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Can nuclear power survive Fukushima?

- **Fukushima: serious accident and a credibility loss for the nuclear industry**

We believe the Fukushima accident was the most serious ever for the credibility of nuclear power. Chernobyl affected one reactor in a totalitarian state with no safety culture. At Fukushima, four reactors have been out of control for weeks—casting doubt on whether even an advanced economy can master nuclear safety.

- **Detailed review of plans and prospects globally**

We have undertaken a bottom-up review of the nuclear power industry as a whole and by country. In consultation with UBS utilities analysts and industry specialists (including some that have worked at the Fukushima site and others involved in the Chernobyl clean up), we have identified the key considerations for nuclear power going forward.

- **Review of existing nuclear; higher costs for new nuclear**

Most countries have announced in-depth nuclear reactor safety reviews and near-term moratoriums on new plants. We expect safety standards to be tightened, life extensions to be limited, and some plants to be 'sacrificed' to restore public confidence. Old plants close to seismically-active areas or borders are at particular risk. We estimate operating costs for nuclear plants to be higher than alternatives, so this option is chosen mostly to limit carbon emissions and diversify fuel mix. In developing markets such as China, we continue to expect strong capacity growth.

- **Gas and energy efficiency the winners; climate and the economy the losers**

Near-term policies are likely to favour gas and energy efficiency and, to a lesser extent, coal. Undersupply will put upward pressure on energy prices and already-stretched climate objectives are even less likely to be met. Our preferred stocks are either companies we think will benefit from reduced nuclear power generation or those exposed to nuclear issues, but their share prices have overreacted.

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We would like to thank the International Atomic Energy Agency (IAEA) for their permission to make use of their databases for the primary source of information contained in Appendices 1-3 and used elsewhere in this report.

Executive summary

Following the earthquake and tsunami on 11 March, the Fukushima Daiichi nuclear power station faced a total station blackout, a loss of cooling and several of the reactors and spent fuel pools overheated. The accident is still ongoing. While we are still in the early days, we have worked with nuclear power industry consultants and the UBS utilities team analysts around the world to consider a number of issues arising from the Fukushima accident:

- What went wrong at Fukushima?
- What are the lessons to be learned?
- What are the implications for the global nuclear power industry and how are the countries with nuclear power responding to events in Japan?

There has been a significant effect on the share prices of companies exposed to nuclear power industry and we highlight some stock ideas arising.

Key takeaways

During the preparation of this report, we identified three key takeaways:

Tail risks were underappreciated

Firstly, Fukushima is a case of underestimated tail risk: the design of the power plant never anticipated the scale of tsunami that hit it, and the company seems to have had no contingency plan for such an event occurring. Also, the financial consequences of this tail risk were not clearly considered and the ultimate division of liability between the operator and the government is now the subject of uncertainty.

Countries around the world are now re-evaluating the tail risk in their reviews of safety standards, and we expect questions of liability insurance will arise too. Although many have initially concentrated on earthquake/tsunami risk, other events could have similarly devastating effects that the regulators may not have previously considered. These could include asset concentration risk (too many units on the same site or in close proximity producing a disproportionate amount of the regions required generation).

Responsibility for the financial consequences of a catastrophic event are not clear

Secondly, the scale of the financial effect of a tail risk event such as the one at Fukushima Daiichi is probably not fully considered in costs of capital. Countries will need to decide who is responsible in such events. If the government takes the risk, then it needs to take into account this risk when deciding future energy policy. But if liability will be wholly or partly with the operators, we think discount rates will likely need to be higher.

TEPCO’s share price illustrates our view. Before the Fukushima accident, TEPCO was viewed as a low risk regulated utility, mainly bought for its stable earnings and dividends. However, the events at Fukushima have led to an 80% decline in its share price and discussions about the future viability of the company. Such a quick change in prospects would have been unlikely if Fukushima had been a traditional thermal generation plant. This additional risk linked to nuclear exposure has not, it seems to us, been properly priced in by the market.

Thirdly, the age of the plant played a part in this accident. The older design appears to have made it more vulnerable to the tsunami and gave the operator less time to react in managing the situation. That said, we think most technologies would have been unable to cope with this event, but may have struggled on for a bit longer. Perhaps only the very latest designs, such as AP1000 units, which make use of passive cooling systems, would have held up. We think passive systems could become a requirement for future power plant construction.

Most designs would have struggled to survive the Japanese tsunami

Significant industry implications

A serious accident and a credibility loss for the industry

While the 1986 Chernobyl accident, at least to date, had a significantly greater environmental impact, we would argue that Fukushima raises even larger credibility issues for the nuclear industry than previous accidents.

- Fukushima is happening in an advanced economy using American/Japanese reactor technology, not in a totalitarian state with substandard technology and no safety culture.
- The size and duration of the accident is unprecedented. Four reactors are facing significant damage and it has already lasted three weeks without engineers getting the situation under control.

Previous major accidents, at Three Mile Island (1979) and Chernobyl (1986), both led to strong popular and political movements questioning whether nuclear power generation can be operated in a safe way. These accidents led to higher safety standards and nuclear phase-out decisions in some countries. We believe Fukushima will have a similar impact.

Higher safety standards, closures and a possible moratorium on new plants

Most countries have launched reviews of safety standards

Most countries operating nuclear plants have already announced that they will undertake full reviews of nuclear safety and development plans including lessons learned from Fukushima. In the near term, we expect there to be a lot of political rhetoric in light of recent events.

Safety standards: For existing plants, we think the focus will be on lessons learnt from Fukushima, such as the risks from seismic activity and water/waves, the quality of back-up power systems, and crisis management procedures. We also expect an increased focus on reactor age and less willingness to allow extensions beyond the initial design life. We think existing plants will be required to upgrade systems to comply with new standards. Owners will need to make economic decisions on a project-by-project basis as to whether any re-configuration and retrofitting required to comply with new standards makes economic sense.

Closures: We believe that most countries, even pro-nuclear countries such as France, will be required to close at least a couple of plants to show political action and to restore public acceptance of nuclear power generation. We believe older plants, particularly if they are located in seismically-active areas and/or close to a border (thus creating worries in another country) are most likely to be closed. We have identified the 30 oldest reactors globally that could be at risk of closure.

New term project implementation will be difficult

New nuclear: We believe the implementation of new nuclear projects will be difficult in the near term, especially in developed countries. Most countries have announced moratoriums on any decisions until the lessons have been drawn from Fukushima. Energy reviews may very well conclude that there are not many realistic options to nuclear, but the question is: who will build the plants? Higher safety standards are likely to make already expensive plants even more costly.

We estimate new 'state-of-the-art' nuclear power costs around US$100/MWh in mature markets, such as the US and Europe. For emerging markets, which may not require the same technology level, we estimate costs of around US$50/MWh. We estimate the capital costs for new nuclear to be US$5,000-6,000/kW in the US and Europe and about US$2,000/kW in China—about two to eight times the cost of new fossil-fuelled capacity. In this situation, we think investor-owned utilities are unlikely to consider nuclear a good risk-reward option. We believe it will mainly be an option only for public or semi-public entities and in particular in systems with regulated cost pass-through regimes.

Gas and energy efficiency the winners; climate and the economy the losers

Gas could benefit from less nuclear, but renewables are not a realistic replacement

Gas: We believe gas will be the main winner from any nuclear power plant closures and scaled back new-build plans. The gas market is oversupplied and there is a good possibility it will pick up incremental demand from closures. Carbon emissions are relatively low, and plants are comparatively cheap and quick to build. We expect more positive policies on unconventional gas exploration, for instance in China and Europe.

Coal (but only to a marginal extent): Coal is already the main source for new power generation in developing countries. We do not expect developed countries to give up on climate targets (even if we do not believe the targets can be met) and thus we do not believe new coal is more than a marginal option in the US or Europe.

Renewables: For renewables, expectations of benefits from anti-nuclear policies could be positive for valuations near term. In reality, we do not think it is feasible for utilities to replace large-scale base-load nuclear power with small-scale intermittent power generation technology. We do not expect already costly renewables subsidies schemes to be scaled up even further.

However, more negative nuclear policies will, in our view, lead to more energy constraints. Fuel prices, in particular gas, are likely to increase and supply-demand balances tighten. In deregulated power markets, this will put additional upwards pressure on prices. Higher prices will put additional focus on improved energy efficiency measures, which we see as an additional winner from more restrictive nuclear policies.

Utilities operating nuclear plants that have to close will, of course, be among the losers on this development, unless they have a natural offset, such as exposure to upstream gas. Otherwise, we believe energy users, and in particular electricity intensive companies, will be the main losers. Such companies often benefit from preferential contracts at low prices, very often supplied from nuclear power stations. With potential undersupply in global power markets, such preferential contracts are more unlikely.

Lastly, nuclear power is a prerequisite, in our view, to meet already stretched climate objectives. Less nuclear means meeting such targets becomes even more unlikely. While this is stating the obvious, we do not expect countries to revise their commitments, at least not in the near term. To the extent that there are prices on emissions (CO_2/SOx/NOx) in some markets, these prices could increase.

Preferred stocks

Our preferred picks among global utility stocks are those we believe 1) will benefit from investment opportunities and/or higher fuel or power prices, or 2) should not be significantly impacted by nuclear closures or cancelled development projects. We also highlight stocks that could benefit from the construction of more non-nuclear capacity. Lastly, we think some companies will be negatively affected due to their exposure to the nuclear industry, but that their share prices have overreacted to the potential impact. Table 1 at the end of this section summarises valuation metrics for these stocks. Please see Appendix 4 for full valuation tables showing all utilities under UBS coverage.

EDF (Buy rating, €40.00 PT)

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Electricite de France's (EDF) share price declined 10% in March, underperforming the European utilities index by 8% over the same period, and by 22% over the 12 months to end-March. We attribute this underperformance mainly to uncertainty on the company's future given the repeated delays in the implementation of France's new law on the liberalisation of the power market. However, we expect the important regulatory decisions on this to be taken over the next weeks and months. This should lead to significantly better visibility and higher earnings. We estimate a 17% earnings CAGR until 2016. In the near term, we also expect upgrades in consensus earnings estimates, as lower German nuclear output will be, to a large extent, replaced by EDF supply. In the medium term, we also see potential for improved nuclear output. We expect the company to publish a new mid-term strategy, including higher dividends, probably towards the end of H1. We expect the two Fessenheim nuclear reactors, the oldest in France and close to the German and Swiss borders, to close following the country's nuclear stress tests. However, we expect this downside to be more than compensated by improved output on the remaining 56 reactors.

E.ON (Buy rating, €24.00 PT)

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E.ON fell 9% in March, underperforming the European utilities index by 8%. We believe this underperformance to be caused by Germany's decision to close 7GW of nuclear capacity pending a safety review. We think these closures are likely to be permanent, but that the impact on the company will be relatively small. E.ON is losing 2.2GW of capacity and 17TWh of generation. We estimate that will reduce its net income by €278m. The tightening of the European gas and power markets are however, on a mid term basis, more than offsetting this downside. Stripping out the €1.5 per share dividend to be paid in a few weeks the stock is trading at 8x 2013E PE. We believe this is too cheap, considering the good assets and solid balance sheet.

Korea Electric Power (Buy rating, Won 40,000 PT)

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Korea Electric Power's (KEPCO) share price has underperformed the KOSPI by 7% since the earthquake on concern about cost pressure, as the loss of Japanese nuclear generation capacity is likely to raise demand for LNG, coal, and oil, leading to higher fuel prices. Our sensitivity analysis suggests a 1% increase in either coal or LNG prices would lower KEPCO's EPS by 2-3%. However, we believe higher fuel prices could be mitigated by the implementation of a fuel cost pass-through scheme in July, which means any increase in fuel costs could be passed on to customers. As the three month average fuel price will be applied after two months, any change in average fuel prices from March-May to February-April will be reflected in the August electricity price. We believe the negative impact from the earthquake on KEPCO will be short-lived, and that the recent pullback provides an attractive buying opportunity.

TECO Energy (Buy rating, US$20.00 PT)

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TECO Energy's share price has outperformed the Philadelphia UTY Index by 5.0% since the earthquake, as demand for coal—and hence coal pricing—is likely to increase in its aftermath. TECO Energy produces 8.5-9.0 million tons of steam and metallurgical coal annually. The company's projected 2011 production is largely hedged and priced. However, the real opportunity comes in 2012, where currently only 22% of its expected output has been contracted and priced, while another 8% is contracted but not yet priced. In our view, the TECO Energy story remains one where the core utility earns its allowed returns, the coal business experiences margin expansion, and management has the option of selling the non-strategic assets when appropriate.

Public Service Enterprise Group (Buy rating, US$35.00 PT)

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Public Service Enterprise Group's (PEG) shares have performed in line with the Philadelphia UTY index since the earthquake. On a PE basis, PEG shares are trading at an 8% discount to its hybrid peers, as at 31 March, based on our 2013 estimate. We think the discount is unwarranted. Capex risk is abating following the release of the Environmental Protection Agency's (EPA) once-through-cooling rules. We believe PEG is ideally situated to be a beneficiary of tightening capacity pricing resulting from EPA-driven coal plant retirements. Further, the upcoming capacity auction in the Eastern Mid-Atlantic Area Council (EMAAC) is likely to be better than consensus expectations. Additionally, the Potomac Appalachian Transmission Highline (PATH) transmission project has been indefinitely suspended, lower priced energy from the west will not move east. This should keep pricing relatively higher for PEG's generation fleet given that it operates mostly in a capacity constrained region. That said, PEG's two Salem nuclear units have licences that expire in 2016 and 2020, respectively.

GE (Buy rating, US$23.00 PT, UBS Key Call)

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We believe General Electric (GE) could benefit from any shift in preference from nuclear power generation to gas and/or wind over time, while its nuclear service revenue could improve from increased inspections in the near term. While GE does have a nuclear business, it is primarily a fuel and service provider, and the company's gas and wind turbine businesses are far larger (both in terms of new equipment and services). We also believe GE's market share is materially higher for both gas and wind than for nuclear. We expect that in the near to medium term, GE's service businesses could improve as gas plants in certain countries are used more frequently to compensate for nuclear plants that have been temporarily or permanently shut down. In the longer term, we believe GE could record incrementally higher gas and wind turbine orders as utilities adjust their power generation plans to reflect greater concerns about nuclear power, higher construction and insurance costs, and a more stringent regulatory environment. GE's Energy Infrastructure segment contributed around 37% of 2010 segment profit. Its gas and wind businesses are the largest single component of that segment profit, and the gas and wind businesses are the largest single component of that segment.

Siemens (Buy rating, €115.00 PT)

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We expect Siemens to benefit from any move away from nuclear power generation. The company is No.2 globally in gas turbine production, according to our estimates, with around a 35% market share. According to the company, it leads the world in gas turbine power plant solutions with about a 22% market share and is also the global No.1 in advanced GT frames with an overall GT market penetration above 45%. We believe Siemens has one of the best products in gas with H- and F-class turbines for base and peak load demand. It is also No.1 in offshore wind turbine production. We therefore believe Siemens is well positioned to benefit from a move away from nuclear in Europe, especially in Germany, as well as in the US and emerging markets. Fossil and renewable power generation accounts for 20% of the company's profit. Its exposure to nuclear is less than 2%, according to our estimates.

Gazprom (Buy rating, US$46.00 PT)

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Gazprom is a play on gas volume and price recovery in Europe. Gazprom exported 138 bcm to Europe in 2010, a 23% market share. We do not see a potential for increased exports in 2011, which should help improve the currently depressed market price given higher European demand due to nuclear closures. We expect Gazprom's production to start growing in 2012 We forecast Gazprom's gas exports to increase from 138 bcm in 2010 to 158 bcm in 2015, implying a five-year CAGR of 2.7%. We estimate that a 10% price hike in the gas market price would increase Gazprom's EBITDA by 1.5%.

Woodside Petroleum (Buy rating, A$60.00 PT)

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We expect Woodside Petroleum (Woodside) to benefit from an increase in LNG demand as a result of the closure of nuclear capacity in Japan. The Pluto LNG T-1 (WPL 90%) project is backed by sales agreements with 10% project partners Tokyo Gas and Kansai Electric and is to start up by October this year. Pluto LNG T-1 is a very material project for Woodside and is largely responsible for our forecast Woodside 2012 production and EPS growth of 45% and 60%, respectively. The proposed Pluto LNG T-2 project has no LNG contracts in place yet, but Woodside has stated that the first right of refusal for the LNG offtake will go to the existing Pluto LNG T-1 Japanese project partners. Woodside has also recently committed to front-end engineering and design (FEED) work for the proposed Browse LNG project, and is targeting a project final investment decision date by mid 2012 and for the project to be ready for start up by 2017. Preliminary LNG sales agreements are in place with Osaka Gas and CDC (Taiwan). We see potential for further strong Japanese support for the proposed Browse LNG project development.

Shanghai Electric (Buy rating, HK$5.75 PT)

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Shanghai Electric's share price has declined 13% since the earthquake. We believe it has been oversold. We conducted a worst-case scenario analysis for the company, with no new nuclear order flow from 2011 and no compensating hydro or wind orders. The outcome is EPS only starting to decline from 2013, at 17% below our current estimate, as a nuclear order backlog of more than Rmb30bn needs to be delivered, despite possible delays. Further assuming mid-term growth in line with GDP (5%-7%), we re-run our DCF model in this scenario and derive present values higher than current trading prices.

We expect the government to encourage most future nuclear projects to adopt AP1000, a perceived safer technology. Shanghai Electric should be the key beneficiary as it focuses on manufacturing AP1000 equipment. Shanghai Electric received Rmb3.97bn of new nuclear island orders and Rmb700m of conventional island orders in 2010. A nuclear order backlog of around Rmb19bn has been secured by signed contract. We expect the recent inspection of nuclear plants under construction to have only a limited impact on Shanghai Electric’s revenues and earnings in the next two years.

Table 1: Preferred stocks: Valuation metrics

Company	Country	Currency	Share price	Price target	PE (x) 2011E	PE (x) 2012E	Dividend yield (%) 2011E	Dividend yield (%) 2012E	P/BV (x) 2011E
EDF	France	€	29.22	40.00	13.2	10.7	4.8	4.7	1.5
E.ON	Germany	€	21.55	24.00	12.6	11.3	6.0	6.0	0.9
KEPCO	Korea	Won	26,900	40,000	14.7	8.9	1.9	1.8	0.4
TECO Energy Inc.	United States	US$	18.76	20.00	13.0	11.0	4.5	4.5	1.7
Public Service Enterprise Group	United States	US$	31.50	35.00	11.8	13.3	4.3	4.3	1.6
General Electric Co.	United States	US$	20.05	23.00	15.5	12.5	2.9	2.9	1.6
Siemens	Germany	€	96.71	115.00	11.9	10.3	3.3	3.3	2.5
Gazprom	Russia	RBL	32.37	46.00	4.4	3.9	1.5	1.5	0.8
Woodside Petroleum Limited	Australia	A$	46.80	60.00	21.2	13.3	3.6	3.5	3.0
Shanghai Electric Group	China	HK$	3.89	5.75	13.2	11.2	2.3	2.7	1.4

Based on 31 March share prices. Source: UBS estimates

Fukushima—what happened?

Initial damage to the plant and loss of cooling

The power plant coped with the earthquake but was overwhelmed by the subsequent tsunami

Tokyo Electric Power's (TEPCO) Fukushima Daiichi (No. 1) nuclear power plant is located in Fukushima prefecture in Japan, with six boiling water reactor (BWR) units. A 9.0 magnitude earthquake occurred at 14.46 Japan Standard Time (JST) on 11 March 2011 off the north east cost of Japan. The power plant coped with the earthquake, even though the earthquake's intensity exceeded the designed tolerances. At the time of the earthquake, Units 4, 5, and 6 were all shut down for planned maintenance. Units 1, 2 and 3 were shut down automatically after the earthquake.

However, the seawall protection proved inadequate. The earthquake generated a tsunami, which TEPCO estimated to be about 14 metres high. However, this is more than double the wave height that the plant's sea wall was designed to protect against. As a result, the generator building was swamped and the diesel back-up generators failed at 15.41 JST.

Once the back up generators were lost, the only remaining power supply for the pumps were batteries, which were depleted after about eight hours. An isolation condenser system continued to provide cooling for a short while but after this, the power plant had no remaining continuous cooling capability.

Why cooling is important

Heat production continues after plant shut down

Cooling is necessary to remove the heat caused by radioactive decay, even after a power plant is shut down. After shutdown, chain reactions from decay products continue to release energy; this decay heat slowly reduces over a few days before the reactor can be considered 'cold'.

The following table shows the residual heat generation of a reactor after it has been stopped.

Table 2: Nuclear reactor residual heat generation over time from shut down

Time after reactor stop	Residual power (% of operating power)
1 second	17%
1 minute	5%
1 hour	1.5%
1 day	0.5%
1 week	0.3%
1 month	0.15%
1 year	0.03%

Source: Autorité de Sûreté Nucléaire (ASN)

In addition to the reactors, cooling is required for the spent fuel pools inside each reactor building. When spent fuel is removed from a reactor, it is initially transferred to a spent fuel pool where it remains for a period of time until it has cooled enough to be transferred for long-term storage or reprocessing—usually about 18 months. Recently-active fuel rods produce more heat from the decay process than ones that have been inactive longer.

Consequences of loss of cooling at the plant

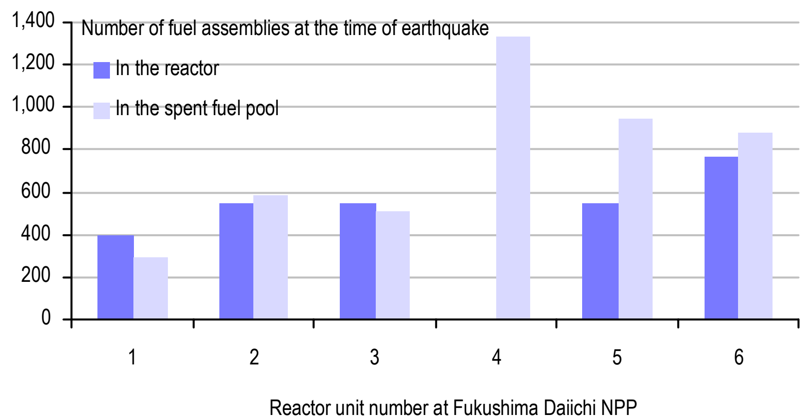
Without cooling, temperatures began rising at Units 1, 2, and 3. Of particular concern was Unit 3, because, since September 2010, the plant had been fuelled with mixed oxide, or MOx, which contains about 93% uranium and 7% plutonium. Plutonium is much more radioactive than uranium.

Lack of cooling led to higher temperatures, damage to facilities and rising radiation

The lack of water led to a build up in temperature and the production of steam and rising hydrogen levels inside the reactor containment vessels. TEPCO vented steam, which had the near-term effect of cooling the reactors, but also reducing water levels, thus requiring the addition of yet more water to keep the reactor cores under water. Rising temperatures and the loss of water seems to have led to fuel rods being exposed, in turn, increasing radiation levels and, probably, causing reactor core meltdowns. In addition, vented hydrogen from the reactor containment vessels released into the buildings seems to have led to explosions that damaged Unit 1's building, the pressure suppression system of Unit 2 and the building housing Unit 3.

In addition, temperatures at the spent fuel pools also began rising without cooling. Unit 4's reactor pool was of particular concern because it has a full core's worth of spent fuel that had recently been removed (and hence had more recently been active) from the reactor at the start of its scheduled inspection period on 30 November 2010. Although Units 5 and 6 were also shut down at the time of the earthquake, the reactors were still fuelled, so there was not a significant quantity of recently active fuel in their pools. Chart 1 shows the number of assemblies in the reactor and spent fuel pool of each unit at the time of the earthquake, according to the Japan Times.

Chart 1: Fuel assemblies at the time of earthquake



Source: Japan Times

Without cooling, the heat generated from the decay process raised the temperature of the water, which began evaporating. As water levels fell, fuel rods became exposed, which led to even more heating and rising levels of radiation.

Explosions thought to be caused by hydrogen building up near the spent fuel pool damaged the Unit 4 building and further damaged Unit 3's building.

Trying to reduce radiation levels, TEPCO, Japan Self-Defence Force personnel and fire brigades sprayed sea water into the reactor buildings from fire-fighting devices and dropped water on the buildings from helicopters. This proved to be partially effective as a temporary measure.

More water for cooling results in more radioactive water leakage, less cooling results in rising temperatures and higher radiation levels

The direct injection of cooling water into the reactors is proving to be a challenge: while injecting water helps cool the reactor, it is resulting in radioactive water seeping out into reactor turbine buildings and surrounding water trenches outside the reactor buildings (measured at more than 1,000 millisieverts per hour) that house power cables and pipes. On 28 March, TEPCO said it wanted to reduce the amount of water being injected into reactor 2 to reduce leakages (to 7 tons per hour from 16 tons per hour), but this will result in higher temperatures.

The solution to the problems at the power plant is to restore a continuous cooling capability. By 19 March, grid power was available to the entire plant, but power was not activated. Although the media initially concluded that power had been restored, this was not the case. Damage caused by the tsunami, subsequent explosions and the spraying of sea water has resulted in significant damage to electrical systems, switchboards, pipes and pumps. Most recently, higher radiation levels have slowed progress, with workers being pulled back for safety reasons.

By 23 March, only Units 5 and 6, which escaped significant damage, had power supplies and normal pumping function. Water cooling for the other units continued to be provided by injection using means such as spraying from special fire appliances and this spraying had to be periodically suspended when radiation levels rose.

The latest status of the units of Fukushima Daiichi from the Japan Atomic Industrial Forum is shown in the following table.

Table 3: Status of Fukushima Daiichi Nuclear Power station as of 16:00 JST, 1 April 2011

Unit	1	2	3	4	5	6
Electric/thermal power output (MW)	460 / 1,380	784 / 2,381	784 / 2,381	784 / 2,381	784 / 2,381	1100 /3,293
Type of reactor	BWR-3	BWR-4	BWR-4	BWR-4	BWR-4	BWR-5
Start construction	25-Jul-67	9-Jun-69	28-Dec-70	12-Feb-73	22-May-72	26-Oct-73
First criticality	10-Oct-70	10-May-73	6-Sep-74	28-Jan-78	26-Aug-77	9-Mar-79
Commercial operation	26-Mar-71	18-Jul-74	27-Mar-76	12-Oct-78	18-Apr-78	24-Oct-79
Reactor supplier	General Electric	General Electric	Toshiba	Hitachi	Toshiba	General Electric
Fuel	Uranium	Uranium	Mixed oxide ((93% uranium, 7% plutonium)	Uranium	Uranium	Uranium
Operation status at the earthquake occurred	In service -> shutdown	In service -> shutdown	In service -> shutdown	Outage	Outage	Outage
Core and fuel Integrity (Loaded fuel assemblies)	Damaged	Damaged	Damaged	No fuel rods	Not damaged	Not damaged
Reactor pressure vessel integrity	Unknown	Unknown	Unknown	Not damaged	Not damaged	Not damaged
Containment vessel integrity	Not damaged	Damage suspected and leakage	Not damaged	Not damaged	Not damaged	Not damaged
Core cooling requiring AC power 1 (large volumetric freshwater injection)	Not functional	Not functional	Not functional	Not necessary	Functional	Functional
Core cooling requiring AC power 2 (cooling through heat exchangers)	Not functional	Not functional	Not functional	Not necessary	Functioning (in cold shutdown)	Functioning (in cold shutdown)
Building integrity	Severely damaged (hydrogen explosion)	Slightly damaged	Severely damaged (hydrogen explosion)	Severely damaged (hydrogen explosion)	Open a vent hole on the rooftop for avoiding hydrogen explosion	
Water level of the rector pressure vessel	Fuel exposed partially or fully	Fuel exposed partially or fully	Fuel exposed partially or fully	Safe	Safe	Safe
Pressure / temperature of the reactor pressure vessel	Gradually increasing / decreasing after increase	Unknown	Stable	Safe	Safe	Safe
Containment vessel pressure	Gradually Increasing	Stable	Decreasing after increase 20 Mar	Safe	Safe	Safe
Water injection to core (Accident Management)	Continuing	Continuing	Continuing	Not necessary	Not necessary	Not necessary
Water injection to containment vessel (AM)	(confirming)	To be decided(seawater)	(Confirming)	Not necessary	Not necessary	Not necessary
Containment venting (AM)	Temporally stopped	Temporally stopped	Temporally stopped	Not necessary	Not necessary	Not necessary
Fuel integrity in the spent fuel pool (stored spent fuel assemblies)	Unknown	Unknown	Damage suspected	Possibly damaged	Not damaged	Not damaged
Cooling of the spent fuel pool	Water spraying started	Continued water injection	Water spraying and injection	Water spraying and injection	Pool cooling capability was recovered	Pool cooling capability was recovered
Main control room habitability & operability	Poor due to loss of AC power (Lighting has been recovered.)		Poor due to loss of AC power (lighting has been recovered)		Not damaged (estimate)	
International nuclear event scale (estimated by NISA)	Level 5	Level 5	Level 5	Level 3	—	—

Source: Japan Atomic Industrial Forum, Nuclear and Industrial Safety Agency, Tokyo Electric Power

Consequences for the population and the environment

Widespread contamination is less likely but localised radioactive contamination is building in severity

Over time, we think the risks for widespread high-level contamination at significant distances from the plant (such as Tokyo) are decreasing, but the costs and difficulties in cleaning up the immediate surrounding area are increasing. It will probably take weeks (at least) to accomplish as it is increasingly evident that TEPCO will need to rebuild most systems (such as pumps, pipes, and water intakes), in a difficult and radioactive environment. It will take time to assess the full impact and negative surprises are still possible.

Radiation released from the power plant has had the following effects:

- **Significant exposure of plant workers to radiation.** Chief Cabinet Secretary Edano said on 15 March that radiation rates as high as 440mSv/h (millisieverts per hour) had been recorded near Unit 3. Japan's Health and Labour Ministry increased the maximum permissible dose for workers to be exposed to in one year from 100mSv to 250mSv. Some workers have been hospitalised with radiation burns after standing in highly radioactive water.

- **Contamination at the power plant site.** TEPCO announced on 28 March that it had found high levels of radiation in trenches outside the turbine buildings of Units 1 to 3. We assume this water is seeping from reactors as a result of the direct injection of cooling water, but TEPCO said it was still trying to determine the source. These trenches contain pipes and power cables. There is a risk of this contaminated water flowing into ground water or the sea, which is already showing elevated levels of radiation. The trenches extend 76 metres towards the sea but do not reach the sea, according to TEPCO, which has resorted to the use of sandbags and concrete to try and stop the trench outlet of Unit 1 from overflowing.

  TEPCO also announced that it had found plutonium at the site, which must have come from the MOx fuel in reactor 3. The levels found are low however. Plutonium-239 has a half-life of 24,200 years. It is not readily absorbed by the body, but what is absorbed irradiates surrounding tissue and is carcinogenic.

- **Contamination of the surrounding area.** The government established a 20km zone around the Fukushima Daiichi power plant and a 10km zone around the Fukushima Daini power plant, where people were required to evacuate. People living between 20km and 30km from the Fukushima Daiichi plant were advised to stay indoors. However, within a week, elevated radiation levels had been found in a variety of vegetables, raw milk and local water supplies, which prompted many governments (such as the US, Hong Kong and Australia) to ban the importation of food products from Fukushima and surrounding prefectures. Other countries, such as Canada, introduced enhanced screening procedures. The Japanese government later advised people living up to 30 km from the Fukushima Daiichi plant to evacuate. Some areas, particularly to the northeast of the plant, are showing potentially unsafe levels of radiation at distances more than 20km. On 31 March, the IAEA recommended to the government that the evacuation zone be expanded.

- **Contamination further afield.** On 23 March, 210 becquerels/litre of Iodine 131 was found in Tokyo's water supply system—above the recommended safe maximum level for infants of 100 becquerels/litre. These levels have since declined. Higher levels were also found in other cities such as Kawaguchi, in Saitama prefecture. We suspect winds blowing from the northeast on the previous Sunday, coupled with rain, resulted in radioactive contamination in the water catchment area.

Lessons to be learned

The Fukushima accident will result in reviews by most countries, as well as the International Atomic Energy Agency (IAEA). There are several matters that will need to be considered in respect of the reviews of Fukushima Daiichi and in potential later legislation:

Insufficient protection against extreme events

The tsunami wave was higher than the maximum envisaged when the plant was designed

The essential event creating the accident was without doubt the height of the tsunami wave, which TEPCO estimated to be about 14 metres high. This is more than double the wave height the plant's sea wall was designed to protect against. We understand that while the earthquake indeed was the most severe to have hit Japan since measurement started; the tsunami that followed the 1896 Meiji Sanriku earthquake produced an even higher tsunami wave than the one that swept through Fukushima. We thus expect regulators to systematically focus in on the worst possible event.

A key issue here is clearly how regulators and politicians will look at terrorist activity. We believe that with the possible exception for nuclear plants in seismic areas (such as Japan, Taiwan and California), most plants will prove to have sufficient safety measures in place to protect them from the worst possible natural phenomena. To perfectly protect against sabotage is likely to be almost impossible.

Interdependence between back-up systems

All back-up systems were lost in the tsunami

The earthquake meant the station lost grid power and the resultant tsunami destroyed the back-up power facilities. It also flooded the connection points that linked external backup power to the plant. This raises the question to what extent safety systems were really independent of each other at Fukushima. Assessing the quality, depth and independence of individual safety systems is an obvious focus for the safety review. On back-up power systems, we can envision that the Fukushima event will lead to new regulations worldwide. We believe, however, that improving the back-up power facilities would involve moderate capex, likely to be in the tens of millions of US dollars rather than the hundreds of millions, and that it is unlikely to stop any new plant construction.

Slow crisis management and poor communications

Faster, decisive action may have contained the problem

There has already been criticism, both in Japan and internationally, about slow and ad-hoc crisis management. The decision to start cooling the reactors with sea water was not taken immediately, as this would destroy the reactors. Therefore, important time was lost in cooling the reactors before they overheated. The cooling of the spent fuel pools using fire trucks and cement pumps gives the impression that the current situation had not been considered in advance. Information has been partial and late, and continues to be so. To us, the most helpful information has often come from other countries' safety authorities, such as those from the USA and France. We believe there will be requirements for much clearer contingency plans going forward for worst case situations. This should mainly be a question of organisation and should not lead to materially higher costs.

Old reactor design

There has been a lot of focus in the media on the fact that the Fukushima Daiichi reactors are some of the oldest in Japan. The younger plants at Fukushima Daini and Oganawa were as close or closer to the epicentre of the earthquake, but they did not experience the same problems. Our research indicates that reactor designs have become more robust over time and that newer reactors are indeed safer than older ones. Age is also a simple indicator and thus opportune for use in the political debate. From a technical perspective, we see at least three areas regulators will focus on in the Fukushima analysis.

Insufficient protection of spent fuel pools

At Fukushima there is almost as much radioactive material in the spent fuel pools as there is in the reactors. But while the fuel in the reactor is protected by multiple layers, the spent fuel stored in water pools is only protected by the simple housing building, which blew away during the first days of the accident. At this stage, it also seems that most of the radiation leakage so far relates to the spent fuel pools.

The focus has been more on reactor containment than on spent fuel protection

We thus expect regulators to require the safer management of spent fuel. Potentially there will be requirements either to better protect the fuel pools or to remove the spent fuel from the reactors immediately after its use. This could mean that refuelling would take longer, to allow for some first cooling, and it could also potentially create increased radiation risks for personnel, further slowing the change of fuel. It is also likely to lead to some new capex requirement, for instance, to construct a new protected building on the site to take care of 'fresh' used fuel. This could potentially be a significant investment and could also lower utilisation rates by a few percent. It is, however, unlikely to lead to the closure of any plants.

Need for active systems (pumps) for cooling

Most designs would have struggled to cope with the tsunami because they rely on active pumping

Newer reactor designs have increasingly focused on reducing the need for pumping to ensure emergency cooling. The Westinghouse AP 1000 design, for instance, has safety systems built on gravity, not pumping, and could thus probably have dealt with a total station black out.

However, other existing reactor designs are dependent on active pumping. We believe a focus area here could be the time available to re-establish power supply before there is a significant negative impact on the reactor. Initial debate on the accident focussed on the fact that it affected a boiling water reactor (BWR), whereas newer reactors mostly pressurised water reactors (PWR).

In general, we do not believe BWR technology is worse from a safety perspective. These reactors operate with lower pressure and at lower temperatures, normally considered features that should reduce risks, and PWR are chosen mainly because they are more efficient.

However, it is possible that a PWR could have allowed some more time to respond to a loss of power. There are two cooling circuits—a primary and a secondary—in a PWR, whereas only one in a BWR. Also, there is typically more coolant in a PWR and thus a slightly better possibility to emergency cool. This could become a focus of safety reviews.

Old reactors in seismic areas at border most at risk

We believe that in addition to the technical assessment, there will also be a political one. Politicians may need to close some reactors to show they have learnt from Fukushima and to re-establish some credibility for nuclear power.

Decisions on plant closures could be political

Based on previous experience and what we have heard in the current debate, we believe these plants will be chosen for closure based on four criteria. Theoretically, first in line for closure would be plants where safety reviews reveal serious safety concerns. However, in reality, we expect the plants to 'sacrifice' to be selected on a simpler basis.

- We believe age will be the main criteria. The older the plant, the bigger the risk it has to close. It is easier to argue, and probably true, that older plants do not have the same robustness as newer ones.
- Seismic or extreme weather risks: We think plants located in seismic areas have a higher risk of being closed down—in particular in countries, such as the US, that also has non-seismic areas.
- Plants close to a border. Nuclear plants close to neighbouring countries are always sensitive and receive a lot of criticism, particularly when the neighbouring country does not have nuclear power.

The areas that are most seismically active, other than Japan, are Taiwan and regions on the west coast of the USA.

Use of MOx heightened fuel risk

Fukushima Daiichi Unit 3 was fuelled with mixed oxide (MOx), which is about 93% uranium and 7% plutonium. This has caused additional worries for TEPCO and the government, because MOx is more radioactively aggressive. We think national nuclear safety reviews might consider restrictions on its use.

Nuclear new build economics

Nuclear has high capital but low operating costs

Nuclear power has high upfront investment costs, but generally lower operating costs than alternatives. Thus, the actual cost of generation becomes highly contingent on investment costs, financing and lifetime expectations for the plant. The following table shows some recent overnight construction costs, that is, excluding interest during construction for the latest generation of reactors. There is a significant difference in costs between the plants in Europe and the US on the one hand, and China of the other hand.

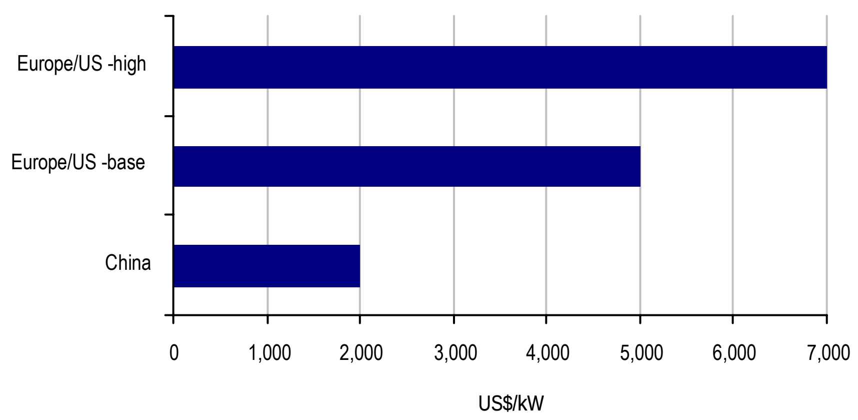
Table 4: Recent capital cost estimates for nuclear

Cost (US$ bn)	Capacity (GW)	US$/kW	Configuration	Country	Estimate by	Year
11.0	2.3	4,924	2*AP1000	US	Duke Energy	2008
14.0	2.3	6,066	2*AP1000	US	Progress Energy	2008
8.0	4.6	1,733	4*AP1000	China	Chinese authorities	2009
15.6	3.3	4,727	2* EPR	UK	EDF	2010
13.4	2.3	6,091	2*AP1000	US	Southern Company	2011
10.5	2.2	4,700	2*AP1000	US	Scana Corp.	2011

Note: Figures shown represent total project cost, not inflation adjusted.
Source: EDF, Chinese nuclear commission, Duke Energy, Progress Energy, Southern, and Scana

We expect regulatory requirements to be higher for future plants so the above estimates will prove to on the low side. To forecast nuclear generation costs we therefore use the estimates in the following chart:

Chart 2: Estimation of new nuclear capital costs (US$/kW)



Source: UBS estimates

All-in costs are much lower in developing markets than in Europe and the US

We use these capital cost calculations as a starting point to then estimate the full cost of nuclear power. For fuel costs, we use the current market price; for other cost items we use what we think are reasonable estimates. We therefore estimate that built in China, it could be possible to achieve a generation cost of around US$50/MWh due to much lower construction costs. In Europe or in the US, however, we estimate a generation cost of double that figure—between US$91/MWh and US$120/MWh.

Table 5: Estimated full cost for new nuclear generation

	China	US/Europe—base	US/Europe—high
New plant standard size in MW	1,500	1,500	1,500
Thermal efficiency	33%	33%	33%
Uranium price (US$/pound U308)	62	62	62
Fuel cost (US$/MWh)	7.1	7.1	7.1
Other variable costs [US$/MWh]	4	4	4
I) Total variable cost [US$/MWh]	11.1	11.1	11.1
Maintenance rate [% of invest / a]	2.20%	2.20%	2.00%
Personnel costs (US$ '000/pa)	30	110	110
Load factor	90%	90%	90%
Maintenance cost [US$/kW/a]	44	110	140
Staff [FTE/GW]	120	100	100
Staff cost [$/kW]	4	11	11
II) Operating costs [US$/MWh]	6.0	15.3	19.2
Capex [US$/kW]	2,000	5,000	7,000
Time of construction [a]	5	6	6
WACC-post tax real (%)	6.5%	6.2%	6.2%
Assumed lifetime [a]	40	40	40
NPV interests while construction [US$/kW]	255	813	1,138
NPV capex [US$/kW]	2,255	5,813	8,138
Financial annuity [% of invest / a]	7.9%	7.9%	7.9%
Capital costs [US$/kWa]	179	458	641
III) Capital costs [US$/MWh]	25.2	64.6	90.4
Total generation cost [US$/MWh]	42.3	91.0	120.6

Source: UBS estimates

Capital cost assumptions are of course critical. The following table shows how we reached our capital cost assumptions.

Table 6: ROIC calculation for new nuclear

ROIC	China	US/Europe—base	US/Europe—high
Interest pre-tax (%)	8.0%	6.0%	6.0%
ROE post-tax (%)	15.0%	12.0%	12.0%
Debt ratio (%)	60%	50%	50%
Equity ratio (%)	40%	50%	50%
Tax rate (%)	28.0%	28.0%	28.0%
ROIC pre tax	13.1%	11.3%	11.3%
WACC-post tax nominal	9.5%	8.2%	8.2%
WACC-post tax real	6.5%	6.2%	6.2%

Source: UBS estimates

Oil>US$130/bbl required to be competitive in Europe/Asia

In developed markets, nuclear is not competitive with gas

In the following table, we calculate the gas price required for nuclear power to be competitive with gas in Europe and the US. In our base case, we estimate the gas price needs to be above US$15/mmBTU and in our high case US$21/mmBTU. This is three to five times the current US gas price and much higher than other gas prices around the world.

Assuming gas prices are linked to oil prices, currently mainly relevant for Asia and Europe, we indicate on a straight parity basis these gas prices correspond to oil prices of US$88-122/bbl. In Europe, traditional oil indexed contracts are indexed at around 70% of the oil price. This implies an oil price of US$131-182/bbl would be required to reach generation costs as high as for nuclear.

Table 7: Estimated breakeven oil price gas versus nuclear generation

	US/Europe—base	US/Europe—high
Nuclear generation costs (US$/MWh)	91	126
Gas capital costs (US$/MWh)	15	15
Breakeven fuel cost (US$/MWh)	76	111
Thermal efficiency	58%	58%
Breakeven fuel price (US$/MWh)	44	61
Breakeven fuel price (US$/mmBTU)	15.1	21
Implied oil price		
At calorific parity with oil (US$/bbl)	88	122
At 70% indexation vs. oil (US$/bbl)	131	182

Source: UBS estimates

Insurance situation for the industry

Insurance costs could rise post-Fukushima

In addition to the direct costs of coping with the Fukushima accident, and the eventual costs of dismantling or entombing units of the power plant, the disaster has also created additional economic challenges to the area surrounding the power station to those already felt as a result of the tsunami. Faced with the contamination of soil and, possibly, ground water Fukushima and surrounding prefectures could face medium-term challenges—especially the agricultural sector.

Given the scale of the economic impact we believe future insurance costs could rise, which could have a negative effect on the economics of existing or planned future nuclear power plants.

Operators of nuclear power plants are liable for damage caused, so they usually take out third-party insurance. The insurance of nuclear power plants is governed by international conventions, national liability and the pooling of insurance capacity.

Because the effect could be cross-border, there is an international framework regime to govern this, but not all countries have ratified the relevant conventions:

- The Vienna Convention on civil liability for Nuclear Damage (IAEA); and
- The Paris Convention and the Brussels Supplementary Convention on Third Party Liability in the Field of Nuclear Energy (OECD), which covers most West European countries.

These conventions do not specify consistent limits on liability. The Vienna Convention was changed to increase liability to €700m in 2004, but this has not been ratified.

In general, the limitations of liability seem quite low and we think pressure to increase the liability of nuclear power plant operators could increase. Major arrangements are shown in the table on the next page.

For example, in the UK, the Energy Act of 1983 brought legislation into line with the Paris/Brussels conventions. This set a limit for installations that was, according to the World Nuclear Association, increased in 1994 to £140m. The government is proposing legislation that would require insurance of €1.2bn.

Canada's Canadian Nuclear Liability Act requires nuclear power plant operators to provide a maximum C$75m of insurance coverage although, according to the Canadian Nuclear Association, consideration is being given to raising this limit.

US insurance arrangements come under the Price-Anderson Nuclear Industries Indemnity Act. Pooled insurance funds in the US amount to just over US$12bn in 2011; beyond the size of the fund, we think the US government would fund costs.

