Power Market Prices, Nuclear Generation & Greenhouse Gas Policy

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Introduction & Overview

Recently, merchant baseload plants have had their profits eroded by low natural gas prices, entry of renewables, and depressed demand growth

- Reduced coal generation = lower average CO_2 emissions from generation
  - Coal generation down because of gas price/renewables/demand
  - Coal retirements from the above + EPA regulations
  - Surviving coal generation capacity factor remains low, could grow (esp. offpeak)
- Continued market conditions are now affecting merchant nuclear generation
  - Average all-hours energy price in PJM was $34/MWh in 2012 and $38/MWh in 2013; capacity prices also low in most sub-regions
  - Nuclear plants typically need $30-45/MWh to cover fuel, fixed O&M and CapEx
  - Forward prices of power through 2015 not much more favorable

If nuclear plants shut down due to a few years of cash flow shortfalls, the long-term consequences to CO_2 emissions raise significant concerns

- In the near term, generation shortfall made up with dispatchable coal/gas
- Regret if CO_2 policy enacted and resulting market would support nuclear
- Assuming no coal long term, a smaller nuclear fleet would require all gas baseload

Absent a CO_2 price, retaining some marginal nuclear plants may require a modest "uplift" type of payment, a "green RMR" policy to prevent retirements and resultant CO_2 emissions

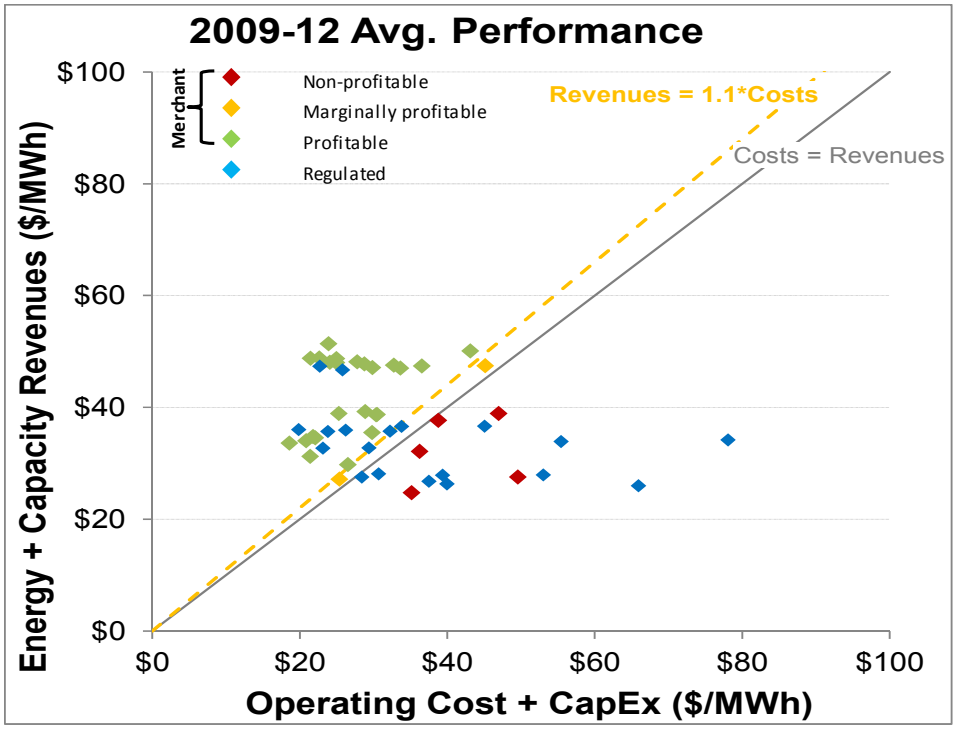
Recent Merchant Nuclear Plant Retirements

