



Electric Energy Storage and Wind

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Topics

- **AWEA Position on Wind and Storage**
- **Texas Wind and Power Market**
- **ERCOT Market Prices and Storage Opportunities**
- **Ancillary Services Market**



AWEA Position on Energy Storage and Wind

- **Wind energy can provide 20% or more of US electricity without any need for energy storage by using sources of flexibility that are already present on the grid.**
- **A tremendous amount of flexibility is already built into the power grid.**
- **It is almost always much cheaper to use this flexibility than to build new sources, such as storage**



AWEA Position on Wind and Storage

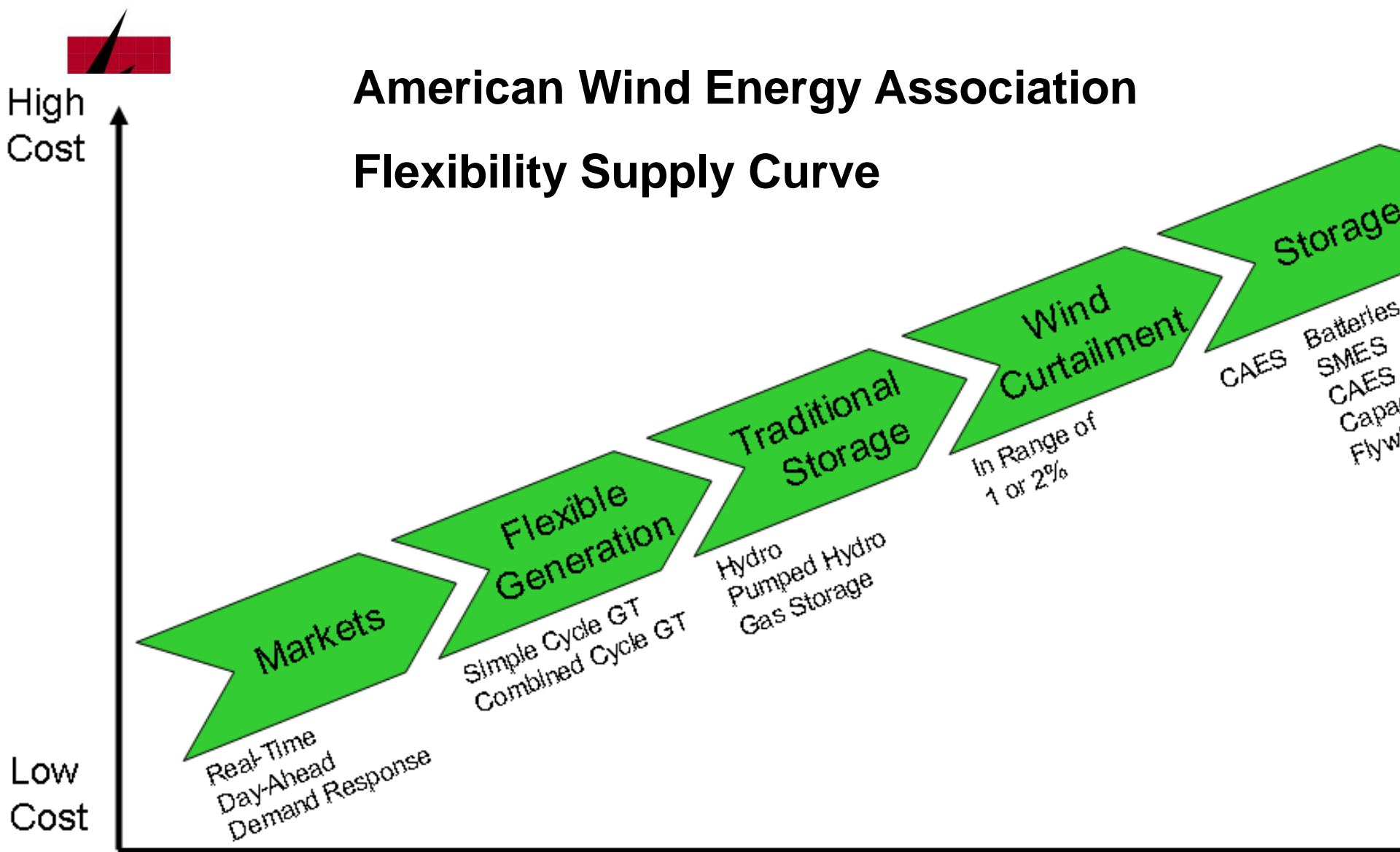
- **As wind penetration continues to grow, at some point in the distant future, the amount of flexibility currently on the grid may be fully tapped.**
- **Wind energy shows very little variability over the minute-to-minute timeframe. Significant changes in wind output tend to occur over time periods of 30 minutes or more.**