Table 8: Insurance requirements and liability caps for countries with significant nuclear power capacity

Country	Insurance requirement / liability cap	Commentary
USA	Pooled insurance funds in the US amount to just over US$12bn in 2011. Beyond the size of the fund, we think the US government would fund costs.	We expect insurance premiums to rise.
UK	Liability is limited to £140m for each installation. Beyond this, the government contribution is around €360m, as applicable under the Paris/Brussels system.	Proposed legislation requires operators' insurance of €1.2bn. The level would initially be set at €700m specified under the 2004 Paris/Brussels Protocol, later increased by €100m annually.
Germany	Operator liability is unlimited, and operator must provide €2.5bn security for each plant. This security is partly covered by insurance, to €256m.	na
France	Financial security of €91m per plant.	na
Switzerland	Operators are required to insure to €600m. A new proposal requires this to increase to €1.1bn.	na
Finland	The current minimum insurance cover level is €300m.	However a new Act may require operators to take at least €700m insurance cover. Operator liability is to be unlimited beyond the €1.5bn provided under the Brussels Convention. "Nuclear damage" is as defined in revised Paris Convention, and includes that from terrorism.
Sweden	Operators to be insured for at least SEK3,300m (€345m), beyond which the state will cover to SEK6bn per incident.	However, Sweden is reviewing how this relates to the €700m operator's liability under the Joint Protocol amending the Paris convention, and has announced that it will seek unlimited operator liability. Sweden has ratified the 2004 Joint Protocol relating to Paris and Vienna conventions.
Czech Republic	Minimum insurance cover of CZK8bn (€296m)required for each reactor.	The Czech Republic is moving towards ratifying the amendment to the Vienna Convention
Canada	Per plant insurance cover of C$75m for individual licencees required as per a 1976 Act. This would increase to C$650m under an amendment to the 1976 Act tabled in 2008, although the amendment has not yet been passed.	Funds beyond the cap level would be provided by the government.
Japan	Plant operators must provide a financial security amount of JPY120bn (US$1.4bn). Beyond that, the government provides coverage, and liability is unlimited.	Japan is not party to any international liability convention but its law generally conforms to them. In relation to the 1999 Tokaimura fuel plant criticality accident, insurance covered JPY1bn and the parent company (Sumitomo) paid the balance of JPY13.5bn.
Russia	Russia has a domestic nuclear insurance pool comprising 23 insurance companies covering liability of someUS$350m.	Russia is party to the Vienna Convention since 2005, and it has a reinsurance arrangement with Ukraine and is setting one up with China.
Ukraine	Operator liability is capped at 150m SDRs (around €180m). Special provisions apply to work on the Chernobyl shelter so as to extend coverage outside the Vienna Convention countries.	Ukraine adopted a domestic liability law in 1995 and has revised it since in order to harmonise with the Vienna Convention, which it joined in 1996. It is also party to the Joint Protocol and has signed the CSC.
China	na	Liability limit was increased to near international levels in September 2007. For insurance of the plants themselves, Hong Kong-listed Ping'an Insurance Company accounts for more than half of China's nuclear power insurance market.
India	Plant operators are required to insure up to a US$110m liability cap	na

Source: World Nuclear Association

Global outcomes

The following section focuses on the following questions in relation to individual countries around the world:

- What nuclear capacity does the country/region have and how significant is it as part of the energy mix?
- What capacity expansion plans existed prior to Fukushima?
- What statements have come from regulators or government officials on how plans might change?
- What changes, if any, do we expect to actually happen?

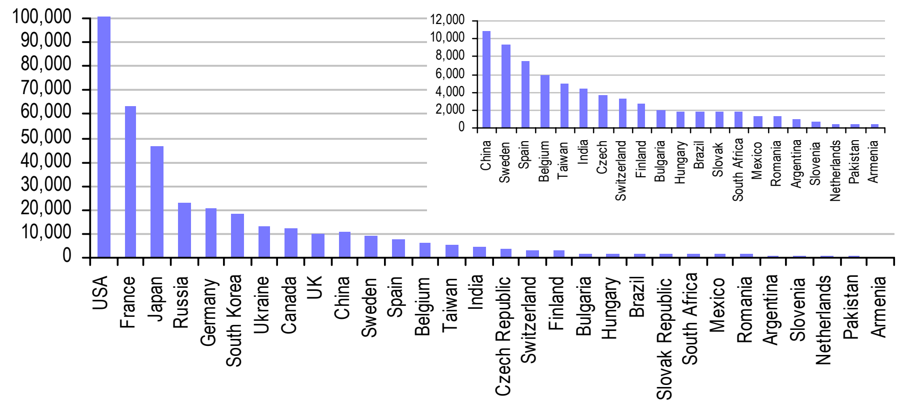
Almost all countries have announced a review of their nuclear power industries, with an obvious focus on safety standards.

Most old capacity is in developed countries, most new and planned capacity is in developing countries

Most of the world's existing nuclear fleet is located in developed countries and, that is typically also where the older reactors are based. In general, power stations in Asia are relatively younger and most construction activity in the last 20 years has been in this region.

The following chart shows global nuclear installed capacity by country, according to the IAEA database, amended by UBS based on information from our global utilities team. Please refer to the Appendix for a detailed listing of all nuclear reactors installed around the world.

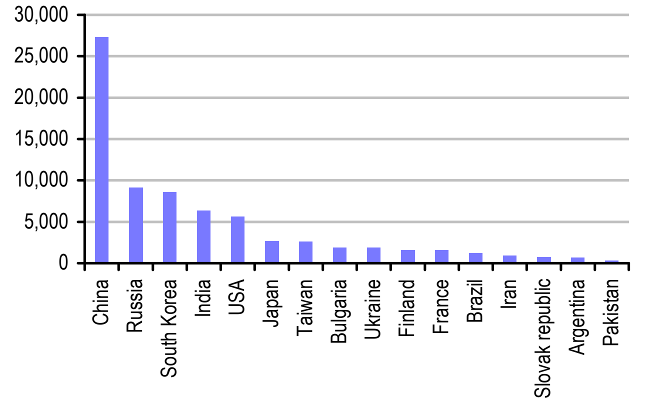
Chart 3: Global installed nuclear capacity (MWe)



Source: IAEA, UBS estimates

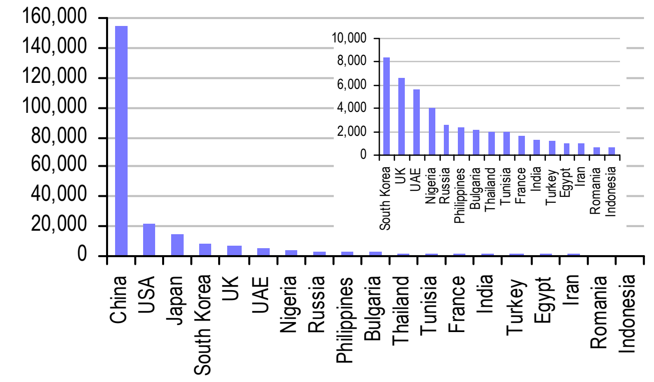
Before the Fukushima accident, most plants under construction and most planned for construction, were also in Asia, as shown in the following charts. We expect these construction plans to be deferred and/or scaled back. However, we expect most of the scaling back to occur in developed countries. Countries such as China are still targeting a large scale build out of nuclear (with only modest deferrals), given their need for new baseload capacity, while at the same time trying to limit their carbon emission growth.

Chart 4: Nuclear capacity under construction (MWe)



Source: IAEA, World Nuclear Association, UBS estimates

Chart 5: Nuclear capacity planned (MWe)

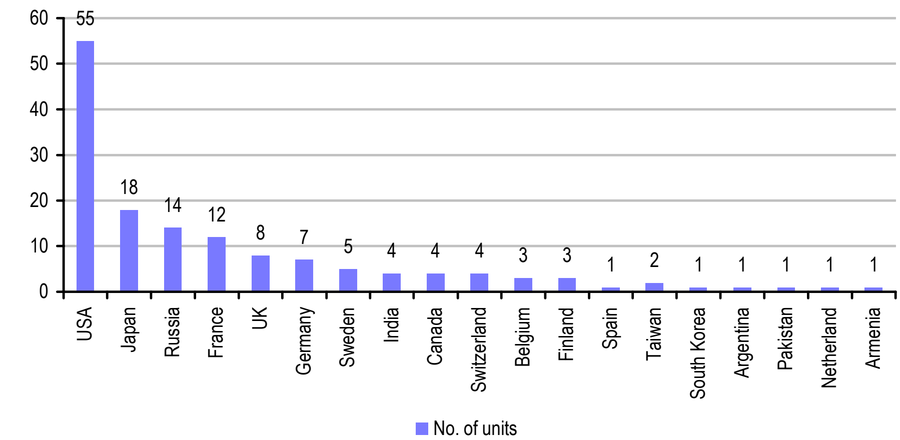


Source: IAEA, World Nuclear Association, UBS estimates

A lot of old plants, especially in the markets that have the most capacity

We also expect a number of power plants to close following the Fukushima accident. Some power plants may need to close for political reasons, but others might need to close because it is not economically feasible to upgrade plants to meet higher safety standards. This decision may not necessarily be related to plant age, but it would likely be a factor. The following chart shows that most of the oldest units are in the developed world. The table on the next page shows the 30 oldest operating reactors in the world.

Chart 6: Number of reactors that have been operational for 30 years or more



Source: IAEA, UBS

Table 9: Oldest operating nuclear plants globally

Country	Station	Type	Net Capacity (MWe)	Operator	Status	Reactor Supplier	Commercial	Age
UK	OLDBURY-A1	GCR	217	BNFL	Operational	TNPG	31-Dec-67	43.28
UK	OLDBURY-A2	GCR	217	BNFL	Operational	TNPG	30-Sep-68	42.53
Switzerland	BEZNAU-1	PWR	365	NOK	Operational	Westinghouse	1-Sep-69	41.61
India	TARAPUR-1	BWR	150	NPCIL	Operational	GE	28-Oct-69	41.45
India	TARAPUR-2	BWR	150	NPCIL	Operational	GE	28-Oct-69	41.45
USA	NINE MILE POINT-1	BWR	621	NMPNSLLC	Operational	GE	1-Dec-69	41.36
USA	OYSTER CREEK	BWR	619	AMERGEN	Operational	GE	1-Dec-69	41.36
Japan	TSURUGA-1	BWR	340	JAPCO	Operational	GE	14-Mar-70	41.07
USA	DRESDEN-2	BWR	867	EXELON	Operational	GE	9-Jun-70	40.84
USA	R.E. GINNA	PWR	560	CCNPP	Operational	Westinghouse	1-Jul-70	40.78
Japan	MIHAMA-1	PWR	320	KEPCO	Operational	Westinghouse	28-Nov-70	40.36
USA	POINT BEACH-1	PWR	512	WEP	Operational	Westinghouse	21-Dec-70	40.30
USA	H.B. ROBINSON-2	PWR	710	PROGRESS	Operational	Westinghouse	7-Mar-71	40.09
USA	MONTICELLO	BWR	572	NORTHERN	Operational	GE	30-Jun-71	39.78
Canada	PICKERING-1	PHWR	515	Ontario Power Generation	Operational	OH/AECL	29-Jul-71	39.70
UK	WYLFA 1	GCR	490	BNFL	Operational	EE/B&W/T	1-Nov-71	39.44
Spain	SANTA MARIA DE GAROc	BWR	446	NUCLENOR	Operational	GE	5-Nov-71	39.43
USA	DRESDEN-3	BWR	867	EXELON	Operational	GE	16-Nov-71	39.40
Switzerland	BEZNAU-2	PWR	365	NOK	Operational	Westinghouse	1-Dec-71	39.36
USA	PALISADES	PWR	778	CONSENEC	Operational	CE	31-Dec-71	39.27
UK	WYLFA 2	GCR	490	BNFL	Operational	EE/B&W/T	3-Jan-72	39.27
Sweden	OSKARSHAMN-1	BWR	623	OKG	Operational	ABBATOM	6-Feb-72	39.17
Russia	NOVOVORONEZH-3	WWER	385	REA	Operational	MNE	29-Jun-72	38.78
Japan	MIHAMA-2	PWR	470	KEPCO	Operational	Westinghouse	25-Jul-72	38.71
USA	POINT BEACH-2	PWR	514	WEP	Operational	Westinghouse	1-Oct-72	38.52
Switzerland	MUEHLEBERG	BWR	355	BKW	Operational	GETSCO	6-Nov-72	38.42
USA	VERMONT YANKEE	BWR	605	ENTERGY	Operational	GE	30-Nov-72	38.36
USA	PILGRIM-1	BWR	685	ENTERGY	Operational	GE	1-Dec-72	38.35
Pakistan	KANUPP-1	PHWR	137	PAEC	Operational*	CGE	7-Dec-72	38.34
USA	TURKEY POINT-3	PWR	693	FPL	Operational	Westinghouse	14-Dec-72	38.32
Total Capacity			14,638					

Source: IAEA, NRC

Asia

China

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What nuclear capacity does China have and how significant is this in its energy mix?

China had 10.8GW of operational nuclear power capacity at the end of 2010, representing 1.1% of national total power capacity of 962GW. Nuclear power accounted for 1.8% of total power generation in 2010.

China now has 13 nuclear power units in service located in coastal China and use direct once-through seawater cooling.

- **Daya Bay**, in Shenzhen, Guangdong
  - It has two 984MWe PWR reactors using the Framatone M310 model (a 900MWe three cooling loop design) and GEC-Alsthom turbine-generator technology. It is the first nuclear plant in China and began operations in 1994.
- **Qinshan,** constructed in three phases, in Haiyan county in Zhejiang
  - Qinshan I and II use PWR. Qinshan I is the first domestically designed and constructed nuclear power plant in China, a single-loop CNP-300 unit developed by CNNC based on Framatone M310 model.
  - Qinshan II (3x650MW operational, 1x650MW under construction) was also a Chinese design, scaled up from the CNP-300 unit at Qinshan I to two-loop CNP600 units.
  - Qinshan III use PHWR (Canadian technology, as the project is technological cooperation between the Canadian and Chinese governments). The two CANDU-6 series of the CANDU reactor designs were supplied by Atomic Energy of Canada (AECL).
- **Ling'ao**, in Dapeng in Guangdong
  - Ling'ao-1 and Ling'ao-2 use French M310 units taking reference from the design of Daya Bay with a number of upgrades and a higher localisation rate in equipment supply.
  - Ling'ao-3 and Ling'ao-4 (under construction) are being built by Areva-Dongfang (a JV of Areva with Dongfang Electric). Ling'ao-3 was the first domestic CPR-1000 nuclear plant in China. The CPR-1000 is a Generation II+, improved from the French three cooling loop design, with most of the components currently built within China. CPR-1000 was constructed and operated by China Guangdong Nuclear Power Corporation (CGNPC) with some intellectual property rights retained by Areva.

- **Tianwan**, in Lianyungang in Jiangsu
  - It consists of two 1,080MW reactors constructed and supplied by Atomstroyexport of Russia (merged from AO Atomenergoeksport [AEE] and VPO Zarubezhatomenergostroy [ZAES]). The plant used VVER-1000 (Russian version of PWR) adapted specifically for China and is a project of technological cooperation between Russia and China.

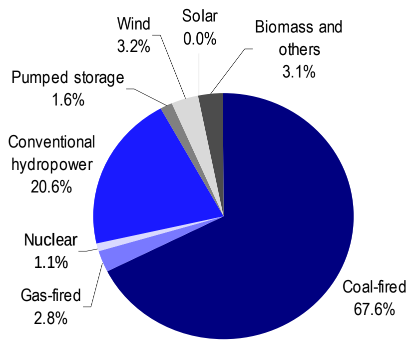
Modest earthquake, but low tsunami risk

Earthquakes do happen in China. A prerequisite in site selection for a nuclear power project in China is no seismic activity in the prior 500 years, before conducting further evaluation and feasibility studies. For instance, within a 300km diameter of the Qinshan nuclear plant, only one earthquake has ever been recorded—a magnitude-five earthquake in the Pacific Ocean.

According to the Ministry of Nuclear and Radiation Safety Department under the Ministry of Environmental Protection (MEP), the threat of tsunamis is quite insignificant. There was a frequency of maybe one every 200 years recorded in the past over 2,000 years.

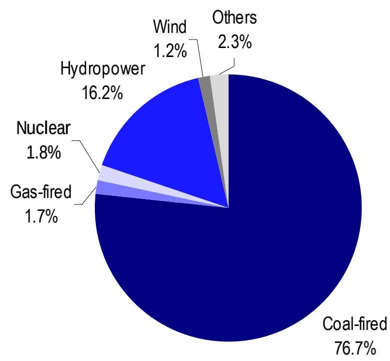
Tsunamis that might affect China's coastal regions could be caused by earthquakes in the Pacific, the Bohai Bay area or the southeast coastal seismic belts. Most of the continental shelves alongside China's coast line are at depths shallower than 200m, according to the China Earthquake Administration. If tsunamis did happen, they may be further buffered by outer islands.

Chart 7: China's power capacity mix at end-2010



Source: CEC, CEIC.

Chart 8: China's power generation mix in 2010



Source: CEC, CEIC.

What capacity expansion plans existed prior to Fukushima?

By the end of 2010, China had approved 35GW of nuclear plants and construction had started on 28GW of this. Many more plants are being planned, including at coastal and also inland sites (such as in Henan, Hubei, and Hunan).

Significant new capacity pipeline

According to the draft of 12th Five-Year plan for the power industry released by China Electricity Council (CEC) in recent months, China will target nuclear capacity of 43GW by 2015 and 90GW by 2020 (see the following table). This would represent 3.0% of total national capacity by 2015, and 4.8% by 2020, compared with 1.1% in 2010. Although the growth of coal-fired power capacity would slow relative to other fuel types, it would still represent the bulk of the capacity of over 60% by 2020 under the forecasts, even with the ramp-up of nuclear and other renewable power capacities.

The last time the National Energy Administration released the specific 'medium- to long-term plan for nuclear power' up to 2020 was in October 2007. In the plan, the nuclear capacity target by 2020 was only 40GW. In early March, China set out the plan for 2011-15 of developing 235GW of power capacity from 'clean energy', including 40GW of nuclear, 120GW of hydro, and 70GW of wind.

China needs nuclear to help reach emissions targets

The central government is targeting 15% of primary energy from non-fossil sources by 2020. In the nearer term, by 2015, it is targeting a 16% reduction in energy consumption per unit of GDP, a 17% reduction in carbon dioxide emission per unit of GDP, and an increase of non-fossil fuel energy as a percentage of total primary energy from 8.3% in 2010 to 11.4% by 2015 in the 12th Five-Year Plan, announced on 16 March 2011.

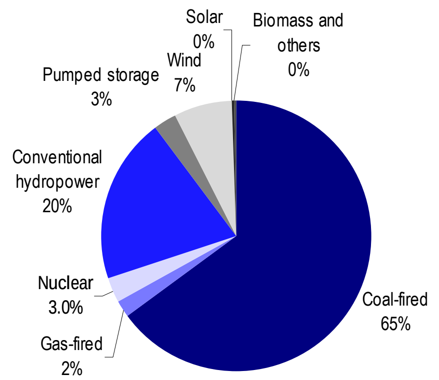
Only three state-owned power groups China National Nuclear Corporation (CNNC), CGNPC and China Power Investment Corporation (CPI Group) have obtained the qualification to develop nuclear power plants. Other power groups, including Datang Group and Huadian Group, can only have minority shareholding in a nuclear power plant for now, but are applying for the qualification.

Table 10: Capacity target in the draft 12th five-year plan for power industry, CEC

	2010		2015E		2020E	
(GW)	Capacity	% of total	Capacity	% of total	Capacity	% of total
National total	962	100.0%	1,437	100.0%	1,885	100.0%
Coal-fired	650	67.6%	933	64.9%	1,160	61.5%
Gas-fired	27	2.8%	30	2.1%	40	2.1%
Conventional hydropower	198	20.6%	284	19.8%	330	17.5%
Pumped storage	15	1.6%	41	2.9%	60	3.2%
Nuclear	11	1.1%	43	3.0%	90	4.8%
Wind	31	3.2%	100	7.0%	180	9.5%
Solar	0	0.0%	2	0.1%	20	1.1%
Biomass	1	0.1%	3	0.2%	5	0.3%
Others	29	3.0%	1	0.1%	-	0.0%

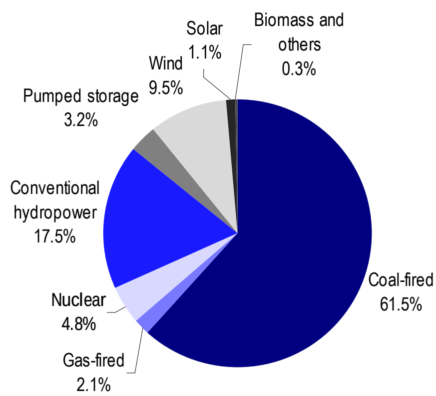
Source: CEC

Chart 9: China's power capacity mix in 2015 under 12th Five Year Plan drafted by CEC



Source: CEC

Chart 10: China's power capacity mix in 2020 under 12th Five Year Plan drafted by CEC



Source: CEC

The nuclear plants under construction all use PWR. The reactors under construction are mostly based on CPR-1000 or CNP-600; which are Chinese versions of the Generation II+ model; while only four units at Sanmen and Haiyang are based on the AP1000 model and two units at Taishan on the European pressurised reactor (EPR) model. These are more advanced third-generation reactor designs but have to be imported from Westinghouse and Areva, respectively.

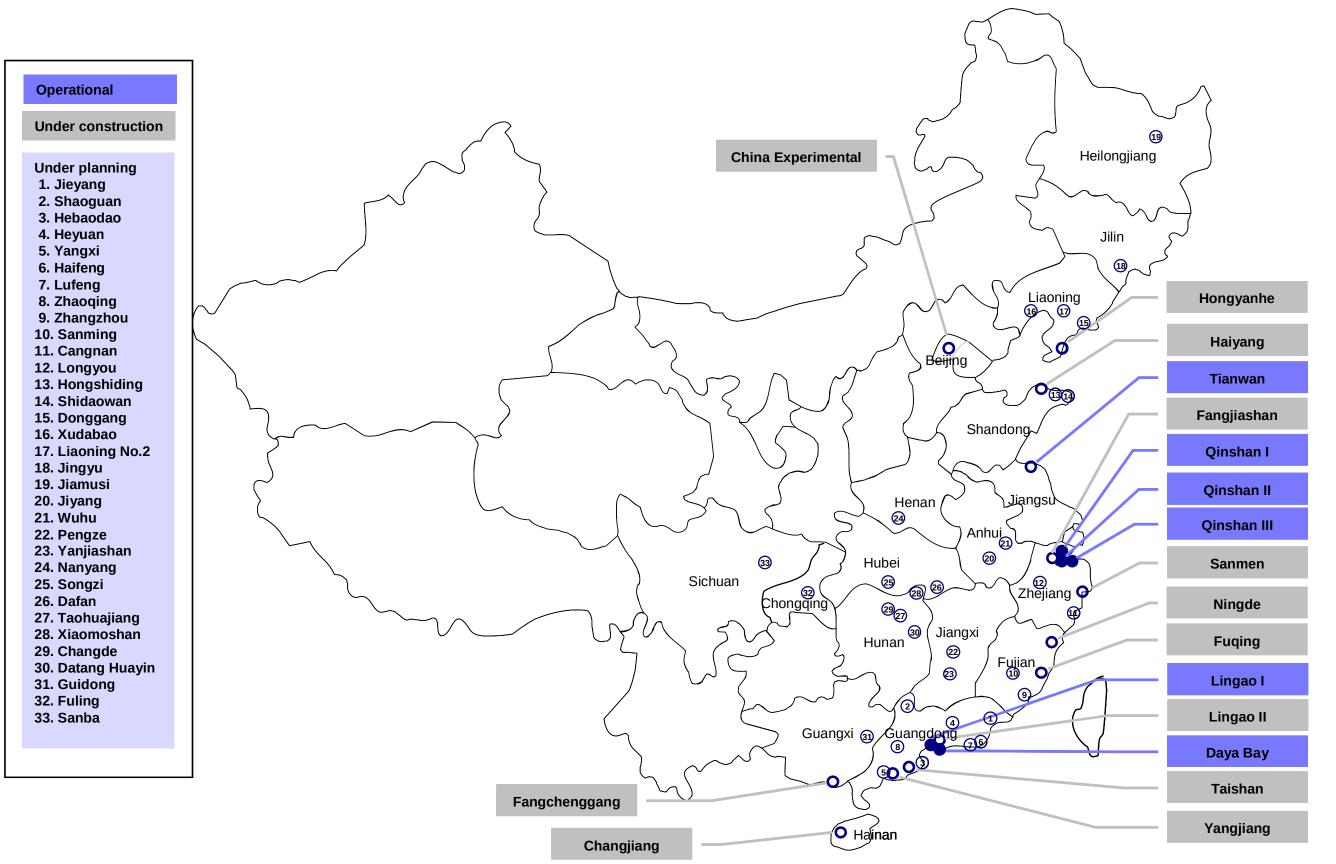
CNNC and CGNPC have guided that most of their planned projects are also likely to use AP1000 technology.

CNNC and CGNPC have guided that most of their planned projects are also likely to use AP1000 technology

While the AP1000 is a more advanced design with a passive safety system in place to provide significant improvement in safety and reliability, no AP1000 units have entered service so far in the world (same for EPR model as well). This compares with the Generation II+ technology which is already quite mature and well-tested globally; and the first Chinese version (CPR-1000) unit at Ling'ao commenced operations in late 2010.

In general, China aims to develop the domestic technologies to become self-sufficient in reactor design, construction, and other parts of the fuel cycle, through technology imports (such as the way it is developing CNP-600 and CPR-1000). In addition to CPR, CGNPC also announced in 2010 a further evolution to its domestic Generation III+ version of ACPR-1000 with full Chinese intellectual property rights.

Figure 1: Location of nuclear power projects in China



Source: CNEC, China Nuclear Power Information, UBS

Table 11: Nuclear power plants in operation and under construction

Name	Province	Type	Technology	Capacity (MWe)	Operator	Reactor supplier	Construction date	Operational date
Operational								
Daya Bay-1	Guangdong	PWR	M310	983.8	CGNPC	FRAM	7-Aug-87	1-Feb-94
Daya Bay-2	Guangdong	PWR	M310	983.8	CGNPC	FRAM	7-Apr-88	7-May-94
Ling'ao 1	Guangdong	PWR	M310	990.3	CGNPC	FRAM	15-May-97	28-May-02
Ling'ao 2	Guangdong	PWR	M310	990.3	CGNPC	FRAM	28-Nov-97	8-Jan-03
Ling'ao 3	Guangdong	PWR	CPR1000	1,080	CGNPC	DFEC	15-Dec-05	15-Dec-10
Qinshan 1	Zhejiang	PWR	CNP300	310	CNNC	CNNC	20-Mar-85	1-Apr-94
Qinshan 2-1	Zhejiang	PWR	CNP650	650	CNNC	CNNC	2-Jun-96	18-Apr-02
Qinshan 2-2	Zhejiang	PWR	CNP650	650	CNNC	CNNC	1-Apr-97	3-May-04
Qinshan 2-3	Zhejiang	PWR	CNP650	650	CNNC	CNNC	28-Mar-06	28-Mar-11
Qinshan 3-1	Zhejiang	PHWR	CANDU 6	700	CNNC	AECL	8-Jun-98	31-Dec-02
Qinshan 3-2	Zhejiang	PHWR	CANDU 6	700	CNNC	AECL	25-Sep-98	24-Jul-03
Tianwan 1	Jiangsu	PWR	AES-91	1,060	CNNC	AEE&ZAES	20-Oct-99	17-May-07
Tianwan 2	Jiangsu	PWR	AES-91	1,060	CNNC	AEE&ZAES	20-Oct-00	16-Aug-07
Under construction								
Ling'ao 4	Guangdong	PWR	CPR1000	1,080	CGNPC	DFEC	15-Jun-06	
Qinshan 2-4	Zhejiang	PWR	CNP650	650	CNNC	CNNC	28-Jan-07	
Hongyanhe 1	Liaoning	PWR	CPR1000	1,000	CGNPC	DFEC	18-Aug-07	
Hongyanhe-2	Liaoning	PWR	CPR1000	1,000	CGNPC		28-Mar-08	
Hongyanhe 3	Liaoning	PWR	CPR1000	1,000	CGNPC		7-Mar-09	
Hongyanhe 4	Liaoning	PWR	CPR1000	1,000	CGNPC		15-Aug-09	
Ningde 1	Fujian	PWR	CPR1000	1,000	CGNPC		18-Feb-08	
Ningde 2	Fujian	PWR	CPR1000	1,000	CGNPC		12-Nov-08	
Ningde 3	Fujian	PWR	CPR1000	1,000	CGNPC		8-Jan-10	
Ningde 4	Fujian	PWR	CPR1000	1,000	CGNPC		29-Sep-10	
Fuqing 1	Fujian	PWR	CPR1000	1,000	CNNC		21-Nov-08	
Fuqing 2	Fujian	PWR	CPR1000	1,000	CNNC		17-Jun-09	
Fuqing 3	Fujian	PWR	CPR1000	1,000	CNNC		31-Dec-10	
Yangjiang 1	Guangdong	PWR	CPR1000	1,000	CGNPC		16-Dec-08	
Yangjiang 2	Guangdong	PWR	CPR1000	1,000	CGNPC		4-Jun-09	
Yangjiang 3	Guangdong	PWR	CPR1000	1,000	CGNPC		15-Nov-10	
Sanmen 1	Zhejiang	PWR	AP1000	1,000	CNNC		19-Apr-09	
Sanmen 2	Zhejiang	PWR	AP1000	1,000	CNNC		17-Dec-09	
Fangjiashan 1	Zhejiang	PWR	CPR1000	1,000	CNNC		26-Dec-08	
Fangjiashan 2	Zhejiang	PWR	CPR1000	1,000	CNNC		17-Jul-09	
Haiyang 1	Shandong	PWR	AP1000	1,000	CPI Group		24-Sep-09	
Haiyang 2	Shandong	PWR	AP1000	1,000	CPI Group		21-Jun-10	
Taishan 1	Guangdong	PWR	EPR1600	1,700	CGNPC		18-Nov-09	
Taishan 2	Guangdong	PWR	EPR1600	1,700	CGNPC		15-Apr-10	
Fangchenggang 1	Guangxi	PWR	CPR1000	1,000	CGNPC		30-Jul-10	
Changjiang 1	Hainan	PWR	CNP650	610	CNNC		25-Apr-10	
Changjiang 2	Hainan	PWR	CNP650	610	CNNC		21-Nov-10	

Source: World Nuclear Association, IAEA, CNEC

Table 12: Pipeline of nuclear projects in China

Name	Province	Technology	Phase I (MWe)	Planned (MWe)	Operator
Jieyang	Guangdong	AP1000	2x1,000	6x1,000	CGNPC
Shaoguan	Guangdong	AP1000	2x1,000	4x1,000	CGNPC
Hebaodao	Guangdong				CNNC
Heyuan	Guangdong			4x1,000	CNNC
Yangxi	Guangdong		2x1,000	6x1,000	Datang Group
Haifeng	Guangdong			8x1,000	CNNC
Lufeng	Guangdong	CPR1000	2x1,080	6x1,080	CGNPC
Zhaoqing	Guangdong			6x1,000	CGNPC
Zhangzhou	Fujian	AP1000	4x1,250	6x1,250	CPI Group
Sanming	Fujian	CPR1000	2x1,000	4x1,000	CNNC
Cangnan	Zhejiang	CPR1000	2x1,000	6x1,000	CGNPC
Longyou	Zhejiang		2x1,000	4x1,000	CNNC
Hongshiding	Shandong		2x1,000	6x1,000	CNNC
Shidaowan	Shandong	HTGR	1x200	1x200 + 6x1,000	CNNC
Donggang	Liaoning			6x1,000	Huadian Group
Xudabao	Liaoning		2x1,000	6x1,000	CNNC
Liaoning No.2	Liaoning				CPI Group
Jingyu	Jilin	AP1000	4x1,250	6x1,250	CPI Group
Jiamusi	Heilongjiang	CPR1000	2x1,000	4x1,000	CGNPC
Jiyang	Anhui	AP1000	2x1,000	4x1,000	CNNC
Wuhu	Anhui	AP1000	4x1,000	4x1,000	CGNPC
Pengze	Jiangxi	AP1000	2x1,000	4x1,000	CPI Group
Yangjiashan	Jiangxi			4x1,000	CNNC
Nanyang	Henan		2x1,000	6x1,000	CNNC
Songzi	Hubei			4-6x1,000	CGNPC
Dafan	Hubei	AP1000		4x1,000	CGNPC
Taohuajiang	Hunan	AP1000	4x1,000	4x1,000	CNNC
Xiaomoshan	Hunan	AP1000	2x1,000	6x1,000	CPI Group
Changde	Hunan		2x1,000	4x1,000	CGNPC
Datang Huayin	Hunan		2x1,000	4x1,000	Datang Group
Guidong	Guangxi		2x1,000	4x1,000	CPI Group
Fuling	Chongqing	AP1000	2x1,250	4x1,250	CPI Group
Sanba	Sichuan		2x1,000	4x1,000	CGNPC

Source: World Nuclear Association, IAEA, CNEC, Electric365

What statements have come from regulators or government officials on how plans might change?

Following the accident at Fukushima, the Chinese government announced the following immediate action:

(1) The State Council had suspended approval for new nuclear plants from the pipeline;

(2) The National Energy Administration would despatch a team to inspect the safety level/standards of nuclear plants under construction, and core equipment quality procedure, and to order the suspension of construction of plants not fulfilling the standards. However, according to local media reports, the daily operation and construction of plants has been unaffected;

(3) The State Nuclear Safety Bureau under MEP, which is responsible for nuclear safety regulation, is reviewing the nuclear safety regulation system focusing on the capability of nuclear power stations to survive in a nuclear crisis caused by a natural disaster.

Safety inspections and a rechecking of earthquake and tsunami risk are plans

It is carrying out several measures at the moment:

- A review to ensure the adequacy of procedures in place for all nuclear plants in operation to handle emergencies and to review—and, if necessary, improve—the crisis management guidelines. This is to ensure the safety standards of current nuclear plants in service are comparable with the new ones;
- To investigate and analyse the geology of China's coastal land including a wider area (currently within a 150km-range), to re-assess the causes of tsunamis further, strengthen the tsunami forecast system, and to confirm the likely impact of a tsunami on coastal China. This is to provide more scientific and reliable data to reaffirm the anti-earthquake capability of existing and new nuclear power plants and to deal with current inadequacies in safety systems;
- To propose the design of nuclear plants to prepare for the possibility of natural disasters simultaneously affecting several units of the same plant;
- To educate the public about nuclear power and safety issues.

The government will also try to formulate a new version of the 'Medium- to Long-term Plan for Nuclear Power', which was last disseminated in October 2007.

Meanwhile, the China Electricity Council has indicated that the 2020 national nuclear capacity target may be cut by at least 10GW from its original forecast of 90GW and that its 2015 target of 43GW could also be too optimistic. It predicted the proportion of total primary energy consumption for nuclear will be below 3% in the future. It estimates that China may slow the construction of nuclear plants in light of the Japanese incident.

What changes, if any, do we expect to actually happen?

In our view, China has no option but to develop nuclear power and we think the Fukushima accident is unlikely to change the government's commitment in this area. China has to constantly resolve the conflict between the need to generate electricity for growth and environment pressure, because it has undertaken to cut 40-45% of carbon emission per GDP unit by 2020.

Nuclear construction to continue, but perhaps with modest delays

Government officials have asserted that China will continue developing nuclear power, albeit under stricter safety requirements. Several industry participants and experts have also been stating similar attitudes and views.

However, we believe the safety inspections and suspension of approvals may cause delays in project construction and imply downside to the 2015 and 2020 nuclear power targets.

China Guangdong Nuclear Power Corporation and China National Nuclear Corporation have both made statements that the nuclear plants in service and under operation have ensured safe operations even in the event of a tsunami or earthquake. According to CGNPC, existing nuclear power plants in China have been designed to resist 8.0 magnitude earthquakes and 6.5-metre high tsunami waves. For example, Daya Bay, the first nuclear power plant in China, has its nuclear reactor on a seven metre high base and is also protected by a 16-metre high breakwater. CGNPC says it believes the Fangchenggang plant in Guangxi has robust safety structures in place, with careful site selection and planning.

We believe such designs alone might not be viewed as being adequate. Further mitigation measures in handling serious accidents could be required. Based on the lesson from the Fukushima incident, we think China will focus more on designs to prevent and lower the risk of core meltdown. The plants should possess water storage tanks to release a large amount of water to lower the temperature in case of crisis.

Fukushima could lead to more use of AP1000 technology

The Fukushima incident could also have implications for nuclear technology direction. Considering the pros and cons for AP1000 versus CPR/CNP mentioned in the section above, the Chinese government has not confirmed the preference of technology yet. We believe after this incident, the government will prefer AP1000 more than before in future nuclear development, because of its passive-protection mechanism.

Nonetheless, we think the government will likely choose to defer the decision-making and slow project approval until 2014-15 when the first AP1000 is up and running. We think nuclear plant operators are generally waiting for the State Council's final decision and announcements before making more specific arrangements.

China may also strengthen the management of nuclear plants and further emphasise the expertise and training of workers operating the plants, in our view.

Hong Kong

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How significant is nuclear power to Hong Kong's energy mix?

There are no power plants in Hong Kong, but CLP Power (CLP) buys 70% of the output of the 25%-owned Daya Bay power plant 50 kilometres away in Shenzhen, China. Daya Bay has two 984MWe PWR reactors from Framatone ANP (now part of Areva) of France, which entered service in August 1993 and February 1994. The plants are named Guangdong-1 and Guangdong-2 in the IAEA database.

Unlike Japan, the area where the Daya Bay nuclear power plant is located is not a seismically-active area and the risk of earthquakes/tsunamis is relatively low, in our view.

Imports from Daya Bay accounted for one third of overall power supplies to CLP's network, with the balance coming from coal and gas-fired power plants. This is supplied under a long-term power purchase agreement (PPA). The original PPA was due to expire in 2014, but CLP has entered into a 20-year extension.

What capacity expansion plans existed prior to Fukushima?

Climate change strategy calls for more reliance on nuclear

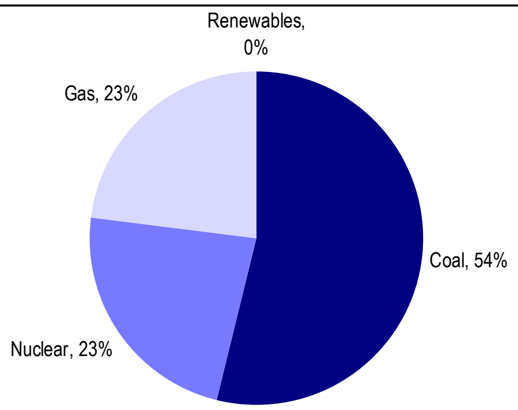
The consultation period for the Hong Kong government's proposed 'Climate Change Strategy and Action Agenda' finished on 31 December 2010. The government is proposing reducing Hong Kong's carbon intensity by 50-60% by 2020 from 2005 levels (compared to GDP). This would imply a reduction of 19-33% in total annual emissions.

To do this, the government is proposing reducing local greenhouse gas (GHG) emissions through various means, including community-wide participation in enhancing energy efficiency and the wider use of clean, low carbon fuels for electricity generation. According to the government, power generation accounts for about two-thirds of Hong Kong's total GHG emissions.

The government consultation paper proposed reducing coal-fired power generation to less than 10% of the generation mix, from about 54% in 2009, and emphasising gas-fired and nuclear power generation. The following charts compare the fuel mix of Hong Kong's power generation in 2009 and the government's proposed 2020 target. Renewable energy remains a small part of the generation mix because of space and resource constraints in Hong Kong.

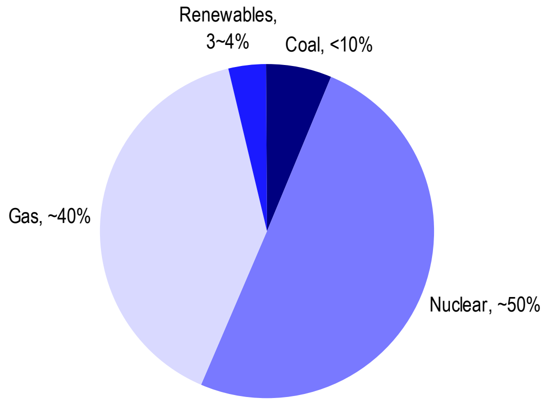
To achieve this, the government proposals envisage more nuclear power being imported from China as well as additional gas-fired units being installed at existing power plants in Hong Kong (probably at the site of CLP's existing coal-fired Castle Peak-A power plant and at Hongkong Electric's Lamma Extension power plant). Our current forecasts for both CLP and Power Assets (the holding company for Hongkong Electric) assume the construction of new gas-fired units but no additional nuclear imports from China.

Chart 11: Fuel mix for power generation in 2009



Source: *Hong Kong's Climate Change Strategy and Action Agenda, Consultation Document,* Hong Kong Government

Chart 12: Proposed fuel mix for power generation in 2020



Source: *Hong Kong's Climate Change Strategy and Action Agenda, Consultation Document,* Hong Kong Government

What statements have come from regulators or government officials on how plans might change?

Government comments have been relatively limited so far. On 21 March, the Secretary for the Environment told the Finance Committee of Hong Kong's Legislative Council when reporting on the recent consultation process: *"We are now consolidating views obtained in the public consultation, with a view to planning the way forward to revamp our fuel mix for power generation. We acknowledge concerns on the safety of nuclear power arising from the Fukushima incident. We will take account of the impact of the incident, in particular on the future development of nuclear industry, in considering our way forward"*.

What changes, if any, do we expect to actually happen?

Hong Kong's energy needs are increasingly interlinked with China's and we do not expect the government to remove nuclear from its energy mix. We think increased public resistance to nuclear power in the wake of the Fukushima event could lead to modifications to the government's original proposals. If this happens, we would expect any scale back in nuclear power with the Hong Kong power supply mix to be to the benefit of gas. In coming years, we expect new offshore fields, LNG receiving terminals in China and the Second West-East Pipeline to be sources of new gas supplies for Hong Kong.

If less nuclear is imported from China, the local utilities will need to build more gas-fired units instead

Any reduction in the extent of nuclear power investment by the Hong Kong utilities is not a negative. If CLP and Hongkong Electric invest in additional gas fired power plants instead, then the companies will be able to earn a permitted 9.99% return on the average net fixed asset investment.

We do not expect significant changes to be required of the Daya Bay nuclear power plant. According to Hong Kong Nuclear Investment Company, Daya Bay has three back-up electricity sources: power supply from the Guangdong electricity network, power supply from CLP's system, and on-site diesel generators—all of which can continue to power major auxiliary facilities, such as cooling systems, in the unlikely event of the discontinuation of nuclear power. Even in the event that all these electricity supplies are interrupted, a steam driver pump can operate to pump cooling water.

In addition, Daya Bay has three sets of back-up feed water pumps to support residual heat removal from the reactor—two driven by electricity and one driven by steam generated from the secondary cooling system. In case of the loss of electrical power, the steam driven pump is still available to pump the cooling water for residual heat removal, which could effectively help reduce the possibility of the reactor overheating.

India

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What nuclear capacity does India have and how significant is this in its energy mix?

There are 20 nuclear power reactors currently operating in India, comprising 18 pressurised heavy water reactors and two BWRs with total installed capacity of 4,780MW.

Table 13: India—Nuclear power generation capacity

Plant	Unit	Type	Capacity (MWe)	Date of commercial operation
TARAPUR ATOMIC POWER STATION (TAPS) , Maharashtra	1	BWR	160	28-Oct-69
TARAPUR ATOMIC POWER STATION (TAPS) , Maharashtra	2	BWR	160	28-Oct-69
TARAPUR ATOMIC POWER STATION (TAPS) , Maharashtra	3	PHWR	540	18-Aug-06
TARAPUR ATOMIC POWER STATION (TAPS) , Maharashtra	4	PHWR	540	12-Sep-05
RAJASTHAN ATOMIC POWER STATION (RAPS), Rajasthan	1	PHWR	100	16-Dec-73
RAJASTHAN ATOMIC POWER STATION (RAPS), Rajasthan	2	PHWR	200	1-Apr-81
RAJASTHAN ATOMIC POWER STATION (RAPS), Rajasthan	3	PHWR	220	1-Jun-00
RAJASTHAN ATOMIC POWER STATION (RAPS), Rajasthan	4	PHWR	220	23-Dec-00
RAJASTHAN ATOMIC POWER STATION (RAPS), Rajasthan	5	PHWR	220	4-Feb-10
RAJASTHAN ATOMIC POWER STATION (RAPS), Rajasthan	6	PHWR	220	31-Mar-10
MADRAS ATOMIC POWER STATION (MAPS), Tamil Nadu	1	PHWR	220	27-Jan-84
MADRAS ATOMIC POWER STATION (MAPS), Tamil Nadu	2	PHWR	220	21-Mar-86
KAIGA GENERATING STATION, Karnataka	1	PHWR	220	16-Nov-00
KAIGA GENERATING STATION, Karnataka	2	PHWR	220	16-Mar-00
KAIGA GENERATING STATION, Karnataka	3	PHWR	220	6-May-07
KAIGA GENERATING STATION, Karnataka	4	PHWR	220	20-Jan-11
NARORA ATOMIC POWER STATION (NAPS) , Uttar Pradesh	1	PHWR	220	1-Jan-91
NARORA ATOMIC POWER STATION (NAPS) , Uttar Pradesh	2	PHWR	220	1-Jul-92
KAKRAPAR ATOMIC POWER STATION (KAPS), Gujarat	1	PHWR	220	6-May-93
KAKRAPAR ATOMIC POWER STATION (KAPS), Gujarat	2	PHWR	220	1-Sep-95
Total Capacity			4,780	

Source: NPCIL

There are no private companies in India that operate nuclear power plants. All the reactors are operated and managed by Nuclear Power Corporation of India Limited (NPCIL), which is a public sector enterprise wholly owned by the government under the administrative control of the Department of Atomic Energy (DAE). It was registered in September 1987 as a public limited company, to design, build, operate and maintain nuclear power stations for the government under the provisions of the Atomic Energy Act, 1962. In the financial year 2009-10, NPCIL produced 3% of India's total electricity. It is planning to contribute a significant share of the 2032 capacity of 63,000MW envisaged by the government's integrated energy policy. The key stated objectives of that policy are as follows:

(1) Increase nuclear power capacity to at least 20,000MW in the next 10 years.

(2) The transformation from 540MW reactors to 700MW.

(3) Design of Indian pressurised water reactor.

(4) Work on light water reactors of 1,000MW and higher unit size through international cooperation.

What capacity expansion plans existed prior to Fukushima?

Relatively modest earthquake risk compared to Japan

At present, six nuclear power reactors of different types and sizes are at various stages of construction. Within five years, India plans to achieve installed capacity of 9,580MW. Unlike Japan, the areas where most of the Indian plants are located are not very seismically-active. However, India has experienced severe earthquakes in past and the risk of earthquakes/tsunamis cannot be entirely ruled out.

