



# World Nuclear Industry Status Report 2012

By Mycle Schneider  
and Antony Froggatt  
with Julie Hazemann

A Mycle Schneider Consulting Project  
Paris, London, July 2012

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**Foundation**

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## Note

*This report contains a very large amount of factual and numerical data. While we do our utmost to verify and double-check, nobody is perfect. The authors are always grateful for corrections and suggestions of improvement.*

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## Executive Summary & Conclusions

Twenty years after its first edition, *World Nuclear Industry Status Report 2012* portrays an industry suffering from the cumulative impacts of the world economic crisis, the Fukushima disaster, ferocious competitors and its own planning and management difficulties.

The report provides a global overview of the history, the current status and trends of nuclear power programs in the world. It looks at units in operation and under construction. Annex 1 also provides detailed country-by-country information. A specific chapter assesses the situation in potential newcomer countries. For the first time, the report looks at the credit-rating performance of some of the major nuclear companies and utilities. A more detailed chapter on the development patterns of renewable energies versus nuclear power is also included.

The performance of the nuclear industry over the 18 months since the beginning of 2011 can be summed up as follows:

### Reactor Status and Nuclear Programs

- **Startups and Shutdowns.** Only seven reactors started up, while 19 were shut down in 2011<sup>1</sup> and to 1 July 2012, only two were started up, just compensating for two that were shut down so far this year. As of end of June 2012 no reactor was operating in Japan and while two units at Ohi have got restart permission, it remains highly uncertain, how many others will receive permission to restart operations.
- **Nuclear Phase Out Decisions.** Four countries announced that they will phase out nuclear power within a given timeframe: Belgium, Germany, Switzerland and Taiwan.
- **Newcomer Program Cancellations.** At least five countries have decided not to engage or re-engage in nuclear programs, although they had previously planned to do so: Egypt, Italy, Jordan, Kuwait, and Thailand.
- **New Nuclear Countries.** Iran became the first country to start commercial operation of a new nuclear power program since Romania in 1996.

### Construction & New Build Issues

- **Construction Cancellation.** In both Bulgaria and Japan two reactors under construction were abandoned.
- **Construction Starts.** In 2011, construction began on four reactors and two so far in 2012.
- **New Build Project Cancellation.** In Brazil, France, India and the United States new build projects were officially cancelled. In the Netherlands, the U.K. and the U.S. key utilities withdrew leaving projects in jeopardy.
- **Certification Delays.** The certification of new reactor technologies has been delayed numerous times. The latest announcement concerns the certification in the U.S. of the Franco-German designed EPR<sup>2</sup> that was pushed back by 18 months to the end of 2014.
- **Construction Start Delays.** In various countries firmly planned construction starts were delayed, most notably in China, where not a single new building site was opened, but also in Armenia, Finland and the U.S.

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<sup>1</sup> We define shut down as definitively taken off the grid. This includes the 10 Fukushima reactors, of which four are destroyed; units 5 and 6 at Daiichi and the four reactors at Daiini remain in cold shutdown and are almost certain never to operate again. However, their definitive closure has not yet been officially confirmed.

<sup>2</sup> European Pressurized Water Reactor (in Europe) or Evolutionary Pressurized Water Reactor (in the U.S. and elsewhere).

- **Construction License Delays.** In the U.S. licensing applications for 28 reactors were received for the first time in over three decades in a two-year period between July 2007 and June 2009, but nothing since. Of the 28 applications, 16 were subsequently delayed and eight were suspended indefinitely or officially cancelled. However, for the first time in over 30 years two construction licenses were issued.
- **Construction Delays.** Of the 59 units under construction in the world, at least 18 are experiencing multi-year delays, while the remaining 41 projects were started within the past five years or have not yet reached projected start-up dates, making it difficult to assess whether they are running on schedule. On construction delays the U.S. Watts-Bar-2 project holds the record. Construction started in 1973 and grid connection was finally planned for 2012, but was delayed again until “late 2015 or 2016”.
- **Newcomer Countries.** The analysis of a number of potential newcomer countries<sup>3</sup> shows that few, if any, new members of the nuclear operators club to be expected over the next few years. No financing agreements are in place for any of the cases studied, many of them have to deal with significant public opposition, especially after the Fukushima accident and often they lack a skilled workforce and appropriate legal framework. Some countries have to deal with particularly adverse natural conditions (earthquake and flooding risks, lack of cooling water access, etc.). Finally, nuclear power’s principle competitors, mainly renewables and natural gas on the production side, increasingly are more affordable and much faster to install.

