

Nuclear Energy 2014: Status and Outlook

Paul Genoa

Nuclear Energy Institute



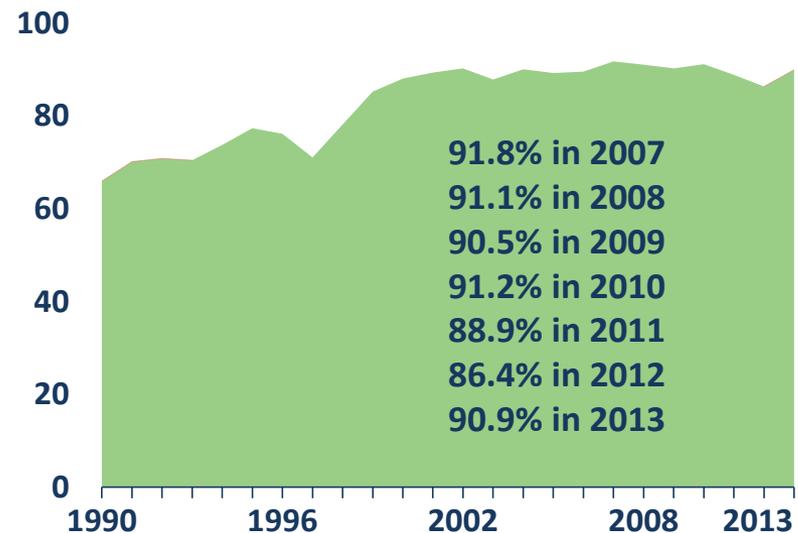
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U.S. Nuclear Industry ... At a Glance

