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Financial Challenges of Operating U.S. Nuclear Power Plants

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Agenda

- Introduction and Overview of U.S. Nuclear Power
- Actual, Planned, and Potential Reactor Closures
- Merchant Nuclear Power Plant Economics
 - *Generation Costs*
 - *Wholesale Electricity Prices*
 - *How Natural Gas Impacts Wholesale Electricity Prices*
 - *Locational Marginal Prices*
 - *Other Revenue Sources*
 - *Case Study: Quad Cities*
 - *Plant-Level Analysis*
- Policy Options and Considerations



Overview of U.S. Nuclear Power

- 60 operating power plants
- 99 reactors
- 99,316 Megawatts of Net Summer Generating capacity
- Approximately 20% of total power generation
- Most of existing capacity started operating in the 1970's and 1980's

History of U.S. Power Reactor Orders, Startups, and Shutdowns

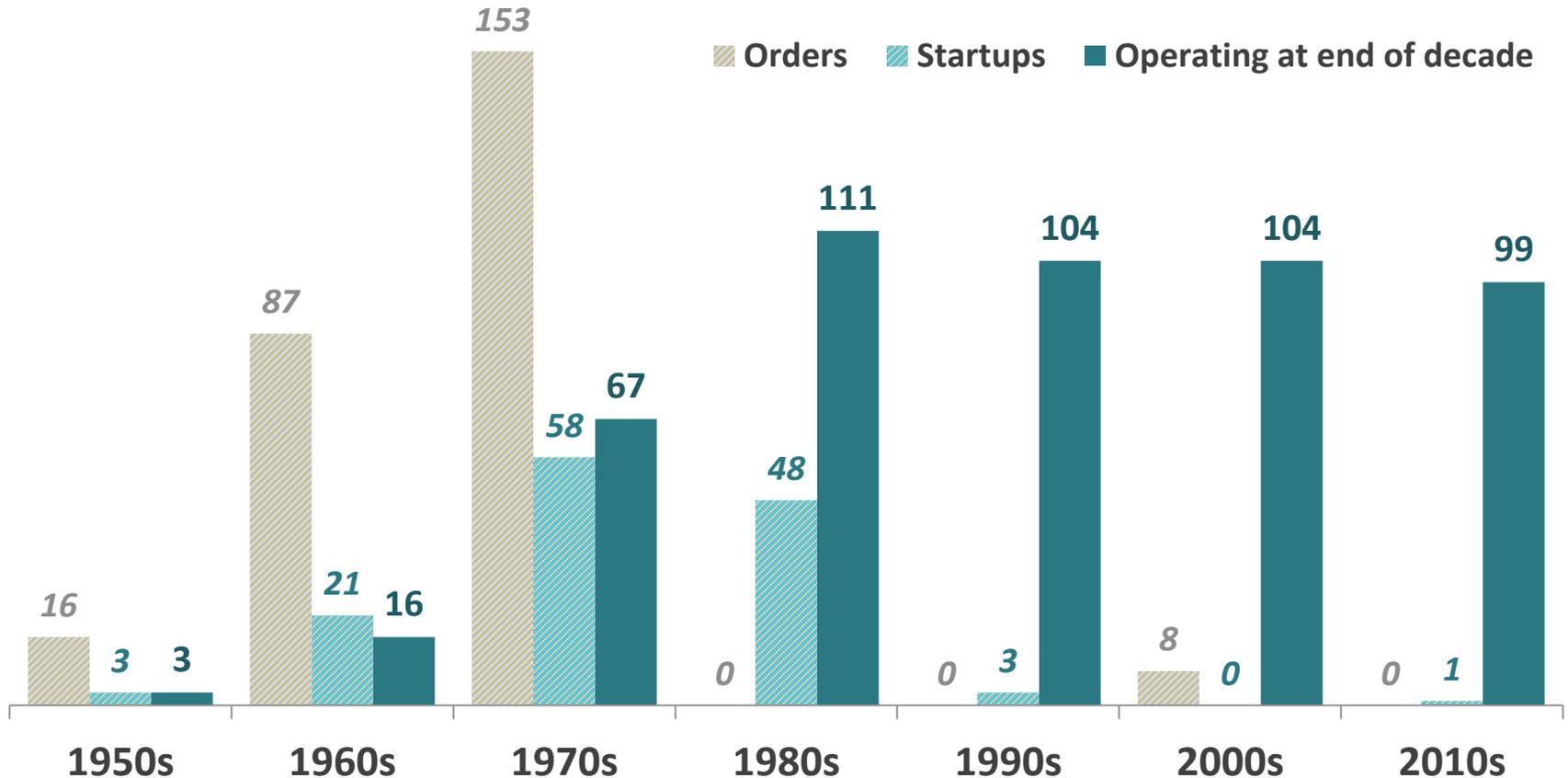
Years	Orders	Cancellations	Startups	Shutdowns	Operating at end of decade
1950s	16	0	3	0	3
1960s	87	0	21	8	16
1970s	153	57	58	7	67
1980s	0	58	48	4	111
1990s	0	5	3	10	104
2000s	8	0	0	0	104
2010s	0	6	1	6	99
Total	264	126	134	35	

Source: Nuclear Energy Institute, Nuclear Regulatory Commission.



