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Student Webinar Series

Nuclear Economics: Future of Nuclear

April 3, 2020

Panelists

Harsh Desai, *Nuclear Energy Institute*
Scott Rasmussen, *NuScale Power*
Eric Loewen, *GE Hitachi Nuclear Energy*

Moderator

Ishita Trivedi, *North Carolina State University*

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Harsh Desai

Nuclear Energy Institute

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Economics and Future of Nuclear

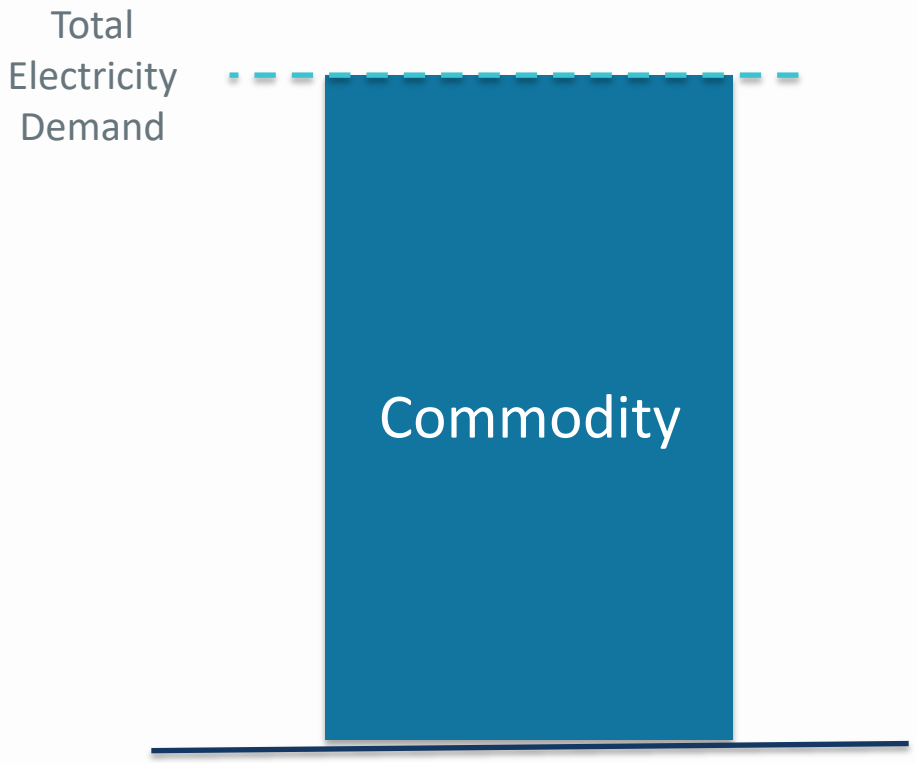
Harsh S. Desai
hsd@nei.org

April 3, 2020

NUCLEAR ENERGY INSTITUTE

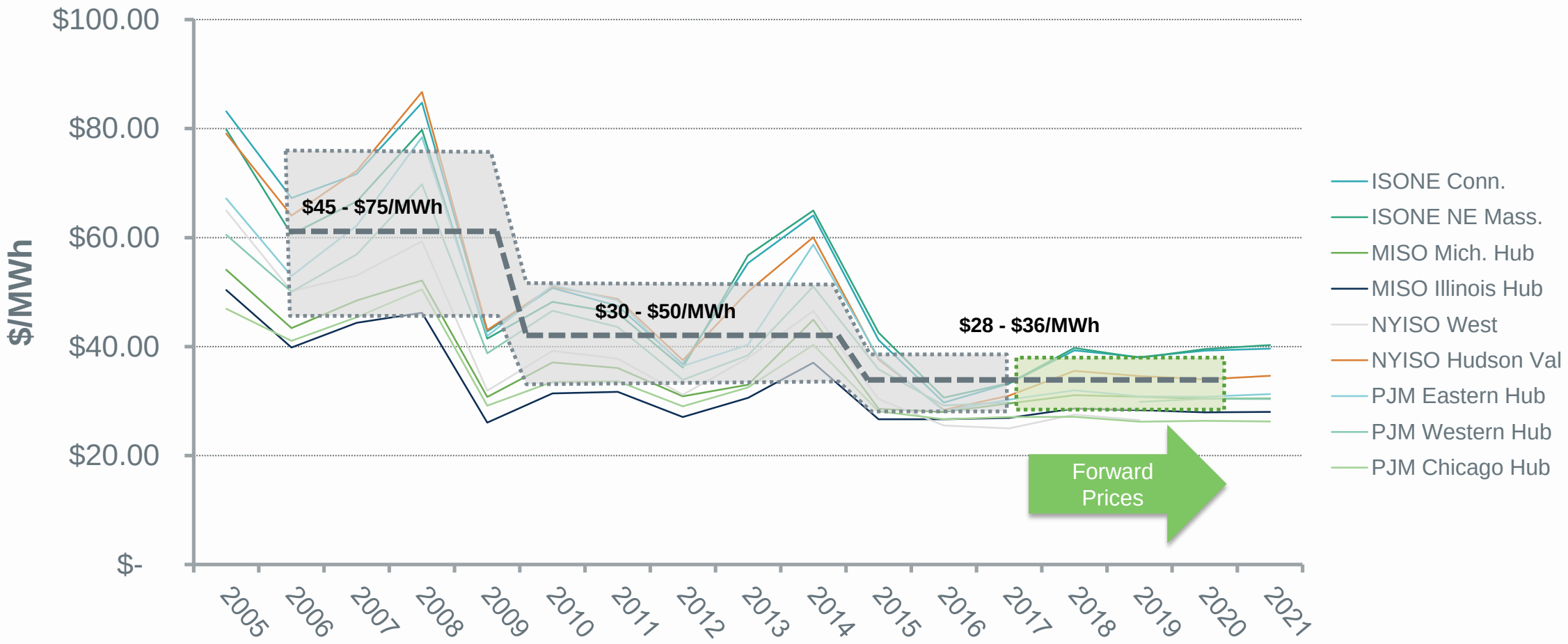
Electricity Markets

Commodity Market Segment

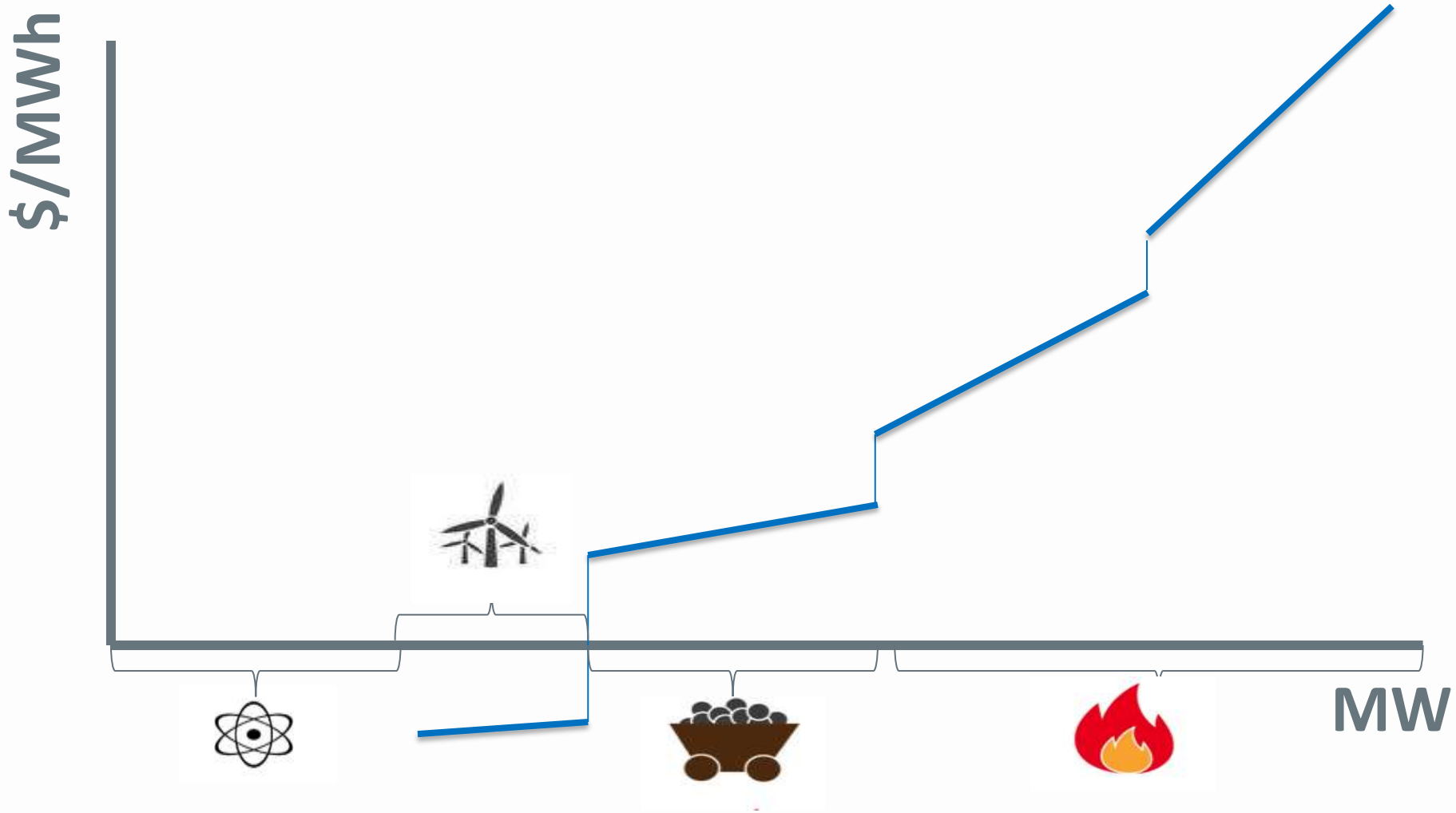


In the commodity market segment all electrons are treated equally and the most price-competitive are rewarded

