An American Nuclear Society Perspective on the Future of Nuclear Reactors

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Nuclear Power in the USA

• The USA is the world's largest producer of nuclear power, accounting for more than 30% of worldwide nuclear generation of electricity.

• The country's 100+ nuclear reactors produced 789 billion kWh in 2013, over 19% of total electrical output. There are now 100 units operable and five under construction.

• Following a 30-year period in which few new reactors were built, it is expected that six new units may come on line by 2020, four of those resulting from 16 licence applications made since mid-2007 to build 24 new nuclear reactors.

• However, lower gas prices since 2009 have put the economic viability of some existing reactors and proposed projects in doubt.

- **Coal**: 37%
- **Petro**: 1%
- **Gas**: 31%
- **Hydro**: 7%
- **Nuclear**: 19%
- **Renewable**: 6%

* Gas includes natural gas, blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuel.

** Hydroelectric includes conventional hydroelectric and hydroelectric pumped storage.

*** Renewable energy includes geothermal, wood and nonwood waste, wind, and solar energy.

A Declaration on Sustainable Development

- Essential to address from a global perspective
- All energy sources – nuclear, fossil, hydroelectric, solar, wind and others will be needed
- Rational assessment based on the effect to the environment and economic considerations over the life cycle of the energy source
Performance-based, technology neutral policy approaches must be the standard and are the best way to encourage innovation and achieve intended carbon reduction goals.

Nuclear energy is the only energy technology with a proven capability of delivering large amounts of essentially carbon-free baseload electricity.
Nuclear - Important Clean Energy Source

- Nuclear power is clean, reliable base load energy source
  - Provides over 70% of U.S. emission-free electricity
  - Avoids about 600 MMTCO₂ each year
  - Helps reduces overall NOx and SOx levels
Maximizing Use of Existing Nuclear Power Plants

- Fleet maintaining about 90% average capacity factors
- Life beyond 60 being pursued
- Power up-rates continue
- Utilities exercising options to use prior nuclear investments

<table>
<thead>
<tr>
<th>Year</th>
<th>Capacity Factor</th>
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<tbody>
<tr>
<td>2008</td>
<td>92%</td>
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<tr>
<td>2009</td>
<td>91%</td>
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<tr>
<td>2010</td>
<td>92%</td>
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<td>2011</td>
<td>89%</td>
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<tr>
<td>2012</td>
<td>89%</td>
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<tr>
<td>2013</td>
<td>86%</td>
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</table>
Power Uprates: Past, Current, and Future

*Uprates Under Review: 827 MWe*

*Uprates Completed 1977–2013: 7,034.9 MWe Equal to about 7 Reactors*

*Projected Uprates 2014–2017: 1,097 MWe*

U.S. NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment
AUGUST 2014
Reactor License Renewal

- Commercial power reactor operating licenses are valid for 40 years and may be renewed for up to an additional 20 years.
- 28 units with original license
- 43 sites comprised of 72 units issued renewal licenses
- 12 sites with license renewal applications in review
- 6 sites with letters of intent to submit renewal license applications

http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1350/
U.S. Commercial Nuclear Power Reactor Operating Licenses—Expiration by Year

License Expiration

- **2013–2019**: 3
- **2020–2023**: 4
- **2024–2030**: 26
- **2031–2049**: 67

Indicates Indian Point 2, which entered timely renewal on Sept. 29, 2013.

Note: These numbers include Vermont Yankee, which is scheduled to cease operations at the end of 2014.

AUGUST 2014
Improved Performance

• At the end of 1991 (prior to passage of the Energy Policy Act), there was 97,135 MWe of operable nuclear generating capacity in the USA. In March 2009, it was 101,119 MWe.

• A decrease of 5,709 MWe, due to the premature shutdown of eight reactors, due to their having high operating costs.

• A net increase of 6,223 MWe, due to changes in power ratings.

