

Price and Investment Implications of Renewables

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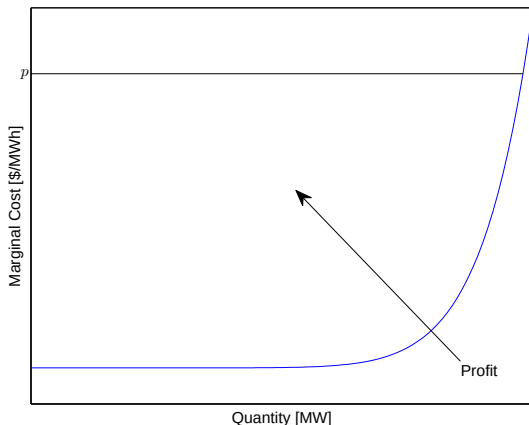


Electricity Sector Investment

- In a restructured market-based electricity sector, generation and transmission investments should be driven by price signals
 - Generation built to capture energy and other revenues
 - Transmission earns locational price differences (*i.e.*, differences in the cost of supplying energy at the two ends of a line)
- Neither system has worked perfectly

Electricity Sector Investment

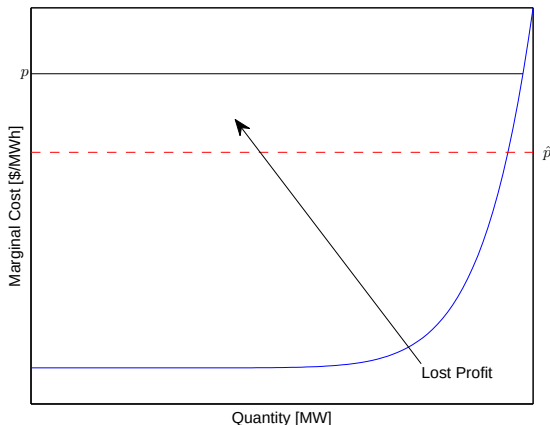
Generation Investment



- Prices are supposed to rise when capacity is scarce
- Price caps, market mitigation, or other administrative measures may suppress this
- Weaker signal for capacity to enter the market
- PJM uses a separate capacity market to incent investment

Electricity Sector Investment

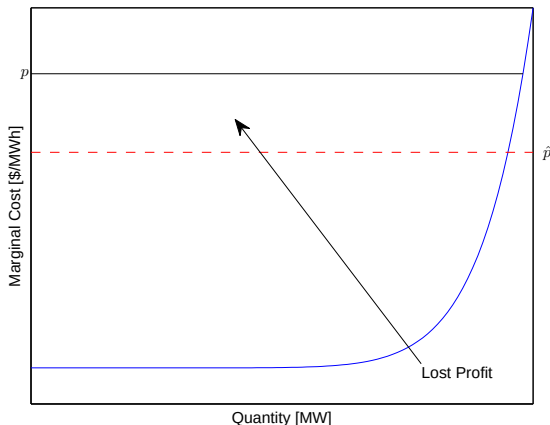
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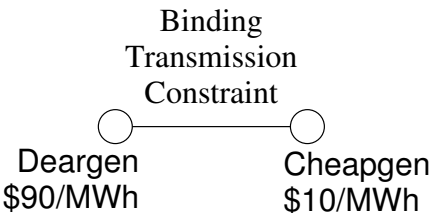
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Electricity Sector Investment

Transmission Investment



- Locational prices (\$90/MWh and \$10/MWh) reflect marginal cost of energy at two locations
- Paying transmission owner the \$80/MWh price difference provides theoretically correct signal for transmission investment
- More difficult in practice, due to lumpy investments, complex power flows, and market power

