

# Nuclear Energy 2014

## Status and Outlook for Small Reactors

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*New Mexico State Legislative Committee  
On Radioactive and Hazardous Materials*

November 7, 2014



NUCLEAR ENERGY INSTITUTE

nuclear. clean air energy.

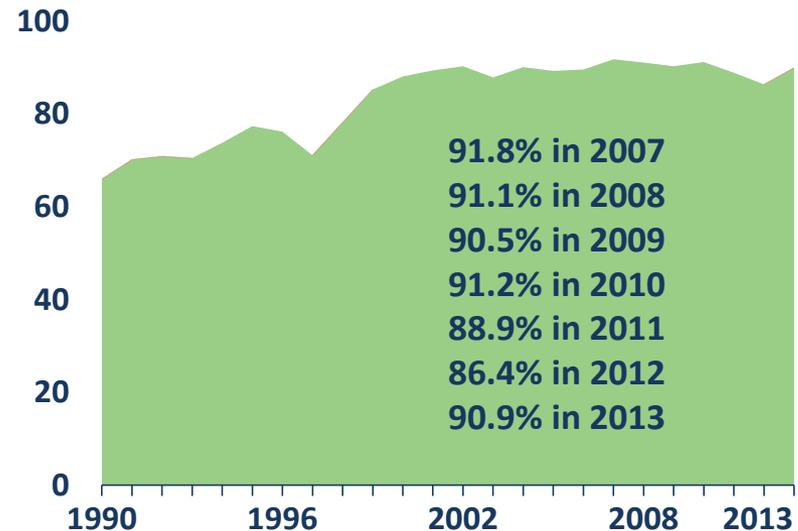


STORIED HISTORY  
BRIGHT FUTURE

# U.S. Nuclear Industry ... At a Glance

- Consistently high levels of safety, reliability
- Increased safety and ability to handle extreme natural events
- Halfway through a 30-billion-dollar-plus construction program
- Used fuel: Legislation to restructure program introduced in Senate; court ordered Nuclear Regulatory Commission to resume review of Yucca Mountain license application; ordered Department of Energy to stop collecting nuclear waste fee

**Sustained Reliability and Productivity:  
U.S. Nuclear Plant Capacity Factors**



*Source:  
Energy Information  
Administration*

# New Nuclear Development



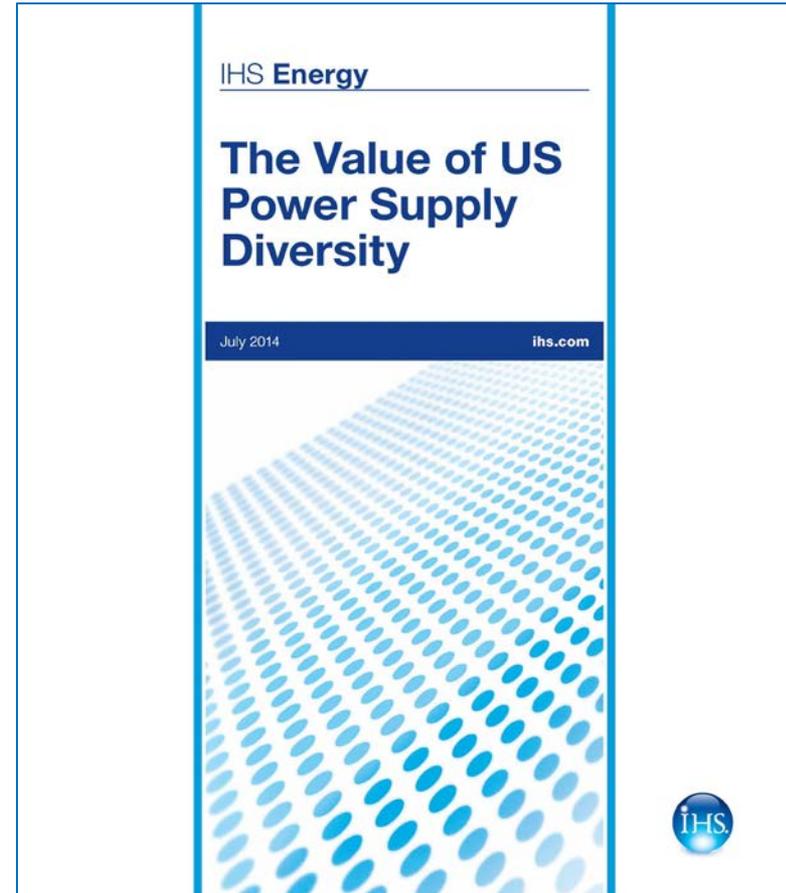
# New U.S. Reactor Projects

- Five reactors under construction
  - Watts Bar 2, online in 2015
  - Vogtle 3 & 4, online in 2017, 2018
  - Summer 2 & 3, online in 2017, 2018