• An increase of 3,470 MWe due to the start-up of two new reactors (Comanche Peak 2, Watts Bar 1) and the restart of one unit (Browns Ferry 1).

• So far more than 140 uprates have been implemented, totalling over 6500 MWe, and another 3400 MWe is prospective, under NRC review.
The Need for Near-Term Deployment of New Nuclear Power Plants

- United States will need about 281 gigawatts of new electricity generating capacity by 2025.
- Maintain current share of 20% means 40 to 50 large new nuclear power plants to start operation in the next 20 years.
- Maintain a technically knowledgeable workforce and a supply and manufacturing infrastructure.
- Enable the United States to maintain a leadership role in nuclear development and non-proliferation issues worldwide.
Outlook on New Construction
Challenges to New Construction

- High capital costs ($10-15 billion)
- Used fuel issue
- Availability of nuclear qualified components
- Availability of skilled personnel
- Lengthy licensing and construction schedule
- Cost and schedule performance
- Anti-nuclear resistance/concerns/misunderstandings
Trends in Public Opinion in the U.S.

Annual Averages Until 2010, %ages

Bisconti Research, Inc. surveys of nationally representative samples of 1,000 U.S. adults, margin of error plus or minus 3 %age points
March 2014 National Survey Results

• 25% believe that nuclear energy releases no greenhouse gas, 44% “a little”, and 23% “a lot”

• 63% favor nuclear energy (31 % strongly, 33 % somewhat), 16 % somewhat oppose, and 18 % strongly oppose

• 82% agree we should renew the license of nuclear power plants that continue to meet federal safety standards,

• 72% agree that electric utilities should prepare now so that new nuclear power plants could be built if needed in the next decade, and

• 57% agree that we should definitely build more nuclear power plants in the future.

• 66% said they would find it acceptable to add a new reactor at operating sites (30 % not acceptable, 4% unsure)

• Awareness of hearing or reading information about key nuclear energy topics declined since September 2013
The Need for Deployment of the Next Generation Nuclear Plant Projects

- Supports the Next Generation Nuclear Plant Project (NGNP) established by Congress under Section 641 of the Energy Policy Act of 2005
- Generation IV reactors expected to use recycled fuel, lower generation of waste, higher safety and physical protection levels, higher reliability, better economic performance
- Supports a robust Generation IV development in parallel with current Generation III+ efforts to ensure ever-increasing safety levels and will help nuclear energy fulfill its vital role in worldwide electricity generation.
# The Evolution of Nuclear Power

## Generation I
- Early Prototype Reactors
  - Shippingport
  - Magnox

## Generation II
- Current Commercial Power Reactors
  - LWR PWR (W)
  - BWR (GE)
  - CANDU (AECL)
  - VVER/RBMK (Russian)

## Generation III
- Evolutionary Reactors
  - Improved safety and reliability
  - Enhanced maintainability
  - Control room advances
- Advanced Evolutionary and Passive Reactors
  - Simplified design
  - Improved economics
  - Passive safety
  - Less equipment
  - Less operator actions

## Generation III+
- Highly economical
- Enhanced safety
- Minimize wastes
- Proliferation resistant
- High temperature/hydrogen production

## Generation IV
- Very High Temperature Reactor (VHTR)
- Gas-cooled Fast Reactor (GFR)
- Lead-cooled Fast Reactor (LFR)
- Sodium-cooled Fast Reactor (SFR)
- Molten Salt Reactor (MSR)
- Supercritical Water-cooled Reactor (SCWR)