- 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*

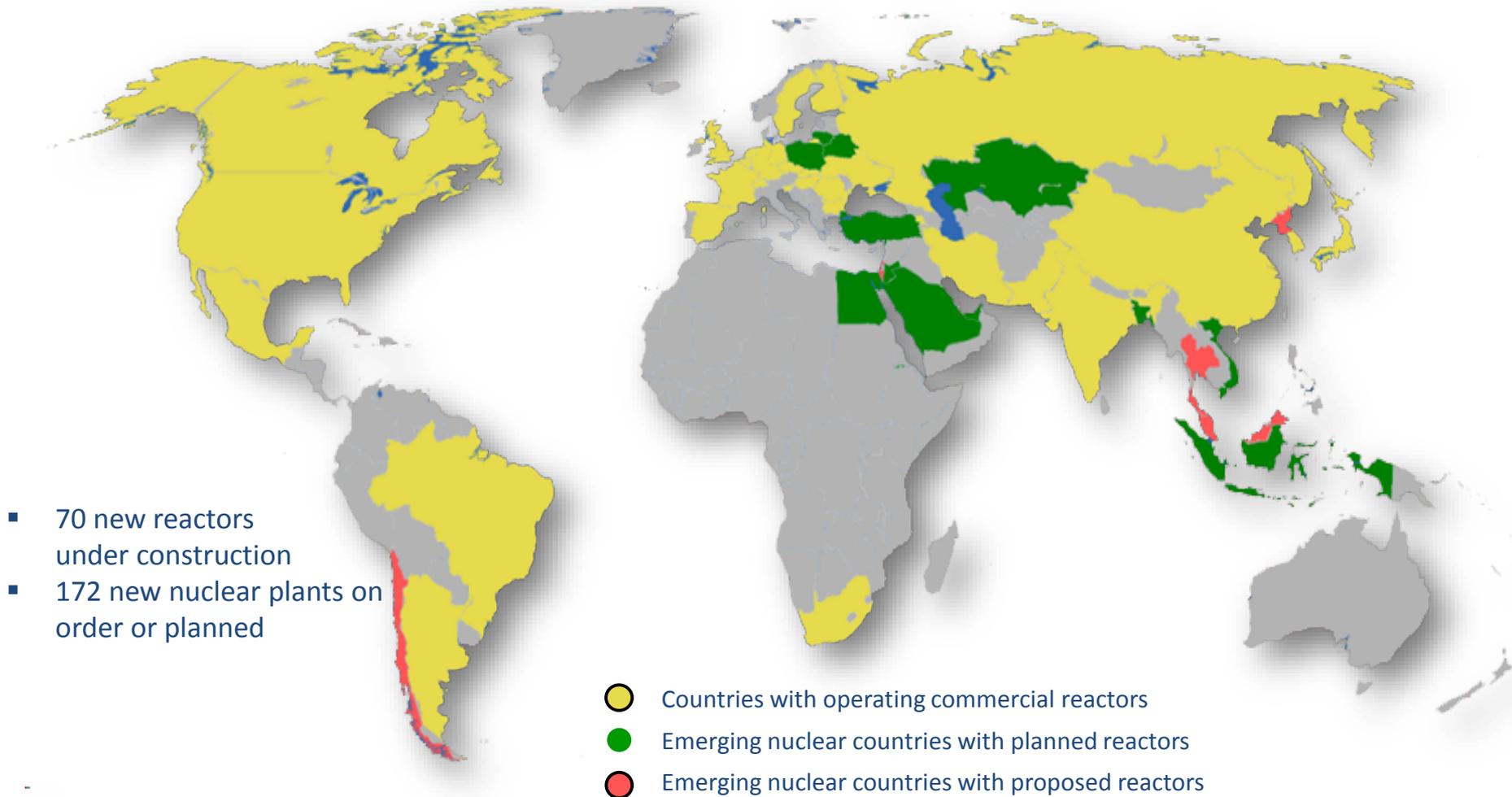
Global Outlook for Nuclear Energy



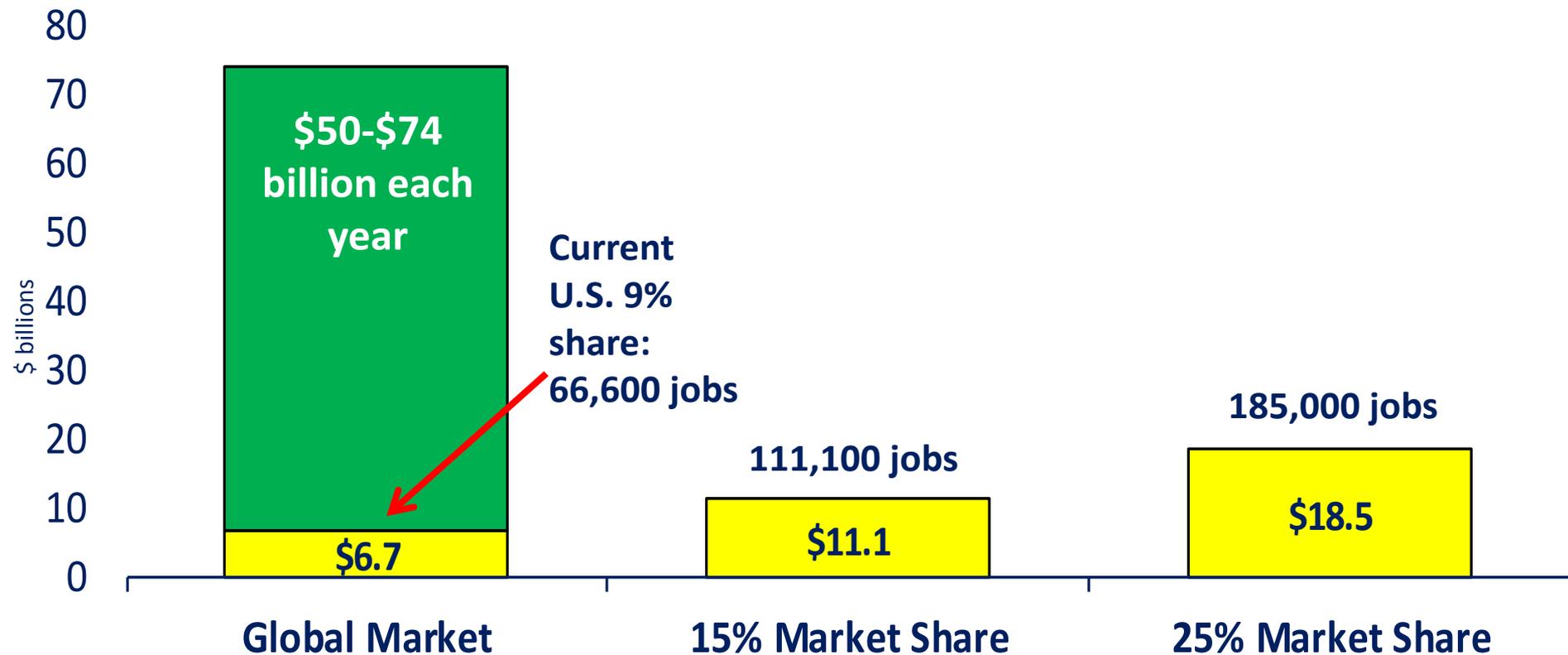
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Global Nuclear Energy Development



U.S. Market Share Tied Directly to Jobs



U.S. Exports = U.S. Jobs

New Plants

- Power Plants
 - Design
 - Major components
 - Sub-components
 - Consumables
- Consulting Services
 - Engineering
 - Legal and Regulatory
 - Project Management
- Construction
- Workforce Development



U.S. Exports = U.S. Jobs

Ongoing Operations

- Plant operations
 - Services
 - Replacement components
 - Maintenance and repair services
- Fuel
 - Natural uranium
 - Conversion
 - Enrichment
 - Fabrication
 - Used fuel management
- Modifications and upgrades



U.S. Exports = U.S. Jobs Decommissioning

- Decommissioning
 - Clean-up
 - Remediation
 - Waste management
 - Environmental services