# Fuel Diversity

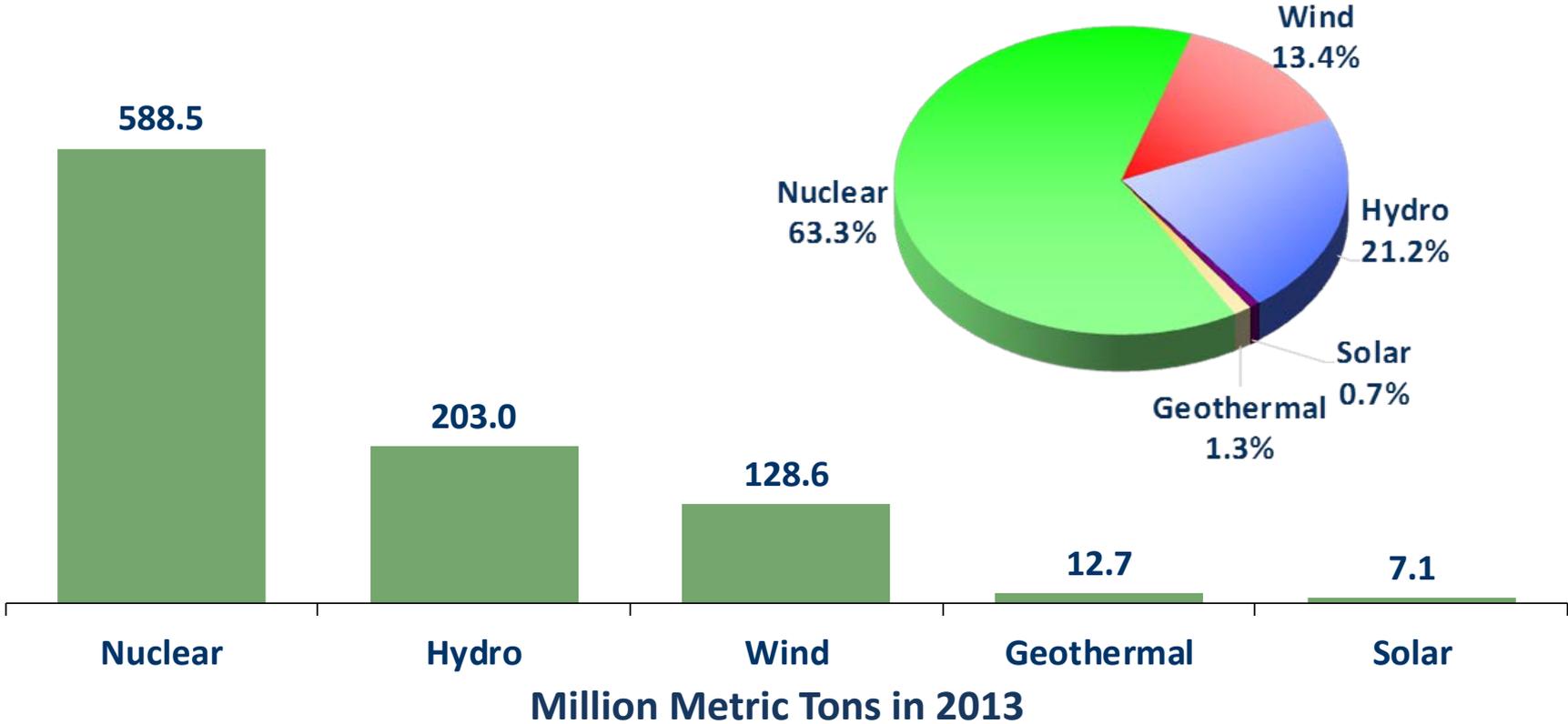
- Existing diversity in the electric system saves \$93 billion for consumers
- Reduced diversity case results in:
  - 75% increase in wholesale power prices; 25% for retail
  - \$200 billion reduction in GDP
  - Loss of 1 million jobs
  - \$2,100 reduction in household disposable income



# Nuclear Energy and Carbon

- Nuclear energy essential in any credible program to reduce carbon emissions
- EPA proposed rule under 111(d) recognizes compliance value of nuclear energy
- Two nuclear components to 111(d) rule
  - For every state with nuclear capacity, 6% of 2012 nuclear kilowatt-hours (“at risk” capacity) added to denominator
  - Output from five nuclear units under construction added to denominator in GA, SC, TN
- Treatment of nuclear energy lowers states’ carbon intensity targets

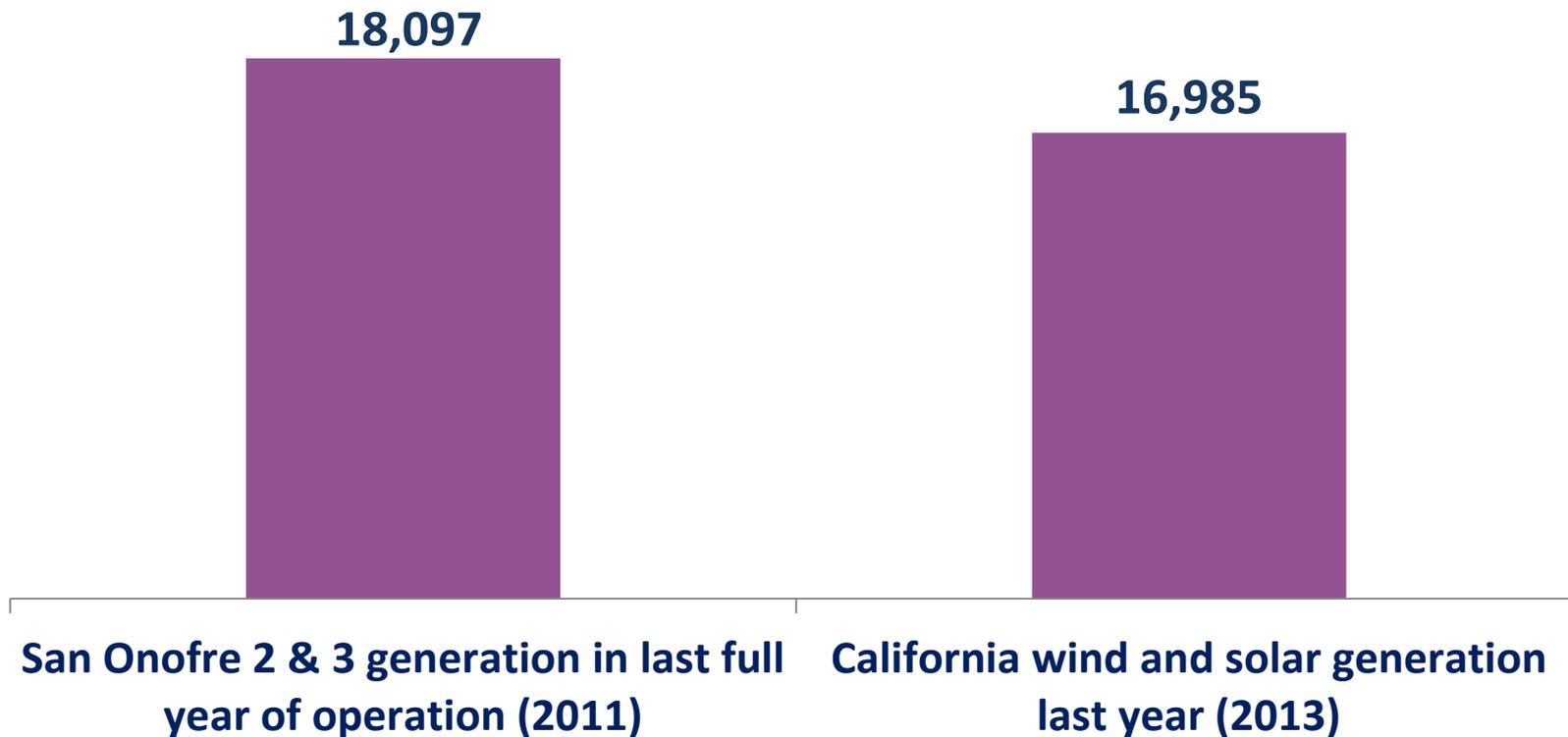
# U.S. Electric Power Industry CO<sub>2</sub> Avoided



