spezial

Nuclear Energy

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All independent analyses and forecasts of global energy needs project large increases in the century ahead. The principal drivers are global population growth and economic development in today's developing countries. Even in scenarios where OECD countries in Europe and the Pacific begin immediately to reduce their energy use – in absolute terms – the reductions are still swamped by developing countries aspiring to reach just a fraction of the OECD's prosperity.

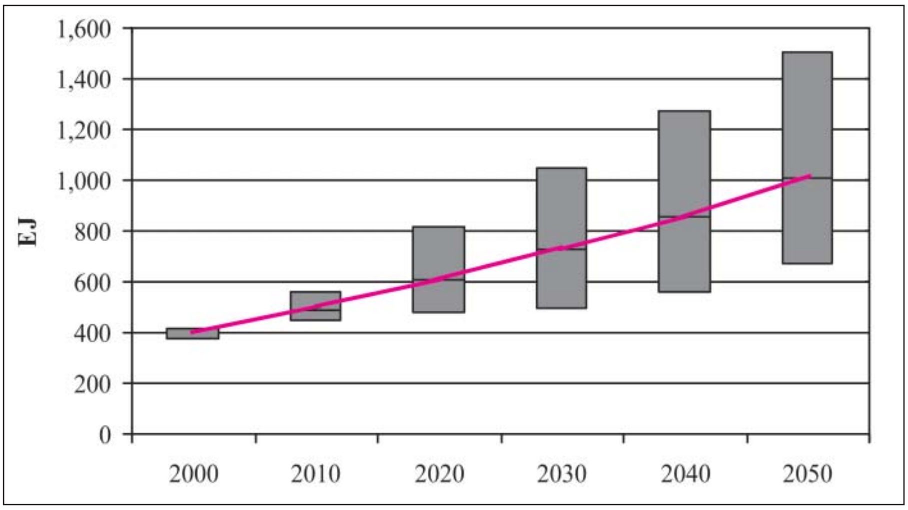

Fig. 1: The range of future global primary energy demands reflected in the 40 SRES scenarios (IPCC, 2000). EJ is the abbreviation for "exajoules". The red line connects the median values for each reported year.

Figure 1 shows the range of future global primary energy use in the 40 scenarios in the Special Report on Emissions Scenarios (SRES) of the Intergovernmental Panel on Climate Change (IPCC). The median projection is for an increase between 2000 and 2050 by a factor of 2.5.

What role might nuclear energy play in meeting these demands? Medium-term projections (for the next few decades) and long-term projections (as in the SRES scenarios) give different answers. ***Figure 2*** shows, on the left, the history of nuclear power (IAEA 2003 a, 2003 b). Expansion was rapid in the 1970s and 1980s, but slowed greatly in the 1990s for at least three reasons. First, electricity market deregulation exposed excess capacity, reduced demand for new build, and shifted demand toward natural gas fired power plants with their lower capital costs and, at that time, low gas prices. Second, the delayed effect of efficiency improvements prompted by the oil shocks of the 1970s had caused electricity demand to grow more slowly than expected. Third, the Chernobyl accident in 1986 increased opposition to nuclear power, particularly in Europe.

