

# Power Market Prices, Nuclear Generation & Greenhouse Gas Policy

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THE **Brattle** GROUP

# Introduction & Overview

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**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<sub>2</sub> 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<sub>2</sub> emissions raise significant concerns**

- In the near term, generation shortfall made up with dispatchable coal/gas
- Regret if CO<sub>2</sub> 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<sub>2</sub> price, retaining some marginal nuclear plants may require a modest “uplift” type of payment, a “green RMR” policy to prevent retirements and resultant CO<sub>2</sub> emissions**

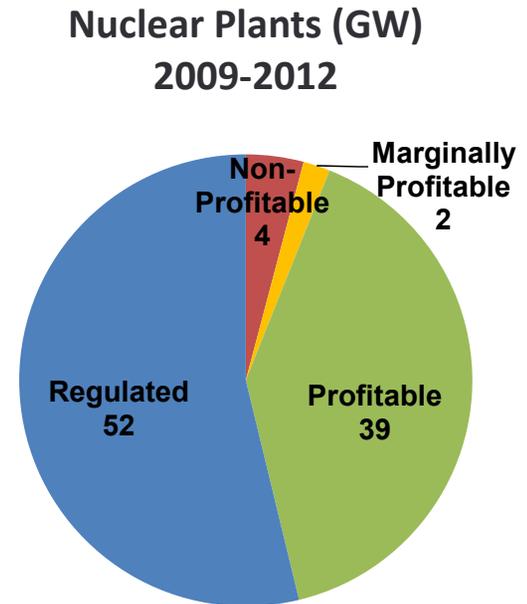
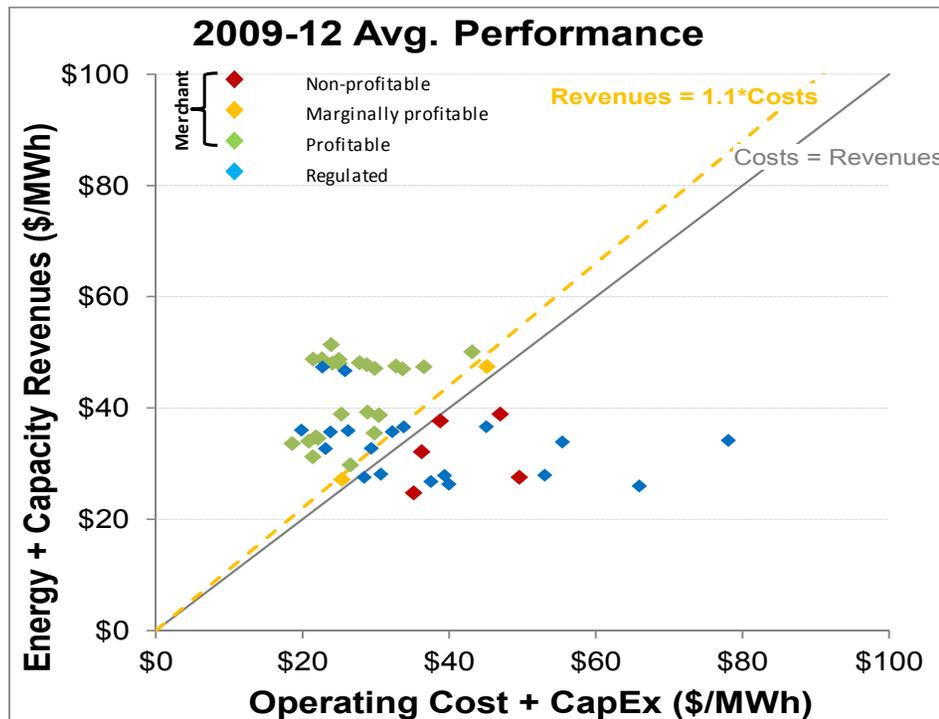
# Recent Merchant Nuclear Plant Retirements

|                                    | Vermont Yankee   | Kewaunee  |
|------------------------------------|--|---|
|                                    |  |  |
| <b>Operator and Plant Location</b> | Entergy; Vernon, VT  | Dominion; Carlton, WI   |
| <b>Installed Capacity</b>          | 628 MW   | 574 MW  |
| <b>Annual Output (2012)</b>        | 4,989 GWh (90% CF)   | 4,516 GWh (90% CF)  |
| <b>Marginal Generation Fuels</b>   | 80% Gas/20% Coal   | 30% Gas/70% Coal  |
| <b>CO<sub>2</sub> avoided</b>      | 2.7 MMtons/yr  | 3.78 MMtons/yr  |
| <b>Vehicle Equivalent</b>          | 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.