Sources: Emissions avoided are calculated using regional and national fossil fuel emission rates from the Environmental Protection Agency and plant generation data from the Energy Information Administration.

# California Energy Comparison

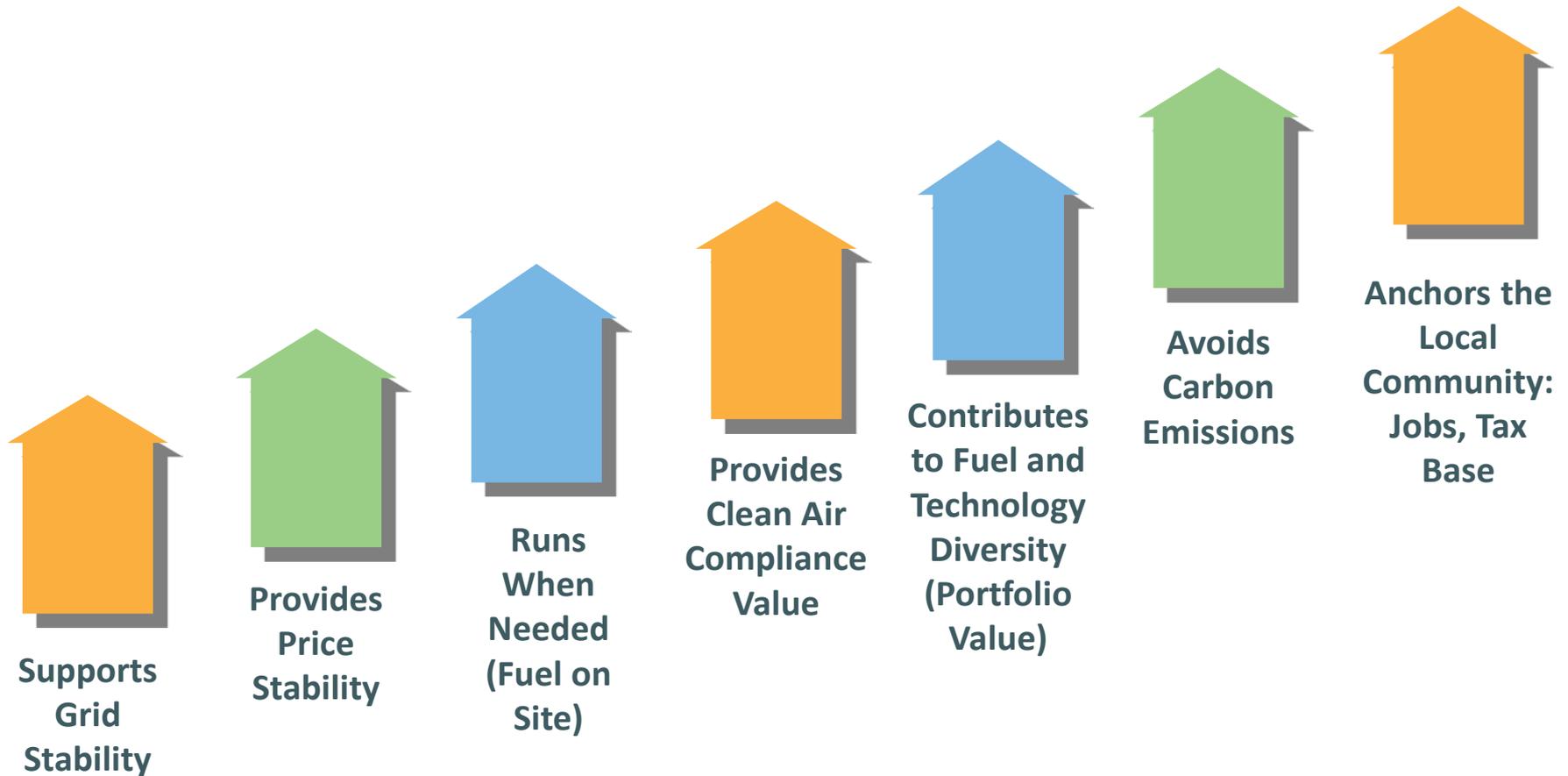
GWh



Sources: San Onofre – Energy Information Administration; California – California Energy Commission

