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Value of Flexible Operation of Advanced Coal Plants with CCS

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Workshop on Operating Flexibility of Power Plants with CCS

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Background

- Emerging literature on flexible operation of coal with CCS (e.g., Gibbins, Chalmers, et al.)
  - Appears technically feasible – though many engineering questions remain
  - Little analysis of the potential economic benefits
    - May differ significantly by region
    - Will include economic benefits that are hard to measure
  - Little discussion of political viability
- EPRI's CoalFleet for Tomorrow program undertook an economic "scoping" analysis in 2007:
  - Rough estimate of the economic value of flexibility over time in several US regions
- Updating and extending analyses in 2009-2010

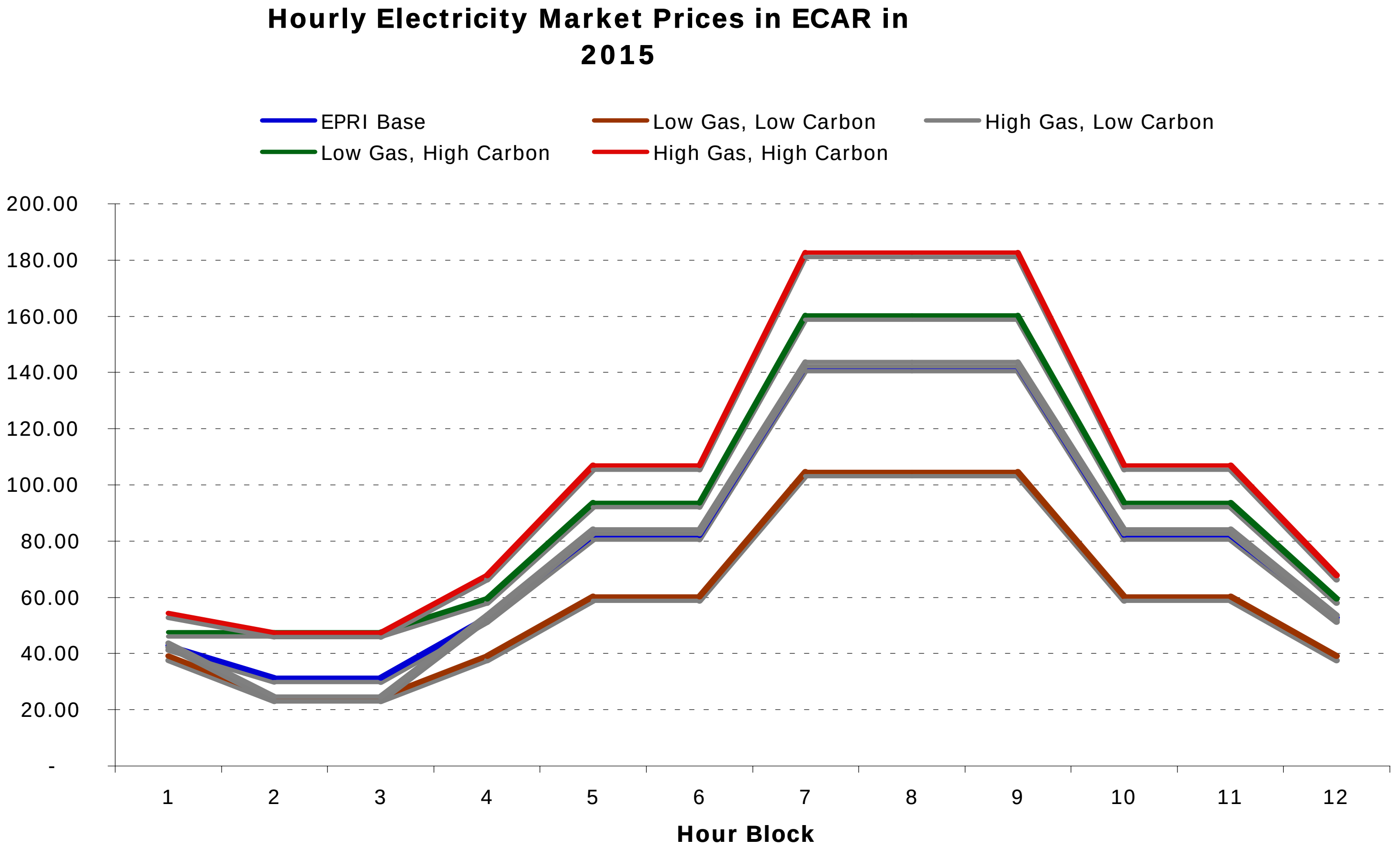
Why Consider Flexible Operation of Advanced Coal w/ CCS?