Orders, Startups, and Shutdowns

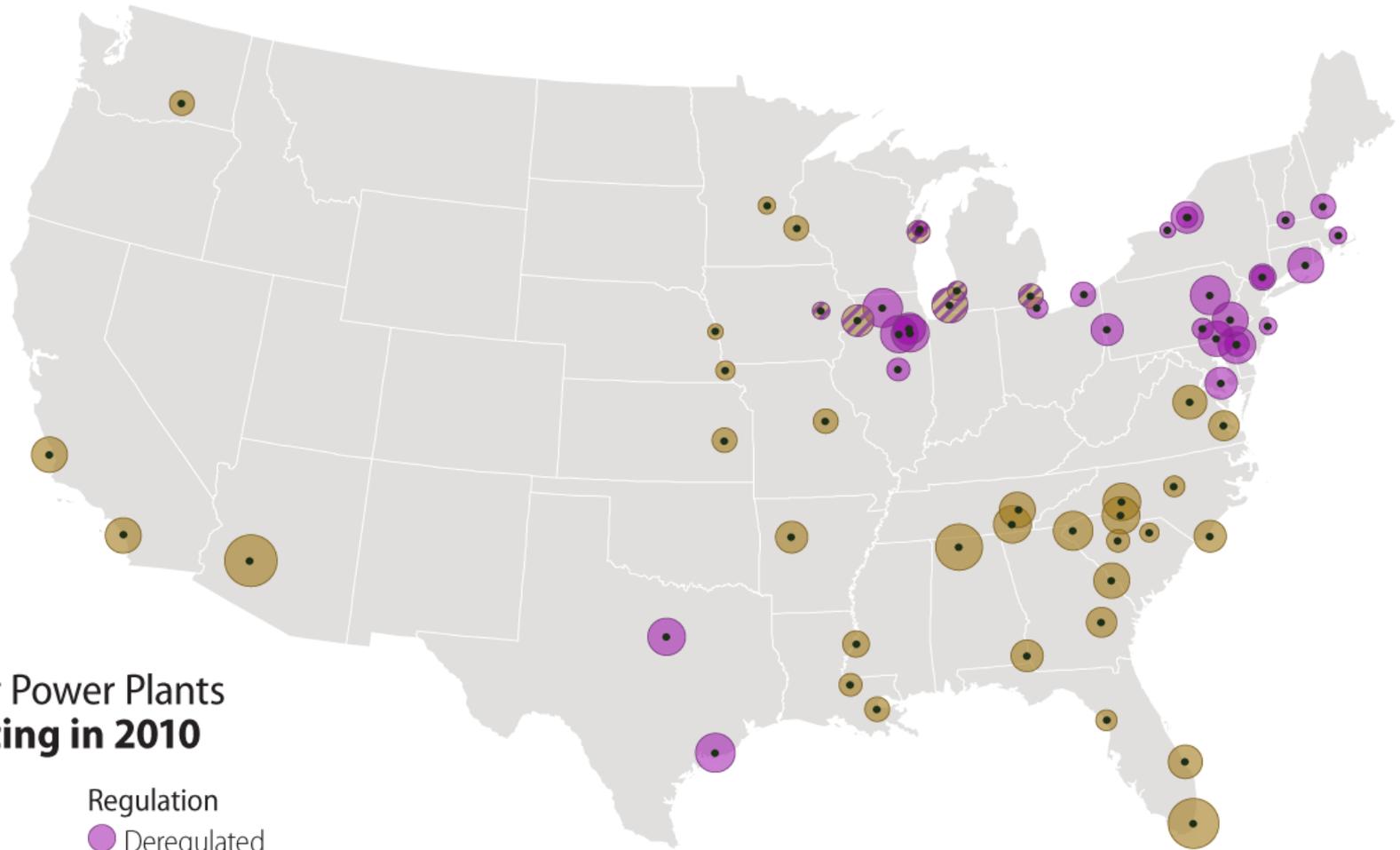
Most of existing capacity started operating in the 1970s and 1980s



Source: Nuclear Energy Institute, Nuclear Regulatory Commission.



Nuclear Power Plants



Nuclear Power Plants Operating in 2010

Megawatt Capacity



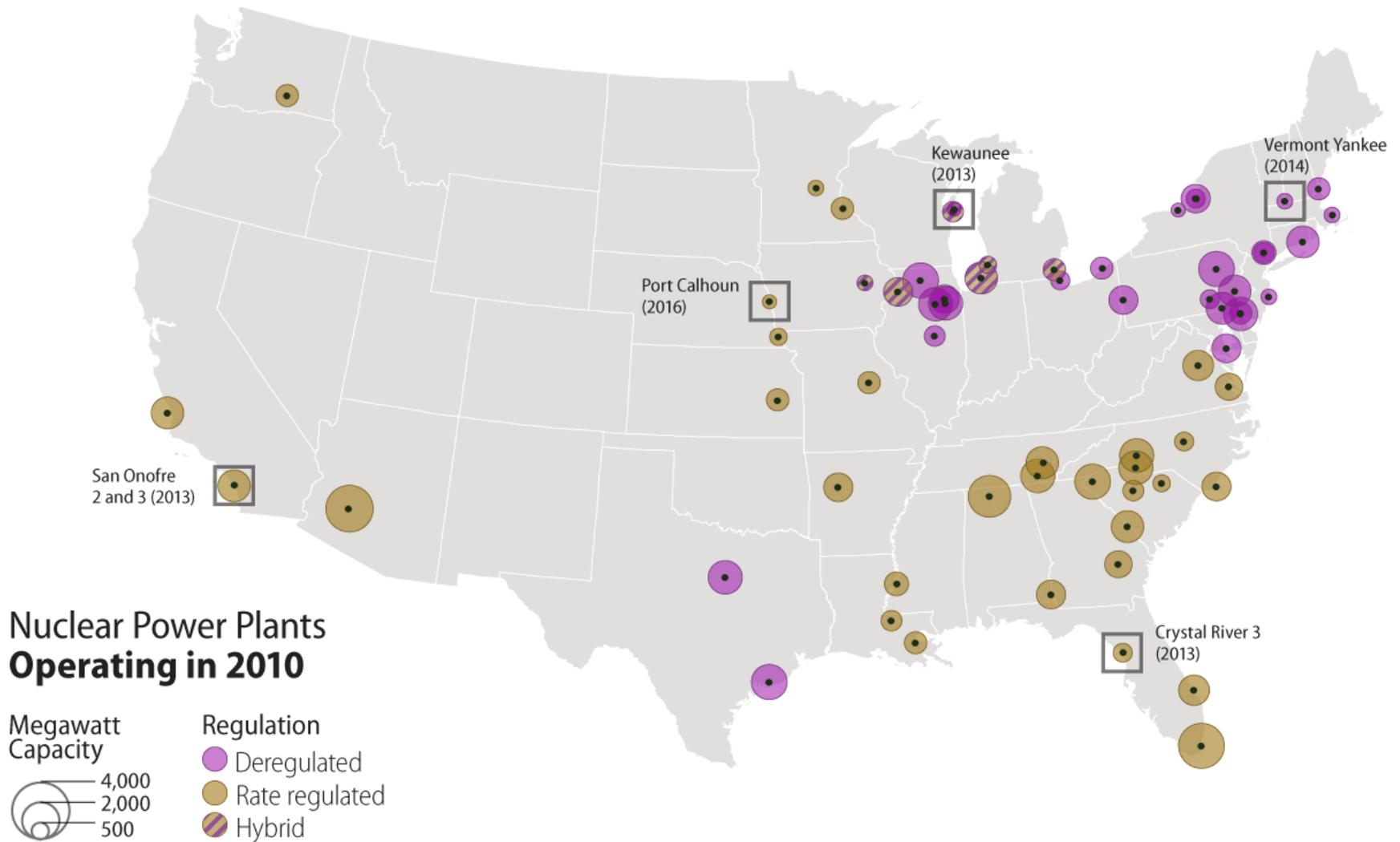
Regulation



Source: Map by CRS using data from S&P Global Platts geospatial data layers, 2016; and Esri Data & Maps, 2014.

