A Global View of the Power Market in the Post-Fukushima Era

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Global GDP and Energy Demand Growth by Region

Source: ExxonMobil – The Outlook for Energy - A View to 2040
Importance of Energy and Power (Electricity) in Modern Society

- Energy use is well correlated with national economic prosperity and individual quality of life
- Global energy use will grow ~30% by 2040, but in non-OECD countries by ~60%, where most population increases will occur
- Energy to make power is the single biggest driver of demand; will account for more than 40% of global energy consumption by 2040
- Power is easily transported, can be converted into many useful forms, but is very difficult to store
- Energy demand growth will slow as economies mature, efficiency gains accelerate, and population growth moderates
Global Energy Demand by Fuel Type

From its peak in 2025, coal will decline by more than 10 percent by 2040.

Latin America and China are the biggest users of hydro power, which makes up over 80 percent of total Hydro/Geo supplies.

Source: ExxonMobil – The Outlook for Energy - A View to 2040
Power Generation Growth by Fuel Type

- Power demand grows by 80%
- Natural gas used to generate power will grow the most (~30%), coal and oil will decline, and nuclear and renewables will gain significantly
- Nuclear predicted to grow globally ≥2.0%/year, which is lower than prior to the Great East Japan Earthquake and Tsunami

Source: ExxonMobil – The Outlook for Energy - A View to 2040
What’s Driving Our Growth?

- World population will increase ~28 percent in the next 30 years (from 7 to 9 billion) with most of that growth in countries with emerging economies.
- Rising energy demand from economic output and improved standards of living will strain energy supplies.
- While global energy demand will grow 30%, power demand will grow 80% by 2040 (it will account for more than 40% of global energy consumption).

What’s the solution?

Realistic Balanced Energy Portfolio!
Balanced Energy Portfolio includes......
Plus Conservation

- Solar
- Gas
- Oil
- Wind
- Nuclear
Solar Potential – A U.S. Example
Wind Potential – A U.S. Example
Equivalent Wind Power to New V.C. Summer Nuclear Plants

Equivalent Wind

Turbines 3 deep (3/4 mi) along the entire South Carolina coastline!
U.S. Electricity Sources Today Which Do Not Emit Greenhouse Gases

Solar, Wind & Geothermal 9.5%

Hydro 21.6%

Nuclear 68.9%

Ventyx; Energy Information Administration, U.S. Department of Energy, Updated 5/11
<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Average Capacity Factors (%)</th>
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<tbody>
<tr>
<td>Nuclear</td>
<td>91.2</td>
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<tr>
<td>Biomass</td>
<td>85.5</td>
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<tr>
<td>Geothermal</td>
<td>71.6</td>
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<tr>
<td>Coal (Steam Turbine)</td>
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<td>Gas (Combined Cycle)</td>
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<td>Wind</td>
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<td>Solar</td>
<td>17.7</td>
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<tr>
<td>Gas (Steam Turbine)</td>
<td>12.9</td>
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<tr>
<td>Oil (Steam Turbine)</td>
<td>8.9</td>
</tr>
</tbody>
</table>

Source: Ventyx Velocity Suite / Energy Information Administration Updated: 4/11
U.S. Electricity Production Costs
1995-2009, In 2009 cents per kilowatt-hour

- Coal: 2.97 cents per kWh
- Gas: 5.00 cents per kWh
- Nuclear: 2.03 cents per kWh
- Petroleum: 12.37 cents per kWh

Source: Ventyx Velocity Suite
Updated: 5/10
U.S. Power Generation Cost in 2030 (with and without CO₂ cost penalty)

Source: ExxonMobil – The Outlook for Energy - A View to 2040
Why Nuclear Power?

