GRID-INTERACTIVE ELECTRIC THERMAL STORAGE (ETS)WATER HEATING

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A Thermal Storage "Battery"

- Industry seeking a battery to store renewable energy
- Think of a 105 gallon water heater as a 26 kWh battery
  - Nominal two day supply of hot water
- GRE is storing approx. 1GWH each night, every night, in water heaters

Grid-interactive Electric Thermal Storage (ETS) Water Heating

- Provides renewables integration
- Offers ancillary value to wholesale markets
- Reduces carbon emissions
- Helps keep electric rates low

Smart "Grid-Interactive Controller"

- Adjusts the water temperature up or down in response to energy price or availability of renewable energy
- Varies the wattage to water heater electric elements
- Assures comfort is never compromised – home always has hot water

Renewable Integration

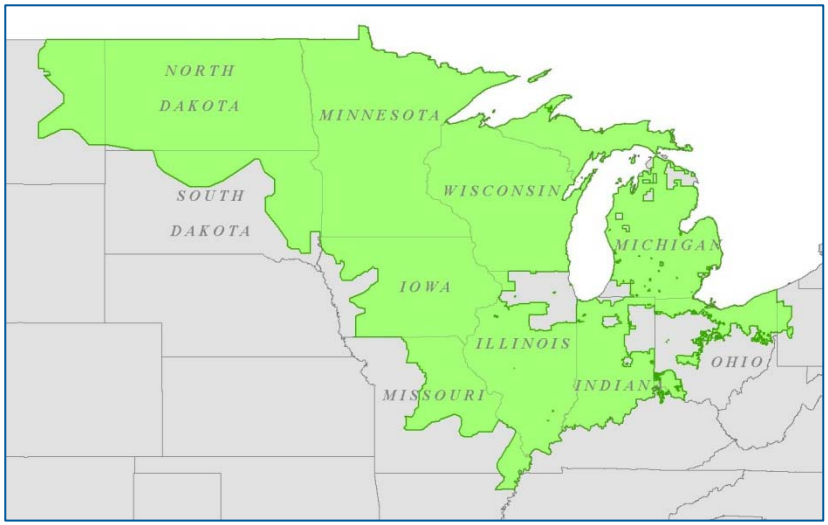
Wind and solar energy ramps up and down quickly…

- Grid-Interactive Controllers can ramp up and down as fast
  - Allows a higher percentage of renewable energy to be utilized
  - Enhances the value of renewable energy
  - Reduces water heater carbon footprint
  - Lowers operating costs