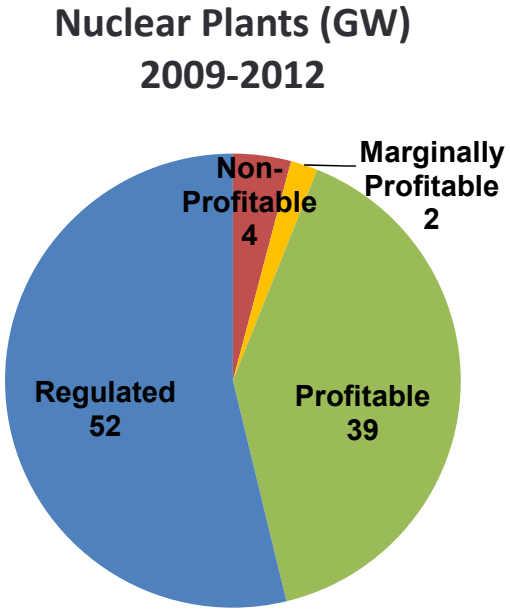
	Vermont Yankee	Kewaunee
		
Operator and Plant Location	Entergy; Vernon, VT	Dominion; Carlton, WI
Installed Capacity	628 MW	574 MW
Annual Output (2012)	4,989 GWh (90% CF)	4,516 GWh (90% CF)
Marginal Generation Fuels	80% Gas/20% Coal	30% Gas/70% Coal
CO_2 avoided	2.7 MMtons/yr	3.78 MMtons/yr
Vehicle Equivalent	400,000 Vehicles	550,000 Vehicles

Recent Nuclear Operating Margins

2009-2012 annual average margins (energy & capacity revenues less operating cost) against wholesale spot prices were negative for 5 merchant nuclear plants (4 GW) and only marginally positive for 2 plants (2 GW)

- During the same period, 11 regulated nuclear plants also had operating and CapEx costs higher than revenues they would have earned from wholesale markets.



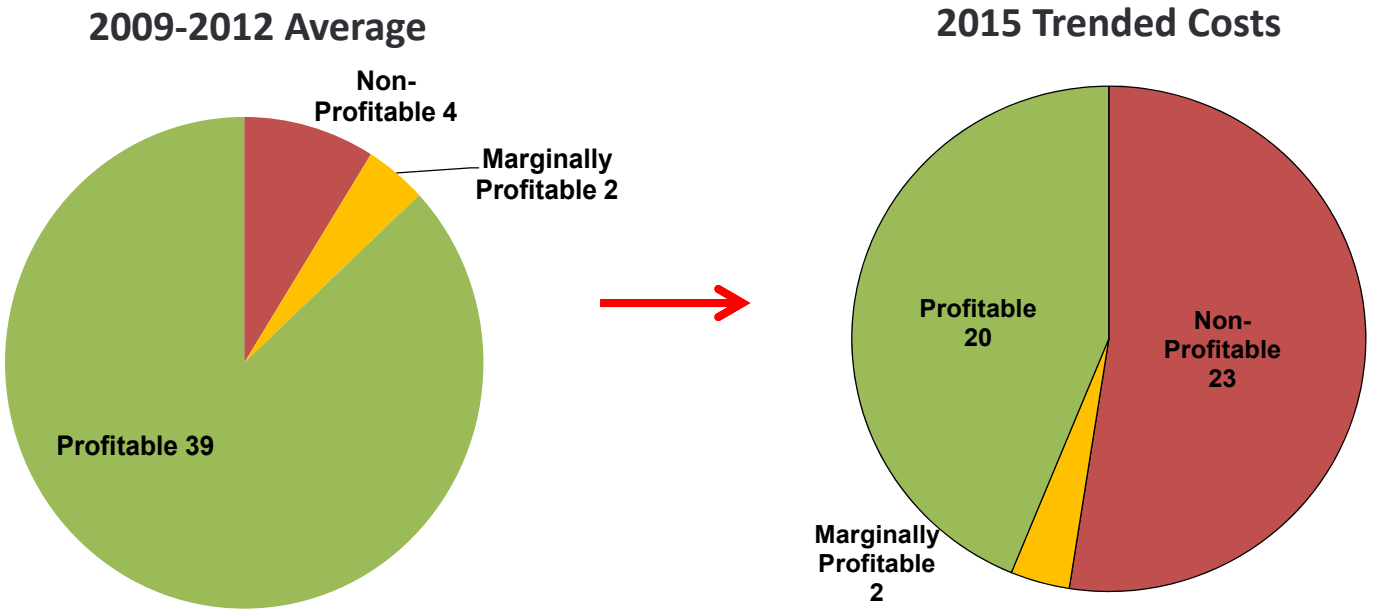


Merchant Nuclear Margins by 2015

6 GW out of the 45 GW merchant nuclear fleet (13%) would not have been profitable or only marginally profitable at spot prices during 2009-2012