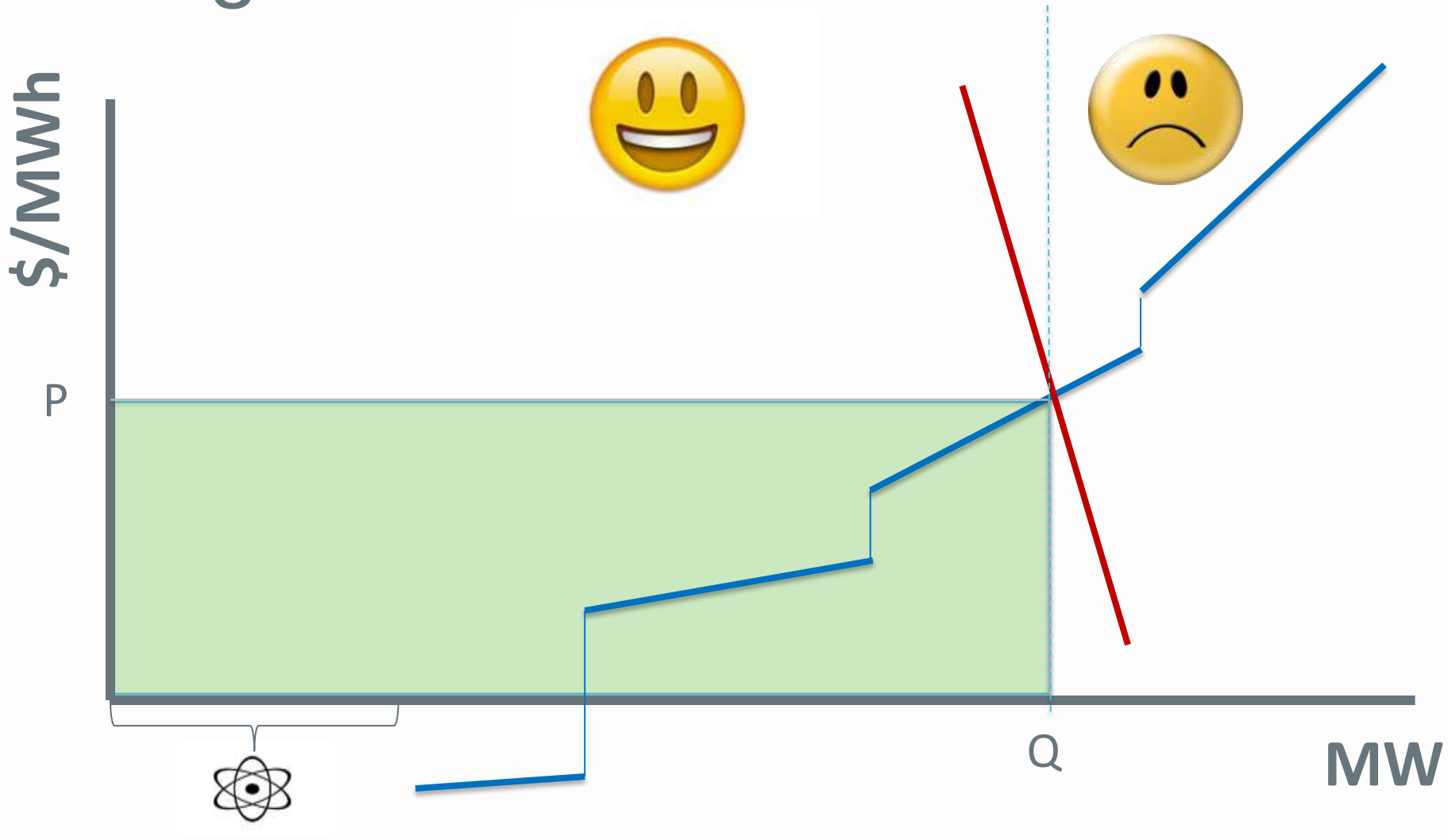
Declining Electricity Prices



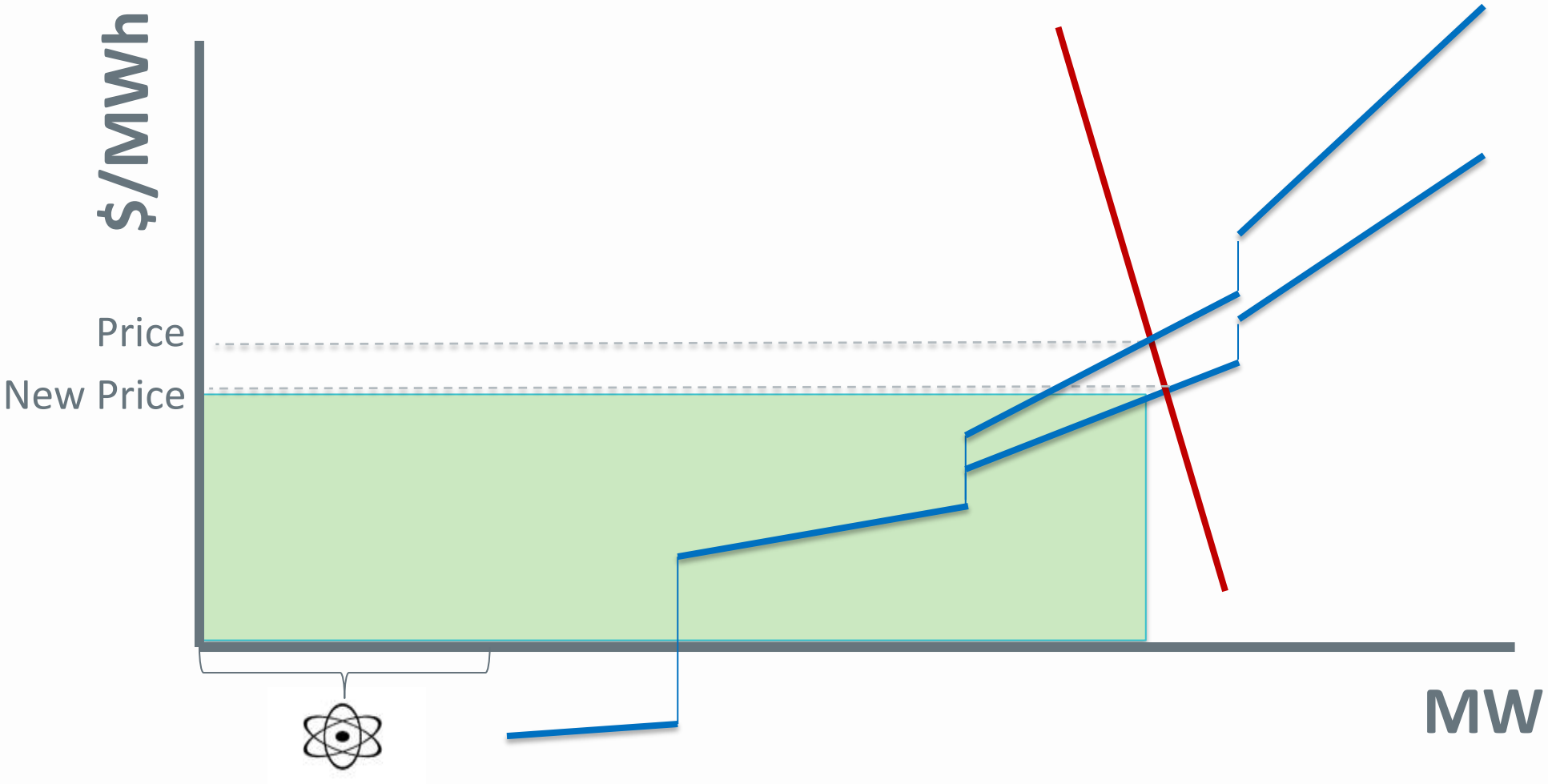
Building a Marginal Supply Curve



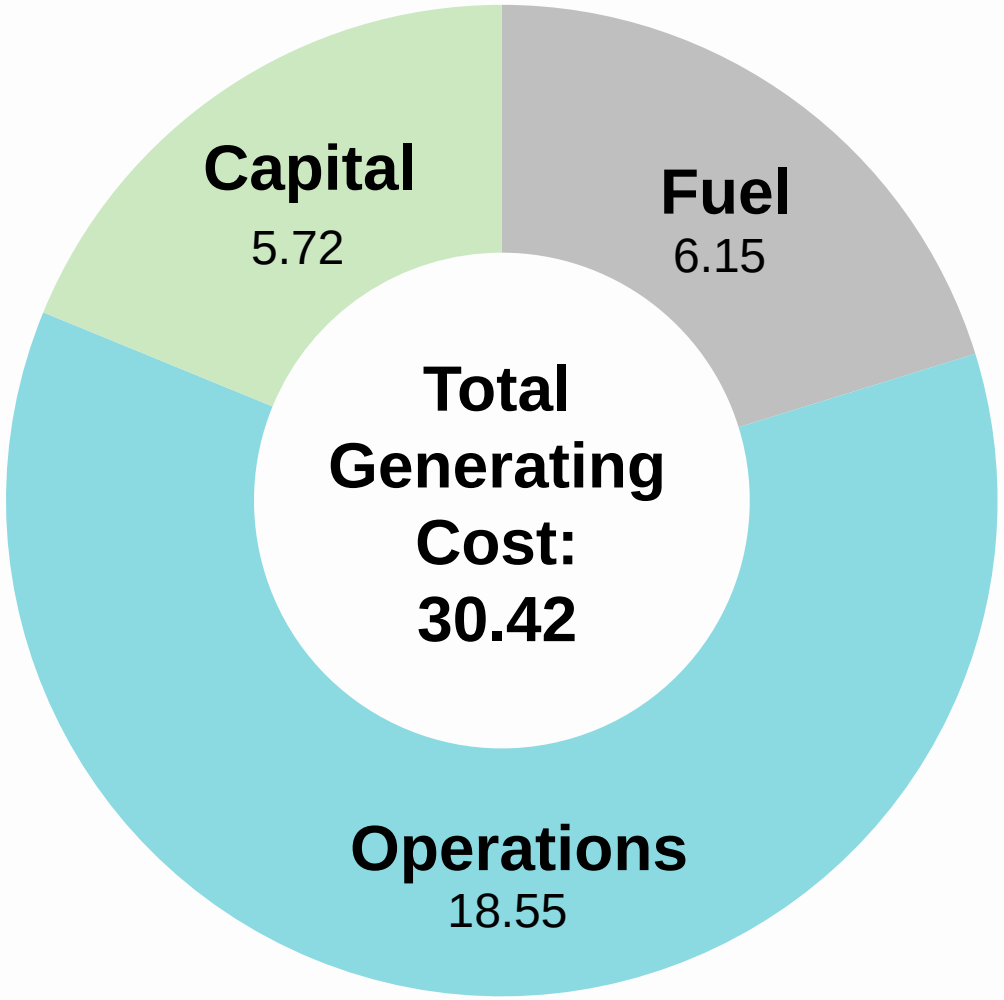
Finding a Price



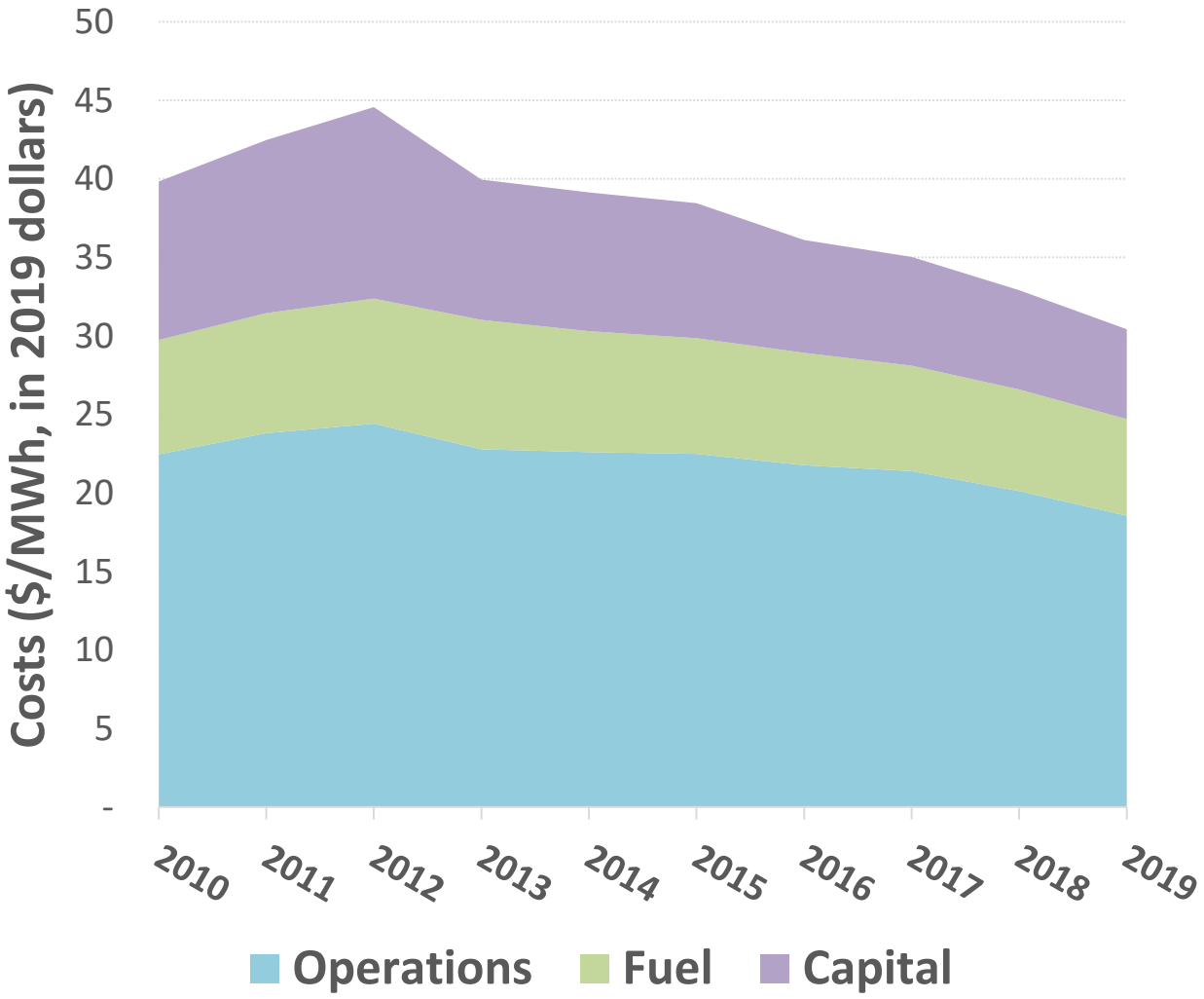
Falling Natural Gas Prices



U.S. Nuclear Power Plant Costs are Record Low



2019 Costs ($/MWh)



Source: Electric Utility Cost Group
Updated: February 2020

Delivering the Nuclear Promise – Achieved!

