Appendix I for Mapping Global Nuclear Energy Expansion

Sharon Squassoni
Senior Associate,
Carnegie Endowment for International Peace

Description of Scenarios and Sources

The maps in the briefing slides are based on estimates of nuclear power capacity under three different scenarios. The first is a "business as usual" projection for 2030 done by the Energy Information Administration. The second is not a projection, but rather an estimate, based on official statements by countries, for which a variety of sources was used. Country statements were taken at face value and these do not necessarily correlate to any measurable indicators (such as GDP growth or electricity demand, etc.). In some cases, the plans are unlikely to materialize. Scenario II figures should be regarded not as projections, but as a "wish list" for many countries.

Scenario III seeks to estimate nuclear energy in 2050. Since one of the prime motivations for greater nuclear energy expansion is the notion that nuclear energy is a "clean and green" technology, and that it can help mitigate global climate change, Scenario III looks at the range of possibilities. The first, Scenario IIIa is an estimate if nuclear energy were to reduce 1 gigaton of carbon emissions by 2050, constituting one "wedge" according to the work of Princeton professors Steven Pacala and Robert Socolow. This estimate would bring us to about 1050 GWe. The maps depict data primarily for Scenario IIIb, except in the case of enrichment, where all 3 cases in Scenario III are depicted.

Scenario IIIb. is based on figures from the 2003 study by MIT, *The Future of Nuclear Power*. Figures were taken from the "High 2050" scenario in Appendix 2: "Global Electricity Demand and the Nuclear Power Growth Scenario." The MIT study used an underlying assumption that the developed countries would continue with a modest annual increase in per capita electricity use and the developing countries would move to the 4000 kWh per person per year benchmark if at all feasible (the 4000 kWh benchmark being the dividing line between developed and advanced countries). Electricity demand was then pegged to estimated population growth. Finally, it was assumed that nuclear energy would retain or increase its current share of electricity generation. The least-off developing countries were assumed in the MIT study not to have wherewithal for nuclear energy. A final caveat in the MIT study is that the 2050 projection is "an attempt to understand what the distribution of nuclear power deployment would be if robust growth were realized, perhaps driven by a broad commitment to reducing greenhouse gas emissions and a concurrent resolution of the various challenges confronting nuclear power's acceptance in various countries." A few countries that the MIT High 2050 case included but we do not are countries that currently have laws restricting nuclear energy. For example, we did not include Austria as a state that will install nuclear reactors, given its 1978 law prohibiting nuclear energy.

Scenario IIIc. is based on the Stern Report on global climate change, which postulated that nuclear energy could perhaps reduce between 2 gigatons to 6 gigatons of carbon emissions. This is included for illustrative purposes.

All further references to Scenario III reflect Scenario IIIb.

A Few Caveats

There is a good reason why the EIA and IEA do not make projections out to 2050 – it is a highly uncertain undertaking. Some of the many uncertainties include input and construction costs, government support and reactor operation safety. As we have seen from experience since Three Mile Island and Chernobyl, plans for nuclear power plant construction can be put off indefinitely in the wake of accidents.

Explanatory Note for Reactor Data

All figures are rounded to the nearest integer and expressed in Gigawatts, electrical (GWe) (if less than 0.5 GWe, however, it has been rounded to 0.5). The organization of the data along OECD and non-OECD groupings reflects the availability of EIA projections under Scenario I. In particular, the EIA does not make projections for individual countries except where noted. Therefore, the countries are grouped by region.

In Scenario I, blank entries should not necessarily be equated with no nuclear capacity; unfortunately, the EIA does not always make individual country projections. The regional projections will include nuclear capacity for those countries that already have nuclear energy today.

In Scenarios II and III, blank entries should be equated with no nuclear capacity or plans. In cases where a country has proposed power plants under Scenario II but no figure appears under Scenario III, the MIT 2050 High Scenario did not anticipate any nuclear power development in the least developed countries, including Bangladesh, Ghana, Nigeria, and Yemen. Other states that the MIT study did not include but might build nuclear power by 2050 are the GCC states, Jordan, Tunisia and Chile.

In addition, there are several cases where a country has no current nuclear power plans, but the MIT study predicts nuclear power for them in 2050. These include: New Zealand, Australia, Austria, Italy, Portugal, Philippines, and Venezuela. Several countries included in the 2050 MIT projections were not included in our maps or in the data below.

Finally, there are several "placeholder" slots, where countries have expressed plans for nuclear energy but there are no associated number of reactors or capacity. These include Syria (which announced it would like to generate 6% of its energy needs by 2020 with nuclear in a 2006 statement to IAEA) and Venezuela, among others.