- Technical Requirements
  - What if CO_2 compression fails or pipeline does not accept CO_2?
- Operational Value
  - Advanced coal with CCS is more like a chemical plant than a conventional power plant
    - Distinct intermediate products produced for use in other processes
    - Components operating in parallel rather than in series
    - Integration

And …

Why Consider Flexible Operation of Advanced Coal w/ CCS? (continued)

- Economic reasons
  - Regaining capacity at peak hours



Examples: Consider Two Types of Flexibility for an IGCC Plant with CCS

- Free Venting
  - When electricity price is high and CO_2 price is low, CCS is halted to produce more electricity from reduced auxiliary loads
  - No capital investment is required to alter the plant so this always makes money
- Oversize Air Separation Unit
  - Additional investment required, so you may win or lose

Analysis Assumptions – Free Venting

556 MW IGCC Plant

	CCS Operation	Freely Venting
Heat Rate (Btu/kWh)	10,505	9,505
CO_2 Emissions (ton/MWh)	.10	.94
Auxiliary Loads (MW)	189	146
Output Gain (MW)		43

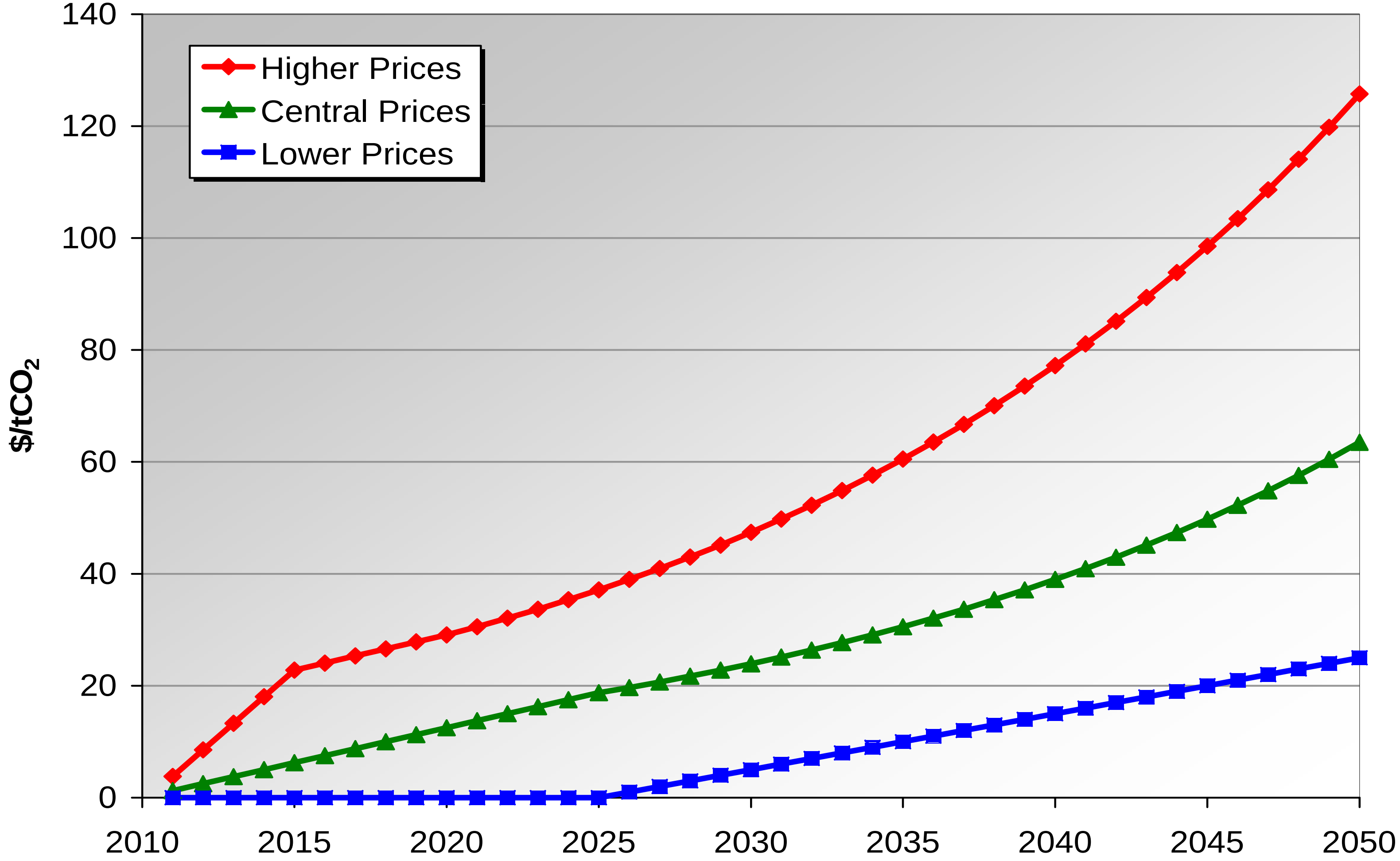
Also, assumes that policy framework allows you to vent