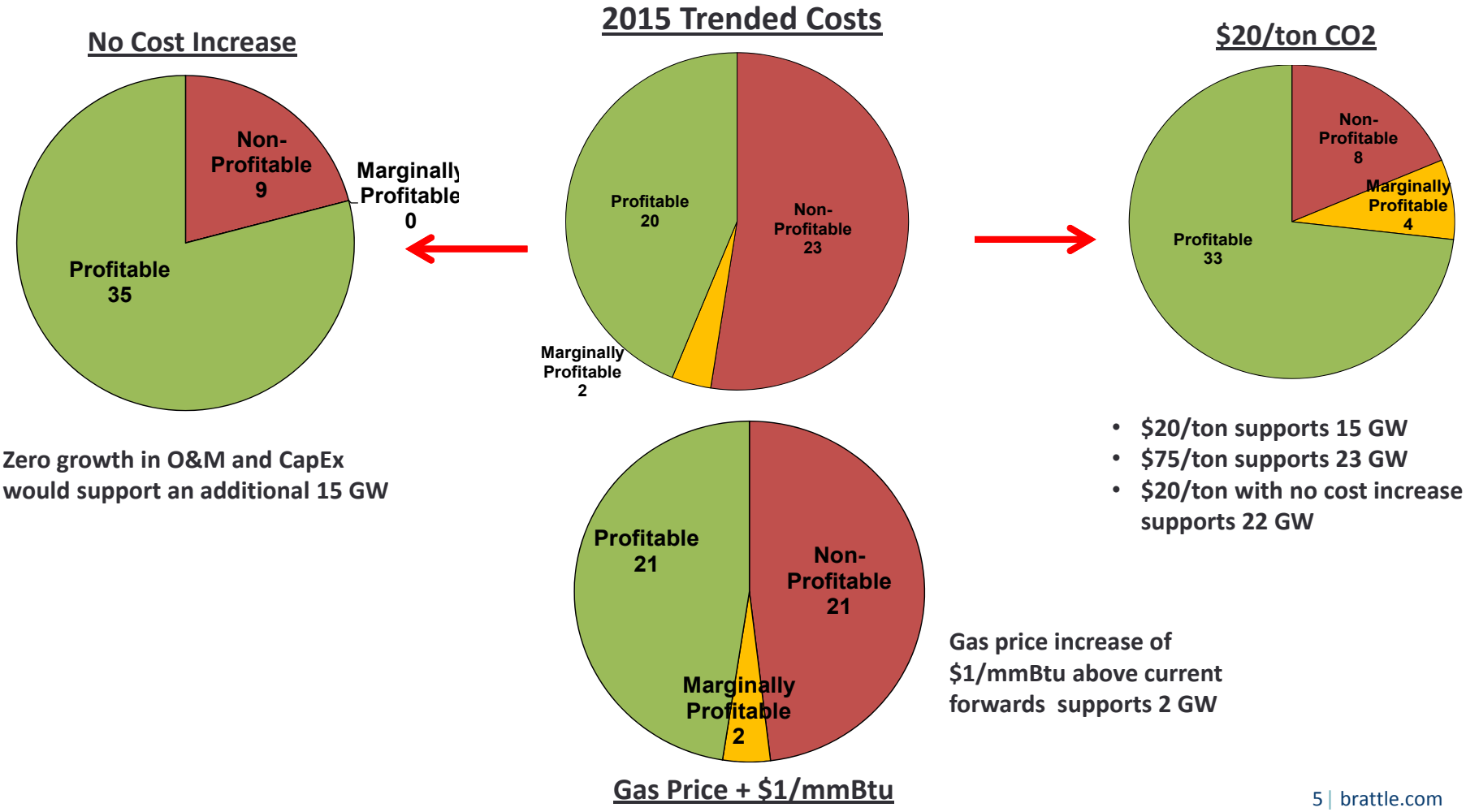
Forward prices and cost trends for 2015 imply that 23 GW of merchant nuclear capacity (51%) are at risk of not fully recovering fixed operating costs (depends on protection from market exposure via PPAs).