Current (Orange Globes):	2008 nuclear power capacity
Scenario I (Blue Rings):	2030 – Data from Energy Information Administration, International Energy Outlook 2007, DOE/EIA-0484(2007)
Scenario II (Red Rings, Red Dots):	2030 – Proposed reactor capacities according to individual government statements. Sources are varied, but include World Nuclear Association, *Nucleonics Week,* and major trade press.
Scenario III (Green Rings, Green Dots):	2050 – MIT projection, new or expanded nuclear power capacity

OECD	Orange	Blue	Red	Green
Country	**Current**	**Scenario I**	**Scenario II**	**Scenario III**
Australia	0	0	0	10
Canada	13	17	19	62
Japan	48	60	66	91
Korea, S	18	32	27	37
Mexico	1	1	3	20
New Zealand	0	0		1
OECD Europe *(see breakout below)*	130	113	121	237
Turkey	0		5	9
USA	99	113	142	477
Regional Total	**309**	**336**	**383**	**944**

Non-OECD Europe/Eurasia

Country	Current	Scenario I	Scenario II	Scenario III
Non-OECD Europe *(see breakout below)*	19	23	48.5	25
Russia	22	42	44	52
Regional Total	**41**	**65**	**92.5**	**77**

Non-OECD Asia

Country	Current	Scenario I	Scenario II	Scenario III
Bangladesh	0		2	0
China	9	42	120	200
India	4	19	21	175
Indonesia	0		6	39
Korea, N	0		1	5
Malaysia	0			3
Pakistan	0.5		3	20
Philippines	0			9
Taiwan	5		7	16
Thailand	0		4	8
Vietnam	0		8	5
Regional Total	**18.5**	**72**	**172**	**480**

Middle East

Country	Current	Scenario I	Scenario II	Scenario III
Gulf Cooperation Council	0			0
Iran	0		6	22
Israel	0		1	2
Jordan	0			0
Syria	0			0
Yemen*	0		5	0
Regional Total	**0**	**1**	**12**	**24**

Africa

Country	Current	Scenario I	Scenario II	Scenario III
Algeria	0			5
Egypt	0		1	10
Ghana	0		1	0
Libya	0			1
Morocco	0			3
Namibia	0			0
Nigeria*	0		4	0
South Africa	2	3	27	15
Tunisia*	0		0.5	0
Regional Total	**2**	**3**	**33.5**	**34**

Central and South America

Country	Current	Scenario I	Scenario II	Scenario III
Argentina	1	2	3	10
Brazil	2	3	7	34
Chile	0			0
Venezuela	0			4
Regional Total	**3**	**5**	**10**	**48**

World Total

World Total	**373.5**	**482**	**703**	**1607**

Notes:
Asterisks (*) depict countries that are not included in Maps VI or VII but have possible GWe figures for Scenario II. These Scenario II figures were not included in the map because nuclear planning for these countries is still in the early exploratory phase.

The EIA has stated that the Africa region will produce 3 GWe of nuclear power by 2030. This table conjectures that this energy will be produced by South Africa. The country already produces nuclear power and does not face the barriers other African countries will face in developing a new nuclear power industry.

Breakouts of OECD Europe and non-OECD Europe

OECD Europe

Country	Current	Scenario I	Scenario II	Scenario III
Belgium	6		0	11
Czech Republic	3		6	3
Finland	3		5	8
France	63		67	68
Germany	20		0	49
Hungary	2		4	3
Italy	0			8
Netherlands	0.5		1	4
Norway	0			5
Poland	0		3	3
Portugal	0			1
Slovakia	2		5	3
Spain	7		7	18
Sweden	9		9	16
Switzerland	3		4	5
UK	11		10	32
Total	**129.5**	**113**	**121**	**237**

Non-OECD Europe

Country	Current	Scenario I	Scenario II	Scenario III
Albania	0			0
Armenia	0.5		1	1
Azerbaijan	0		1	1
Belarus	0		4	1
Bulgaria	2		4	3
Georgia	0			0
Kazakhstan	0		0.5	1
Kyrgyzstan	0			1
Lithuania	1		2	1
Romania	1		3	2
Slovenia	1		2	1
Turkmenistan	0			1
Ukraine	13		30	8
Uzbekistan	0			4
Total	**18.5**	**23**	**47.5**	**25**

Notes:
Scenario I EIA projections are done primarily by region and blank spaces should not be considered to reflect no nuclear power. Please refer to the regional totals only in Scenario I. In Scenario II, blank spaces may indicate lack of data about number or capacity of reactors, even as countries have declared interest in nuclear power.

Enrichment Capacities (Millions of separative work units, or SWU)

Nuclear Plant/Country	2007	Scenario I	Scenario II	Scenario III
TENEX	22	25	25	66
EURODIF	10.8	7.5	7.5	30
URENCO	8.1	11	11	24
JNFL	1	1.5	1.5	4.5
CNNC	1	1	1	16
USEC	8	7.5	7.5	13.5
RESENDE	0.12	0.12	0.4	5
Argentina				0.5
Australia				6
Canada				9
Egypt				1
India				8
Indonesia				1
Iran			1	3
Jordan				1
Kazakhstan				6
Pakistan			8	8
South Africa			3	6
Taiwan				6
Ukraine			3	3

Scenario III figures are estimates based on whether a state is projected to have at least 10 GWe nuclear capacity in 2050 and has expressed an interest (even if tentative) in uranium enrichment. Although Australia is estimated to develop enrichment capacity, primarily for export, the recent change in government may slow down any such development.

Reprocessing

No attempt was made to estimate how reprocessing capacities might grow since this is even more highly subjective than reactor or enrichment growth, depending entirely on government policies. However, the United States, South Africa, and Ukraine have all expressed an interest in closing the fuel cycle. Undoubtedly, more reprocessing or recycling capability will be required if the Global Nuclear Energy Partnership proceeds as envisioned.