Nuclear Plant Shutdowns: The Situation

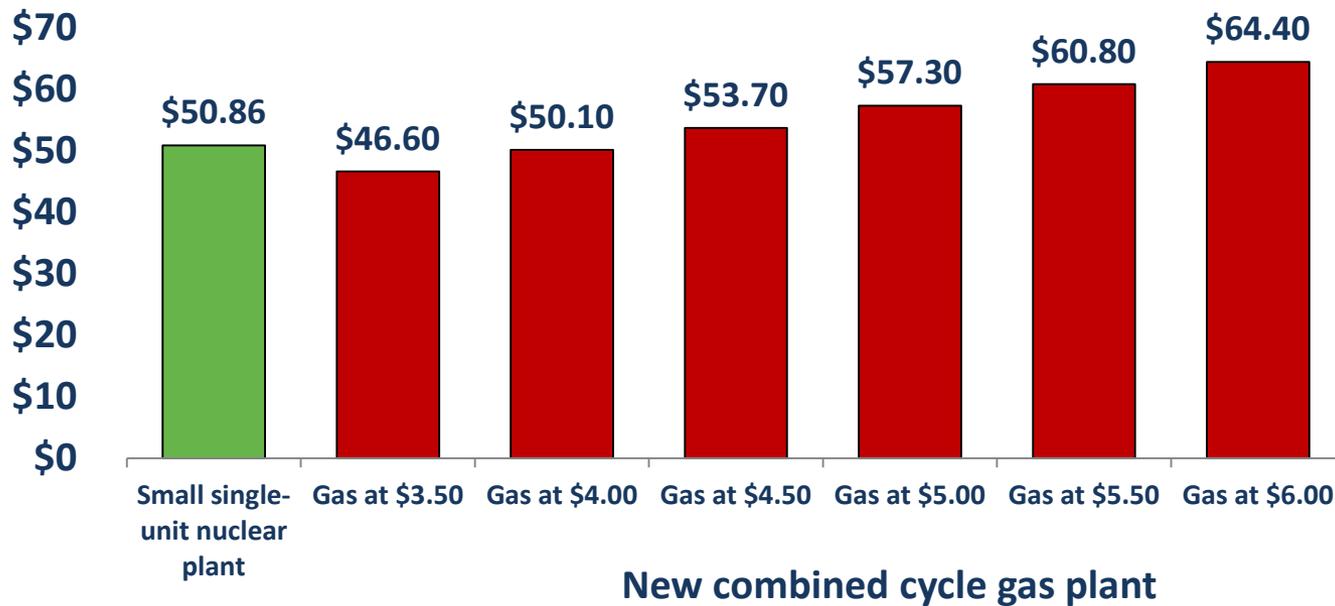
- Reactor shutdowns
 - Four in 2013
 - One at the end of 2014
- Crystal River 3, San Onofre 2 and 3 were unique events
 - Over 110 PWRs (57 in the U.S.) have replaced steam generators
- Kewaunee, Vermont Yankee shut down because of adverse market conditions
- Others at risk

Market Issues ... At a Glance

- Price signals inadequate to support operating capacity, or investment in new capacity (except gas-fired)
- Prices suppressed by RTO policies and actions, and by state and federal mandates and subsidies
- Fuel/technology diversity is taken for granted and undervalued
- Failure to address problems will:
 - Compromise resource adequacy and reliability
 - Expose consumers to increasing price volatility
 - Frustrate efforts to reduce carbon emissions

The Cost of Premature Nuclear Power Plant Shutdown

(\$ per MWh)



- Kewaunee 2009-2011 capacity factor: ~ 95%
- Vermont Yankee 2010-2012 capacity factor: ~ 90%
- Nothing wrong with the plants; something wrong with the markets