### **Economics & Finances**

- **Cost Increases.** Construction costs are a key determinant of the final nuclear electricity generating costs and many projects are significantly over budget: The U.S. Watts-Bar-2 reactivation project alone increased by 60 percent over the past five years; the EPR cost estimate has increased by a factor of four (adjusted for inflation) over the past ten years.
- **Credit Rating.** Of eleven assessed nuclear companies and utilities, seven were downgraded by credit rating agency Standard and Poor’s over the past five years; four companies remained stable, while none were upgraded over the same period. Rating agencies consider nuclear investment risky and “a nuclear project could be the thing that pushes [the utility] over the edge—it’s just another negative factor”, explains Moody’s. On the contrary, the rating agency welcomed the decision by German utilities RWE and E.ON to pull the plug on their U.K. new build plans as they “can instead focus on investment in less risky projects”. Similarly, electronics giant Siemens announcement to entirely withdraw from nuclear power “frees up funds that Siemens can redeploy in businesses with better visibility”. Both decisions are consequently considered “credit positive”.
- **Share Value.** The assessment of a dozen nuclear companies reveals that all performed worse than the UK FTSE100 index, the only exception being Scottish SSE, which has recently pulled out of plans to build nuclear plants in the UK. TEPCO, owner of the devastated Fukushima site, lost 96% of its share value since 2007. Over the same time period, more surprisingly, the shares of the world’s largest nuclear operator, French state utility EDF, lost 82 percent of their value, while the share price of the world’s largest nuclear builder, French state company AREVA, fell by 88 percent.

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<sup>3</sup> Bangladesh, Belarus, Indonesia, Jordan, Poland, Saudi Arabia, Thailand, Turkey, United Arab Emirates, and Vietnam. As indicated, programs were officially abandoned in Egypt, Italy and Kuwait.

## Nuclear Power vs. Renewable Energy Deployment

In contrast to many negative indicators for nuclear power renewable energy development has continued with rapid growth figure. This has taken place during the ongoing international economic crisis, significant cuts in guaranteed feed-in tariffs and worldwide manufacturing overcapacities.