# Nuclear Energy: A Solid Value Proposition

## Safe, Reliable Electricity 24-by-7-by-365 Plus ...



# Signs of Progress

- FERC Commissioners now recognize the problem
- Some RTOs seem to recognize that baseload nuclear, coal deserve additional compensation because they have fuel on site and will run when called
- Policy community increasingly alarmed
- Awareness growing in the states (e.g., Illinois)



# Role for Small Reactors



# Small Reactors Advance U.S. Policy

- Improve Energy/national Security
  - Expand fuel & technology diversity
- Advance our clean energy future
  - Adds additional carbon-free, base load optionality
- Re-vitalize manufacturing, create high quality jobs
  - every \$1 billion of U.S. exports = 5,000 to 10,000 domestic jobs
- Capture share of global clean energy market
  - \$500-\$740 Billion over next 10 years (U.S. DOC)

# Small Reactor Applications

- Innovative, Modular Light Water Reactors
  - NuScale, B&W, Westinghouse, Holtec
- Mini, distributed & fuel-cycle applications
  - GEN4, Toshiba, GE Hitachi
- HTGR's for process heat and hydrogen
  - AREVA and General Atomics

# High Level of Interest

**third way**  
 THE CLEAN ENERGY PROGRAM  
 NUCLEAR ENERGY | SEPTEMBER 2010  
**Thinking Small On Nuclear Power**  
 By Josh Freed, Elizabeth Horvitz, and Jeremy Enshow  
 IDEA BRIEF

**A**s the United States transitions to clean energy, we don't have technologies available to meet all our energy needs. Small modular nuclear reactors (SMRs) could provide clean, baseload power to utilities of all sizes and processes. And because many of the leading models are American-designed and can be domestically manufactured, their global deployment could mean tens of thousands of new, well-paying jobs in the United States. In the course of exploring every path to a clean energy future, we should pursue policies that facilitate the development and commercialization of these next-generation reactors.

Earlier this year, shovel broke ground for the first two new commercial nuclear reactors to be built in the United States in more than 30 years.<sup>1</sup> When the project is completed, it will generate enough electricity for 1.7 million households, without any carbon emissions.<sup>2</sup> This is the promise of new, only nuclear energy is a currently available hydrocarbon already harnessed, consistent amounts of electricity available technology capable of generating at this scale and emissions-free.

U.S. Department of Commerce  
 International Trade Administration  
**The Commercial Outlook for U.S. Small Modular Nuclear Reactors**

In May 2009, President Barack Obama called for harnessing the power of nuclear energy "to help lead our efforts to combat climate change and to usher in a new era of energy security for all people." Meeting the energy requirements for climate change in the 21st century will require new energy solutions and technologies that meet our needs and our values. One such technology is small modular nuclear reactors (SMRs). SMRs are a new class of nuclear reactors that are smaller, more flexible, and easier to build than traditional large-scale nuclear reactors. They offer a number of advantages, including the ability to be built in a controlled factory setting and installed module by module, reducing the financing challenge and matching a variety of needs for low-carbon energy.

SMR designs are available in industry as a commercial opportunity and governments are actively pursuing energy needs with their own SMR-based energy. They may be designed, built, and operated by a variety of entities, including utilities, independent power producers, and other energy providers. Because of the long life of nuclear reactors, the nature of their waste, and the serious consequences of any potential accident, SMR designs are being developed and brought to market in a more cautious and regulated manner than a world-class regulatory system here in the United States. This report provides an overview of the U.S. SMR development, examines the status of the technology, and offers recommendations for the U.S. nuclear manufacturing industry. Other countries are also developing SMR technology, and the U.S. nuclear manufacturing industry needs to be ready to compete in the global market for SMRs.

**Manufacturing and Services Competitiveness Report**  
 February 2011

SMR themes ..... 2  
 Strength of SMR ..... 2  
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 International Outlook for U.S. SMR Competitiveness ..... 2  
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**NEI**  
 NUCLEAR ENERGY INSTITUTE  
**FACT SHEET**  
 NUCLEAR ENERGY INSTITUTE

**Small Reactors Provide Clean, Safe Power and Industrial Process Heat**  
 January 2010

**Key Facts**

- Near-term construction of large, new nuclear plants will address two of our nation's top priorities: additional supplies of clean energy and job creation. Small, modular reactors can complement these large-scale projects by expanding the level of deployment and application options for carbon-free nuclear energy. Small-scale reactors provide energy companies and other users with a broader array of energy options.
- Their small size—typically fewer than 350 megawatts (MW)—and modular construction will allow these reactors to be built in a controlled factory setting and installed module by module, reducing the financing challenge and matching a variety of needs for low-carbon energy.
- The potential applications for small reactors include electricity generation. Small reactors may be more compatible with the needs of smaller U.S. utilities from the standpoint of generation, transmission, and financing than large 1,400-megawatt (MW) plants. The industry envisions modular reactors built in clusters, with modules added as needed to match growth in energy demand.
- Small, modular reactors could be used for industrial process heat applications, such as those used in the petrochemical industry, desalination or water purification.
- Another use for small reactors is providing power for the development of tar sands, oil shale and coal-to-liquids applications, reducing the overall life-cycle carbon footprint of these activities.

**Designs Target Diverse Applications**  
 Many small, modular reactor designs are under development to meet specific U.S. and international market needs, and they are attracting considerable attention from Congress and the news media.