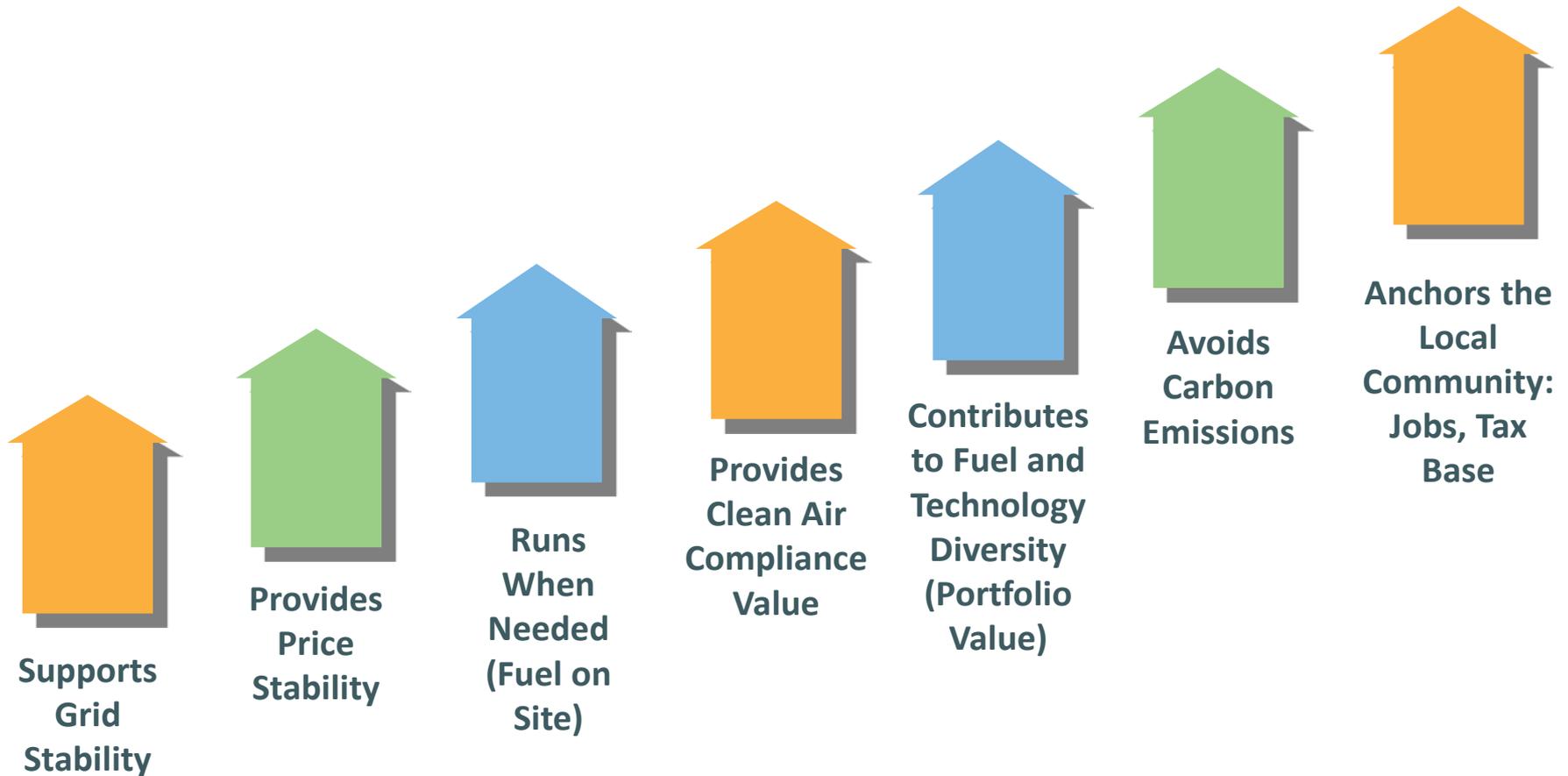
Sources: 2010-2012 average total generating cost of seven small (approx. 600 MW) nuclear plants from Electric Utility Cost Group (EUCG). Gas-fired combined cycle plant costs from NEI financial model: Debt at 5.0%, 15% return on equity, debt/equity structure of 50/50. Capital, O&M assumptions for natural gas are from the Energy Information Administration's *Annual Energy Outlook 2013*.

A Straightforward Policy Approach

- Goods and services only produced when priced and valued in the market
- All electricity has certain attributes, depending on how it is produced
 - if markets do not value those attributes in market design and market policies, then suppliers will stop providing them
- Nuclear power plants have a number of attributes that have value to the grid
- Most of these attributes not monetized by competitive markets

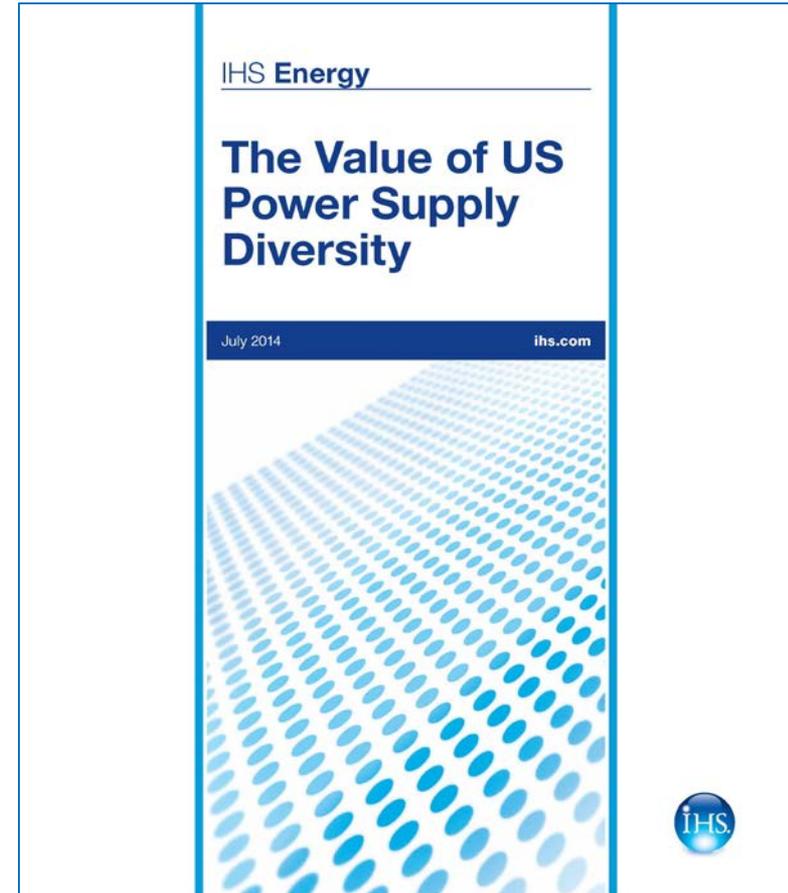
Nuclear Energy: A Solid Value Proposition