Notes: No nuclear power plants are located in Alaska or Hawaii.

Nuclear Power Plants

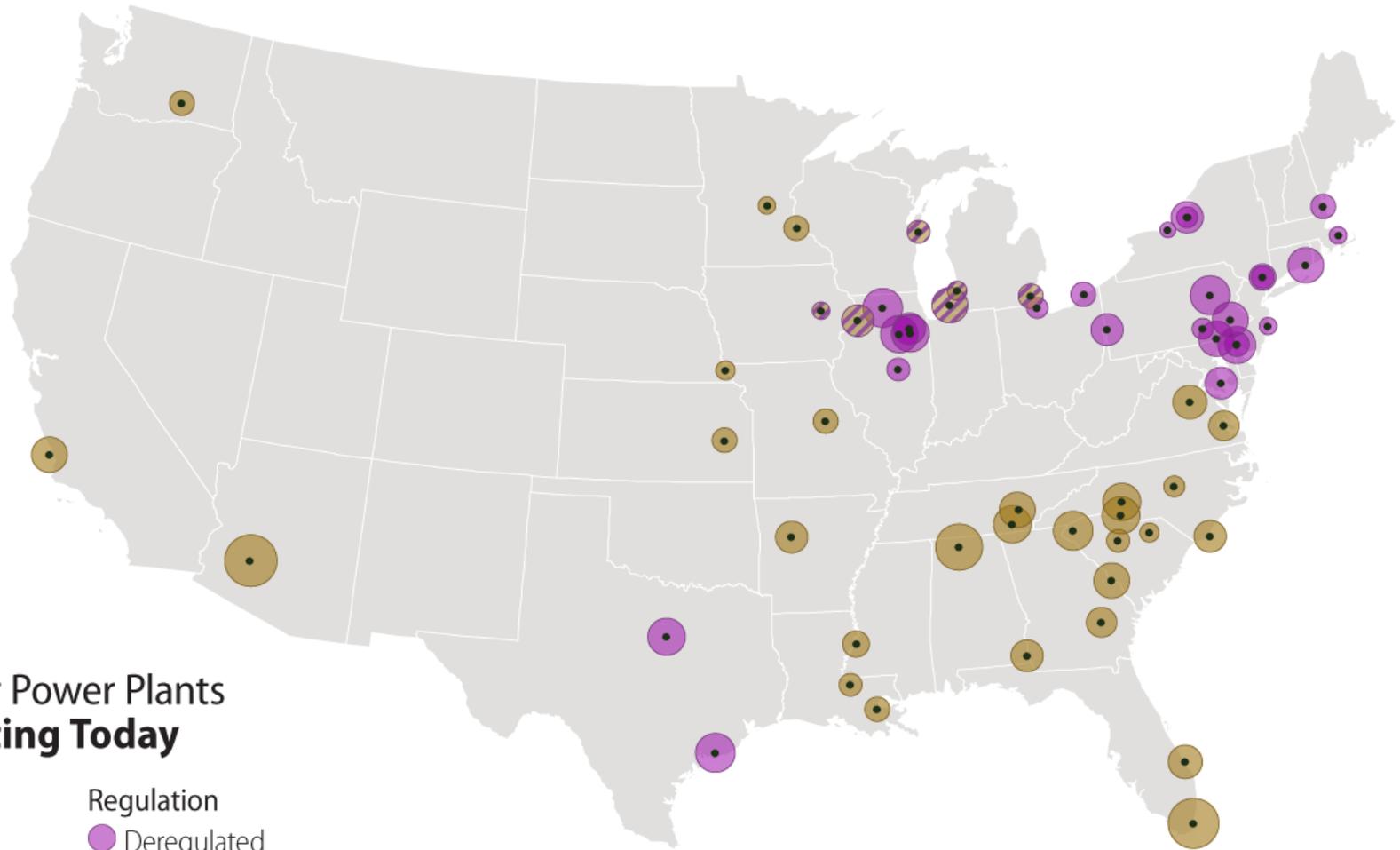


Source: Map by CRS using data from S&P Global Platts geospatial data layers, 2016; and Esri Data & Maps, 2014.