The international community has been evaluating the feasibility of small reactor technologies for the past several years through the Generation IV International Forum. The forum is a global organization for nuclear energy research and development.

**AEPI** Energy Policy Institute  
**CAES** Center for Advanced Energy Studies

**The Energy Policy Institute**

**ECONOMIC AND EMPLOYMENT IMPACTS OF SMALL MODULAR NUCLEAR REACTORS**  
 June 2010

**NEI**  
 NUCLEAR ENERGY INSTITUTE  
**POLICY BRIEF**  
 NUCLEAR ENERGY INSTITUTE

**Small Reactor Development Advances Energy, Environmental Benefits in New Markets**  
 October 2010

**Key Points**

- Small-scale reactors can complement large nuclear plant projects by expanding potential markets in the United States and abroad for carbon-free energy production. Smaller reactors provide energy companies and other users with additional options that help achieve critical energy and environmental policies.
- Their small size—less than 350 megawatts (MW)—and modular construction will allow some of these new reactors to be built in a controlled factory setting and installed module by module, improving manufacturing efficiency and cost while reducing construction time and financing costs.
- Small reactors may be more compatible with the needs of smaller U.S. utilities from the standpoint of generation, transmission, and financing than large 1,400-megawatt (MW) plants. The industry envisions modular reactors built in clusters, with modules added as needed to match growth in energy demand.
- Another use for small reactors is providing power for the development of tar sands, oil shale and coal-to-liquids applications, reducing the overall life-cycle carbon footprint of these activities.

**POST-PARTISAN POWER**

**HOW A LIMITED AND DIRECT APPROACH TO ENERGY INNOVATION CAN DELIVER CLEAN, CHEAP ENERGY, ECONOMIC PRODUCTIVITY AND NATIONAL PROSPERITY**

**AEI** BROOKINGS  
 BREAKTHROUGH ENERGY



# Timeline to deployment

- Small light water designs have most in common with existing fleet
  - Closer fit to 10 CFR 50/52 process
  - Nuclear Regulatory Commission: more expertise, utilities: more interest
  - First deployment post-2020
- High temperature gas reactors and fast reactor designs face additional challenges and most expect post-2025 use

# Challenges

- Generic regulatory issues must be resolved to establish business case:
  - Appropriate safety, security, emergency management, staffing and financial requirements must be established
  - Existing regulatory paradigm must change
- Gas and metal cooled designs require materials and fuels R&D

# Secretary of Energy Advisory Board



## SEAB Recommendations on SMR development

- SMRs will help re-establish US nuclear leadership
- Directly support strategic national goals:
  - Environmental
  - Energy Security
  - Economic Development
- Establishing SMR industry-long-term endeavor
- Will require U.S. support beyond licensing program



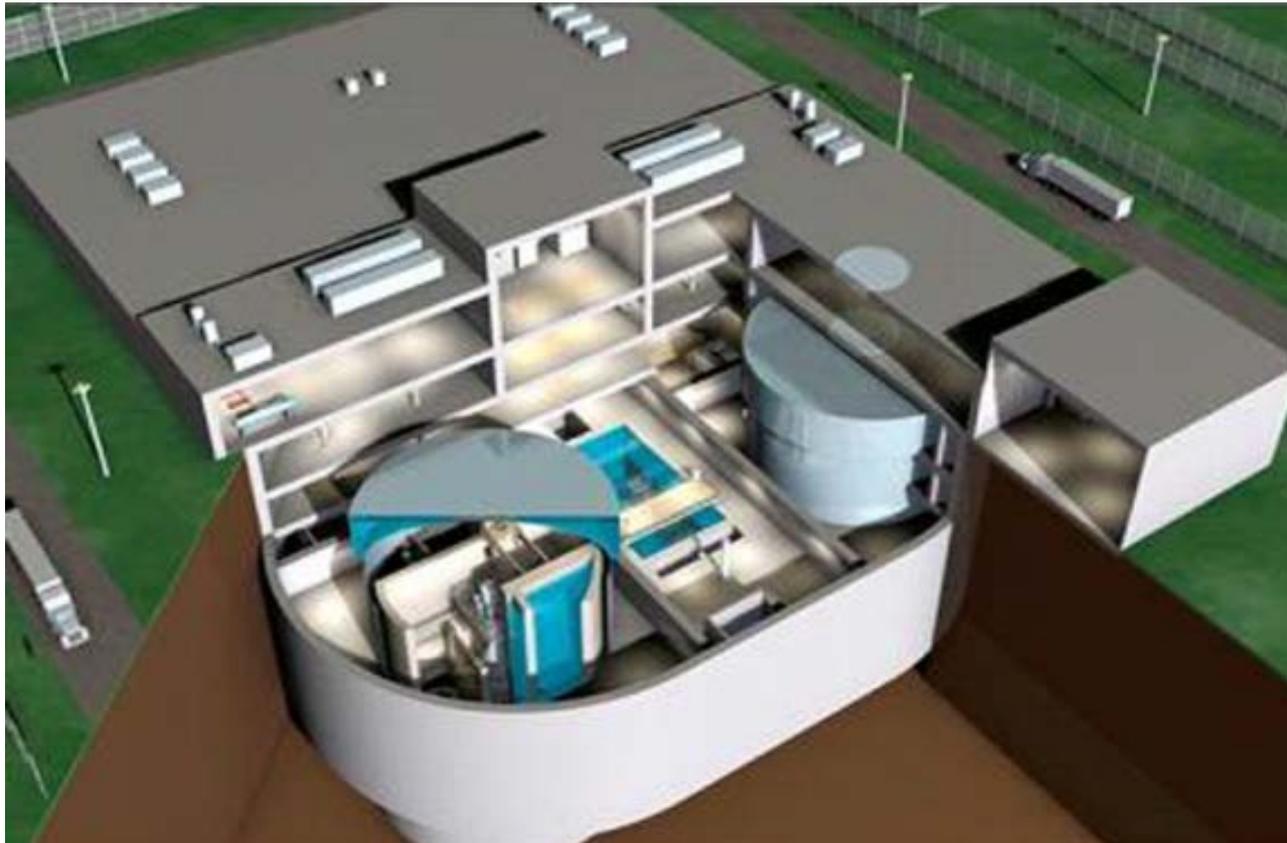
NEI urged Secretary Chu to assist with licensing support and commercialization support in parallel