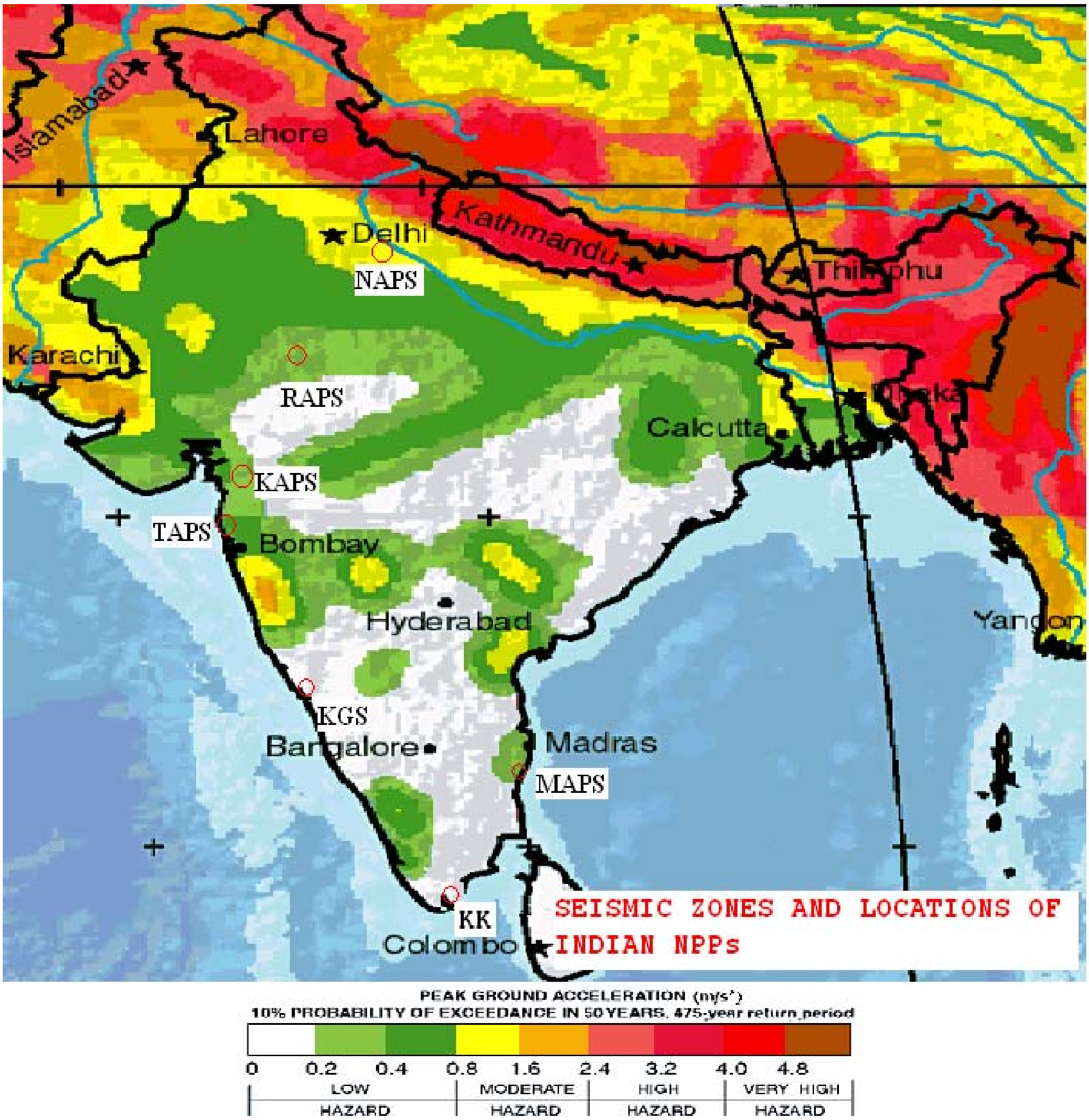
In addition, two nuclear power reactors of 1,000MW each are planned at Jaitapur, Maharashtra. Overall, the current plan is to reach a capacity of around 12,000MW by 2017.

Table 14: India—nuclear power generation capacity (under construction)

Plant	Units	Capacity (MWe)	Date of commercial operation
KUDANKULAM ATOMIC POWER PROJECT	2	2,000	Unit 1 – Jun-2011, Unit 2 – Mar-2012
RAJASTHAN ATOMIC POWER PROJECT	2	1,400	Unit 7 – Jun-2016, Unit 8 – Dec-2016
KAKRAPAR ATOMIC POWER PROJECT	2	1,400	Unit 3 – Jun-2015, Unit 4 – Dec-2015
Total Capacity		4,800	

Source: NPCIL

Chart 13: Seismic zones—India



Source: NPCIL

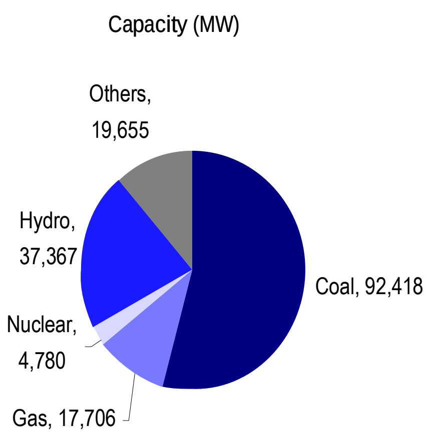
In 2008, India and the US signed a nuclear deal; this was done to increase the use of nuclear energy and build new plants in India. The nuclear deal was aimed at helping India address two basic problems:

(1) Uranium ore supplies are limited and India has inadequate facilities for making highly enriched uranium (HEU) for domestic power and military strategy needs. India needs an interim supply of HEU until the transition to self-sufficiency building reactors operating with Thorium.

(2) The expertise and technology to build >1,000MW nuclear power plants (the Kudankulam was based on Russian technology and Russia has not agreed for further support).

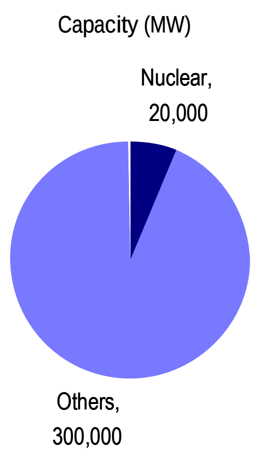
Under the deal, India would be eligible to buy US dual-use nuclear technology, including materials and equipment that could be used to enrich uranium or reprocess plutonium. It would also receive imported fuel for its nuclear reactors. The DAE has formulated a programme for increasing the installed nuclear capacity to 20,000MW by 2020, of which 10,000MW will be based on uranium fuelled PHWRs.

Chart 14: Capacity mix for power generation (February 2011)



Source: Central Electricity Authority

Chart 15: Proposed capacity mix for power generation in 2020



Source: DAE, Central Electricity Authority, UBS estimates

What statements have come from regulators or government officials on how plans might change?

Similar to other countries, a review of safety standards has been ordered

Government comments have been measured so far. On 18 March, India suggested that it was re-examining the safety standards of its nuclear energy programme in light of the problems at the Fukushima Daiichi power plant. Prime Minister Manmohan Singh, said during a public event: "*The tragic nuclear incidents in Japan make us revisit strategies for nuclear safety. I have already ordered a thorough safety review by the Department of Atomic Energy*".

Against the backdrop of the nuclear crisis in Japan, Maharashtra chief minister Prithviraj Chavan said the state government would not go ahead with the Jaitapur plant unless it was fully secure (the 2x1,000MW Jaitapur plant is located in Maharashtra). However, he added that natural resources such as coal are limited, and tapping nuclear energy to meet growing demands was inevitable.

Minister for Environment and Forests, Jairam Ramesh, said India needed to learn appropriate lessons from the nuclear disaster in Japan and take additional safeguarding action, but that the country could not abandon its nuclear energy programme. He added that it was still too early to say what impact the Japanese disaster would have on India's nuclear programme, and that the Nuclear Power Corporation and Atomic Energy Regulatory Board (AERB) had to conduct safety reviews.

What changes, if any, do we expect to actually happen?

India's energy needs are increasingly interlinked with the country's growth rate and we do not believe India can afford to exclude nuclear from its energy mix. However, we agree that increased public resistance to nuclear power in the wake of the Fukushima event could lead to delays and/or modifications to the government's original proposals. If this happens, we would expect any scale-back in nuclear power to benefit coal.

Development of a nuclear insurance pool has been prioritised

The nuclear crisis in Japan has led the Indian government to speed up the development of a nuclear insurance pool for similar accidents in the country. According to media reports, the government has convened a meeting involving the Nuclear Power Corporation and General Insurance Corporation (GIC), the only domestic re-insurer in the country, to take stock of the progress. It is possible the government is in the process of opening certain parts of nuclear plants for inspection by reinsurers to assess the risk, and that based on this, a pricing model could be developed. The size of a pool varies with the size of a plant, the machinery used, and the levels of radiation expected. GIC has been in talks with various global reinsurance firms for additional capacity.

We also expect increased opposition from the local population (in areas near existing and proposed nuclear power plants) and various non-profit organisations. This could lead to a re-assessment of locations, although we believe outright cancelations are highly unlikely. We also expect there to be further scrutiny on environmental impact by the Ministry of Environment and Forests.

Any reduction in the extent of nuclear power investment by NPCIL would not be a near-term positive for the companies in our coverage universe. However, in the long-term, if there is more investment in coal-fired power plants instead, other companies (such as NTPC, Tata Power, Adani Power, Lanco, Reliance Power in our coverage universe) will be able to grow their capacity base.

The impact on Indian companies

Significant orders for nuclear would benefit local equipment suppliers and contractors

If the plans to build nuclear power plants go ahead on schedule, this could lead to more than US$10bn of orders for the Indian contractors and equipment makers by 2015, assuming the planned projects are awarded. Civil contractors (Larsen & Toubro, Hindustan Construction Company and Gammon) and manufacturers of turbo generator (TG) sets, reactor cores, such as Larsen & Toubro (L&T) and Bharat Heavy Electricals (BHEL) stand to gain the most, in our view. However, we believe high construction costs, a technology gap and clearances are still relevant issues, and that the real gains would be evident only when the technology to be deployed is finalised, and what the international partners leave for the domestic vendors. To date Indian manufacturers have been involved only in the sub-500MW units. The India-US nuclear deal would give India access to technology for making 1,000MW+ units, and provide them with necessary fuel. The costs of new builds have risen and are now about US$2,000/kW.

Table 15: Existing vendors for nuclear power

	Companies
Civil	HCC, Gammon, L&T
Large fabrications	L&T, BHEL, Walchand Industries, Godrej & Boyce, Richardson & Crudas
Small fabrications	Agro Engineers, Lokesh Machines, Variety Engineers, Gansons, Lloyd Steel, Vividh High Fab
Turbo-generators	BHEL
Condensers	BHEL, L&T and Bharat Heavy Plates
Heat exchangers	Alfa Laval and IDMC Ltd.
Electrical equipment	BHEL, L&T, Siemens, Crompton & Greeves, NGEF, TELK, Kirloskar Electric, Alsthom
Special forgings	Bharat Forge, BHEL, Fomas,MGM
Pipes and tubes	Maharashtra Seamless, Ratnamani, Surya Roshni
Pumps	Bharat Pumps and Compressors Ltd, Kirloskar Brothers, Mather and Platt, Jyoti Limited and KSB
Valves	Audco division of L&T, BHEL, Fouress Ltd., Instrumentation Ltd., MIL
Plates and structural	SAIL, TISCO, Jindal

Source: UBS

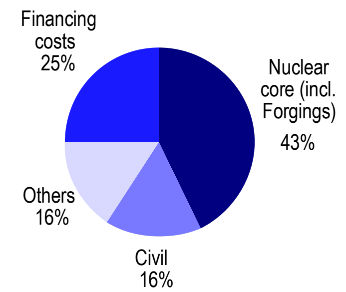
Who could be the main suppliers?

The first nuclear power station at Tarapur was built by a US company on a turnkey basis. Local equipment manufacturing began with the second nuclear power station at Rawatbhata in Rajasthan. This was set up in collaboration with Canada and the design of equipment was based on the manufacturing capabilities available in the North American continent at that time. There was a wide gap between the facilities available in India at that time and those required for the manufacture of equipment for the nuclear power programme. This gap was gradually narrowed by systematic efforts by the DAE and the Indian manufacturers, following a well thought out strategy.

Thus the gap was narrowed and almost all the major equipment was manufactured in India for the third nuclear power station at Kalpakkam. There has been further progress towards self-reliance in subsequent projects as more and more items have been localised and multiple alternative manufacturers have been established for all items.

Of the total cost of a nuclear power plant, we estimate 25% is interest during construction, 15-20% for civil contractors, and the balance the cost of equipment (main plant + auxiliaries). The Nuclear Power Corporation has indicated that there is a potential pipeline of 6,800MW of new contracts over the next two years. The total pie could be Rs430bn (US$10bn) for contractors + equipment suppliers. Among large potential beneficiaries are L&T and BHEL. We estimate BHEL's business potential at about 25-30% of the contract size for the turbine generator sets, electrical equipment. L&T could participate in about 50% of the contract value (including civil engineering projects and the reactors), Alfa Laval 3-4%, and other civil contractors and fabricators are involved. Steel for nuclear power plants in India generally comes from Steel Authority of India (SAIL) and Tisco and forgings from Bharat Forge/BHEL.

Chart 16: Typical costs of nuclear power



Source: UBS estimates

Japan

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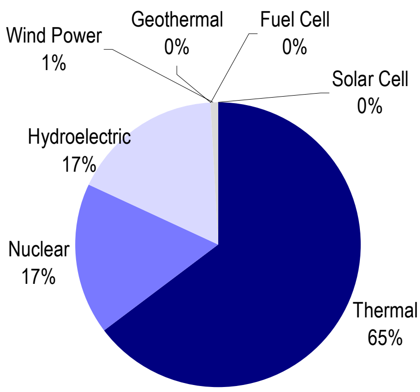
What nuclear capacity does Japan have and how significant is it as part of the energy mix?

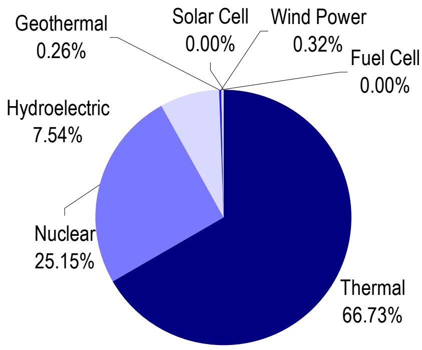
Japan has no meaningful national energy resources and relies heavily on imported fuel. As a result, nuclear energy has long been considered an important part of the country's power generation mix. At the time of the 11 March earthquake, Japan had 55 units operating. All Japanese electric power companies (EPCO) have nuclear power plants, except for Okinawa Electric Power. In the 2009 fiscal year (the year ended 31 March 2010), Japan's 49GW of nuclear power plants made up 17% of total capacity and accounted for 25% of the total national power generation (see the following charts).

Chart 17: Installed capacity break-down by fuel type



Source: Federation of Electric Power Companies of Japan (FEPC Japan)

Chart 18: Electricity generation by fuel type



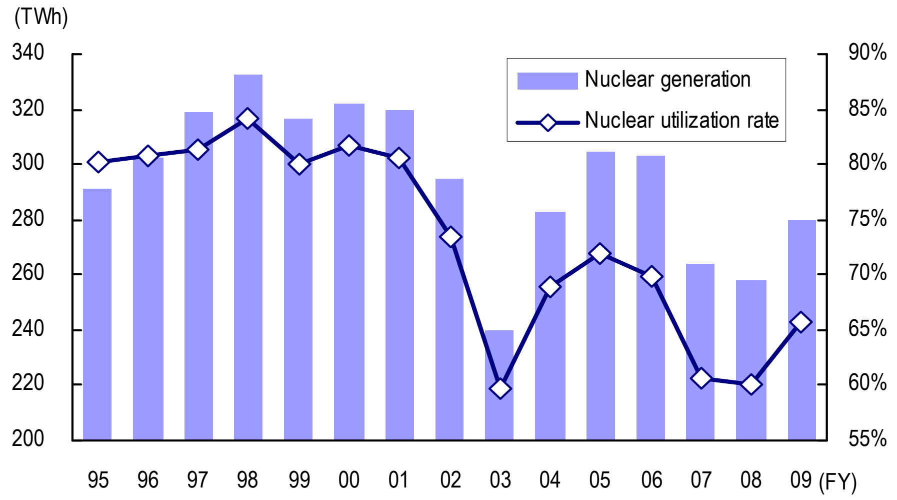
Source: FEPC Japan

As shown in the following chart, nuclear facility utilisation rates in Japan have remained low since FY02. Operations at some of Japan's nuclear power plants have been stopped for long periods to allow for inspections and for the drawing up of measures to prevent various problems. The following are some of the major stoppages:

- Operations were halted as periodic checks had to be carried out on all units in 2002–2003 by TEPCO after the discovery of falsified voluntary inspection records in August 2002;
- Periodic inspections had to be carried out on all units by Kansai EPCO following damage to secondary pipes at the No.3 unit at its Mihama nuclear plant in August 2004;
- Operations were suspended for inspection, repairs, and reinforcement of earthquake resistance at Tohoku EPCO's Onagawa plant, Hokuriku EPCO's Shika plant, and TEPCO's Kashiwazaki-Kariwa plant in 2005–2007 as a result of a major earthquake that exceeded the plants' structural design standards and automatically shut down all units;
- Consequent revisions to earthquake resistance standards forced more than half of the units in Japan to reinforce their earthquake resistance;

- Discovery of efforts to conceal a past accident at Hokuriku EPCO's Shika plant in 2007 led to a stoppage;
- The discovery of discrepancies in inspection records and the excessive use of certain equipment at Chugoku EPCO's Shimane plant in 2010 also led to a stoppage.

Chart 19: Nuclear power generation and Utilisation rates in Japan



Source: FEPC, Company data, UBS

The following table shows Japan's nuclear power plants as at 31 March 2010, with details of each reactor unit.

Table 16: Nuclear power reactors operating as on 31 March 2010

Station	Type	Net capacity (MWe)	Operator	Reactor supplier	Construction date	Criticality date	Grid date	Commercial date
FUKUSHIMA-DAIICHI-1	BWR	439	TEPCO	GE/GETSC	25-Jul-67	10-Oct-70	17-Nov-70	26-Mar-71
FUKUSHIMA-DAIICHI-2	BWR	760	TEPCO	GE/TOSHIBA	9-Jun-69	10-May-73	24-Dec-73	18-Jul-74
FUKUSHIMA-DAIICHI-3	BWR	760	TEPCO	TOSHIBA	28-Dec-70	6-Sep-74	26-Oct-74	27-Mar-76
FUKUSHIMA-DAIICHI-4	BWR	760	TEPCO	HITACHI	12-Feb-73	28-Jan-78	24-Feb-78	12-Oct-78
FUKUSHIMA-DAIICHI-5	BWR	760	TEPCO	TOSHIBA	22-May-72	26-Aug-77	22-Sep-77	18-Apr-78
FUKUSHIMA-DAIICHI-6	BWR	1,067	TEPCO	GE/TOSHIBA	26-Oct-73	9-Mar-79	4-May-79	24-Oct-79
FUKUSHIMA-DAINI-1	BWR	1,067	TEPCO	TOSHIBA	16-Mar-76	17-Jun-81	31-Jul-81	20-Apr-82
FUKUSHIMA-DAINI-2	BWR	1,067	TEPCO	HITACHI	25-May-79	26-Apr-83	23-Jun-83	3-Feb-84
FUKUSHIMA-DAINI-3	BWR	1,067	TEPCO	TOSHIBA	23-Mar-81	18-Oct-84	14-Dec-84	21-Jun-85
FUKUSHIMA-DAINI-4	BWR	1,067	TEPCO	HITACHI	28-May-81	24-Oct-86	17-Dec-86	25-Aug-87
GENKAI-1	PWR	529	KYUSHU	MHI	15-Sep-71	28-Jan-75	14-Feb-75	15-Oct-75
GENKAI-2	PWR	529	KYUSHU	MHI	1-Feb-77	21-May-80	3-Jun-80	30-Mar-81
GENKAI-3	PWR	1,127	KYUSHU	MHI	1-Jun-88	28-May-93	15-Jun-93	18-Mar-94
GENKAI-4	PWR	1,127	KYUSHU	MHI	15-Jul-92	23-Oct-96	12-Nov-96	25-Jul-97
HAMAOKA-3	BWR	1,056	CHUBU	TOSHIBA	18-Apr-83	21-Nov-86	20-Jan-87	28-Aug-87
HAMAOKA-4	BWR	1,092	CHUBU	TOSHIBA	13-Oct-89	2-Dec-92	27-Jan-93	3-Sep-93
HAMAOKA-5	BWR	1,325	CHUBU	TOSHIBA	12-Jul-00	23-Mar-04	26-Apr-04	18-Jan-05
HIGASHI DORI 1 (TOHOKU)	BWR	1,067	TOHOKU	TOSHIBA	7-Nov-00	24-Jan-05	9-Mar-05	8-Dec-05
IKATA-1	PWR	538	SHIKOKU	MHI	15-Jun-73	29-Jan-77	17-Feb-77	30-Sep-77
IKATA-2	PWR	538	SHIKOKU	MHI	21-Feb-78	31-Jul-81	19-Aug-81	19-Mar-82
IKATA-3	PWR	846	SHIKOKU	MHI	1-Nov-86	23-Feb-94	29-Mar-94	15-Dec-94
KASHIWAZAKI KARIWA-1	BWR	1,067	TEPCO	TOSHIBA	5-Jun-80	12-Dec-84	13-Feb-85	18-Sep-85
KASHIWAZAKI KARIWA-2	BWR	1,067	TEPCO	TOSHIBA	18-Nov-85	30-Nov-89	8-Feb-90	28-Sep-90
KASHIWAZAKI KARIWA-3	BWR	1,067	TEPCO	TOSHIBA	7-Mar-89	19-Oct-92	8-Dec-92	11-Aug-93
KASHIWAZAKI KARIWA-4	BWR	1,067	TEPCO	HITACHI	5-Mar-90	1-Nov-93	21-Dec-93	11-Aug-94
KASHIWAZAKI KARIWA-5	BWR	1,067	TEPCO	HITACHI	20-Jun-85	20-Jul-89	12-Sep-89	10-Apr-90
KASHIWAZAKI KARIWA-6	BWR	1,315	TEPCO	TOSHIBA	3-Nov-92	18-Dec-95	29-Jan-96	7-Nov-96
KASHIWAZAKI KARIWA-7	BWR	1,315	TEPCO	HITACHI	1-Jul-93	1-Nov-96	17-Dec-96	2-Jul-97
MIHAMA-1	PWR	320	KANSAI	WH	1-Feb-67	29-Jul-70	8-Aug-70	28-Nov-70
MIHAMA-2	PWR	470	KANSAI	WH	29-May-68	10-Apr-72	21-Apr-72	25-Jul-72
MIHAMA-3	PWR	780	KANSAI	MHI	7-Aug-72	28-Jan-76	19-Feb-76	1-Dec-76
OHI-1	PWR	1,120	KANSAI	WH	26-Oct-72	2-Dec-77	23-Dec-77	27-Mar-79
OHI-2	PWR	1,120	KANSAI	WH	8-Dec-72	14-Sep-78	11-Oct-78	5-Dec-79
OHI-3	PWR	1,127	KANSAI	MHI	3-Oct-87	17-May-91	7-Jun-91	18-Dec-91
OHI-4	PWR	1,127	KANSAI	MHI	13-Jun-88	28-May-92	19-Jun-92	2-Feb-93
ONAGAWA-1	BWR	498	TOHOKU	TOSHIBA	8-Jul-80	18-Oct-83	18-Nov-83	1-Jun-84
ONAGAWA-2	BWR	796	TOHOKU	TOSHIBA	12-Apr-91	2-Nov-94	23-Dec-94	28-Jul-95
ONAGAWA-3	BWR	796	TOHOKU	TOSHIBA	23-Jan-98	26-Apr-01	30-May-01	30-Jan-02
SENDAI-1	PWR	846	KYUSHU	MHI	15-Dec-79	25-Aug-83	16-Sep-83	4-Jul-84
SENDAI-2	PWR	846	KYUSHU	MHI	12-Oct-81	18-Mar-85	5-Apr-85	28-Nov-85
SHIKA-1	BWR	505	HOKURIKU	HITACHI	1-Jul-89	20-Nov-92	12-Jan-93	30-Jul-93
SHIKA-2	BWR	1,304	HOKURIKU	HITACHI	20-Aug-01	26-May-05	4-Jul-05	15-Mar-06
SHIMANE-1	BWR	439	CHUGOKU	HITACHI	2-Jul-70	1-Jun-73	2-Dec-73	29-Mar-74
SHIMANE-2	BWR	789	CHUGOKU	HITACHI	2-Feb-85	25-May-88	11-Jul-88	10-Feb-89
TAKAHAMA-1	PWR	780	KANSAI	WH/MHI	25-Apr-70	14-Mar-74	27-Mar-74	14-Nov-74
TAKAHAMA-2	PWR	780	KANSAI	MHI	9-Mar-71	20-Dec-74	17-Jan-75	14-Nov-75
TAKAHAMA-3	PWR	830	KANSAI	MHI	12-Dec-80	17-Apr-84	9-May-84	17-Jan-85
TAKAHAMA-4	PWR	830	KANSAI	MHI	19-Mar-81	11-Oct-84	1-Nov-84	5-Jun-85
TOKAI-2	BWR	1,060	JAPCO	GE	3-Oct-73	18-Jan-78	13-Mar-78	28-Nov-78
TOMARI-1	PWR	550	HEPCO	MHI	12-Jul-85	16-Nov-88	6-Dec-88	22-Jun-89
TOMARI-2	PWR	550	HEPCO	MHI	8-May-86	25-Jul-90	27-Aug-90	12-Apr-91
TSURUGA-1	BWR	340	JAPCO	GE	24-Nov-66	3-Oct-69	16-Nov-69	14-Mar-70
TSURUGA-2	PWR	1,110	JAPCO	MHI	6-Nov-82	28-May-86	19-Jun-86	17-Feb-87
TOMARI-3	PWR	866	HEPCO	MHI	18-Nov-04	25-Jan-09	20-Mar-09	22-Dec-09

Source: IAEA, UBS estimates

What capacity expansion plans existed prior to Fukushima?

As shown in the following table, the construction of three units is currently underway in Japan: the No.3 unit at Chugoku EPCO's Shimane plant; J-Power's Ohma nuclear power plant; and the No.1 unit at TEPCO's Higashidori plant, while preparation work is proceeding for other three units: the No.1 unit at Chugoku EPCO's Kaminoseki plant; and the No.3 and No.4 units at Japan Atomic Power Company's Tsuruga plant. In addition, there are construction plans in place for eight units, and several electric power suppliers are also considering replacement of their obsolete and smaller units with larger units.

It would seem highly unlikely that the two planned units at Fukushima Daiichi will now be built.

Table 17: Under construction and planned reactor units in Japan

Nuclear power facility	Type	Gross capacity (MWe)	Owner	Construction date	Commercial date
Under construction					
Shimane 3	ABWR	1,373	Chugoku EPCO	Dec-05	Dec-11
Oma	ABWR	1,383	J-POWER	May-08	Nov-14
Higashi Dori (TEPCO) 1	ABWR	1,385	TEPCO	Dec-10	Mar-17
Preparing for construction					
Kaminoseki 1	ABWR	1,373	Chugoku EPCO	Jun-12	Mar-18
Tsuruga 3	APWR	1,538	Japan Atomic Power	Oct-10	Jul-17
Tsuruga 4	APWR	1,538	Japan Atomic Power	Oct-10	Jul-18
Planned construction					
Namie Odaka	BWR	825	Tohoku EPCO	FY16	FY21
Higashi Dori (Tohoku) 2	ABWR	1,385	Tohoku EPCO	FY16 or later	FY21 or later
Higashi Dori (TEPCO) 2	ABWR	1,385	TEPCO	FY14 or later	FY20 or later
Fukushima Daiichi 7	ABWR	1,380	TEPCO	FY12 or later	FY16 or later
Fukushima Daiichi 8	ABWR	1,380	TEPCO	FY12 or later	FY17 or later
Hamaoka 6	ABWR	1,400	Chubu EPCO	FY16	FY20 or later
Sendai 3	APWR	1,590	Kyushu EPCO	FY13	FY19
Kaminoseki 2	ABWR	1,373	Chugoku EPCO	FY17	FY22

Source: FEPC, Company data, UBS estimates

What statements have come from regulators or government officials on how plans might change

Japan's revised basic energy plan of June 2010 states that nuclear power generation is an indispensable key form of energy for achieving a stable supply of energy and a society with a small carbon footprint. Specifically, the blueprint calls for establishing nine new nuclear plants by 2020 and raising the facility utilisation rate to 85% (with 54 operational units, the ratio came to 64% in FY09 and 84% in FY98). The goal for 2030 under the plan is for at least 14 new nuclear plants and a facility utilisation ratio of about 90%.

On 30 March, Trade Minister Kaieda acknowledged that nuclear power is an important part of the generation mix, but that Japan needed to start reconsidering energy policy as a whole in light of what happened at Fukushima. The government announced that it would come up with comprehensive new safety rules after analysing the Fukushima events. At the same time, the ministry announced an upgrade of safety standards for existing power plants with extra measures to be taken by the end of April, but that no plants needed to close to carry out these immediate steps.

A revision of Japan's energy plan and a review of safety standards have already been ordered

What changes, if any, do we expect to actually happen?

In the light of the natural disaster of the earthquake and tsunami, the power companies are moving to strengthen disaster prevention measures at nuclear power plants, including emergency power generation facilities, additional salt water supply pumps, and moving to tackle tsunami risk by establishing protective barriers and building dams.

Confidence in the safety of nuclear power has been substantially damaged by the incident at Fukushima Daiichi. As such, we believe the building of new nuclear power facilities and remodelling of existing facilities may be difficult for some time.

A loss of public confidence will make new plant construction difficult for some time

It is almost certain that the heavily damaged Units 1-4 of Fukushima Daiichi will not operate and we doubt it would be feasibly politically to operate Units 5 and 6 either. Government authorities have indicated that the facility is to be scrapped, and reactor decommissioning is likely. We also do not expect the proposed Units 7 and 8 to be built.

The quake led to the halting of operations at three other nuclear power plants. There was some damage to structures and facilities as well as flooding at TEPCO's Fukushima-2 unit, Tohoku Electric Power's Onagawa plant, and Japan Atomic Power's Tokai-2 unit. All were up and running at the time, but they automatically shut down immediately, and cooling stopped. Accordingly, once checks, maintenance, and remodelling have taken place, these units are likely to come back on line after having obtained approval from the central government and local authorities.

There were six nuclear power units being built or in the process of preliminary work when the quake occurred and work has been stopped at each one. The projects are likely to recommence after additional safety measures have been put in place, but the timing for operational start ups could be delayed relative to the schedule. We believe that plans for fresh construction could also be impacted, including through delays or cancellations.

Furthermore, we think there could be some impact on the revision of regulations/systems aimed at enhancing facility utilisation ratios. In light of the above, the likelihood has increased that Japan may have to revise nuclear power policies and overall energy policies.

In order to offset power supply shortages, concerned parties are likely to look into curbing power demand by enhancing energy efficiency, constructing new LNG thermal power generation facilities, and looking to shift to very efficient coal-fired and oil-fired thermal powered facilities.

LNG is likely to be the fuel of choice to substitute for loss of nuclear generation

South Korea

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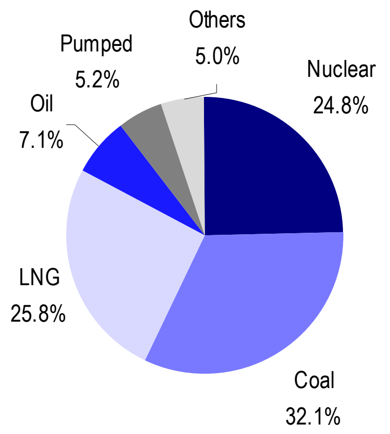
What nuclear capacity does South Korea have and how significant is this in its energy mix?

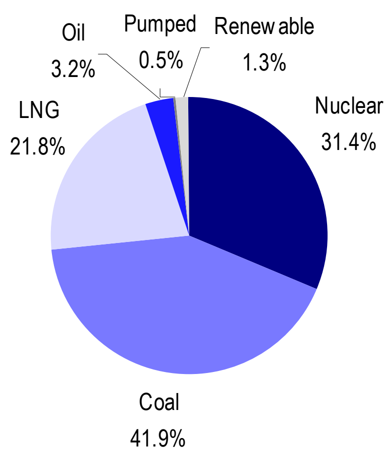
21 nuclear plants in operation: In Korea, 21 nuclear power plants are presently in commercial operation, with a total power generation capacity of 18,716MW. Nuclear is one of the key sources of power in Korea. Nuclear accounts for 24.8% of total power generation capacity in Korea, the third highest after coal (32.1%) and LNG (25.8%). In terms of generation mix, nuclear accounts for 31.4% of total power generation mix, second highest after coal (41.9%).

Chart 20: Power capacity mix in Korea (2010)



Source: Ministry of Knowledge and Economy (MKE)

Chart 21: Power generation mix in Korea (2010)



Source: MKE

What capacity expansion plans existed prior to Fukushima?

Reliance on nuclear power to increase: Given Korea's high reliance on fossil fuel and considering the economic value and environmental impact, the government's current plan is to further increase the number of nuclear power plants in Korea. According to the '5th Basic Plan of Long-Term Electricity Supply and Demand', Korea plans to launch 13 additional nuclear reactors by 2024, which implies an additional nuclear generation capacity of 17.2GW.

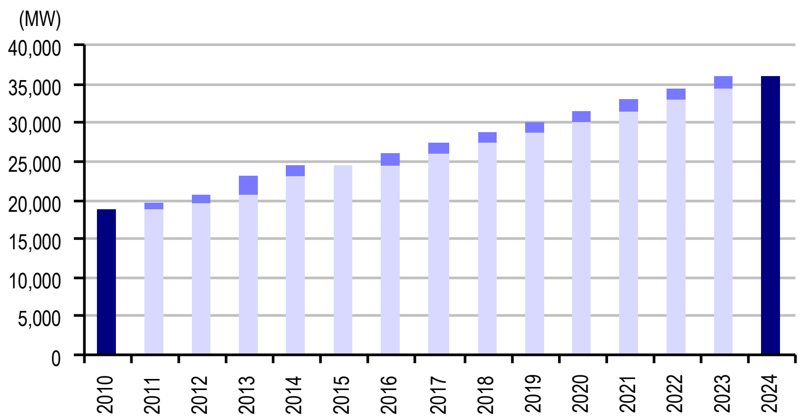
About 1,000-1,400MW of new nuclear capacity is scheduled be added almost every year, which would effectively raise nuclear generation from 24.8% of total power generation capacity in 2010 to 25.5% by 2015, and to 31.9% by 2024. Moreover, nuclear generation in the mix is expected to rise from 31.4% in 2010 to 37.2% in 2015 and 48.5% by 2024, according to MKE.

Table 18: Power generation capacity expansion plan (2010-2024)

		Nuclear	Coal	LNG	Oil	Pumped	Others	Total
Capacity (MW)	2010	18,716 (24.8)	24,205 (32.1)	19,422 (25.8)	5,372 (7.1)	3,900 (5.2)	3,801 (5.0)	75,416 (100)
	2015	24,516 (25.5)	30,945 (32.1)	23,517 (24.4)	4,108 (4.3)	4,700 (4.9)	8,497 (8.9)	96,283 (100)
	2024	35,916 (31.9)	31,445 (27.9)	23,517 (20.9)	4,108 (3.7)	4,700 (4.2)	12,907 (11.5)	112,593 (100)
Generation mix (%)	2010	31.4	41.9	21.8	3.2	0.5	1.3	100
	2015	37.2	40.8	16.6	1.3	0.5	3.7	100
	2024	48.5	31	9.7	0.5	1.3	8.9	100

Source: MKE

Chart 22: Nuclear capacity to increase gradually until 2024



Source: MKE

What statements have come from regulators or government officials on how plans might change

Safety reviews already announced to be done in coming weeks

Comprehensive safety inspection under way: The nuclear reactors that are currently operating in Korea have been designed to withstand a magnitude 6.5 earthquake. However, in response to the nuclear crisis in Japan, the Nuclear Safety Commission under the Ministry of Education, Science and Technology (MEST), which is in charge of enforcing safety standards on nuclear power plants, announced it will conduct a comprehensive safety inspection of all nuclear plants in Korea by the end of April. This will include their ability to withstand natural disasters, such as earthquakes and tsunamis. The examination team will put more focus on the safety of nine plants that have been in operation for more than 20 years, assuming Korea faces a worst-case scenario. For any plants considered to have serious flaws, the nuclear safety commission may suspend operations to facilitate more thorough and extensive examination.

While the government stressed that the nuclear model in Korea is relatively safe, it also raised the need for 1) an automatic halt system in the event of large earthquake; 2) enhanced protective measures against earthquakes that exceed design standards; and 3) earthquake countermeasure systems.

Heighten safety guidelines for future nuclear plants: The government is planning to heighten safety guidelines for future nuclear reactors, by requiring them to be designed to withstand a magnitude 7.0 earthquake. Moreover, when searching for sites for new nuclear plants, the government will consider all past recorded earthquakes and fault lines.

Capacity expansion plan to proceed as planned: The government emphasised, however, that it has no intention to change its nuclear capacity expansion plan. The Minister of Knowledge and Economy stated that there is no alternative to nuclear energy for Korea at present, given that it is a heavy energy consuming country and there is growing need for low cost power sources.

What changes, if any, do we expect to actually happen?

No major changes to plans—no viable alternatives to nuclear for Korea

We do not expect changes in the nuclear plan in the near term: We do not believe the government will change its nuclear power policy in response to the Japanese earthquake. Nuclear power currently supplies 31.4% of the total electricity in Korea and we do not believe there are viable alternatives in the near term. However, given public sentiment on nuclear power, it is likely that future nuclear power developments will go through much more stringent safety inspection process. We believe the nuclear issue could be one of the key policy factors in the next presidential election in 2012.

Setback in Korea's nuclear export strategy: What may concern the Korean government the most, in fact, is a potential setback in overseas nuclear projects. Korea has won a landmark order to build four nuclear power plants in the United Arab Emirates, boosting its footprint in the global nuclear business. The Korean government has since set nuclear equipment and construction as one of its new export drivers, with the eventual goal of becoming the third-largest nuclear plant exporting country in the world by 2030, by delivering 80 nuclear power plants globally. However, we believe there are likely to be delays or cancellations of nuclear projects globally, and this could hurt the Korean government's ambitious goal to foster its nuclear business overseas.

UAE project remains intact: One of the concerns in the market is whether the nuclear power plant project in the UAE will proceed as planned. The UAE government has announced that the Federal Authority of Nuclear Regulation (FANR) will carry out a thorough review of the licence application for nuclear power plants putting key emphasis on seismic safety. KEPCO believes there will be no delay in the construction of the nuclear projects and it has already incorporated the time needed to review safety standards in its construction plan. We also believe the possibility of the cancellation of the project is very low. But there is a chance the completion schedule may be slightly delayed given the imposition of much stricter and enhanced safety standards.

Taiwan

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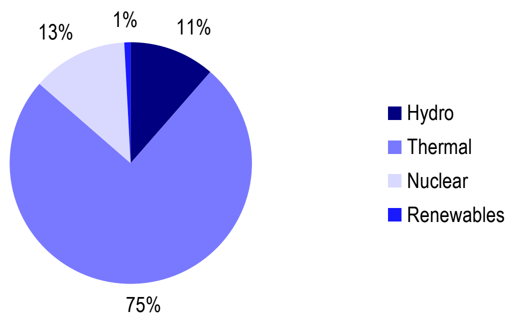
What nuclear capacity does Taiwan have and how significant is this in its energy mix?

Taiwan has three power plants in service with a combined capacity of 5,144MW. The first two nuclear power plants (Chinshan and Kuosheng) are located at the northern tip of the island, and each has two General Electric boiling water reactors (BWR). They are licenced for use by Taiwan Power Company (Taipower) only until 2017 and 2018, and 2021 and 2023, respectively. The third nuclear plant (Maanshan), located at the southern tip of the island, has two Westinghouse pressurised water reactors, which are currently licenced for operation until 2024 and 2025. Taipower, which runs these nuclear facilities, has applied to the Atomic Energy Council for a 20-year extension to these licences.

A fourth nuclear power plant is being built in Yenliao township in New Taipei City on the coast of northeast Taiwan, which will have two advanced boiling water reactors (ABWR). These reactors are scheduled to begin commercial operations in December 2012 and December 2013, respectively.

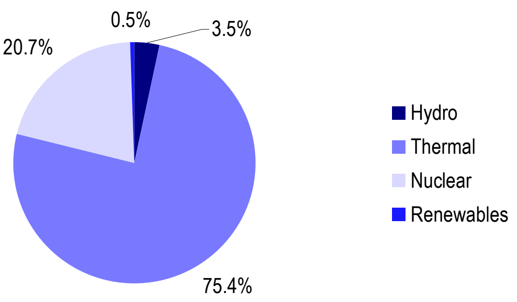
For the past two decades, nuclear power has been an important part of Taiwan's electricity supply, and currently accounts for 11% of installed capacity, and 17% of the total electricity supply. Chart 24 breaks down electricity generation according to different fuel types.

Chart 23: Installed capacity breakup by fuel type



Source: Taiwan Power Company

Chart 24: Electricity generation by fuel type



Source: Taiwan Power Company

Seismic threat

Taiwan is even more seismically active than Japan

Taiwan is located in one of the most seismically active zones on the planet, and its nuclear power plants are built in geologically active locations close to the coastline. Thus, the greatest risk for nuclear power plants in Taiwan is from earthquakes and tsunamis. From a plant design perspective, it is critical that the structures and various components of the safety systems are designed to withstand heavier probable earthquake impact than similar structures in other parts of the world.

The structural design of a nuclear power plant is for a SSE (Safe Shutdown Earthquake). This represents the maximum vibratory ground motion at a plant site that can be reasonably predicted from seismic and geological evidence. Structural design intended for these limits can assure that in case such an earthquake does occur, then:

- The integrity of the reactor coolant pressure boundary is not compromised;
- The capability to shut down the reactor and maintain it in a safe condition is not compromised;
- The capability to prevent or mitigate the consequences of accidents, which could result in potential offsite exposures comparable to the limiting exposures of the Enforcement Rules for the Implementation of Nuclear Reactor Facilities Regulation Act, is not compromised[1].

Taiwan's plants are designed to withstand significant seismic forces

According to Taipower, the Chin Shan and Maanshan nuclear power plants are designed to withstand peak ground accelerations (PGA) of up to 0.51G, the Kuosheng plant forces of up to 0.53G, and the Lungmen plants of up to 0.66G. The PGA is a measure of how hard the earth shakes at a given point during an earthquake.

As a frame of reference, the earthquake that struck central Taiwan in 1999 had a PGA of 1.01G. However, it is worth noting that the nuclear plant in Fukushima was constructed to withstand a PGA in the 0.6-0.7 range as well, and did not lose its structural integrity even when impacted by an earthquake that measured 9.0 on the Richter scale, and recorded a maximum single direction PGA of 2.7G.

What capacity expansion plans existed prior to Fukushima?

Taiwan is building a fourth nuclear power plant, which is about 90% complete. Fuel supplies are scheduled to commence by the end of 2011, with operations due to start in late 2012. The Lungmen plant in north-east Taiwan will have two GE ABWRs of 1,350MWe each.

Taiwan's nuclear power plants faced significant popular opposition even before the Fukushima incident

There were discussions in 2009 about the possible construction of two additional reactors after Lungmen with these new reactors to be online by 2020. However, there has been considerable political and civilian opposition to the expansion of nuclear power. More recently, the only projected addition being discussed after Lungmen is a single unit to be potentially on-line by 2025. Thus, even before Fukushima, expansion plans for nuclear power have been generally experiencing downward revisions.

[1] Atomic Energy Council, Taiwan, Republic of China

What statements have come from regulators or government officials on how plans might change?

A review of energy policy is now been announced, which will reconsider the future for nuclear power in Taiwan

The government's reaction, during the initial days of the crisis at Fukushima, was generally supportive of nuclear power. However, following pressure from the main opposition party, the government later said Taiwan would study and review its energy strategy; and a possible outcome of this review may include the decommissioning Taiwan's three nuclear plants, and ending construction of the fourth nuclear plant. The opposition Democratic Progressive Party (DPP) chairperson, and the former Vice Premier, Tsai Ing-wen, has called for the complete phasing out of nuclear power in Taiwan by 2025.

The opposition's anti-nuclear stance could have an important impact on Taiwan's future nuclear strategy, in our view. Tsai is likely to be DPP's candidate in the presidential elections early next year, and has significant public support for his opposition to the expansion of nuclear power in Taiwan. Another DPP candidate and former party Chairman, Hsu Hsin-liang, has asked for a referendum on the fourth nuclear power plant.

What changes, if any, do we expect to actually happen?

We expect nuclear power in Taiwan to be subject to considerable scrutiny, following the events in Fukushima. The case for an overall review of nuclear power facilities located in Taiwan is stronger than for other places because Taiwan is seismically very active. The plants in Taiwan have been designed to withstand an earthquake measuring 6 to 7 on the Richter scale; but the events in Japan have shown that probabilistic analysis of earthquakes and tsunamis of even larger magnitudes may need to be done, and structural and technological upgrades required. In our view, the comprehensive safety reviews that will now follow will most likely lead to the following outcomes:

Delay in the fourth nuclear power plant becoming operational

Fourth nuclear power plant's commissioning will likely be delayed

Although the current administration has been supportive of the construction of the fourth nuclear power plant in Yenliao, there has been considerable opposition from other political parties and residents. At the very least, even if it is just to placate public opinion, we believe there will be a comprehensive review of the fourth plant. This should mean a delay in this plant becoming operational, even though technologically, the fourth plant already incorporates some of the latest safety designs available.

The two new units at this plant are GE advanced boiling water reactors (ABWR). These incorporate Generation III rector designs, with passive safety features. The design includes electro-hydraulic systems which allow for finer control over fuel rod positioning, and this allows for defence-in-depth should primary hydraulics fail. The units have also undergone further seismic hardening, such that during an earthquake, they can tolerate higher ground accelerations compared to a typical GE ABWR.

Review of licence extensions for all or some existing nuclear plants

Operating license extension may be more difficult for existing plants

The Chinshan nuclear power plant, which is Taiwan's oldest, expires in 2017. However, Taipower, the utility that owns and operates the nuclear power plants, has applied for a 20 year extension for all six reactors in the three operating plants. The following table shows the start date and the expected licence-expiry date. For the Chinshan plants, the new licence expiry dates would be in 2037 and 2038 for its two units.

The Atomic Energy Council undertook safety evaluations of the Chinshan plant in 2007, and had said that the plant is safe for further extension. However, we believe that after the events in Japan, extension of the licence will be reconsidered. Technological upgrades can be done, but as anti-nuclear public opinion builds up, the oldest reactors may not get extensions due to political reasons.

Table 19: Operational reactors and licence expiry dates

Units	Type	Installed MWe gross	Start date	Licence expiry
Chinshan 1	BWR	636	1978	2017
Chinshan 2	BWR	636	1979	2018
Kuosheng 1	BWR	985	1981	2021
Kuosheng 2	BWR	985	1983	2023
Maanshan 1	PWR	951	1984	2024
Maanshan 2	PWR	951	1985	2025

Source: World Nuclear Association

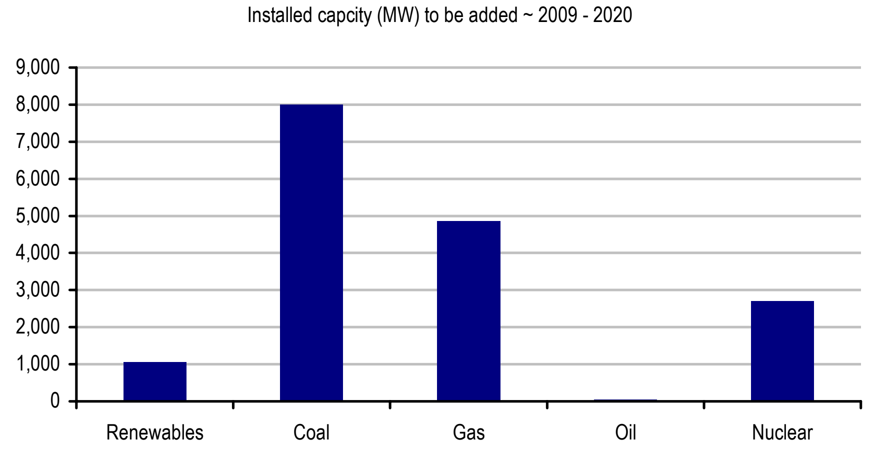
More investment in thermal units, mostly running on imported LNG

If nuclear plans are scaled back or existing plants are closed, reserve margins would become extremely tight, and more gas-fired power plants would be needed

Electricity demand in Taiwan has historically grown at 5% pa, and Taipower expects demand to grow at 3.3% pa by 2013. Given that nuclear accounts for 20.7% of electricity generated, nuclear power is currently a significant part of the fuel mix. Taipower's operating reserve for the year was 22%, according to the head of the company. If the nuclear plants stopped operation, Taipower believes this number would decline to 7%, and then to 3% in 2012 and -2.2% in 2013. To bring the reserve capacity to acceptable levels of around 15%, Taiwan would need to invest more into thermal power plants. Should this happen, we expect most of the new units to be gas fired, running on imported LNG.