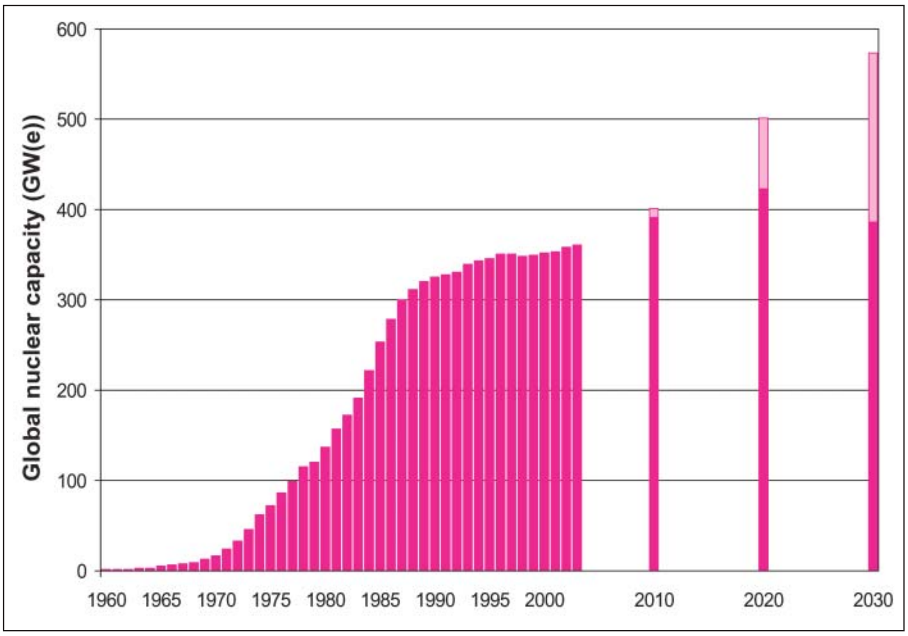

Fig. 2: Global nuclear power capacity since 1960 and two IAEA projections through 2030.

On the right the figure shows two medium-term projections by the International Atomic Energy Agency (IAEA). The low projection (the dark red bars) assumes no new nuclear power plants (NPPs) beyond what is already being built or firmly planned, plus the retirement of old NPPs. In this case, global nuclear capacity peaks around 2020 and then begins a slow decline. The high projection, which takes into account additional reasonable nuclear proposals, shows steady growth through 2030 and beyond, although at a slower pace than in the 1970s and 1980s. ***Table 1*** shows regional details of the high and low projections in terms of nuclear electricity generation, rather than nuclear capacity as in ***Figure 2.***

Country Group	2002			2010			2020			2030		
	Total Elect.	Nuclear		Total Elect.	Nuclear		Total Elect.	Nuclear		Total Elect.	Nuclear	
	TW.h	TW.h	%	TW.h	TW.h	%	TW.h	TW.h	%	TW.h	TW.h	%
North America	4779	851.1	17.8	5034	874	17	5784	870	15	6451	844	13
				5444	894	16	6709	939	14	8146	944	12
Latin America	1078	28.6	2.7	1178	29	2.5	1628	47	2.9	2227	30	1.3
				1427	38	2.7	2291	50	2.2	3758	92	2.4
Western Europe	3084	880.2	28.5	3352	858	26	3634	823	23	3942	564	14
				3609	893	25	4687	961	20	6061	1090	18
Eastern Europe	1758	298.5	17.0	1884	319	17	2174	423	19	2463	378	15
				2074	399	19	2867	552	19	4133	611	15
Africa	459	12.0	2.6	538	13	2.5	699	14	2.0	876	14	1.6
				612	14	2.3	973	24	2.4	1530	60	3.9
Middle East and South Asia	1176	19.6	1.7	1342	41	3.1	1805	53	3.0	2327	70	3.0
				1626	47	2.9	2596	100	3.9	3946	194	4.9
South East Asia and the Pacific	600			736			934			1162		
				786			1119	5.5	0.5	1584	18	1.2
Far East	3157	484.3	15.3	3399	695	20	4199	855	20	5073	981	19
				4296	702	16	6605	1125	17	9830	1361	14
World Total – Low Estimate	16090	2574.2	16.0	17463	2830	16	20857	3085	15	24520	2881	12
World Total – High Estimate				19873	2987	15	27848	3756	13	38989	4369	11

Table 1. *Estimates of total electricity generation and the contribution of nuclear power.*

Two caveats are in order. First, total global electricity use in both projections grows faster than nuclear electricity production, so the percentage of electricity supplied by nuclear energy decreases slowly in both cases. That percentage has been remarkably stable around 16% since 1986. Although nuclear *capacity* has grown only slowly since then, as shown in ***Figure 2,*** nuclear *generation* has kept pace with global electricity growth thanks to steadily improving energy availability factors at nuclear power plants. Partly because of operating improvements motivated by the Chernobyl accident and the competition of deregulated electricity markets, the global average energy availability factor has risen from 71% in 1990 to 83.7% in 2002. That is equivalent to adding over 34 GW(e) of new capacity at almost no cost.