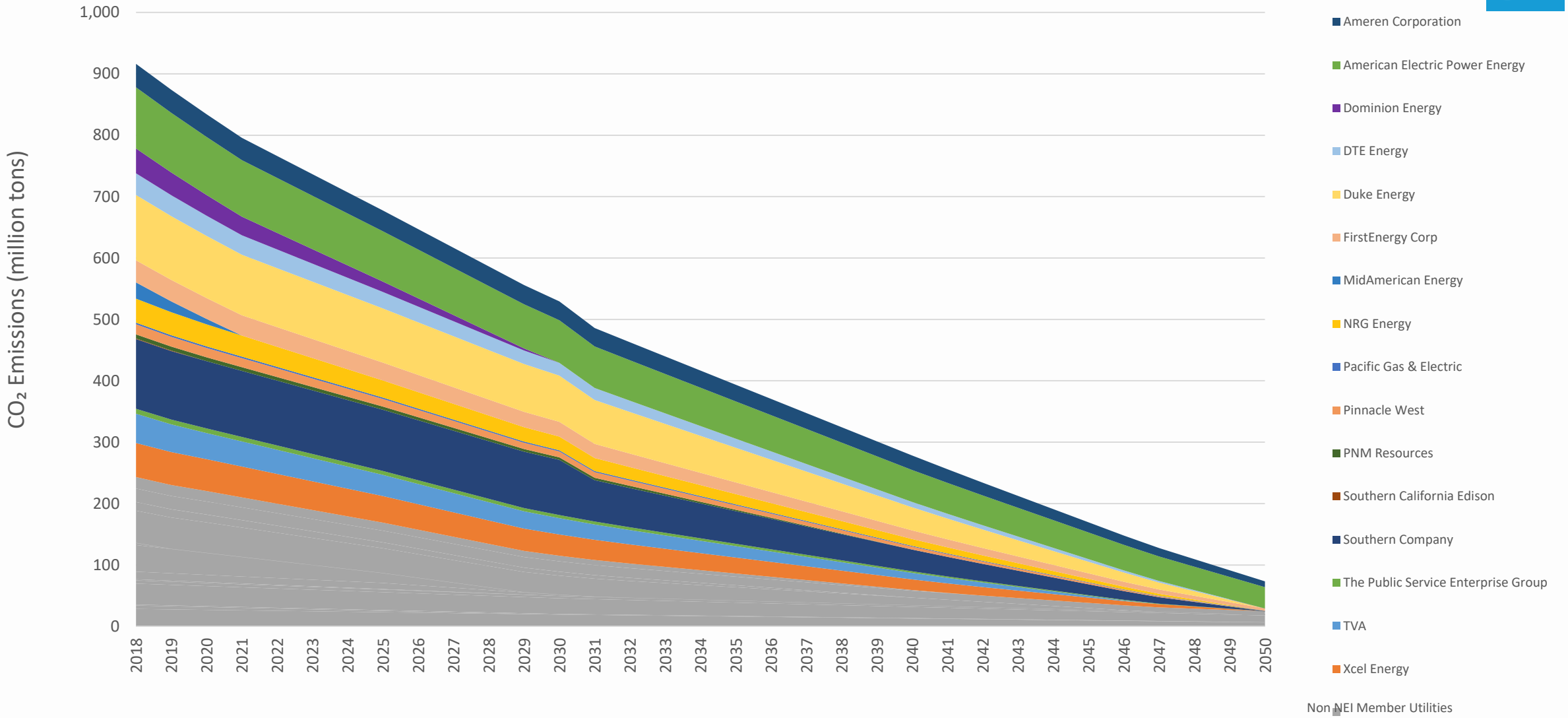
Costs in 2019 dollars ($/MWh)				
Cost Category	**Reduction Goal**	**2012 Costs**	**2019 Costs**	**Realized Reductions**
Fuel		$7.97	$6.15	$1.81 (23%)
Capital		$12.19	$5.72	$6.47 (53%)
Operations		$24.41	$18.55	$5.86 (24%)
Total Generating	**$13.36 (30%)**	**$44.57**	**$30.42**	**$14.15 (32%)**

Nuclear industry achieved the DNP goal.

Source: Electric Utility Cost Group
Updated: February 2020

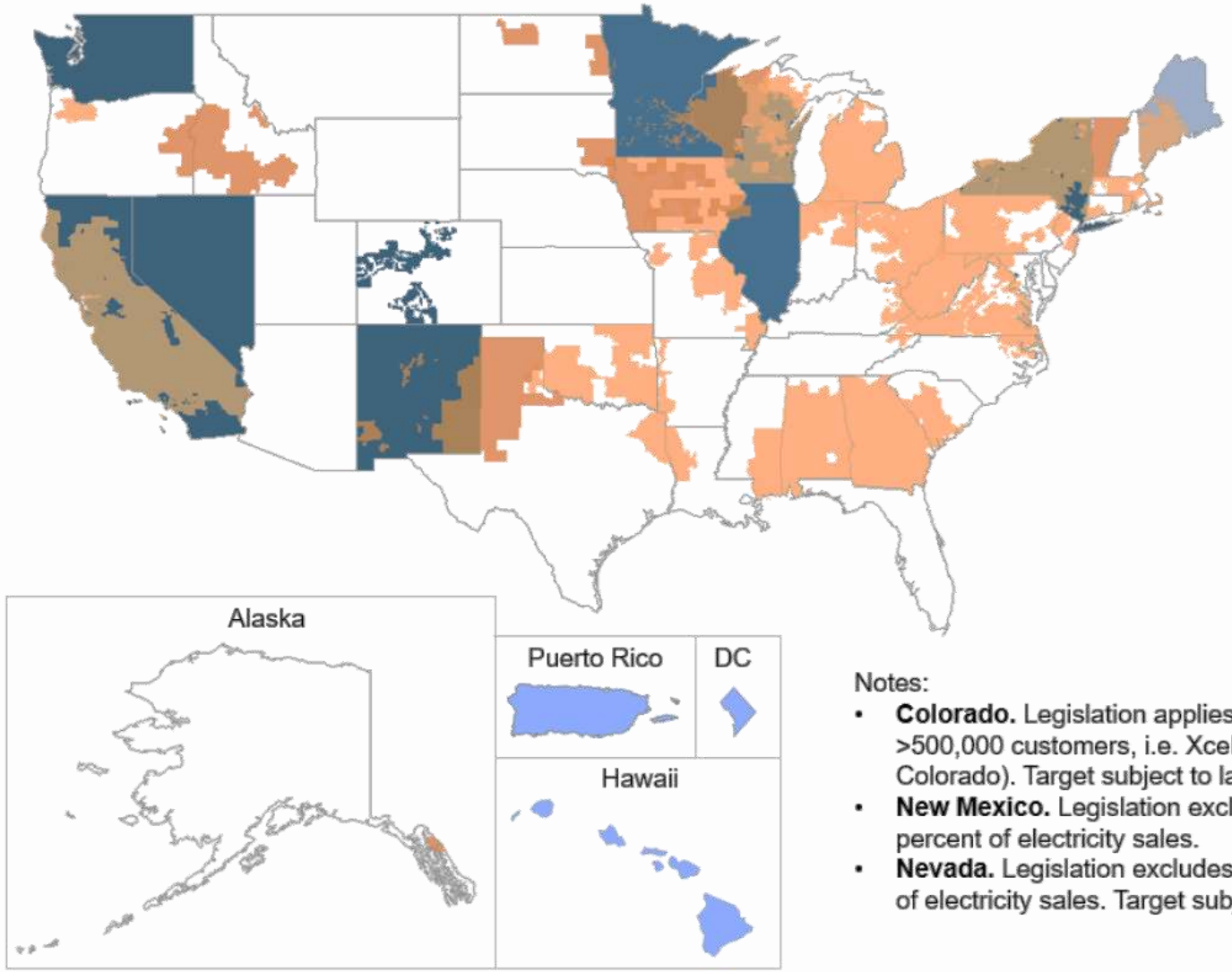
Future Electricity Grid Opportunities

Utility carbon emission projections based on pledges



Source: ABB Velocity Suite, U.S. Environmental Protection Agency, Utility press releases

Regions with Clean Energy Goals



- States with 100% Clean Energy Standards, in Law
- States with 100% Clean Energy Standards, Introduced
- States with 100% Renewable Energy Portfolios, in Law
- States with 100% Renewable Energy Portfolios, Introduced
- Utilities with 100% Clean Energy / Zero-Carbon Pledges
- Utilities with 80-90% GHG Emission Reduction Pledges

Notes:

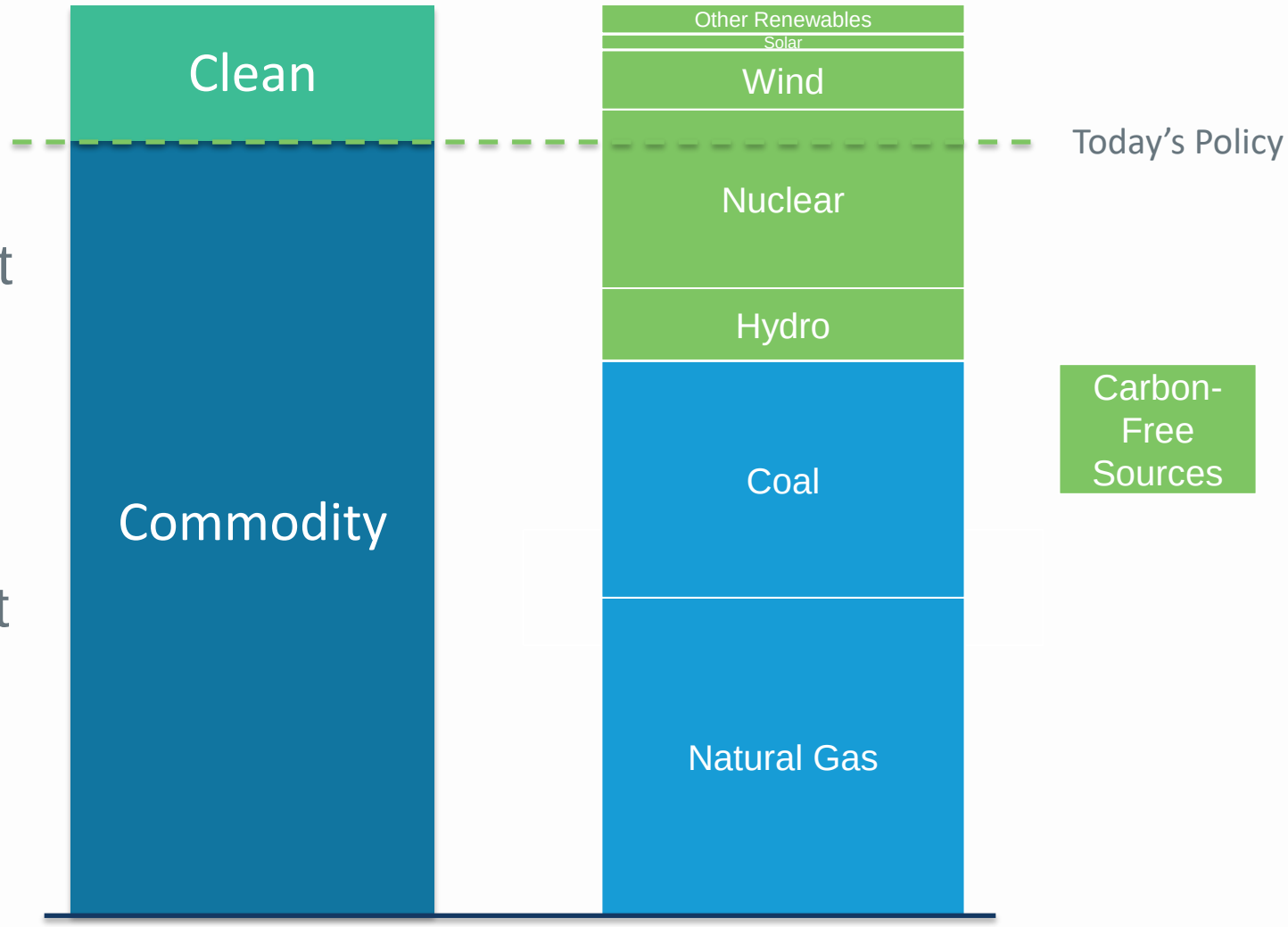
- **Colorado.** Legislation applies only to non-municipal utilities that serve >500,000 customers, i.e. Xcel Energy (Public Service Company of Colorado). Target subject to later study or action.
- **New Mexico.** Legislation excludes co-ops, which account for about 20 percent of electricity sales.
- **Nevada.** Legislation excludes co-ops, which account for about 6 percent of electricity sales. Target subject to later study or action.

