 2009 to 61.7 GW in 2019, by far the largest expansion of any energy technology[84].
- These plans will now have to be substantially revised, with the country needing to replace lost domestic nuclear capacity as well as meet future demand.
- A drop in power demand in Japan is not expected, despite the severe socio-economic impacts of the earthquake and tsunami - the World Bank estimates the cost of the damage at $122 to $235 billion (2.5% to 4% of GDP)[85], while the Japanese government subsequently (March 23rd) released an official cost estimate of over $300 billion, making it the world's costliest natural disaster.
- Nonetheless, analysts expect Japan's GDP to shrink in the second quarter by about 3% on an annualized basis, largely as a result of the power shortage and rolling blackouts: "We hadn't initially expected the quake to impact the national economy to this degree… But the lingering power shortages will be widespread," said Mr. Kanno, Chief Economist at JPMorgan Securities Japan.[86]
- The power shortage is expected to be compounded by an increase in demand as summer approaches, and other resources will have to be used to both replace lost generating capacity and meet increased seasonal demand: "At the summer peak, the shortfall will be in the 10% to 20% range", said Masakazu Toyoda, chairman of the Institute of Energy Economics research organization affiliated with the Ministry of Economy, Trade and Industry.[87]
- In addition to enforcing rolling blackouts, Tokyo Electric is trying to make up the lost generating capacity by restarting shuttered plants, repairing the damaged ones, tapping hydropower reserves and temporarily operating gas turbines. It is expected that natural gas, coal and petroleum will be have to be used to plug the "power gap" with increased capacity utilization expected at existing plants in the very short term (particularly of peakers) and fuel switching to coal, natural gas and petroleum.
- This shift will have an upward impact on global oil, coal and LNG prices, and over the medium to longer term, greater capacity build-out of gas and renewable energy are likely to be the options most favored by the Japanese government. With the right government support, there is huge renewable energy deployment potential in Japan – as Paul Gipe argues in his recent paper: ***"if Japan were to follow the path blazed by Germany, it could more than replace the electricity generation lost by the damaged plants at Fukushima in less time than it would take to build new reactors… If Japan were to develop renewable energy at the same pace as Germany has over the past decade, it could add 120 TWh per year of new renewable generation."***[88]

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[83] *PFC Energy, as cited in the New York Times, March 28, 2011*
[84] *"Electricity Supply Plan of 2010", Ministry of Economy, Trade and Industry, March 31, 2010*
[85] *"The Recent Earthquake and Tsunami in Japan: Implications for East Asia", World Bank, March 21, 2011*
[86] *As cited in "Japan's Electricity Shortage to Last Months", New York Times, March 29, 2011*
[87] *As cited in "Japan's Electricity Shortage to Last Months", New York Times, March 29, 2011*
[88] *Note: the 6 damaged reactors at Fukushima generated about 30 TWh in 2010, while Germany added 80 TWh of new renewable energy generation from 2000 to 2010. Source: "What Japan could do if it followed Germany's lead on Renewalbe Energy", Paul Gipe, Alliance for Renewable Energy, April 14, 2011*

- Indeed, Japan has already made announcements in this direction – committing itself to re-building the tsunami-devastated areas with "eco-towns" that use district heating and biomass to supply power and heating: ***"We will situate residences on higher ground carved out of mountainsides and commute to fishing ports and other workplaces along the coastlines. We will create eco-towns that are fully equipped with district heating utilizing plant matter and biomass from the region and cultivate features of communities that thoroughly foster public welfare. We will proceed by moving forward with the world's most advanced reconstruction plan, with a vision of going beyond mere restoration to the previous state and instead create a truly marvelous Tohoku region and indeed a marvelous Japan."***[89]
- A focus on energy efficiency (for example, implementation of a smart grid) is also expected, as this may be able to provide the single largest "source of energy" that Japan turns to at the margin in coming years.

[89] *Speech by Japan's Chief Cabinet Secretary, Yukiyo Edano, at the World Economic Forum, April 7, 2011*

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