AWEA Position on Storage

- **It is much more expensive to provide flexibility over shorter – ie second to second timeframes than 30 minute timeframes**
- **Some energy storage technologies, such as flywheels and batteries may be cost effective for providing flexibility for short timeframes.**
- **But storage technologies cannot compete with conventional sources for wind's longer duration variability**

American Wind Energy Association Flexibility Supply Curve

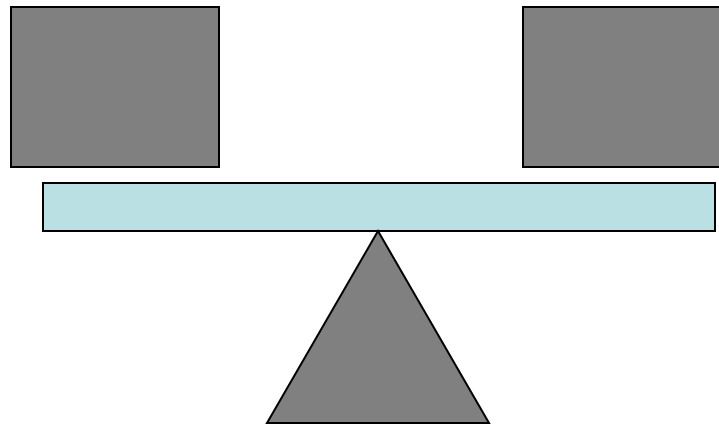




First Principle of Any Electric Power System

**MW
generated**

**MW
consumed**





ERCOT Market – Energy Auction

- **Security Constrained Economic Dispatch**
- **Day Ahead Market – Load Schedules and Supplier Bids submitted to ERCOT**
- **Energy scheduled – 5 minute interval**

- **Ancillary Services**
 - **Reserve (spin and replacement)**
 - **Frequency Regulation**