Source: Clean Air Task Force, June 2019

Distribution of Competition Today

Technology centered clean policies (e.g., renewable portfolio standards) have unnecessarily cut out certain carbon free sources of energy

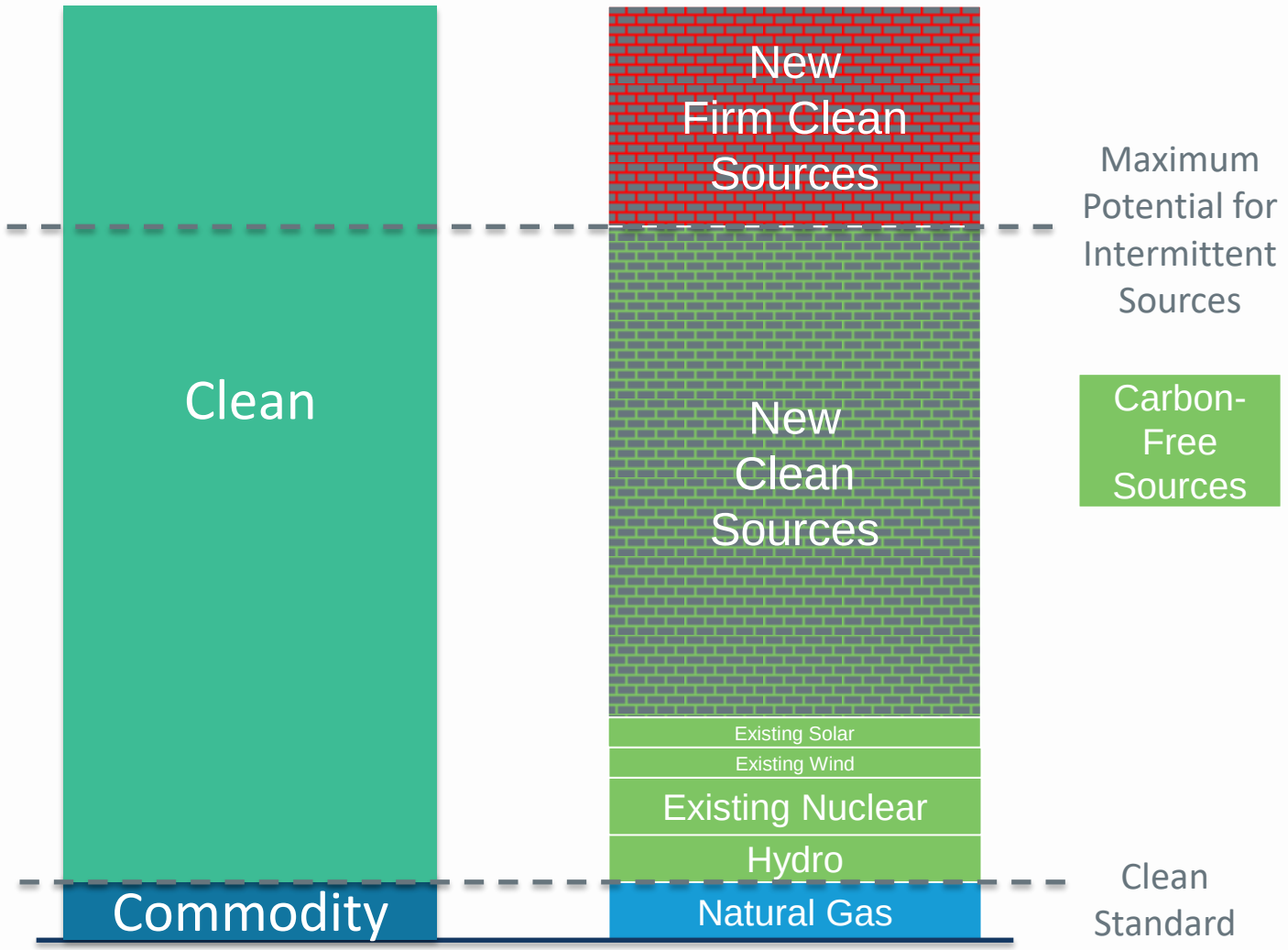
- Unbalanced competition and pricing in clean market segment
- Encourages investment in less competitive technologies



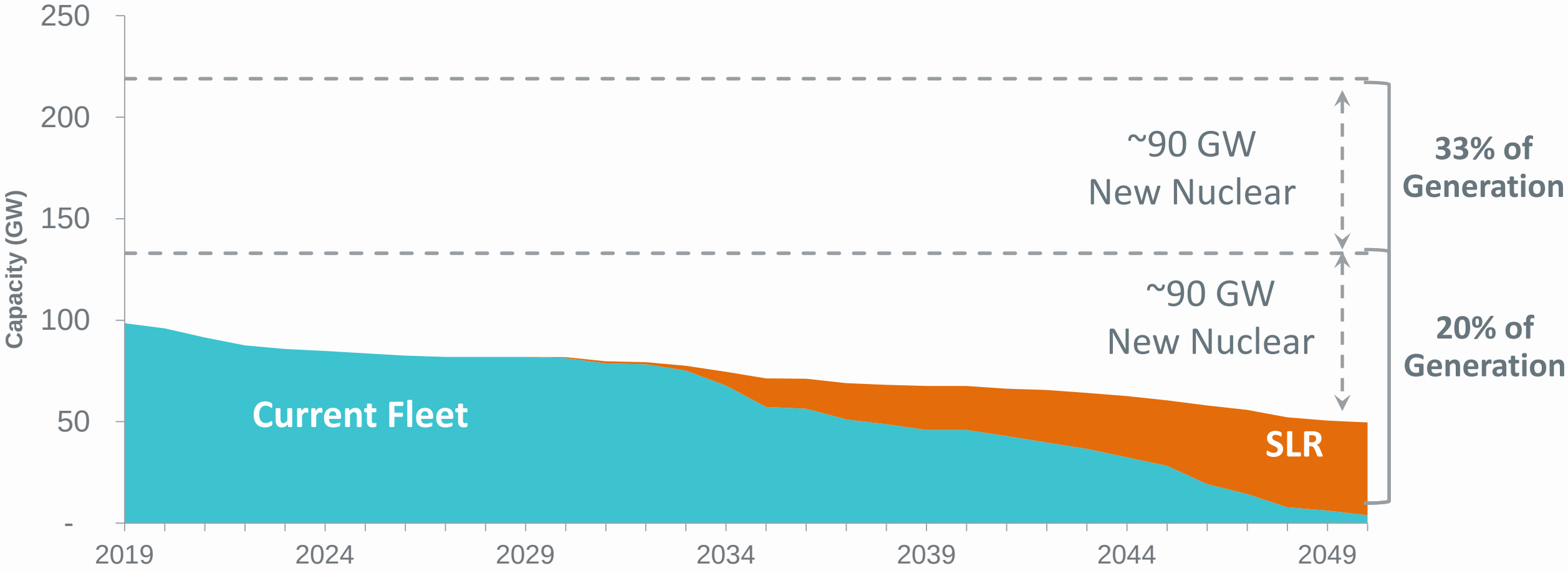
Technology Driven Market Segment

Saturation of market with intermittent renewables will force a new market segment to emerge:

- To maintain reliability of the grid market will need to incorporate *firm clean energy sources* for balance



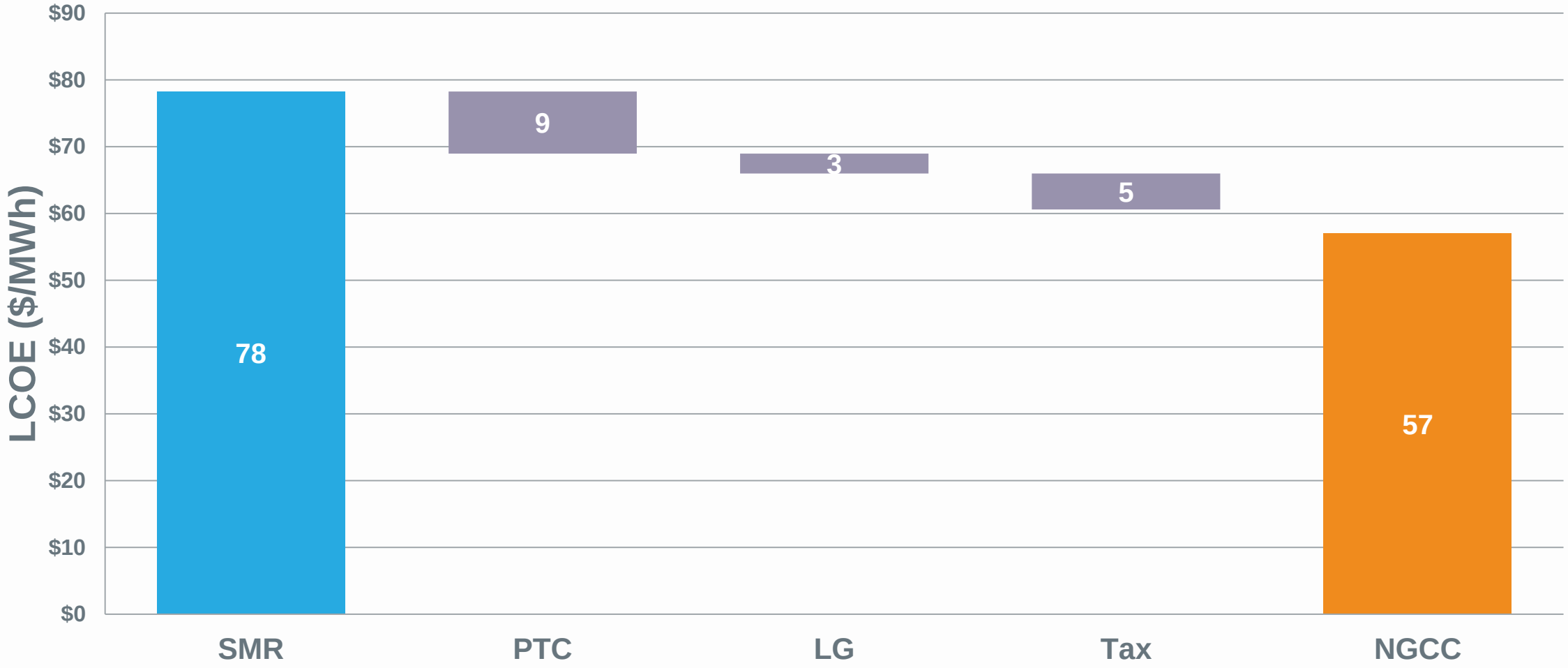
Nuclear's Role in a Low Carbon Electricity Future



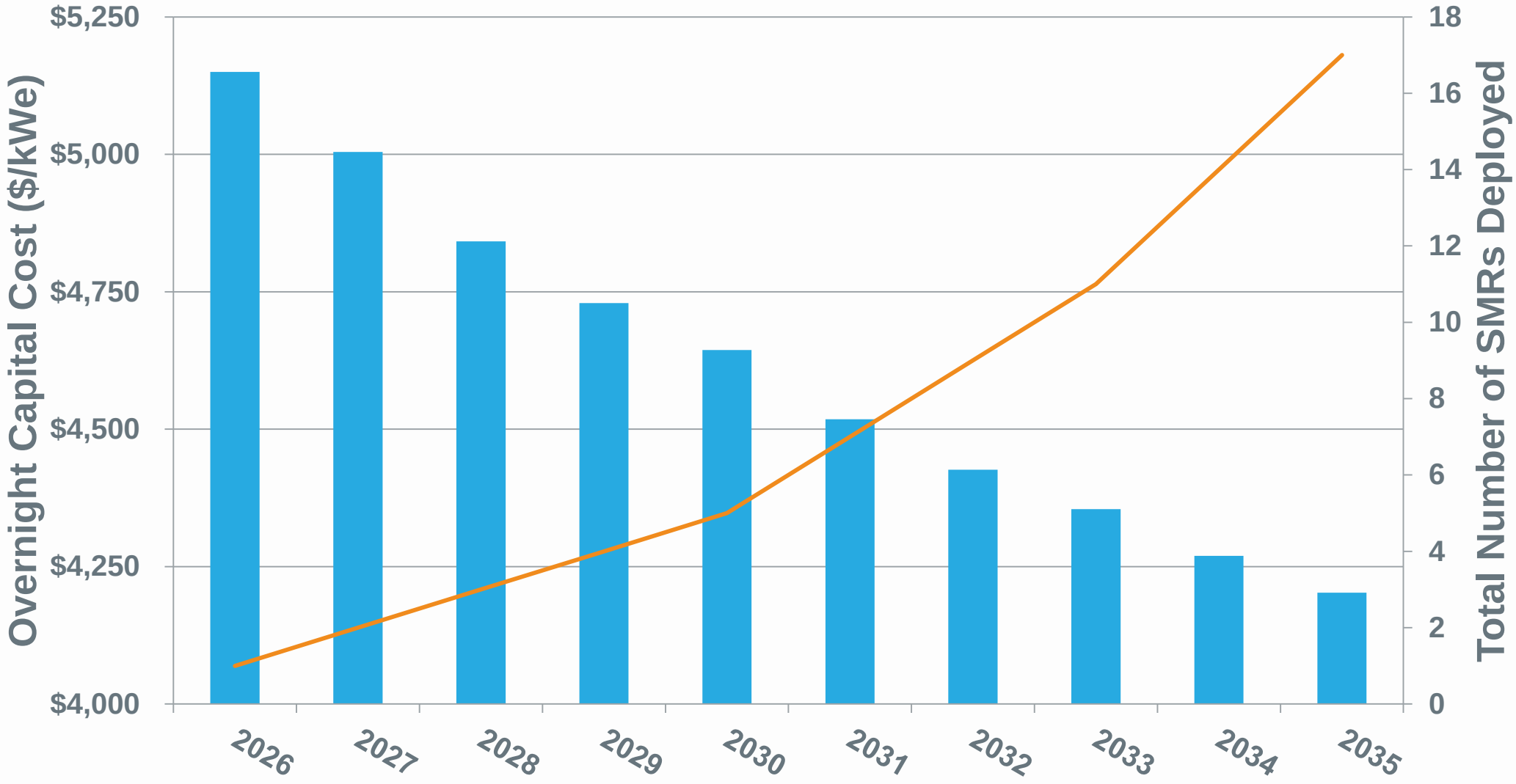
Does not account for decarbonization of other sectors

What about Future Nuclear Plants?