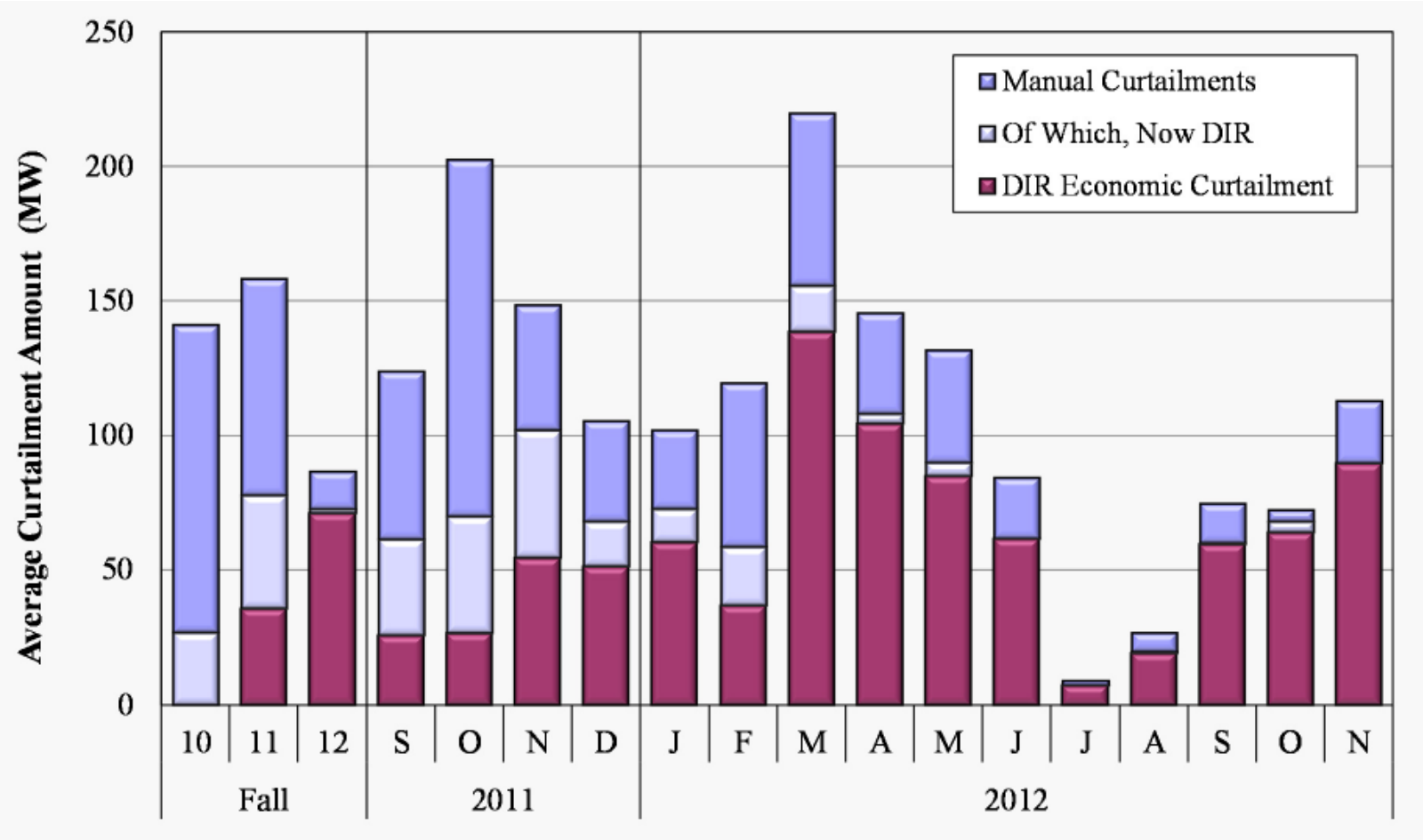
Renewable Integration

The bulk electric supply system continues to change…

- MISO set an all time wind peak at just over 10 GW on the morning of November 23rd.
  - More than 25% of the generation output being used at the time.



Wind Curtailments in MISO Fall 2010 - 2012

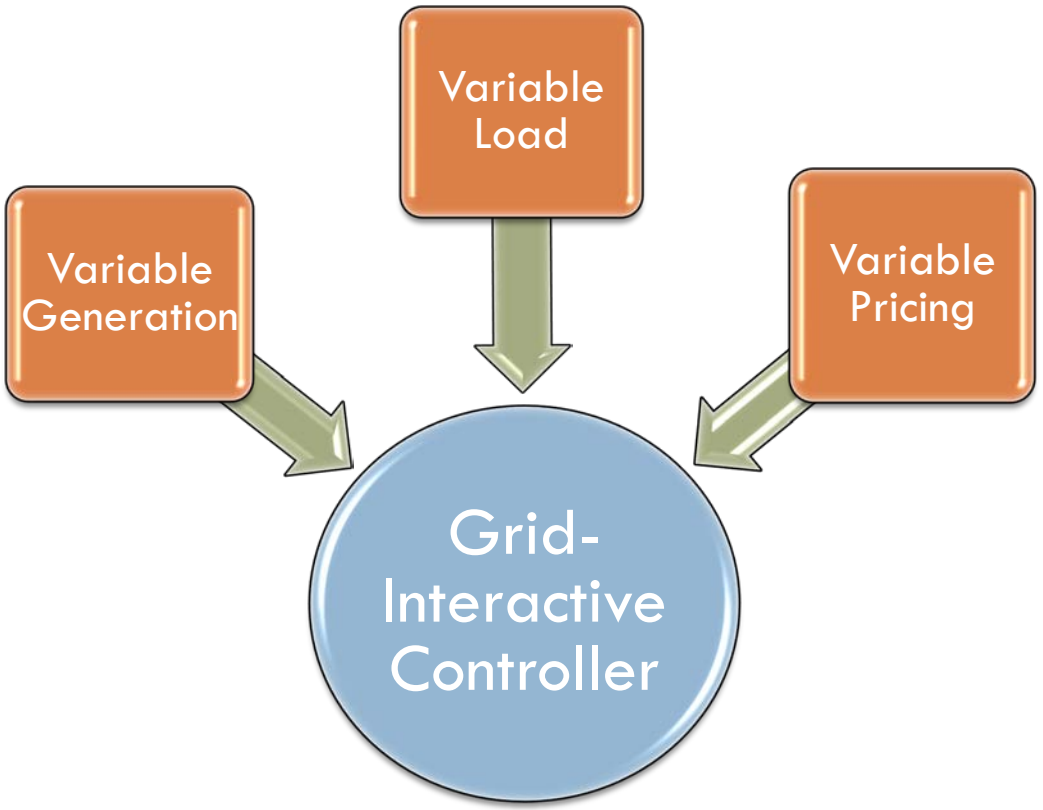


https://www.midwestiso.org/Library/Repository/Meeting%20Material/Stakeholder/BOD/Markets%20Committee/2012/20121212/20121212%20Markets%20Committee%20of%20the%20BOD%20Item%2003%20IMM%20Quarterly%20Report%20Fall.pdf