- Market forwards for 2015 are similar to 2009-2012 average spot prices
- Over the last 5 years, O&M increased by 5% per year and CapEx increased by 17% per year (nominal, average over the entire nuclear fleet)



Potential Economic Improvements

Eliminating growth in fixed costs, higher gas prices, or economy wide carbon price would increase the profitability of merchant nuclear units:



Zero growth in O&M and CapEx would support an additional 15 GW

- $20/ton supports 15 GW
- $75/ton supports 23 GW
- $20/ton with no cost increase supports 22 GW

Gas price increase of $1/mmBtu above current forwards supports 2 GW

Nuclear - CO_2 Emissions & Avoided Cost

1 GW nuclear avoids 3.4 MMtons/yr of CO_2 relative to gas combined cycle, equivalent to 500,000 gasoline cars @ 15,000 miles/yr and 20 mpg

- About twice as large a CO_2 benefit vs. coal-only generation

1 GW of lost nuclear output at (90% capacity factor) would require large amounts of alternative carbon-free resources

- 2,600 MW of wind @35% CF (about 4-5 Cape Wind projects)
- More than the entire U.S. solar fleet in 2013 (4,500 MW @17% CF)

Levelized cost of avoided CO_2 for NEW wind & solar can be quite high

- Solar PV about $286-563/ton
- Wind about $74-165/ton

Levelized cost of avoided CO2 for NEW nuclear is also $100+/ton

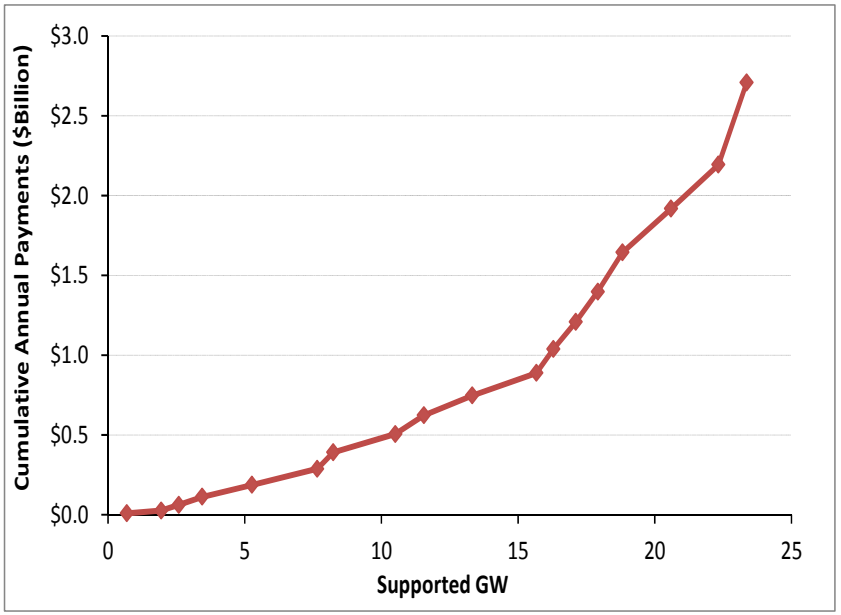
Key public policy questions become:

- **If existing nuclear is threatened, what would it cost to avoid retirement?**
  - Overall cost and $/ton CO_2 emissions avoided
- **If preserving existing nuclear is a relatively cheap way of avoiding CO_2, what kind of policy could work?**

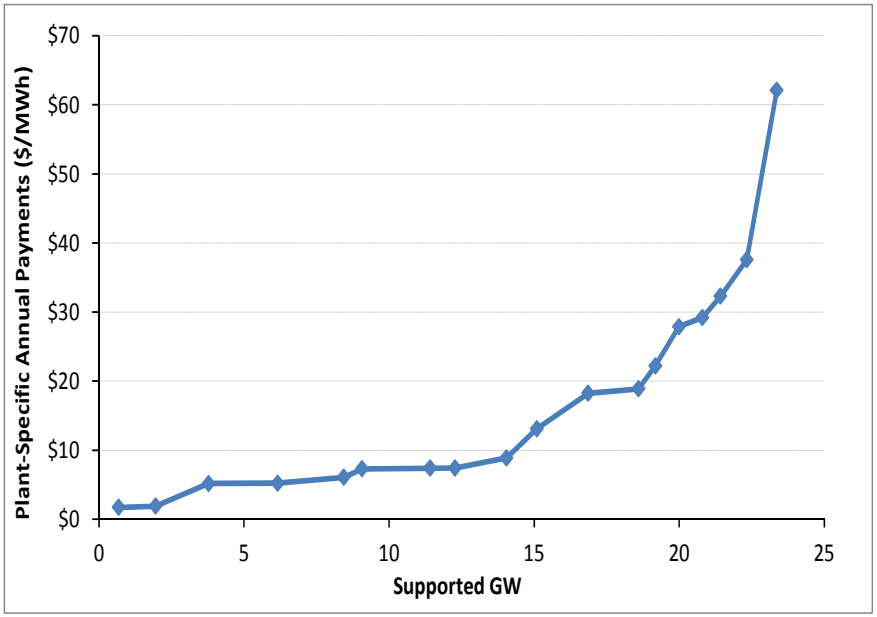
Cost of Sustaining Merchant Nuclear Plants