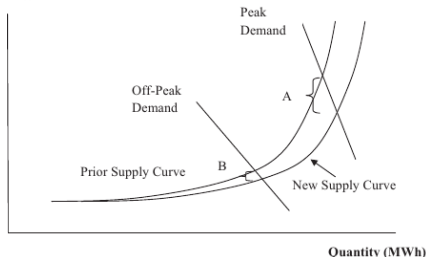
- Thus, transmission investment typically done through central planning
- Guided, in part, by prices

Price Effects of Renewables

Energy Prices

- Renewables are (near-)zero marginal cost
- Supply curve shifts rightward
- Reduces energy prices, with more pronounced effect during high-load periods
- Simulations suggest up to \$10/MWh of price suppression at current penetrations; cf.:
 - Sensfuß *et al.* (2008): *Energy Policy*, 36(8) 3086–3094
 - Sioshansi (2011): *The Energy Journal*, 32(2) 1-30

Wholesale Energy Price (\$/MWh)

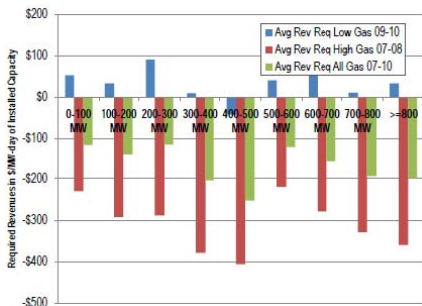


Felder (2011): *The Electricity Journal*, 24(4) 34–46.

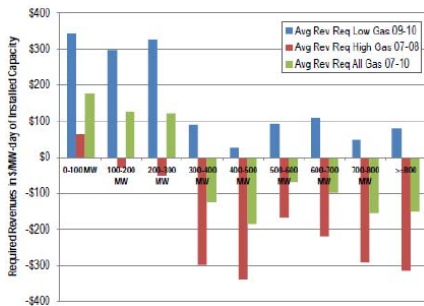
Price Effects of Renewables

Capacity Prices

- Lower energy prices mean generators must go elsewhere (*i.e.*, capacity market) for revenues
- Exact capacity prices hard to predict, but recent experience due to low natural gas prices and emissions retrofits demonstrate possible scale



No retrofits



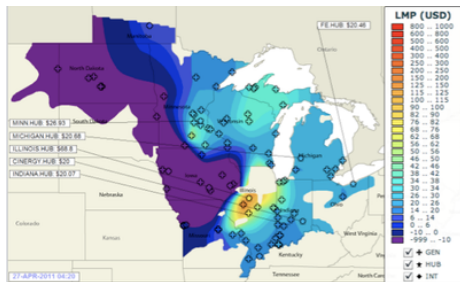
Retrofits

Figures: Capacity market revenues needed for coal generators in PJM.
Sotkiewicz (2012): *Proc. 2012 IEEE PES GM*.

Price Effects of Renewables

Locational Energy Prices

- Renewables can also suppress locational prices
- When transmission constraints prevent wind being delivered to consumers
- Two predominant effects:
 - Costly for conventional (e.g., steam turbine) generators to cycle on and off $\Rightarrow$ prefer to generate at a marginal loss
 - Wind generators prefer to generate at a marginal loss to capture production tax or other payments (e.g., REC)

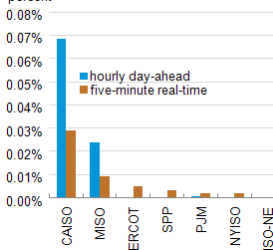


27 April, 2011. Midwest ISO Website

Price Effects of Renewables

Transmission Investment Signals

Frequency of negative prices, 2011
percent



Source: US DOE EIA

- Likely to see more negative prices as renewable penetrations rise
- Exacerbated by lagging transmission expansion
- Nothing 'theoretically wrong' with negative prices
- If driven by conventional generator constraints, provide strong signals to replace with more flexible generation or increase transmission capacity
- If driven by RECs, provide signals that transmission capacity is needed to deliver renewable energy to consumers
- Production tax credit and other subsidies can distort signal, make transmission seem necessary when not socially desirable