Analysis Approach

- To calculate the added cash flow we estimate electricity price and CO_2 value for every hour of the year
- CO_2 is vented if it increases cash flow for that hour
- The yearly value is the sum of the hourly values

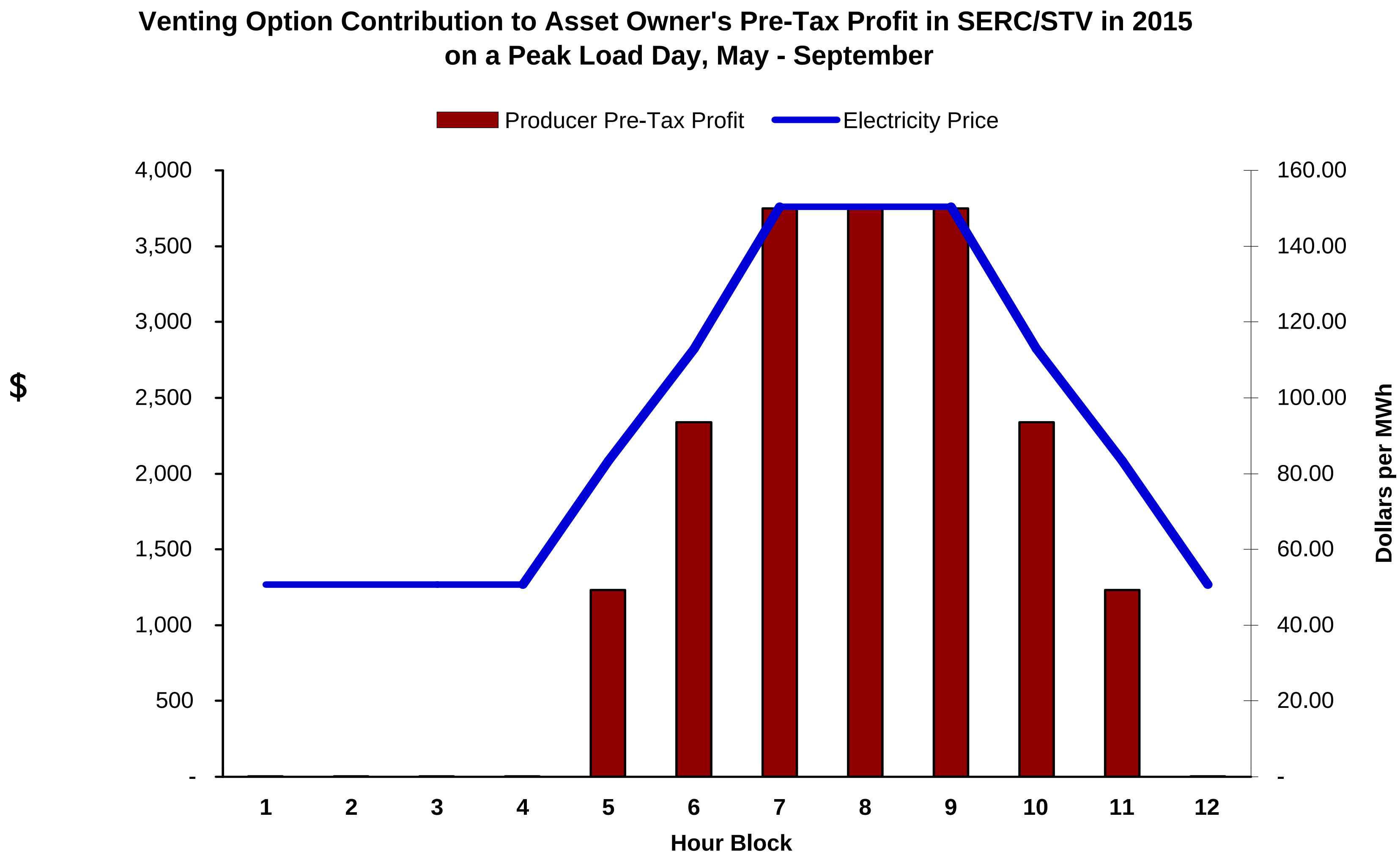
Simulations of electricity markets utilized a multi-region US electric sector model, NESSIE

