Power Market Prices, Nuclear Generation & Greenhouse Gas Policy

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THE Brattle GROUP
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 CO₂ 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 CO₂ emissions raise significant concerns

- In the near term, generation shortfall made up with dispatchable coal/gas
- Regret if CO₂ policy enacted and resulting market would support nuclear
- Assuming no coal long term, a smaller nuclear fleet would require all gas baseload

Absent a CO₂ price, retaining some marginal nuclear plants may require a modest “uplift” type of payment, a “green RMR” policy to prevent retirements and resultant CO₂ emissions
## Recent Merchant Nuclear Plant Retirements

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<th><strong>Vermont Yankee</strong></th>
<th><strong>Kewaunee</strong></th>
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<tbody>
<tr>
<td><strong>Operator and Plant Location</strong></td>
<td>Entergy; Vernon, VT</td>
<td>Dominion; Carlton, WI</td>
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<tr>
<td><strong>Installed Capacity</strong></td>
<td>628 MW</td>
<td>574 MW</td>
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<td><strong>Annual Output (2012)</strong></td>
<td>4,989 GWh (90% CF)</td>
<td>4,516 GWh (90% CF)</td>
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<tr>
<td><strong>Marginal Generation Fuels</strong></td>
<td>80% Gas/20% Coal</td>
<td>30% Gas/70% Coal</td>
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<td><strong>CO₂ avoided</strong></td>
<td>2.7 MMtons/yr</td>
<td>3.78 MMtons/yr</td>
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<td><strong>Vehicle Equivalent</strong></td>
<td>400,000 Vehicles</td>
<td>550,000 Vehicles</td>
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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).

2009-2012 Average

- Profitable 39
- Marginally Profitable 2
- Non-Profitable 4

2015 Trended Costs

- Profitable 20
- Marginally Profitable 2
- Non-Profitable 23
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 - CO₂ Emissions & Avoided Cost

1 GW nuclear avoids 3.4 MMtons/yr of CO₂ relative to gas combined cycle, equivalent to 500,000 gasoline cars @ 15,000 miles/yr and 20 mpg
- About twice as large a CO₂ 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 CO₂ 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 CO₂ emissions avoided
- If preserving existing nuclear is a relatively cheap way of avoiding CO₂, 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:
**CO₂ 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 CO₂ emissions per year, based on the regional fuel mix (gas v. coal) that would replace it in the near term:

Cost and Avoided CO₂ From Retaining Merchant Nuclear Plants

![Graph showing cumulative annual payments vs. annual CO₂ avoided](image-url)
Marginal and Average Cost of CO₂ Avoided

About half of the threatened nuclear fleet could be supported with an average cost per ton of CO₂ avoided below $10/ton; while the most expensive reductions would be about $75/ton, the average cost would be $20/ton:

Costs of Avoided CO₂ From Retaining Merchant Nuclear Plants
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
The Authors

The Brattle Group provides consulting and expert testimony in economics, finance, and regulation to corporations, law firms, and governments around the world. The Principals involved in asset retirement studies are:

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Mr. Chupka provides expertise on the market impacts of both domestic and international energy and environmental policy. He assists energy market clients and counsel in a broad span of management analysis, regulatory proceedings, and litigation support. Mr. Chupka has focused on integrated resource planning, electricity and fuel procurement policies, renewable energy policy design, and climate change policies.

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