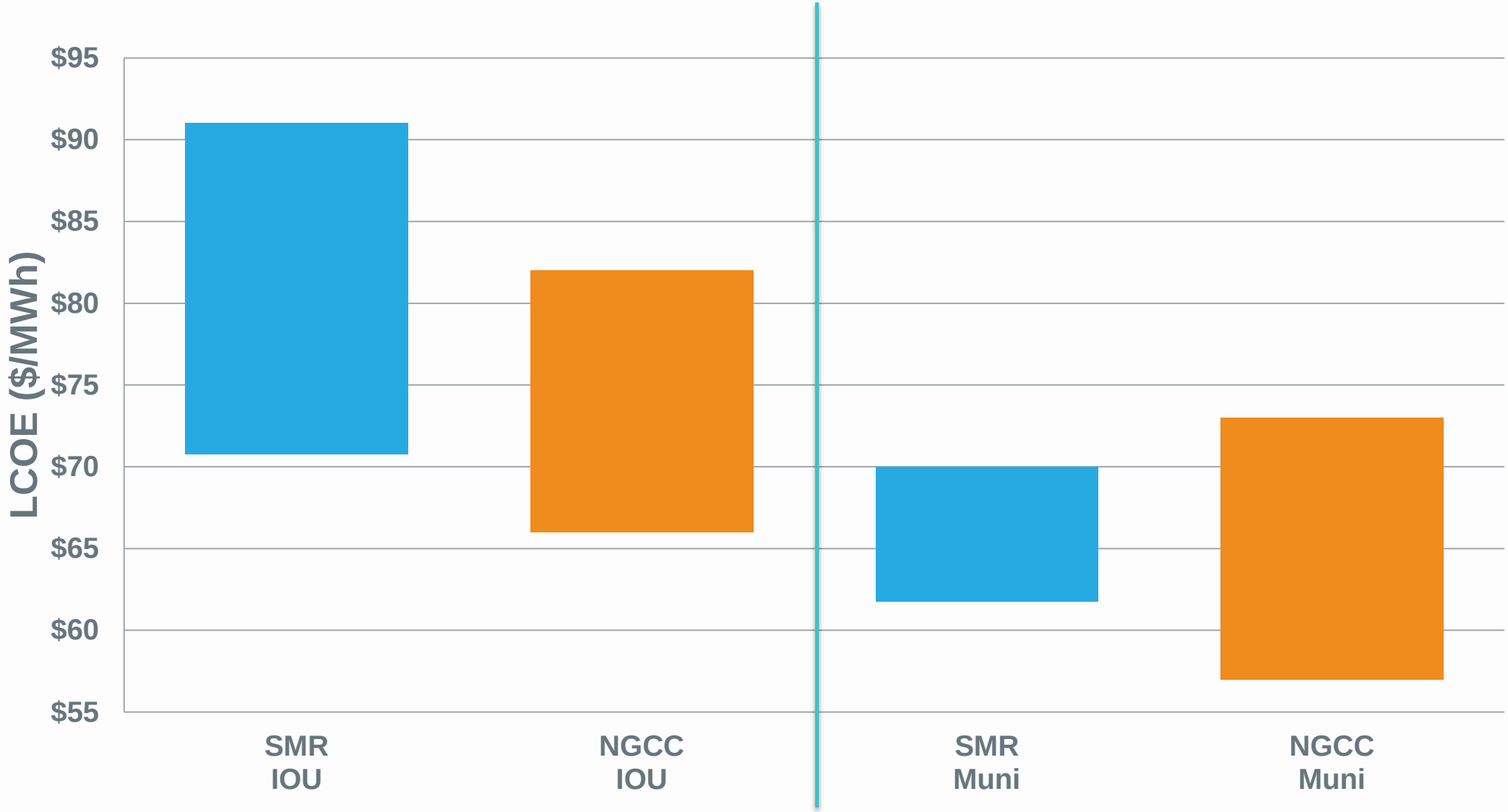
Comparison of Costs for First SMR & Natural Gas Combined Cycle Plant



Cost Reductions for Future SMRs

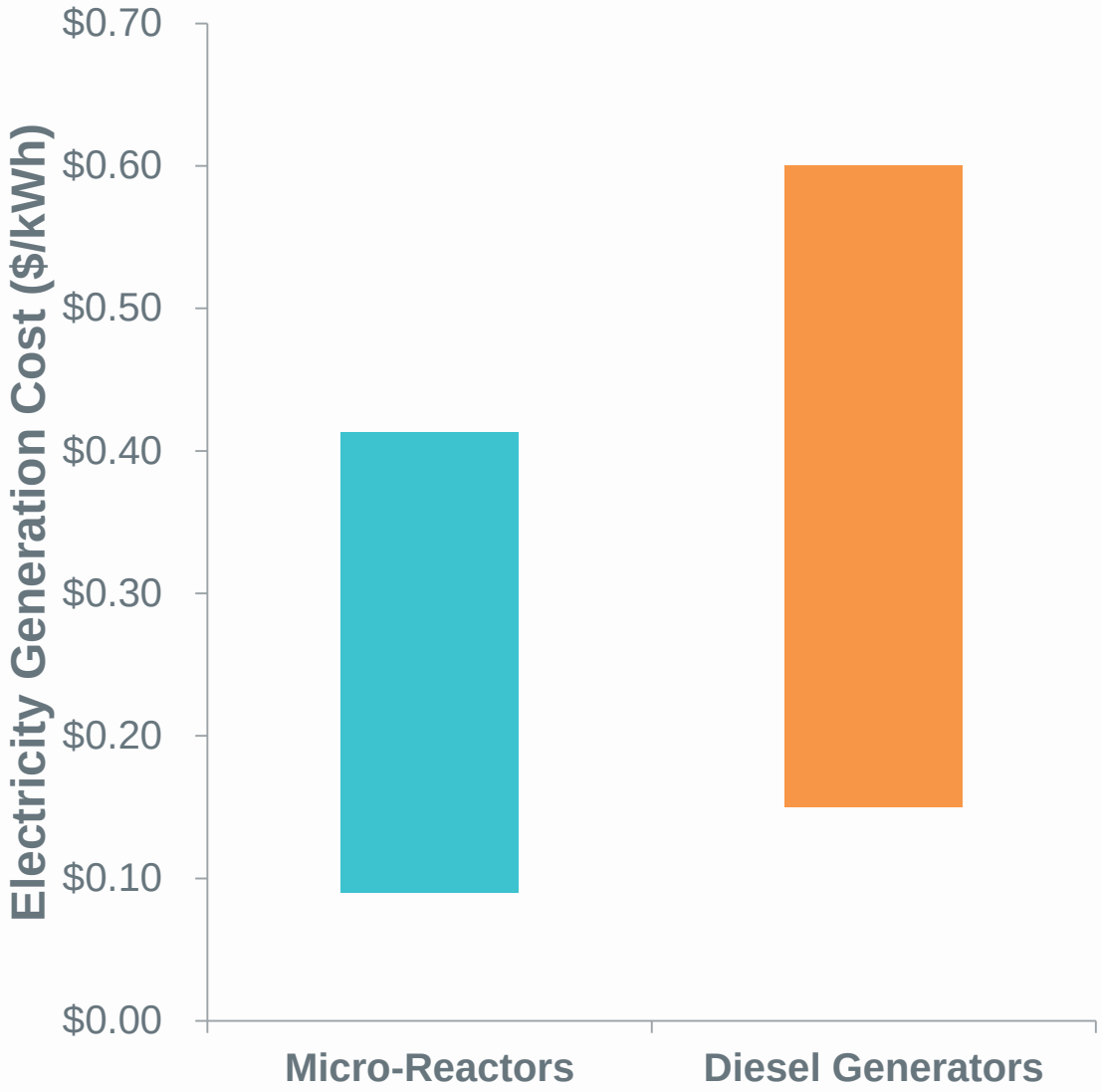


Comparison of SMRs & NGCC Costs in 2030

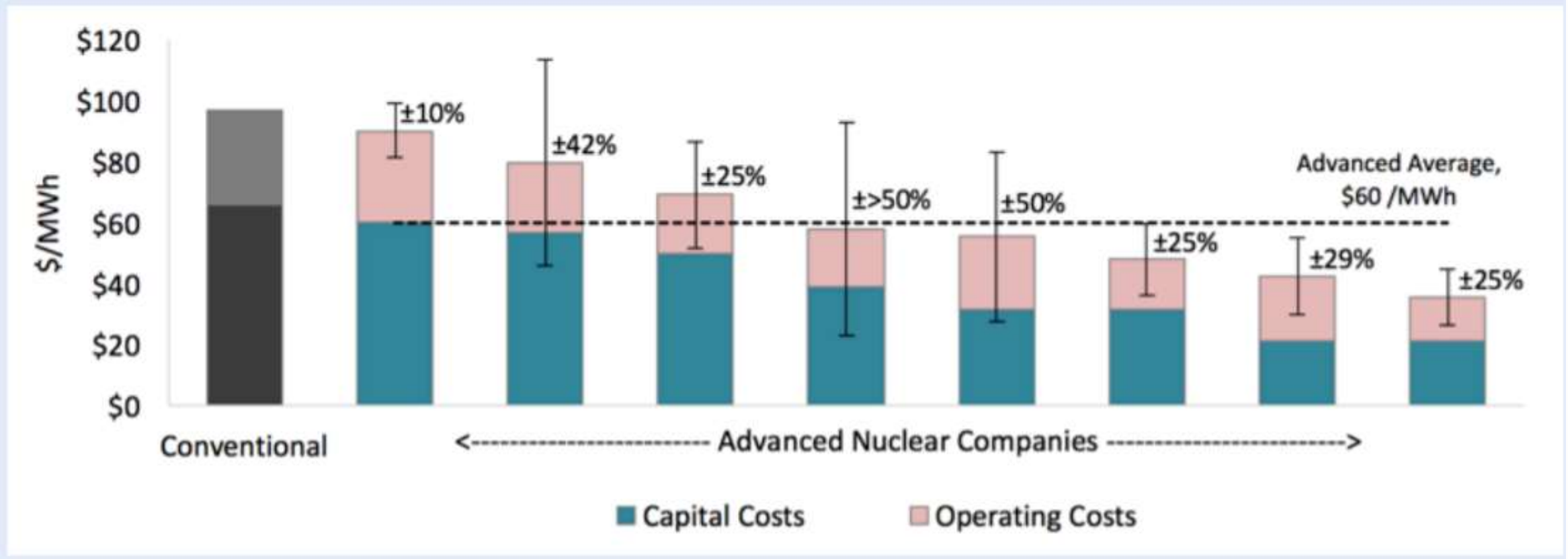


Microreactors Cost Comparisons

- Diesel generator costs
  - Primarily fuel costs
  - Fuel from $2.86/gallon to $4.89/gallon
- Micro-reactor costs
  - Include used fuel disposal and decommissioning
  - 10 year fuel life
  - 40 year plant life
  - 95% capacity factor

