Potential Implications of the Fukushima Daiichi Accident for Nuclear Power

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Outline of Presentation

• World use of nuclear power
• Barriers to new build
• Reactions from various countries
• Implications for Mark I BWRs and MOX
• Next steps for nuclear power and implications for safety, education, economics, and waste disposal
Snapshot of Nuclear Power Today

• about 13% of global electricity use and about 6% of total global, primary energy use

• 30 countries + Taiwan with about 440 commercial reactors (but about 50 shut down in Japan) (≈ 370 GW total global capacity)

• 11 countries enriching uranium

• 5 countries with commercial spent fuel reprocessing facilities

• 0 countries with geologic repositories for nuclear waste
Can Nuclear Power Provide More Electricity?

Global electricity demand is estimated to nearly double by 2030, with nuclear power currently accounting for about 15 percent of global use.

Global Electricity Demand (in billion kilowatt hours)

<table>
<thead>
<tr>
<th>Year</th>
<th>Nuclear</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>15,750</td>
</tr>
<tr>
<td>2010</td>
<td>19,050</td>
</tr>
<tr>
<td>2015</td>
<td>21,700</td>
</tr>
<tr>
<td>2020</td>
<td>24,370</td>
</tr>
<tr>
<td>2025</td>
<td>27,130</td>
</tr>
<tr>
<td>2030</td>
<td>30,120</td>
</tr>
</tbody>
</table>

For nuclear to do nothing more than maintain its current share of global electricity to 2030—15 percent—a 1,000-megawatt reactor must be built ...

...every 16 days for the next 21 years.

Can Nuclear Power Reduce Emissions?

Annual emissions of greenhouse gases are similarly expected to double by 2050, from a current 7 billion tons of carbon dioxide each year to more than 14 billion tons.

Global Emissions (in billions of tons)

<table>
<thead>
<tr>
<th>Year</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>6.7</td>
</tr>
<tr>
<td>2010</td>
<td>7.8</td>
</tr>
<tr>
<td>2020</td>
<td>9.1</td>
</tr>
<tr>
<td>2030</td>
<td>10.5</td>
</tr>
<tr>
<td>2040</td>
<td>12.2</td>
</tr>
<tr>
<td>2050</td>
<td>14.2</td>
</tr>
</tbody>
</table>

For nuclear energy to offset just a small fraction of those additional 7 billion tons—say, 1 billion tons by 2050—a 1,000-megawatt reactor will need to come online ...

...every 14 days between now and 2050.

Sources: EIA, Oak Ridge National Laboratory, and Foreign Policy
Reactors Under Construction

- In 2011, the IAEA listed more than 60 reactors as under construction.
- But 12 have been listed as under construction for > 20 years.
- Some newer under construction reactors have experienced significant delays such as EPRs in Finland and France.
- Almost 3/4 of the under construction reactors are in only 4 countries: China, South Korea, India, and Russia (very strong govt support).
- China and South Korea have made the most progress with new plants.
Barriers to New Build

- Many factors complicate new nuclear build
  - Cost
  - Time
  - Personnel

Sources: IAEA PRIS and *Foreign Policy*
Nuclear Power’s Usage and Share of Electricity

- A country’s use of nuclear power has much to do with government intervention, for example:
  - Streamlined regulations
  - Loan guarantees, tax credits, and additional incentives
  - Other policies, possibly carbon pricing in the future

- Use also depends on fossil fuel availability and pricing

- Capital costs for coal and natural gas power plants are significantly lower than for nuclear plants – inverse relationship for fuel costs
“Natural Gas is Queen”
Reactions from Various Countries

- Polls showed decrease of public support—generally not surprising
- Countries against became more against
- Countries in favor stayed in favor except for Japan, which reversed its position
- U.S. still in favor but economics and competition from nat gas are the main problems for new nuclear
- Let’s look at China, Germany, France, Switzerland, Italy, UAE, Jordan, Vietnam, Thailand, and the Philippines.
China in 2009 and 2010: Nuclear Future Looked Bright

Sites of Nuclear Power Plants in China

Nuclear Power is Key to China's Energy Future

Planned
Under Construction
In Operation

Source: Research Institute of Tepia (as of Nov. 2008)
China: Post-Fukushima

- Positive sign: Beijing temporarily halted construction → needed to deal with “safety gap”
- China was building too fast and had not kept pace with training high quality workforce
- Did not order any new plants in 2011
- Reaffirmed on March 5, 2012: Government support to “safely and effectively” develop nuclear power
- In Feb., launched a series of research and development projects to improve emergency response mechanisms for nuclear power plants in the case of extreme disasters
Tale of Two Countries
Reversal of the Reversal

• Soon after the accident, German Chancellor Merkel reversed previous reversal that had extended life of reactors.

• In April unveiled 6 point plan to phase out nuclear power in 10 years
More Negative Reactions and Implications

• Switzerland decided to phase out nuclear power by 2030
• Italy has pulled back from considering new build—referendum in June was very negative
• Philippines (making money from tours of Bataan NPP), Thailand (seeking advice from Germany), and Malaysia have reconsidered building nuclear plants.
Rays of Hope for the Nuclear Industry

- South Korea forging ahead and has established a stronger regulatory agency and seeks to capture at least 20 percent of export market
- KEPCO building 4 reactors in the UAE
- Jordan looks to be moving ahead but needs financing (may get from Qatari bank)
- Vietnam is not deterred, either: considering deals with Russia, Japan, and Korea
Fukushima Daiichi Plant Design

Boiling Water Reactor System

- Reactor Building (Secondary Containment)
- Inerted Drywell (Primary Containment)
- Reactor Core
- Control Rods
- Torus
- Main Steam Lines
- Turbine Generators
- Electricity to Switchyard
- Feedwater Pumps
- Condenser
Use of Plutonium-based Fuels

- Reactor #3 at Fukushima was recently fueled with mixed oxide (MOX) fuel, which contains plutonium oxide.
- Japan has invested about $28 billion in a plutonium recycling program.
- U.S. has refrained from reprocessing spent fuel to use plutonium since the Carter administration.
- But the United States has planned to dispose of weapons-grade Pu by using MOX. Will this change?
Next Steps: Safety

• Need for strong, independent regulatory agencies

• Need to instill safety culture among all workers and plant management

• Need for safety retrofits where needed and phase outs of oldest plants—esp. BWR Mark I

• Need for greater international cooperation
Next Steps: Education

• Need for better and more transparent information to the public
• Develop clear means to communicate complex technical concepts such as radiation exposure and dose
• Need to inform/educate political leadership—don’t hide bad news
Next Steps: Economics

• Estimate the external costs (including climate change, other forms of pollution, security, etc.) for each energy source

• Include these costs into the price

• Compete energy options on an even economic playing field
Next Steps: Waste Disposal

• Continue R&D into potential proliferation-resistant means (including pyro-processing) to recycle fissionable materials and dispose of HLW

• Continue R&D into fast reactor technologies

• Move forward with interim spent fuel storage using dry storage casks

• In parallel, develop geologic repository for permanent storage of HLW and ILW
Thank You Very Much for Your Attention

For more information about the Federation of American Scientists, please see: www.fas.org

For more info on nuclear energy →