The second caveat is that both projections are below the median of long-term projections, e. g., the SRES scenarios. ***Figure 3*** shows the range of nuclear capacities in the SRES scenarios with vertical bars, their medians with the dotted line, and the IAEA's high and low scenarios with the red and black lines respectively. This "projection gap" between even the high medium-term projection and the median of the long-term projections could be due to at least four factors.

First, the long-term projections are based on computer models that incorporate such factors as fossil fuel depletion over the whole 21st century in choosing the optimal investment for today. Most power plant investments affecting the medium-term scenarios are unlikely to be based on similarly forward looking analyses.

Second, the medium-term scenarios are based largely on today's technologies and their current costs, while the long-term scenarios allow for greater improvements in technology and cost.

Third, while the current politics of nuclear energy have a significant impact on the medium-term scenarios, the choices reflected in the long-term scenarios are based much more heavily on economics, not politics.

Finally, the perfect-foresight optimisation models used in building the long-term scenarios make all investments essentially risk-free. Current plans underlying the medium-term scenarios, however, reflect the politics of countries where opposition to nuclear investments might make them a significant financial risk. Which boundary of the projection gap is more likely – the upper boundary that reflects long-term optimisation models or the lower boundary that reflects existing plans based on the political and economic realities of today? First, we should look in more detail at the immediate situation.

Immediate Details

Nuclear power plants are concentrated in industrialized countries. Of 440 operating NPPs, 142 are in Western Europe, 120 are in North America, 68 are in accession countries, Eastern Europe and Russia, 73 are in Japan and South Korea, and only 38 are in developing countries. Russia gets 16% of its electricity from nuclear power, the USA gets 20%, the UK 22%, Germany 30%, Japan 35%, South Korea 39%, Switzerland 40%, Sweden 46%, Belgium 57%, France 78%, and Lithuania 80%. In contrast, for the big developing countries of Brazil, India and China, the percentages are today only 4%, 3.7% and 1.4% respectively.

Current expansion and growth are centered in Asia. Of 31 NPPs currently under construction, 18 are in China, India, Japan, North Korea, South Korea and Taiwan. Twenty of the last 29 reactors to be connected are in the Far East and South Asia.

Western Europe and North America have been focussed largely on license extensions given the strong safety performance of existing NPPs and their profitable operating record. For example, 19 NPPs in the USA have already received 20-year license extensions, bringing the total licensed lifetime of each to 60 years. Seventeen more applicants are in the queue and many more expected.

The differences among regions result from several factors. First, new NPPs are most attractive where energy demand growth is rapid, alternative resources are scarce, energy supply security is a priority or nuclear power is important for reducing air pollution and greenhouse gas emissions. One or more of these factors characterizes all the Asian countries listed above.

Second, energy markets in Western Europe and North America have been significantly liberalized over the last decade, and the "front-loaded" cost structure of new nuclear plants, with high capital costs and low operating costs, is a disadvantage in liberalized markets that value rapid returns. Nuclear plants are large (to benefit from economies of scale), have generally longer construction times than alternatives, and risk organized opposition to regulatory approval. In the relatively liberalized markets of Western Europe and North America, they thus present more of an investment risk than particularly new natural gas fired capacity, and recent investments in these regions have steered away from nuclear and most often toward natural gas.