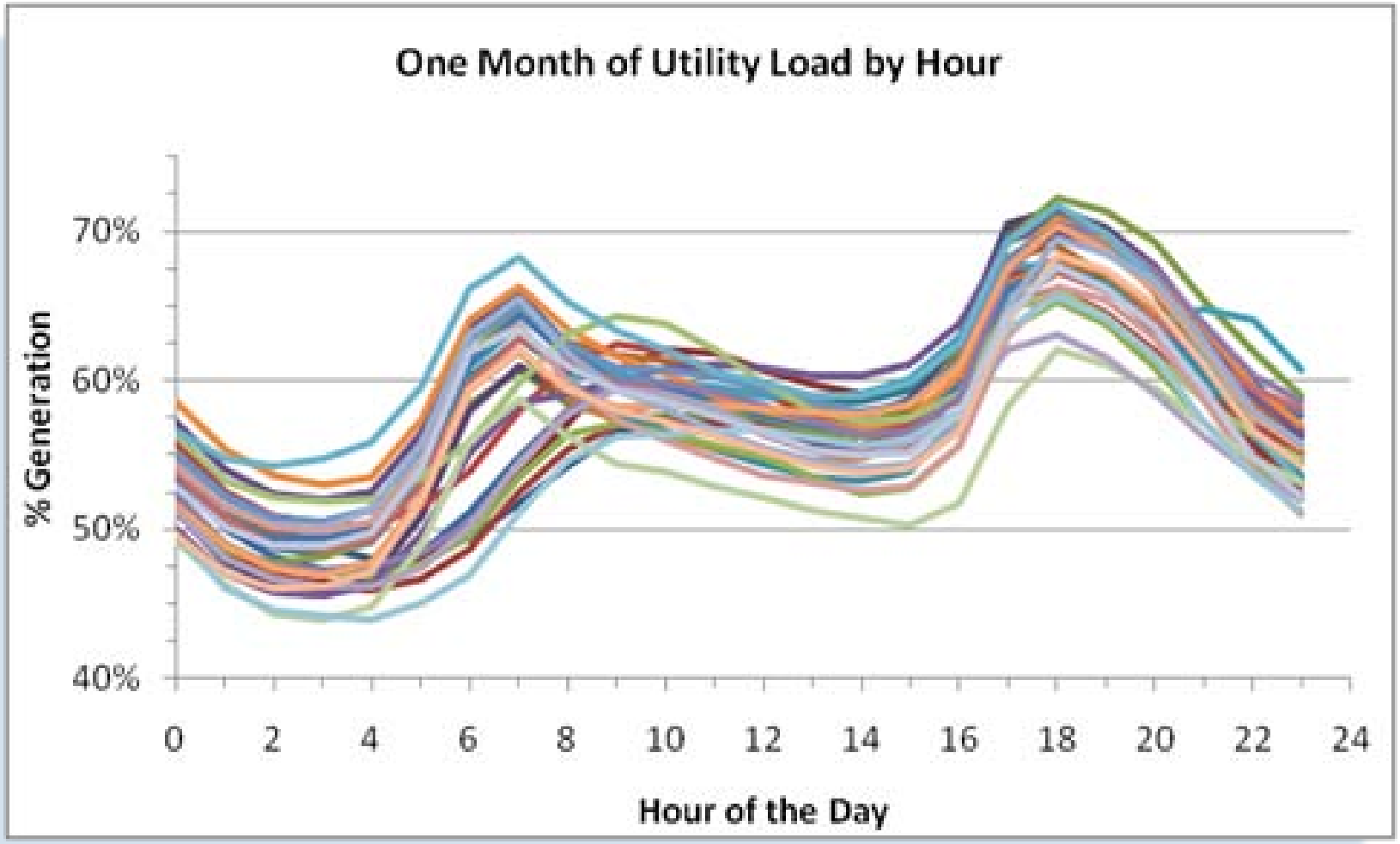
The Balancing Act

The needs of the smart grid include a balancing of…

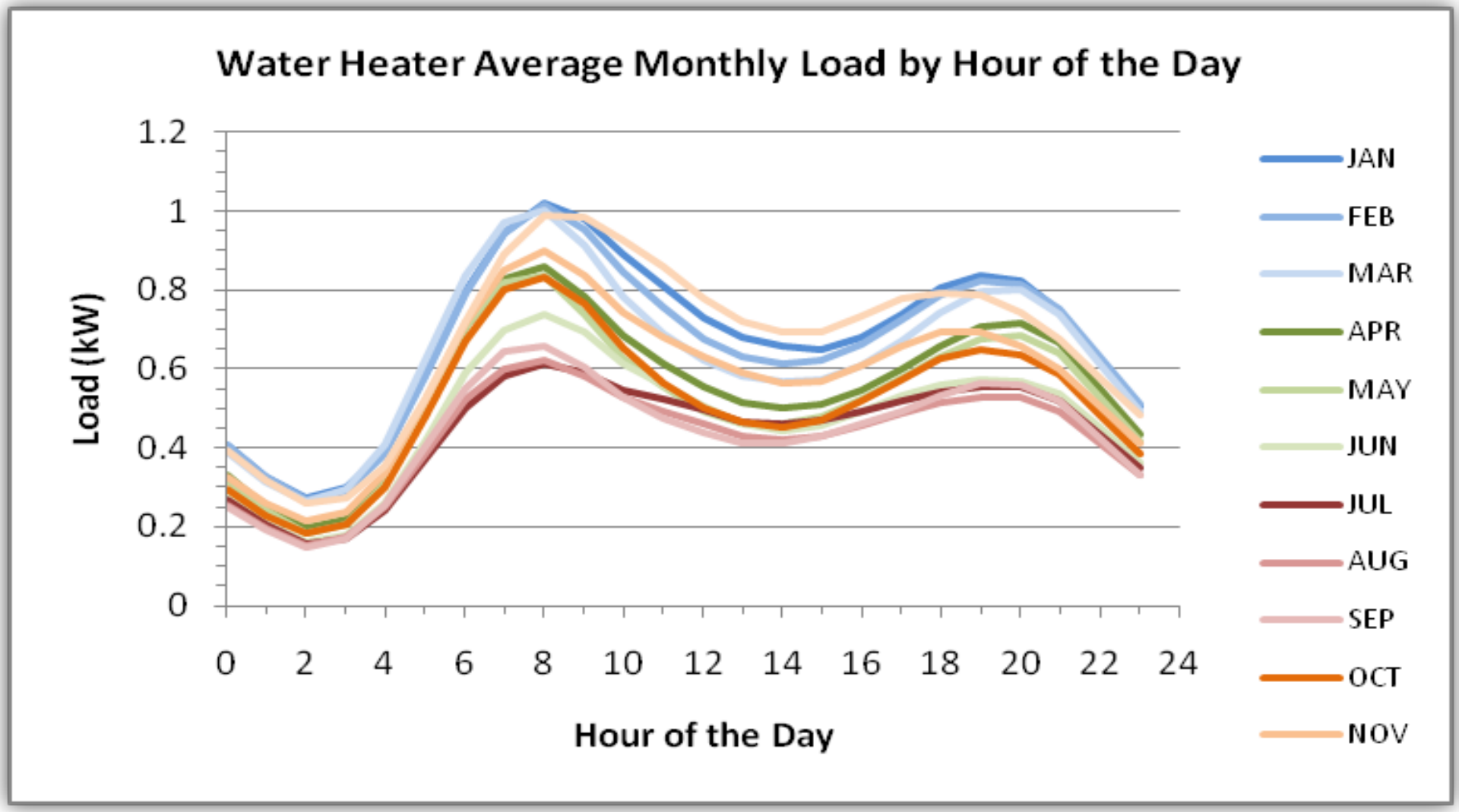
- Variable generation
- Variable load
- Variable pricing