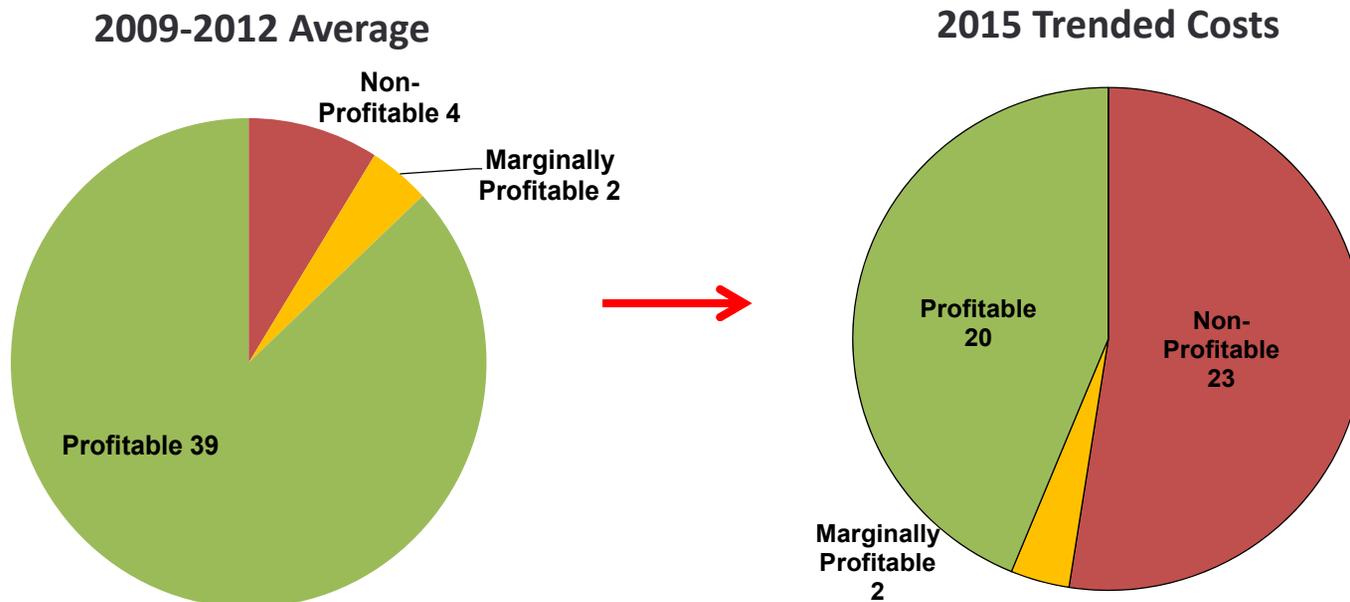


# Merchant Nuclear Margins by 2015

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).

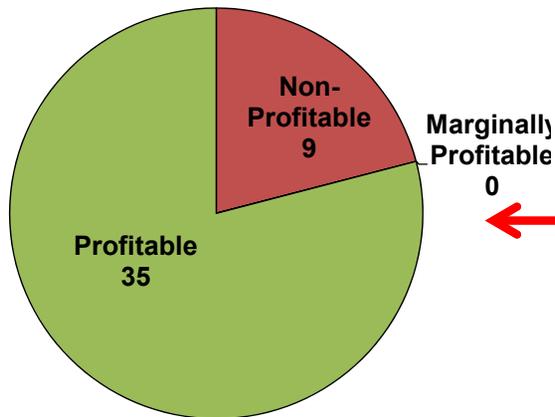
- Market forwards for 2015 are similar to 2009-2012 average spot prices
- Over the last 5 years, O&M increased by 5% per year and CapEx increased by 17% per year (nominal, average over the entire nuclear fleet)