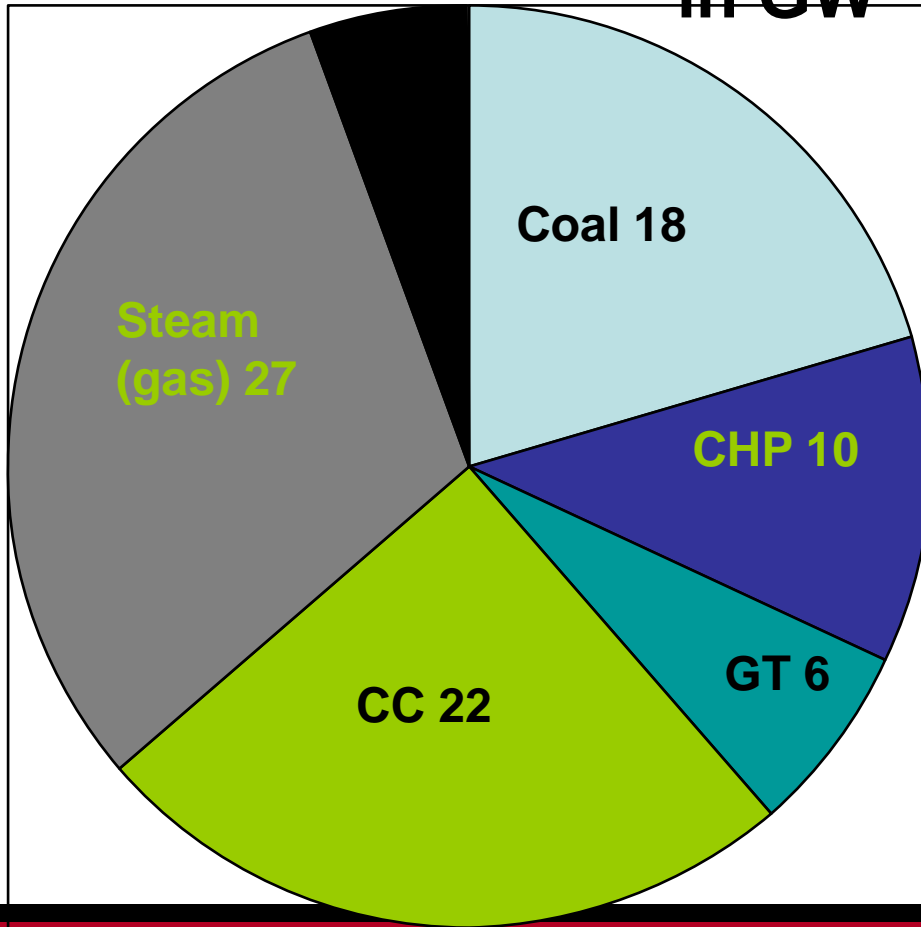


Ramp Rates in % of Capacity per Minute

- **Nuclear** **0**
- **Coal** **2.5% per minute**
- **Combined Cycle** **2.5%**
- **Gas-fired Steam** **3.0%**
- **Gas Turbine** **20%**