The following chart gives Taipower's estimate of power development in Taiwan until 2020. These estimates were presented before the Japan earthquake, and the nuclear additions are those attributable to the fourth nuclear power plant.

Chart 25: Long-term power development in Taiwan (estimates made pre Japan crisis)



Source: Taiwan Power Company

Complete phase out of nuclear power unlikely

Energy security and climate change objectives will make nuclear plant closure difficult in reality

The government has already said it will consider all possible options while reviewing the nuclear power plants in Taiwan, including the closure of all facilities. However, we believe this could be just political rhetoric, as the government tries to ease public concern. There are two considerations that Taiwan will need to keep in mind, when it considers a total shutdown of its nuclear power plants:

- **Energy security:** Taiwan is not a resource-rich nation, and depends on imports for virtually all of its energy needs. Any external disruption which prevents incoming LNG and coal could be a cause of significant strategic concern to Taiwan. Taiwan's establishment has encouraged nuclear power and other renewable energy in the past, to lessen its dependence on imports. Energy security will continue to be an important variable when the future of nuclear power in Taiwan is discussed.

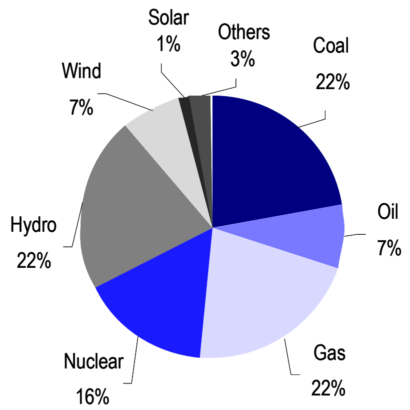
- **Climate change objectives:** President Ma Ying-jeou has said Taiwan should aim to reduce greenhouse gas emissions to 2000 levels by 2025, and then to half that level by 2050. However, we expect that should nuclear be taken off line, most of the gap—at least in the medium term—will be filled by thermal power, rather than wind or solar. Therefore, removing nuclear from the fuel mix would have a negative impact on emissions.

Europe

Nuclear energy's importance in Europe's electricity mix

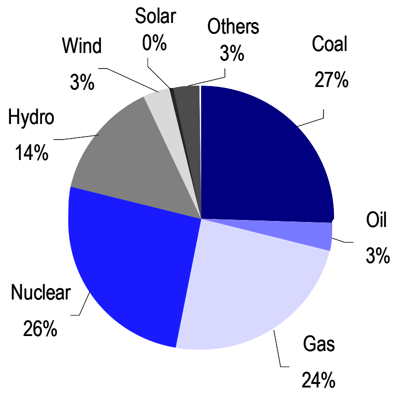
Nuclear generation currently generates 26% of Europe's electricity and makes up 16% of total installed capacity. In total, nuclear generated 936TWh in 2008 and there was 137GW of installed capacity.

Chart 26: Installed capacity in Europe, 2008 (100% = 881GW)



Source: Eurostat

Chart 27: Generation output in Europe, 2008 (100% = 3,600TWh)



Source: Eurostat

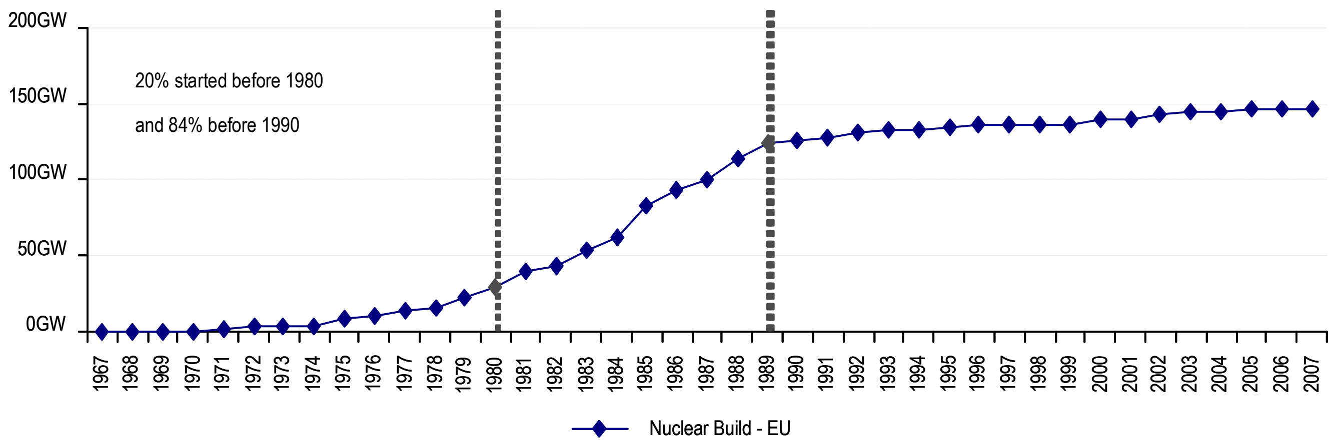
France has by far the largest nuclear fleet in Europe, with 58 reactors and 62GW of installed capacity. Other countries with large fleets include Russia, Germany, Sweden, Ukraine and the UK. France is the country most reliant on nuclear power, followed by Sweden, Ukraine and Belgium.

Most plants built 1980-90

Two-thirds of the fleet started operations in the 1980s

The chart below shows the current operating capacity as a function of year of commissioning. Decisions on building most nuclear plants were taken during the oil crises in the 1970s and the plants were commissioned between 1980 and 1990. Only 20% of the current fleet has a commissioning year before 1980 and only 16% after 1990, thus almost two-thirds of the fleet started commercial operations during the 1980s.

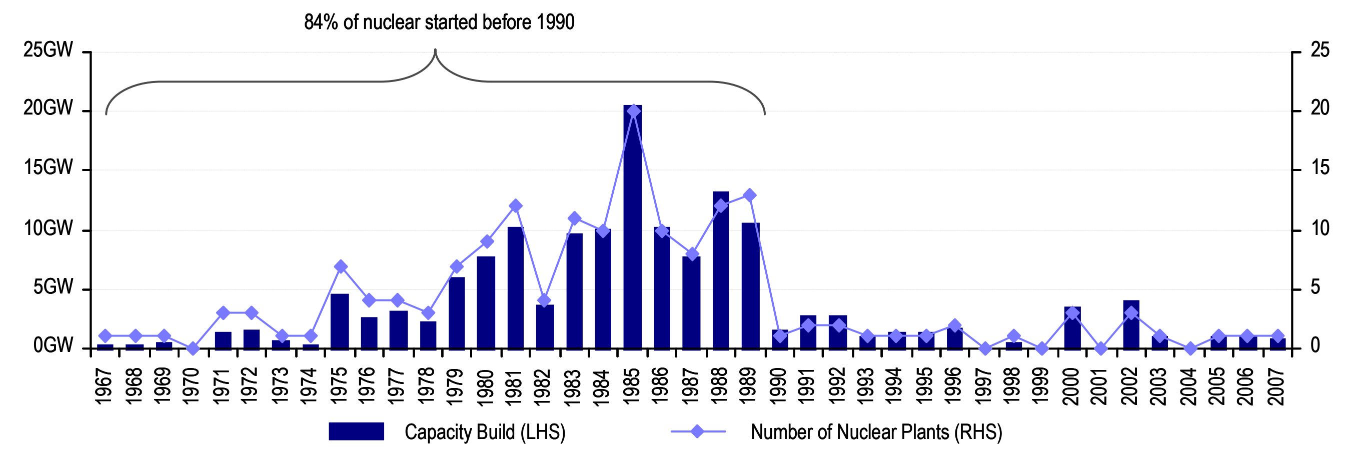
Chart 28: Cumulative installed nuclear capacity as a function of commissioning year



Source: IAEA

The chart below shows the capacity still on line and the commissioning year. The ramp up started in 1979 and only limited new capacity has been built after 1989. Most of the later reactors are French.

Chart 29: Commissioning years for Europe's nuclear fleet



Source: IAEA

The following table show the 16 reactors in Europe which started commercial operations in or before 1975. The two oldest UK reactors are set to close this year. Other countries with several older reactors include Switzerland, Sweden, Belgium and the UK. Potentially, these countries could thus have a larger potential for closures. It is noteworthy that the list includes only one German reactor and none from France.

Table 20: European reactors commissioned in or before 1975 and still in operation

Country	Name	Net (GW)	Commercial operation
United Kingdom	Oldbury-1	0.217	1967
United Kingdom	Oldbury-2	0.217	1968
Switzerland	BEZNAU-1	0.365	1969
Spain	SANTA MARIA DE GARONA	0.446	1971
Switzerland	BEZNAU-2	0.365	1971
United Kingdom	Wylfa-1	0.49	1971
Sweden	OSKARSHAMN-1	0.473	1972
Switzerland	MUEHLEBERG	0.373	1972
United Kingdom	Wylfa-2	0.49	1972
Netherlands	BORSSELE	0.487	1973
Belgium	DOEL-1	0.392	1975
Belgium	DOEL-2	0.433	1975
Belgium	TIHANGE-1	0.962	1975
Germany	BIBLIS-A	1.167	1975
Sweden	OSKARSHAMN-2	0.624	1975
Sweden	RINGHALS-2	0.813	1975

Source: IAEA

Capacity expansion plans prior to Fukushima

The capacity expansion plans are elaborated on in the respective country sections. The countries with the largest and most immediate nuclear expansion plans are the UK, Italy and Switzerland, where there have been plans to decide on several nuclear reactors in the near term.

EU statements following the Fukushima accident

Europe has reacted rapidly to the events in Fukushima on a domestic and EU-wide level. The table below summarises the responses. We have indicated where there has been commitment to launch a safety review; where key political decision makers have explicitly said this could lead to closures; and where expansion plans have temporarily been put on hold. We have also added a column with our assessment of how many existing and new reactors could potentially be at risk. We see up to 16 existing nuclear plants and nine new plant projects as being at risk. This assumes that the UK policy remains unchanged, which could prove optimistic.

We see up to 16 existing nuclear plants and nine new plant projects as being at risk of closure

Table 21: Potential impact of European nuclear policy changes

Country	No. of reactors	Safety checks on existing	Potential closures	Moratorium on new	Existing reactors at risk	New reactors at risk
EU+CH		x			17	5
France	58	x	x		2	1
Russia	31	x				
Germany	17	x	x	NR	7	0
UK	19	x		x		
Ukraine	15	x				
Sweden	10	x		NR	0	
Belgium	7	x	x	NR	3	
Spain	8	x		NR	2	
Czech Republic	6	x			0	
Switzerland	5	x	x	x	3	4
Finland	4	x		x	0	
Italy	NR			x		4

Source: UBS estimates

We will discuss the domestic comments in the European country sections; here we focus on the EU response. The EU decided last week that all 14 EU countries with nuclear reactors should conduct stress tests of their nuclear fleets before the end of the year.

The European Nuclear Safety Regulatory Group (ENSREG) will develop the scope and modalities of these tests. However, it is still unclear how coordinated the tests will be. At the time of writing, it appears that the tests will be designed and performed by the national safety authorities. In particular, there seem to be differences in opinion between Germany and France concerning the tests, which could have a political background.

All 14 EU countries with nuclear reactors should conduct stress tests of their fleets before end-2011

Germany was one of the first countries to propose that there should be an EU-led safety review. It is not difficult to imagine that this was at least partly caused by domestic political considerations. Considering that the German fleet is one of the youngest in Europe, and given the German utility tradition of 'gold plating', common tests are likely to show that the German reactors are among the safest in Europe. The German scepticism of nuclear power also means they want the tests to include very extreme scenarios, such as terrorist attacks from the air.

France, on the other hand, has Europe's largest nuclear fleet by a significant margin, and it is also highly standardised. In our view, France is therefore reluctant to leave the decisions to other countries as the potential impact would be much larger in France due to the size of the nuclear sector and the level of standardisation. For instance, if the tests were to indicate a need for improvement in generation 1 reactors, 34 French reactors could potentially be affected.

Potential effects of the stress tests

We think the course of action governments take will be decided at the national, rather than the EU, level

We think that to preserve public acceptance of nuclear power governments will be required to take some action. We think these are most likely to be decided on a national level rather than the EU level. In our view, age, any seismic activity in the area, and proximity to borders are issues that will be factors in what are in the end political decisions to close any plants. This could, for instance, be important in decisions regarding the French Fessenheim reactors. We think Austria's longstanding opposition to the Czech Temelin nuclear reactors, which are close to the Austrian border, could also be raised again, through probably to limited effect.

Austria

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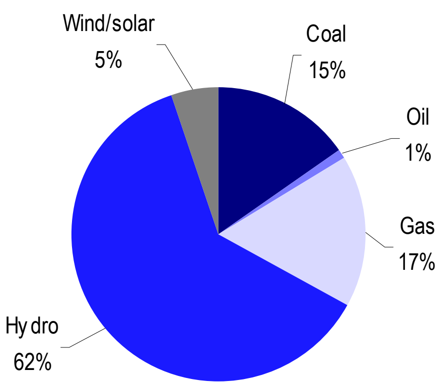
What nuclear capacity does Austria have and how significant is this in its energy mix?

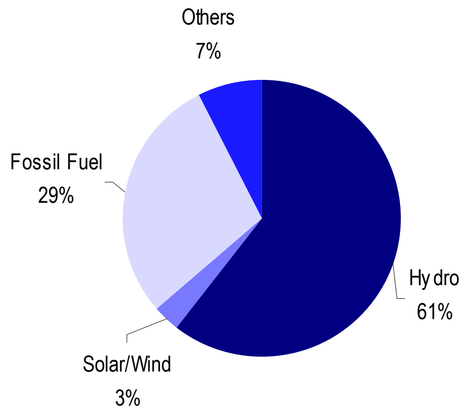
Austria generates around two-thirds of its total electricity from hydro assets. The generation mix reflects the presence of the Alps, which makes hydro highly economical. Austria has a long standing no-nuclear policy.

Chart 30: Installed capacity in Austria, 2009 (100% = 20.2GW)



Source: IEA, UBS estimates

Chart 31: Generation output in Austria, 2009 (100% = 67.1TWh)



Source: IEA, UBS estimates

What capacity expansion plans existed prior to Fukushima?

Austria prohibited nuclear power generation following a 1978 national referendum

In 1978, there was a national referendum on nuclear power. Only 49% of voters were in favour with the rest against it. Immediately after the referendum the Austrian parliament unanimously passed a law prohibiting nuclear production. The decision was underscored by the Three Mile Island accident the following year. The Chernobyl incident, which occurred seven years later, caused contamination in some parts of Austria.

What statements have come from regulators/ government officials on how plans might change?

Post the Japan nuclear incident, Austria has stepped up its anti-nuclear stance and has been one of the key supporters of the nuclear stress tests in the EU. Although Austria is not directly exposed to nuclear power within its territory, the country has raised concerns due to its indirect exposure via its neighbours—the Czech Republic and Slovakia (the Temelin and Mochovce nuclear plants, respectively). It is also important to note that nuclear plant closures elsewhere would be beneficial to Austria’s hydro assets. The Austrian state is the largest shareholder in Verbund, the country’s biggest power generator.

What changes, if any, do we expect to actually happen?

We think it is very unlikely that Austria will alter its stand against nuclear power.

Belgium

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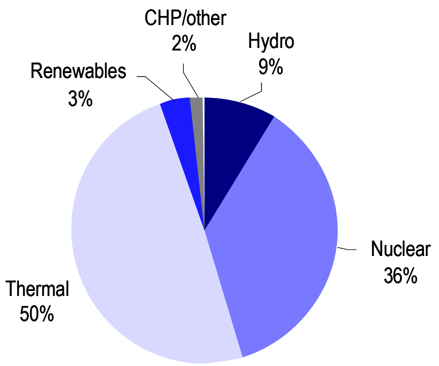
What nuclear capacity does Belgium have and how significant is this in its energy mix?

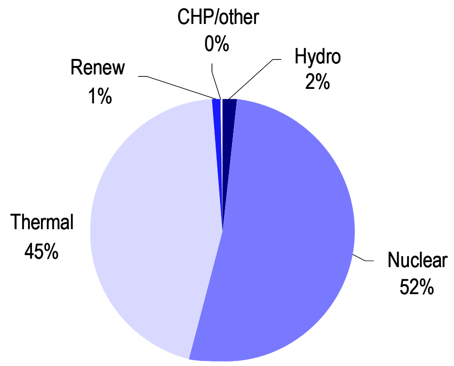
Nuclear is the largest source of power generation in Belgium, with over 50% of output (see chart below) and over one-third of installed capacity. Most thermal capacity is gas.

Chart 32: Installed capacity in Belgium, 2010 (100% = 16GW)



Source: Eurostat, UBS

Chart 33: Generation output in Belgium, 2010 (100% = 86.4 TWh)



Source: Eurostat, UBS

The table below shows the nuclear fleet in Belgium. There are seven operational nuclear plants from two generations. Doel 1 and 2 and Tihange 1 were decided around 1970 and belong to the first generation of PWRs in Europe. The remaining four plants are of a more modern design, and are very similar to EDFS generation one plants.

Table 22: Nuclear fleet in Belgium

Station	Type	Net capacity (MWe)	Operator	Status	Reactor supplier	Construction date	Commercial date
DOEL-1	PWR	392	ELECTRAB	Operational	ACECOWEN	01-Jul-69	15-Feb-75
DOEL-2	PWR	433	ELECTRAB	Operational	ACECOWEN	01-Sep-71	01-Dec-75
DOEL-3	PWR	1,006	ELECTRAB	Operational	FRAMACEC	01-Jan-75	01-Oct-82
DOEL-4	PWR	1,008	ELECTRAB	Operational	ACECOWEN	01-Dec-78	01-Jul-85
TIHANGE-1	PWR	962	ELECTRAB	Operational	ACLF	01-Jun-70	01-Oct-75
TIHANGE-2	PWR	1,008	ELECTRAB	Operational	FRAMACEC	01-Apr-76	01-Jun-83
TIHANGE-3	PWR	1,015	ELECTRAB	Operational	ACECOWEN	01-Nov-78	01-Sep-85

Source: IAEA

What capacity expansion plans existed prior to Fukushima?

There have been discussions in Belgium about extending the life of existing plants beyond the 40 years required by current law

Belgium was an early mover in the development of European nuclear power. However, with an increasingly strong green movement, policies turned gradually more negative during the 1990s. In 2003, Parliament enacted a law limiting the lifetime of the existing nuclear fleet to 40 years, which will lead to a gradual phase out over 2014-25. In 2009, an expert panel recommended a 10-year life extension for the three oldest reactors and a 20-year life extension for the four newer reactors. On the basis of this report, and an agreement with the industry (notably GDF-Suez) to pay an additional tax, the government proposed a 10-year life extension for the oldest plants in parliament. However, the government resigned before parliament voted on the proposal, which has still not been voted on due to problems in forming a new government. The phase out law therefore remains in place.

There have been studies concerning the potential for further capacity upgrades of the newer stations, but no discussion of building new nuclear plants in Belgium.

What statements have come from regulators or government officials on how plans might change?

Belgium's nuclear debate has focused on profitability and taxes; the nuclear tax could be increased further

The recent debate on nuclear power in Belgium has been focused on profitability and the tax situation for the industry. In particular, following Germany's new nuclear tax there have been talks about further increasing Belgian nuclear taxes. The agreement for a life extension would lead to a nuclear tax for the industry of €245m per annum (90% paid by GDF-Suez), and the Belgian Commission for Electricity and Gas Regulation (CREG) has estimated a German-level tax at €675m pa. A decision on a new tax is likely in the next few months, in our view.

Belgium's 'caretaker' government has not directly commented on what the events in Japan could mean for the potential life extension. However, the government has criticised Germany's unilateral decision to temporarily close its seven oldest reactors. The government argues that decisions to close nuclear plants for safety reasons should be taken on a European level.

The green movement has reiterated its resistance to nuclear power and wants the country to stick to the previous phase out plan.

What changes, if any, do we expect to actually happen?

Immediate life extension of the oldest plants is unlikely; they are among Europe's oldest and thus candidates for closure

We believe that an immediate life extension of the three oldest plants looks rather unlikely in the current situation. We think the Belgian government will most likely wait for the European stress tests and then take a decision. These plants are among the oldest in Europe and therefore they could potentially be at risk of closure.

Czech Republic

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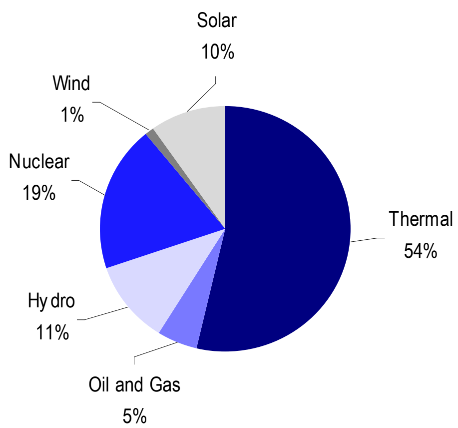
What nuclear capacity does the Czech Republic have and how significant is this in its energy mix?

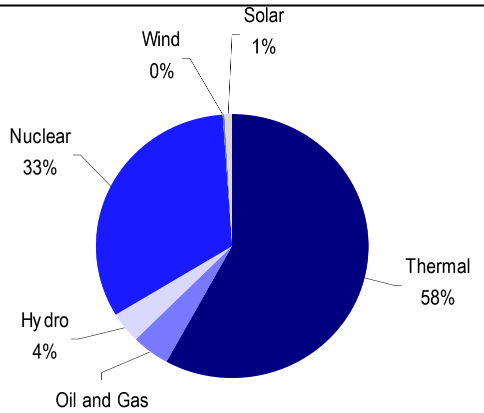
The Czech Republic has a total of six nuclear reactors with an installed capacity of 3.7GW, generating one-third of the country's electricity. Both nuclear plants (Dukovany and Temelin) are owned by CEZ. Dukovany (1.8GW) and Temelin (1.9GW) started operations in 1979 and 1987, respectively.

Chart 34: Installed capacity in Czech Republic, 2010 (100% = 20GW)



Source: CEZ, ERU, UBS estimates

Chart 35: Generation output in Czech Republic, 2010 (100% = 86TWh)

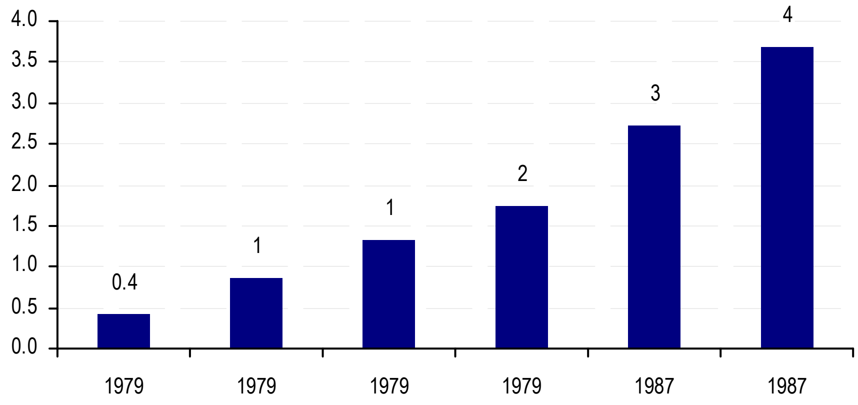


Source: CEZ, ERU, UBS estimates

What capacity expansion plans existed prior to Fukushima?

In 2008, CEZ announced its intention to build two or more nuclear reactors in the Czech Republic. The two nuclear reactors, with a total capacity of 2-3GW, are scheduled to come online at the Temelin site by 2023-24. CEZ has already shortlisted vendors for the construction of the reactors. The bidding process is likely to happen around 2012, with construction work scheduled to begin after 2013. In addition to building new nuclear plants, CEZ is also revamping its existing Dukovany fleet (1.8GW) to increase capacity by approximately 10%. Once approved and licensed, CEZ will be able to run the Dukovany fleet beyond 2015, possibly until 2035-45.

Chart 36: Nuclear plant build-up in Czech Republic (GW)



Source: IAEA, UBS estimates

What statements have come from regulators/ government officials on how plans might change?

The Czech government supports nuclear power, and we think changes to Czech nuclear policy are unlikely

The government fully supports nuclear power in the Czech Republic. According to an interview with the Prime Minister, the government sees no reason to alter its nuclear strategy following the Japan accident. We therefore think changes to the existing nuclear policy in the Czech Republic are unlikely.

What changes, if any, do we expect to actually happen?

We do not see any imminent political risk for nuclear plants located in the Czech Republic, due to the ongoing political support for the sector and the government's approximately 70% stake in CEZ. Replacement requirements would also be significant, as more than one-third of the country's power generation is from nuclear plants. CEZ has already expressed its intention of continuing with the expansion of the Temelin project. However, we would not rule out higher capex requirements for plant safety and lower load factors due to a stricter handling of incidents. This could jeopardise CEZ's efforts to increase electricity output from its existing nuclear stations, in our view.

Finland

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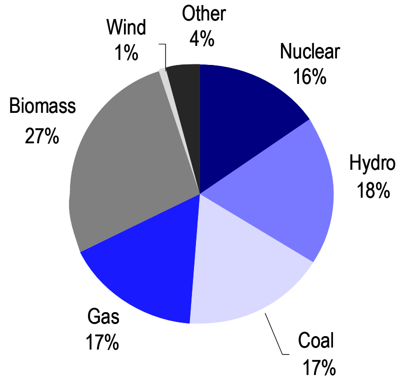
What nuclear capacity does Finland have and how significant is this in its energy mix?

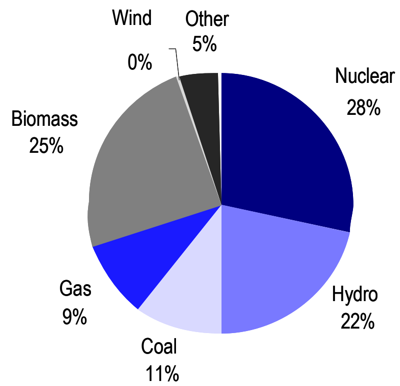
In 2009, nuclear energy made up just under 30% of Finnish electricity generation and 16% of installed capacity.

Chart 37: Installed capacity in Finland, 2009 (100% = 17GW)



Source: Nordel

Chart 38: Generation output in Finland, 2009 (100% = 74TWh)



Source: Nordel

There are four operational reactors and one at an advanced stage of construction. The two Loviisa reactors are operated by Fortum and were designed in Russia, but much of the equipment and engineering expertise came from Westinghouse and Siemens. They are pressurised water reactors of the so called VVER design (the Russian version of the PWR), and are generally considered significantly safer than the graphite moderated RBMK reactors at Chernobyl (please see Russia section for more details).

There are also two boiling water reactors designed by ABB and operated by TVO. These reactors are similar to the Swedish boiling water reactors.

There is also a new Areva EPR reactor under construction. Owned by TVO, the reactor has faced significant delays and cost overruns. It was initially planned to start commercial operations in 2009, but a 2013-14 start date now looks likely.

Table 23: Nuclear fleet in Finland

Station	Type	Gross/Net capacity (MWe)	Operator	Status	Reactor supplier	Construction date	Commercial date
LOVIISA-1	PWR	510/488	FORTUMPH	Operational	AEE	01-May-71	09-May-77
LOVIISA-2	PWR	510/488	FORTUMPH	Operational	AEE	01-Aug-72	05-Jan-81
OLKILUOTO-1	BWR	890/860	TVO	Operational	ASEASTAL	01-Feb-74	10-Oct-79
OLKILUOTO-2	BWR	890/860	TVO	Operational	ASEASTAL	01-Aug-75	10-Jul-82
OLKILUOTO-3	PWR	1600	TVO	Under Construction	AREVA NP	12-Aug-05	

Source: IAEA

What capacity expansion plans existed prior to Fukushima?

There has historically never been a major political debate in Finland about nuclear power. The situation has therefore been very different from that in Sweden and Germany and more similar to that in France. We attribute this partly to the country's dependence on electricity-intensive industries, particularly the pulp and paper and steel industries.

There has historically never been a major political debate in Finland about nuclear power

In addition to the nuclear plant currently under construction, the government has recently considered issuing licences to another one to two nuclear reactors to come on line towards 2020 to ensure self sufficiency in electricity. Several utilities, including Fortum, have pushed hard to get a licence to construct a new nuclear reactor.

What statements have come from regulators or government officials on how plans might change?

Finland is in the middle of an election campaign, with a general election coming up in mid-April. The country's nuclear policy has been a key topic in the campaign. Though the existing reactors and the reactor under construction have not been a major issue the population and the political parties appear to be divided down the middle on expanding nuclear power. Parties that are more green want to stop new nuclear plants, whereas the current government favours ensuring that the best available technology is used for any additional new build.

However, nuclear policy—particularly expansion—has been a key topic in the current election campaign

What changes, if any, do we expect to actually happen?

As mentioned above, the situation is difficult to assess given the unclear political situation. However, Finland has a long tradition of selecting solutions that are non-political and practical. We therefore would be surprised—and this is the case for all European countries—if any new licences were given in the short term, until all the lessons learned from Japan have been assimilated. This could very well take one to two years and we could see further delays in issuing new licences. On the other hand, with construction costs significantly above the current forward prices, we would imagine that utilities would anyway be hesitant to build new plants.

France

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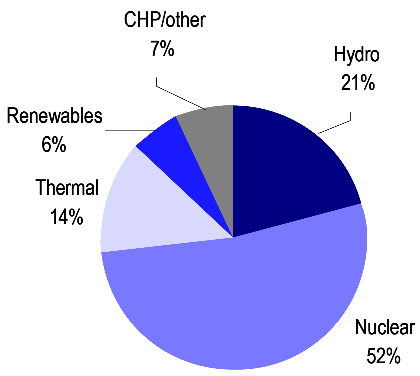
What nuclear capacity does France have and how significant is this in its energy mix?

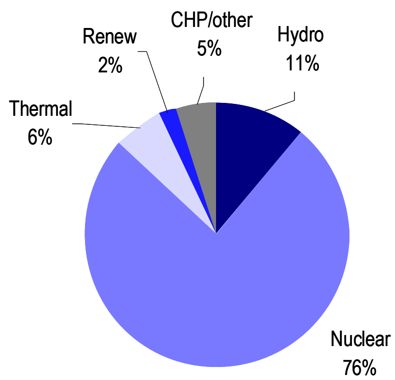
France has the second largest nuclear fleet in the world after the US, and is the country most dependent on nuclear power. In 2010, nuclear contributed 76% of France's total power generation, as shown in the chart below. There have been operational issues over the past couple of years, and we expect the nuclear sector's share to increase towards 80% of the total over the next new years. The nuclear fleet makes up a bit more than 50% of generation capacity, but this includes low utilisation hydro and thermal peaking units.

Chart 39: Installed capacity in France, 2010 (100% = 120GW)



Source: Réseau de Transport d'Électricité

Chart 40: Generation output in France, 2010 (100% = 541TWh)



Source: Réseau de Transport d'Électricité

The French began to develop their own reactors in the 1960s, mainly using graphite moderated designs. However, these first generation reactors have been closed. There are currently 58 operating reactors and one under construction. All are majority owned by EDF; 5GW are owned by other European utilities including GDF-Suez, the Swiss utilities, and, for the reactor under construction, Enel.

The reactors were all constructed by Areva-Framatome and are PWR-type. The fleet is heavily standardised into three series. There are 34 units of the 900 MW-series. These plants were licensed from Westinghouse and the design is very similar to the Westinghouse PWR reactors of the same size. Generations 2 and 3 are evolutions that deviate more from the Westinghouse reactor. The EPR, currently under construction, is a more genuinely new design.

Table 24: Nuclear fleet in France

Station	Type	Net capacity (MWe)	No. of reactors	Total net capacity (MWe)	Reactor supplier	Construction sate	Commercial date
Generation 1	PWR	880-915	34	30,770	FRAM	1971-79	1978-88
Generation 2	PWR	1,300-1,330	20	26,370	FRAM	1979-84	1985-94
Generation 3	PWR	1,500	4	7,590	FRAM	1984-91	2000-02
EPR	PWR	1,600	1	1,600	FRAM	2003-Dec-07	2014
Total			59	66,330			

Source: IAEA

What capacity expansion plans existed prior to Fukushima?

France's nuclear programme was built on optimistic assumptions regarding economic and power demand growth

The debate about nuclear power that followed the Three Mile Island accident never had a significant impact in France. The French instead launched a programme built on optimistic assumptions regarding economic and power demand growth. As a result, the programme became oversized and for the last 15 years France has suffered from significant overcapacity, meaning the plants cannot operate in pure baseload mode. The lack of decisions about new capacity between 1991 and 2007 was because there was no need for new capacity rather than a policy rethink. In 2007, the decision to build the new EPR was explicitly justified by industrial policy needs to preserve competence, rather than a need for new capacity.

In 2010, there was also a decision to build another new EPR at Penly, planned to be operational by around 2020. This plant has to a large extent also been justified by industrial policy rather than real need. Construction has not yet commenced.

Strong growth in electricity demand has led to negative reserve margins, but priority has been adding mid merit/peak thermal capacity

In recent years electricity demand has grown quickly in France, leading to negative reserve margins. France has frequently needed to import up to 8GW (8% of total peak demand) at peak hours. However, this has mainly been caused by poor availability of the existing fleet as well as a rapidly expanding peak load (5% peak demand growth CAGR since 2001) due to an increase in electric heating and widespread installation of heat pumps incentivised by low electricity prices. The priorities have therefore been adding new mid merit/peak thermal capacity as well as limiting peak demand growth. French nuclear policy has therefore focused on improving the operations of the existing fleet and exporting French nuclear technology and know-how.

What statements have come from regulators or government officials on how plans might change?

The authorities have reiterated their commitment to nuclear energy, but also said it is important to learn lessons from events in Japan

The French authorities have reiterated their commitment to nuclear energy, while at the same time saying it is important to draw all the lessons to be learned from the events in Japan. The government has thus asked the French nuclear safety authorities to review all existing 58 nuclear plants by the end of the year and assess their safety.

The audit will cover five points, the risks associated with: 1) floods; 2) earthquakes; 3) loss of electric power; 4) ultimate heat sink; and 5) the operational management of accident situations. Each installation will be assessed to determine what improvements are necessary. The detailed specifications for the audits and the specific timetable should be available within a month.

According to media reports, France has insisted that the review should be designed and managed by the French authorities. It seems that the main point of contention has been the risks associated with terrorist attacks, which the Germans, in particular, want to be part of the tests, but which French authorities are sceptical of.

The French regulatory procedure for licensing deviates from most other countries. Nuclear plants go through an in-depth review every 10 years; if the plant passes it receives an operating licence for the next 10 years. The oldest reactors are now going through the reviews to have their operating licences extended for a fourth decade. The first reactor, Tricastin 1, was granted its fourth 10-year licence in November 2010 and the decision on the next reactor, Fessenheim 1, is scheduled for April 2011.

Groups opposed to France's heavy dependence on nuclear power have reiterated their concerns

There is some opposition to France's heavy dependence on nuclear power in the country, and these groups have of course reiterated their worries following the Fukushima accident. However, so far this seems to have had a limited impact on the public debate.

EDF and Areva have acknowledged that recent events could slow the development of new nuclear plants and therefore impact French exports of nuclear technology. However, the French authorities have also argued that this could work in their favour. In 2010, a French consortium trying to sell the Areva EPR reactor lost a large tender to sell nuclear power to the United Arab Emirates. The tender was won by a Korea-led consortium. However, Areva now argues that the additional cost for its reactors is mainly because of higher safety standards, which could now become mandatory on a global basis.

What changes, if any, do we expect to actually happen?

We do not expect any major changes to the French nuclear policy following the Fukushima accident. However, we could potentially see some impact.

We think licence extensions could be delayed and capex requirements could rise after the stress tests

First, there is likely to be debate concerning the new 10-year licences for the oldest plants. We think Fessenheim 1, and its sister plant Fessenheim 2, in particular, could potentially face issues. These plants belong to the first group of six plants built in France. They are also located very close to the German border, and with Germany potentially closing a significant part of its nuclear fleet they have become a political liability for France, in our view.[*]

Second, the French safety authority, ASN, and EDF are currently working on the requirements for extending the design life of the current fleet from 40 to 60 years. EDF has estimated that the cost of such an extension, spread over the period, could amount to €400-600m per reactor. ASN had previously said that it planned to issue a first communication on the feasibility of such extensions this year. We think we could very well see a delay and stricter requirements following the Fukushima accident.

Finally—and potentially having the largest impact—would be any additional capex requirements for the existing fleet arising from the upcoming stress tests. At the moment this is rather hypothetical, but given the size of the fleet this could have quite a significant impact on EDF. However, we note that the forthcoming new French electricity law stipulates that the regulated price (known as ARENH) should include any capex requirements for the fleet, so it should be earnings neutral to EDF.

[*] The plants are also located only 35km from Basel, which saw a large earthquake in 1356.

Germany

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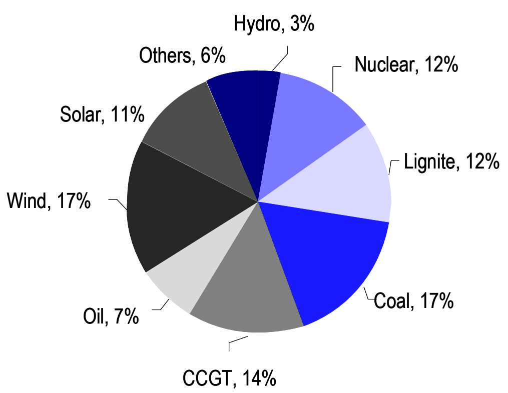
What nuclear capacity does Germany have and how significant is this in its energy mix?

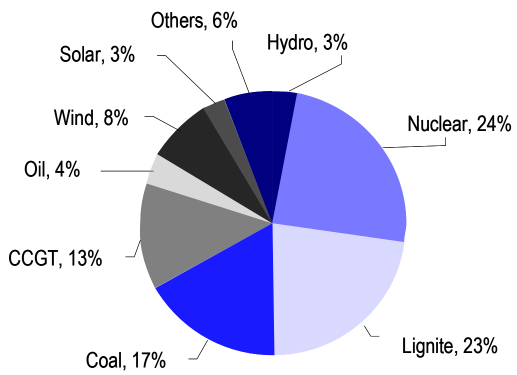
Germany has 17 nuclear power plants with a total installed capacity of 20.5GW, generating almost one-fourth of Germany's total electricity. E.ON owns 41% of the nuclear capacity and RWE 27%. The remaining stations are owned by Vattenfall and state-controlled EnBW.

Chart 41: Installed capacity in Germany, 2010 (100% = 167GW)



Source: UBS estimates

Chart 42: Generation output in Germany, 2010 (100% = 583TWh)

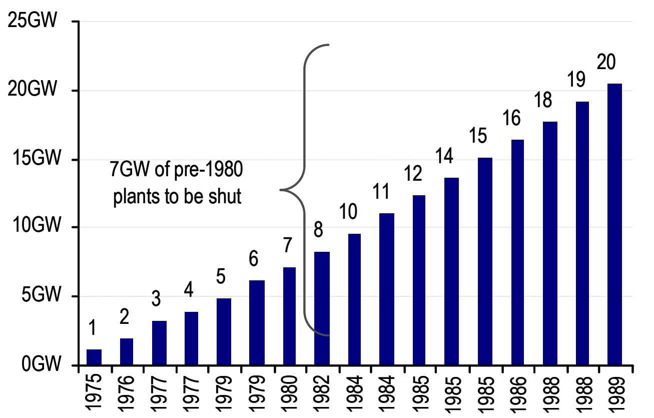


Source: UBS estimates

What capacity expansion plans existed prior to Fukushima?

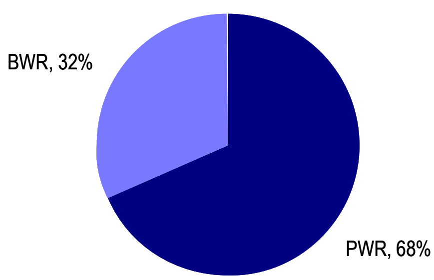
The nuclear meltdown at Chernobyl in 1986 was a game-changer for nuclear policy in Germany, and planning for new nuclear plants was stopped that year. In 1989, Neckarwestheim 2 was the last nuclear plant to go operational.

Chart 43: Nuclear plant build-up in Germany



Source: IAEA, UBS estimates

Chart 44: Nuclear plant types



Source: IAEA, UBS estimates

What statements have come from regulators/ government officials on how plans might change?

Immediately after the Japanese nuclear disaster, the German government announced the three-month shutdown of Germany's seven nuclear plants (total capacity 7GW) built prior to 1980. Plant safety inspections will be carried out during this moratorium period. We think these plants will be mothballed for good, due to increasing public pressure. The positive side effect of this would be the impact on reserve margins and spreads on coal/gas stations.

Chancellor Angela Merkel has established two expert panels to discuss Germany's nuclear strategy. One panel will deal with the technical and safety issues (reporting to the environmental minister) while the other will focus on the ethical aspects of nuclear power. We read this as an attempt by the federal government to avoid overly harsh, rushed decisions on plant closures. At the same time, Merkel is pushing for stricter nuclear regulation in the whole EU in order to avoid isolated national nuclear policy in Germany, in our view.

What changes, if any, do we expect to actually happen?

Chancellor Merkel is losing public support, with nuclear policy being the main driver of the negative momentum, in our view

Chancellor Merkel, whose Christian Democratic Party (CDU) faces another four state elections this year, is losing public support, with nuclear policy being the main driver of the negative momentum, in our view. The CDU recently lost regional elections in the important state of Baden Wuerttemberg. For the first time ever the Green party will be the ruling party in a German federal state, together with junior partner, the SPD.

In 2010, Merkel reversed a decision taken by the SPD/Green government in 2002 and extended the life of nuclear plants by an average of 12 years (from a 32-year total lifetime). In our view, the outcome of the Baden Wuerttemberg state elections will only intensify the nuclear debate. We believe that Merkel is striving for a consensus on a 'moderate' nuclear phase-out plan, which we believe could include an approximately eight-year life extension for plants built after 1980, in connection with safety upgrades. These would imply significant capex for safety upgrades (we estimate up to €500m per reactor). We think what can be ruled out is the construction of new nuclear capacity in Germany.

Italy

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What nuclear capacity does Italy have and how significant is this in its energy mix?

Following the 1986 Chernobyl disaster, a referendum led to the closure of the Italian nuclear fleet. Today, Italy has no domestic nuclear production. However, nuclear is still part of the Italian mix to some extent, as the country imports some 15-20% of its energy needs (mostly nuclear output) from France and Switzerland.

What capacity expansion plans existed prior to Fukushima?

Plans for new plants identified 2013 as a start date for construction works

The Berlusconi government had started preparatory works to develop new nuclear plants. The original plans identified 2013 as a start date for construction works, and 2020 for completion. The idea was to supply 20-25% of domestic needs from nuclear sources, which could have implied an installed nuclear base of 8GW.

What statements have come from regulators or government officials on how plans might change?

Italy was scheduled to hold a referendum to decide on the new nuclear builds in June. Given the recent events in Japan, the government has decided on a 12-month moratorium to assess the nuclear expansion plan more thoroughly in light of the Fukushima incident.

In our view, the government also announced the moratorium to 'buy time' since a referendum so soon after the images of explosions at nuclear reactors would likely result in a vote against the nuclear development programme.

What changes, if any, do we expect to actually happen?

We believe the government will carry on with its energy policy, though securing public support will now be more difficult

We believe the government will carry on with its energy policy. Clearly though, securing public support will now be more difficult. We believe the emotional dust might not settle for another couple of years. Therefore, at best, we expect the Italian nuclear renaissance to be delayed by two years.

Poland

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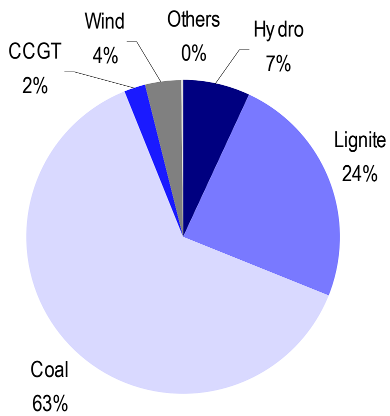
What nuclear capacity does Poland have and how significant is this in its energy mix?

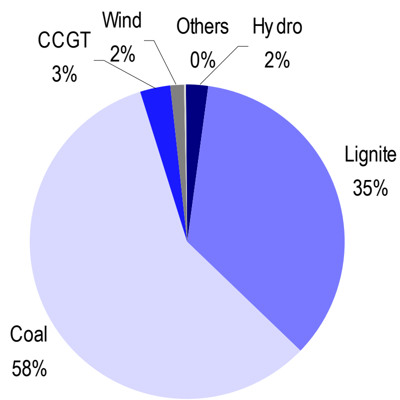
There are currently no nuclear plants in Poland. As one of the largest producers of coal in the EU, its energy mix is biased towards hard coal and lignite: almost 95% of Poland's total electricity output is generated by coal/lignite plants.

Chart 45: Installed capacity in Poland, 2009 (100% = 33.8GW)



Source: IEA, UBS estimates

Chart 46: Generation output in Poland, 2009 (100% = 144TWh)



Source: IEA, UBS estimates

What capacity expansion plans existed prior to Fukushima?

In 2005, the Polish government decided to introduce nuclear power in the country with the aim of generating 15% of electricity (6GW) from nuclear power by 2030 to reduce the burden from higher CO^2 costs. The government then approved plans for the construction of two 3,000MW nuclear plants by 2030. In 2009, PGE announced its decision to build both nuclear plants, with PGE holding a 51% stake and foreign partners the remaining 49%. In January 2011, the government re-approved the relevant legislation, which was amended to include transparency and a stable regulatory framework. The legislation is likely to be presented in parliament by mid-2011.

What statements have come from regulators/ government officials on how plans might change?

The Prime Minister is a strong supporter of nuclear power. He has said the ongoing nuclear crisis in Japan is the result of an earthquake, a risk to which Poland is not exposed. However, he has recently been quoted as saying he would not rule out holding a national referendum on nuclear power in the future.

What changes, if any, do we expect to actually happen?

In our view, although the Polish government continues to support the plans to build nuclear plants, the ultimate decision is likely to be taken through a national referendum. In a recently conducted online sample poll, only 32% of respondents were in favour of building nuclear plants in Poland, down significantly from January, when 42% of respondents expressed support.

The Polish government continues to support plans to build nuclear plants, but the ultimate decision is likely to be taken through a national referendum

Russia

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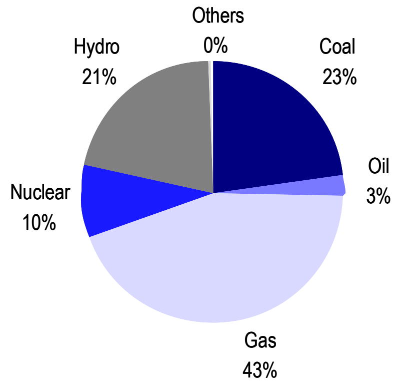
What nuclear capacity does Russia have and how significant is this in its energy mix?

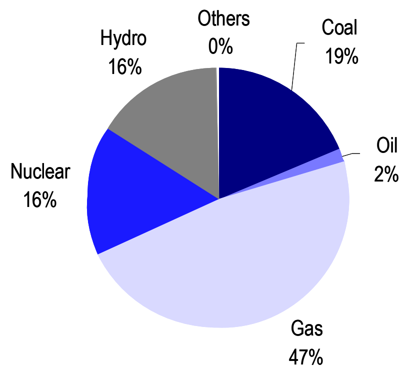
Nuclear power generates 16% of Russia's total 1,038TWh of electricity generation and makes up 10% of installed capacity. In 2009, total nuclear output was 163TWh.