# Obama Administration Support

- FY 2012
  - \$67 M for Licensing Support
  - \$125 M for Reactor Concepts R&D (includes \$28.7 M for R&D)
  - \$49.6 M for gas reactor development
- DoE's FY 2013 request
  - \$65 M for Licensing Support
  - House Appropriators increased to \$114 M
  - Senate Appropriators remained at \$65 M
  - Government to operate under continuing resolution



# mPower America Partnership Selected by DOE for Initial Cost-Share Award



# Obama Administration: Continued Support

- DoE's FY 2014 request
  - \$70 M for Licensing Support
  - SMR program expanded to six years
- Industry support on generic technical/licensing issues
- SMR commercialization support
- Advanced SMR R&D

# Energy Secretary Nominee on Small Reactors

“I think it’s a very promising direction we need to pursue. Its where a lot of innovation is going on with nuclear energy. There’s a great potential payout there along with very strong safety considerations associated with these reactors.”

– Dr. Ernest Moniz, Nominee for Secretary of Energy, confirmation hearing, April 9, 2013

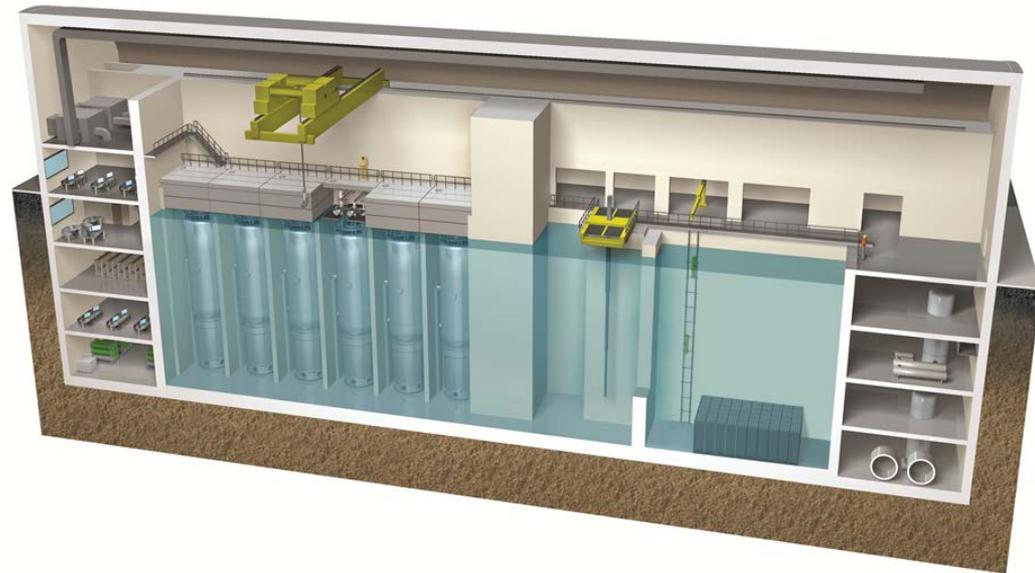


# DOE Announces Follow-on FOA Award

## December 12, 2013

Oregon based NuScale awarded \$226 M to facilitate innovative design development

- Enhanced safety, operations and performance
- Focus on design development & certification



# Westinghouse SMR

ONE SMALL WESTINGHOUSE REACTOR

Another giant step by  
the true leader in  
commercial nuclear energy



WESTINGHOUSE ELECTRIC COMPANY, LLC

Westinghouse, the world leader in the development, licensing and deployment of commercial nuclear energy plants, is again leading the industry, this time with a 225 MWe integrated pressurized water reactor that can generate electricity for a residential community of 45,000 homes without emitting any greenhouse gases.

And unlike other designs, the Westinghouse Small Modular Reactor (SMR) is an outgrowth of proven, land-based nuclear reactor technology that takes safety, reliability and constructability to unsurpassed levels.

To make this exciting new reactor a reality, Westinghouse, with the full support and backing of its majority owner Toshiba Corporation, is working with a distinguished group of partners, notably Ameren Missouri, the Association of Missouri Electric Cooperatives, Associated Electric Cooperative, Inc., The Empire District Electric Company, Kansas City Power & Light Company and the Missouri Public Utility Alliance.

Proud of our track record of success, but always looking to the future, Westinghouse nuclear technology will help provide future generations with safe, clean and reliable electricity.