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Nuclear Power Plants



Nuclear Power Plants Operating Today

Megawatt Capacity



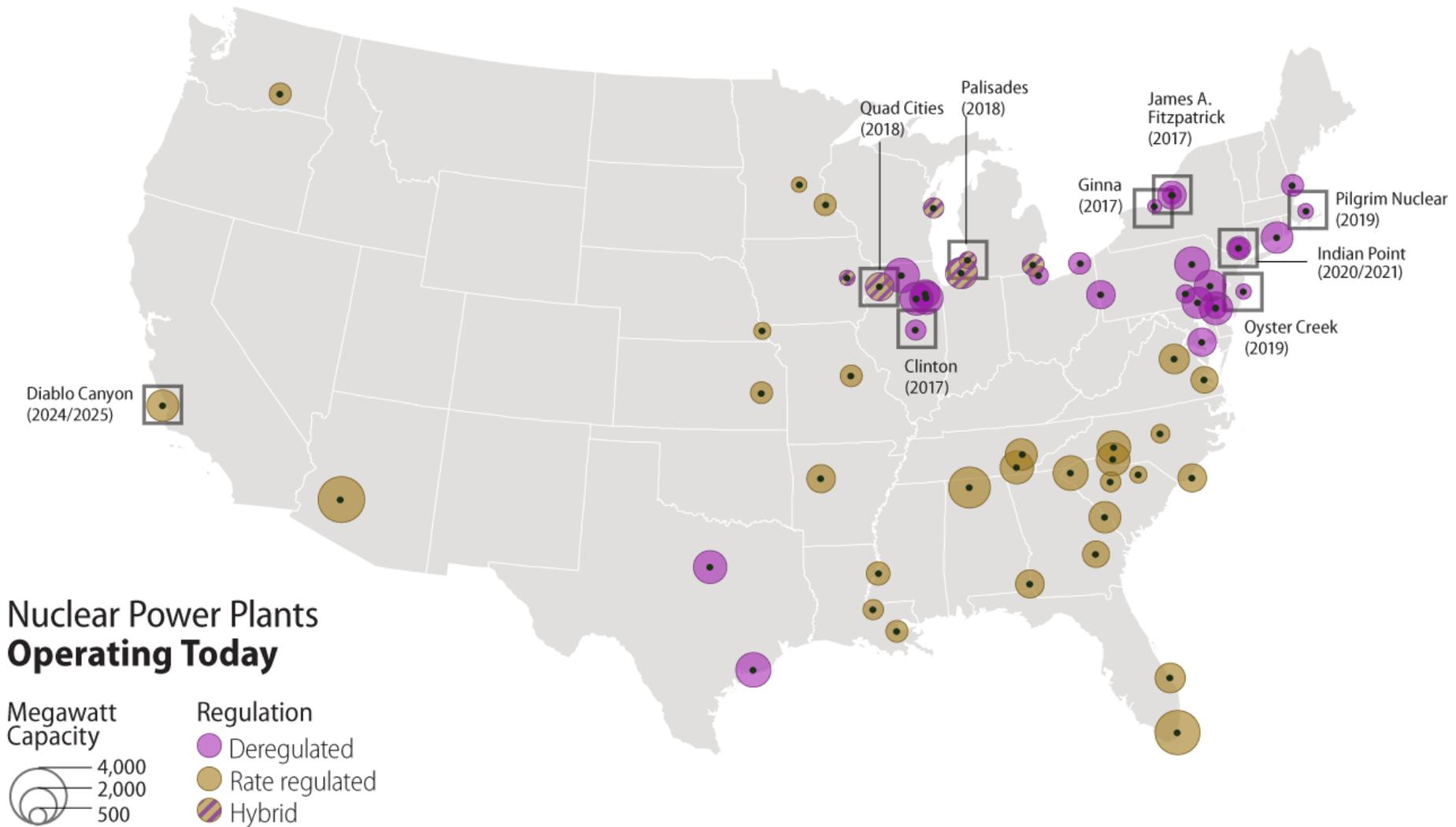
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Nuclear Power Plants

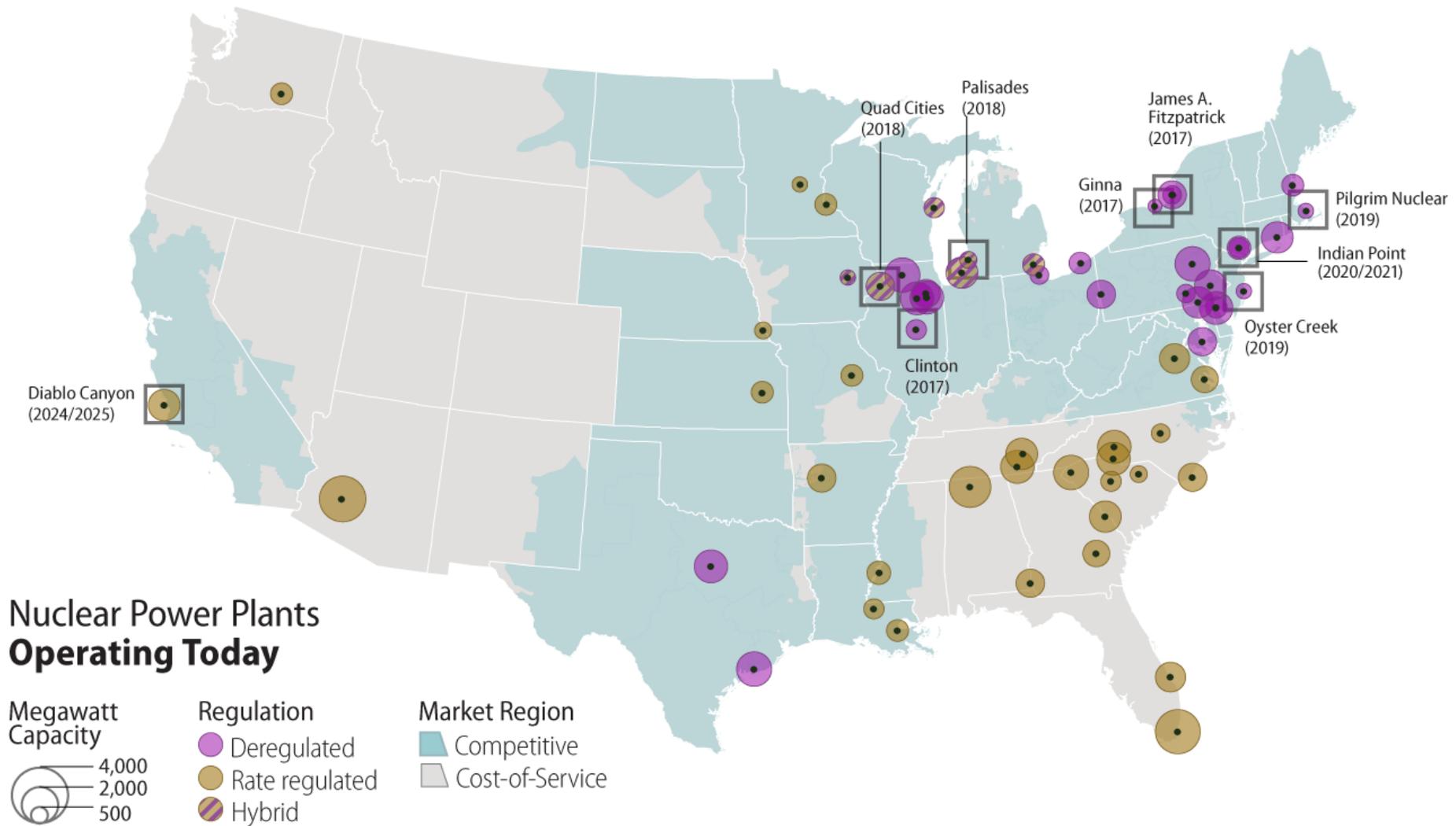


Source: Map by CRS using data from S&P Global Platts geospatial data layers, 2016; and Esri Data & Maps, 2014.