- **Investment.** Global investment in renewable energy totaled US\$260 billion in 2011, up five percent from the previous year and almost five times the 2004 amount. Considering a 50 percent unit price drop over the past year, the performance of solar photovoltaics (PV) with US\$137 billion worth of new installations, an increase of 36 percent, is all the more impressive. The total cumulative investment in renewables has risen to over US\$1 trillion since 2004, according to Bloomberg New Energy Finance, this compares to our estimate of nuclear power investment decisions of approximately \$120 billion over the same time period. The rise and fall of nuclear investments is essentially due to the evolution of the Chinese program, with 40 percent of current worldwide construction.
- **Installed Capacity.** Installed worldwide nuclear capacity decreased in the years 1998, 2006, 2009 and again in 2011, while the annual installed wind power capacity increased by 41 GW<sup>4</sup> in 2011 alone. China constitutes an accelerated version of this global pattern. Installed wind power capacity grew by a factor of 50 in the past five years to reach close to 63 GW, five times more than the installed nuclear capacity and equivalent to the French nuclear fleet.<sup>5</sup> Solar capacity was multiplied by a factor of 47 in those five years to reach 3.8 GW, while nuclear capacity increased by a factor of 1.5 to 12 GW. Since 2000, within the European Union nuclear capacity decreased by 14 GW, while 142 GW of renewable capacity was installed, 18 percent more than natural gas with 116 GW.<sup>6</sup>
- **Electricity Generation.** The quantity of electricity produced by nuclear power plants globally has been increased only slightly over the past decade and as a result its contribution to the global energy mix is decreasing as other sources accelerate production. In 2011 wind turbines produced 330 TWh more electricity than it did at the turn of the century, which is a four times greater increase than was achieved by the nuclear sector over the same period. The growth in solar PV generated power has been impressive in the last decade and especially in the past few years, with a tenfold increase in the past five years. In Germany, for the first time, power production from renewables at 122 TWh (gross), only second to the contribution of lignite 153 TWh, exceeded coal's 114.5 TWh, nuclear power's 102 TWh and natural gas' 84 TWh. The German renewable electricity generation thus corresponded to 29 percent of French nuclear production. One should recall that France generates almost half of the European Union's nuclear electricity. In China, just five years ago, nuclear plants were producing ten times as much electricity as wind, by 2011 the difference had shrunk to less than 30 percent.
- **Grid Parity.** Grid parity occurs when the unit costs of renewable energy is equal to the price that end users pay for their electricity. Grid parity for solar photovoltaic power has already happened in a number of markets and regions with particular conditions. Several assessments expect that this will become a worldwide phenomenon within less than a decade. This will radically change the incentives for further large scale expansion of solar facilities around the world.

## Lifetime Extensions and Stress Tests

As a result of insufficient new capacities coming online, the average age of the world's operating nuclear fleet continues to increase and now stands at 27 years. Assuming a 40-year lifetime, 67 additional units or 35 GW would have to be ordered, built and commissioned by 2020, beyond the units already under construction, just to maintain the status quo. This is an unlikely scenario,

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<sup>4</sup> GW stands for gigawatt or thousand megawatt.

<sup>5</sup> Note that nuclear plants usually generate between two and five times more electricity per installed GWe than wind turbines.

<sup>6</sup> Note that the electricity generation per installed GWe varies considerably between energy sources.

although not entirely impossible, if China were to restart building large numbers of reactors. Furthermore, as our lifetime extension projections illustrate, the systematic prolonged operation of reactors up to licensed limits (up to 60 years) would not fundamentally change the problem of the industry.<sup>7</sup> An additional 19 reactors would have to begin operation in order to break even by 2020, but the installed capacity would be slightly positive (+4 GW). This scenario is possible, but will require a number of specific conditions including that the generalized lifetime extension is technically feasible, economically attractive and publicly and politically acceptable.

Plant life extension seems the most likely survival strategy of the nuclear industry at this point. The French case illustrates this. As the French Court of Audits has calculated, eleven EPRs would have to be built in France by the end of 2022 in order to maintain the current nuclear share. “This seems highly unlikely, if not impossible, including for industrial reasons”, the Court comments and concludes: “This implies one of two things: a) either it is assumed that plants will operate for more than 40 years (...); b) or the energy mix will move towards other energy sources. However, no clear public decision has been made concerning these major strategic issues, even though they call for short-term action and major investments.” An appropriate description for the situation in many nuclear countries.

Serious questions need to be raised about the extent to which the lessons of Fukushima are being even considered by today’s nuclear operators. There are around 400 nuclear power reactors in operation and in the absence of a major new build the nuclear industry is pushing to keep those units operating as long as possible. The fact that one third of the nuclear countries generated their historic maximum of nuclear electricity in 2011<sup>8</sup> raises the troubling question of the depth of the nuclear safety assessments or so-called “stress tests” carried out around the world after 3/11. This study did not assess safety issues, but if plant life extension becomes the only future for the industry, the pressure on safety authorities will grow substantially.