Evaluated Value Across Three CO_2 Emission Allowances Price Scenarios *(EPRI Report 1011769)*



Note: This was 2007; the higher path would be viewed as low cost under current legislative proposals

Free Venting Allows Additional Revenue with Additional Cost of Paying for CO_2 Emissions



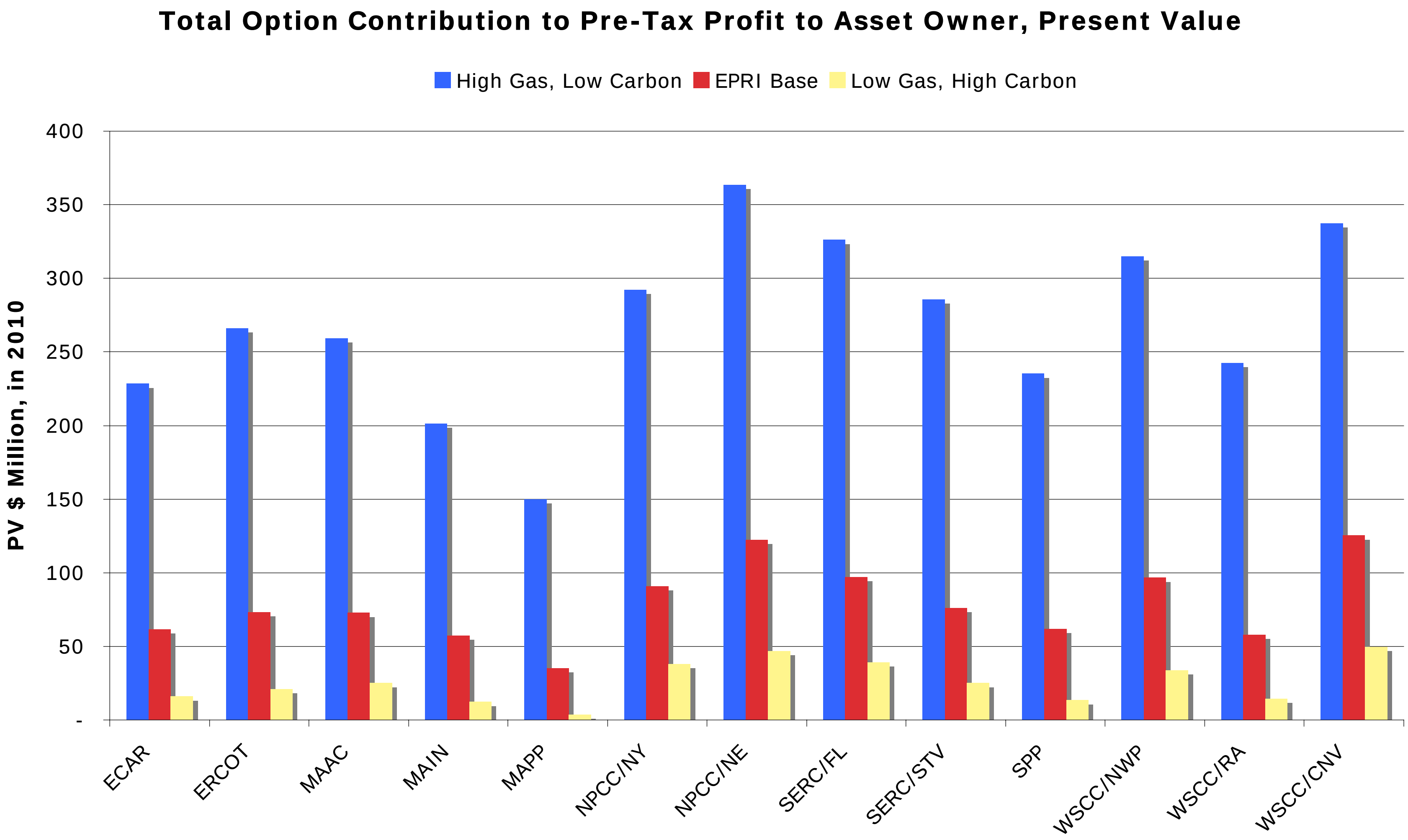
Venting Option Impact in the Southeast (SERC/TVS)