Notes: No nuclear power plants are located in Alaska or Hawaii. Announced closures as of 1/10/2017. Diablo Canyon and Quad Cities are both two-reactor sites.



Nuclear Power Plants



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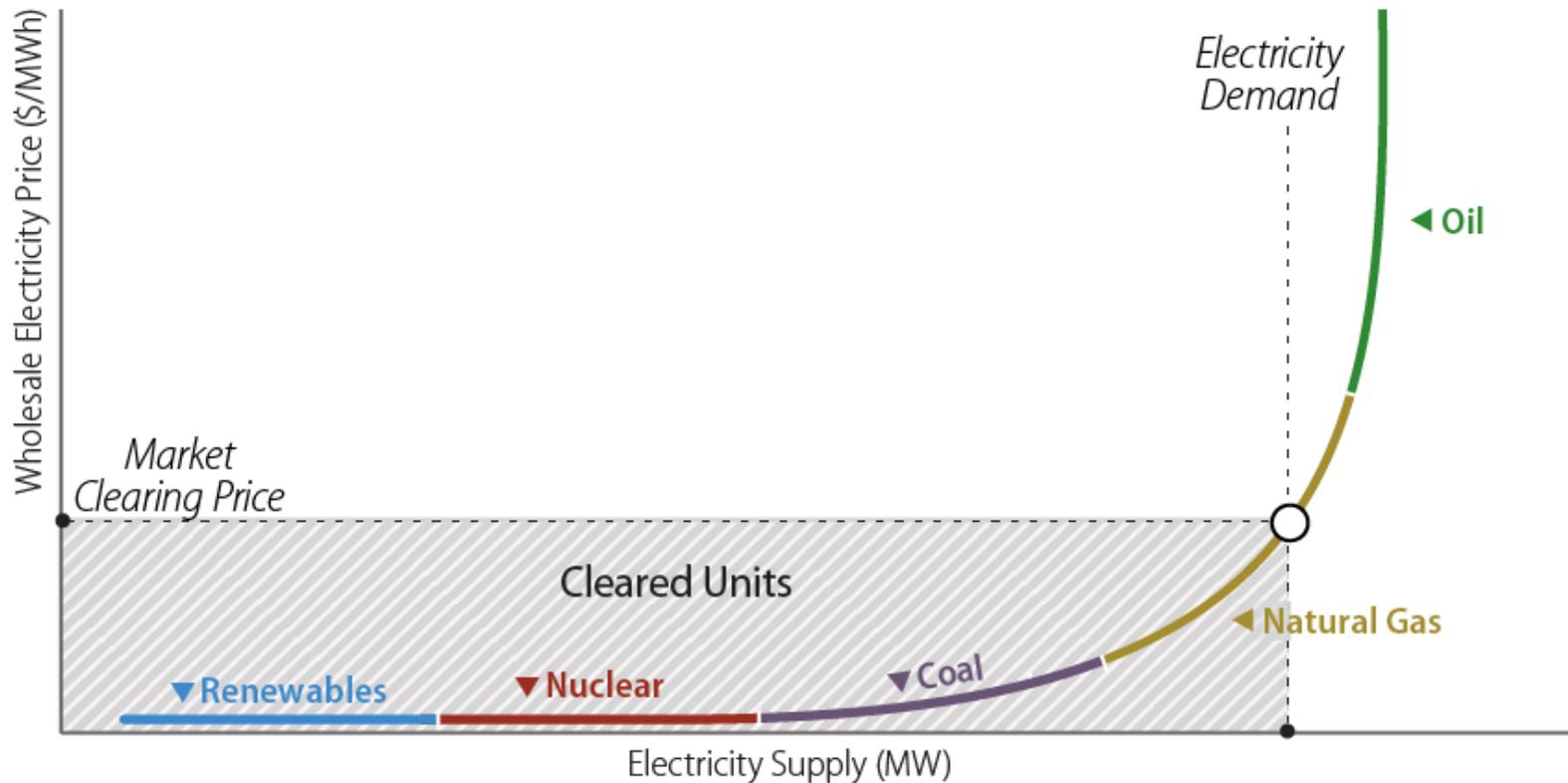