Chart 47: Installed capacity in Russia, 2009 (100% = 227GW)



Source: IEA

Chart 48: Generation output in Russia, 2009 (100% = 1,038TWh)



Source: IEA

In total there are now 31 operating nuclear reactors with 21.7GW of installed capacity. There are five different types of plants. There are 15 graphite moderated plants, including 11 of the RBMK type similar to that at Chernobyl. There are 15 PWR reactors and one breeder reactor.

Table 25: Nuclear fleet in Russia

Station	Type	Net capacity (MWe)	No. of reactors	Commercial Date
Graphite moderated	RBMK	925-971	11	1974-86
Graphite moderated	EGP-6	11	4	1974-77
1st generation PWRs	VVER-440/230	411-432	4	1973-75
2nd generation PWRs	VVER 400/213	411	2	1982-84
3rd generation PWRs	V-320	950-990	9	1986-2010
Breeder	BN600	560	1	1981

Source: World Nuclear Association

What capacity expansion plans existed prior to Fukushima?

Russia rapidly expanded nuclear power in the 1970s and 1980s, but stopped after the Chernobyl accident in 1986

Russia rapidly expanded nuclear power in the 1970s and 1980s, but stopped development plans after the Chernobyl accident in 1986. Following export orders to Iran, China and India in the late 1990s, domestic investments in new nuclear capacity accelerated. From 2006 there has been a strategy to add 2-3GW per annum of new nuclear capacity until 2030. There are currently five reactors under construction, mainly third generation PWR reactors.

What statements have come from regulators or government officials on how plans might change?

Prime Minister Putin has reaffirmed that Russia will continue to build nuclear power plants but he has also asked for a review of the safety of the current fleet. Russia wants to reduce its large dependence on gas for power generation and therefore needs to increase nuclear capacity. Prime Minister Putin has been quoted as saying: *"It is impossible to speak about a global energy balance without the nuclear power industry"*. Nuclear technology is also a significant export industry for Russia.

Prime Minister Putin has reaffirmed that Russia will continue to build nuclear power plants but has also asked for a review of the safety of the current fleet

However, Russia has a significant environmental lobby that has expressed concerns, particularly regarding the safety of the RBMK graphite moderated reactors.

What changes, if any, do we expect to actually happen?

We believe that there could be a short-term moratorium on new nuclear capacity. The safety review could also conclude that the older graphite moderated reactors should be replaced by more modern reactors. However, we doubt that there will be any significant change in Russian nuclear policy.

Spain

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What nuclear capacity does Spain have and how significant is this in its energy mix?

Nuclear output accounts for approximately 20% (55TWh) of total Spanish generation. Spain has six plants (eight reactors: two BWR and six PWR) with a total installed base of 7.5GW. These plants were brought online mostly during the 1980s and are on average 25 years old. The GE reactors highlighted in the table below are similar in design to the Fukushima reactors.

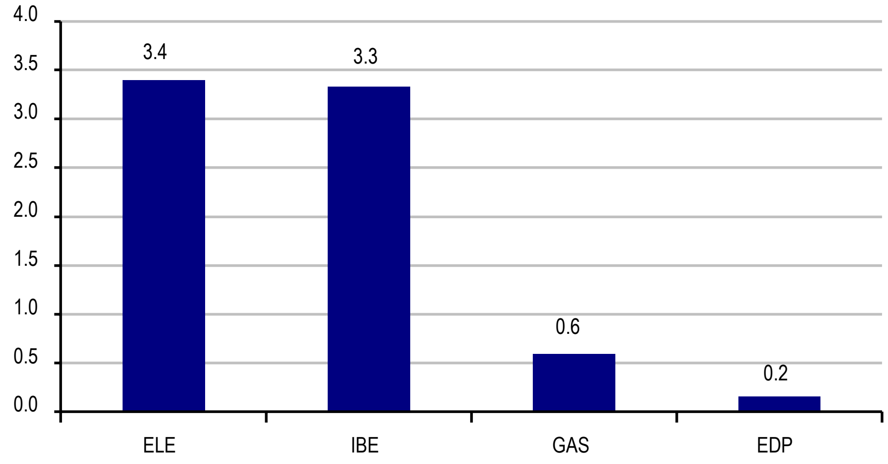
Table 26: Nuclear fleet in Spain

Name	Type	Net capacity (MWe)	Owner	Supplier	Construction	Commercial	Licenced until
ALMARAZ-1	PWR	944	Endesa, Iberdrola, Gas Natural Fenosa	WH	1973	1983	2021
ALMARAZ-2	PWR	956	Endesa, Iberdrola, Gas Natural Fenosa	WH	1975	1985	2023
ASCO-1	PWR	995	Endesa, Iberdrola	WH	1974	1984	2023
ASCO-2	PWR	997	Endesa, Iberdrola	WH	1975	1986	2025
COFRENTES	BWR	1,064	Iberdrola	GE	1975	1985	2023
GARONA	BWR	446	Iberdrola, Endesa	GE	1966-9	1971	2013
TRILLO-1	PWR	1003	Endesa, Iberdrola, Gas Natural Fenosa, EDP	KWU	1979-8	1988	2028
VANDELLOS-2	PWR	1045	Endesa, Iberdrola	WH	1980-12	1988	2027

Source: IAEA, UBS

Some 90% of Spain's nuclear assets are owned by Endesa (ELE) or Iberdrola (IBE), which own over 3GW each, as shown in the chart below.

Chart 49: Installed nuclear base by company (GW)



Source: UBS, company data

What capacity expansion plans existed prior to Fukushima

The construction of new nuclear plants in Spain was stopped before the 1990s. In 1989, Trillo and Vandellos 2 were the two last nuclear reactors to go operational.

Nuclear plant life is currently certified for 38-40 years, depending on the plant. To continue operating beyond that date utilities require government approval. The Socialist government pondered a nuclear phase-out for many years, but that position changed when it considered the extra costs this would have brought to consumers' electricity bills and the intermittency of renewable sources.

In July 2010, the government decided to extend the life span of the Garona plant to 2013, when it will reach a life of 42 years. We also understand that the government has been considering an extension in useful life, possibly in exchange for a levy. However, Spain has no plans to develop any new nuclear capacity.

What statements have come from regulators/government officials on how plans might change?

Immediately after the Fukushima incident the Spanish government reiterated its plans to keep nuclear plants working

The Spanish population does not appear to be particularly anti-nuclear and the opposition party has also historically taken a pro-nuclear stance. Therefore it is not surprising that the Spanish government has not been particularly vocal about the situation. Immediately after the Japanese nuclear disaster, the Spanish government reiterated its plans to keep the nuclear plants working.

Nonetheless, the Spanish government has said it will review security measures at all six nuclear power plants. Specifically, a supplementary seismic survey has been requested as well as a study on the risk of flooding. We would particularly expect scrutiny of plants built before 1980 (Garona, 450MW), and Cofrentes, as this is a BWR plant (1,092MW).

What changes, if any, do we expect to actually happen?

However, we expect the government to be much stricter when granting plant life extensions

We expect the government to be much stricter when granting life extensions. This process is likely to imply: 1) somewhat higher capex requirements for safety upgrades; and 2) shorter extensions (ie three to five years at a time, as opposed to 10-15 year extensions).

Sweden

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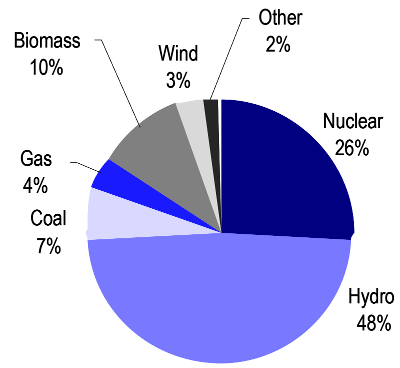
What nuclear capacity does Sweden have and how significant is this in its energy mix?

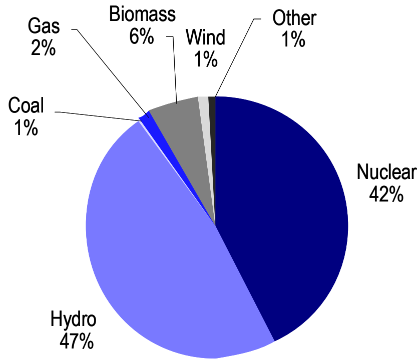
The chart below shows generation output in Sweden in 2008, when nuclear made up 42% of total output. We have chosen 2008 as problems and upgrades have kept output unusually low for the last two years. Going forward, after a series of capacity upgrades, nuclear will be close to 50% of total generation output. In terms of installed capacity, nuclear is of less importance at 26% of total capacity. However, given hydro's large share, with high installed capacity but low load factors, we believe it is more relevant to assess importance by looking at output in the Nordic markets. In which case, Sweden is heavily dependent on nuclear power.

Chart 50: Installed capacity in Sweden, 2008 (100% = 34GW)



Source: Nordel

Chart 51: Generation output in Sweden, 2008 (100% = 144TWh)



Source: Nordel

The table below shows the key characteristics of the fleet. There are 12 reactors in the country. However, the two Barseback plants were shut in 1999 and 2005, respectively, and there are now 10 operating plants.

Sweden's nuclear fleet is relatively old by international standards: most construction was completed in 1975-85

The fleet is relatively old by international standards, since most construction began in the early 1970s and was completed in 1975-85. Seven of the plants are BWRs built by ABB and the remaining three are Westinghouse-built PWRs.

The operating track record was very good in the first decades, but since 2000 there have been some issues, in particular concerning the older BWR fleet (particularly Oskarshamn 1 and Forsmark 1).

Table 27: Nuclear fleet in Sweden

Station	Type	Net Capacity (MWe)	Operator	Status	Reactor Supplier	Construction Date	Commercial Date	Shutdown Date
FORSMARK-1	BWR	1,014	FKA	Operational	ABBATOM	01-Jun-73	10-Dec-80	
FORSMARK-2	BWR	1,014	FKA	Operational	ABBATOM	01-Jan-75	07-Jul-81	
FORSMARK-3	BWR	1,190	FKA	Operational	ABBATOM	01-Jan-79	18-Aug-85	
OSKARSHAMN-1	BWR	623	OKG	Operational	ABBATOM	01-Aug-66	06-Feb-72	
OSKARSHAMN-2	BWR	598	OKG	Operational	ABBATOM	01-Sep-69	01-Jan-75	
OSKARSHAMN-3	BWR	1,197	OKG	Operational	ABBATOM	01-May-80	15-Aug-85	
RINGHALS-1	BWR	880	RAB	Operational	ABBATOM	01-Feb-69	01-Jan-76	
RINGHALS-2	PWR	870	RAB	Operational	WH	01-Oct-70	01-May-75	
RINGHALS-3	PWR	1,010	RAB	Operational	WH	01-Sep-72	09-Sep-81	
RINGHALS-4	PWR	915	RAB	Operational	WH	01-Nov-73	21-Nov-83	
BARSEBACK-1	BWR	615	BKAB	Permanent Shutdown	ASEASTAL	01-Feb-71	01-Jul-75	30-Nov-99
BARSEBACK-2	BWR	615	BKAB	Permanent Shutdown	ABBATOM	01-Jan-73	01-Jul-77	31-May-05

Source: IAEA

What capacity expansion plans existed prior to Fukushima?

In the 1960-70s, Sweden was one of the most pro-nuclear countries in the world and in terms of installed capacity per capita it developed the largest fleet of any OECD-country. However, the situation changed dramatically from 1975, when a strong anti-nuclear movement emerged. Nuclear power developed into the top political issue in the country and was the key reason for the resignation of a government in 1977.

A referendum following Three Mile Island led to a decision to finalise ongoing plant construction but then phase-out all nuclear until 2010

The accident at Three Mile Island in 1979 strengthened the anti-nuclear movement further and led to a referendum on the future of nuclear power in 1980. The referendum resulted in a decision to finalise ongoing plant construction but then phase-out all nuclear until 2010. From the 1990s the anti-nuclear policy gradually softened, and only the reactors perceived as ‘most dangerous’ were closed. The two shut down Barseback reactors are located less than 20 km from downtown Copenhagen and had received significant criticism from the Danish government.

Over the last five years the policy has turned even more positive. The plants’ operating licences were extended to 60 years and as part of this the decision was taken to increase the capacity of the newest plants up to 25%. These upgrades are currently ongoing and will add 1.1GW of new nuclear capacity in 2011-14. The current government has also announced that it could consider giving licences to new nuclear plants to replace existing plants when they close.

What statements have come from regulators or government officials on how plans might change?

Considering the previously strong anti-nuclear movement, the Swedish reaction to the nuclear crisis has been surprisingly muted. The Prime Minister, Mr Reinfeld, has stated that while it is of course important to draw the lessons from Fukushima, the current policy remains unchanged. The green movements have of course reiterated their negative stance, but even these comments have been relatively modest, not asking for the immediate closure discussed in Germany, for instance. We have so far not seen any statements asking for work to stop on the ongoing capacity upgrades of existing reactors.

The Prime Minister has stated that although it is important to draw lessons from Fukushima, the current nuclear policy remains unchanged

As in many other counties, safety authorities have started a large information campaign concerning nuclear safety and radiation.

What changes, if any, do we expect to actually happen?

Despite the current statements, we think it is highly unlikely in the short term that Sweden would take a decision to build new nuclear reactors. However, given that the current policy is to potentially replace nuclear power facilities as they close, and with such closure likely to be more than 10 years away, we would have viewed such a decision as unlikely even before the Fukushima accident.

We expect Sweden to actively participate in the European nuclear stress tests that have recently been decided on by the EU. If these tests were to highlight any systemic problems, it could of course lead to additional capex requirements, particularly since the Swedish fleet is relatively old.

Over the past two years there has also been an intense debate about the low recent availability in the nuclear fleet, and we think pressure on the operators to improve operations could increase further, particularly with regard to safety aspects.

But overall we do not see any major likely risks or shifts in policy in Sweden.

Switzerland

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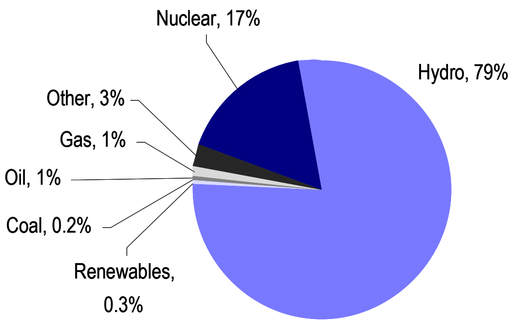
What nuclear capacity does Switzerland have and how significant is this in its energy mix?

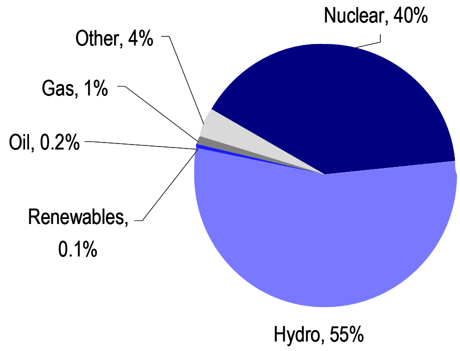
Nuclear power contributed 40% of Switzerland's 68.6TWh of generation in 2010. It is less important in installed capacity, at 17%, due to a significant volume of peaking hydro and thermal stations.

Chart 52: Installed capacity in Switzerland, 2010 (100% = 19.4GW)



Source: IEA/OECD Electricity Statistics

Chart 53: Generation output in Switzerland, 2010 (100% = 68.6TWh)



Source: IEA/OECD Electricity Statistics

The table below shows the nuclear capacity in Switzerland. The country has five operational reactors: three PWR and two boiling water reactors. Three of the plants (Beznau 1-2 and Muehleberg) are among the world's oldest reactors still in operation, and under current law are supposed to close by 2019-22. No closing date has been set for the two newer and larger reactors, Goesgen and Leibstadt, and they have unlimited life operating licences.

Table 28: Nuclear fleet in Switzerland

Station	Type	Net capacity (MWe)	Operator	Status	Reactor supplier	Construction date	Commercial date
BEZNAU-1	PWR	365	NOK	Operational	WH	01-Sep-65	01-Sep-69
BEZNAU-2	PWR	365	NOK	Operational	WH	01-Jan-68	01-Dec-71
GOESGEN	PWR	970	KKG	Operational	KWU	01-Dec-73	01-Nov-79
LEIBSTADT	BWR	1,165	KKL	Operational	GETSCO	01-Jan-74	15-Dec-84
MUEHLEBERG	BWR	355	BKW	Operational	GETSCO	01-Mar-67	06-Nov-72

Source: IAEA

What capacity expansion plans existed prior to Fukushima?

The Swiss government announced in 2007 that the existing nuclear plants would in due course be replaced with new units. Following this decision the industry developed several plans to build new nuclear plants. The latest plan, announced in December 2010 by regional utilities Axpo, Alpiq and BKW, was to build two reactors of up to 1,600MW at two sites, ie in total up to 6,400MW. The plan was for start up after 2020.

In 2007, the government announced that existing nuclear plants would in due course be replaced with new units

What statements have come from regulators or government officials on how plans might change?

The Swiss government has suspended the authorisation for new reactors so that safety standards can be revisited. The country will also conduct a study on the safety of the existing fleet. Switzerland, particularly the western area around Basel, is geologically active, and experienced a 6.5 Richter scale earthquake in 1356.

The Swiss government has suspended the authorisation for new reactors so that safety standards can be revisited

The social democratic and green opposition wants to go further and has proposed shutting down the three oldest reactors by 2012 at the latest. Centre-right parties remain pro-nuclear, but acknowledge that plans need to be reassessed.

Switzerland will have elections this autumn and the debate is therefore likely to continue. Being pro-nuclear is hardly a vote winner so even economy-friendly parties are now talking about a potential exit from nuclear power, albeit at a moderate pace. It is difficult to assess the outcome, and Switzerland is already dependent on energy imports, in particular from France. On the other hand, the three reactors are small and many argue that the Swiss system could deal with a loss of around 1GW.

There is also a heated debate in Switzerland about the French Fessenheim reactors. The Swiss have noted that these are the oldest reactors in France, albeit more modern than the older Swiss ones, but are also located close to a seismically active region and are only 35km from Basel. We think the Swiss could put pressure on France to close these units.

What changes, if any, do we expect to actually happen?

We believe that a moratorium on new nuclear capacity is likely. We think a quicker phase-out plan for the three oldest plants is also likely as they have been operating for 39-42 years, and as this would seem to be a prerequisite for putting credible pressure on France to phase out the Fessenheim reactors.

Ukraine

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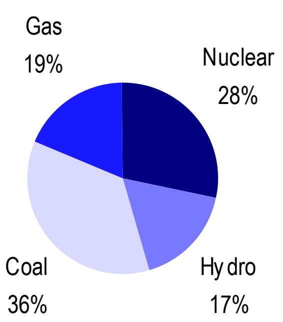
What nuclear capacity does Ukraine have and how significant is this in its energy mix?

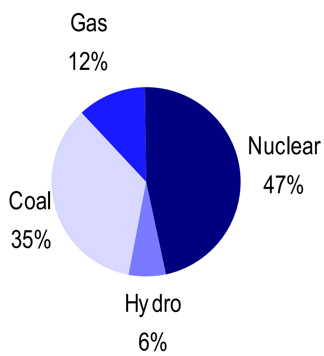
Nuclear power supplies almost half of Ukraine's total electricity generation of 192TWh.

Chart 54: Installed capacity in Ukraine, 2009 (100% = 49GW)



Source: IEA

Chart 55: Generation output in Ukraine, 2009 (100% = 192TWh)



Source: IEA

There are 15 reactors with over 13GW of installed nuclear capacity in Ukraine. The table below shows the reactors in the country, including the four closed reactors at Chernobyl (it was reactor number four at Chernobyl had a serious accident on 26 April 1986). The remaining Ukrainian reactors are of the more modern Russian PWR designs, which have a higher safety level than the graphite moderated Chernobyl reactors.

Table 29: Nuclear fleet in Ukraine

Station	Type	Net capacity (MWe)	Operator	Status	Reactor supplier	Construction date	Shutdown date
KHMELNITSKI-1	WWER	950	NNEGC	Operational	PAA	01-Nov-81	
ROVNO-1	WWER	381	NNEGC	Operational	PAIP	01-Aug-73	
ROVNO-2	WWER	376	NNEGC	Operational	PAIP	01-Oct-73	
ROVNO-3	WWER	950	NNEGC	Operational	PAIP	01-Feb-80	
SOUTH UKRAINE-1	WWER	950	NNEGC	Operational	PAIP	01-Mar-77	
SOUTH UKRAINE-2	WWER	950	NNEGC	Operational	PAA	01-Oct-79	
SOUTH UKRAINE-3	WWER	950	NNEGC	Operational	PAA	01-Feb-85	
ZAPOROZHE-1	WWER	950	NNEGC	Operational	PAIP	01-Apr-80	
ZAPOROZHE-2	WWER	950	NNEGC	Operational	PAIP	01-Jan-81	
ZAPOROZHE-3	WWER	950	NNEGC	Operational	PAIP	01-Apr-82	
ZAPOROZHE-4	WWER	950	NNEGC	Operational	PAIP	01-Apr-83	
ZAPOROZHE-5	WWER	950	NNEGC	Operational	PAIP	01-Nov-85	
ZAPOROZHE-6	WWER	950	NNEGC	Operational	PAIP	01-Jun-86	
KHMELNITSKI-2	WWER	950	NNEGC	Operational	PAIP	01-Feb-85	
KHMELNITSKI-3	WWER	950	NNEGC	Under Construction		01-Mar-86	
KHMELNITSKI-4	WWER	950	NNEGC	Under Construction		01-Feb-87	
ROVNO-4	WWER	950	NNEGC	Operational	PAIP	01-Aug-86	
CHERNOBYL-1	LWGR	725	SSE ChNPP	Shut Down	MNE	01-Mar-70	30-Nov-96
CHERNOBYL-2	LWGR	925	SSE ChNPP	Shut Down	MNE	01-Feb-73	30-Nov-91
CHERNOBYL-3	LWGR	925	SSE ChNPP	Shut Down	MNE	01-Mar-76	15-Dec-00
CHERNOBYL-4	LWGR	925	SSE ChNPP	Shut Down	MNE	01-Apr-79	26-Apr-86

Source: IAEA

What capacity expansion plans existed prior to Fukushima?

Ukraine has significant ambitions to increase its nuclear capacity, but feasibility will largely depend on achieving favourable financing

Ukraine has significant ambitions to increase its nuclear capacity. In 2010, the government confirmed plans to complete the ongoing Khmelnitski 3 and 4 projects, with the ambition to have them completed by 2016-17. The government energy plan includes up to six additional reactors to be operational by 2025, with additional reactors added thereafter. The feasibility of these plans will to a large extent depend on achieving favourable financing, in particular from the Russian industry, which is likely to supply most of the plants.

What statements have come from regulators or government officials on how plans might change?

So far we have not seen any government statements indicating that Ukraine is reconsidering its plans to expand nuclear power. Prime Minister Azarov said in an interview following the Japanese accident that *"only rich countries can afford to discuss the possibility of closing nuclear plants"*. However, he did state that Ukraine will review its energy policy, but that it is unlikely to make radical changes.

What changes, if any, do we expect to actually happen?

We expect that safety standards will be somewhat raised, but we do not expect significant changes to Ukraine's nuclear policy following the Fukushima accident.

United Kingdom

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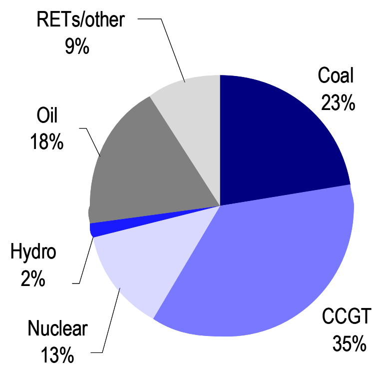
What nuclear capacity does the UK have and how significant is this in its energy mix?

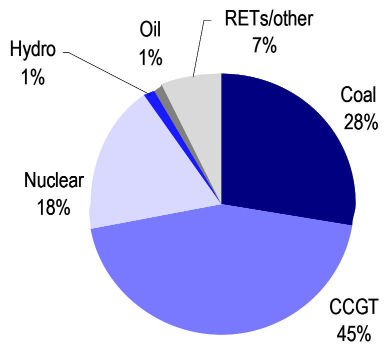
Nuclear generation is 13% of the UK's installed capacity, or 18% by generation volume.

Chart 56: Installed capacity in the UK, 2010 (100% = 85GW)



Source: Decc

Chart 57: Generation output in the UK, 2010 (100% = 375TWh)



Source: Decc

Over the next 18 months 1,450MW of nuclear capacity is scheduled to leave the system as the old Magnox stations are decommissioned. The UK's nuclear capacity is presented in the table below. It is worth remembering that of the remaining 9.6GW, 8.4GW are advanced gas-cooled reactor (AGR) technology and the remainder are PWR. Historically, the AGR UK fleet has had a less stable operating track record than PWR, and these are the only reactors of their kind in the world.

The following table gives our expectations of the remaining life of the existing fleet. Our forecast closure dates include five years of life extension for the AGRs.

Table 30: Nuclear fleet in the UK

Station	Type	Net capacity (MWe)	Operator	Status	Reactor supplier	Construction date	Commercial date	Shutdown date*
DUNGENESS-B1	GCR	545	BE	Operational	APC	01-Oct-65	01-Apr-85	2023
DUNGENESS-B2	GCR	545	BE	Operational	APC	01-Oct-65	01-Apr-89	2023
HARTLEPOOL-A1	GCR	595	BE	Operational	NPC	01-Oct-68	01-Apr-89	2019
HARTLEPOOL-A2	GCR	595	BE	Operational	NPC	01-Oct-68	01-Apr-89	2019
HEYSHAM-A1	GCR	585	BE	Operational	NPC	01-Dec-70	01-Apr-89	2019
HEYSHAM-A2	GCR	575	BE	Operational	NPC	01-Dec-70	01-Apr-89	2019
HEYSHAM-B1	GCR	615	BE	Operational	NPC	01-Aug-80	01-Apr-89	2019
HEYSHAM-B2	GCR	615	BE	Operational	NPC	01-Aug-80	01-Apr-89	2019
HINKLEY POINT-B1	GCR	430	BEG	Operational	TNPG	01-Sep-67	02-Oct-78	2016
HINKLEY POINT-B2	GCR	430	BE	Operational	TNPG	01-Sep-67	27-Sep-76	2016
HUNTERSTON-B1	GCR	420	BE	Operational	TNPG	01-Nov-67	06-Feb-76	2016
HUNTERSTON-B2	GCR	420	BE	Operational	TNPG	01-Nov-67	31-Mar-77	2016
OLDBURY-A1	GCR	217	BNFL	Operational	TNPG	01-May-62	31-Dec-67	2012
OLDBURY-A2	GCR	217	BNFL	Operational	TNPG	01-May-62	30-Sep-68	2012
SIZEWELL-B	PWR	1,188	BE	Operational	PPC	18-Jul-88	22-Sep-95	2055
TORNESS 1	GCR	625	BE	Operational	NNC	01-Aug-80	25-May-88	2028
TORNESS 2	GCR	625	BE	Operational	NNC	01-Aug-80	03-Feb-89	2028
WYLFA 1	GCR	490	BNFL	Operational	EE/B&W/T	01-Sep-63	01-Nov-71	2012
WYLFA 2	GCR	490	BNFL	Operational	EE/B&W/T	01-Sep-63	03-Jan-72	2012

Note: *Shutdown dates are UBS estimates.
Source: UK government, UBS estimates

What capacity expansion plans existed prior to Fukushima?

In January 2008, a government white paper on nuclear power proposed that:

- new nuclear power stations should have a role to play in the country's future energy mix, alongside other low-carbon sources
- it would be in the public interest to allow energy companies the option of investing in new nuclear power stations
- the government should take active steps to facilitate this

The coalition government published its programme in June 2010. This set out its vision that energy companies could build new nuclear power stations provided they were subject to the normal planning process for major projects and received no public subsidies.

The government has confirmed eight potential sites for new nuclear plants

The government has already confirmed eight potential sites for new nuclear power stations, with the first estimated to be working by 2018. The sites are: Bradwell (Essex), Hartlepool (Borough of Hartlepool), Heysham (Lancashire), Hinkley Point (Somerset), Oldbury (South Gloucester), Sellafield (Cumbria), Sizewell (Suffolk), Wylfa (Isle of Anglesey).

We believed, prior to the events in Japan, that 4x1,600MW of new nuclear stations would be built in the first phase of the programme, with the first coming on line by 2020. EDF had given indications that it planned to build at least a twin EPR reactor, assuming that an appropriate regulatory framework was in place. Other operators remained more sceptical.

What statements have come from regulators or government officials on how plans might change?

The government will consider the Nuclear National Policy Statement in light of the nuclear crisis in Japan

Since the Fukushima accident, the Secretary of State for Energy and Climate Change Chris Huhne has asked Dr Mike Weightman for an interim report by mid-May 2011, and a final report within six months. Both reports will be made public.

At the Nuclear Development Forum, the Secretary of State told the industry that the government would consider the Nuclear National Policy Statement in light of the emerging nuclear crisis in Japan before proceeding with the ratification process.

What changes, if any, do we expect to actually happen?

We believe the UK will maintain its strategy of building new nuclear reactors. Due to the Large Combustion Plant Directive, the EU law requiring coal plants without de-sulphurisation equipment to close by 2016, the UK faces a sizable level of plant closures (approximately 11GW). This makes the new nuclear facilities an important part of the fuel mix. The UK is also strongly committed to reducing its carbon emissions and it is difficult to see how this would be achieved without nuclear power. Public opposition to new nuclear also seems more muted than in many other European countries.

We think the main risk is additional safety capex for old and new stations. This could make plant economics worse and further reduce operator interest in building nuclear plants.

Latin America

Likely policy responses

Nuclear power is not a significant source of energy today in Latin America and no government in the region had plans to make it an important source of power in the medium or long term, even pre-Fukushima.

Nuclear power is not a significant source of energy in Latin America and plans were limited even pre-Fukushima

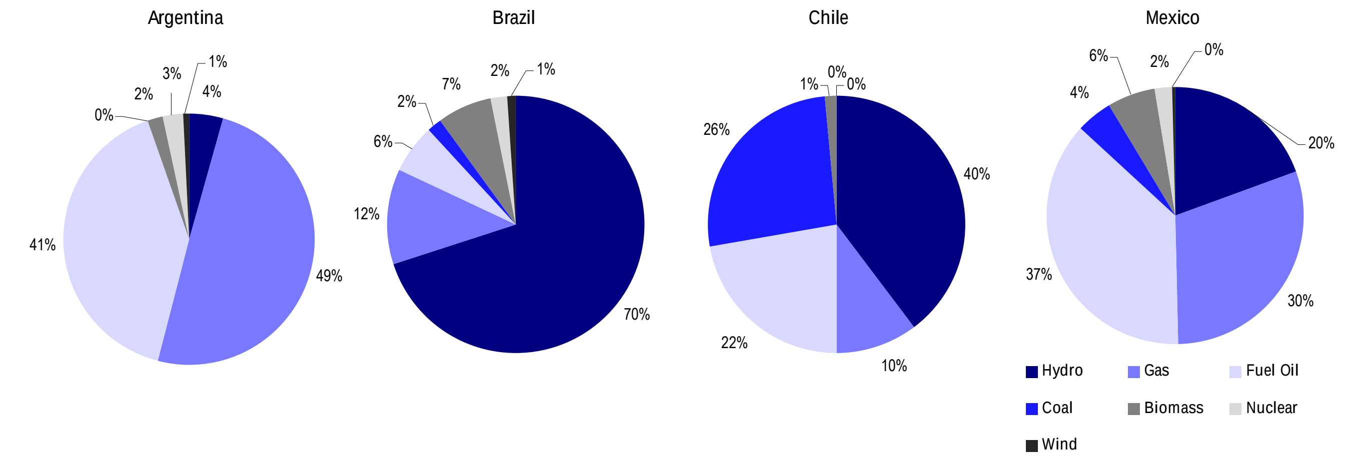
Post-Fukushima, we think the likelihood of significant nuclear power additions is even lower, as it has increased the scrutiny of safety issues. Brazil, Argentina and Mexico are all going ahead with their nuclear power projects, but these are quite modest.

Government authorities in these countries have said they will employ best practices to make sure safety safeguards and emergency evacuation infrastructure/procedures are reviewed to ensure better risk control. At the same time, they have indicated they expect no changes in their energy policies arising from the incident.

In Latin America, the energy matrix is comprised mostly of hydroelectricity, with nuclear power projects representing only up to 3% of specific countries' electricity matrix. Today only Brazil, Argentina and Mexico have nuclear power plants. Colombia, Cuba, Chile, Ecuador, Peru, Uruguay and Venezuela all have nuclear power programmes, but since the incident only Hugo Chavez has announced that Venezuela is immediately suspending such plans.

Only Brazil, Argentina and Mexico have nuclear power plants

Chart 58: Installed capacity in Latin America, 2010



Source: ELETROBRAS, Nucleoelectrica Argentina SA, CFE, UBS

ELETROBRAS (EBR/ELET3 and EBR.B/ELET6, Neutral) is the only listed company in Latin America with exposure to nuclear power (see the table below). However, we note that nuclear power assets represent less than ~1% of ELETROBRAS's total assets.

Table 31: Latin American nuclear capacity, 2010

	Existing capacity		Capacity under construction	Planned additions pre-Fukushima	Reactor	Reactor	
	(MW, nominal)	(% of country's total)	(MW, nominal)	(MW, nominal)	type	supplier	Owner/operator
Brazil	2,007	2%	1,405	4 plants of 1,000MW each	PWR	Westinghouse/ KWU	ELETROBRAS' subsidiary Eletronuclear (federally-owned)
Argentina	1,005	2%	745	n.a.	PHWR	Siemens/AECL	Local private group NASA - Nucleoelectrica Argentina SA
Mexico	1,365	3%	0	4-10 new plants	BWR	GE	Federally-owned CFE

Source: ELETROBRAS, Nucleoelectrica Argentina SA, CFE, UBS

Brazil

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What nuclear capacity does Brazil have and how significant is this in its energy mix?

Brazil has 2,007MW of current capacity (Angra 1 and 2). Both plants are owned and operated by federally-owned ELETROBRAS (listed). Nuclear represents about 3% of current nominal installed capacity. Nuclear power assets represent less than ~1% of ELETROBRAS's total assets.

What capacity expansion plans existed prior to Fukushima?

No changes to current energy policy. As seen in recent energy auctions for greenfield projects, the government's key focus to tap the 5-6% electricity demand CAGR it estimates for the next 10 years remains renewable sources, namely hydroelectricity (despite the fact that it already contributes >80% of the country's generation) plus biomass and wind farms (growing fast but with a very low base). We think gas will likely be another priority, but only after PETROBRAS is able to confirm what seem to be huge gas reserves from the newly discovered pre-salt accumulations, ie not in the next two to three years.

Nuclear power is part of Brazil's electricity matrix, with the 2,007MW nominal installed capacity of the producing Angra 1 and 2 plants, while the 1,405MW Angra 3 should start up within five years, and there are plans for about 4,000MW in additional power plants in the Government's 30-Year Plan.

What statements have come from regulators or government officials on how plans might change?

The Japan tragedy will raise further questions in the already controversial debate over Brazil's nuclear plans

According to local media reports, the Japan tragedy will raise further questions in the already controversial debate over Brazil's nuclear plans. Leonam dos Santos Guimaraes, assistant to the CEO of Eletronuclear (the ELETROBRAS subsidiary in charge of nuclear power projects) has said, "*There is no reason for delays in existing projects, but delays will likely occur*".

Eletronuclear has stated that the Angra 3 project will not face any change in design or specifications, but there might be improvements for coming projects. Angra 1 and 2 were built to bear quakes of up to 6.5 on the Richter scale and 7m-high waves, although Brazil does not face these types of natural disasters.

Authorities have said that Brazil's safety systems are already more efficient than those at Fukushima

Energy minister Edison Lobão has also indicated that the country's plans will not change, and Minister of Science and Technology Aloízio Mercadante has said that Brazil's safety systems are already more efficient than those of Fukushima, according to local media reports.

However, Senate president Jose Sarney has stated that "*if nuclear power projects already faced restrictions in Brazil, we will have to think a bit more post this Japan tragedy*". We think such a statement applies mainly to Brazil's plan for uranium enrichment—a controversial R$3bn project for the construction of two domestic plants, in partnership with France and Canada.

What changes, if any, do we expect to actually happen?

Angra 3 build-up goes on, but cost is uncertain, in our view. Start up of Angra 3's 1,405MW is expected in 2015, according to the 2019 Expansion Plan, but we think it could be delayed to 2016 (our base case) mostly due to execution risk of ELETROBRAS rather than an energy policy issue.

Angra 3 is already 10% complete according to ELETROBRAS, but the reactors were contracted a long time ago, and the plant should soon get Board approval for the electromechanical build-up phase, Eletronuclear CEO Othon Luiz Pinheiro recently confirmed.

According to an interview with Mr Pinheiro's assistant in the local press, the Angra 3 project will not face any changes in design or specifications, but there might be improvements for upcoming nuclear power projects. However, we note that the German government seems to be re-evaluating €1.3bn in credit letters for German companies that export nuclear power assets, which might lead to cost pressure, in our view.

Angra 3 is being built by Siemens/AREVA, but the project was based on 30-year old technology *"in a country of low safety standards and without an independent nuclear power authority"* according to unnamed German authorities cited in local press reports.

No major implications for current Brazilian nuclear power plants

Brazil not prone to earthquakes, tsunamis or tornadoes, so expect fine tuning on project and design. We also see no major implications from Fukushima for the current Brazilian nuclear plants. Angra 1 and 2 will continue to operate as usual, but the Brazilian authorities will certainly make sure safety safeguards and emergency procedures are reviewed to ensure better risk control.

Angra 1 and 2 were built to bear quakes of up to 6.5 on the Richter scale and 7m-high waves, although Brazil does not face such natural disasters. Moreover, Eletronuclear indicated to Congress (which began a hearing to discuss the topic on 24 March, following the Fukushima incident) that the Angra 1 and 2 reactors are more modern (and allegedly safer) than those used in Japan, while the uranium fuel cycle is very safe in Brazil.

Mr Pinheiro, Eletronuclear's CEO, added that the biggest risk in the nuclear facilities would be fire. He also reassured congressmen that new procedures will be used to improve the energy supply system that cools the reactors in light of the Fukushima incident. The company is even studying building a small hydro plant to secure energy supply and avoid the 'residual heat' that comes with the cooling system used at Fukushima. Questions are also arising regarding infrastructure for evacuation plans, but not on power plant operations per se.

Additional 4GW by 2030 is planned, but the plan is indicative (not determinative). Nuclear expansion was not included in the latest 10-year energy planning study (2010-19). However, the Brazilian government included 4,000MW of nuclear power (four 1,000MW plants) in the longer-horizon plan (2007-2030). The sites have not been confirmed but the government indicates they are likely to be located in the northeast and southeast.

The 4,000MW amount was set based on the quantity of domestic uranium Brazil would be able to supply. We believe that nuclear power, although included in the Government's 2030 Energy Plan, will continue to be left out of upcoming editions of the 10-year energy plan (with the exception of Angra 3, which is under construction).

Costs of nuclear power are already high and may now increase; costs are an important factor for Brazil

Cost also matters for Brazil. One less discussed but equally important issue in the Brazilian debate is the cost of nuclear plants in Brazil. With recent hydro projects showing a US$35-40/MWh generation price, the nuclear power price for consumers of US$81/MWh (Angra 3 price) already seems costly and costs of new nuclear power plants seem to be even higher today.

Argentina and Mexico

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Argentina has the 357MW Atucha I and 648MW Embalse, and is building the 745MW Atucha II. We do not see many implications for Argentina's nuclear plan from Fukushima. We believe the Argentinean government will inaugurate the 745MW Atucha II before the election in October 2011, even though it will not be finished by then.

These nuclear power plants are located in the Pampas, quite far from the earthquake-sensitive areas of the Andes. Atucha II is part of a US$3.5bn project announced in 2006 that includes the revamping of Atucha I and Embalse for an additional 25 years. With negative reserve margins in the country, Atucha II is seen as key by the government and the population to allow Argentina to continue to grow.

Argentina is the only developing country that exports its nuclear technology

Nuclear technology made in Argentina. Argentina is the only developing country that exports its nuclear technology, having exported nuclear facilities to Australia, Egypt and other countries. But we note that if demand for anything related to nuclear energy drops around the world, implications would be quite marginal for the country from a macro standpoint, in our view.

Mexico has the 1,365MW Laguna Verde with two reactors, and could add another ten—but plans remain vague. The Laguna Verde reactors are the same type as Fukushima's and were also built to bear earthquakes of more than 7 on the Richter scale. Located close to Veracruz City, they are safe from tsunamis but in the past faced earthquakes of as high as 6.8. Laguna Verde is currently undergoing a 20% capacity expansion and will need to renew the licence with GE. Some improvements are likely during the expansion, in our view.

However, there are no real plans for adding further nuclear capacity, although the government operating programmes include a few more plants 'with technology to be determined'. Similar to what we see in Brazil or Argentina, we think new nuclear power plants are now even less likely post-Fukushima.

North America

Canada

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What nuclear capacity does Canada have and how significant is this in its energy mix?

Nuclear power represents about 15% of Canada's electricity generation, most of which is concentrated in the province of Ontario where it accounts for half of generation. The country has 17 operational reactors but a further three reactors are being refurbished and will return to service within a year, bringing total generating capacity to 14GW. Upon completion of refurbishments, all but two of the country's reactors will be located at the Bruce (eight), Pickering (six) and Darlington (four) facilities.

Nuclear power represents about 15% of Canada's electricity generation; mostly in Ontario where it accounts for half of generation

All Canadian reactors follow the CANDU design, a pressurised heavy water reactor, unique in its use of heavy water (deuterium-oxide) as the moderator. This design feature permits the use of low-enriched uranium as fuel due to reduced neutron absorption compared to light water reactors. Future new build reactors should incorporate similar technology.

What capacity expansion plans existed prior to Fukushima?

The provinces of Ontario and Alberta are currently considering additional nuclear generation at new and existing sites. However, economic considerations, public resistance and an abundance of hydro and renewable power generation projects have limited progress to date. Nevertheless, a proposal for four additional reactors at the Darlington site continues to move through the regulatory process. In our view, it is unlikely that new nuclear generation will be brought on stream before 2020 given permitting time, construction time, and a lack of necessity. In the interim, we expect most new generation to be natural gas-fired, balancing an increasingly renewable palate. That said, nuclear generation is likely to remain an integral part of Ontario's long-term generation plan.

What statements have come from regulators or government officials on how plans might change?

Authorities have requested that all regional power authorities review initial lessons learned from Fukushima, focusing on risks from external hazards

Canadian nuclear safety is overseen by the Canadian Nuclear Safety Commission (CNSC) which as recently as 22 March went on record that earthquake risk is a non-issue in Canada. That said, the CNSC has requested that all regional power authorities review initial lessons learned from the Japanese disaster, focusing on risks from external hazards and including remedies to address any shortfalls. It should be emphasised that the request from the CNSC is only for a review of existing emergency plans.

What changes, if any, do we expect to actually happen?

A large proportion of Canada's nuclear fleet will reach the end of its planned 40-year life over the next 10 years. Prior to the events in Japan, the Ontario government was committed to refurbishing most existing units to allow for a further 20 years of operation. At present we see no movement to modify these plans. Contributing to the province's commitment to nuclear power is a goal of eliminating coal-fired generation by 2014. We also note that none of the operating facilities are located in geologically sensitive areas.

Given a fairly pragmatic response from the industry to date, we are inclined to expect the status quo in past and prospective plant design.

United States

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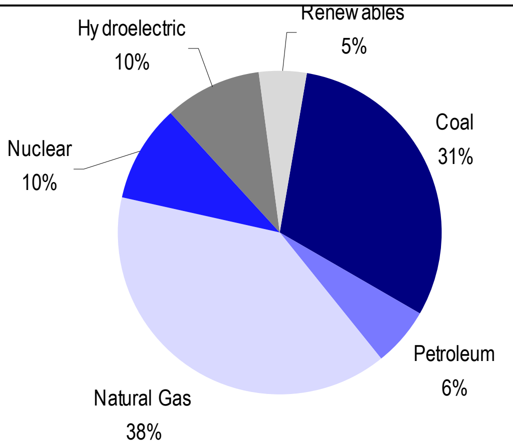
What nuclear capacity does the United States have and how significant is this in its energy mix?

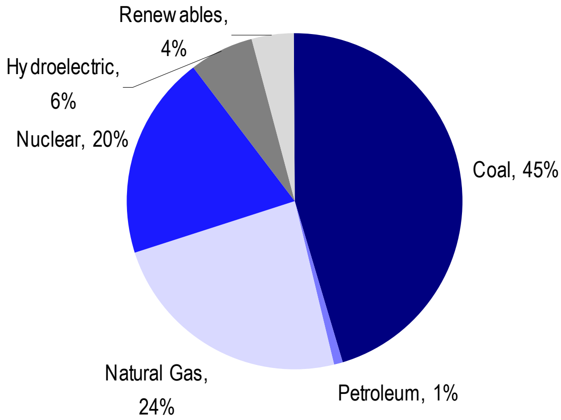
In 2009, the US capacity mix consisted of 10% nuclear, 31% coal, 38% natural gas, 15% renewables (including hydro, wind, and solar), and 6% petroleum. In terms of generation output, the mix was 20% nuclear, 45% coal, 24% natural gas, 10% renewables (including hydro, wind, and solar), and 1% petroleum. Commercial and industrial sales represent 61% of US demand; by region, the Southeast and Mid-Atlantic comprise 51% of total US demand. The US generation and demand profiles are shown in the four charts below.

Chart 59: US generating capacity, 2009



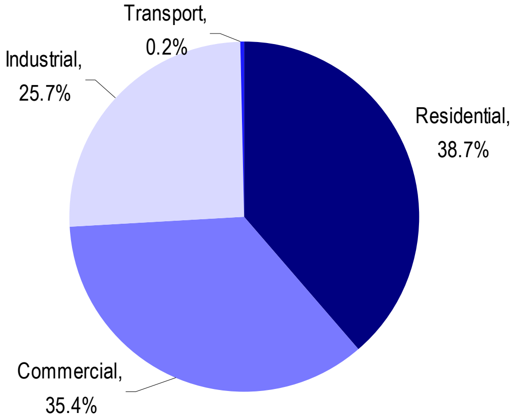
Source: EIA

Chart 60: US generation output, 2009



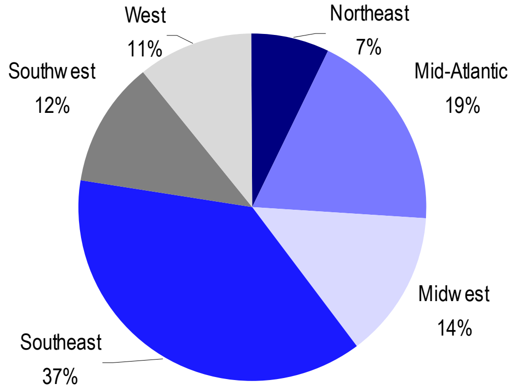
Source: EIA

Chart 61: US electricity demand, by sector, 2010



Source: EIA

Chart 62: US electricity demand, by region, 2010



Source: EIA

Regulatory status of US nuclear fleet

The US nuclear fleet consists of 104 reactor units, totalling 101GW of capacity, according to the Nuclear Regulatory Commission (NRC): 51% of the capacity is operated under regulated regimes, while 41% is merchant-owned. The remaining 8% of the fleet is government-owned.