# Potential Economic Improvements

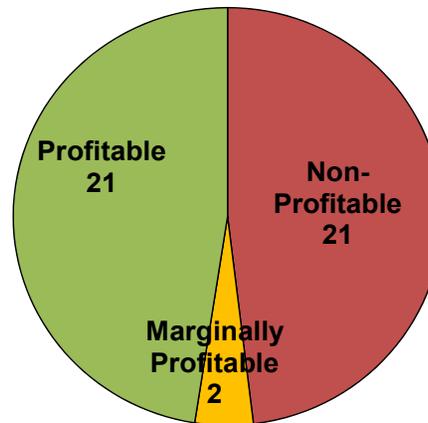
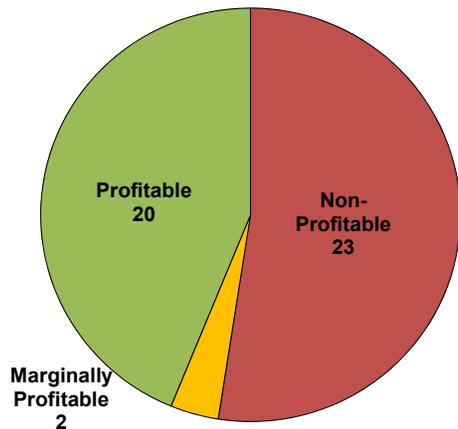
Eliminating growth in fixed costs, higher gas prices, or economy wide carbon price would increase the profitability of merchant nuclear units:

No Cost Increase



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

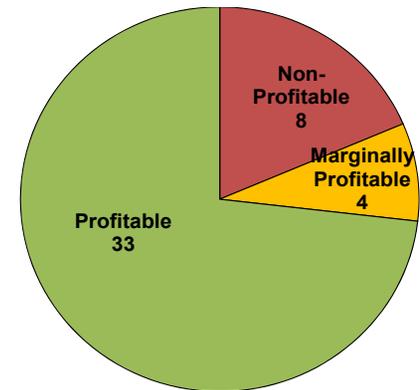
2015 Trended Costs



Gas Price + \$1/mmBtu

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

\$20/ton CO2



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

# Nuclear - CO<sub>2</sub> Emissions & Avoided Cost

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**1 GW nuclear avoids 3.4 MMtons/yr of CO<sub>2</sub> relative to gas combined cycle, equivalent to 500,000 gasoline cars @ 15,000 miles/yr and 20 mpg**

- About twice as large a CO<sub>2</sub> 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<sub>2</sub> for NEW wind & solar can be quite high**

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

**Levelized cost of avoided CO<sub>2</sub> for NEW nuclear is also \$100+/ton**

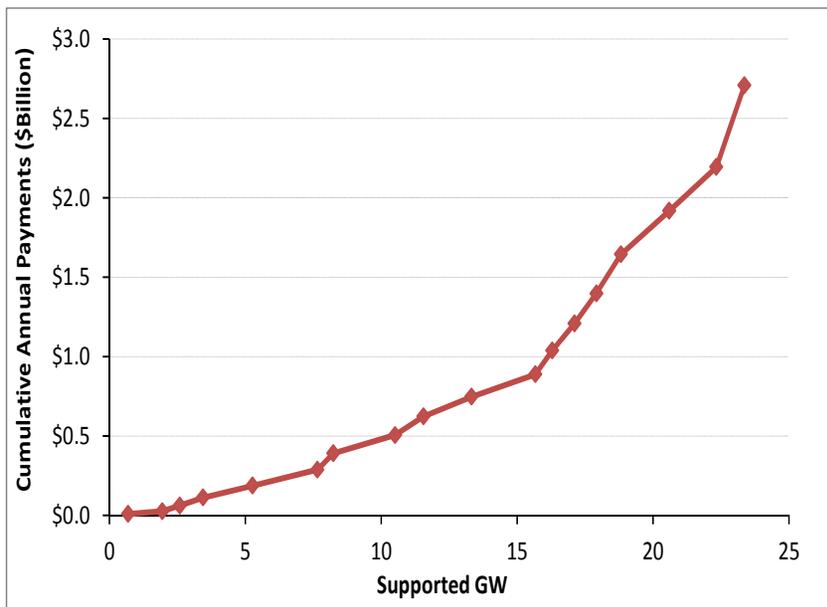
**Key public policy questions become:**

- **If existing nuclear is threatened, what would it cost to avoid retirement?**
  - Overall cost and \$/ton CO<sub>2</sub> emissions avoided
- **If preserving existing nuclear is a relatively cheap way of avoiding CO<sub>2</sub>, what kind of policy could work?**