Merchant Nuclear Power Plant Economics



How Competitive Wholesale Electricity Prices Are Determined



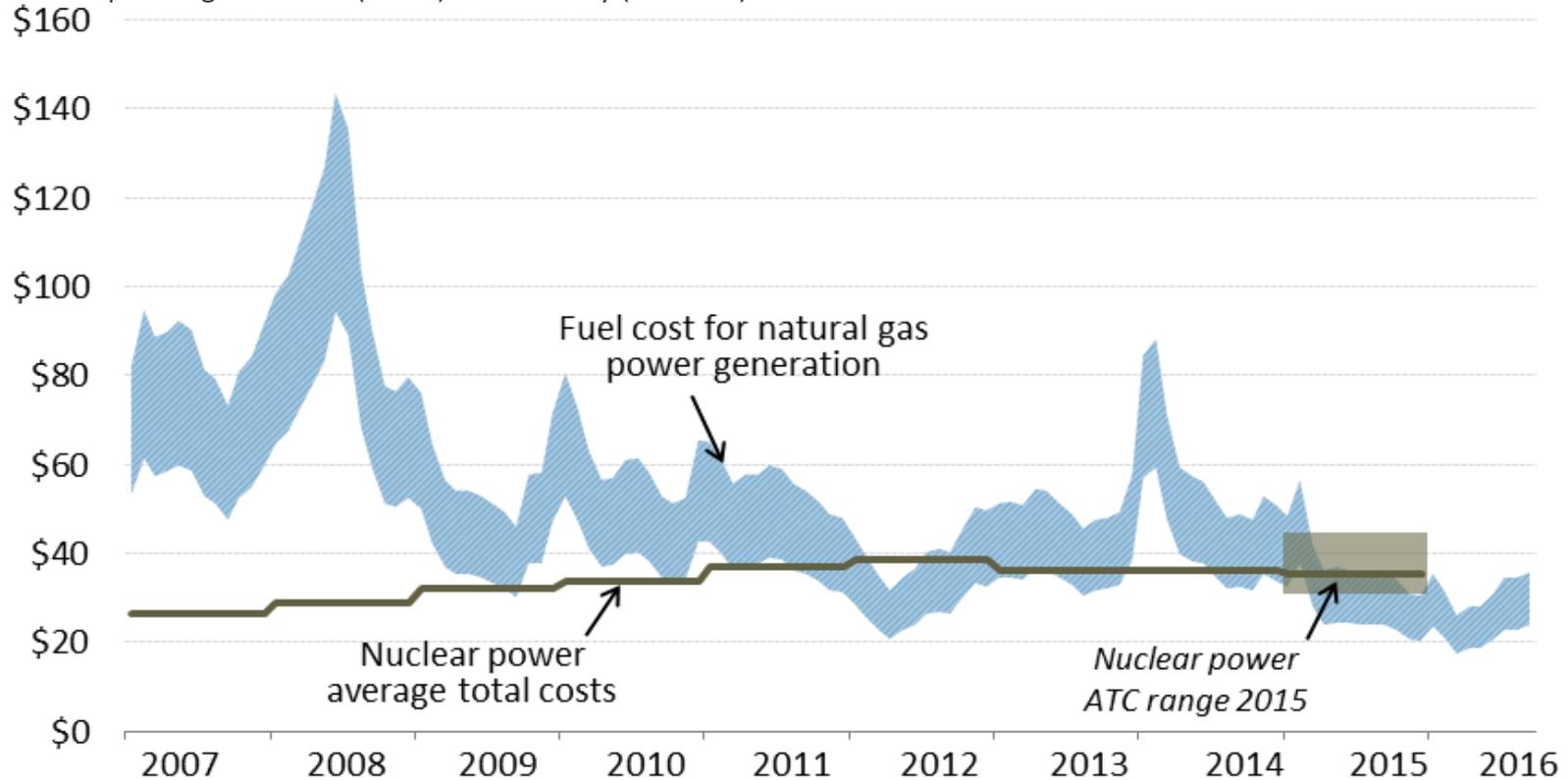
Source: CRS

Notes: Not representative of actual RTO/ISO market clearing results. Actual values for electricity prices and electricity supply are not indicated in this figure, as they will vary by market, generation mix, time-of-day, and location.



How Natural Gas Prices Impact Wholesale Electricity Prices, Compared with Nuclear Costs

Dollars per Megawatthour (MWh) of Electricity (Nominal)



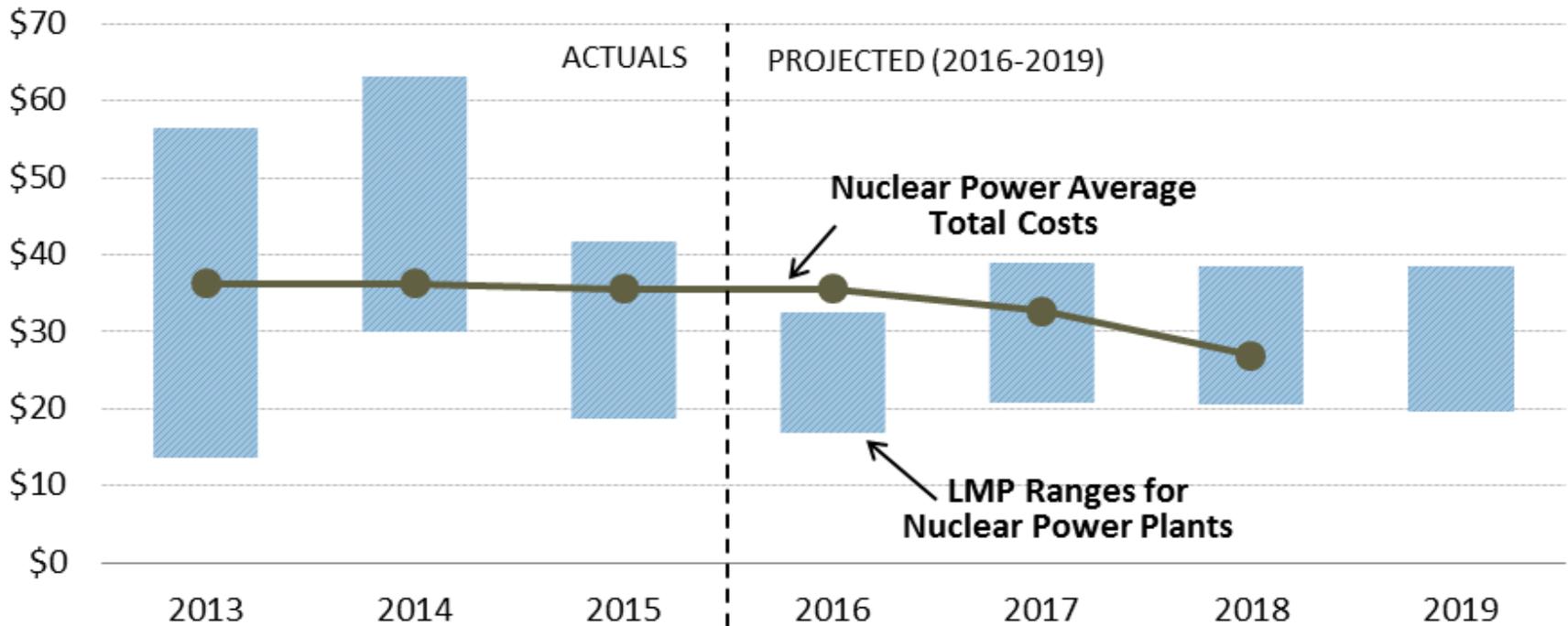
Source: Natural gas power generation marginal cost range: CRS, using heat rate and monthly natural gas for electric power price information from Energy Information Administration, Natural Gas Prices, available at http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm, accessed December 2016 with data through September 2016. Nuclear power average total costs and range: Nuclear Energy Institute, Nuclear Costs in Context, April 2016.

Notes: Nuclear power average total costs include fuel, O&M, and capital.