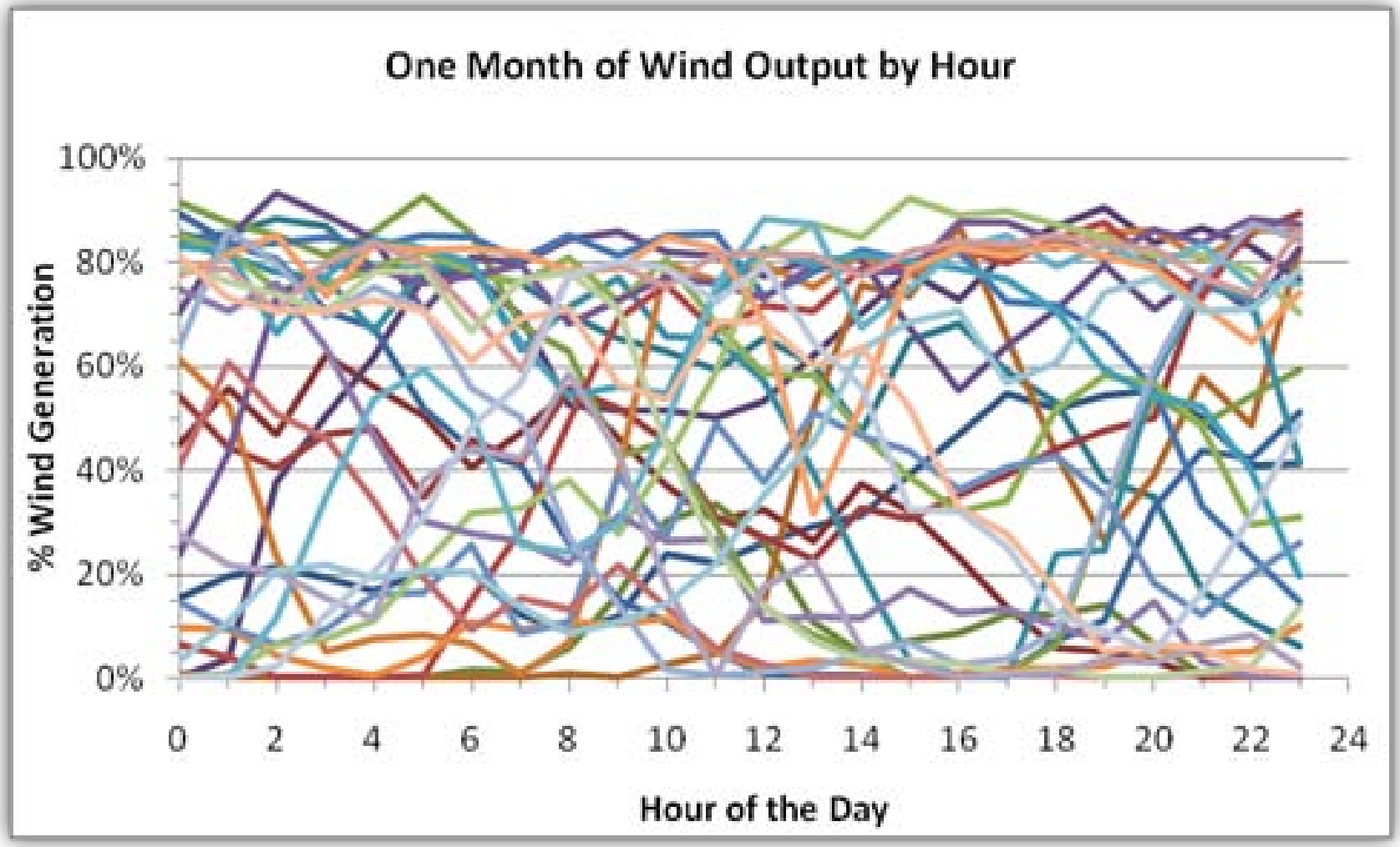
Variability of System Load



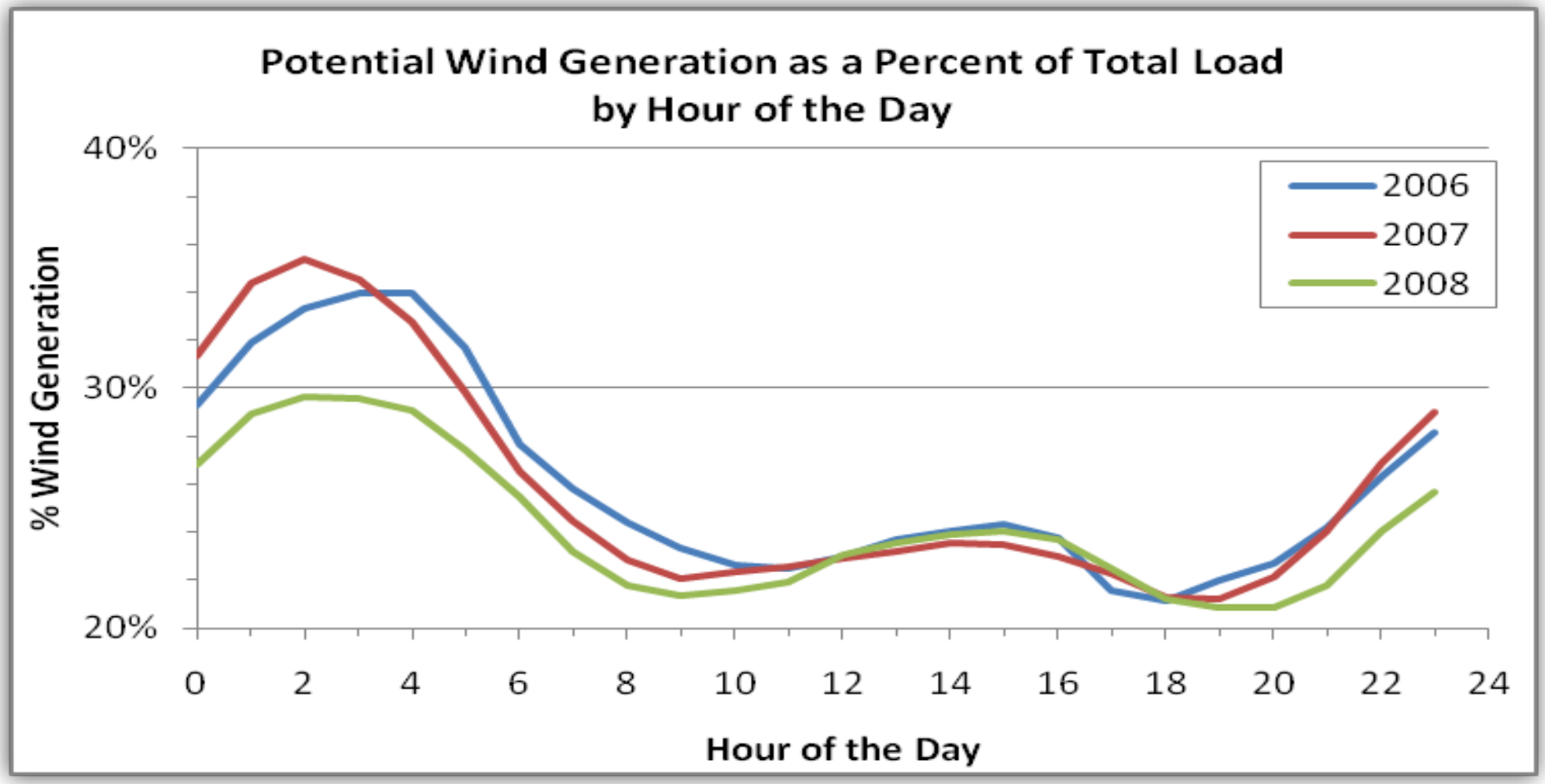
Variability of Water Heater Load



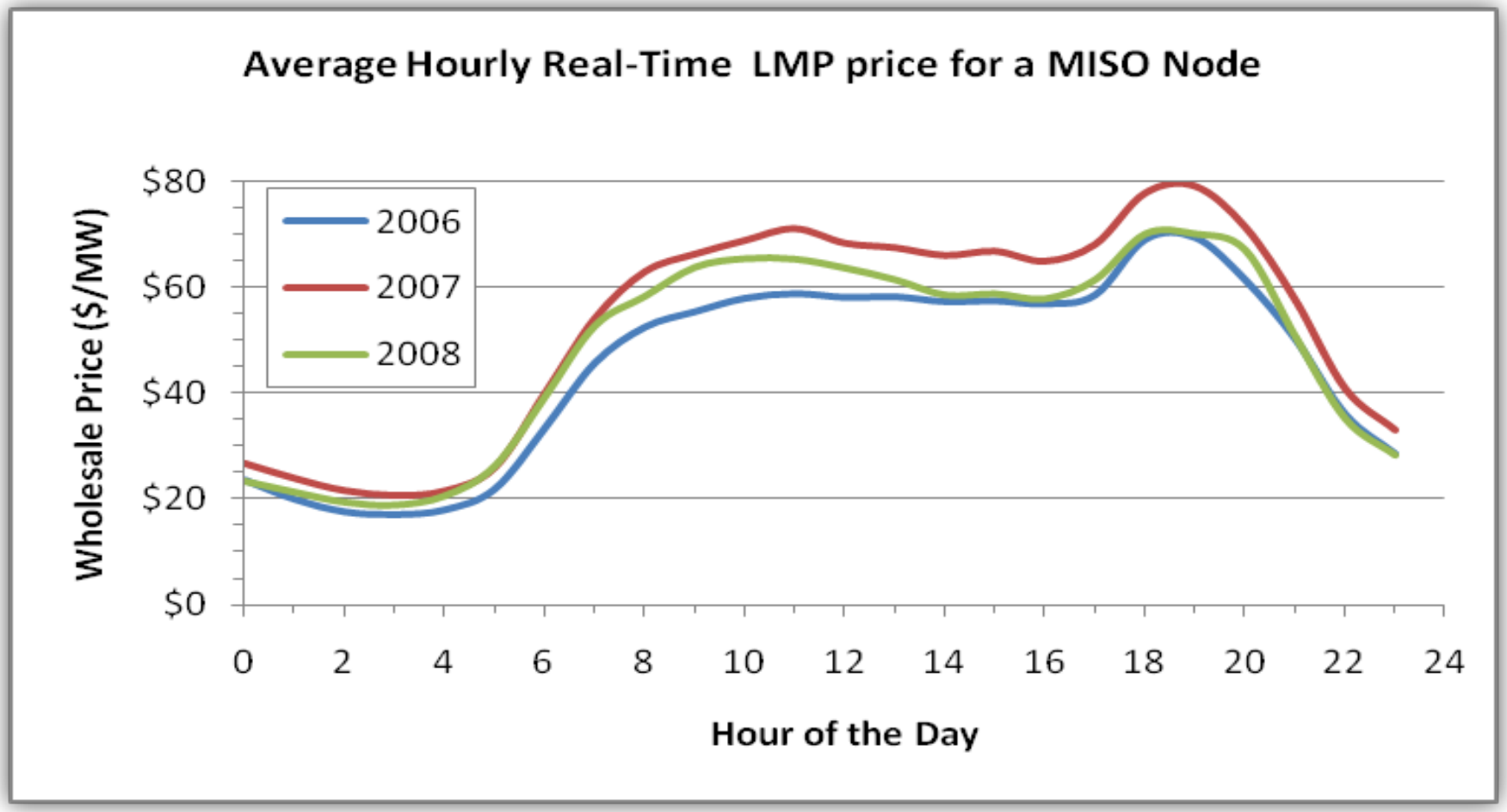
Variability of Renewables



Variability of Renewables



Variability of Pricing

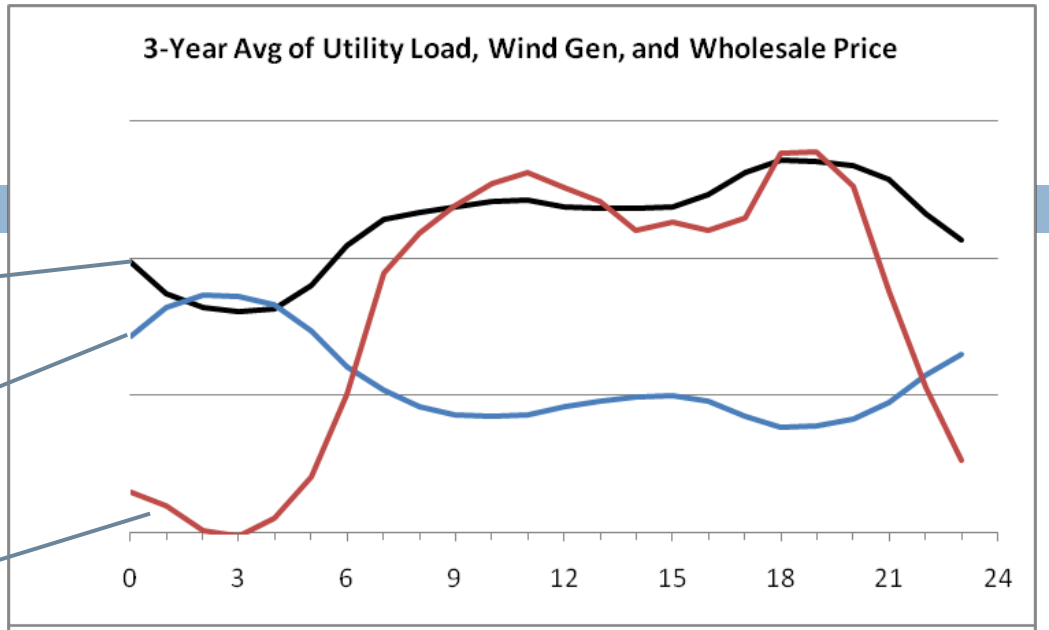


Putting it all Together

Overall Utility Load