Check us out at [www.westinghousenuclear.com](http://www.westinghousenuclear.com)

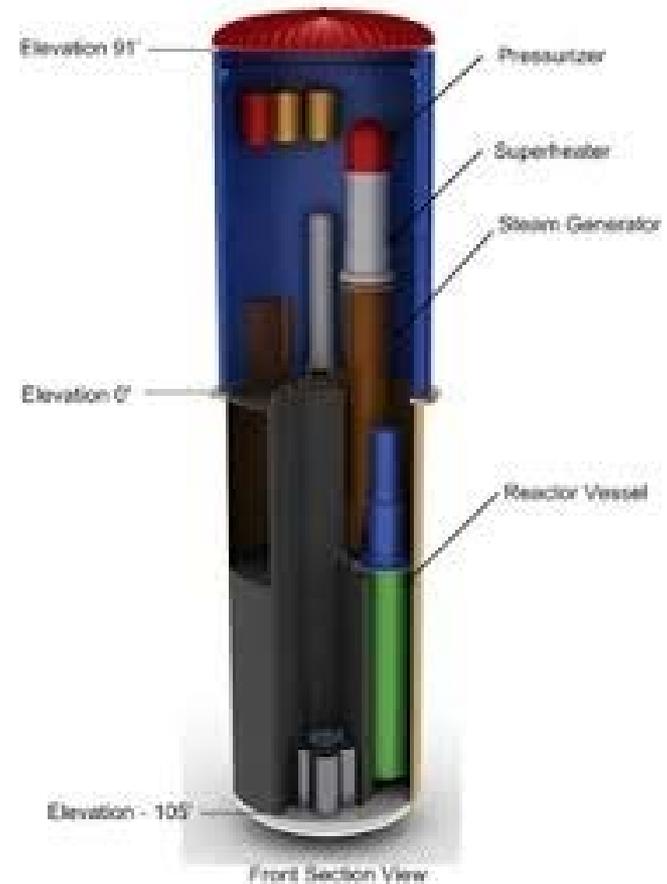


A Toshiba Group Company

You can be sure...  
If it's Westinghouse



# Holtec SMR



# Licensing Activities

- Address generic regulatory issues
- Prepare consensus position papers
- Regular interactions with regulators

# Generic Regulatory Issues

## Industry White Papers Submitted to NRC

- ✓ Annual Fees
  - ✓ Decommissioning Funding
  - ✓ Pre-Application Engagement
  - ✓ Modularity – Licensing
  - ✓ Price-Anderson (liability)
  - ✓ Control Room Staffing
  - ✓ Physical Security
  - ✓ ITAAC
  - ✓ Source-Term Methodology
  - ✓ Emergency Preparedness
- Note**-Resolution of regulatory policy issues often requires NRC licensing action

# Significant Work Has Been Accomplished

**SECY-10-0034: Potential Policy, Licensing, and Key Technical Issues for Small Modular Nuclear Reactor Designs**

**SECY-11-0024: Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews**

**SECY-11-0079: License Structure for Multi-Module Facilities related to Small Modular Nuclear Power Reactors**

**SECY-11-0098: Operator Staffing for Small or Multi-Module Nuclear Power Plant Facilities**

**SECY-11-0112: Staff Assessment of Selected Small Modular Reactor Issues Identified in SECY-10-0034**

**SECY-11-0152: Development of an Emergency Planning and Preparedness Framework for Small Modular Reactors**

**SECY-11-0156: Feasibility of Including Risk Information in Categorizing Structures, Systems, and Components as Safety-Related or Non-Safety Related**

**SECY-11-0178: Insurance and Liability Regulatory Requirements for Small Modular Reactor Facilities**

**SECY-11-0181: Decommissioning Funding Assurance for Small Modular Nuclear Reactors**

**SECY-11-0184: Security Regulatory Framework for Certifying, Approving, and Licensing Small Modular Nuclear Reactors**

**Commission Memo: Current Status of the Source Term and Emergency Preparedness Policy Issues for Small Modular Reactors (5/30/13)**

**Commission Memo: Update Regarding Recommendations for Use of Risk Insights for Small Modular Reactor Reviews (1/30/14)**

**Commission Memo: Status of Mechanistic Source Term Policy Issue for Small Modular Reactors (06/20/14)**

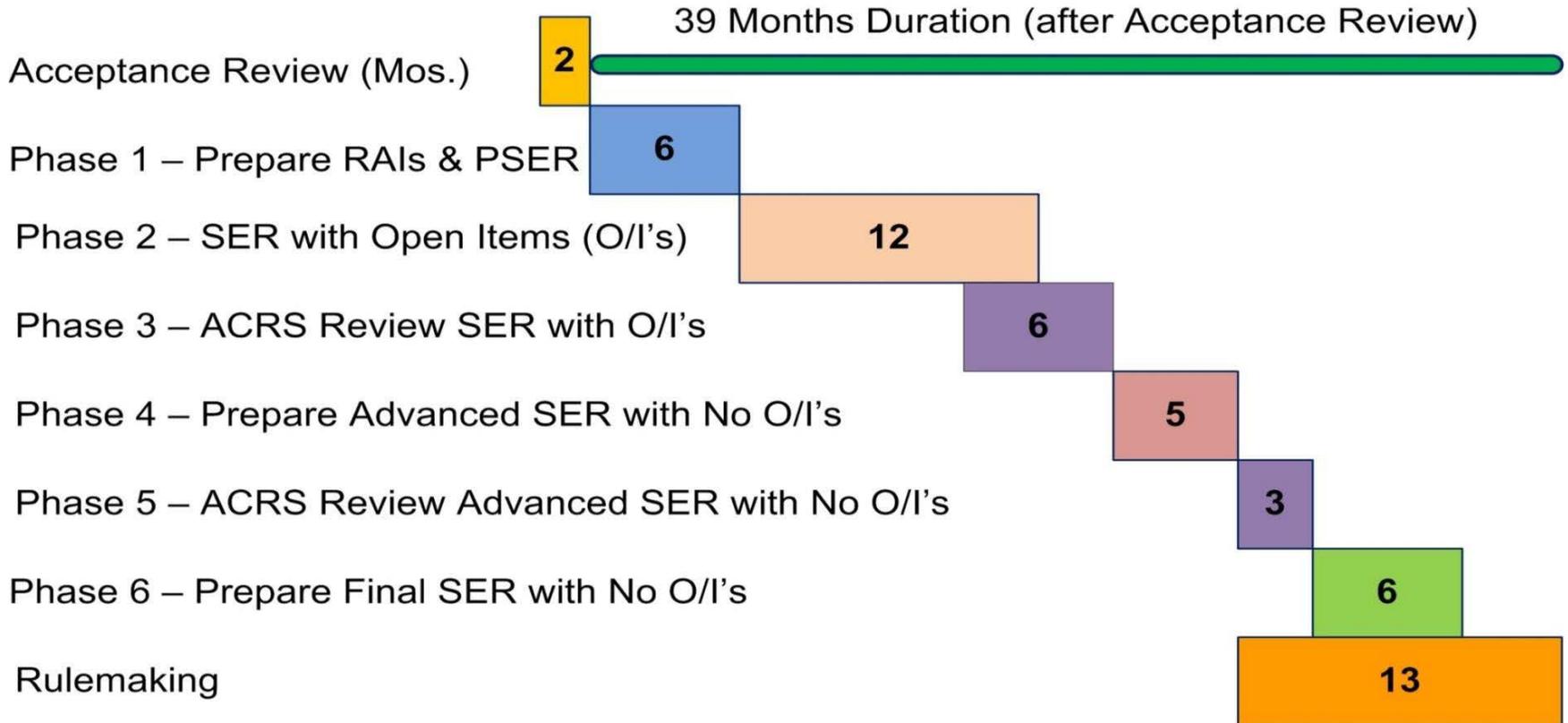
**SECY-14-0095: Status of the Office of New Reactors Readiness to Review Small Modular Reactor Applications**