- Meets policy goals to reduce greenhouse gas emissions and is insensitive to future carbon taxes
- Highest reliability power source
- Low-cost electricity generation now and in the future (low production costs)
- Stable uranium fuel price with small fraction of total production cost
- Provides high degree of energy security
Great East Japan Earthquake – Fukushima Event

- The Fukushima nuclear plants experienced a series of unprecedented natural disasters that exceeded their design basis
  - Magnitude 9 Earthquake with ground force acceleration of 0.51g vs. design of 0.45g
  - Tsunami wave 14 meters high vs. design of tsunami wall at 5.7 meters
- Approximately 20,000 people dead or missing and over 100,000 still displaced from their communities
- Lessons learned from this event will be used to incorporate necessary changes to existing and planned reactors
Strong Prompt Reaction in Selected Countries

- Broad based re-evaluation of operating reactors safety against severe external events
- Announcement of reactor shutdowns, e.g., Germany and Japan
- Stoppage of plans for future reactor build, e.g., Italy and Switzerland
- Pause of new build authorizations, e.g., China
- Confirmation of existing plans for future reactor build, e.g., UK, UAE, South Korea, India
U.S. NRC’s Post-Fukushima Recommendations

- Made a series of recommendations for operating nuclear plants to enhance their safety
  - Defense-in-depth approach will be strengthened by explicitly including beyond design basis events
  - Upgrades to seismic, flooding, and loss of all AC power
  - Strengthening on-site and off-site emergency response capabilities

- Acknowledged the two design certifications currently in the rulemaking process have the passive safety design features necessary to address their post-Fukushima recommendations
Comparison of Nuclear Plants with Active and Passive Safety Systems

Standard Gen II PWR (only 2 safety trains)

AP1000 Passive PWR
The Move Toward Passive Safety Systems

- Began nearly 20 years ago with the development of the AP600
- Lessons learned from operating fleet applied to development of passive designs – Westinghouse AP1000 and GE ESBWR)
  - Safe shutdown condition without operator action and no AC power for 72 hours
  - With simple operator action after 72 hours, passive plants continue to maintain reactor core cooling and spent fuel pool cooling indefinitely
- Provides superior coping capabilities for severe external events as well as significantly reduced risk for core damage
Passive Safety Plant Results in Simpler Design Requiring Less Equipment

- 50% Fewer Valves
- 35% Fewer Pumps
- 80% Less Pipe*
- 80% Fewer Heating, Ventilating & Cooling Units
- 45% Less Seismic Building Volume
- 70% Less Cable

* No safety grade pumps
** Safety Grade
Modular Construction Benefits
(Parallel Construction Approach)

Decreases construction time and costs, and improves quality
Eight AP1000 units currently under construction:

- Four in the U.S.: first new plant contracts in U.S. in 30 years – eight additional units are planned
- Four in China, with dozens more planned in next 10 years
Continued Strong Worldwide Interest in Nuclear Energy

Americas
- Argentina
- Brazil
- Canada
- Chile
- United States

Asia
- China
- India
- Indonesia
- South Korea
- Taiwan
- Vietnam

Europe
- Bulgaria
- Czech Republic
- France
- Hungary
- Lithuania
- Netherlands
- Poland
- Romania

Slovakia
- Slovenia
- Spain
- Turkey
- United Kingdom
- Finland
- Sweden

Oceana
- Australia
- New Zealand

Africa
- South Africa
- Egypt
- Morocco
- Nigeria
- Saudia Arabia
- UAE

Other
- Belarus
- Russia
- Ukraine
Summary

- Energy demand will continue to grow significantly as underdeveloped (non-OECD) countries prosper.
- Power demand will grow faster than overall energy demand because it drives economies and quality of life.
- Oil and natural gas are expected to be the fuels of choice over the long term, with renewables and nuclear making significant gains.
- National energy policies and cost of carbon will be important drivers away from fossil fuels to alternatives.
- Nuclear power will continue to grow worldwide, but at a slower pace than predicted before the Fukushima accidents.
- The trend in nuclear technology will be to designs with passive safety systems that have greater resilience to the unexpected.
Questions