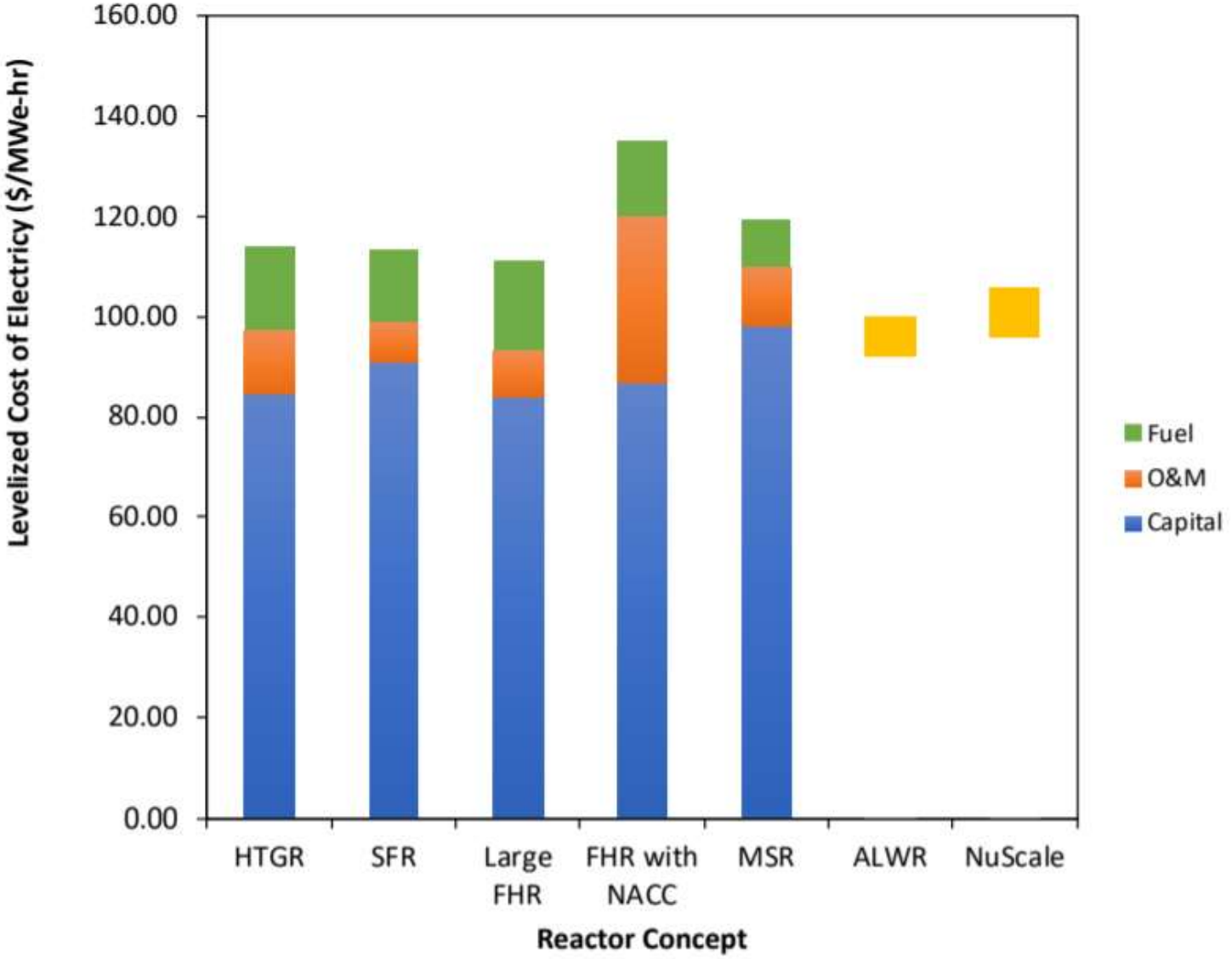


Non-LWR Advanced Reactor Cost Estimates



Source: Energy Innovation Reform Project

Non-LWR Advanced Reactor Cost Estimates



Source: MIT: The Future of Nuclear in a Carbon-Constrained World

Financing Options

- Private financing
  - Municipal utilities
  - Developer or third party capital
- Federal support
  - Production tax credits
  - Loan guarantees
  - Power purchase agreements
- State support
  - Reduce barriers to entry
  - Tax incentives
  - Construction work in progress

State Policy Options

- Valuing carbon-free electricity
  - Zero emissions credits
  - Carbon-free or low-carbon standard
  - Carbon tax or cap and trade
- Lowering financing costs
  - Advanced cost recovery
  - Integrated resource planning
- Tax incentives
  - Production tax credit / investment tax credits
  - Property tax credit
- Purchasing power
- Infrastructure support (e.g., training, transportation)

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Scott Rasmussen

NuScale Power

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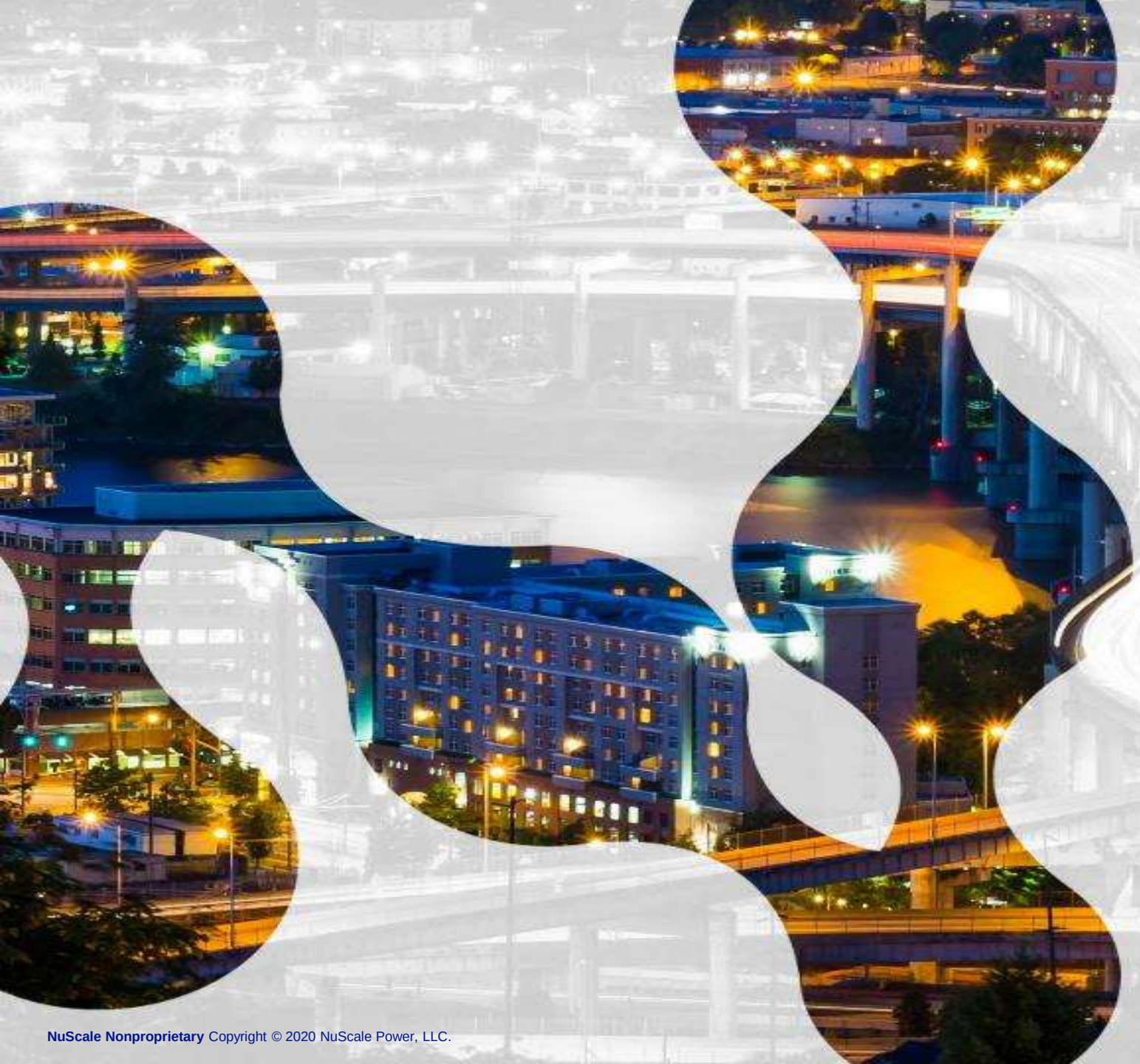

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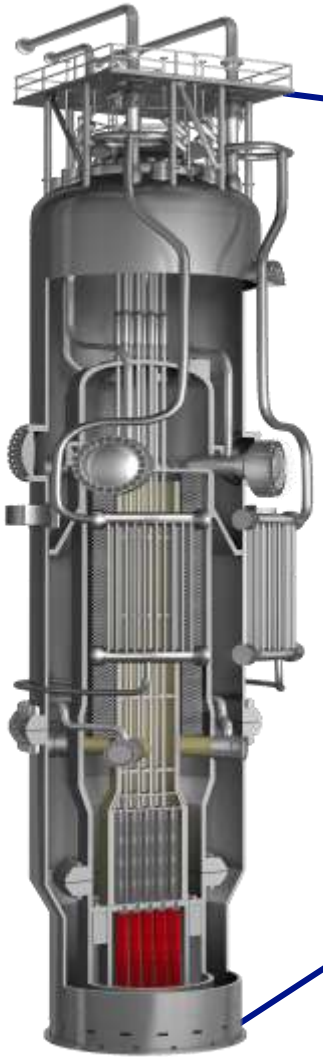
Power for all humankind