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



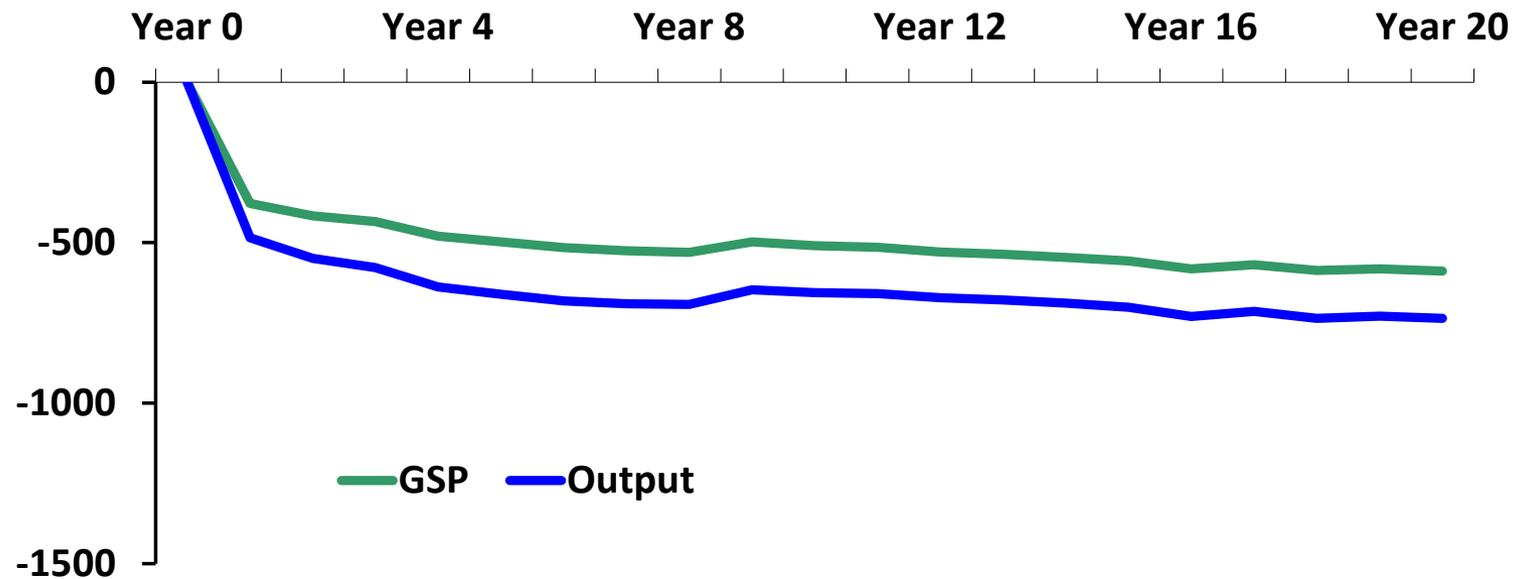
Fuel Diversity

- 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 Power Plant Retirement: Impact on the State

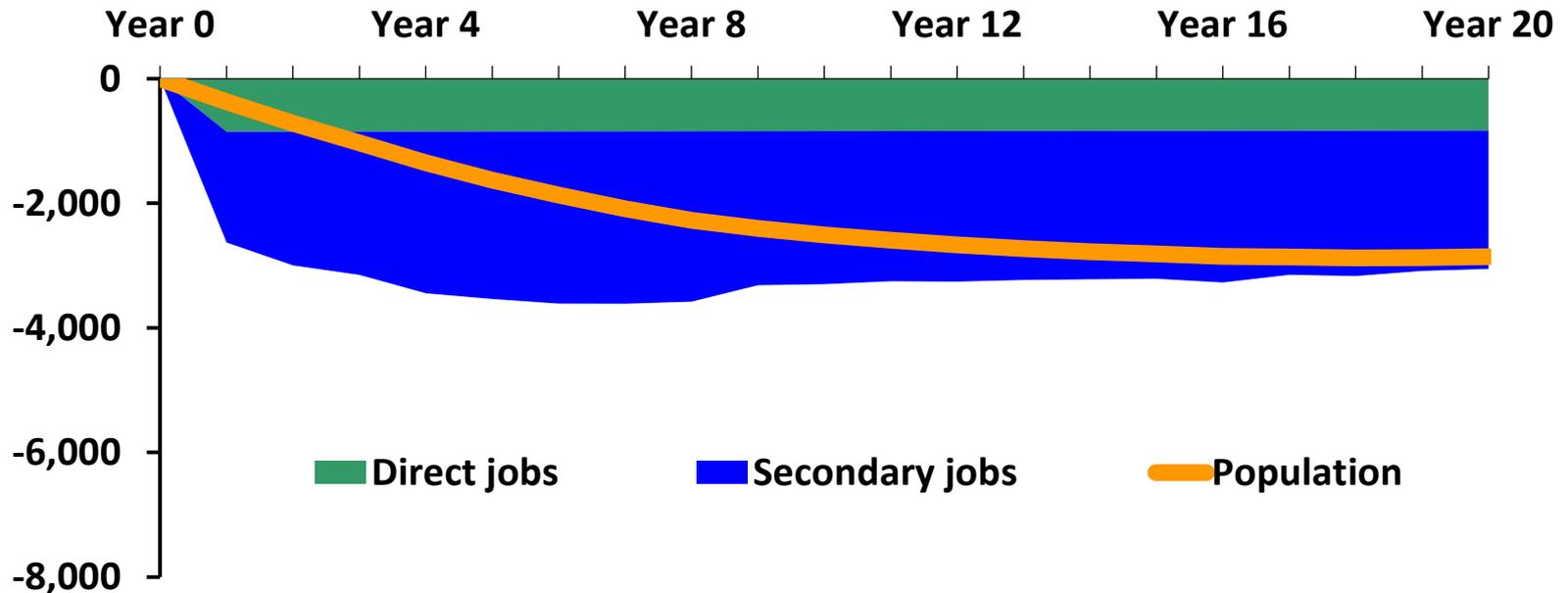
Lost Gross State Product and Output (dollars in 2013 millions)