Locational Marginal Prices (LMP) for Nuclear Plants

LMP and Nuclear Average Total Costs (Nominal)
Dollars per Megawatthour (MWh)

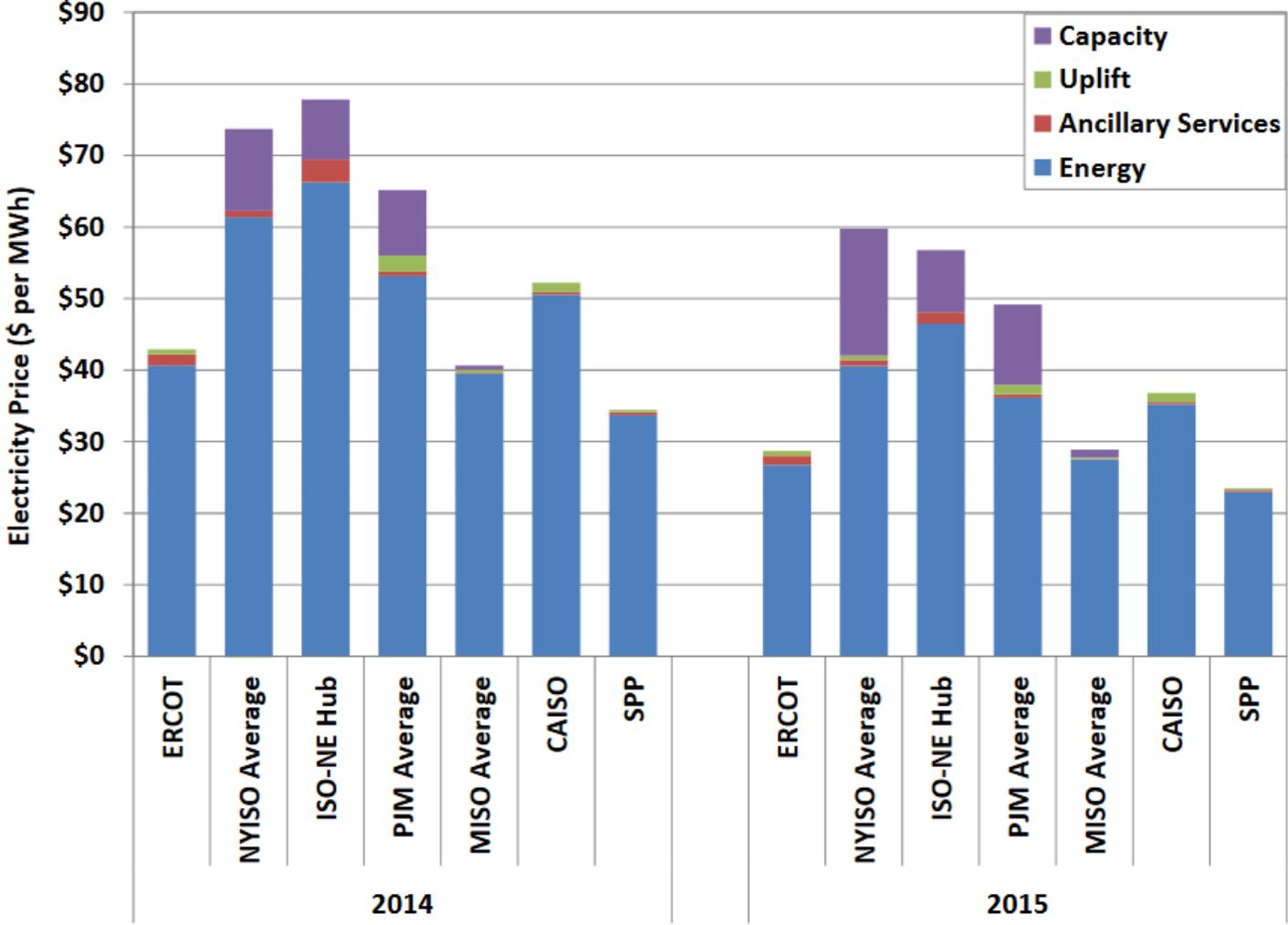


Source: CRS. LMP ranges from Bloomberg New Energy Finance, *Reactors in the Red: Financial Health of the US Nuclear Fleet*, July 2016. Nuclear average total costs from Nuclear Energy Institute, *Nuclear Costs in Context*, April 2016.

Notes: LMPs for each nuclear plant were obtained from the Bloomberg terminal, which also includes forward price projections through 2019. Nuclear power average total costs through 2015 are from NEI, with 2016 to 2018 projections calculated based on NEI's "Delivering the Nuclear Promise" stated goals.