The majority of the unregulated generation is concentrated in the Illinois to New York City to Washington DC triangle, with Exelon (EXC) and Public Service Enterprise Group (PEG) being the primary owners. Constellation Energy (CEG) and Entergy's (ETR) operations are largely concentrated in New York and New England; Dominion (D) and NextEra's (NEE) un-regulated nuclear plants are in New England and the Midwest.

The US nuclear fleet consists of 104 reactor units, totalling 101GW of capacity

Table 32: Regulatory status of US nuclear fleet

US nuclear capacity - regulatory breakdown	Units	MWe	% of total
Regulated	53	51,171	50.8%
Unregulated	43	41,662	41.3%
Government-owned	8	7,922	7.9%
Total	104	100,755	100.0%

Note: Government-owned figures do not incorporate minority ownership stakes.
Source: NRC, UBS estimates

US nuclear operations with similar technology

There are currently 23 units with a nameplate capacity of 20.8GW utilising GE BWRs with Mark 1 containment structures in the US. Approximately 33% of this capacity is regulated, 48% is unregulated and 20% is government owned. The highest concentrations are with EXC (unregulated), the Tennessee Valley Authority (government), and ETR (the unregulated nuclear fleet operation).

Table 33: US nuclear GE BWR reactors with Mark 1 containment structures

Owner/operator	Reactor name	Net capacity (MWe)	Status
Constellation Energy	Nine Mile Point 1	621	Unreg
DTE Energy	Enrico Fermi 2	1,122	Reg
Entergy	James A. Fitzpatrick	854	Unreg
Entergy	Vermont Yankee 1	620	Unreg
Entergy	Pilgrim 1	685	Unreg
Exelon	Dresden 2	867	Unreg
Exelon	Dresden 3	867	Unreg
Exelon	Oyster Creek 1	615	Unreg
Exelon	Peach Bottom 2	1,112	Unreg
Exelon	Peach Bottom 3	1,112	Unreg
Exelon	Quad Cities 1	867	Reg
Exelon	Quad Cities 2	867	Reg
Nebraska Public Power	Cooper	770	Govt
NextEra Energy	Duane Arnold	580	Unreg
Progress Energy	Brunswick 1	938	Reg
Progress Energy	Brunswick 2	920	Reg
PSEG	Hope Creek 1	1,161	Unreg
Southern Company	Edwin I. Hatch 1	876	Reg
Southern Company	Edwin I. Hatch 2	883	Reg
Tennessee Valley Authority	Browns Ferry 1	1,065	Govt
Tennessee Valley Authority	Browns Ferry 2	1,104	Govt
Tennessee Valley Authority	Browns Ferry 3	1,105	Govt
Xcel	Monticello	572	Reg
Total US Reactors	23	20,182	

Source: NEI, SNL Financial, company data, UBS estimates

More importantly, nuclear has been an anchor fuel source in three of the country's primary manufacturing regions: the Reliability First Corporation (RFC), which is primarily Delaware, Illinois, Indiana, Maryland, Michigan, New Jersey, Ohio, Pennsylvania and West Virginia; the Southeastern Electric Reliability Council (SERC); which is primarily Alabama, Georgia, Mississippi, Missouri, Kentucky, North Carolina, South Carolina, Tennessee and Virginia; and the Northeast Power Coordinating Council (NPCC); primarily Connecticut, Maine, Massachusetts, New York, Rhode Island and Vermont. In each of these three regions, nuclear has historically contributed 25-30% of the overall demand profile.

Nuclear has been an anchor fuel source in three of the country's primary manufacturing regions

Table 34: NERC* regional capacity and generation profiles, 2009

	ERCOT	FRCC	MRO	NPCC	RFC	SERC	SPP	WECC
Capacity (MW)	75,000	55,000	49,000	70,000	220,000	246,000	51,000	160,000
Peak demand (MWh)	64,000	47,000	38,000	56,000	161,000	191,000	41,000	128,000
Capacity by fuel type								
Coal	18%	16%	43%	7%	46%	36%	33%	17%
Gas	66%	53%	27%	44%	28%	39%	53%	42%
Nuclear	5%	7%	7%	13%	14%	13%	2%	5%
Renewables	10%	1%	17%	16%	5%	10%	10%	35%
Oil	0%	23%	5%	20%	6%	3%	2%	0%
Other	0%	0%	0%	0%	1%	0%	0%	0%
Generation by fuel type								
Coal	33%	25%	70%	11%	61%	49%	60%	30%
Gas	49%	47%	3%	36%	8%	17%	27%	31%
Nuclear	12%	14%	14%	30%	28%	26%	4%	9%
Renewables	6%	2%	13%	20%	3%	7%	9%	29%
Oil	0%	10%	0%	2%	0%	0%	0%	0%
Other	0%	1%	0%	0%	0%	0%	0%	0%

*North American Electric Reliability Corporation.
Source: EIA, SNL, UBS estimates

As shown in the table above, the SERC and RFC regions meet a substantial portion of their demand through a combination of base load nuclear and coal; these two low-cost fuel sources have allowed the region to attract business customers. We estimate replacing nuclear generation entirely with gas in the SERC region would create an incremental demand of 6.4 bcf/d in gas, equivalent to roughly 11% the country's current daily consumption. This could have negative implications for the US manufacturing base cost structures, especially in a rising gas price environment.

Table 35: Nuclear-to-gas switching analysis

	Peak	Off peak
New nuclear plant capacity (MW)	1,000	1,000
Avg. marginal heat rate (btu/Kwh)	10,500	6,500
Heat rate (mmbtu/Mwh)	10.50	6.50
Annual hours	8,760	8,760
Availability factor	95%	95%
Capacity factor	90%	90%
Annual mmBTU burned	78,642,900	48,683,700
Annual bcf burned	76.58	47.51
Peak hours (5x16)	0.48	0.52
Daily on peak bcf burned @100% gas on margin	0.10	0.07
% gas on margin	100%	50%
Adjusted gas burn daily bcf	0.10	0.04
Daily mmcf burned	99.91	68.04

Source: UBS estimates

What capacity expansion plans existed prior to Fukushima?

New build applications

Prior to the Japanese earthquake, Southern (SO) and Scana (SCG) were the only two companies on track to build new nuclear. Both had chosen the Westinghouse AP1000 design and were undertaking significant site preparation work. The companies expect to receive their construction and operating licences (COL) in late 2011/early 2012, allowing them to proceed with construction. It should be noted that the AP1000 design has passed key technical safety hurdles, including seismic, tsunami, and backup power systems safety risk.

SO will operate and own 45.7% of the two new Vogtle units; its co-owners and partners are Georgia-based municipalities. SO's share of the two new units will add a total of 1,100 MW to its overall capacity, at an approximate cost of US$6.1bn. SCG will operate and own 55% of two proposed units totalling 2,234 MW at the existing VC Summer nuclear facility. SCG's total projected cost is US$6.3bn, including financing. Since the earthquake, both companies have stated that they remain on budget and on schedule.

While we concur, in theory, with both companies' assessment that their plans remain on track, in reality SO and SCG are both currently awaiting receipt of a COL from the NRC, and we expect these COLs to be delayed.

SO and SCG are both awaiting receipt of a COL from the NRC, and we expect these to be delayed

In addition to SO and SCG, Dominion Resources (D), Duke Energy (DUK), NextEra Energy Resources (NEE), and Progress Energy (PGN) each contemplate new reactors. Constellation Energy (CEG) withdrew its request for new nuclear due to factors other than Japan. On 22 March, NRG Energy (NRG) acknowledged that its new nuclear aspirations at the South Texas Project faced seemingly insurmountable hurdles, in part due to difficulties associated with securing financing from its Japan-based financial partners, TEPCO and Toshiba.

Licence extensions

There are 19 licence extension applications pending before the NRC, involving a total 20.8GW of capacity. Another application, from Vermont Yankee, was approved by the NRC on 21 March, but immediately faced political pressure to reconsider for additional safety evaluations and in light of the timing immediately following the Japanese situation.

Table 36: Pending nuclear licence applications

Reactor	Net capacity (MWe)	Renewal application date	Licence expiration date	Years in operation
Pilgrim 1	685	12/1/1972	6/8/2012	38.4
Vermont Yankee 1	620	11/30/1972	3/21/2012	38.4
Indian Point 2	1,025	8/1/1974	9/28/2013	36.7
Indian Point 3	1,040	8/30/1976	12/15/2015	34.6
Prairie Island 1	551	12/16/1973	8/9/2013	37.3
Prairie Island 2	545	12/21/1974	10/29/2014	36.3
Palo Verde 1	1,311	1/28/1986	6/1/2025	25.2
Palo Verde 2	1,314	9/19/1986	4/24/2026	24.5
Palo Verde 3	1,317	1/8/1988	11/25/2027	23.2
Crystal River 3	860	3/13/1977	12/3/2016	34.1
Hope Creek 1	1,161	12/20/1986	4/11/2026	24.3
Salem 1	1,174	6/30/1977	8/13/2016	33.8
Salem 2	1,158	10/13/1981	4/18/2020	29.5
Diablo Canyon 1	1,122	5/7/1985	11/2/2024	25.9
Diablo Canyon 2	1,118	3/13/1986	8/20/2025	25.1
Columbia Generating Station 2	1,131	12/13/1984	12/20/2023	26.3
Seabrook 1	1,245	8/19/1990	3/15/2030	20.6
Davis Besse	879	7/31/1978	4/22/2017	32.7
South Texas Project 1	1,280	8/25/1988	8/20/2027	22.6
South Texas Project 2	1,280	6/19/1989	12/15/2028	21.8
Total	20,817			

Source: NRC

Uprates

According to the NRC, there have been 5,810MW of completed uprates since 1977 and another 1,568MW that are expected to be completed by 2013. In aggregate, the amount of the planned uprates equates to an increase of 1.5% of current nuclear capacity. Several of the planned uprates, namely the Brown's Ferry units, could face incremental headwinds given that the Tennessee Valley Authority is a government authority.

Table 37: Uprate applications currently under review

Reactor	%	MWt	MWe	Expected completion date	Type*
Browns Ferry 1	14.3	494.0	164.7	TBD	E
Browns Ferry 2	14.3	494.0	164.7	TBD	E
Browns Ferry 3	14.3	494.0	164.7	TBD	E
Monticello	12.9	229.0	76.3	TBD	E
Point Beach 1	17.0	260.0	86.7	Fall 2011	E
Point Beach 2	17.0	260.0	86.7	Spring 2011	E
Nine Mile Point 2	15.0	521.0	173.7	Fall 2011	E
Limerick 1	1.6	57.0	19.0	March 2011	MU
Limerick 2	1.6	57.0	19.0	March 2011	MU
Grand Gulf	13.1	510.0	170.0	Fall 2011	E
Turkey Point 3	15.0	344.0	114.7	Fall 2011	E
Turkey Point 4	15.0	344.0	114.7	Fall 2011	E
St. Lucie 1	11.9	320.0	106.7	TBD	E
St. Lucie 2	11.9	320.0	106.7	TBD	E
Total		4,704.0	1,568.0		

*E = Extended, MU = Measurement Uncertainty Recapture; MWt = Megawatts thermal, MWe = Megawatts electric.
Note: As at 16 March 2011.
Source: NRC

What statements have come from regulators or government officials on how plans might change?

At this stage, the US government remains committed to nuclear power

At this stage, the US government remains committed to nuclear power. In prepared remarks to the House Energy and Commerce Committee on 15 March, Energy Secretary Chu stated that: *"the Administration believes we must rely on a diverse set of energy sources, including renewables like wind and solar, natural gas, clean coal and nuclear power. The Administration is committed to learning from Japan's experience as we work to continue to strengthen America's nuclear industry"*. Later in the week, President Obama echoed those comments while ordering a comprehensive review of the country's nuclear power facilities. Many in Congress, both Democrats and Republicans, have expressed continued support for nuclear but want more feasibility studies conducted. The lone holdout is Massachusetts Senator Markey. New York's Governor Cuomo and California Senator Boxer have led the charge for additional attention regarding seismic risk and plant proximity to large metropolitan areas.

What changes, if any, do we expect to actually happen?

We expect the US to delay licence extensions, uprates, and new licence applications until an assessment of the Fukushima situation is complete

We expect the US to delay licence extensions, uprates, and new licence applications until an assessment of the Fukushima situation is complete. Following the Three Mile Island (TMI) incident in 1979, there were substantial delays with the new build cycle (51 units were in construction at the time of TMI). A final report on TMI took more than a year to complete following an extensive root cause assessment. Once that report was complete, new regulatory requirements as well as changes to existing regulations occurred, resulting in scheduling delays and cost overruns. Importantly, during this time, our understanding is that the NRC provided limited leadership to companies on how to proceed, which exacerbated the financial impact and time delays.

At this stage, we anticipate the following:

- A delay of at least one year for all pending applications: uprates, extensions, new facilities. We think the licence application process could become a bit more fractious;
- A significant amount of incremental analysis on plants in known seismic or tsunami susceptible regions. In the US, the Pacific Northwest to Alaska is the only region with subduction plate tectonics similar to Japan;
- A significant amount of incremental analysis on back-up power and battery systems;
- Further strengthening of safety systems for those nuclear facilities located near major population centres;
- An evaluation of asset concentration (number of units at a single site or close proximity);
- We believe there will be a re-doubling of efforts on spent fuel management policy and the debate between on-site and off-site storage is likely to escalate at both the Federal and state levels. Yucca Mountain in Nevada is the chosen, but unutilised, off-site repository. Energy Secretary Chu is not in favour of off-site storage, but the Fukushima events call into question the validity of on-site storage;
- We expect renewed focus on the status of decommissioning funding levels;
- We expect a host of yet-to-be-determined regulations that will emanate from the final Fukushima assessment;
- We do not expect a unilateral ordering of nuclear plant shutdowns. The impact on the economy and the companies would be significant. The earnings, cash flow and balance sheet impacts for both regulated and merchant nuclear ownership, the incremental demand for natural gas, and the attendant end-user price increases appear to be untenable;
- We expect the Institute of Nuclear Power Operators (INPO) (see 'Oversight' below), to release its preliminary assessment of the state of the US nuclear industry in early summer. INPO has ordered a 90-day status report on all nuclear facilities and is expected to have interim 30- and 60-day reports. INPO has order an 'A to Z' inspection of each site but has not made public its criteria; and,
- We expect renewed focus on energy policy in the US, but any such policy is unlikely until the conclusion of the next presidential election (November 2012).

Oversight: Following the TMI incident, there was a complete rebuild of the US nuclear power industry. There were numerous modifications to plant, plant trains, etc, including the implementation of physical modifications, human performance evaluations, and safety systems, among others. INPO was formed and strict standards were established. Additionally, significant oversight occurred, including mandatory plant inspections every two years that include a top to bottom review of all aspects of a plant's operations, design basis, and safety systems. Further, the formation of INPO created a minimum requirement for two resident inspectors to be permanently assigned to each unit.

Following TMI, there was a complete rebuild of the US industry and significant oversight was introduced, this could be repeated now

Following Chernobyl, the World Association of Nuclear Power Operators (WANO) was formed, but it still does not have the accountability and safety requirements that INPO requires in the US. For example, WANO recommends inspections every five to six years, but has no enforcement power.

After the 9/11 terror attacks in the United States, B.5.b. rules were implemented regarding safety beyond the design basis. These were security measures designed to thwart terrorist activities.

Appendix 1: Nuclear reactors operational globally

Table 38: Nuclear reactors operational around the world as of end-2010

Serial No.	Country	Station	Type	Net Capacity (MWe)	Operator	Reactor Supplier	Commercial	Age
1	Argentina	ATUCHA-1	PHWR	335	Nucleoelectrica Argentina	Siemens	24-Jun-74	36.79
2	Argentina	EMBALSE	PHWR	600	Nucleoelectrica Argentina	Atomic Energy of Canada Ltd (AECL)	20-Jan-84	27.21
3	Armenia	ARMENIA-2	PWR	376	ANPPJSC	FAEA	3-May-80	30.93
4	Belgium	DOEL-1	PWR	392	Electrabel	Acecowen	15-Feb-75	36.15
5	Belgium	DOEL-2	PWR	433	Electrabel	Acecowen	1-Dec-75	35.36
6	Belgium	DOEL-3	PWR	1,006	Electrabel	Framaceco	1-Oct-82	28.52
7	Belgium	DOEL-4	PWR	1,008	Electrabel	Acecowen	1-Jul-85	25.77
8	Belgium	TIHANGE-1	PWR	962	Electrabel	ACLF	1-Oct-75	35.52
9	Belgium	TIHANGE-2	PWR	1,008	Electrabel	Framaceco	1-Jun-83	27.85
10	Belgium	TIHANGE-3	PWR	1,015	Electrabel	Acecowen	1-Sep-85	25.60
11	Brazil	ANGRA-1	PWR	626	Eletronuclear	Westinghouse	1-Dec-84	26.35
12	Brazil	ANGRA-2	PWR	1,270	Eletronuclear	KWU	1-Feb-01	10.17
13	Bulgaria	KOZLODUY-5	PWR	953	KOZNPP	AEE	23-Dec-88	22.28
14	Bulgaria	KOZLODUY-6	PWR	953	KOZNPP	AEE	30-Dec-93	17.26
15	Canada	BRUCE-3	PHWR	750	Bruce Power	NEI.P	1-Feb-78	33.18
16	Canada	BRUCE-4	PHWR	750	Bruce Power	NEI.P	18-Jan-79	32.22
17	Canada	BRUCE-5	PHWR	790	Bruce Power	OH/AECL	1-Mar-85	26.10
18	Canada	BRUCE-6	PHWR	822	Bruce Power	OH/AECL	14-Sep-84	26.56
19	Canada	BRUCE-7	PHWR	806	Bruce Power	OH/AECL	10-Apr-86	24.99
20	Canada	BRUCE-8	PHWR	795	Bruce Power	OH/AECL	22-May-87	23.88
21	Canada	DARLINGTON-1	PHWR	878	Ontario Power Generation	OH/AECL	14-Nov-92	18.39
22	Canada	DARLINGTON-2	PHWR	878	Ontario Power Generation	OH/AECL	9-Oct-90	20.49
23	Canada	DARLINGTON-3	PHWR	878	Ontario Power Generation	OH/AECL	14-Feb-93	18.14
24	Canada	DARLINGTON-4	PHWR	878	Ontario Power Generation	OH/AECL	14-Jun-93	17.81
25	Canada	GENTILLY-2	PHWR	635	Ontario Power Generation	BBC	1-Oct-83	27.52
26	Canada	PICKERING-1	PHWR	515	Ontario Power Generation	OH/AECL	29-Jul-71	39.70
27	Canada	PICKERING-4	PHWR	515	Ontario Power Generation	OH/AECL	17-Jun-73	37.81
28	Canada	PICKERING-5	PHWR	516	Ontario Power Generation	OH/AECL	10-May-83	27.91
29	Canada	PICKERING-6	PHWR	516	Ontario Power Generation	OH/AECL	1-Feb-84	27.18
30	Canada	PICKERING-7	PHWR	516	Ontario Power Generation	OH/AECL	1-Jan-85	26.26
31	Canada	PICKERING-8	PHWR	516	Ontario Power Generation	OH/AECL	28-Feb-86	25.10
32	Canada	POINT LEPREAU	PHWR	635	NB Power	AECL	1-Feb-83	28.18
33	China	Daya Bay-1	PWR	984	Ching Guangdong Nuclear Power Corporation	FRAM	1-Feb-94	17.17
34	China	Daya Bay-2	PWR	984	Ching Guangdong Nuclear Power Corporation	FRAM	7-May-94	16.91
35	China	LINGAO 1	PWR	990	Ching Guangdong Nuclear Power Corporation	FRAM	28-May-02	8.85
36	China	LINGAO 2	PWR	990	Ching Guangdong Nuclear Power Corporation	FRAM	8-Jan-03	8.23
37	China	LINGAO 3	PWR	1,080	Ching Guangdong Nuclear Power Corporation	DFEC	15-Dec-10	0.29
38	China	QINSHAN 1	PWR	310	China National Nuclear Corporation	China National Nuclear Corporation	1-Apr-94	17.01
39	China	QINSHAN 2-1	PWR	650	China National Nuclear Corporation	China National Nuclear Corporation	18-Apr-02	8.96
40	China	QINSHAN 2-2	PWR	650	China National Nuclear Corporation	China National Nuclear Corporation	3-May-04	6.92
41	China	QINSHAN 2-3	PWR	650	China National Nuclear Corporation	China National Nuclear Corporation	28-Mar-11	0.01
42	China	QINSHAN 3-1	PHWR	700	China National Nuclear Corporation	AECL	31-Dec-02	8.25
43	China	QINSHAN 3-2	PHWR	700	China National Nuclear Corporation	AECL	24-Jul-03	7.69
44	China	TIANWAN 1	PWR	1,060	China National Nuclear Corporation	AEE&ZAES	17-May-07	3.88

Table 38: Nuclear reactors operational around the world as of end-2010 (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Operator	Reactor Supplier	Commercial	Age
45	China	TIANWAN 2	PWR	1,060	China National Nuclear Corporation	AEE&ZAES	16-Aug-07	3.63
46	Czech Republic	DUKOVANY-1	PWR	412	CEZ	SKODA	3-May-85	25.93
47	Czech Republic	DUKOVANY-2	PWR	412	CEZ	SKODA	21-Mar-86	25.05
48	Czech Republic	DUKOVANY-3	PWR	427	CEZ	SKODA	20-Dec-86	24.30
49	Czech Republic	DUKOVANY-4	PWR	427	CEZ	SKODA	19-Jul-87	23.72
50	Czech Republic	TEMELIN-1	PWR	930	CEZ	SKODA	10-Jun-02	8.81
51	Czech Republic	TEMELIN-2	PWR	930	CEZ	SKODA	18-Apr-03	7.96
52	Finland	LOVIISA-1	PWR	510/488	Fortum	AEE	9-May-77	33.92
53	Finland	LOVIISA-2	PWR	510/488	Fortum	AEE	5-Jan-81	30.25
54	Finland	OLKILUOTO-1	BWR	890/860	Teollisuuden Voima (TVO)	ASEASTAL	10-Oct-79	31.50
55	Finland	OLKILUOTO-2	BWR	890/860	Teollisuuden Voima (TVO)	ASEASTAL	10-Jul-82	28.75
56	France	BELLEVILLE-1	PWR	1,310	Electricite de France (EdF)	FRAM	1-Jun-88	22.85
57	France	BELLEVILLE-2	PWR	1,310	Electricite de France (EdF)	FRAM	1-Jan-89	22.26
58	France	BLAYAIS-1	PWR	910	Electricite de France (EdF)	FRAM	1-Dec-81	29.35
59	France	BLAYAIS-2	PWR	910	Electricite de France (EdF)	FRAM	1-Feb-83	28.18
60	France	BLAYAIS-3	PWR	910	Electricite de France (EdF)	FRAM	14-Nov-83	27.40
61	France	BLAYAIS-4	PWR	910	Electricite de France (EdF)	FRAM	1-Oct-83	27.52
62	France	BUGEY-2	PWR	910	Electricite de France (EdF)	FRAM	1-Mar-79	32.11
63	France	BUGEY-3	PWR	910	Electricite de France (EdF)	FRAM	1-Mar-79	32.11
64	France	BUGEY-4	PWR	880	Electricite de France (EdF)	FRAM	1-Jul-79	31.77
65	France	BUGEY-5	PWR	880	Electricite de France (EdF)	FRAM	3-Jan-80	31.26
66	France	CATTENOM-1	PWR	1,300	Electricite de France (EdF)	FRAM	1-Apr-87	24.02
67	France	CATTENOM-2	PWR	1,300	Electricite de France (EdF)	FRAM	1-Feb-88	23.18
68	France	CATTENOM-3	PWR	1,300	Electricite de France (EdF)	FRAM	1-Feb-91	20.18
69	France	CATTENOM-4	PWR	1,300	Electricite de France (EdF)	FRAM	1-Jan-92	19.26
70	France	CHINON-B-1	PWR	905	Electricite de France (EdF)	FRAM	1-Feb-84	27.18
71	France	CHINON-B-2	PWR	905	Electricite de France (EdF)	FRAM	1-Aug-84	26.68
72	France	CHINON-B-3	PWR	905	Electricite de France (EdF)	FRAM	4-Mar-87	24.09
73	France	CHINON-B-4	PWR	905	Electricite de France (EdF)	FRAM	1-Apr-88	23.01
74	France	CHOOZ-B-1	PWR	1,500	Electricite de France (EdF)	FRAM	15-May-00	10.88
75	France	CHOOZ-B-2	PWR	1,500	Electricite de France (EdF)	FRAM	29-Sep-00	10.51
76	France	CIVAUX-1	PWR	1,495	Electricite de France (EdF)	FRAM	29-Jan-02	9.18
77	France	CIVAUX-2	PWR	1,495	Electricite de France (EdF)	FRAM	23-Apr-02	8.95
78	France	CRUAS-1	PWR	915	Electricite de France (EdF)	FRAM	2-Apr-84	27.01
79	France	CRUAS-2	PWR	915	Electricite de France (EdF)	FRAM	1-Apr-85	26.02
80	France	CRUAS-3	PWR	915	Electricite de France (EdF)	FRAM	10-Sep-84	26.57
81	France	CRUAS-4	PWR	915	Electricite de France (EdF)	FRAM	11-Feb-85	26.15
82	France	DAMPIERRE-1	PWR	890	Electricite de France (EdF)	FRAM	10-Sep-80	30.58
83	France	DAMPIERRE-2	PWR	890	Electricite de France (EdF)	FRAM	16-Feb-81	30.14
84	France	DAMPIERRE-3	PWR	890	Electricite de France (EdF)	FRAM	27-May-81	29.87
85	France	DAMPIERRE-4	PWR	890	Electricite de France (EdF)	FRAM	20-Nov-81	29.38
86	France	FESSENHEIM-1	PWR	880	Electricite de France (EdF)	FRAM	1-Jan-78	33.27
87	France	FESSENHEIM-2	PWR	880	Electricite de France (EdF)	FRAM	1-Apr-78	33.02
88	France	FLAMANVILLE-1	PWR	1,330	Electricite de France (EdF)	FRAM	1-Dec-86	24.35
89	France	FLAMANVILLE-2	PWR	1,330	Electricite de France (EdF)	FRAM	9-Mar-87	24.08
90	France	GOLFECH-1	PWR	1,310	Electricite de France (EdF)	FRAM	1-Feb-91	20.18
91	France	GOLFECH-2	PWR	1,310	Electricite de France (EdF)	FRAM	4-Mar-94	17.09
92	France	GRAVELINES-1	PWR	910	Electricite de France (EdF)	FRAM	25-Nov-80	30.37
93	France	GRAVELINES-2	PWR	910	Electricite de France (EdF)	FRAM	1-Dec-80	30.35
94	France	GRAVELINES-3	PWR	910	Electricite de France (EdF)	FRAM	1-Jun-81	29.85
95	France	GRAVELINES-4	PWR	910	Electricite de France (EdF)	FRAM	1-Oct-81	29.52
96	France	GRAVELINES-5	PWR	910	Electricite de France (EdF)	FRAM	15-Jan-85	26.22
97	France	GRAVELINES-6	PWR	910	Electricite de France (EdF)	FRAM	25-Oct-85	25.45

Table 38: Nuclear reactors operational around the world as of end-2010 (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Operator	Reactor Supplier	Commercial	Age
98	France	NOGENT-1	PWR	1,310	Electricite de France (EdF)	FRAM	24-Feb-88	23.12
99	France	NOGENT-2	PWR	1,310	Electricite de France (EdF)	FRAM	1-May-89	21.93
100	France	PALUEL-1	PWR	1,330	Electricite de France (EdF)	FRAM	1-Dec-85	25.35
101	France	PALUEL-2	PWR	1,330	Electricite de France (EdF)	FRAM	1-Dec-85	25.35
102	France	PALUEL-3	PWR	1,330	Electricite de France (EdF)	FRAM	1-Feb-86	25.18
103	France	PALUEL-4	PWR	1,330	Electricite de France (EdF)	FRAM	1-Jun-86	24.85
104	France	PENLY-1	PWR	1,330	Electricite de France (EdF)	FRAM	1-Dec-90	20.35
105	France	PENLY-2	PWR	1,330	Electricite de France (EdF)	FRAM	1-Nov-92	18.42
106	France	ST. ALBAN-1	PWR	1,335	Electricite de France (EdF)	FRAM	1-May-86	24.93
107	France	ST. ALBAN-2	PWR	1,335	Electricite de France (EdF)	FRAM	1-Mar-87	24.10
108	France	ST. LAURENT-B-1	PWR	915	Electricite de France (EdF)	FRAM	1-Aug-83	27.68
109	France	ST. LAURENT-B-2	PWR	915	Electricite de France (EdF)	FRAM	1-Aug-83	27.68
110	France	TRICASTIN-1	PWR	915	Electricite de France (EdF)	FRAM	1-Dec-80	30.35
111	France	TRICASTIN-2	PWR	915	Electricite de France (EdF)	FRAM	1-Dec-80	30.35
112	France	TRICASTIN-3	PWR	915	Electricite de France (EdF)	FRAM	11-May-81	29.91
113	France	TRICASTIN-4	PWR	915	Electricite de France (EdF)	FRAM	1-Nov-81	29.43
114	Germany	BIBLIS-A (KWB A)	PWR	1,167	RWE	KWU	26-Feb-75	36.12
115	Germany	BIBLIS-B (KWB B)	PWR	1,240	RWE	KWU	31-Jan-77	34.19
116	Germany	BROKDORF (KBR)	PWR	1,370	E.ON	KWU	22-Dec-86	24.29
117	Germany	BRUNSBUETTEL (KKB)	BWR	771	KKB	KWU	9-Feb-77	34.16
118	Germany	EMSLAND (KKE)	PWR	1,329	KLE	SIEM, KWU	20-Jun-88	22.79
119	Germany	GRAFENRHEINFELD (KKG)	PWR	1,275	E.ON	KWU	17-Jun-82	28.81
120	Germany	GROHNDE (KWG)	PWR	1,360	E.ON	KWU	1-Feb-85	26.18
121	Germany	GUNDREMMINGEN-B (KRB B)	BWR	1,284	KGG	KWU	19-Jul-84	26.72
122	Germany	GUNDREMMINGEN-C (KRB C)	BWR	1,288	KGG	KWU	18-Jan-85	26.22
123	Germany	ISAR-1 (KKI 1)	BWR	878	E.ON	KWU	21-Mar-79	32.05
124	Germany	ISAR-2 (KKI 2)	PWR	1,400	E.ON	KWU	9-Apr-88	22.99
125	Germany	KRUEMMEL (KKK)	BWR	1,320	KKK	KWU	28-Mar-84	27.03
126	Germany	NECKARWESTHEIM-1 (GKN 1)	PWR	785	EnBW	KWU	1-Dec-76	34.35
127	Germany	NECKARWESTHEIM-2 (GKN 2)	PWR	1,269	EnBW	SIEM, KWU	15-Apr-89	21.98
128	Germany	PHILIPPSBURG-1 (KKP 1)	BWR	890	EnBW	KWU	26-Mar-80	31.04
129	Germany	PHILIPPSBURG-2 (KKP 2)	PWR	1,392	EnBW	KWU	18-Apr-85	25.97
130	Germany	UNTERWESER (KKU)	PWR	1,345	E.ON	KWU	6-Sep-79	31.59
131	Hungary	PAKS-1	PWR	437	PAKS RT.	AEE	10-Aug-83	27.66
132	Hungary	PAKS-2	PWR	441	PAKS RT.	AEE	14-Nov-84	26.39
133	Hungary	PAKS-3	PWR	433	PAKS RT.	AEE	1-Dec-86	24.35
134	Hungary	PAKS-4	PWR	444	PAKS RT.	AEE	1-Nov-87	23.43
135	India	KAIGA-1	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	CANDU	16-Nov-00	10.38
136	India	KAIGA-2	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	CANDU	16-Mar-00	11.05
137	India	KAIGA-3	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	CANDU	6-May-07	3.91
138	India	KAIGA-4	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	CANDU	20-Jan-11	0.19
139	India	KAKRAPAR-1	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	6-May-93	17.92
140	India	KAKRAPAR-2	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	1-Sep-95	15.59
141	India	MADRAS-1	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	27-Jan-84	27.19
142	India	MADRAS-2	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	21-Mar-86	25.05

Table 38: Nuclear reactors operational around the world as of end-2010 (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Operator	Reactor Supplier	Commercial	Age
143	India	NARORA-1	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	1-Jan-91	20.26
144	India	NARORA-2	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	1-Jul-92	18.76
145	India	RAJASTHAN-1	PHWR	90	Nuclear Power Corp of India Ltd (NPCIL)	AECL	16-Dec-73	37.32
146	India	RAJASTHAN-2	PHWR	187	Nuclear Power Corp of India Ltd (NPCIL)	AECL/DAE	1-Apr-81	30.02
147	India	RAJASTHAN-3	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	1-Jun-00	10.84
148	India	RAJASTHAN-4	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	23-Dec-00	10.28
149	India	RAJASTHAN-5	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	4-Feb-10	1.15
150	India	RAJASTHAN-6	PHWR	202	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	31-Mar-10	1.00
151	India	TARAPUR-1	BWR	150	Nuclear Power Corp of India Ltd (NPCIL)	GE	28-Oct-69	41.45
152	India	TARAPUR-2	BWR	150	Nuclear Power Corp of India Ltd (NPCIL)	GE	28-Oct-69	41.45
153	India	TARAPUR-3	PHWR	490	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	18-Aug-06	4.62
154	India	TARAPUR-4	PHWR	490	Nuclear Power Corp of India Ltd (NPCIL)	Department of Atomic Energy (DAE)	12-Sep-05	5.55
155	Japan	FUKUSHIMA-DAIICHI-2	BWR	760	Tokyo Electric Power Co (TEPCO)	GE/Toshiba	18-Jul-74	36.73
156	Japan	FUKUSHIMA-DAIICHI-3	BWR	760	Tokyo Electric Power Co (TEPCO)	Toshiba	27-Mar-76	35.04
157	Japan	FUKUSHIMA-DAIICHI-4	BWR	760	Tokyo Electric Power Co (TEPCO)	Hitachi	12-Oct-78	32.49
158	Japan	FUKUSHIMA-DAIICHI-5	BWR	760	Tokyo Electric Power Co (TEPCO)	Toshiba	18-Apr-78	32.98
159	Japan	FUKUSHIMA-DAIICHI-6	BWR	1,067	Tokyo Electric Power Co (TEPCO)	GE/Toshiba	24-Oct-79	31.46
160	Japan	FUKUSHIMA-DAINI-1	BWR	1,067	Tokyo Electric Power Co (TEPCO)	Toshiba	20-Apr-82	28.97
161	Japan	FUKUSHIMA-DAINI-2	BWR	1,067	Tokyo Electric Power Co (TEPCO)	Hitachi	3-Feb-84	27.18
162	Japan	FUKUSHIMA-DAINI-3	BWR	1,067	Tokyo Electric Power Co (TEPCO)	Toshiba	21-Jun-85	25.79
163	Japan	FUKUSHIMA-DAINI-4	BWR	1,067	Tokyo Electric Power Co (TEPCO)	Hitachi	25-Aug-87	23.62
164	Japan	GENKAI-1	PWR	529	Kyushu Electric Power	MHI	15-Oct-75	35.48
165	Japan	GENKAI-2	PWR	529	Kyushu Electric Power	MHI	30-Mar-81	30.02
166	Japan	GENKAI-3	PWR	1,127	Kyushu Electric Power	MHI	18-Mar-94	17.05
167	Japan	GENKAI-4	PWR	1,127	Kyushu Electric Power	MHI	25-Jul-97	13.69
168	Japan	HAMAOKA-3	BWR	1,056	Chubu Electric Power	Toshiba	28-Aug-87	23.61
169	Japan	HAMAOKA-4	BWR	1,092	Chubu Electric Power	Toshiba	3-Sep-93	17.59
170	Japan	HAMAOKA-5	BWR	1,325	Chubu Electric Power	Toshiba	18-Jan-05	6.20
171	Japan	HIGASHI DORI 1 (TOHOKU)	BWR	1,067	Tohuku Electric Power	Toshiba	8-Dec-05	5.32
172	Japan	IKATA-1	PWR	538	Shikoku Electric Power	MHI	30-Sep-77	33.52
173	Japan	IKATA-2	PWR	538	Shikoku Electric Power	MHI	19-Mar-82	29.05
174	Japan	IKATA-3	PWR	846	Shikoku Electric Power	MHI	15-Dec-94	16.30
175	Japan	KASHIWAZAKI KARIWA-1	BWR	1,067	Tokyo Electric Power Co (TEPCO)	Toshiba	18-Sep-85	25.55
176	Japan	KASHIWAZAKI KARIWA-2	BWR	1,067	Tokyo Electric Power Co (TEPCO)	Toshiba	28-Sep-90	20.52
177	Japan	KASHIWAZAKI KARIWA-3	BWR	1,067	Tokyo Electric Power Co (TEPCO)	Toshiba	11-Aug-93	17.65
178	Japan	KASHIWAZAKI KARIWA-4	BWR	1,067	Tokyo Electric Power Co (TEPCO)	Hitachi	11-Aug-94	16.65
179	Japan	KASHIWAZAKI KARIWA-5	BWR	1,067	Tokyo Electric Power Co (TEPCO)	Hitachi	10-Apr-90	20.99
180	Japan	KASHIWAZAKI KARIWA-6	BWR	1,315	Tokyo Electric Power Co (TEPCO)	Toshiba	7-Nov-96	14.41
181	Japan	KASHIWAZAKI KARIWA-7	BWR	1,315	Tokyo Electric Power Co (TEPCO)	Hitachi	2-Jul-97	13.76
182	Japan	MIHAMA-1	PWR	320	Kansai Electric Power Co	Westinghouse	28-Nov-70	40.37
183	Japan	MIHAMA-2	PWR	470	Kansai Electric Power Co	Westinghouse	25-Jul-72	38.71
184	Japan	MIHAMA-3	PWR	780	Kansai Electric Power Co	MHI	1-Dec-76	34.35
185	Japan	OHI-1	PWR	1,120	Kansai Electric Power Co	Westinghouse	27-Mar-79	32.04
186	Japan	OHI-2	PWR	1,120	Kansai Electric Power Co	Westinghouse	5-Dec-79	31.34
187	Japan	OHI-3	PWR	1,127	Kansai Electric Power Co	MHI	18-Dec-91	19.30
188	Japan	OHI-4	PWR	1,127	Kansai Electric Power Co	MHI	2-Feb-93	18.17

Table 38: Nuclear reactors operational around the world as of end-2010 (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Operator	Reactor Supplier	Commercial	Age
189	Japan	ONAGAWA-1	BWR	498	Tohuku Electric Power	Hitachi	1-Jun-84	26.85
190	Japan	ONAGAWA-2	BWR	796	Tohuku Electric Power	Hitachi	28-Jul-95	15.69
191	Japan	ONAGAWA-3	BWR	796	Tohuku Electric Power	Hitachi	30-Jan-02	9.17
192	Japan	SENDAI-1	PWR	846	Kyushu Electric Power	MHI	4-Jul-84	26.76
193	Japan	SENDAI-2	PWR	846	Kyushu Electric Power	MHI	28-Nov-85	25.36
194	Japan	SHIKA-1	BWR	505	Hokuriku Electric Power	Hitachi	30-Jul-93	17.68
195	Japan	SHIKA-2	BWR	1,304	Hokuriku Electric Power	Hitachi	15-Mar-06	5.05
196	Japan	SHIMANE-1	BWR	439	Chugoku Electric Power Co	Hitachi	29-Mar-74	37.03
197	Japan	SHIMANE-2	BWR	789	Chugoku Electric Power Co	Hitachi	10-Feb-89	22.15
198	Japan	TAKAHAMA-1	PWR	780	Kansai Electric Power Co	WH/MHI	14-Nov-74	36.40
199	Japan	TAKAHAMA-2	PWR	780	Kansai Electric Power Co	MHI	14-Nov-75	35.40
200	Japan	TAKAHAMA-3	PWR	830	Kansai Electric Power Co	MHI	17-Jan-85	26.22
201	Japan	TAKAHAMA-4	PWR	830	Kansai Electric Power Co	MHI	5-Jun-85	25.84
202	Japan	TOKAI-2	BWR	1,060	Japan Atomic Power Co (JAPCO)	GE	28-Nov-78	32.36
203	Japan	TOMARI-1	PWR	550	Hokkaido Electric Power Co	MHI	22-Jun-89	21.79
204	Japan	TOMARI-2	PWR	550	Hokkaido Electric Power Co	MHI	12-Apr-91	19.98
205	Japan	TOMARI-3	PWR	866	Hokkaido Electric Power Co	MHI	1-Dec-09	1.33
206	Japan	TSURUGA-1	BWR	340	Japan Atomic Power Co (JAPCO)	GE	14-Mar-70	41.08
207	Japan	TSURUGA-2	PWR	1,110	Japan Atomic Power Co (JAPCO)	MHI	17-Feb-87	24.13
208	Lithuania	IGNALINA-1	LWGR	1,185	INPP	MAEP	1-May-84	26.93
209	Lithuania	IGNALINA-2	LWGR	1,185	INPP	MAEP	20-Aug-87	23.63
210	Mexico	LAGUNA VERDE-1	BWR	680	CFE	GE	29-Jul-90	20.69
211	Mexico	LAGUNA VERDE-2	BWR	680	CFE	GE	10-Apr-95	15.99
212	Netherland	BORSSELE	PWR	482	EPZ	S/KWU	26-Oct-73	37.45
213	Pakistan	CHASNUPP-1	PWR	325	PAEC	CNNC	15-Sep-00	10.55
214	Pakistan	KANUPP-1	PHWR	137	PAEC	CGE	7-Dec-72	38.34
215	Romania	CERNAVODA Unit1	PHWR	707	SNN	AECL	2-Dec-97	13.34
216	Romania	CERNAVODA Unit2	PHWR	707	SNN	AECL	5-Oct-07	3.49
217	Russia	BALAKOVO-1	WWER	950	REA	MNE	23-May-86	24.87
218	Russia	BALAKOVO-2	WWER	950	REA	MNE	18-Jan-88	23.22
219	Russia	BALAKOVO-3	WWER	950	REA	MNE	8-Apr-89	21.99
220	Russia	BALAKOVO-4	WWER	950	REA	MNE	22-Dec-93	17.28
221	Russia	BELOYARSKY-3	FBR	560	REA	MNE	1-Nov-81	29.43
222	Russia	BILIBINO UNIT A	LWGR	11	REA	MNE	1-Apr-74	37.02
223	Russia	BILIBINO UNIT B	LWGR	11	REA	MNE	1-Feb-75	36.19
224	Russia	BILIBINO UNIT C	LWGR	11	REA	MNE	1-Feb-76	35.19
225	Russia	BILIBINO UNIT D	LWGR	11	REA	MNE	1-Jan-77	34.27
226	Russia	KALININ-1	WWER	950	REA	MNE	12-Jun-85	25.82
227	Russia	KALININ-2	WWER	950	REA	MNE	3-Mar-87	24.10
228	Russia	KALININ-3	WWER	950	REA	MNE	8-Nov-05	5.40
229	Russia	KOLA-1	WWER	411	REA	MNE	28-Dec-73	37.28
230	Russia	KOLA-2	WWER	411	REA	MNE	21-Feb-75	36.13
231	Russia	KOLA-3	WWER	411	REA	MNE	3-Dec-82	28.35
232	Russia	KOLA-4	WWER	411	REA	MNE	6-Dec-84	26.33
233	Russia	KURSK-1	LWGR	925	REA	MNE	12-Oct-77	33.49
234	Russia	KURSK-2	LWGR	925	REA	MNE	17-Aug-79	31.64
235	Russia	KURSK-3	LWGR	925	REA	MNE	30-Mar-84	27.02
236	Russia	KURSK-4	LWGR	925	REA	MNE	5-Feb-86	25.17
237	Russia	LENINGRAD-1	LWGR	925	REA	MNE	1-Nov-74	36.44
238	Russia	LENINGRAD-2	LWGR	925	REA	MNE	11-Feb-76	35.16
239	Russia	LENINGRAD-3	LWGR	925	REA	MNE	29-Jun-80	30.78
240	Russia	LENINGRAD-4	LWGR	925	REA	MNE	29-Aug-81	29.61
241	Russia	NOVOVORONEZH-3	WWER	385	REA	MNE	29-Jun-72	38.78
242	Russia	NOVOVORONEZH-4	WWER	385	REA	MNE	24-Mar-73	38.05