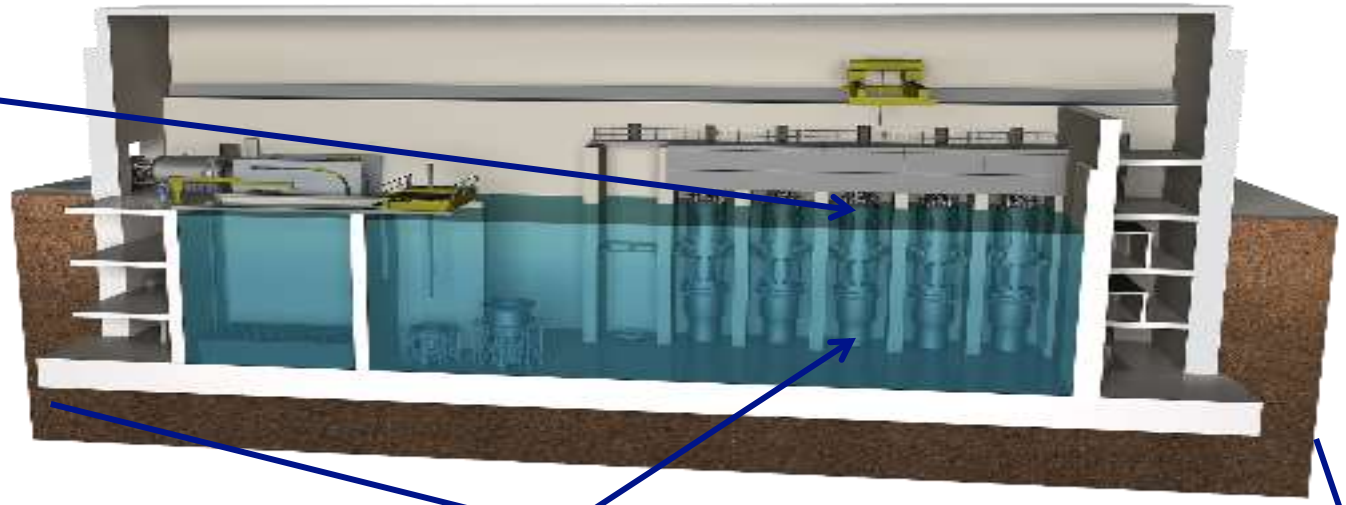
ANS Student Webinar – Nuclear Economics

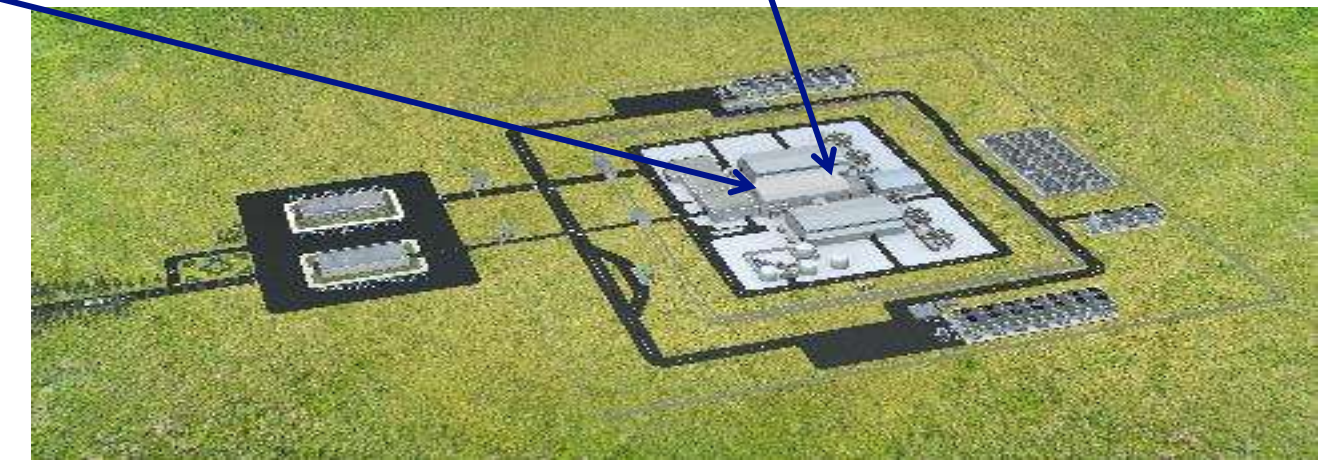
April 3, 2020

Scott Rasmussen
Director of Sales

NuScale Plant Site Overview







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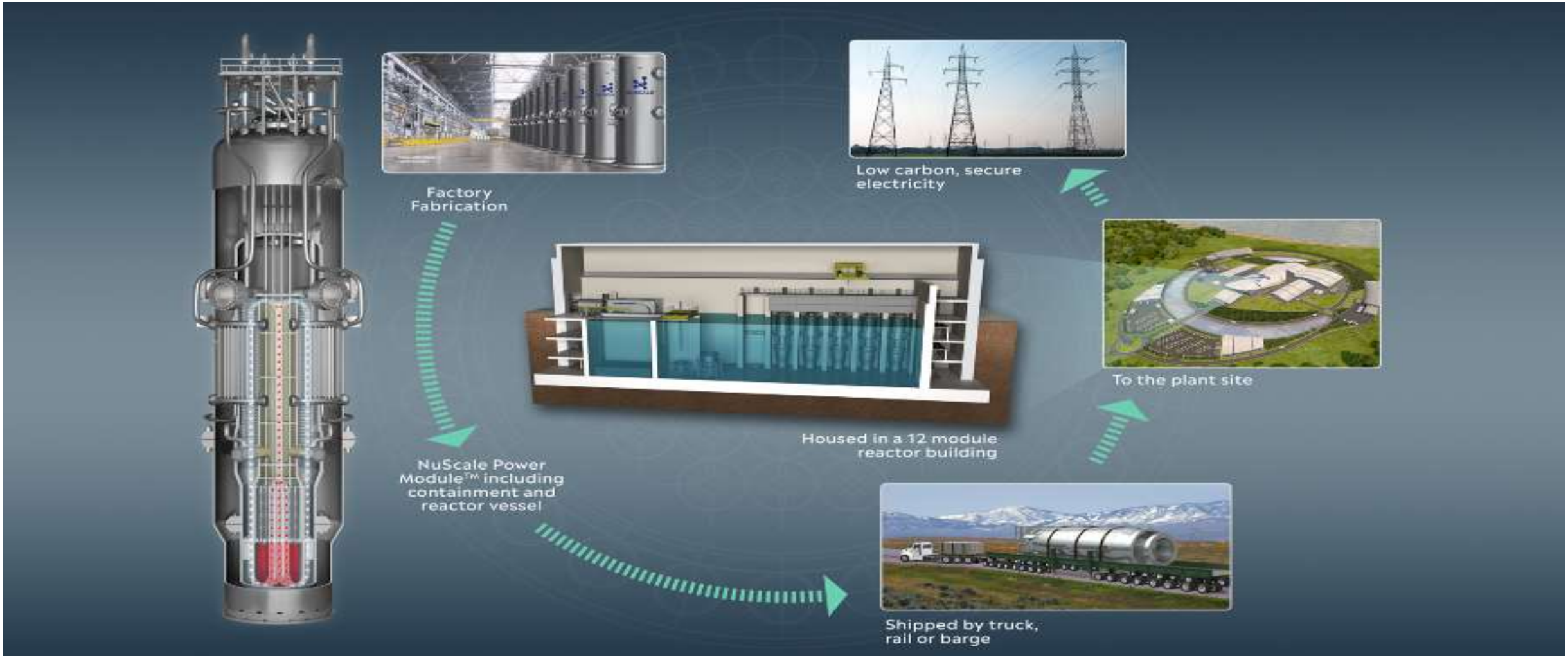
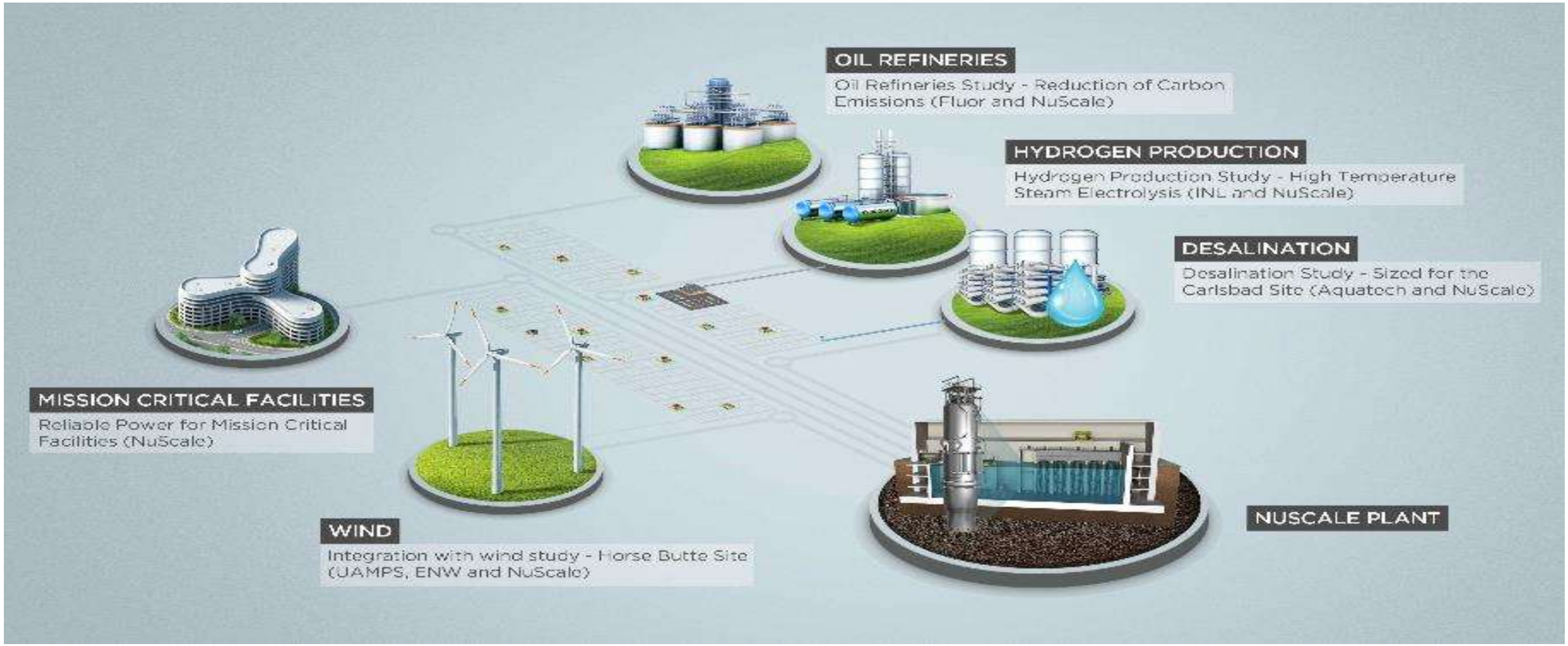
A New Approach to Construction and Operation



Beyond Baseload: NuScale Diverse Energy Platform



Reports for associated technical studies are available at: www.nuscalepower.com/technology/technical-publications

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Eric Loewen

GE Hitachi Nuclear Energy

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GE Hitachi Nuclear Energy

Advanced Reactors

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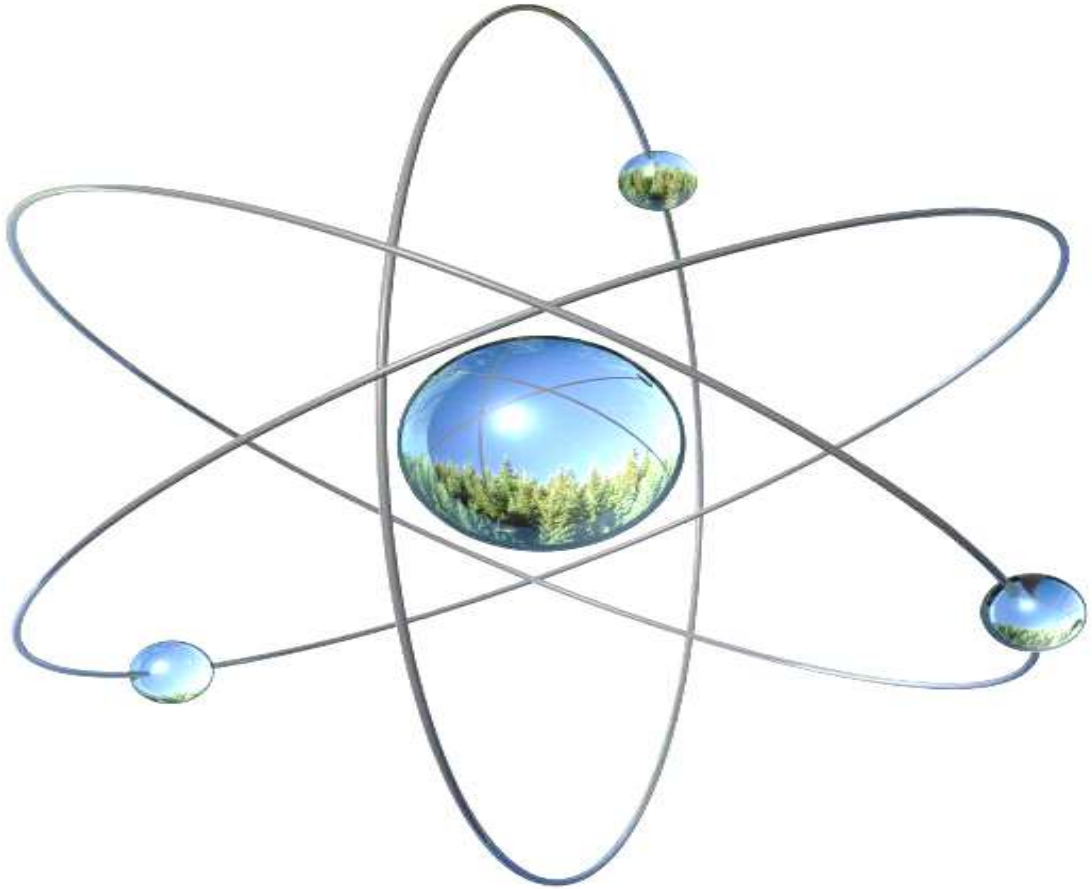
April 3, 2020

Eric Loewen, Ph.D.