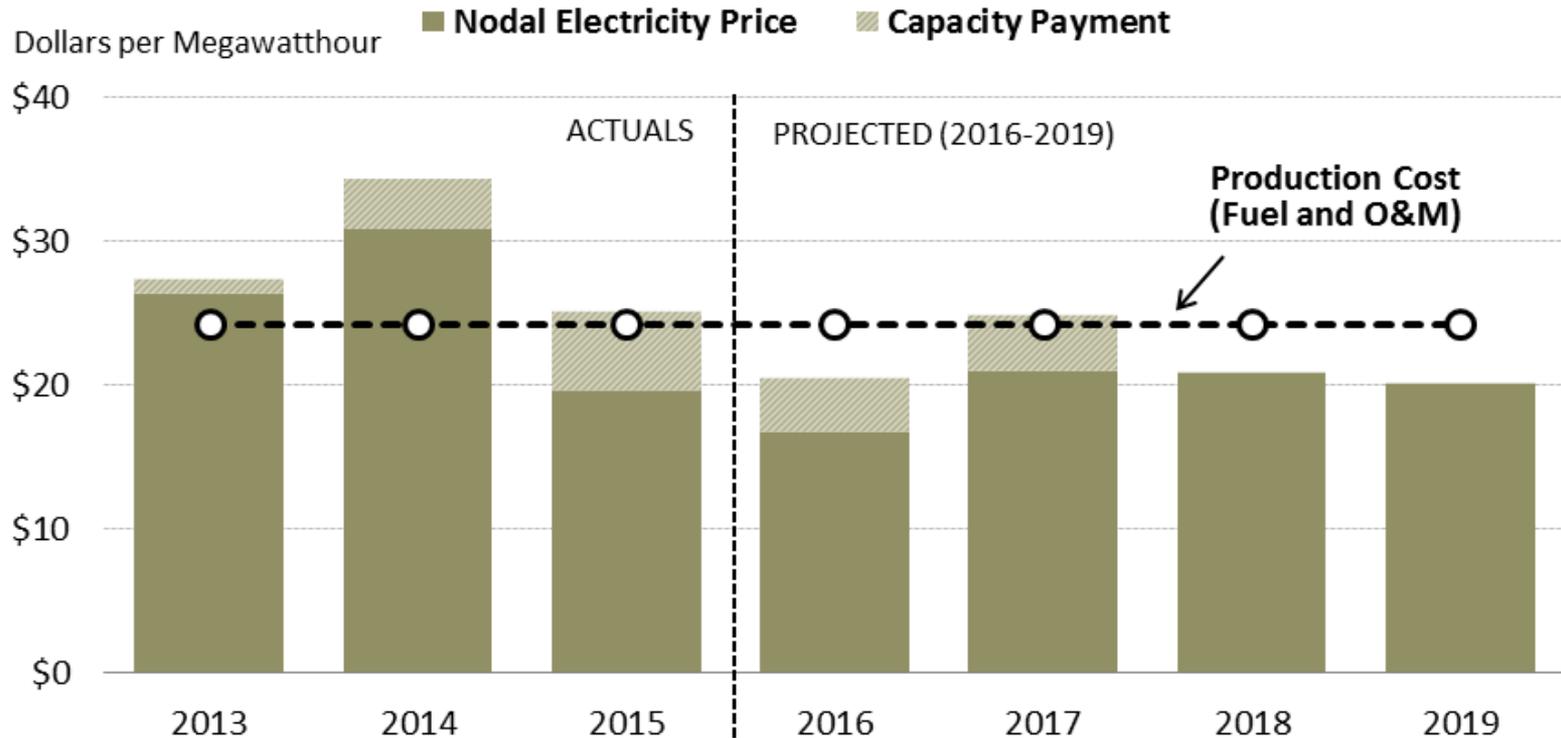
Other Electricity Revenue Sources



Source: Potomac Economics, *ERCOT 2015 State of the Market Report*, June 2016.



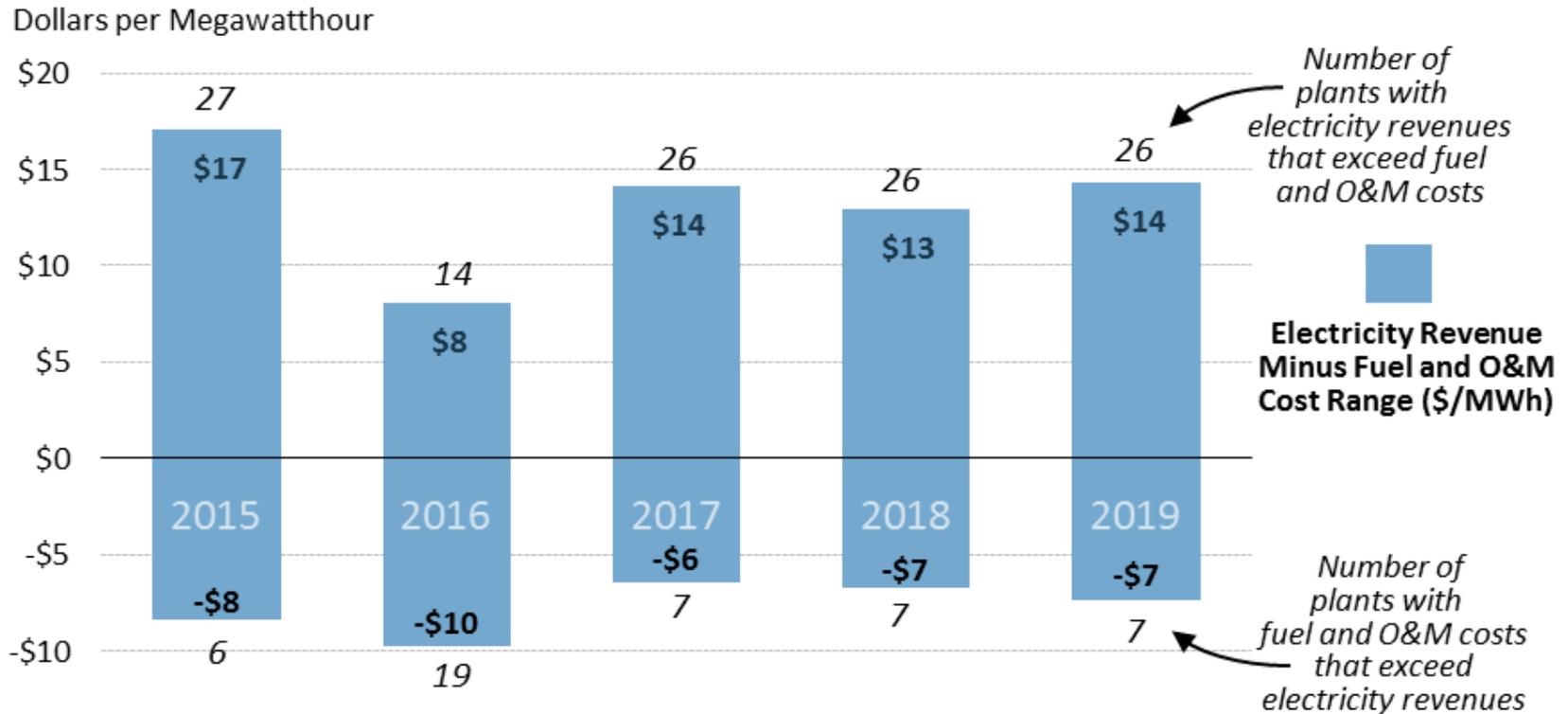
Case Study: Quad Cities



Source: Nodal Electricity Price: Bloomberg as reported in Bloomberg New Energy Finance, *Reactors in the Red: Financial Health of US Nukes*, July 2016. Capacity Payment: CRS analysis of PJM capacity prices for the COMED zone as reported by Monitoring Analytics, LLC, *Quarterly State of the Market Report for PJM: January through June, 2016*. Production cost information for 2015 as reported in Nucleonics Week, "US Utility Operating Costs," June 2, 2016.



Plant-Level Analysis: Electricity Sales Revenue and Fuel and O&M Costs



Source: CRS using data from third-party reports. Bloomberg New Energy Finance, *Reactors in the Red: Financial Health of the US Nuclear Fleet*, July 11, 2016. R Street Institute, *Where Have All the Nuclear Plants Gone?*, October 2016.





Federal Policy Options



Federal Policy Options

- Power Market Price Formation Changes
- Tax Incentives
- Carbon Price
- Federal Power Purchase Agreements

To Date, All Policy Action to Support Operational Nuclear Plants Has Occurred at the State Level: New York, Illinois, Ohio, Connecticut



QUESTIONS?



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