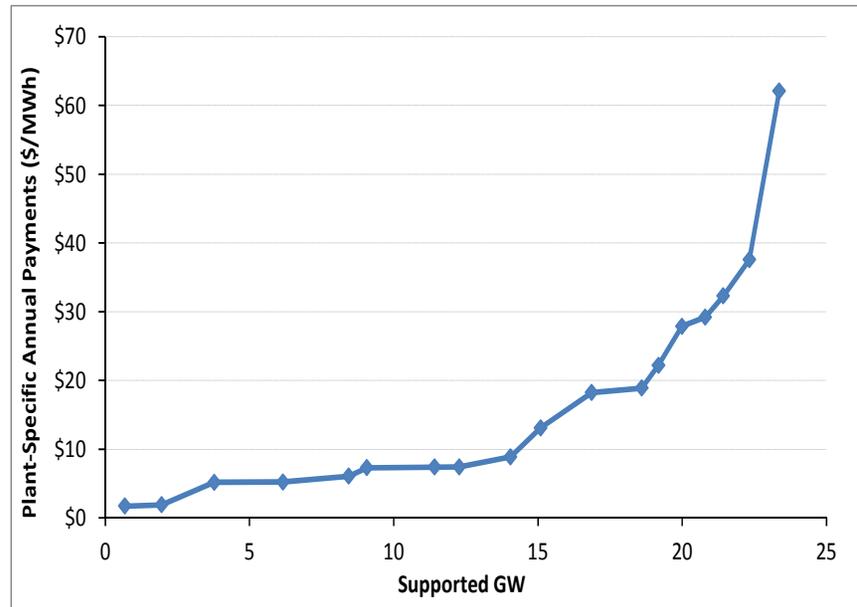
# Cost of Sustaining Merchant Nuclear Plants

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



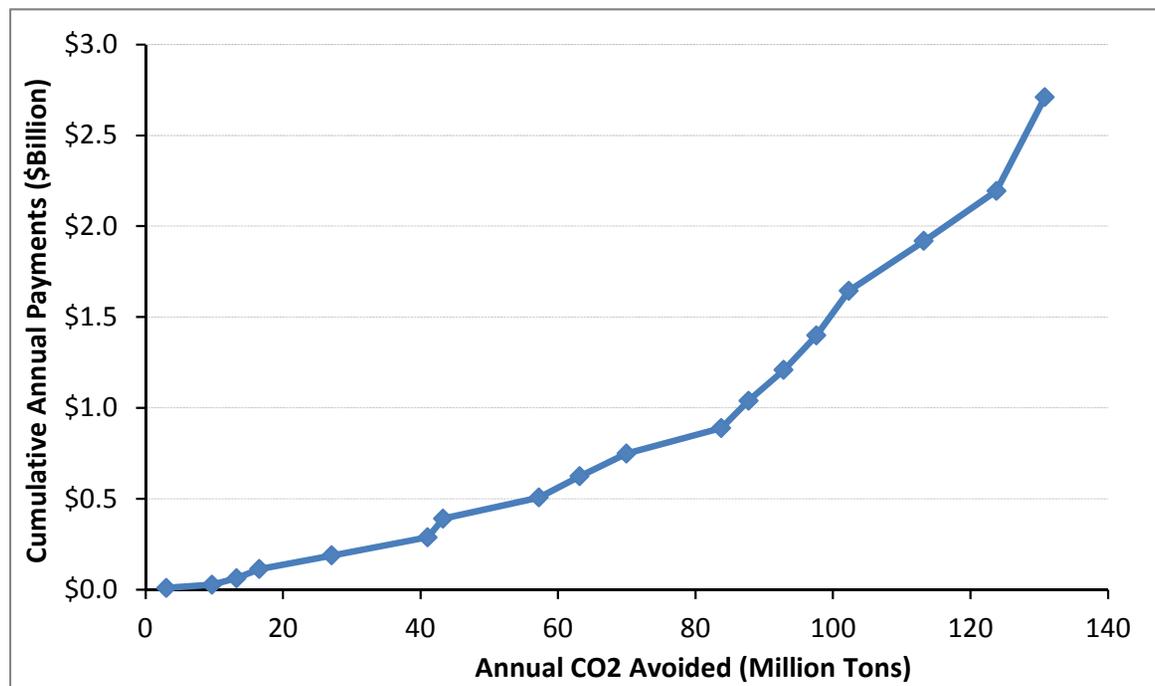
\$/MWh Equivalent Needed to Sustain Merchant Nuclear Plants