Producer Profit (PV in 2010)	
Net Profit ($ Million)	44.7
Net Profit ($ per kW)	80.4
Customer Cost (PV $ Million in 2010)	
Rate Savings due to Avoided Capacity	29.6
Taxpayer Receipts (PV $ Million in 2010)	
Net Taxpayer Receipts	19.6
Total Social Impact (PV $ Million in 2010)	**93.8**

Sensitivity of Value to CO_2 and Gas Prices

	High Gas, Low Carbon	EPRI Base	Low Gas, High Carbon
Producer Profit (PV in 2010)			
Net Profit ($ Million)	164.7	44.7	13.6
Net Profit ($ per kW)	296.2	80.4	24.5
Customer Cost (PV $ Million in 2010)			
Rate Savings due to Avoided Capacity	29.6	29.6	29.6
Taxpayer Receipts (PV $ Million in 2010)			
Net Taxpayer Receipts	84.2	19.6	2.8
Total Social Impact (PV $ Million in 2010)	**278.4**	**93.8**	**46.0**

Value of Option to Vent Varies by Region



2nd Example of Flexibility: Oversized Air Separation Unit (ASU)

- Oversize the ASU by one third and provide storage for six hours of air products
  - Run ASU and overproduce at periods of low electric prices
  - Shut down ASU when electric prices are high, use stored air products, and sell production from reduced aux power loads into grid