Table 38: Nuclear reactors operational around the world as of end-2010 (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Operator	Reactor Supplier	Commercial	Age
243	Russia	NOVOVORONEZH-5	WWER	950	REA	MNE	20-Feb-81	30.13
244	Russia	SMOLENSK-1	LWGR	925	REA	MNE	30-Sep-83	27.52
245	Russia	SMOLENSK-2	LWGR	925	REA	MNE	2-Jul-85	25.76
246	Russia	SMOLENSK-3	LWGR	925	REA	MNE	30-Jan-90	21.18
247	Russia	VOLGODONSK-1	WWER	950	REA		25-Dec-01	9.27
248	Slovakia	BOHUNICE V-2; Unit 3	PWR	408	SE,plc	SKODA	14-Feb-85	26.14
249	Slovakia	BOHUNICE V-2; Unit 4	PWR	408	SE,plc	SKODA	18-Dec-85	25.30
250	Slovakia	MOCHOVCE-1	PWR	405	SE,plc	SKODA	29-Oct-98	12.43
251	Slovakia	MOCHOVCE-2	PWR	405	SE,plc	SKODA	11-Apr-00	10.98
252	Slovenia	KRSKO	PWR	666	NEK	WH	1-Jan-83	28.27
253	South Africa	KOEBERG-1	PWR	900	Eskom	FRAM	21-Jul-84	26.71
254	South Africa	KOEBERG-2	PWR	900	Eskom	FRAM	9-Nov-85	25.41
255	South Korea	KORI-1	PWR	587	Korea Hydro & Nuclear Power	Westinghouse	1-Apr-78	33.02
256	South Korea	KORI-2	PWR	650	Korea Hydro & Nuclear Power	Westinghouse	1-Jul-83	27.77
257	South Korea	KORI-3	PWR	950	Korea Hydro & Nuclear Power	Westinghouse	1-Sep-85	25.60
258	South Korea	KORI-4	PWR	950	Korea Hydro & Nuclear Power	Westinghouse	1-Apr-86	25.02
259	South Korea	SHIN KORI-1	PWR	1,000	Korea Hydro & Nuclear Power	DHIC	1-Dec-10	0.33
260	South Korea	ULCHIN-1	PWR	950	Korea Hydro & Nuclear Power	Framatom	1-Sep-88	22.59
261	South Korea	ULCHIN-2	PWR	950	Korea Hydro & Nuclear Power	Framatom	1-Sep-89	21.59
262	South Korea	ULCHIN-3	PWR	1,000	Korea Hydro & Nuclear Power	KHI/KAERI	1-Aug-98	12.67
263	South Korea	ULCHIN-4	PWR	1,000	Korea Hydro & Nuclear Power	KHI/KAERI	1-Dec-99	11.34
264	South Korea	ULCHIN-5	PWR	1,000	Korea Hydro & Nuclear Power	DHIC	1-Jul-04	6.75
265	South Korea	ULCHIN-6	PWR	1,000	Korea Hydro & Nuclear Power	DHIC	1-Apr-05	6.00
266	South Korea	WOLSONG-1	PHWR	679	Korea Hydro & Nuclear Power	AECL	1-Apr-83	28.02
267	South Korea	WOLSONG-2	PHWR	700	Korea Hydro & Nuclear Power	AECL/KHI	1-Jul-97	13.76
268	South Korea	WOLSONG-3	PHWR	700	Korea Hydro & Nuclear Power	KHI/AECL	1-Jul-98	12.76
269	South Korea	WOLSONG-4	PHWR	700	Korea Hydro & Nuclear Power	KHI/AECL	1-Oct-99	11.51
270	South Korea	YONGGWANG-1	PWR	950	Korea Hydro & Nuclear Power	Westinghouse	1-Aug-86	24.68
271	South Korea	YONGGWANG-2	PWR	950	Korea Hydro & Nuclear Power	Westinghouse	1-Jun-87	23.85
272	South Korea	YONGGWANG-3	PWR	1,000	Korea Hydro & Nuclear Power	KHI/KAERI	1-Mar-95	16.10
273	South Korea	YONGGWANG-4	PWR	1,000	Korea Hydro & Nuclear Power	KHI/KAERI	1-Jan-96	15.26
274	South Korea	YONGGWANG-5	PWR	1,000	Korea Hydro & Nuclear Power	DHIC	1-May-02	8.92
275	South Korea	YONGGWANG-6	PWR	1,000	Korea Hydro & Nuclear Power	DHIC	1-Dec-02	8.34
276	Spain	ALMARAZ-1	PWR	944.43	Centrales Nucleares Almaraz-Trillo (CNAT)	Westinghouse	1-Sep-83	27.60
277	Spain	ALMARAZ-2	PWR	955.70	Centrales Nucleares Almaraz-Trillo (CNAT)	Westinghouse	1-Jul-84	26.77
278	Spain	ASCO-1	PWR	995.8	Asociacion Nuclear Asco-Vandellos (ANAV)	Westinghouse	10-Dec-84	26.32
279	Spain	ASCO-2	PWR	997.2	Asociacion Nuclear Asco-Vandellos (ANAV)	Westinghouse	31-Mar-86	25.02
280	Spain	COFRENTES	BWR	1,064	IB G	GE	11-Mar-85	26.07
281	Spain	SANTA MARIA DE GAROc	BWR	446	NUCLENOR	GE	5-Nov-71	39.43
282	Spain	TRILLO-1	PWR	1,000	Centrales Nucleares Almaraz-Trillo (CNAT)	KWU	8-Jun-88	22.83
283	Spain	VANDELLOS-1	PWR	508	HIFRENSA	CEA	8-Jan-72	39.25
284	Sweden	FORSMARK-1	BWR	1,014	FKA	ABBATOM	10-Dec-80	30.33
285	Sweden	FORSMARK-2	BWR	1,014	FKA	ABBATOM	7-Jul-81	29.75
286	Sweden	FORSMARK-3	BWR	1,190	FKA	ABBATOM	18-Aug-85	25.64
287	Sweden	OSKARSHAMN-1	BWR	623	OKG	ABBATOM	6-Feb-72	39.18
288	Sweden	OSKARSHAMN-2	BWR	598	OKG	ABBATOM	1-Jan-75	36.27
289	Sweden	OSKARSHAMN-3	BWR	1,197	OKG	ABBATOM	15-Aug-85	25.64
290	Sweden	RINGHALS-1	BWR	880	RAB	ABBATOM	1-Jan-76	35.27
291	Sweden	RINGHALS-2	PWR	870	RAB	Westinghouse	1-May-75	35.94
292	Sweden	RINGHALS-3	PWR	1,010	RAB	Westinghouse	9-Sep-81	29.58
293	Sweden	RINGHALS-4	PWR	915	RAB	Westinghouse	21-Nov-83	27.38

Table 38: Nuclear reactors operational around the world as of end-2010 (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Operator	Reactor Supplier	Commercial	Age
294	Switzerland	BEZNAU-1	PWR	365	NOK	Westinghouse	1-Sep-69	41.61
295	Switzerland	BEZNAU-2	PWR	365	NOK	Westinghouse	1-Dec-71	39.36
296	Switzerland	GOESGEN	PWR	970	KKG	KWU	1-Nov-79	31.44
297	Switzerland	LEIBSTADT	BWR	1,165	KKL	GETSCO	15-Dec-84	26.31
298	Switzerland	MUEHLEBERG	BWR	355	BKW	GETSCO	6-Nov-72	38.42
299	Taiwan	Chinshan 1	BWR	604	Taipower	Westinghouse	10-Dec-1978	32.33
300	Taiwan	Chinshan 2	BWR	604	Taipower	Westinghouse	15-Jul-1979	31.73
301	Taiwan	Kuosheng 1	BWR	948	Taipower	Westinghouse	28-Dec-1981	29.28
302	Taiwan	Kuosheng 2	BWR	948	Taipower	Westinghouse	16-Mar-1983	28.06
303	Taiwan	Maanshan 1	PWR	900	Taipower	Westinghouse	27-Jul-1984	26.70
304	Taiwan	Maanshan 2	PWR	923	Taipower	Westinghouse	18-May-1985	25.89
305	UK	DUNGENESS-B1	GCR	545	BE	APC	1-Apr-85	26.02
306	UK	DUNGENESS-B2	GCR	545	BE	APC	1-Apr-89	22.01
307	UK	HARTLEPOOL-A1	GCR	595	BE	NPC	1-Apr-89	22.01
308	UK	HARTLEPOOL-A2	GCR	595	BE	NPC	1-Apr-89	22.01
309	UK	HEYSHAM-A1	GCR	585	BE	NPC	1-Apr-89	22.01
310	UK	HEYSHAM-A2	GCR	575	BE	NPC	1-Apr-89	22.01
311	UK	HEYSHAM-B1	GCR	615	BE	NPC	1-Apr-89	22.01
312	UK	HEYSHAM-B2	GCR	615	BE	NPC	1-Apr-89	22.01
313	UK	HINKLEY POINT-B1	GCR	430	BEG	TNPG	2-Oct-78	32.52
314	UK	HINKLEY POINT-B2	GCR	430	BE	TNPG	27-Sep-76	34.53
315	UK	HUNTERSTON-B1	GCR	420	BE	TNPG	6-Feb-76	35.17
316	UK	HUNTERSTON-B2	GCR	420	BE	TNPG	31-Mar-77	34.02
317	UK	OLDBURY-A1	GCR	217	BNFL	TNPG	31-Dec-67	43.28
318	UK	OLDBURY-A2	GCR	217	BNFL	TNPG	30-Sep-68	42.53
319	UK	SIZEWELL-B	PWR	1,188	BE	PPC	22-Sep-95	15.53
320	UK	TORNESS 1	GCR	625	BE	NNC	25-May-88	22.87
321	UK	TORNESS 2	GCR	625	BE	NNC	3-Feb-89	22.17
322	UK	WYLFA 1	GCR	490	BNFL	EE/B&W/T	1-Nov-71	39.44
323	UK	WYLFA 2	GCR	490	BNFL	EE/B&W/T	3-Jan-72	39.27
324	Ukraine	KHMELNITSKI-1	WWER	950	NNEGC	PAA	13-Aug-88	22.65
325	Ukraine	KHMELNITSKI-2	WWER	950	NNEGC	PAIP	18-Jan-06	5.20
326	Ukraine	ROVNO-1	WWER	381	NNEGC	PAIP	21-Sep-81	29.55
327	Ukraine	ROVNO-2	WWER	376	NNEGC	PAIP	30-Jul-82	28.69
328	Ukraine	ROVNO-3	WWER	950	NNEGC	PAIP	16-May-87	23.89
329	Ukraine	ROVNO-4	WWER	950	NNEGC	PAIP	15-Mar-06	5.05
330	Ukraine	SOUTH UKRAINE-1	WWER	950	NNEGC	PAIP	18-Oct-83	27.47
331	Ukraine	SOUTH UKRAINE-2	WWER	950	NNEGC	PAA	6-Apr-85	26.00
332	Ukraine	SOUTH UKRAINE-3	WWER	950	NNEGC	PAA	29-Dec-89	21.27
333	Ukraine	ZAPOROZHE-1	WWER	950	NNEGC	PAIP	25-Dec-85	25.28
334	Ukraine	ZAPOROZHE-2	WWER	950	NNEGC	PAIP	15-Feb-86	25.14
335	Ukraine	ZAPOROZHE-3	WWER	950	NNEGC	PAIP	5-Mar-87	24.09
336	Ukraine	ZAPOROZHE-4	WWER	950	NNEGC	PAIP	14-Apr-88	22.98
337	Ukraine	ZAPOROZHE-5	WWER	950	NNEGC	PAIP	27-Oct-89	21.44
338	Ukraine	ZAPOROZHE-6	WWER	950	NNEGC	PAIP	16-Sep-96	14.55
339	USA	ARKANSAS ONE-1	PWR	836	Entergy Nuclear Operations, Inc.	B&W	19-Dec-74	36.31
340	USA	ARKANSAS ONE-2	PWR	998	Entergy Nuclear Operations, Inc.	CE	26-Mar-80	31.04
341	USA	BEAVER VALLEY-1	PWR	851	FirstEnergy Nuclear Operating Co.	Westinghouse	1-Oct-76	34.52
342	USA	BEAVER VALLEY-2	PWR	851	FirstEnergy Nuclear Operating Co.	Westinghouse	17-Nov-87	23.39
343	USA	BRAIDWOOD-1	PWR	1,178	Exelon Generation Co., LLC	Westinghouse	29-Jul-88	22.69
344	USA	BRAIDWOOD-2	PWR	1,152	Exelon Generation Co., LLC	Westinghouse	17-Oct-88	22.47
345	USA	BROWNS FERRY-1	BWR	1,065	Tennessee Valley Authority	GE	1-Aug-74	36.69
346	USA	BROWNS FERRY-2	BWR	1,118	Tennessee Valley Authority	GE	1-Mar-75	36.11
347	USA	BROWNS FERRY-3	BWR	1,114	Tennessee Valley Authority	GE	1-Mar-77	34.11

Table 38: Nuclear reactors operational around the world as of end-2010 (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Operator	Reactor Supplier	Commercial	Age
348	USA	BRUNSWICK-1	BWR	938	Progress Energy	GE	18-Mar-77	34.06
349	USA	BRUNSWICK-2	BWR	937	Progress Energy	GE	3-Nov-75	35.43
350	USA	BYRON-1	PWR	1,164	Exelon Generation Co., LLC	Westinghouse	16-Sep-85	25.56
351	USA	BYRON-2	PWR	1,136	Exelon Generation Co., LLC	Westinghouse	21-Aug-87	23.63
352	USA	CALLAWAY-1	PWR	1,190	Ameren UE	Westinghouse	19-Dec-84	26.30
353	USA	CALVERT CLIFFS-1	PWR	873	Constellation Energy	CE	8-May-75	35.92
354	USA	CALVERT CLIFFS-2	PWR	862	Constellation Energy	CE	1-Apr-77	34.02
355	USA	CATAWBA-1	PWR	1,129	Duke Energy Power Company, LLC	Westinghouse	29-Jun-85	25.77
356	USA	CATAWBA-2	PWR	1,129	Duke Energy Power Company, LLC	Westinghouse	19-Aug-86	24.63
357	USA	CLINTON-1	BWR	1,052	Exelon Generation Co., LLC	GE	24-Nov-87	23.37
358	USA	COLUMBIA	BWR	1,131	Energy Northwest	GE	13-Dec-84	26.32
359	USA	COMANCHE PEAK-1	PWR	1,150	TXU Generating Company LP	Westinghouse	13-Aug-90	20.65
360	USA	COMANCHE PEAK-2	PWR	1,150	TXU Generating Company LP	Westinghouse	3-Aug-93	17.67
361	USA	COOPER	BWR	760	Nebraska Public Power District	GE	1-Jul-74	36.78
362	USA	CRYSTAL RIVER-3	PWR	838	Progress Energy	B&W	13-Mar-77	34.07
363	USA	DAVIS BESSE-1	PWR	891	FirstEnergy Nuclear Operating Co.	B&W	31-Jul-78	32.69
364	USA	DIABLO CANYON-1	PWR	1,122	Pacific Gas & Electric Co.	Westinghouse	7-May-85	25.92
365	USA	DIABLO CANYON-2	PWR	1,087	Pacific Gas & Electric Co.	Westinghouse	13-Mar-86	25.07
366	USA	DONALD COOK-1	PWR	1,016	Indiana/Michigan Power Co.	Westinghouse	28-Aug-75	35.62
367	USA	DONALD COOK-2	PWR	1,077	Indiana/Michigan Power Co.	Westinghouse	1-Jul-78	32.77
368	USA	DRESDEN-2	BWR	867	Exelon Generation Co., LLC	GE	9-Jun-70	40.84
369	USA	DRESDEN-3	BWR	867	Exelon Generation Co., LLC	GE	16-Nov-71	39.40
370	USA	DUANE ARNOLD-1	BWR	581	Florida Power & Light Co.	GE	1-Feb-75	36.19
371	USA	ENRICO FERMI-2	BWR	1,111	Detroit Edison Co.	GE	23-Jan-88	23.20
372	USA	FARLEY-1	PWR	851	Southern Nuclear Operating Co.	Westinghouse	1-Dec-77	33.35
373	USA	FARLEY-2	PWR	860	Southern Nuclear Operating Co.	Westinghouse	30-Jul-81	29.69
374	USA	FITZPATRICK	BWR	852	Entergy Nuclear Operations, Inc.	GE	28-Jul-75	35.70
375	USA	FORT CALHOUN-1	PWR	478	Omaha Public Power District	CE	26-Sep-73	37.54
376	USA	GRAND GULF-1	BWR	1,266	Entergy Nuclear Operations, Inc.	GE	1-Jul-85	25.77
377	USA	H.B. ROBINSON-2	PWR	710	Progress Energy	Westinghouse	7-Mar-71	40.10
378	USA	HATCH-1	BWR	876	Southern Nuclear Operating Co., Inc.	GE	31-Dec-75	35.27
379	USA	HATCH-2	BWR	883	Southern Nuclear Operating Co., Inc.	GE	5-Sep-79	31.59
380	USA	HOPE CREEK-1	BWR	1,059	PSE&G Nuclear	GE	20-Dec-86	24.30
381	USA	INDIAN POINT-2	PWR	1,020	Entergy Nuclear Operations, Inc.	Westinghouse	1-Aug-74	36.69
382	USA	INDIAN POINT-3	PWR	1,025	Entergy Nuclear Operations, Inc.	Westinghouse	30-Aug-76	34.61
383	USA	KEWAUNEE	PWR	556	Dominion Generation	Westinghouse	16-Jun-74	36.82
384	USA	LASALLE-1	BWR	1,118	Exelon Generation Co., LLC	GE	1-Jan-84	27.27
385	USA	LASALLE-2	BWR	1,120	Exelon Generation Co., LLC	GE	19-Oct-84	26.47
386	USA	LIMERICK-1	BWR	1,134	Exelon Generation Co., LLC	GE	1-Feb-86	25.18
387	USA	LIMERICK-2	BWR	1,134	Exelon Generation Co., LLC	GE	8-Jan-90	21.24
388	USA	MCGUIRE-1	PWR	1,100	Duke Energy Power Company, LLC	Westinghouse	1-Dec-81	29.35
389	USA	MCGUIRE-2	PWR	1,100	Duke Energy Power Company, LLC	Westinghouse	1-Mar-84	27.10
390	USA	MILLSTONE-2	PWR	882	Dominion Generation	CE	26-Dec-75	35.29
391	USA	MILLSTONE-3	PWR	1,155	Dominion Generation	Westinghouse	23-Apr-86	24.96
392	USA	MONTICELLO	BWR	572	Nuclear Management Co.	GE	30-Jun-71	39.78
393	USA	NINE MILE POINT-1	BWR	621	Constellation Energy	GE	1-Dec-69	41.36
394	USA	NINE MILE POINT-2	BWR	1,135	Constellation Energy	GE	11-Mar-88	23.07
395	USA	NORTH ANNA-1	PWR	924	Dominion Generation	Westinghouse	6-Jun-78	32.84
396	USA	NORTH ANNA-2	PWR	910	Dominion Generation	Westinghouse	14-Dec-80	30.32

Table 38: Nuclear reactors operational around the world as of end-2010 (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Operator	Reactor Supplier	Commercial	Age
397	USA	OCONEE-1	PWR	846	Duke Energy Power Company, LLC	B&W	15-Jul-73	37.74
398	USA	OCONEE-2	PWR	846	Duke Energy Power Company, LLC	B&W	9-Sep-74	36.58
399	USA	OCONEE-3	PWR	846	Duke Energy Power Company, LLC	B&W	16-Dec-74	36.32
400	USA	OYSTER CREEK	BWR	619	Exelon Generation Co., LLC	GE	1-Dec-69	41.36
401	USA	PALISADES	PWR	778	Entergy Nuclear Operations, Inc.	CE	31-Dec-71	39.28
402	USA	PALO VERDE-1	PWR	1,314	Arizona Public Service Co.	CE	28-Jan-86	25.19
403	USA	PALO VERDE-2	PWR	1,314	Arizona Public Service Co.	CE	19-Sep-86	24.55
404	USA	PALO VERDE-3	PWR	1,247	Arizona Public Service Co.	CE	8-Jan-88	23.24
405	USA	PEACH BOTTOM-2	BWR	1,112	Exelon Generation Co., LLC	GE	5-Jul-74	36.76
406	USA	PEACH BOTTOM-3	BWR	1,112	Exelon Generation Co., LLC	GE	23-Dec-74	36.30
407	USA	PERRY-1	BWR	1,235	FirstEnergy Nuclear Operating Co.	GE	18-Nov-87	23.38
408	USA	PILGRIM-1	BWR	685	Entergy Nuclear Operations, Inc.	GE	1-Dec-72	38.36
409	USA	POINT BEACH-1	PWR	512	FPL Energy Point Beach, LLC	Westinghouse	21-Dec-70	40.30
410	USA	POINT BEACH-2	PWR	514	FPL Energy Point Beach, LLC	Westinghouse	1-Oct-72	38.52
411	USA	PRAIRIE ISLAND-1	PWR	523	Nuclear Management Co.	Westinghouse	16-Dec-73	37.32
412	USA	PRAIRIE ISLAND-2	PWR	522	Nuclear Management Co.	Westinghouse	21-Dec-74	36.30
413	USA	QUAD CITIES-1	BWR	867	Exelon Generation Co., LLC	GE	18-Feb-73	38.14
414	USA	QUAD CITIES-2	BWR	867	Exelon Generation Co., LLC	GE	10-Mar-73	38.08
415	USA	R.E. GINNA	PWR	560	Constellation Energy	Westinghouse	1-Jul-70	40.78
416	USA	RIVER BEND-1	BWR	966	Entergy Nuclear Operations, Inc.	GE	16-Jun-86	24.81
417	USA	SALEM-1	PWR	1,174	PSE&G Nuclear	Westinghouse	30-Jun-77	33.78
418	USA	SALEM-2	PWR	1,130	PSE&G Nuclear	Westinghouse	13-Oct-81	29.48
419	USA	SAN ONOFRE-2	PWR	1,070	Southern California Edison Co.	CE	8-Aug-83	27.67
420	USA	SAN ONOFRE-3	PWR	1,080	Southern California Edison Co.	CE	1-Apr-84	27.02
421	USA	SEABROOK-1	PWR	1,244	Florida Power & Light Co.	Westinghouse	19-Aug-90	20.63
422	USA	SEQUOYAH-1	PWR	1,150	Tennessee Valley Authority	Westinghouse	1-Jul-81	29.77
423	USA	SEQUOYAH-2	PWR	1,127	Tennessee Valley Authority	Westinghouse	1-Jun-82	28.85
424	USA	SHEARON HARRIS-1	PWR	900	Progress Energy	Westinghouse	2-May-87	23.93
425	USA	SOUTH TEXAS-1	PWR	1,280	STP Nuclear Operating Co.	Westinghouse	25-Aug-88	22.61
426	USA	SOUTH TEXAS-2	PWR	1,280	STP Nuclear Operating Co.	Westinghouse	19-Jun-89	21.80
427	USA	ST. LUCIE-1	PWR	839	Florida Power & Light Co.	CE	21-Dec-76	34.30
428	USA	ST. LUCIE-2	PWR	839	Florida Power & Light Co.	CE	8-Aug-83	27.67
429	USA	SURRY-1	PWR	799	Dominion Generation	Westinghouse	22-Dec-72	38.30
430	USA	SURRY-2	PWR	799	Dominion Generation	Westinghouse	1-May-73	37.94
431	USA	SUSQUEHANNA-1	BWR	1,135	PPL Susquehanna, LLC	GE	8-Jun-83	27.83
432	USA	SUSQUEHANNA-2	BWR	1,140	PPL Susquehanna, LLC	GE	12-Feb-85	26.15
433	USA	THREE MILE ISLAND-1	PWR	786	Exelon Generation Co., LLC	B&W	2-Sep-74	36.60
434	USA	TURKEY POINT-3	PWR	693	Florida Power & Light Co.	Westinghouse	14-Dec-72	38.32
435	USA	TURKEY POINT-4	PWR	693	Florida Power & Light Co.	Westinghouse	7-Sep-73	37.59
436	USA	VERMONT YANKEE	BWR	605	Entergy Nuclear Operations, Inc.	GE	30-Nov-72	38.36
437	USA	VIRGIL C. SUMMER-1	PWR	966	South Carolina Electric & Gas Co.	Westinghouse	1-Jan-84	27.27
438	USA	VOGTLE-1	PWR	1,152	Southern Nuclear Operating Co.	Westinghouse	1-Jun-87	23.85
439	USA	VOGTLE-2	PWR	1,149	Southern Nuclear Operating Co.	Westinghouse	20-May-89	21.88
440	USA	WATERFORD-3	PWR	1,158	Entergy Nuclear Operations, Inc.	CE	24-Sep-85	25.53
441	USA	WATTS BAR-1	PWR	1,121	Tennessee Valley Authority	Westinghouse	5-May-96	14.92
442	USA	WOLF CREEK	PWR	1,166	Wolf Creek Nuclear Operating Corp.	Westinghouse	3-Sep-85	25.59

Source: IAEA, World Nuclear Association, UBS

Appendix 2: Nuclear reactors under construction

Table 39: Nuclear reactors under construction

Serial No.	Country	Station	Type	Net Cpacity (Mwe)	Operator	Reactor Supplier
1	USA	WATTS BAR-2	PWR	1,165	Tennessee Valley Authority	Westinghouse
2	USA	V.C. Summer 2	AP1000	1,117	Scana Corp	
3	USA	V.C. Summer 3	AP1000	1,117	Scana Corp	
4	USA	Vogtle 3	AP1000	1,117	Southern Company	
5	USA	Vogtle 4	AP1000	1,117	Southern Company	
6	Brazil	ANGRA-3	PWR	1,224	Eletronuclear	KWU
7	India	KAKRAPAR-3	PHWR	700	Nuclear Power Corp of India Ltd	
8	India	KAKRAPAR-4	PHWR	700	Nuclear Power Corp of India Ltd	
9	India	RAJASTHAN-1	PHWR	700	Nuclear Power Corp of India Ltd	
10	India	RAJASTHAN-2	PHWR	700	Nuclear Power Corp of India Ltd	
11	India	KUDANKULAM-1	PWR	1,000	Nuclear Power Corp of India Ltd	ASE
12	India	KUDANKULAM-2	PWR	1,000	Nuclear Power Corp of India Ltd	ASE
13	India	PFBR	FBR	470	BHAVINI	
14	Argentina	ATUCHA-2	PHWR	692	Nucleoelectrica Argentina	SIEMENS
15	Bulgaria	BELENE-1	PWR	953	KOZNPP	ASE
16	Bulgaria	BELENE-2	PWR	953	KOZNPP	ASE
17	China	LINGAO 4	PWR	1,080	Ching Guangdong Nuclear Power Corporation	DFEC
18	China	QINSHAN 2-4	PWR	650	China National Nuclear Corporation	CNNC
19	China	HONGYANHE 1	PWR	1,000	Ching Guangdong Nuclear Power Corporation, China Power Investment Corporation	DFEC
20	China	HONGYANHE 2	PWR	1,000	Ching Guangdong Nuclear Power Corporation, China Power Investment Corporation	
21	China	HONGYANHE 3	PWR	1,000	Ching Guangdong Nuclear Power Corporation, China Power Investment Corporation	
22	China	HONGYANHE 4	PWR	1,000	Ching Guangdong Nuclear Power Corporation, China Power Investment Corporation	
23	China	NINGDE 1	PWR	1,000	Ching Guangdong Nuclear Power Corporation	
24	China	NINGDE 2	PWR	1,000	Ching Guangdong Nuclear Power Corporation	
25	China	NINGDE 3	PWR	1,000	Ching Guangdong Nuclear Power Corporation	
26	China	NINGDE 4	PWR	1,000	Ching Guangdong Nuclear Power Corporation	
27	China	FUQING 1	PWR	1,000	China National Nuclear Corporation	
28	China	FUQING 2	PWR	1,000	China National Nuclear Corporation	
29	China	FUQING 3	PWR	1,000	China National Nuclear Corporation	
30	China	YANGJIANG 1	PWR	1,000	Ching Guangdong Nuclear Power Corporation	
31	China	YANGJIANG 2	PWR	1,000	Ching Guangdong Nuclear Power Corporation	
32	China	YANGJIANG 3	PWR	1,000	Ching Guangdong Nuclear Power Corporation	
33	China	SANMEN 1	PWR	1,000	China National Nuclear Corporation	
34	China	SANMEN 2	PWR	1,000	China National Nuclear Corporation	
35	China	FANGJIASHAN 1	PWR	1,000	China National Nuclear Corporation	
36	China	FANGJIASHAN 2	PWR	1,000	China National Nuclear Corporation	
37	China	HAIYANG 1	PWR	1,000	China Power Investment Corporation	
38	China	HAIYANG 2	PWR	1,000	China Power Investment Corporation	
39	China	TAISHAN 1	PWR	1,700	Ching Guangdong Nuclear Power Corporation	
40	China	TAISHAN 2	PWR	1,700	Ching Guangdong Nuclear Power Corporation	
41	China	FANGCHENGGANG 1	PWR	1,000	Ching Guangdong Nuclear Power Corporation	
42	China	CHANGJIANG 1	PWR	610	China National Nuclear Corporation	
43	China	CHANGJIANG 2	PWR	610	China National Nuclear Corporation	
44	Finland	OLKILUOTO-3	PWR	1,600	Teollisuuden Voima (TVO)	AREVA NP
45	France	FLAMANVILLE-3	PWR	1,600	Electricite de France (EdF)	FRAM
46	Iran	BUSHEHR-1	PWR	915	AEOI	ASE
47	Pakistan	CHASNUPP- 2	PWR	325	PAEC	CNNC
48	Russia	KALININ-4	WWER	950	REA	MNE
49	Russia	KURSK-5	LWGR	925	REA	MNE
50	Russia	LENINGRAD 2-1	PWR	1,085		
51	Russia	LENINGRAD 2-2	PWR	1,085		
52	Russia	NOVOVORONEZH 2-1	PWR	1,085		
53	Russia	NOVOVORONEZH 2-2	PWR	1,085		
54	Russia	ROSTOV 3	PWR	1,011		
55	Russia	ROSTOV 4	PWR	1,011		

Table 39: Nuclear reactors under construction (cont'd)

Serial No.	Country	Station	Type	Net Cpacity (Mwe)	Operator	Reactor Supplier
56	Russia	SEVERODVINSK-AKADEMIK LOMONOSOV 1	PWR	30	REA	
57	Russia	SEVERODVINSK-AKADEMIK LOMONOSOV 2	PWR	30	REA	
58	Russia	SOUTH URALS 2	FBR	750	REA	MNE
59	Russia	VOLGODONSK-2	WWER	950	REA	
60	Slovakia	MOCHOVCE-3			JAVYS	
61	Slovakia	MOCHOVCE-4			JAVYS	
62	Taiwan	Lungmen 1	ABWR	1,300	Taipower	GE
63	Taiwan	Lungmen 2	ABWR	1,300	Taipower	GE
64	South Korea	SHIN ULCHIN-1	PWR	1,400	Korea Hydro & Nuclear Power	-
65	South Korea	SHIN ULCHIN-2	PWR	1,400	Korea Hydro & Nuclear Power	-
66	South Korea	SHIN KORI-2	PWR	1,000	Korea Hydro & Nuclear Power	DHIC
67	South Korea	SHIN KORI-3	PWR	1,400	Korea Hydro & Nuclear Power	DHIC
68	South Korea	SHIN KORI-4	PWR	1,400	Korea Hydro & Nuclear Power	DHIC
69	South Korea	SHIN WOLSONG-1	PHWR	1,000	Korea Hydro & Nuclear Power	DHIC
70	South Korea	SHIN WOLSONG-2	PHWR	1,000	Korea Hydro & Nuclear Power	DHIC
71	Ukraine	KHMELNITSKI-3	WWER	950	NNEGC	
72	Ukraine	KHMELNITSKI-4	WWER	950	NNEGC	

Source: IAEA, World Nuclear Association, UBS

Appendix 3: Nuclear reactors planned for construction

Table 40: Nuclear reactors planned for construction

Serial No.	Country	Station	Type	Net Capacity (MWe)	Current Status	Start Year	Operator
1	Bulgaria	Belene-1	PWR	1,060	Planned		National Electricity Co (NEC)
2	Bulgaria	Belene-2	PWR	1,060	Planned		National Electricity Co (NEC)
3	China	Jieyang	PWR	6,000	Planned		Ching Guangdong Nuclear Power Corporation
4	China	Shaoguan	PWR	4,000	Planned		Ching Guangdong Nuclear Power Corporation
5	China	Hebaodao			Planned		China National Nuclear Corporation
6	China	Heyuan			Planned		China National Nuclear Corporation
7	China	Yangxi		6,000	Planned		Datang Group
8	China	Haifeng	PWR	8,000	Planned		China National Nuclear Corporation
9	China	Lufeng	PWR	6,480	Planned		Ching Guangdong Nuclear Power Corporation
10	China	Zhaoqing	PWR	6,000	Planned		Ching Guangdong Nuclear Power Corporation
11	China	Zhangzhou	PWR	7,500	Planned		China Power Investment Corporation
12	China	Sanming	PWR	4,000	Planned		China National Nuclear Corporation
13	China	Cangnan	PWR	6,000	Planned		Ching Guangdong Nuclear Power Corporation
14	China	Longyou	PWR	4,000	Planned		China National Nuclear Corporation
15	China	Hongshiding	HTGR	6,000	Planned		China National Nuclear Corporation
16	China	Shidaowan	PWR	6,200	Planned		China National Nuclear Corporation
17	China	Donggang	PWR	6,000	Planned		Huadian Group
18	China	Xudabao	PWR	6,000	Planned		China National Nuclear Corporation
19	China	Liaoning No.2	PWR		Planned		China Power Investment Corporation
20	China	Jingyu	PWR	7,500	Planned		China Power Investment Corporation
21	China	Jiamusi	PWR	4,000	Planned		Ching Guangdong Nuclear Power Corporation
22	China	Jiyang	PWR	4,000	Planned		China Power Investment Corporation
23	China	Wuhu	PWR	4,000	Planned		Ching Guangdong Nuclear Power Corporation
24	China	Pengze	PWR	4,000	Planned		China Power Investment Corporation
25	China	Yangjiashan	PWR	4,000	Planned		China National Nuclear Corporation
26	China	Nanyang	PWR	6,000	Planned		China National Nuclear Corporation
27	China	Songzi	PWR	4,000	Planned		Ching Guangdong Nuclear Power Corporation
28	China	Dafan	PWR	4,000	Planned		Ching Guangdong Nuclear Power Corporation
29	China	Taohuajiang	PWR	4,000	Planned		China National Nuclear Corporation
30	China	Xiaomoshan	PWR	6,000	Planned		China Power Investment Corporation
31	China	Changde	PWR	4,000	Planned		Ching Guangdong Nuclear Power Corporation
32	China	Datang Huayin	PWR	4,000	Planned		Datang Group
33	China	Guidong	PWR	4,000	Planned		China Power Investment Corporation
34	China	Fuling	PWR	5,000	Planned		China Power Investment Corporation
35	China	Sanba	PWR	4,000	Planned		Ching Guangdong Nuclear Power Corporation
36	Egypt	El Dabaa-1		1,000	Planned		Egyptian Atomic Energy Authority (AEA)
37	France	Penly-3	PWR	1,620	Planned		Electricite de France (EdF)
38	India	Kaiga-5	PWR		Planned		Nuclear Power Corp of India Ltd (NPCIL)
39	India	Kaiga-6	PWR		Planned		Nuclear Power Corp of India Ltd (NPCIL)
40	India	Rajasthan-7	PHWR	640	Planned		Nuclear Power Corp of India Ltd (NPCIL)
41	India	Rajasthan-8	PHWR	640	Planned		Nuclear Power Corp of India Ltd (NPCIL)
42	Indonesia	Java-1 (Muria)		600	Planned		Indonesian National Nuclear Energy Agency (BATAN)
43	Iran	Bushehr-2	PWR/VVER	950	Planned		Atomic Energy Organisation of Iran
44	Japan	Fukushima-Daiichi-7	ABWR	1,325	Planned		Tokyo Electric Power Co (TEPCO)
45	Japan	Fukushima-Daiichi-8	ABWR	1,325	Planned		Tokyo Electric Power Co (TEPCO)
46	Japan	Hamaoka-6	ABWR	1,380	Planned		Chubu Electric Power Co
47	Japan	Higashi-Dori-1 (TEPCO)	ABWR	1,320	Planned	2014	Tokyo Electric Power Co (TEPCO)

Table 40: Nuclear reactors planned for construction (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Current Status	Start Year	Operator
48	Japan	Higashi-Dori-2 (TEPCO)	ABWR	1,320	Planned	2016	Tokyo Electric Power Co (TEPCO)
49	Japan	Higashi-Dori-2 (Tohoku)	ABWR	1,385	Planned		Tohoku Electric Power Co
50	Japan	Kaminoseki-1	ABWR	1,320	Planned		Chugoku Electric Power Co
51	Japan	Kaminoseki-2	ABWR	1,320	Planned		Chugoku Electric Power Co
52	Japan	Sendai-3	APWR	1,538	Planned		Kyushu Electric Power Co
53	Japan	Tsuruga-3	PWR	1,500	Planned		Japan Atomic Power Co (JAPCO)
54	Japan	Tsuruga-4	PWR	1,500	Planned		Japan Atomic Power Co (JAPCO)
55	Korea RO (South)	Shin Ulchin 3	PWR	1,400	Planned		Korea Electric Power Corp (Kepco)
56	Korea RO (South)	Shin Ulchin 4	PWR	1,400	Planned		Korea Electric Power Corp (Kepco)
57	Korea RO (South)	Shin-Kori-5	PWR	1,400	Planned		Korea Electric Power Corp (Kepco)
58	Korea RO (South)	Shin-Kori-6	PWR	1,400	Planned		Korea Electric Power Corp (Kepco)
59	Korea RO (South)	Wolsong-5	PHWR	1,400	Planned	2011	Korea Electric Power Corp (Kepco)
60	Korea RO (South)	Wolsong-6	PHWR	1,400	Planned	2012	Korea Electric Power Corp (Kepco)
61	Lithuania	Visaginas-1		~ 1700	Planned		Visagino atominė elektrinė
62	Lithuania	Visaginas-2		~ 1700	Planned		Visagino atominė elektrinė
63	Nigeria	First nuclear power plant		1,000	planned	2014	
64	Nigeria	Second train (3 Plants)		3,000	planned	2018	
65	Philippines	NPP1	PWR	600	planned	2015	
66	Philippines	NPP2	New Generations NPP	600	planned	2017	
67	Philippines	NPP3	New Generations	600	planned	2020	
68	Philippines	NPP4	New Generations	600	planned	2025	
69	Romania	Cernavoda-3	PHWR	630	Planned		RENEL
70	Russia	Beloyarsk-5	FBR	300	Planned		Rosatom Nuclear Company
71	Russia	South Urals 3	FBR	750	Planned		REA
72	Russia	BN-1600	FBR	1,500	Planned		REA
73	Russia	BILIBINO E	LWGR	31	Planned		REA
74	Russia	BILIBINO F	LWGR	31	Planned		REA
75	Russia	BILIBINO G	LWGR	31	Planned		REA
76	Thailand	To be decided	LWR	1,000	Planned	2015	
77	Thailand	To be decided	LWR	1,000	Planned	2017	
78	Tunisia	To be decided		1,000	Planned	2016	
79	Tunisia	To be decided		1,000	Planned	2024	
80	Turkey	Akkuyu	PWR	1,200	Planned		Rosatom Nuclear Company
81	United Arab Emirates	Braka-1	PWR	1,400	Planned		Emirates Nuclear Energy Corporation
82	United Arab Emirates	Braka-2	PWR	1,400	Planned		Emirates Nuclear Energy Corporation
83	United Arab Emirates	Braka-3	PWR	1,400	Planned		Emirates Nuclear Energy Corporation
84	United Arab Emirates	Braka-4	PWR	1,400	Planned		Emirates Nuclear Energy Corporation
85	United Kingdom	Hinkley Point-C1	PWR	1,650	Planned		Electricite de France (EdF)
86	United Kingdom	Hinkley Point-C2	PWR	1,650	Planned		Electricite de France (EdF)
87	United Kingdom	Sizewell-C1	PWR	1,650	Planned		Electricite de France (EdF)
88	United Kingdom	Sizewell-C2	PWR	1,650	Planned		Electricite de France (EdF)
89	USA	Bell Bend	EPR	1,600	Planned	2018-2020	PPL Corp
90	USA	Calvert Cliffs 3	EPR	1,600	Planned		Unistar
91	USA	Comanche Peak 3	APWR	1,700	Planned	2021-2022	Energy Future Holdings
92	USA	Comanche Peak 4	APWR	1,700	Planned	2021-2022	Energy Future Holdings
93	USA	Fermi 3	ESBWR	1,520	Planned		DTE Energy
94	USA	Levy County 1	AP1000	1,117	Planned	2018-2020	Progress Energy Corp
95	USA	Levy County 2	AP1000	1,117	Planned	2018-2020	Progress Energy Corp
96	USA	North Anna 3	APWR	1,500	Planned	2019-2020	Dominion
97	USA	Shearon Harris 2	AP1000	1,117	Planned	2018+	Progress Energy Corp
98	USA	Shearon Harris 3	AP1000	1,117	Planned	2018+	Progress Energy Corp
99	USA	South Texas Project 3	ABWR	1,350	Planned		NRG Energy

Table 40: Nuclear reactors planned for construction (cont'd)

Serial No.	Country	Station	Type	Net Capacity (MWe)	Current Status	Start Year	Operator
100	USA	South Texas Project 4	ABWR	1,350	Planned		NRG Energy
101	USA	Turkey Point 6	AP1000	1,117	Planned	2020-2021	NextEra Energy
102	USA	Turkey Point 7	AP1000	1,117	Planned	2021-2022	NextEra Energy
103	USA	William States Lee III 1	AP1000	1,117	Planned	2021	Duke Energy
104	USA	William States Lee III 2	AP1000	1,117	Planned	2021	Duke Energy
105	USA	Bellefonte 3	AP1000	1,117	Suspended		Tennessee Valley Authority
106	USA	Bellefonte 4	AP1000	1,117	Suspended		Tennessee Valley Authority
107	USA	Callaway 2	EPR	1,600	Suspended		Ameren Corp
108	USA	Grand Gulf 3	ESBWR	1,520	Suspended		Entergy Corp
109	USA	Nine Mile Point 3	EPR	1,600	Suspended		Unistar
110	USA	River Bend 3	ESBWR	1,520	Suspended		Entergy Corp
111	USA	Victoria County Station 1	ESBWR	1,520	Suspended		Exelon Corp
112	USA	Victoria County Station 2	ESBWR	1,520	Suspended		Exelon Corp

Source: IAEA, World Nuclear Association, UBS

Appendix 4: Global utilities valuation metrics

Table 41: Global utilities valuation multiples

Utilities sub-sector valuations

Sub-sectors	P/E				EV/EBITDA				Dividend Yield			
	5yr Avg	2010E	2011E	2012E	5yr Avg	2010E	2011E	2012E	5yr Avg	2010E	2011E	2012E
Generation	16.8x	14.0x	13.7x	12.9x	10.3x	8.5x	8.7x	8.1x	4.3%	4.4%	4.4%	4.6%
Integrated	14.8x	13.0x	13.0x	13.5x	8.7x	7.5x	7.7x	7.6x	4.1%	4.6%	4.5%	4.6%
Integrated Regulated	18.2x	14.8x	16.0x	12.1x	7.3x	8.1x	7.7x	7.5x	3.8%	4.2%	4.3%	4.5%
T&D	19.8x	20.1x	18.4x	16.5x	12.3x	10.5x	9.9x	8.8x	3.3%	3.1%	3.2%	3.3%
Water	22.9x	13.7x	12.9x	10.9x	8.3x	7.6x	7.2x	6.8x	3.3%	5.0%	4.8%	5.0%
Sector	**17.4x**	**14.9x**	**14.9x**	**13.1x**	**9.2x**	**8.5x**	**8.4x**	**7.9x**	**4.0%**	**4.2%**	**4.3%**	**4.4%**

Regional utilities valuations

Regions	P/E				EV/EBITDA				Dividend Yield			
	5yr Avg	2010E	2011E	2012E	5yr Avg	2010E	2011E	2012E	5yr Avg	2010E	2011E	2012E
N America	15.6x	13.3x	14.0x	15.4x	8.5x	7.6x	7.5x	7.9x	3.4%	4.4%	4.4%	4.6%
Europe	16.0x	13.1x	13.3x	12.2x	9.2x	7.5x	7.9x	7.4x	4.8%	5.3%	5.2%	5.3%
APAC ex (Japan + Aus/NZ)	18.8x	19.3x	17.4x	15.2x	13.4x	12.9x	12.0x	10.6x	2.8%	2.2%	2.5%	2.8%
Japan	26.7x	21.2x	27.6x	15.0x	8.8x	8.2x	7.4x	8.0x	2.1%	2.6%	3.3%	2.8%
Australia / NZ	20.8x	18.9x	19.5x	19.1x	9.9x	9.5x	9.2x	7.9x	4.9%	5.5%	5.2%	5.4%
LatAm	17.9x	11.4x	10.2x	8.8x	3.0x	7.2x	6.8x	6.2x	5.6%	5.5%	5.2%	5.7%
Russia	32.1x	19.2x	11.9x	9.1x	24.3x	8.0x	8.2x	5.0x	0.4%	0.0%	0.6%	0.8%
Sector	**17.4x**	**14.9x**	**14.9x**	**13.1x**	**9.2x**	**8.5x**	**8.4x**	**7.9x**	**4.0%**	**4.2%**	**4.3%**	**4.4%**

Note: For Russia, the long-term average is meaningful over two years.