## CO<sub>2</sub> 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<sub>2</sub> emissions per year, based on the regional fuel mix (gas v. coal) that would replace it in the near term:

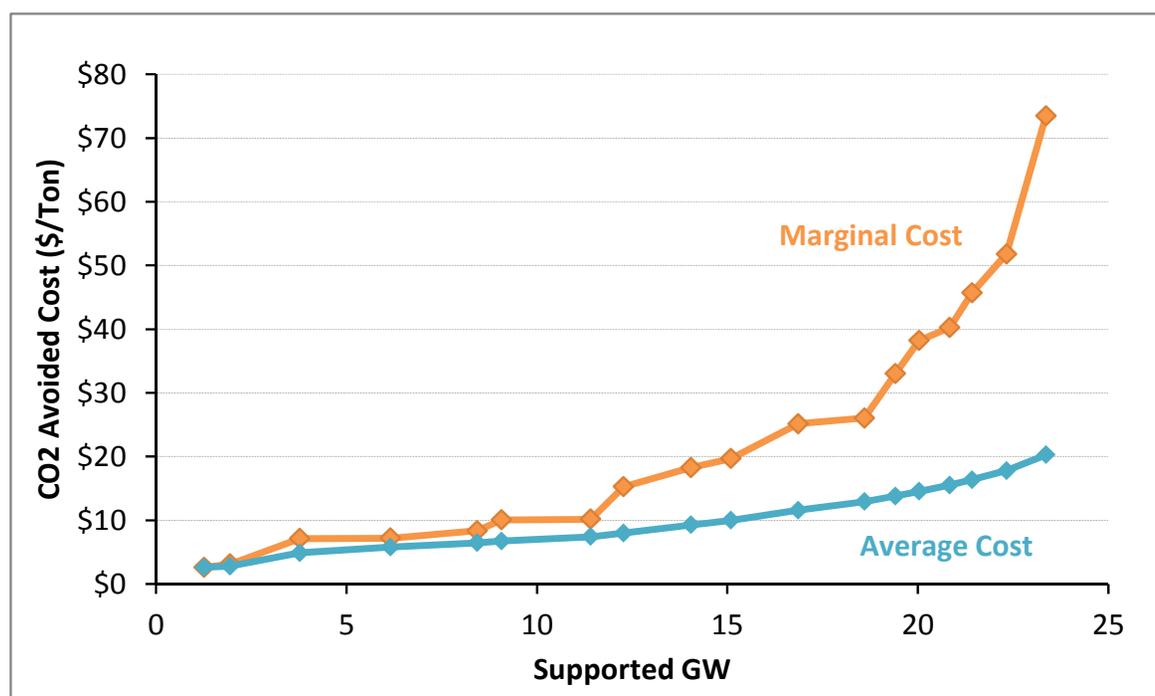
Cost and Avoided CO<sub>2</sub> From  
Retaining Merchant Nuclear Plants



## Marginal and Average Cost of CO<sub>2</sub> Avoided

About half of the threatened nuclear fleet could be supported with an average cost per ton of CO<sub>2</sub> avoided below \$10/ton; while the most expensive reductions would be about \$75/ton, the average cost would be \$20/ton:

Costs of Avoided CO<sub>2</sub> From Retaining Merchant Nuclear Plants



## Policy Design

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**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**

## The Authors

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