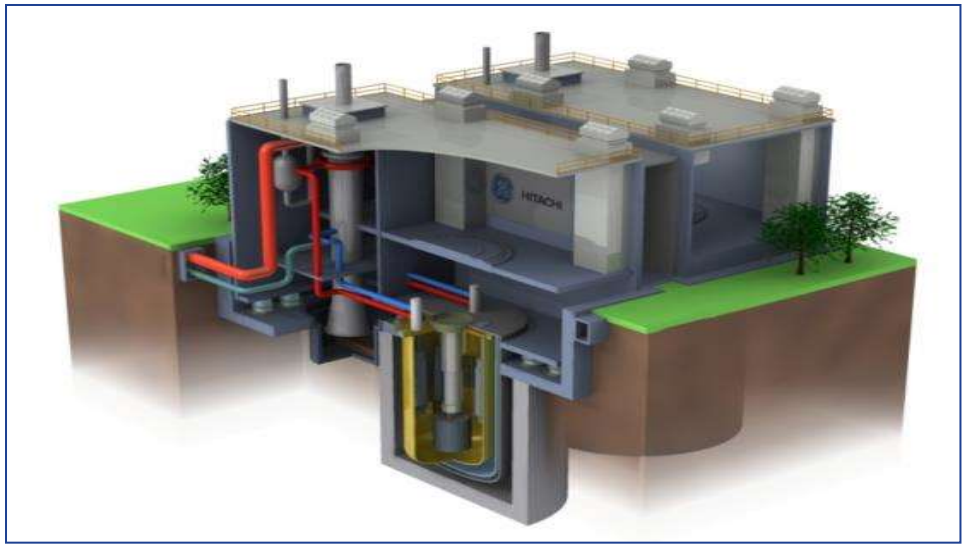
HITACHI

PRISM: The Commercialization of EBR-II

USA's EBR II

- Small
- Pool
- Metal fuel
- Passive safety

EBR-II proved the technology

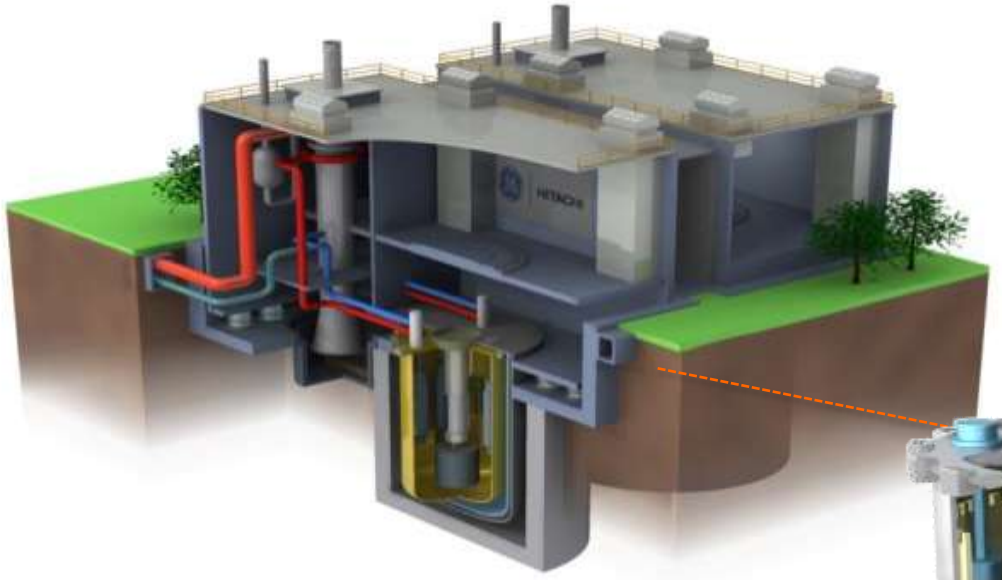


GEH's PRISM

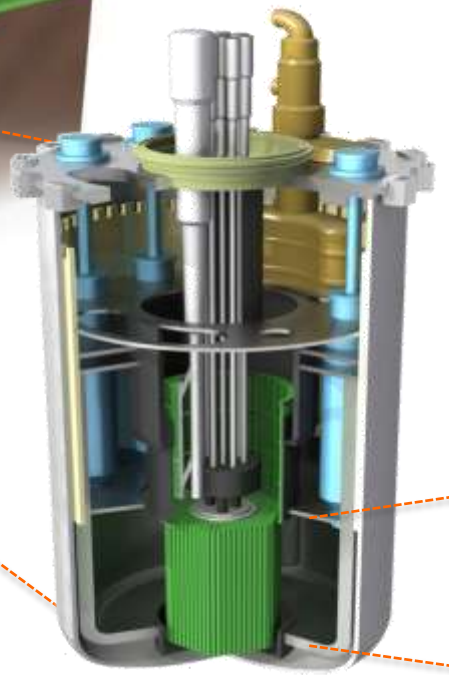
- Small
- Pool
- Metal fuel
- Passive safety

PRISM commercializes the technology

What is PRISM?



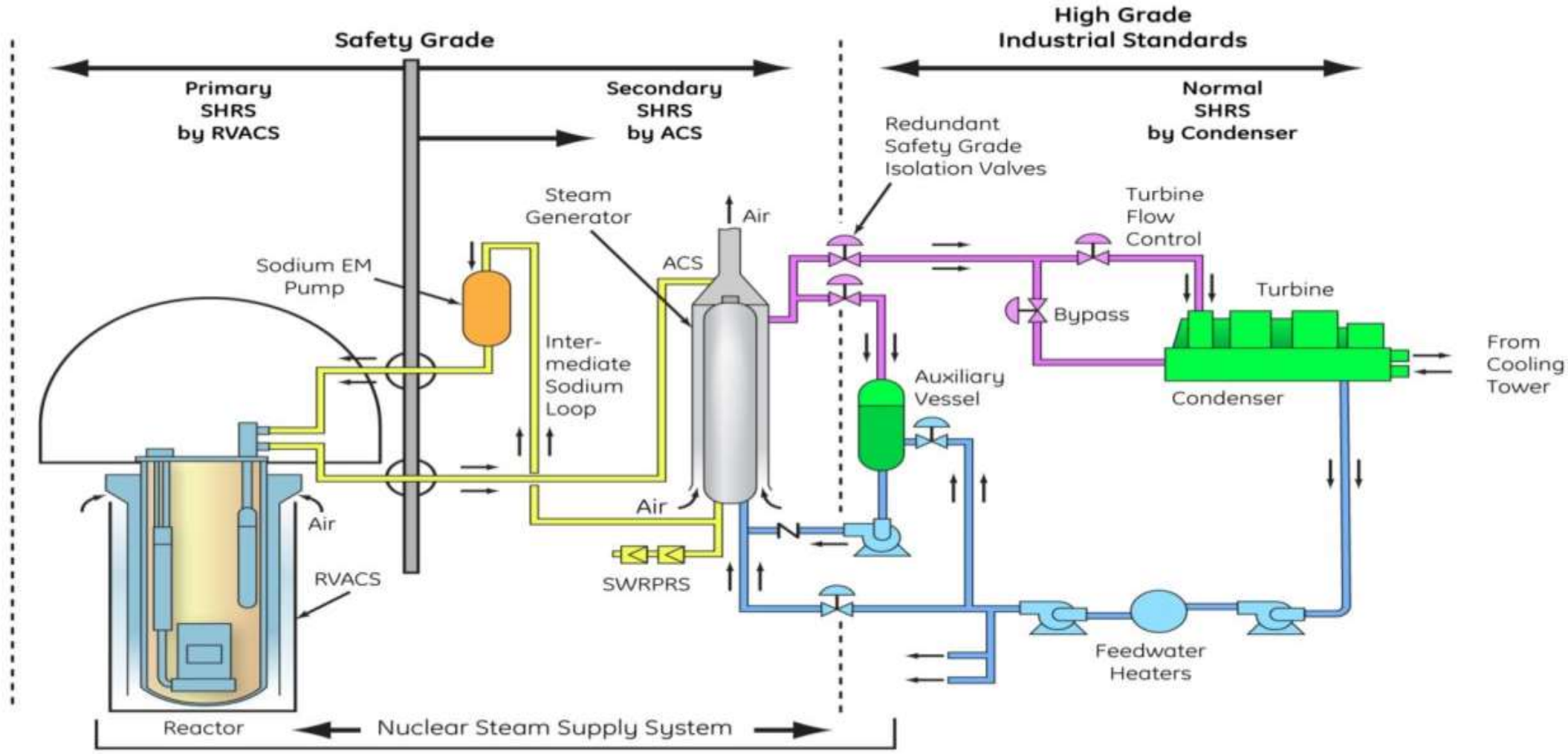
Power Reactor Innovative Small Module (PRISM)



- 311 MWe (840 MWth) per reactor
  - Two reactors per turbine-generator
- Modular components allow for factory fabrication
- Design prevents Loss of Coolant Accident
- Design removes decay heat without automatic or operator actions
- Metallic fuel

Metallic fuel is key

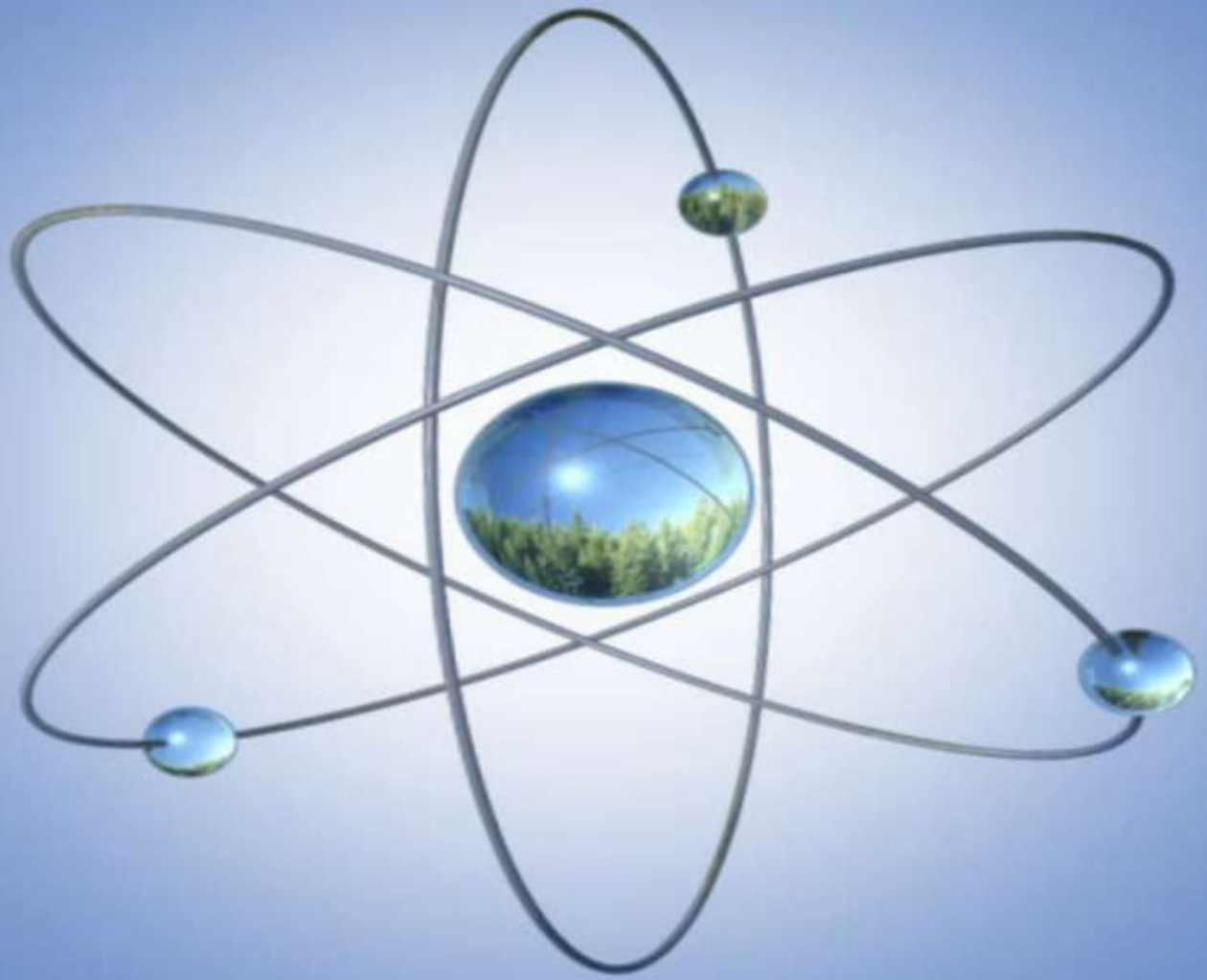
PRISM power extraction cycle



PRISM commercial cost efficiencies

Feature	Cost Advantage
Pool Type	Eliminates LOCA
Metallic Fuel	Passive reactor shut down
Higher Op Temp	Improved efficiency
Fast Fission	High fuel utilization
Higher Power Density	Better thermal efficiency
Passive Safety	Eliminates active systems
Modular Design	Lower on-site construction costs

Questions?



HITACHI

Student Design Competition

- Design Competition sponsored by ETWDD and YMG for senior design teams from various universities
- 10 finalists will be selected to compete in the April 10 competition.
- Finalists will be notified via email by Sunday, April 4.