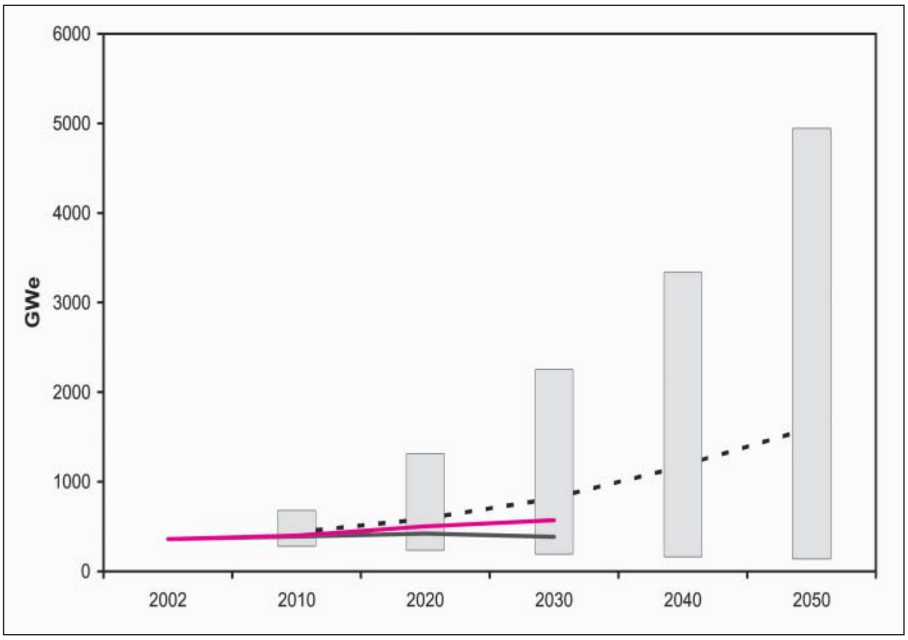

Fig. 3: Three projections of worldwide nuclear capacity: SRES scenarios (vertical bars), IAEA high (red line) and IAEA low (black line). The dotted line connects the median values for the SRES scenarios for each reported year.

However, in Western Europe a major step towards the first new reactor since France's Civaux-2 in 1999 was taken in December 2003 when the Finnish utility TVO signed a contract for a new 1600 MW(e) European Pressurized Water Reactor (EPR), Olkiluoto-3 Excavation work started in February 2004, although plant construction is not scheduled to start until next year. TVO calculated that the EPR would have the lowest electricity generating costs among the available options. The next cheapest would have been a natural gas fired power plant. The most expensive would have been wind power. Because Finnish law mandates that nuclear operators contribute to decommissioning and long-term waste management funds, TVO's calculation includes full nuclear life cycle costs. The Finnish Government and Parliament have already approved and ratified a decision "in principle" for a final repository, with good local support, in a cavern near the nuclear power plants at Olkiluoto.

There are some special features of the Finnish situation that make TVO's choice of nuclear not directly transferable to every other European utility considering new capacity. But these are also illustrative of changes in the overall European situation. First, TVO is owned by major long-term electricity consumers so there is less uncertainty about long-term assured markets than there might be for others. Second, 100% of Finland's natural gas imports come from Russia, so considerations of diversity to ensure reliability have a bigger impact on TVO's bottom line calculation than they might have elsewhere in Europe. And third, Finland has been a leader in carbon taxes, which means TVO must hedge against future carbon emission costs. All of these factors allow (or perhaps force) TVO to take something of a longer-term perspective. As noted above, the value that liberalized markets place on rapid returns generally makes nuclear power a less favorable investment than it would be otherwise. Olkiluoto-3 may be an important counter-example that long-term thinking does not have to be inconsistent with liberalized energy markets.

Conclusion

Which boundary of the projection gap is more probable? As with so much else, "it depends. . ." Because we believe it is more likely that "the politics will follow the economics" than the other way around, we expect the success of nuclear power will depend principally on the course of market liberalization around the world, the extent to which it encourages long-term as opposed to near-term thinking, and the ability of nuclear power plant vendors and fuel suppliers to improve costs at a pace at least as good as their competition.

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