Source: Analysis of shutdown of 600-megawatt nuclear power plant using model developed by Regional Economic Models, Inc.

Nuclear Power Plant Retirement: Impact on the State

(Shutdown-Related Job Losses and Population Migration)



Source: Analysis of shutdown of 600-megawatt nuclear power plant using model developed by Regional Economic Models, Inc.

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)



U.S. New Nuclear Plant Development

Watts Bar 2

- Completion September 2015 - June 2016
- Cost: \$4 billion - \$4.5 billion
- Large-scale construction largely complete, testing of individual plant systems beginning

Vogtle 3 and 4

- On line late 2017 (Unit 3), late 2018 (Unit 4)
- Verification, approval of all capital costs (\$2.21 billion) to date by Georgia PSC

Summer 2 and 3

- On line 4Q 2017 - 1Q 2018 (Unit 2), 4Q 2018 - 1Q 2019 (Unit 3)

Still to come

- NRC reviewing eight applications for combined licenses that represent 12 additional new reactors

Watts Bar 2 – Tennessee



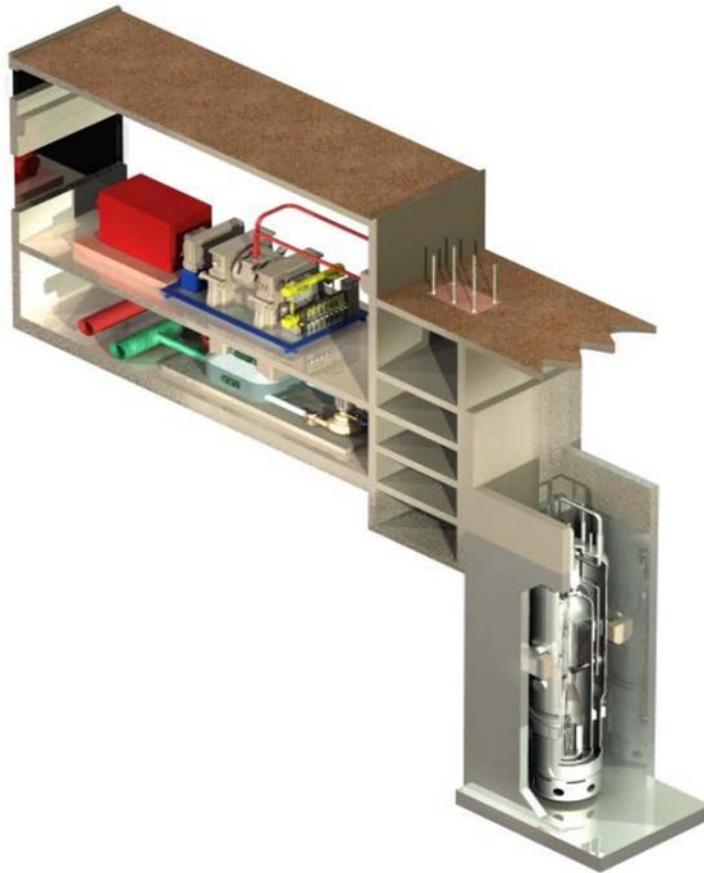
Vogtle 3 & 4 - Georgia



Summer 2 & 3 – South Carolina



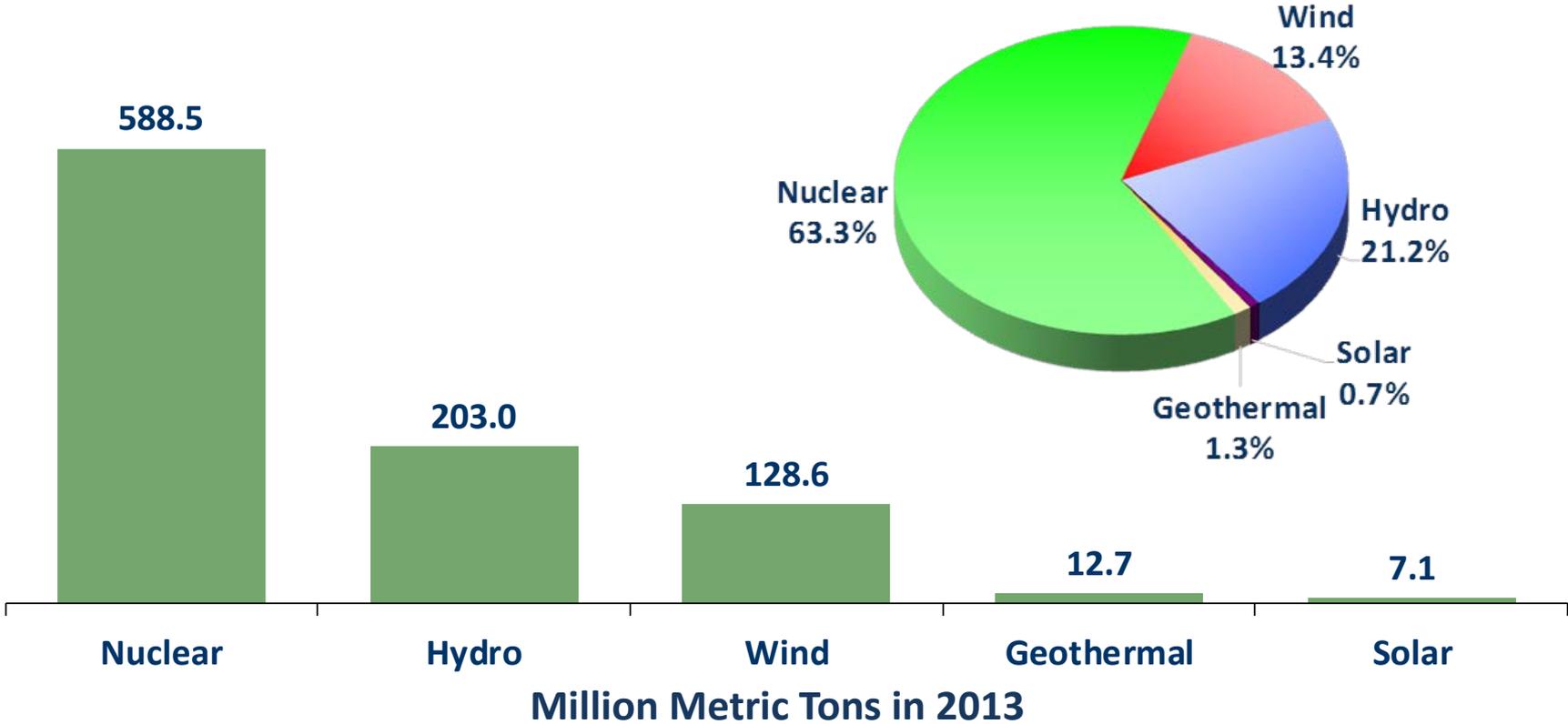
Advanced Designs: Small Modular Reactors