### Reactor Types
- **ABWR**
- **EPR**
- **AP1000**
- **ESBWR**

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<thead>
<tr>
<th>Year</th>
<th>Generation I</th>
<th>Generation II</th>
<th>Generation III</th>
<th>Generation III+</th>
<th>Generation IV</th>
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<tbody>
<tr>
<td>1950</td>
<td>Early Prototype Reactors</td>
<td>Current Commercial Power Reactors</td>
<td>Evolutionary Reactors</td>
<td>Advanced Evolutionary and Passive Reactors</td>
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The development and deployment of advanced nuclear reactors based on fast-neutron fission technology is important to the sustainability, reliability, and security of the world’s long-term energy supply. In conjunction with fuel recycling, this can diminish the cost and duration of storing and managing reactor waste with an offsetting increase in the fuel cycle cost due to recycling. Improve international safeguards by segregating and consuming the plutonium as it is created. Recognize need for cooperative international efforts to build a fast reactor demonstration unit with onsite reprocessing of spent fuel.
NRC Research Funding, FY 2014

Total $50 Million

- Reactor Program—$42.7 M
- New/Advanced Reactor Licensing—$5.0 M
- Homeland Security—$0.2 M
- Materials and Waste—$2.0 M
- Infrastructure Support—$0.1 M

Note: Totals may not equal sum of components because of independent rounding.
SMR’s potential for changing social and energy supply paradigms is compelling

ANS recommended five actions to the US Government:

- Expedite research supporting commercial deployment of SMRs for flexible and scalable electricity generation applications,
- Assist in the identification and resolution of generic SMR licensing issues to establish the most efficient and effective licensing approaches through interactions with all stakeholders and the Nuclear Regulatory Commission,
• Encourage the development and deployment of multiple SMR designs as part of a balanced energy mix and expand their use beyond electricity generation,

• Participate in programs that demonstrate the feasibility of multiple SMR designs and approaches to reduce the time to market, and

• Encourage increased manufacturing/export technology capability in the United States for both domestic deployment and worldwide export within the “123 Agreement Framework” in order to increase the use of nuclear energy as part of a balanced energy mix.
Advanced SMR R&D Program

- Advanced SMR R&D program is funded at $28M in FY12 and the FY13 request is $18.5M.

- DOE is seeking greater interaction with U.S. industry in the development of the Advanced SMR R&D program.
  - Formed a Technical Review Panel to review advanced reactor concepts and help identify R&D needs.
  - DOE intends to issue, on an annual basis, a request for information for external entities to voluntarily submit information on concepts for DOE-NE to consider.
  - Process will assess viability of advanced SMR designs and support alignment of R&D portfolio with needs of advanced SMR designs.

- DOE is establishing a spectrum of experimental facilities to support R&D on advanced concepts.
  - Irradiation, passive cooling, Pb-Bi, Na, salt etc.
Position Statement #79

International Cooperation for Expansion of Nuclear Energy*

- Supports the global expansion of nuclear energy based on use of a nuclear fuel cycle that enhances energy security and sustainability while promoting nonproliferation
- Leading nuclear suppliers should develop a fuel services program in compliance with their nonproliferation obligations to provide nuclear fuel to developing nations
- International safeguards will be needed as an integral part of the global expansion of nuclear energy
Safety is highest priority
for any nuclear power plant
......anywhere

• Power plants have multiple barriers
• Redundant and diverse plant safety systems
• NRC is effective regulator
• Additional industry oversight
• Highly-trained personnel and licensed operators
• Procedural compliance
Realism in the Assessment of Nuclear Technologies

- Encourages the scientific and engineering community and national leaders to apply realism to regulations, practices, and public policy and information related to the use of radiation and radioactive materials.

- “Worst case scenarios” should not violate the laws of nature.

- Scientifically unfounded or unduly exaggerated consequences are a disservice to the scientific community and the public at large.
Thank You for joining ANS to
Inform!
Engage!
Inspire!

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http://www.ans.org/pi/ps/search.php

ANS Center for Nuclear Science and Technology Information
http://www.nuclearconnect.org
Congratulations!

W. Bennett Lewis Award

Presented to

Marcel Boiteux

In recognition of a lifetime of pioneering contributions to sustainable energy, in particular his leadership role in building a large fleet of nuclear power plants, enhancing energy independence and replacing the use of carbon intensive fuels, with reliable, economical, and clean nuclear energy.