# NRC Readiness to Review

- NRC has concluded they are ready to review SMR applications
  - SECY 14-0095 and staff testimony at 11/5 Commission briefing
  - Resolved many issues since 2011
  - NEI provided input through position papers
- Regulatory efficiency can be enhanced by continuing to address issues
- NRC is working on design specific review standards

# Baseline Review, Optimal Scenario

## Baseline SMR Design Certification Review Schedule

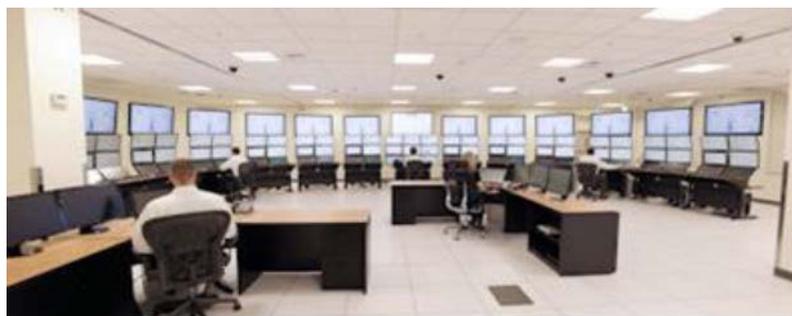


# Engineering and Testing Infrastructure For Design Validation is Progressing



*MASLWR integral test facility continues to support **NuScale** design development and validation*

***NuScale** Control Room at Corvallis, Oregon*



*Component prototype testing on reactor coolant pumps and control drive mechanisms*

# Engineering and Testing Infrastructure For Design Validation is Progressing, *cont.*

*Bore hole drilling at Clinch River*



***B&W mPower  
Integrated  
System Test  
facility in  
Lynchburg, Va.***



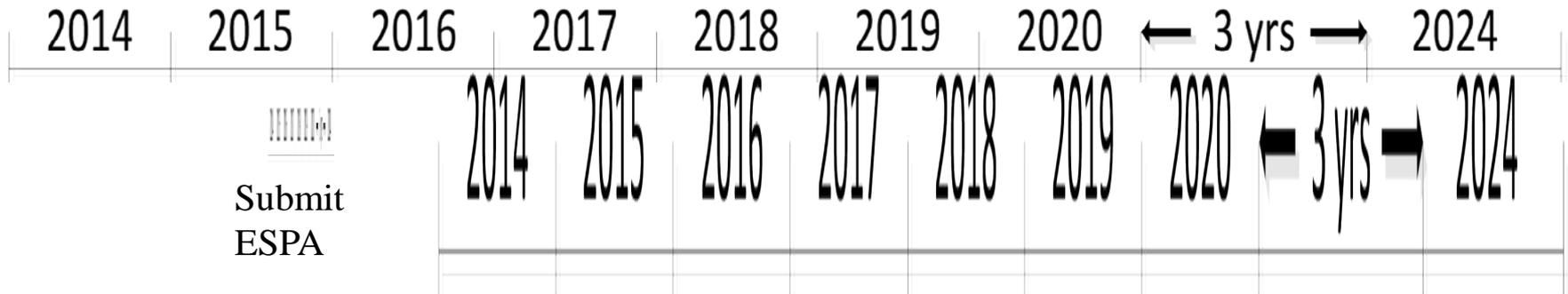
# Sustaining development and licensing investment requires a predictable regulatory framework

- SMR development and investments on target to submit NRC applications in 2015 and 2016
- NRC priority/resources needed on policy issues before applications are submitted
- Apply lessons learned from new plant projects



*CRDM Prototype Testing*  
Euclid, Ohio

# Timeline



- TVA planning ESPA in Fall 2015 for Clinch River
- NuScale planning DCA in late 2016
- Entity for COLA applicant in 2017 and 1<sup>st</sup> operation in 2024 has not been specified

# Questions?

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