## Conclusion

Prior to the March 2011 (3/11) Fukushima disaster, the nuclear industry had made it clear that it could not afford another major accident. Over the past ten years the industry has sold a survival strategy to the world as the nuclear revival or its renaissance. In reality many nuclear companies and utilities were already in great difficulties before the triple disaster hit the Japanese east coast in 2011.

Fifteen months after 3/11, it is likely that the decline of the industry will only accelerate. Fukushima continues to have a significant impact on nuclear developments everywhere. Fifteen years ago, nuclear power provided over one third of the electricity in Japan, but as of May 2012 the last operating reactor was closed. The Japanese government is facing massive opposition to nuclear power in the country, thus making the restart of any reactors difficult. The controversy over the restart permission for the Ohi reactors in the Kansai region illustrates the dilemma. Germany shut down half of its nuclear fleet after 3/11. Japan and Germany could be leading a new trend. The German direction is clear with the possibility of Japan following: an electricity system based on highly efficient use and renewable energy technologies, even if many questions remain, including the timescale, local versus centralized, grid transformation and smart system development. It appears increasingly obvious that nuclear systems are not competitive in this world, whether from systemic, economic, environmental or social points of view.

The nuclear establishment has a long history of failing to deliver. In 1973-1974, the International Atomic Energy Agency (IAEA) forecasted an installed nuclear capacity of 3,600-5,000 GW in the world by 2000, ten times what it is today. The latest example was from Hans Blix, former Director General of the IAEA, who stated two months after 3/11: “Fukushima is a bump in the road...”. The statement is both crass and far from today’s reality.

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<sup>7</sup> It raises a whole range of safety related issues that we have not analyzed in this report.

<sup>8</sup> Brazil, China, Czech Republic, Hungary, India, Iran, South Korea, Pakistan, Russia, Taiwan



### Operation and Construction Data as of 1 July 2012<sup>9</sup>

**Operation.** There are 31 countries operating nuclear power plants in the world<sup>10</sup>, one more than a year ago, with Iran finally starting up the Bushehr reactor that had been under construction since 1975. A total of 429 reactors combine an installed capacity of 364 GWe<sup>11</sup>. These figures assume the final shutdown of the ten Fukushima reactors. It should be noted that as of 5 July 2012 only one (Ohi-3) of the 44 remaining Japanese reactors is operating and their future is highly uncertain. This compares to the historical maximum of 444 reactors in 2002. Installed capacity peaked in 2010 at 375 GWe before declining to the level of a decade ago. Nuclear electricity generation reached a maximum in 2006 with 2,660 TWh and dropped to 2,518 TWh in 2011 (down 4.3 percent compared to 2010), while the nuclear share in the world's power generation declined steadily from a historic peak of 17 percent in 1993 to about 11 percent in 2011.

**Construction.** There are 13 countries currently building nuclear power plants, two fewer than a year ago with Iran starting up its plant and Bulgaria abandoning construction at the two Belene units where work had started in 1987. Japan halted construction at two sites (Ohma and Shimane-3) and Pakistan started construction on two units (Chasnupp-3 and -4). There are currently 59 reactors under construction with a total capacity of 56 GW. However:

- Nine reactors have been listed as “under construction” for more than 20 years.
- Four additional reactors have been listed for 10 years or more.
- Forty-three projects do not have an official (IAEA) planned start-up date.
- At least 18 of the 59 units listed by the IAEA as “under construction” have encountered construction delays, most of them multi-annual. Of the remaining 41 reactor units construction began either within the past five years or they have not reached projected start-up dates yet. This makes it difficult or impossible to assess whether they are on schedule or not.

Nearly three-quarters (43) of the units under construction are located in three countries: China, India and Russia.

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<sup>9</sup> See table in Annex 7 for a country-by-country overview of reactors in operation and under construction as well as the nuclear share in electricity generation and primary energy.

<sup>10</sup> Unless otherwise noted, the figures indicated are as of 1 July 2012.

<sup>11</sup> All figures are given for nominal net electricity generating capacity. GW stands for gigawatt or thousand megawatt.