The potential shortfall in spot operating margins for merchant nuclear threatened (23 GW) under the trended cost/market forward price scenario provides an estimate of the cost of retaining the capacity:

Cumulative Annual Payments Needed to Sustain Merchant Nuclear Plants

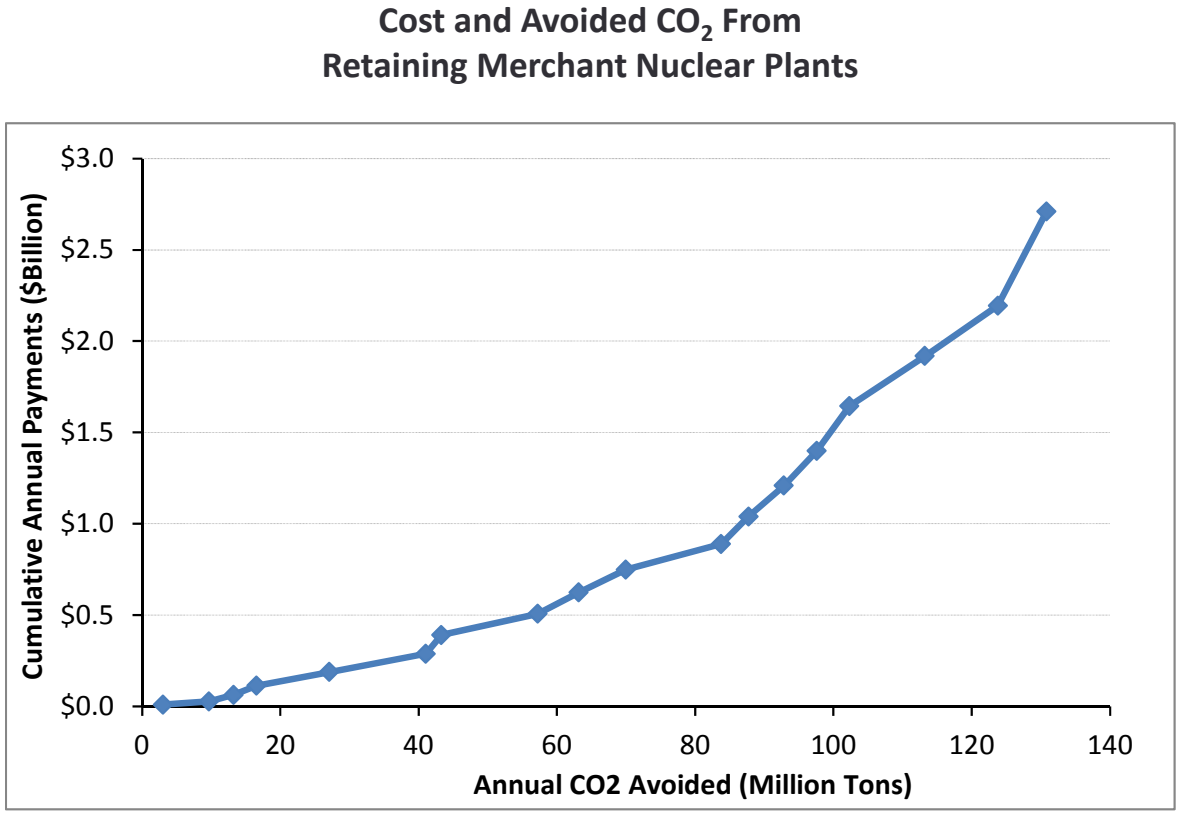


$/MWh Equivalent Needed to Sustain Merchant Nuclear Plants



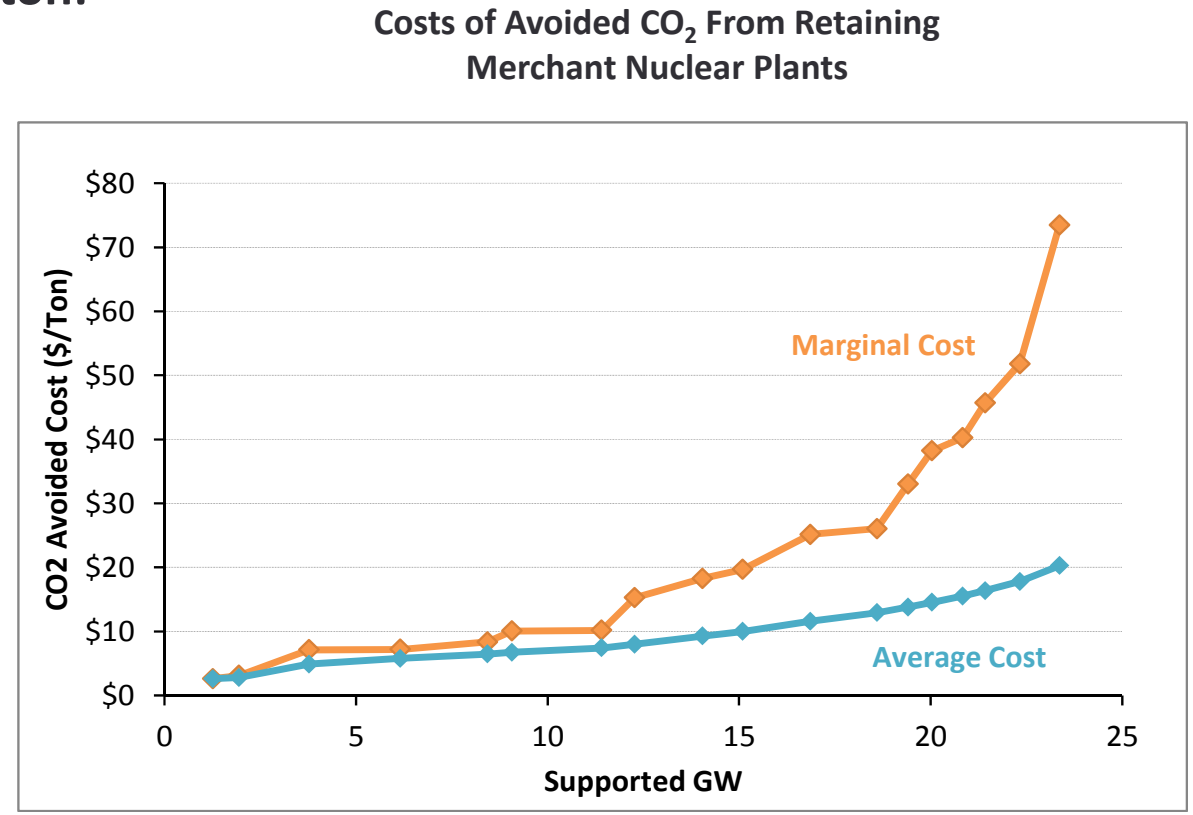
CO_2 Impact of Sustaining Merchant Nuclear Plants

Supporting all 23 GW of threatened merchant nuclear plants would cost about $2.7 annually and avoid over 130 million metric tons of CO_2 emissions per year, based on the regional fuel mix (gas v. coal) that would replace it in the near term:



Marginal and Average Cost of CO_2 Avoided

About half of the threatened nuclear fleet could be supported with an average cost per ton of CO_2 avoided below $10/ton; while the most expensive reductions would be about $75/ton, the average cost would be $20/ton:



Policy Design

An inexpensive, plant-specific "green long-term capacity payment" or "green RMR" program could sustain the GHG benefits of merchant nuclear plants that are at risk of not recovering their fixed costs.

- Ideally, this would comprise only the payment necessary to maintain the capacity
- Merchant units most at risk when their PPAs expire – may provide the opportunity for public support
- Reliability Must-Run (RMR) contracts used to preserve units that were needed for grid reliability but were "stranded " under deregulation provide an example
  - Unit specific, cost-of- service
  - Controversial and litigious
- No national, or all-generation, carbon price would be required
- Payments could be adjusted downward, or even paid back, if energy market prices increase and support is no longer needed, and phased out if an actual carbon price is introduced

In addition, pending EPA rules on existing coal under CAA §111(d) might create a state or regional solution for uplift or other market support for zero-emission resource deployment or retention

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