Wind Generation

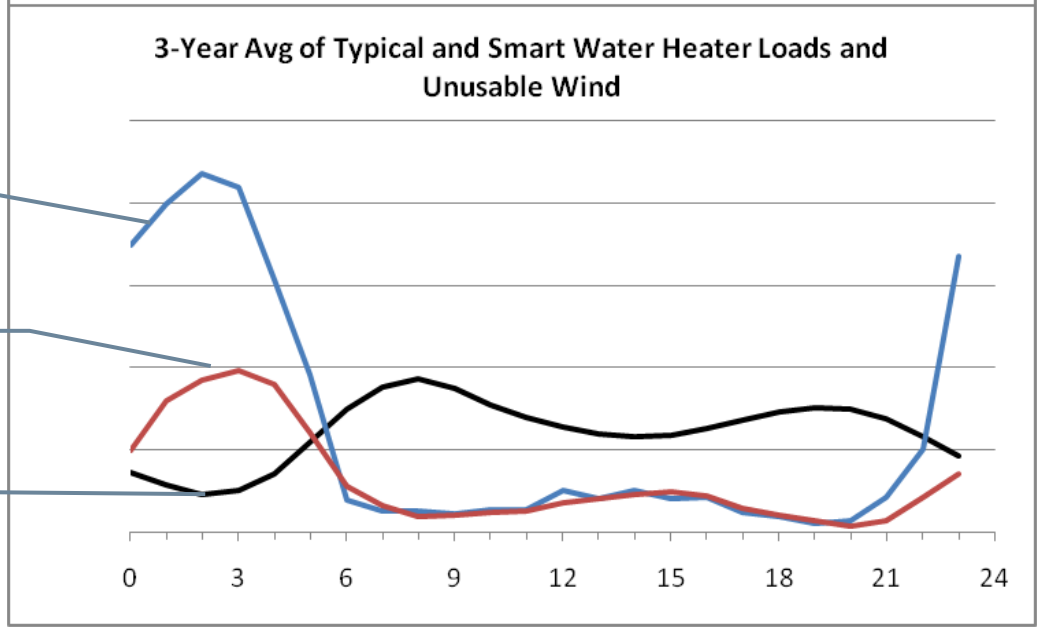
Wholesale Energy Cost



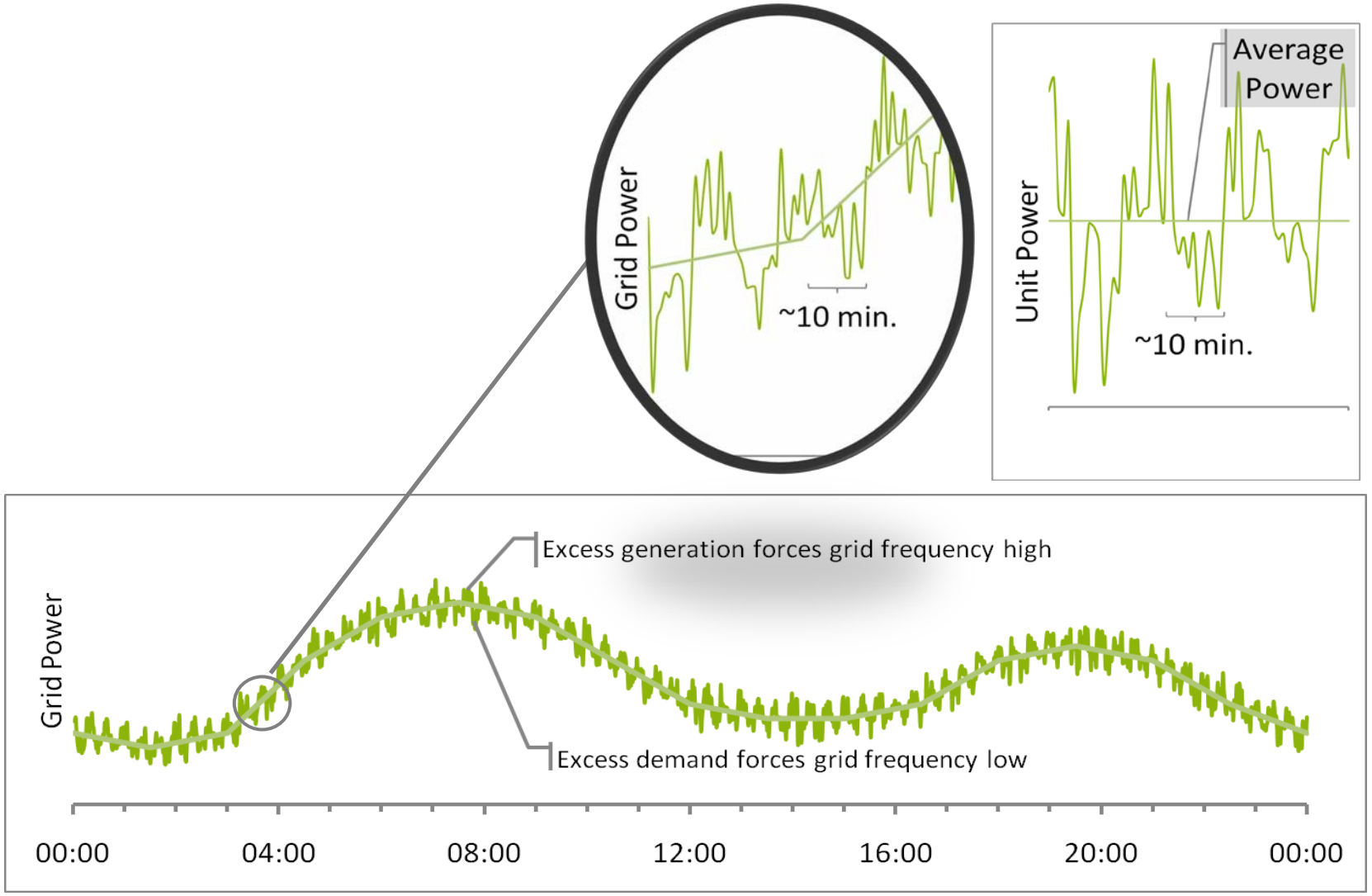
Smart Water Heater Load

Curtailed Wind Generation

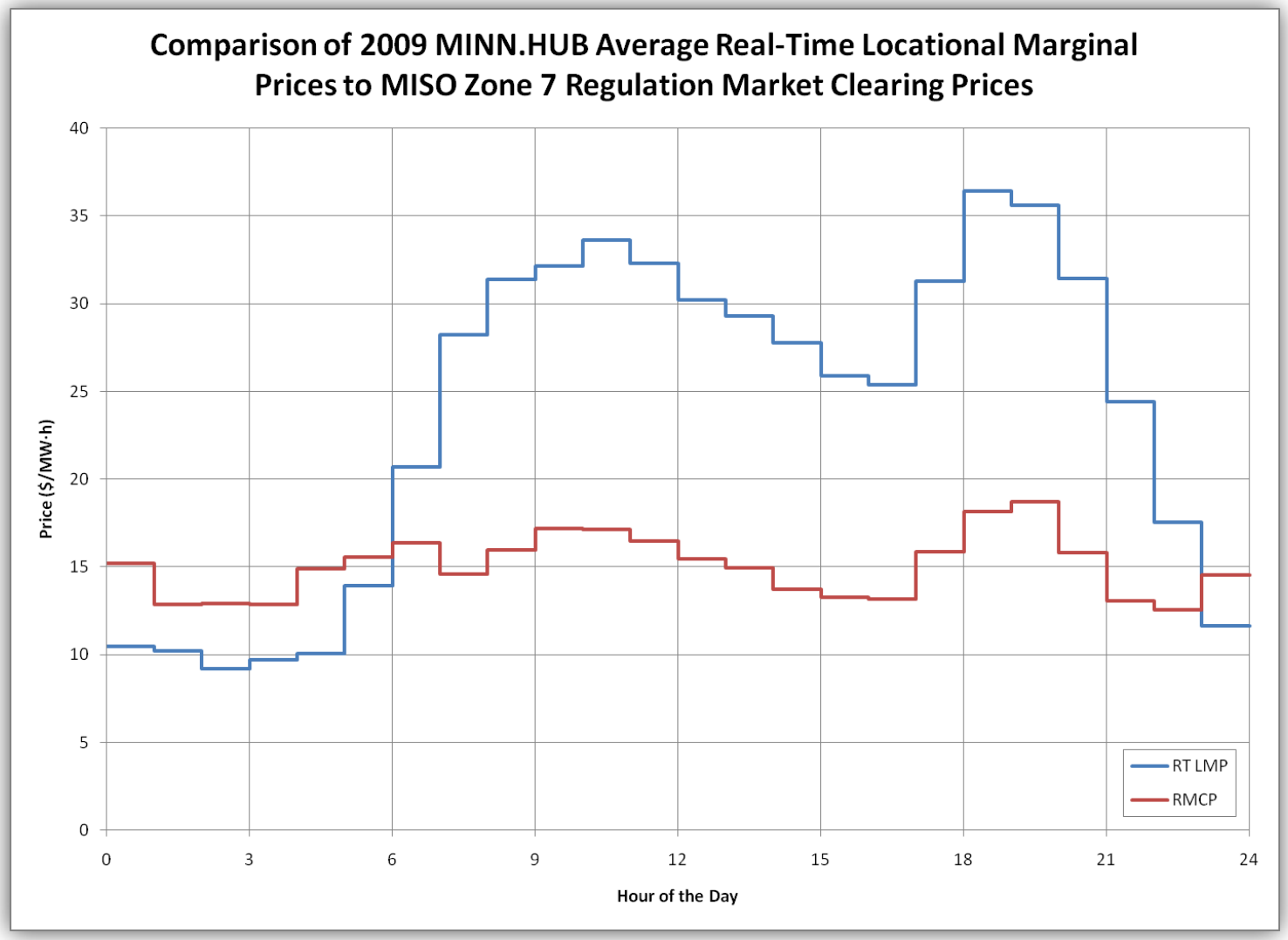
Typ. Water Heater Load



An Additional Value – Regulation



Real Time Prices Vs Regulation Market Clearing Prices



Wholesale Annual Operating Cost

for Electric Water Heater

Type/Method	Energy Cost	Demand/Trans. Other Costs	Total Cost
Uncontrolled	$256	$50 - $200	$306 - $456
Grid-Interactive LMP Optimized	$108	0	$108
Grid-Interactive with Regulation	($80)	0	($80)

- **Uncontrolled Water Heater:** No controls installed on water heater
- **Grid-Interactive Water Heater: Consumes energy when LMP is low, but not doing regulation** Typically there is no additional transmission or demand cost during low demand hours when LMP is low
- **Grid-Interactive with Regulation: Consumes energy when LMP is low and provides regulation.** This option also provides a 70% reduction in CO_2 emissions, independent of the renewable integration value.

Note: PJM has a need for about 700Mw of up and down regulation.

Grid-Interactive Electric Thermal Storage Water Heating Benefits

- Renewable integration
- Arbitrage value
- LMP following
- Ancillary value
- Reduced carbon
- Conservation
- Efficiency
- Economy

THANK YOU

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