Analysis Parameters for ASU Oversizing

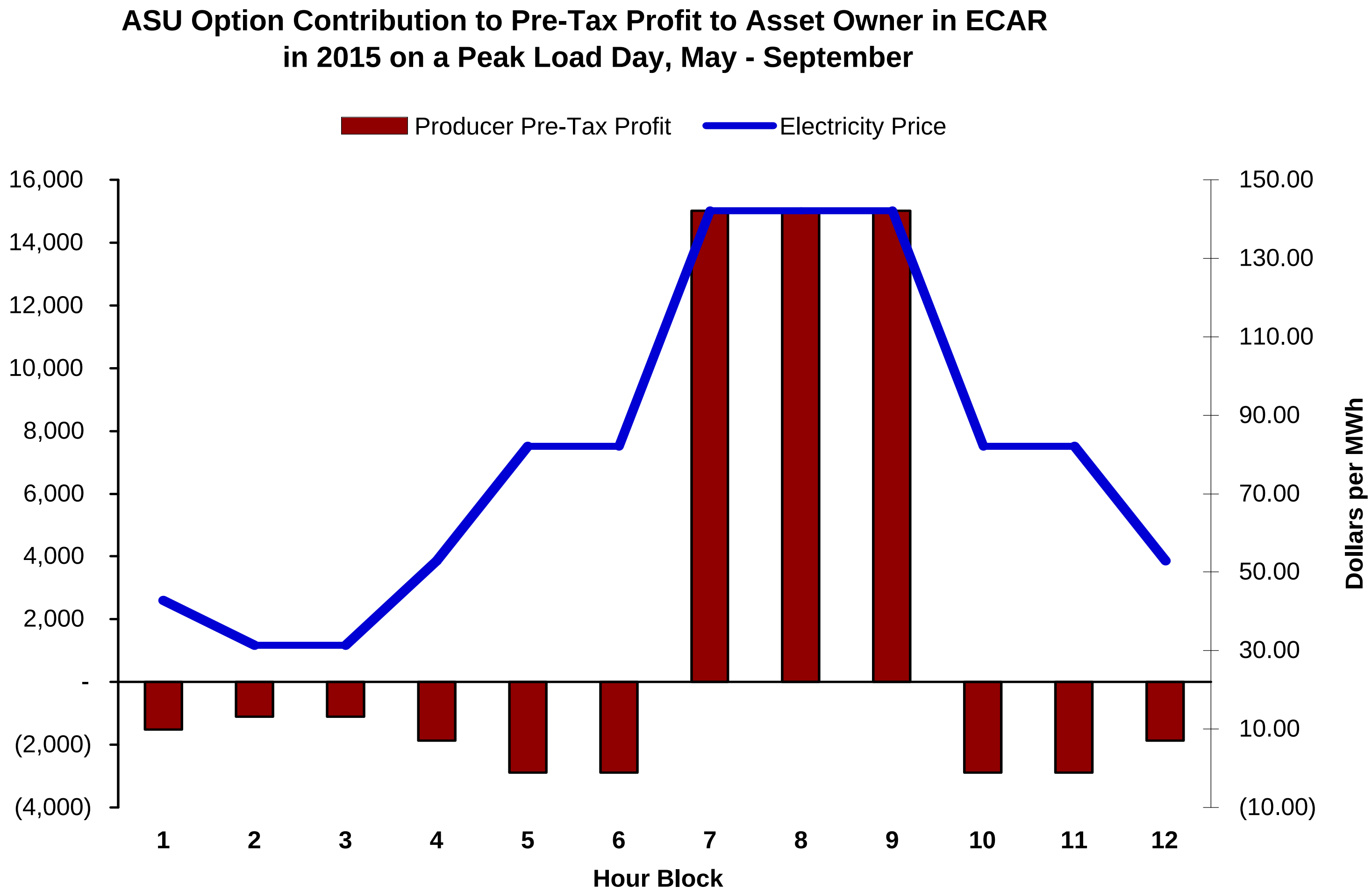
	Normal Operation	Larger ASU On	Larger ASU Off
Auxiliary Loads, MW	120	160	0
Gain in Output, MW		-40	120

Cost of ASU Expansion: 1/3 of Normal ASU Cost

Analysis Approach

- Need the price profile for each day in the year
- Find the highest six hours in the day and shut down the ASU during those hours
- The yearly cash flow value is the sum of the hourly values over the year