Source: UBS estimates

Sub-sector Valuations												
Sub-sectors	P/E				EV/EBITDA				Dividend Yield			
	5yr Avg	2010E	2011E	2012E	5yr Avg	2010E	2011E	2012E	5yr Avg	2010E	2011E	2012E
N. America Generation	28.5x	14.7x	22.3x	42.4x	9.1x	6.8x	7.7x	14.1x	0.7%	1.3%	1.4%	1.4%
N. America Integrated	14.4x	11.0x	10.8x	12.9x	8.1x	6.1x	6.1x	6.7x	4.4%	4.7%	4.8%	4.8%
N. America Integrated Regulated	14.8x	13.6x	13.8x	13.0x	8.1x	7.7x	7.5x	7.3x	4.0%	4.8%	4.8%	5.1%
N. America T&D	17.2x	16.1x	17.5x	16.5x	10.1x	10.0x	9.9x	9.3x	4.2%	4.2%	3.9%	4.0%
N. America Utilities	15.6x	13.3x	14.0x	15.4x	8.5x	7.6x	7.5x	7.9x	3.4%	4.4%	4.4%	4.6%
Europe Generation	15.8x	11.9x	12.3x	11.4x	8.6x	6.8x	7.3x	6.9x	4.9%	5.4%	5.3%	5.4%
Europe Integrated	13.3x	12.2x	13.4x	12.4x	9.4x	8.7x	9.9x	9.1x	4.4%	5.1%	4.4%	4.7%
Europe Integrated Regulated	13.8x	11.9x	13.1x	12.4x	9.5x	9.2x	9.3x	9.0x	5.4%	6.0%	5.8%	6.2%
Europe T&D	42.3x	35.7x	29.6x	23.8x	24.2x	12.4x	11.5x	10.2x	0.4%	0.7%	0.9%	1.1%
Europe Water	21.7x	17.8x	16.1x	13.3x	10.3x	8.9x	8.1x	7.7x	3.2%	5.0%	5.4%	5.5%
Europe Utilities	16.0x	13.1x	13.3x	12.2x	9.2x	7.5x	7.9x	7.4x	4.8%	5.3%	5.2%	5.3%
Asia ex J+A Generation	19.7x	20.3x	18.9x	16.7x	11.9x	11.5x	11.5x	10.4x	2.7%	2.2%	2.2%	2.4%
Asia ex J+A Integrated Regulated	17.0x	15.2x	14.4x	12.0x	9.5x	9.3x	8.4x	7.6x	3.0%	2.3%	2.7%	3.0%
Asia ex J+A T&D	21.2x	20.6x	18.7x	16.2x	14.3x	13.3x	12.1x	10.3x	2.3%	1.9%	2.3%	2.6%
Asia ex J+A Utilities	18.8x	19.3x	17.4x	15.2x	13.4x	12.9x	12.0x	10.6x	2.8%	2.2%	2.5%	2.8%
Australia / NZ Generation	36.0x	18.2x	23.6x	24.0x	13.9x	10.9x	10.6x	9.7x	4.2%	5.3%	6.1%	6.3%
Australia / NZ Integrated	18.7x	21.3x	20.4x	17.1x	10.2x	10.7x	9.9x	8.3x	3.6%	3.5%	3.5%	3.7%
Australia / NZ T&D	21.7x	13.9x	16.9x	22.5x	8.9x	6.8x	7.5x	6.9x	8.1%	9.8%	8.5%	8.7%
Australia / NZ Utilities	20.8x	18.9x	19.5x	19.1x	9.9x	9.5x	9.2x	7.9x	4.9%	5.5%	5.2%	5.4%
Japan Generation	19.0x	14.5x	15.4x	10.4x	9.8x	10.1x	9.3x	9.3x	1.8%	2.5%	2.7%	2.7%
Japan Integrated Regulated	27.1x	21.5x	28.1x	15.2x	8.8x	8.1x	7.3x	7.9x	2.1%	2.6%	3.4%	2.8%
Japan Utilities	26.7x	21.2x	27.6x	15.0x	8.8x	8.2x	7.4x	8.0x	2.1%	2.6%	3.3%	2.8%
LatAm Generation	12.2x	14.4x	11.7x	10.4x	4.8x	8.1x	7.2x	6.5x	7.6%	5.3%	6.9%	7.7%
LatAm Integrated Regulated	19.5x	11.5x	10.3x	8.6x	2.0x	7.3x	6.9x	6.3x	3.8%	5.0%	4.6%	5.1%
LatAm T&D	9.2x	8.5x	9.3x	9.2x	5.9x	6.1x	6.6x	6.4x	12.2%	14.4%	10.7%	9.8%
LatAm Water	27.7x	6.7x	7.4x	6.8x	5.8x	5.4x	5.5x	5.1x	3.9%	4.8%	3.9%	4.1%
LatAm Utilities	17.9x	11.4x	10.2x	8.8x	3.0x	7.2x	6.8x	6.2x	5.6%	5.5%	5.2%	5.7%
Russia Generation	40.1x	21.2x	12.1x	8.8x	26.7x	9.8x	10.8x	5.3x	0.5%	0.0%	0.0%	0.0%
Russia T&D	12.1x	16.5x	11.7x	9.6x	5.2x	5.5x	4.6x	4.4x	0.0%	0.0%	1.5%	1.8%
Russia Utilities	32.1x	19.2x	11.9x	9.1x	24.3x	8.0x	8.2x	5.0x	0.4%	0.0%	0.6%	0.8%
Global Utilities Sector	**17.4x**	**14.9x**	**14.9x**	**13.1x**	**9.2x**	**8.5x**	**8.4x**	**7.9x**	**4.0%**	**4.2%**	**4.3%**	**4.4%**

Source: UBS estimates (Note: for Russia, the long term average is meaningful over 2 years)

Table 42: Global utilities—sub sector and regional performance

	Utilities Performance					Perf rel to Global Equities				
	-1d	-1w	-3m	-1Y	YTD	-1d	-1w	-3m	-1Y	YTD
Sub Sector										
Generation	0.4%	2.8%	3.8%	5.2%	3.8%	0.4%	2.8%	3.3%	-2.0%	3.3%
Integrated	-0.4%	1.4%	5.1%	3.4%	5.1%	-0.4%	1.4%	4.6%	-3.8%	4.6%
Integrated Regulated	-0.2%	0.5%	0.9%	-0.7%	0.9%	-0.2%	0.5%	0.3%	-7.9%	0.3%
T&D	0.2%	2.0%	4.0%	10.2%	4.0%	0.2%	2.0%	3.5%	3.0%	3.5%
Water	0.9%	2.9%	1.5%	22.1%	1.5%	0.9%	2.9%	0.9%	14.8%	0.9%

	Utilities Performance					Perf rel to Local Equities				
	-1d	-1w	-3m	-1Y	YTD	-1d	-1w	-3m	-1Y	YTD
Regional										
N America	-0.1%	1.5%	4.6%	14.1%	4.6%	-0.1%	1.5%	2.7%	3.8%	2.7%
Europe	-0.7%	1.7%	5.1%	-3.4%	5.1%	-0.7%	1.7%	2.9%	-9.1%	2.9%
APAC ex J+A	1.0%	3.3%	-0.7%	1.9%	-0.7%	1.0%	3.3%	4.7%	-5.2%	4.7%
Japan	-1.1%	-7.1%	-11.2%	-20.6%	-11.2%	-1.1%	-7.1%	-3.6%	-18.2%	-3.6%
Australia / NZ	0.9%	2.4%	-1.3%	1.2%	-1.3%	0.9%	2.4%	3.7%	-0.3%	3.7%
LatAm	0.5%	1.9%	7.3%	12.2%	7.3%	0.5%	1.9%	12.7%	7.5%	12.7%
Russia	0.7%	1.6%	-5.7%	-1.0%	-5.7%	0.7%	1.6%	-17.7%	-23.9%	-17.7%

Source: UBS

APAC ex Japan + Aus / NZ	LC	Price Target (LC)	Rating	PE				EV/ EBITDA				Dividend Yield				CAGR (2010 -13E)	
				2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	EPS	EBITDA
Generation																	
China Yangtze Power	CNY	8.7	Buy	16.8x	17.6x	17.0x	16.3x	9.7x	9.7x	9.0x	8.6x	3.6%	3.0%	3.1%	3.3%	1.6%	1.9%
China Resources Power	HKD	19.2	Buy	13.9x	13.1x	10.7x	8.5x	9.0x	8.6x	7.2x	5.8x	2.4%	2.5%	3.1%	4.0%	13.2%	17.9%
China Longyuan Power Group	HKD	8.5	Buy	30.5x	19.9x	17.5x	14.3x	12.0x	10.9x	10.1x	8.6x	0.5%	0.8%	0.9%	1.0%	20.7%	22.4%
Huaneng Power International	HKD	4.6	Neutral	13.8x	26.2x	17.6x	10.3x	9.4x	9.8x	8.8x	7.2x	3.6%	2.0%	2.9%	5.0%	7.5%	12.4%
Datang International Power	HKD	2.8	Neutral	16.3x	16.2x	13.7x	8.0x	11.2x	10.8x	9.6x	8.0x	3.6%	3.1%	3.7%	6.3%	19.5%	16.8%
Huadian Power International	HKD	1.5	Sell	NA	NA	NA	24.4x	12.8x	13.6x	10.6x	8.7x	0.8%	0.0%	0.0%	1.0%	NA	19.4%
China Power International Development	HKD	1.5	Sell	15.0x	14.2x	12.3x	8.2x	10.0x	10.4x	9.1x	7.7x	2.0%	1.9%	2.2%	3.3%	16.4%	11.5%
National Thermal Power Corporation Ltd.	INR	215.0	Buy	18.1x	16.2x	15.1x	12.5x	10.8x	10.0x	9.4x	8.6x	2.2%	2.4%	2.6%	2.9%	6.5%	18.0%
Reliance Power	INR	130.0	Sell	25.1x	42.1x	17.6x	10.2x	20.5x	30.2x	16.0x	9.2x	0.0%	0.0%	0.0%	0.0%	28.8%	NA
Adani Power	INR	110.0	Sell	47.4x	20.9x	8.2x	5.7x	32.8x	13.5x	6.6x	4.7x	0.0%	0.0%	0.0%	0.0%	106.2%	128.5%
Lanco	INR	70.0	Buy	14.6x	9.5x	5.7x	5.2x	8.3x	6.3x	4.5x	5.6x	0.0%	0.0%	0.0%	0.0%	42.2%	34.3%
Ratchaburi Electric	THB	45.0	Buy	11.1x	10.5x	10.1x	9.6x	5.8x	5.0x	4.5x	3.8x	6.0%	5.9%	5.9%	6.1%	5.7%	0.3%
Glow Energy PCL	THB	50.0	Buy	14.3x	13.5x	8.1x	8.4x	12.3x	12.8x	7.2x	6.6x	4.4%	4.5%	5.0%	5.0%	15.5%	18.9%
Electricity Generating Co.	THB	117.0	Buy	7.2x	7.2x	7.3x	6.8x	5.1x	4.7x	5.7x	3.1x	6.1%	5.6%	5.9%	6.2%	4.2%	-16.1%
Energy Development Corp	PHP	6.0	Neutral	13.8x	14.0x	11.6x	9.1x	8.6x	9.6x	8.3x	7.1x	2.0%	2.4%	2.4%	2.8%	12.0%	3.3%
Aboitiz Power	PHP	33.0	Buy	10.0x	10.7x	10.8x	9.7x	8.6x	8.6x	8.1x	7.2x	0.8%	3.0%	2.8%	2.8%	1.8%	0.9%
First Gen Corporation	PHP	15.0	Buy	12.5x	11.0x	8.7x	6.6x	4.0x	3.6x	3.2x	2.8x	0.0%	0.0%	0.0%	0.0%	18.6%	0.7%
YTL Power International	MYR	2.1	Sell	12.5x	12.1x	12.0x	9.2x	8.7x	8.9x	8.9x	8.8x	5.7%	5.7%	5.7%	7.0%	5.1%	5.8%
Mean				**17.2x**	**16.2x**	**12.0x**	**10.2x**	**11.1x**	**10.4x**	**8.2x**	**6.8x**	**2.5%**	**2.4%**	**2.6%**	**3.1%**	**19.1%**	**17.5%**
Weighted Average				**18.7x**	**18.0x**	**14.3x**	**11.6x**	**11.6x**	**10.9x**	**9.1x**	**7.7x**	**2.4%**	**2.4%**	**2.6%**	**3.1%**	**14.3%**	**18.1%**
Integrated Regulated																	
CLP Holdings	HKD	80.0	Buy	16.4x	14.5x	12.7x	12.4x	10.9x	9.7x	8.8x	8.4x	3.9%	4.2%	4.8%	4.9%	7.2%	8.8%
Power Assets/Hongkong Electric	HKD	58.0	Buy	15.4x	12.9x	12.6x	12.2x	11.7x	12.0x	11.3x	10.5x	4.1%	4.1%	4.2%	4.3%	6.0%	0.6%
Tata Power	INR	1,600.0	Buy	17.8x	14.3x	12.6x	12.0x	9.9x	9.0x	8.9x	8.8x	1.1%	2.4%	2.8%	3.4%	12.8%	9.8%
Reliance Infrastructure	INR	1,200.0	Buy	10.8x	10.4x	9.0x	7.9x	4.3x	2.4x	0.9x	-0.7x	0.8%	0.8%	0.9%	0.0%	9.8%	10.2%
Tenaga Nasional	MYR	8.5	Buy	14.4x	14.7x	13.7x	9.5x	6.2x	5.7x	5.4x	4.5x	1.6%	2.4%	1.7%	1.7%	11.9%	8.3%
KEPCO	KRW	40,000.0	Buy	NA	14.7x	8.9x	7.9x	6.9x	5.8x	5.1x	4.8x	0.0%	1.9%	2.6%	3.0%	NA	14.5%
Mean				**15.0x**	**13.6x**	**11.6x**	**10.3x**	**8.3x**	**7.4x**	**6.7x**	**6.0x**	**1.9%**	**2.6%**	**2.8%**	**2.9%**	**9.5%**	**8.7%**
Weighted Average				**15.5x**	**14.0x**	**11.8x**	**10.6x**	**9.0x**	**8.2x**	**7.5x**	**7.0x**	**2.3%**	**3.0%**	**3.3%**	**3.4%**	**8.7%**	**8.5%**
T&D																	
ENN Energy Holdings (Xinao Gas)	HKD	30.9	Buy	18.7x	15.1x	12.4x	11.3x	9.6x	8.4x	7.2x	6.6x	1.2%	1.6%	2.2%	2.7%	13.4%	11.8%
Hong Kong & China Gas	HKD	18.3	Neutral	29.9x	26.6x	23.2x	21.7x	22.1x	19.3x	15.7x	14.3x	1.9%	1.9%	1.9%	1.9%	8.3%	10.3%
China Gas Holdings	HKD	4.0	Buy	24.6x	18.8x	16.2x	15.0x	12.3x	11.0x	9.5x	7.2x	0.4%	0.5%	0.5%	0.6%	11.8%	12.6%
Towngas China	HKD	4.7	Buy	26.2x	19.7x	16.7x	14.7x	18.3x	15.1x	12.8x	10.6x	0.6%	1.0%	1.2%	1.5%	15.4%	12.4%
Power Grid Corp of India	INR	135.0	Buy	16.7x	14.6x	12.5x	11.5x	9.8x	9.1x	7.9x	6.9x	1.4%	1.5%	1.6%	1.7%	14.2%	16.6%
GAIL (India) Ltd.	INR	580.0	Buy	16.2x	13.5x	11.9x	9.8x	10.9x	8.8x	7.4x	5.8x	3.1%	3.7%	4.2%	6.1%	12.4%	10.1%
Indraprastha Gas	INR	400.0	Buy	16.0x	13.7x	11.6x	10.0x	8.1x	6.3x	5.2x	4.5x	2.2%	2.6%	3.0%	3.5%	15.6%	20.9%
Petronet LNG	INR	150.0	Buy	16.1x	14.4x	13.2x	10.7x	9.0x	8.5x	7.7x	6.2x	1.6%	1.7%	1.8%	1.9%	16.1%	19.5%
Manila Electric	PHP	195.0	Sell	23.6x	17.3x	18.6x	18.3x	14.3x	9.3x	9.6x	9.4x	2.2%	3.1%	3.1%	3.1%	7.6%	10.8%
China Resources Gas	HKD	11.0	Neutral	25.3x	20.7x	17.3x	15.6x	12.1x	10.9x	9.3x	8.1x	0.8%	1.0%	1.1%	1.4%	12.9%	22.7%
Perusahaan Gas Negara	IDR	5,500.0	Buy	13.9x	11.7x	9.3x	7.2x	8.8x	7.9x	6.4x	4.7x	3.0%	3.7%	4.4%	5.5%	19.2%	14.0%
Mean				**20.7x**	**16.9x**	**14.8x**	**13.3x**	**12.3x**	**10.4x**	**9.0x**	**7.7x**	**1.7%**	**2.0%**	**2.3%**	**2.7%**	**13.3%**	**14.7%**
Weighted Average				**20.8x**	**17.6x**	**15.5x**	**13.9x**	**13.6x**	**11.5x**	**9.8x**	**8.5x**	**2.1%**	**2.5%**	**2.7%**	**3.3%**	**12.5%**	**12.7%**
Diversified Utilities																	
Cheung Kong Infrastructure	HKD	46	Buy	18.5x	13.0x	12.4x	11.8x	51.6x	43.0x	38.7x	34.3x	3.4%	3.8%	4.0%	4.2%	11.9%	3.4%
Beijing Enterprises Holdings	HKD	65.80	Buy	19.5x	16.1x	13.7x	11.7x	10.8x	8.6x	7.1x	6.3x	1.6%	1.9%	2.3%	2.8%	13.6%	14.8%
Metro Pacific Corp	PHP	5	Buy	20.6x	12.9x	12.0x	10.6x	7.6x	6.0x	5.6x	5.2x	0.0%	0.0%	0.0%	0.0%	19.3%	14.7%
Mean				**19.6x**	**14.0x**	**12.7x**	**11.4x**	**23.3x**	**19.2x**	**17.1x**	**15.2x**	**1.7%**	**1.9%**	**2.1%**	**2.3%**	**14.9%**	**10.9%**
Weighted Average				**19.1x**	**14.1x**	**12.8x**	**11.7x**	**33.8x**	**28.0x**	**25.0x**	**22.2x**	**2.5%**	**2.8%**	**3.1%**	**3.4%**	**13.1%**	**8.3%**
APAC ex J+A Utilities Valuation		**Weighted Average**		**19.3x**	**17.4x**	**15.2x**	**12.8x**	**12.9x**	**12.0x**	**10.6x**	**9.1x**	**2.2%**	**2.5%**	**2.8%**	**3.1%**	**10.9%**	**12.7%**

Source: UBS estimates

Australia / NZ	LC	Price Target (LC)	Rating	PE				EV/ EBITDA				Diviend Yield				CAGR (2010-13E)	
				2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	EPS	EBITDA
Generation																	
TrustPower Limited	NZD	7.5	Neutral	19.4x	19.3x	17.2x	15.9x	11.2x	11.1x	10.0x	9.5x	5.1%	5.3%	5.6%	5.7%	7.4%	6.9%
Infigen Energy	AUD	0.4	Neutral	NA	NA	NA	NA	12.9x	9.5x	8.5x	7.9x	1.6%	5.4%	5.4%	5.4%	0.7%	1.0%
Transfield Services Infrastructure Fund	AUD	0.9	Buy	12.2x	44.5x	57.3x	39.2x	7.8x	9.4x	8.9x	8.4x	9.4%	10.4%	10.6%	10.9%	-24.2%	-1.3%
Mean				**15.8x**	**31.9x**	**37.3x**	**27.5x**	**10.6x**	**10.0x**	**9.1x**	**8.6x**	**5.4%**	**7.0%**	**7.2%**	**7.3%**	**-5.4%**	**2.2%**
Weighted Average				**18.2x**	**23.6x**	**24.0x**	**19.8x**	**10.9x**	**10.6x**	**9.7x**	**9.2x**	**5.3%**	**6.1%**	**6.3%**	**6.4%**	**1.9%**	**4.9%**
Integrated																	
Contact Energy	NZD	6.2	Neutral	24.4x	21.4x	17.6x	15.8x	11.4x	10.1x	8.8x	8.3x	4.1%	4.3%	4.5%	4.6%	12.6%	11.8%
AGL Energy Limited	AUD	16.8	Buy	14.9x	15.6x	14.3x	13.8x	7.5x	7.8x	7.3x	6.9x	4.2%	4.1%	4.3%	4.5%	6.2%	6.7%
Origin Energy	AUD	17.6	Buy	23.7x	22.4x	18.3x	17.1x	12.1x	10.9x	8.6x	6.1x	3.2%	3.1%	3.3%	3.5%	13.7%	21.0%
Mean				**21.0x**	**19.8x**	**16.7x**	**15.6x**	**10.3x**	**9.6x**	**8.2x**	**7.1x**	**3.8%**	**3.8%**	**4.0%**	**4.2%**	**10.8%**	**13.1%**
Weighted Average				**21.3x**	**20.4x**	**17.1x**	**16.0x**	**10.7x**	**9.9x**	**8.3x**	**6.6x**	**3.5%**	**3.5%**	**3.7%**	**3.9%**	**11.5%**	**16.0%**
T&D																	
Vector Limited	NZD	2.3	Sell	10.5x	13.2x	12.9x	13.8x	7.7x	8.2x	8.1x	8.2x	6.9%	5.7%	5.8%	6.2%	0.3%	3.2%
SP AusNet	AUD	1.0	Buy	12.1x	12.0x	14.0x	14.7x	9.0x	8.2x	8.0x	7.9x	9.4%	9.3%	9.6%	9.8%	-5.4%	11.2%
Diversified Utility & Energy Trusts	AUD	1.8	Neutral	10.5x	10.8x	12.4x	12.9x	8.2x	8.6x	8.4x	8.2x	11.7%	11.9%	12.2%	12.4%	-7.4%	5.5%
Spark Infrastructure Group	AUD	1.4	Buy	17.0x	14.4x	13.5x	17.4x	-0.1x	-0.3x	-0.5x	-0.7x	11.6%	8.3%	8.5%	8.7%	NA	0.3%
Envestra Limited	AUD	0.6	Neutral	18.8x	22.3x	13.2x	10.8x	-4.8x	-4.6x	-4.0x	-3.8x	10.8%	9.2%	9.2%	9.5%	24.4%	11.3%
Hastings Diversified Utilities Fund	AUD	2.0	Buy	14.6x	33.7x	95.5x	NA	13.3x	20.6x	13.9x	12.5x	8.9%	6.3%	6.6%	6.9%	NA	18.5%
APA Group	AUD	3.9	Neutral	16.7x	22.7x	28.4x	23.2x	9.0x	10.1x	10.1x	9.6x	10.1%	8.2%	8.6%	9.0%	-3.3%	8.2%
Mean				**14.3x**	**18.5x**	**27.1x**	**15.5x**	**6.0x**	**7.3x**	**6.3x**	**6.0x**	**9.9%**	**8.4%**	**8.6%**	**8.9%**	**1.7%**	**8.3%**
Weighted Average				**13.9x**	**16.9x**	**22.5x**	**16.2x**	**6.8x**	**7.5x**	**6.9x**	**6.7x**	**9.8%**	**8.5%**	**8.7%**	**9.0%**	**-1.2%**	**7.6%**
Australia Utilities Valuation		**Weighted Average**		**18.9x**	**19.5x**	**19.1x**	**12.0x**	**9.5x**	**9.2x**	**7.9x**	**6.8x**	**5.5%**	**5.2%**	**5.4%**	**5.6%**	**7.1%**	**12.6%**
Source: UBS estimates																	

Europe	LC	Price Target (LC)	Rating	PE				EV/ EBITDA				Diviend Yield				CAGR (2010-13E)	
				2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	EPS	EBITDA
Generation																	
RWE	EUR	46.0	Neutral	8.1x	8.8x	9.0x	10.5x	6.5x	6.9x	6.9x	7.3x	6.1%	6.0%	5.8%	4.4%	-10.2%	-1.6%
E.ON	EUR	24.0	Buy	9.5x	12.6x	11.3x	9.3x	6.9x	7.8x	7.2x	6.5x	6.1%	6.0%	6.0%	6.0%	-3.4%	-2.1%
EDF	EUR	40.0	Buy	13.6x	13.2x	10.7x	9.9x	6.4x	7.0x	6.3x	6.0x	3.9%	4.8%	4.7%	5.0%	11.2%	4.2%
GDF Suez	EUR	30.0	Neutral	14.5x	14.5x	13.9x	12.4x	7.8x	7.8x	7.5x	7.2x	5.6%	5.4%	5.5%	5.9%	7.8%	8.0%
Enel	EUR	5.1	Buy	8.3x	9.2x	8.9x	9.0x	5.3x	6.1x	5.9x	5.7x	6.4%	6.3%	6.5%	6.7%	3.2%	-0.2%
EDP	EUR	5.0	Buy	51.2x	31.2x	25.8x	21.4x	12.1x	10.1x	9.1x	8.2x	0.0%	0.4%	0.6%	0.8%	26.5%	15.2%
Endesa	EUR	24.0	Buy	10.6x	9.9x	10.0x	10.1x	6.1x	5.9x	5.8x	5.7x	4.7%	4.7%	5.1%	5.0%	2.8%	1.7%
Tauron	PLN	6.7	Neutral	12.6x	11.7x	11.3x	13.2x	5.7x	5.7x	6.2x	7.1x	2.4%	2.6%	2.6%	3.0%	0.3%	3.8%
Gas Natural Fenosa	EUR	11.0	Neutral	10.7x	11.3x	10.2x	10.4x	6.3x	7.5x	7.1x	6.9x	6.0%	6.3%	6.6%	6.8%	2.5%	-0.5%
Iberdrola	EUR	5.8	Sell	12.2x	12.8x	11.7x	11.9x	8.0x	8.3x	7.7x	7.6x	5.7%	5.3%	5.1%	5.1%	4.0%	4.3%
PPC	EUR	NA	Suspended	4.9x	6.4x	5.5x	20.9x	5.0x	6.7x	6.1x	8.5x	6.4%	5.5%	6.4%	1.7%	-29.1%	-1.9%
CEZ	CZK	1,030.0	Buy	9.7x	12.0x	12.2x	10.8x	6.6x	7.4x	7.4x	7.2x	5.8%	5.1%	5.1%	5.7%	0.6%	2.5%
Scottish & Southern	GBX	1,160.0	Neutral	10.2x	11.3x	10.9x	10.6x	7.8x	8.9x	8.6x	8.4x	6.2%	5.9%	6.2%	6.5%	2.1%	4.2%
Centrica	GBX	355.0	Buy	12.9x	11.7x	10.3x	9.8x	6.6x	6.3x	5.3x	4.9x	4.4%	4.7%	5.2%	5.6%	8.1%	5.6%
Mean				**13.5x**	**12.6x**	**11.6x**	**12.2x**	**6.9x**	**7.3x**	**7.0x**	**7.0x**	**5.0%**	**4.9%**	**5.1%**	**4.9%**	**1.9%**	**3.3%**
Weighted Average				**11.9x**	**12.3x**	**11.4x**	**10.8x**	**6.8x**	**7.3x**	**6.9x**	**6.7x**	**5.4%**	**5.3%**	**5.4%**	**5.6%**	**3.7%**	**3.3%**
Integrated																	
Fortum	EUR	24.0	Buy	13.0x	14.6x	13.0x	12.0x	9.5x	11.0x	9.9x	9.3x	5.2%	4.4%	4.8%	5.0%	9.7%	6.6%
Drax Group	GBX	380.0	Neutral	6.2x	7.9x	12.7x	38.5x	3.9x	4.6x	6.5x	11.8x	7.3%	5.5%	3.3%	1.3%	-36.0%	-25.0%
International Power	GBX	450.0	Buy	10.9x	10.6x	9.9x	8.5x	7.3x	7.2x	6.8x	5.9x	4.1%	4.3%	4.6%	4.8%	7.6%	2.4%
Mean				**10.1x**	**11.0x**	**11.9x**	**19.7x**	**6.9x**	**7.6x**	**7.7x**	**9.0x**	**5.5%**	**4.8%**	**4.2%**	**3.7%**	**-6.2%**	**-5.3%**
Weighted Average				**12.2x**	**13.4x**	**12.4x**	**12.9x**	**8.7x**	**9.9x**	**9.1x**	**8.8x**	**5.1%**	**4.4%**	**4.7%**	**4.8%**	**6.7%**	**4.0%**
Integrated Regulated																	
Red Eléctrica	EUR	40.0	Neutral	13.9x	11.7x	10.5x	9.4x	10.6x	9.1x	8.3x	7.7x	3.9%	4.5%	5.0%	5.7%	12.1%	11.5%
Enagas	EUR	20.0	Buy	11.4x	10.9x	10.0x	9.2x	9.1x	8.5x	8.1x	7.6x	4.9%	5.4%	5.9%	6.5%	7.4%	9.0%
REN	EUR	2.9	Neutral (CBE)	10.7x	9.4x	8.9x	8.5x	8.2x	7.9x	7.8x	7.7x	5.6%	6.4%	6.8%	7.1%	7.7%	6.7%
Snam RG	EUR	4.0	Neutral	12.1x	13.6x	12.9x	13.8x	9.1x	9.7x	9.4x	9.6x	6.4%	6.0%	6.3%	6.5%	0.9%	3.5%
Terna	EUR	3.3	Neutral	16.0x	16.5x	17.5x	17.0x	9.8x	9.9x	10.2x	9.8x	5.7%	5.8%	5.8%	5.7%	0.2%	5.2%
National Grid	GBX	615.0	Buy	10.3x	12.6x	11.6x	10.8x	8.8x	9.2x	8.7x	8.4x	6.5%	6.1%	6.6%	6.8%	2.4%	6.5%
Mean				**12.4x**	**12.4x**	**11.9x**	**11.5x**	**9.3x**	**9.1x**	**8.7x**	**8.4x**	**5.7%**	**5.7%**	**6.1%**	**6.4%**	**5.1%**	**7.0%**
Weighted Average				**11.9x**	**13.1x**	**12.4x**	**12.0x**	**9.2x**	**9.3x**	**9.0x**	**8.7x**	**6.0%**	**5.8%**	**6.2%**	**6.5%**	**3.2%**	**6.2%**
T&D																	
Iberdrola Renovables	EUR	3.0	Neutral	32.4x	30.8x	24.4x	24.8x	12.4x	12.1x	10.6x	10.3x	0.9%	1.0%	1.1%	1.4%	11.5%	10.2%
EDF EN	EUR	38.0	Buy	26.5x	21.9x	18.1x	15.7x	13.2x	11.1x	9.9x	9.2x	1.1%	1.4%	1.7%	1.9%	15.9%	17.2%
EDP Renovaveis	EUR	5.0	Buy	51.2x	31.2x	25.8x	21.4x	12.1x	10.1x	9.1x	8.2x	0.0%	0.4%	0.6%	0.8%	26.5%	15.2%
Mean				**36.7x**	**28.0x**	**22.8x**	**20.6x**	**12.6x**	**11.1x**	**9.9x**	**9.2x**	**0.7%**	**0.9%**	**1.1%**	**1.4%**	**18.0%**	**14.2%**
Weighted Average				**35.7x**	**29.6x**	**23.8x**	**22.8x**	**12.4x**	**11.5x**	**10.2x**	**9.7x**	**0.7%**	**0.9%**	**1.1%**	**1.4%**	**15.4%**	**12.3%**
Water																	
Veolia Env.	EUR	25.0	Buy	18.3x	16.1x	13.3x	12.3x	8.9x	8.3x	7.9x	7.7x	5.5%	5.8%	6.0%	6.1%	12.3%	6.1%
Suez Environnement	EUR	15.0	Neutral	17.2x	16.1x	13.3x	11.8x	9.0x	7.9x	7.4x	7.0x	4.3%	4.7%	4.9%	5.2%	11.1%	8.9%
Mean				**17.7x**	**16.1x**	**13.3x**	**12.0x**	**8.9x**	**8.1x**	**7.6x**	**7.3x**	**4.9%**	**5.2%**	**5.4%**	**5.7%**	**11.7%**	**7.5%**
Weighted Average				**17.8x**	**16.1x**	**13.3x**	**12.1x**	**8.9x**	**8.1x**	**7.7x**	**7.4x**	**5.0%**	**5.4%**	**5.5%**	**5.8%**	**11.8%**	**7.2%**
European Utilities Valuation		**Weighted Average**		**13.1x**	**13.3x**	**12.2x**	**11.1x**	**7.5x**	**7.9x**	**7.4x**	**6.9x**	**5.3%**	**5.2%**	**5.3%**	**5.2%**	**4.4%**	**4.0%**

Source: UBS estimates

Japan	LC	Price Target (LC)	Rating	PE				EV/ EBITDA				Diviend Yield				CAGR (2010 -13E)	
				2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	EPS	EBITDA
Generation																	
Electric Power Development (J-Power)	JPY	2,800.0	Buy	14.5x	15.4x	10.4x	9.6x	10.1x	9.3x	9.3x	9.2x	2.5%	2.7%	2.7%	3.1%	11.6%	4.9%
Integrated Regulated																	
Tokyo Electric Power	JPY	696.0	Neutral (UR)	26.3x	27.4x	NA	24.9x	9.6x	7.2x	14.3x	9.7x	2.5%	6.4%	0.0%	0.0%	-30.6%	-3.5%
Kansai Electric Power	JPY	2,500.0	Buy	14.9x	10.6x	12.4x	10.7x	8.0x	6.8x	6.9x	6.6x	2.9%	3.3%	3.3%	3.3%	7.8%	5.2%
Chubu Electric Power	JPY	2,350.0	Buy	15.4x	16.5x	12.2x	10.7x	8.6x	8.4x	7.8x	7.4x	2.7%	3.2%	3.2%	3.2%	7.8%	3.7%
Tokyo Gas	JPY	400.0	Neutral	18.3x	13.7x	17.3x	14.5x	6.3x	5.3x	5.7x	5.5x	2.2%	2.4%	2.4%	NA	10.2%	4.9%
Tohoku Electric Power	JPY	1,600.0	Neutral	43.0x	11.6x	NA	15.6x	9.0x	7.9x	10.9x	8.8x	3.1%	4.3%	4.3%	4.3%	22.4%	2.7%
Kyushu Electric Power	JPY	2,200.0	Buy	22.5x	20.4x	16.0x	12.2x	8.1x	7.4x	7.0x	6.5x	3.0%	3.7%	3.7%	3.7%	14.0%	3.8%
Osaka Gas	JPY	350.0	Buy	13.6x	14.8x	16.2x	13.7x	5.1x	4.9x	4.8x	4.4x	2.2%	2.4%	2.4%	2.4%	4.1%	2.8%
Chugoku Electric Power	JPY	1,600.0	Sell	18.9x	213.6x	22.3x	19.3x	10.3x	11.8x	9.8x	9.1x	2.6%	3.3%	3.3%	3.3%	-3.1%	5.6%
Shikoku Electric Power	JPY	2,400.0	Neutral	26.6x	16.2x	15.5x	13.7x	9.7x	7.1x	7.3x	6.9x	1.9%	2.7%	2.7%	2.7%	16.7%	6.8%
Hokuriku Electric Power	JPY	2,100.0	Neutral	27.8x	15.8x	17.5x	13.6x	9.4x	7.4x	7.2x	7.0x	2.4%	2.7%	2.7%	3.2%	19.5%	3.3%
Hokkaido Electric Power	JPY	1,700.0	Neutral	38.7x	23.1x	19.5x	14.4x	8.3x	8.7x	9.5x	9.4x	2.8%	3.1%	3.1%	3.1%	28.2%	0.7%
Toho Gas	JPY	480.0	Buy	22.6x	14.2x	13.2x	11.9x	4.6x	5.0x	4.8x	4.6x	1.8%	1.9%	1.9%	1.9%	19.8%	-1.1%
Okinawa Electric Power	JPY	4,700.0	Buy	9.9x	9.1x	7.9x	9.4x	7.2x	7.6x	7.8x	8.0x	1.2%	1.6%	1.6%	1.6%	-2.9%	2.1%
Mean				**22.4x**	**30.2x**	**15.0x**	**13.9x**	**8.2x**	**7.5x**	**8.1x**	**7.4x**	**2.4%**	**3.1%**	**2.7%**	**2.7%**	**9.0%**	**3.0%**
Weighted Average				**21.2x**	**27.6x**	**15.0x**	**13.8x**	**8.2x**	**7.4x**	**8.0x**	**7.2x**	**2.6%**	**3.3%**	**2.8%**	**2.9%**	**7.7%**	**3.5%**
Japan Utilities Valuation		**Weighted Average**		**21.2x**	**27.6x**	**15.0x**	**13.8x**	**8.2x**	**7.4x**	**8.0x**	**7.2x**	**2.6%**	**3.3%**	**2.8%**	**2.9%**	**7.7%**	**3.5%**
Source: UBS estimates																	

Russia	LC	Price Target (LC)	Rating	PE				EV/ EBITDA				Diviend Yield				CAGR (2010-13E)	
				2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	EPS	EBITDA
Generation																	
RusHydro	RUB	2.0	Buy	11.2x	9.4x	7.9x	6.3x	6.8x	5.7x	4.8x	3.5x	0.0%	0.0%	0.0%	0.0%	17.4%	18.8%
Mosenergo	RUB	4.0	Buy	64.8x	19.1x	15.1x	12.3x	6.5x	4.9x	4.6x	4.3x	0.0%	0.0%	0.0%	0.0%	54.0%	13.3%
Interregional GenCo-4	RUB	3.3	Buy	16.1x	10.9x	8.0x	7.3x	10.2x	7.1x	4.9x	4.1x	0.0%	0.0%	0.0%	0.0%	24.1%	24.0%
Interregional GenCo-5	RUB	2.9	Buy	15.4x	10.9x	7.8x	7.4x	10.4x	7.4x	5.1x	4.3x	0.0%	0.0%	0.0%	0.0%	22.3%	21.5%
Regional GenCo-1	RUB	0.0	Buy	17.6x	8.3x	6.4x	4.5x	10.2x	5.9x	4.5x	2.9x	0.0%	0.0%	0.0%	0.0%	43.4%	33.6%
Interregional GenCo-3	RUB	2.0	Buy	30.3x	21.8x	8.9x	5.4x	11.0x	15.1x	5.8x	3.2x	0.0%	0.0%	0.0%	0.0%	56.9%	75.5%
Interregional GenCo-1	RUB	1.3	Buy	32.3x	22.2x	12.4x	6.5x	6.5x	6.2x	5.5x	3.3x	0.0%	0.0%	0.0%	0.0%	51.6%	32.0%
Interregional GenCo-2	RUB	2.4	Buy	14.8x	9.1x	6.5x	4.3x	10.4x	7.0x	5.7x	4.2x	0.0%	0.0%	0.0%	0.0%	38.5%	34.7%
Interregional GenCo-6	RUB	1.5	Neutral	NA	NA	NA	107.1x	45.4x	109.6x	15.7x	12.7x	0.0%	0.0%	0.0%	0.0%	NA	57.2%
Mean				**25.3x**	**14.0x**	**9.1x**	**17.9x**	**13.1x**	**18.8x**	**6.3x**	**4.7x**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**39%**	**35%**
Weighted Average				**21.2x**	**12.1x**	**8.8x**	**11.0x**	**9.8x**	**10.8x**	**5.3x**	**4.1x**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**30%**	**26%**
T&D																	
Federal Grid Company	RUB	0.5	Buy	19.5x	13.5x	10.9x	8.6x	5.5x	4.5x	4.4x	4.2x	0.0%	0.7%	0.9%	1.2%	24.9%	24.7%
MRSK Holding	RUB	5.8	Buy	12.4x	8.5x	7.1x	6.2x	5.9x	5.1x	4.6x	4.2x	0.0%	3.2%	3.9%	4.4%	21.1%	14.5%
Moscow United Electricity Grid	RUB	1.9	Buy	7.0x	8.2x	7.5x	6.7x	4.0x	4.2x	3.9x	3.6x	0.0%	1.8%	2.0%	2.3%	2.9%	3.5%
Mean				**13.0x**	**10.1x**	**8.5x**	**7.1x**	**5.1x**	**4.6x**	**4.3x**	**4.0x**	**0.0%**	**1.9%**	**2.3%**	**2.6%**	**16.3%**	**17.1%**
Weighted Average				**16.5x**	**11.7x**	**9.6x**	**7.8x**	**5.5x**	**4.6x**	**4.4x**	**4.1x**	**0.0%**	**1.5%**	**1.8%**	**2.1%**	**21.8%**	**20.0%**
Russian Utilities sector		**Weighted Average**		**19.2x**	**11.9x**	**9.1x**	**9.6x**	**8.0x**	**8.2x**	**5.0x**	**4.1x**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**24.7%**	**22.7%**

Source: UBS estimates

North America	LC	Price Target (LC)	Rating	PE				EV/ EBITDA				Diviend Yield				CAGR (2010-13E)	
				2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	2010E	2011E	2012E	2013E	EPS	EBITDA
Generation																	
Dynergy, Inc	USD	5.5	Neutral (CBE)	NA	NA	NA	NA	16.5x	10.0x	22.6x	17.8x	0.0%	0.0%	0.0%	0.0%	2.2%	-9.3%
Calpine Corp	USD	17.0	Buy	12.3x	23.5x	76.0x	27.1x	7.8x	8.4x	9.6x	8.4x	0.0%	0.0%	0.0%	0.0%	-13.0%	0.8%
NRG Energy	USD	22.0	Neutral	11.6x	23.3x	19.8x	24.1x	2.0x	2.6x	2.5x	2.5x	0.0%	0.0%	0.0%	0.0%	-16.9%	-7.5%
RRI Energy	USD	4.0	Neutral (CBE)	NA	NA	NA	NA	7.6x	17.8x	98.3x	11.7x	0.0%	0.0%	0.0%	0.0%	9.5%	-10.3%
TransAlta Corporation	CAD	20.0	Neutral	22.1x	19.3x	18.3x	16.3x	9.3x	9.1x	9.1x	8.6x	5.4%	5.7%	5.7%	5.7%	8.1%	3.5%
Mean				**15.3x**	**22.1x**	**38.0x**	**22.5x**	**8.7x**	**9.6x**	**28.4x**	**9.8x**	**1.1%**	**1.1%**	**1.1%**	**1.1%**	**-2.0%**	**-4.5%**
Weighted Average				**14.7x**	**22.3x**	**42.4x**	**23.2x**	**6.8x**	**7.7x**	**14.1x**	**7.3x**	**1.3%**	**1.4%**	**1.4%**	**1.4%**	**-6.9%**	**-2.0%**
Integrated																	
Ameren Corp	USD	27.0	Neutral	9.7x	11.7x	13.2x	15.6x	4.7x	5.6x	5.9x	6.3x	5.8%	5.5%	5.5%	5.5%	-10.0%	-4.9%
Constellation Energy	USD	32.0	Neutral (CBE)	18.1x	9.4x	12.9x	10.5x	8.2x	5.4x	6.2x	5.6x	2.9%	3.1%	3.1%	3.1%	13.0%	9.0%
Dominion Resources	USD	NA	Suspended	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
DTE Energy	USD	49.0	Neutral	13.5x	13.3x	12.8x	11.8x	5.9x	5.8x	5.5x	5.3x	4.5%	4.6%	4.7%	4.9%	3.4%	2.8%
Entergy Corp	USD	74.0	Neutral	10.8x	10.4x	11.5x	12.1x	5.7x	5.3x	5.3x	5.4x	4.2%	4.9%	4.9%	4.9%	-5.9%	-0.4%
Exelon Corp	USD	41.0	Neutral	10.4x	10.1x	13.8x	14.7x	5.8x	6.5x	8.0x	8.3x	5.0%	5.1%	5.1%	5.1%	-8.8%	-7.0%
PPL Corp	USD	26.0	Neutral	8.0x	9.9x	11.4x	12.6x	7.4x	6.0x	6.3x	6.2x	5.5%	5.5%	5.5%	5.5%	-10.6%	4.6%
Public Service Enterprise	USD	35.0	Buy	10.1x	11.8x	13.3x	11.5x	6.0x	6.5x	6.9x	6.2x	4.3%	4.3%	4.3%	4.3%	-3.2%	-0.6%
Sempra Energy	USD	64.0	Buy	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mean				**11.5x**	**10.9x**	**12.7x**	**12.7x**	**6.3x**	**5.9x**	**6.3x**	**6.2x**	**4.6%**	**4.7%**	**4.7%**	**4.8%**	**-3.2%**	**0.5%**
Weighted Average				**11.0x**	**10.8x**	**12.9x**	**13.0x**	**6.1x**	**6.1x**	**6.7x**	**6.6x**	**4.7%**	**4.8%**	**4.8%**	**4.8%**	**-4.9%**	**-1.3%**
Integrated Regulated																	
American Electric Power	USD	36.0	Neutral	11.5x	11.4x	10.7x	10.3x	8.5x	8.7x	8.4x	8.1x	4.9%	5.2%	5.3%	5.4%	3.0%	2.4%
Duke Energy	USD	18.0	Neutral	11.9x	13.3x	13.0x	12.4x	7.2x	7.4x	7.2x	6.8x	5.7%	5.6%	5.8%	6.1%	0.6%	5.0%
Empire District Electric Co	USD	21.5	Neutral	16.8x	14.4x	14.6x	13.2x	8.6x	8.2x	8.3x	8.1x	6.5%	5.9%	5.9%	5.9%	9.0%	5.3%
PG&E Corp	USD	47.0	Neutral	13.0x	11.9x	11.4x	11.1x	9.6x	8.6x	8.0x	7.7x	4.0%	4.4%	4.6%	4.9%	3.8%	5.2%
Pinnacle West	USD	43.0	Neutral	12.7x	13.8x	12.8x	12.7x	8.9x	9.5x	9.0x	8.8x	5.4%	4.9%	4.9%	5.0%	2.6%	1.6%
Progress Energy	USD	45.0	Neutral	13.5x	14.8x	14.5x	13.9x	7.6x	8.4x	8.4x	8.2x	6.0%	5.4%	5.4%	5.4%	2.1%	0.9%
SCANA Corp	USD	40.0	Neutral	12.7x	12.7x	12.2x	11.5x	4.4x	4.2x	3.8x	3.5x	4.9%	4.9%	5.0%	5.0%	3.0%	6.2%
Southern Co	USD	40.0	Neutral	16.1x	14.9x	13.9x	13.3x	6.2x	5.3x	5.3x	5.0x	4.7%	4.9%	5.0%	5.1%	4.8%	5.4%
TECO Energy	USD	20.0	Buy	12.1x	13.0x	11.0x	11.8x	6.7x	6.9x	6.2x	6.4x	5.0%	4.5%	4.6%	4.7%	4.0%	0.8%
Westar Energy	USD	26.0	Neutral	12.8x	15.5x	13.5x	11.9x	6.7x	6.9x	6.1x	5.3x	5.3%	4.8%	5.0%	5.1%	4.9%	7.4%
Wisonsin Energy Corp	USD	34.0	Buy	14.0x	14.7x	13.4x	13.1x	10.1x	10.5x	9.7x	9.5x	1.5%	1.7%	4.1%	4.3%	5.0%	4.2%
Fortis Inc.	CAD	35.0	Neutral	17.8x	19.0x	17.7x	16.9x	9.7x	10.2x	9.8x	9.7x	3.8%	3.5%	3.7%	3.9%	6.1%	6.4%
Mean				**13.4x**	**13.6x**	**12.8x**	**12.3x**	**7.7x**	**7.7x**	**7.3x**	**7.0x**	**4.9%**	**4.7%**	**5.0%**	**5.2%**	**3.9%**	**4.0%**
Weighted Average				**13.4x**	**13.5x**	**12.8x**	**12.3x**	**7.6x**	**7.4x**	**7.1x**	**6.8x**	**4.9%**	**4.8%**	**5.1%**	**5.3%**	**3.2%**	**4.1%**
T&D																	
Center Point	USD	20.0	Buy	14.1x	15.5x	14.7x	13.6x	6.1x	6.5x	6.3x	6.0x	5.3%	4.5%	4.7%	4.8%	5.3%	3.9%
Consolidated Edison	USD	52.0	Neutral	13.4x	14.1x	13.6x	13.1x	8.4x	9.5x	9.1x	8.6x	5.2%	4.7%	4.8%	4.8%	3.0%	3.6%
Northeast Utilities	USD	35.0	Neutral	12.8x	14.9x	14.1x	13.4x	4.3x	5.4x	4.9x	4.6x	3.6%	3.2%	3.4%	3.6%	4.1%	4.7%
Enbridge Inc.	CAD	58.0	Neutral	19.2x	20.9x	19.4x	18.6x	13.7x	12.5x	11.5x	11.0x	3.3%	3.3%	3.6%	3.8%	6.3%	10.0%
Mean				**14.9x**	**16.3x**	**15.4x**	**14.7x**	**8.1x**	**8.5x**	**8.0x**	**7.5x**	**4.4%**	**3.9%**	**4.1%**	**4.3%**	**4.7%**	**5.5%**
Weighted Average				**16.1x**	**17.5x**	**16.5x**	**15.7x**	**10.0x**	**9.9x**	**9.3x**	**8.8x**	**4.2%**	**3.9%**	**4.0%**	**4.2%**	**5.0%**	**6.7%**
N. America Utilities Valuation		**Weighted Average**		**13.3x**	**14.0x**	**15.4x**	**13.7x**	**7.6x**	**7.5x**	**7.9x**	**7.2x**	**4.4%**	**4.4%**	**4.6%**	**4.7%**	**0.4%**	**2.0%**
Source: UBS estimates																	

■ Statement of Risk

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UBS 12-Month Rating	Rating Category	Coverage[1]	IB Services[2]
Buy	**Buy**	49%	40%
Neutral	**Hold/Neutral**	42%	35%
Sell	**Sell**	8%	21%
UBS Short-Term Rating	**Rating Category**	**Coverage[3]**	**IB Services[4]**
Buy	**Buy**	less than 1%	14%
Sell	**Sell**	less than 1%	0%

1:Percentage of companies under coverage globally within the 12-month rating category.
2:Percentage of companies within the 12-month rating category for which investment banking (IB) services were provided within the past 12 months.
3:Percentage of companies under coverage globally within the Short-Term rating category.
4:Percentage of companies within the Short-Term rating category for which investment banking (IB) services were provided within the past 12 months.

Source: UBS. Rating allocations are as of 31 December 2010.

UBS Investment Research: Global Equity Rating Definitions

UBS 12-Month Rating	Definition
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Neutral	FSR is between -6% and 6% of the MRA.
Sell	FSR is > 6% below the MRA.
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Buy	Buy: Stock price expected to rise within three months from the time the rating was assigned because of a specific catalyst or event.
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Forecast Stock Return (FSR) is defined as expected percentage price appreciation plus gross dividend yield over the next 12 months.

Market Return Assumption (MRA) is defined as the one-year local market interest rate plus 5% (a proxy for, and not a forecast of, the equity risk premium).

Under Review (UR) Stocks may be flagged as UR by the analyst, indicating that the stock's price target and/or rating are subject to possible change in the near term, usually in response to an event that may affect the investment case or valuation.

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Equity Price Targets have an investment horizon of 12 months.

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Company Disclosures

Company Name	Reuters	12-mo rating	Short-term rating	Price	Price date
E.ON[4, 5b, 6a, 13, 15, 16b]	EONGn.DE	Buy	N/A	€21.55	31 Mar 2011
EDF[4, 5b, 6a, 16b, 22]	EDF.PA	Buy	N/A	€29.22	31 Mar 2011
Gazprom[5b, 16b, 20]	GAZPq.L	Buy (CBE)	N/A	US$32.37	31 Mar 2011
General Electric Co.[4, 5b, 6a, 6b, 6c, 7, 8, 16b, 18, 22]	GE.N	Buy	N/A	US$20.05	31 Mar 2011
KEPCO[16b, 23]	015760.KS	Buy	N/A	Won26,900	31 Mar 2011
Public Service Enterprise Group[6a, 6b, 7, 16b]	PEG.N	Buy	N/A	US$31.51	31 Mar 2011
Shanghai Electric Group[2, 4, 5b, 16a, 16b]	2727.HK	Buy	N/A	HK$3.89	31 Mar 2011
Siemens[3, 4, 5b, 6a, 13, 14, 15, 16b]	SIEGn.DE	Buy	N/A	€96.71	31 Mar 2011
TECO Energy Inc.[4, 6a, 13, 16b, 22]	TE.N	Buy	N/A	US$18.76	31 Mar 2011
Woodside Petroleum Limited[1, 2, 4, 5a, 5b, 16b]	WPL.AX	Buy	N/A	A$47.40	01 Apr 2011

Source: UBS. All prices as of local market close.
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