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 CO₂ Avoided

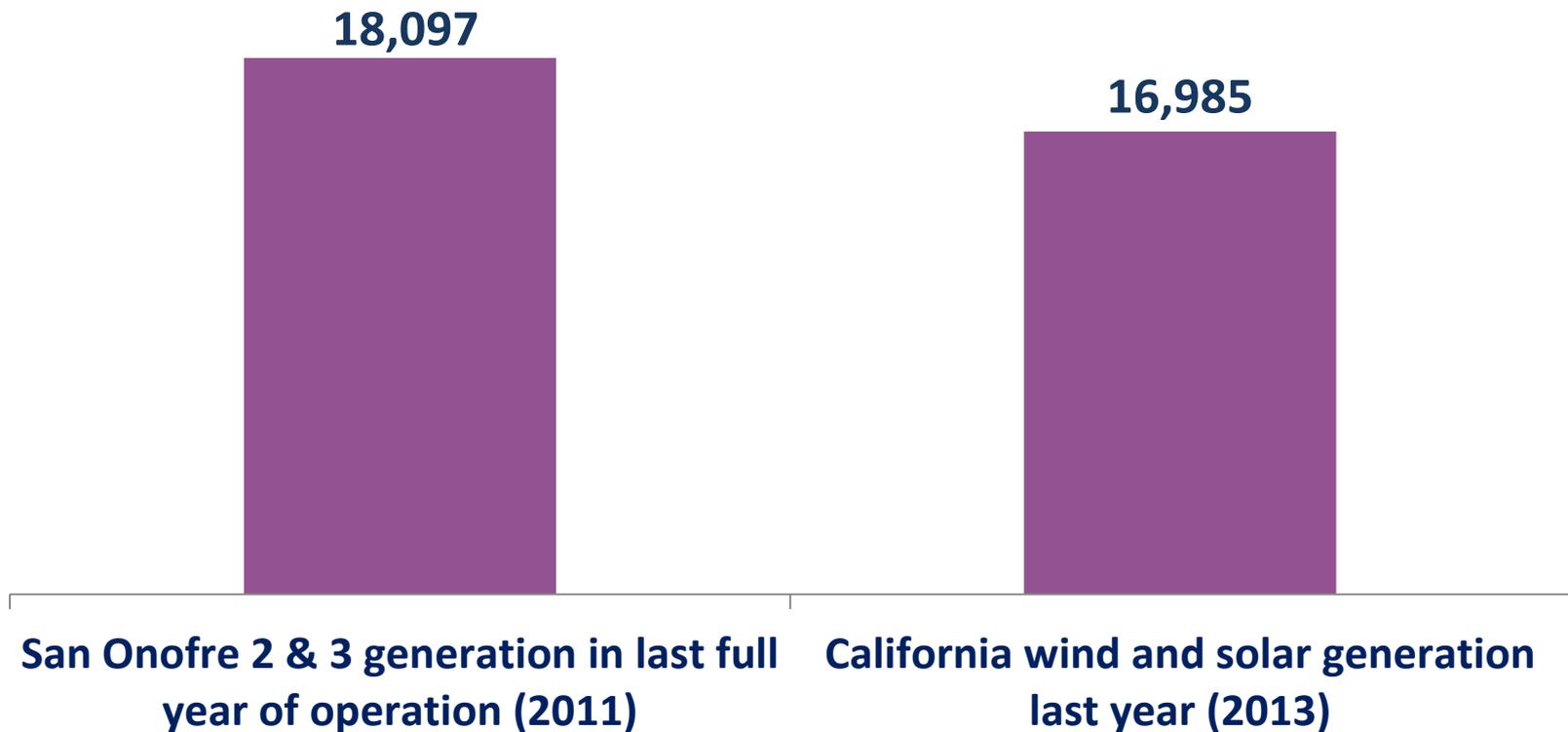


Sources: Emissions avoided are calculated using regional and national fossil fuel emission rates from the Environmental Protection Agency and plant generation data from the Energy Information Administration.



California Energy Comparison

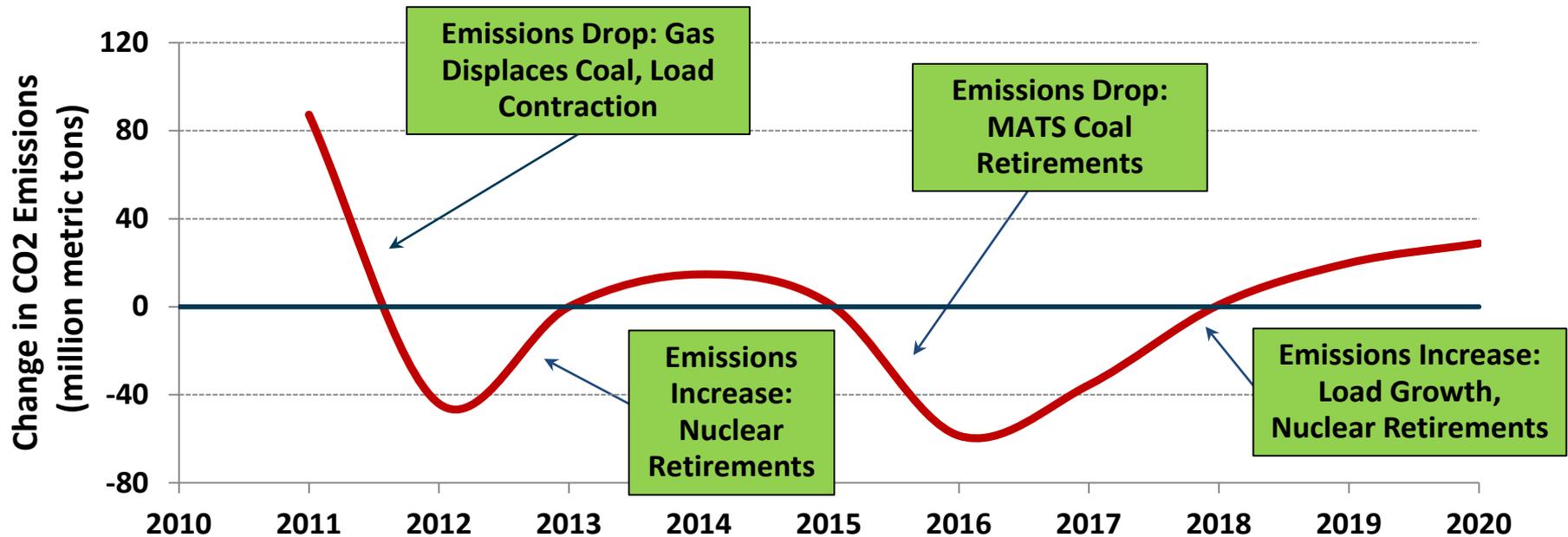
GWh



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

U.S. Power Sector CO₂ Emissions

(From 2013 Level)



Despite ~ 60 GW of coal retirements, the addition of over 6 GW of new nuclear, and the continued build-out of renewable energy, power sector CO₂ emissions increase between now and the end of the decade due to the retirement of 10.3 GW of nuclear energy in AEO 2014.

2030 and Beyond: The Nuclear Energy/Carbon Challenges

- To sustain carbon reductions beyond 2030, must (at a minimum) maintain existing nuclear capacity
 - Develop techniques to finance new nuclear build in merchant markets
 - Ensure multiple technology options (Small Modular Reactors) a strategic imperative
 - Second license renewal period (operation beyond 60 years) a valuable option