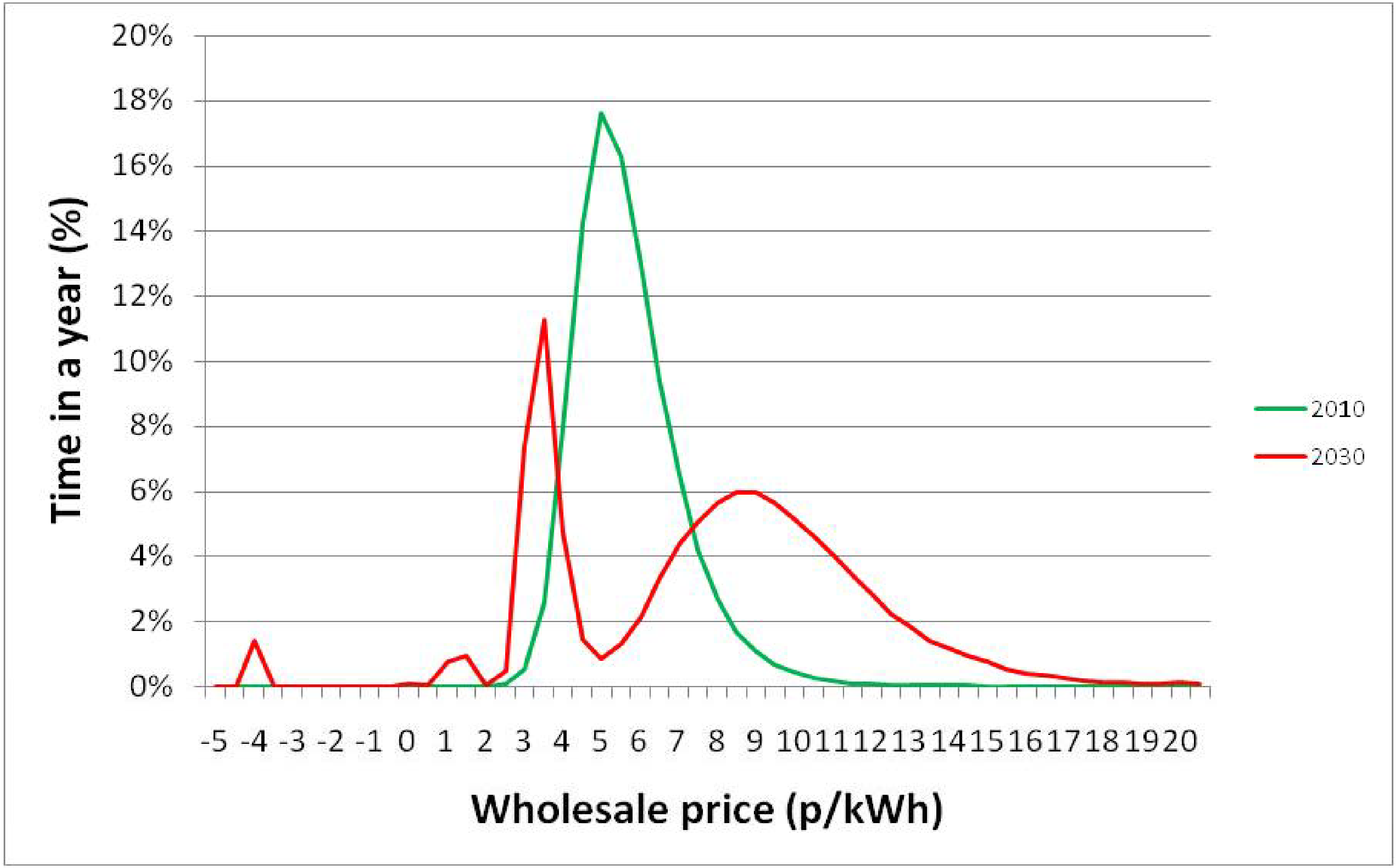
Calculating the Daily Cash Flow



ASU Option Impact in the Midwest (ECAR)

Producer Profit (PV in 2010)	
Net Profit ($ Million)	-51.0
Net Profit ($ per kW)	-91.8
Customer Cost (PV $ Million in 2010)	
Rate Savings due to Avoided Capacity	83.2
Taxpayer Receipts (PV $ Million in 2010)	
Net Taxpayer Receipts	-18.1
Total Social Impact (PV $ Million in 2010)	**14.0**

Value Likely Greater in a Low-Carbon System: E.g., UK Electric Prices in a Low-Carbon World?



Source: Redpoint modelling for Committee on Climate Change

Value Could Be Greater in When CO2 Price Volatility Considered

Source: IETA

Concluding Thoughts

- Both examples – venting and oversizing the ASU – potentially have positive social value even with simple analysis approach
  - Caveat: No detailed engineering done
  - Caveat: Did not consider ancillary services value and other possible value
  - Need more detailed analysis (stochastic, real options) to get better estimates
- Flexibility value depends on owner characteristics – region, electricity prices, need for peaking/quick replacement of intermittent generation
- Venting from a PC will provide more value because the capacity gain is greater than for IGCC
  - Capture technology advances reduce the energy penalty and the option value of flexibility
- Flexible operation will likely be a key issue for advanced coal with CCS
  - Operational reasons
    - If you have to have flexibility and can't vent … how do best implement it?
  - Possibly economic reasons – too early to tell how valuable it might be