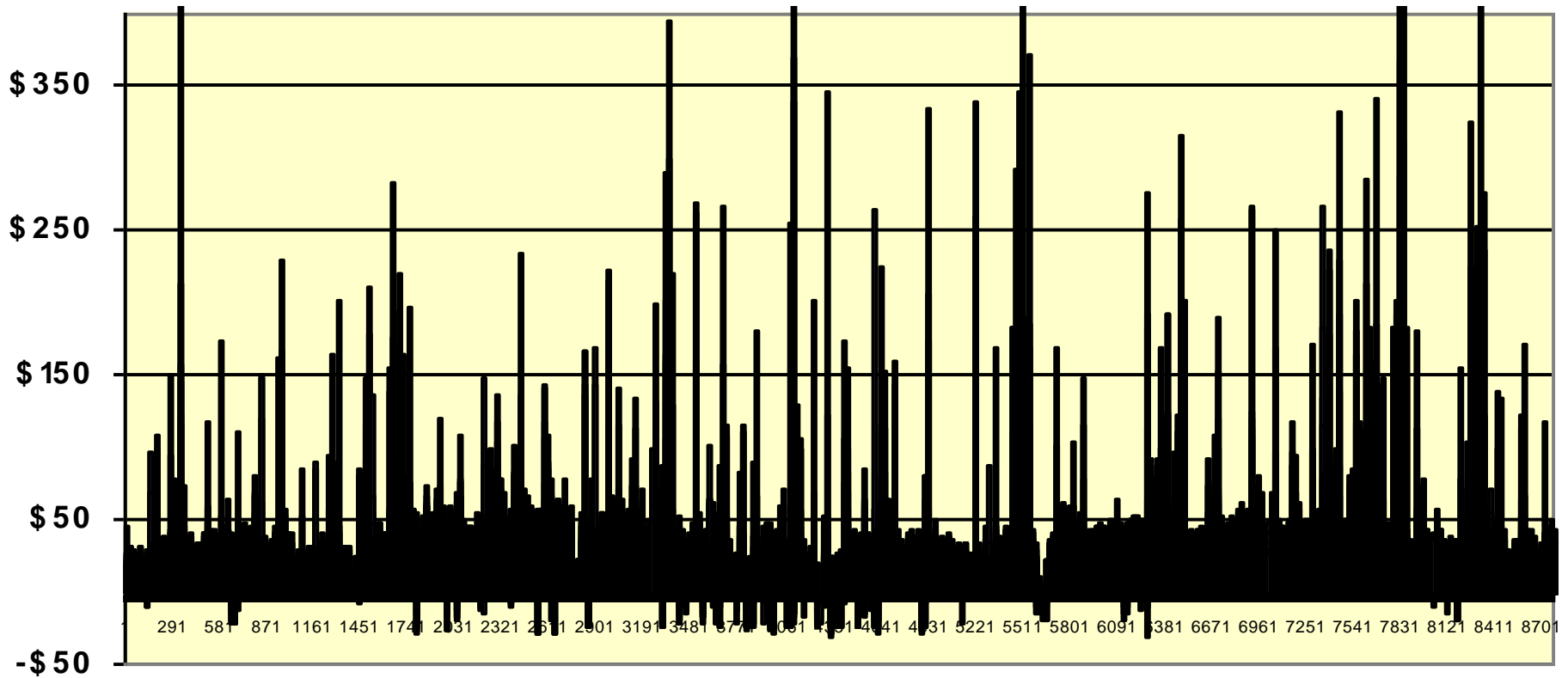


ERCOT Generating Capacity in GW



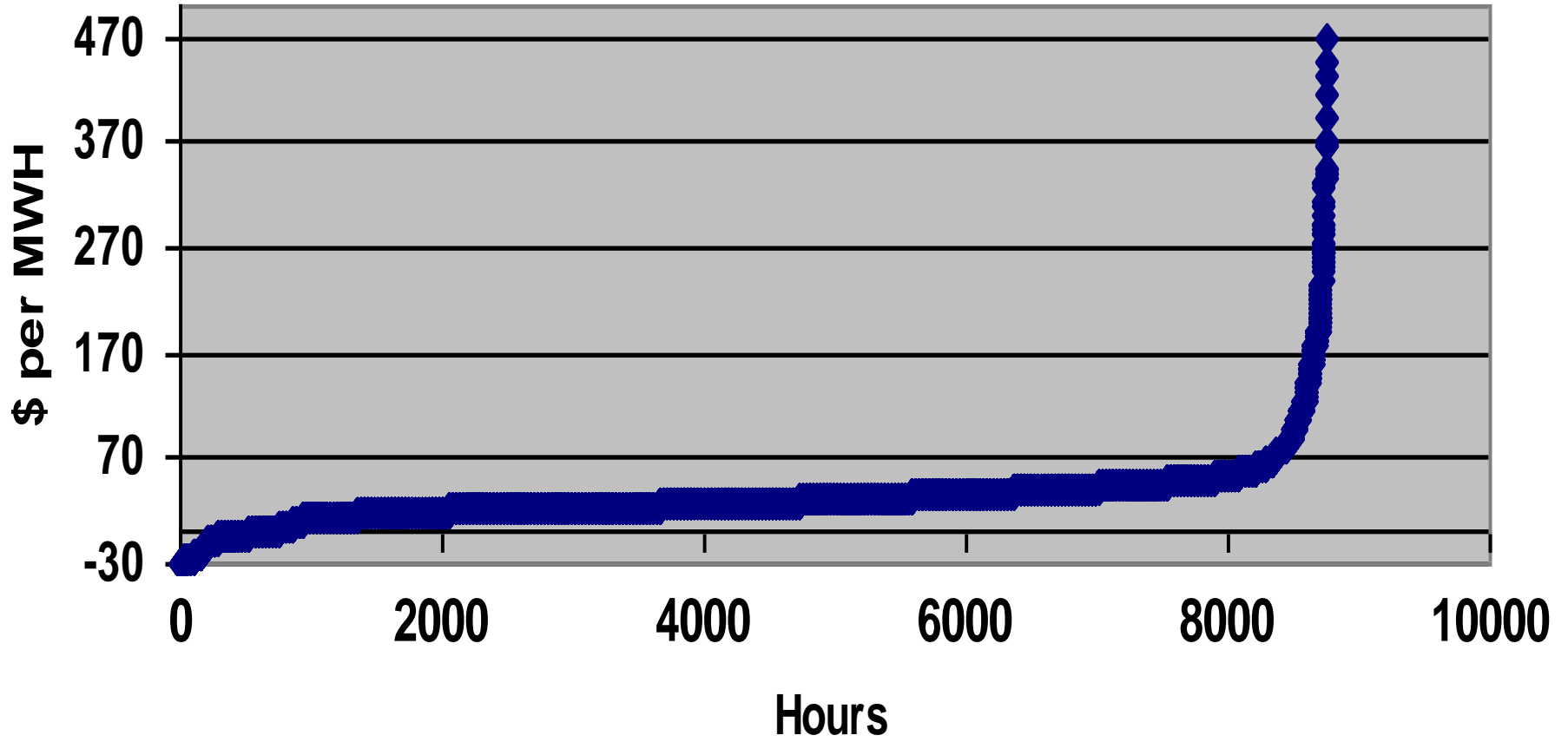


Hourly MCPE in ERCOT West Zone





MCPE



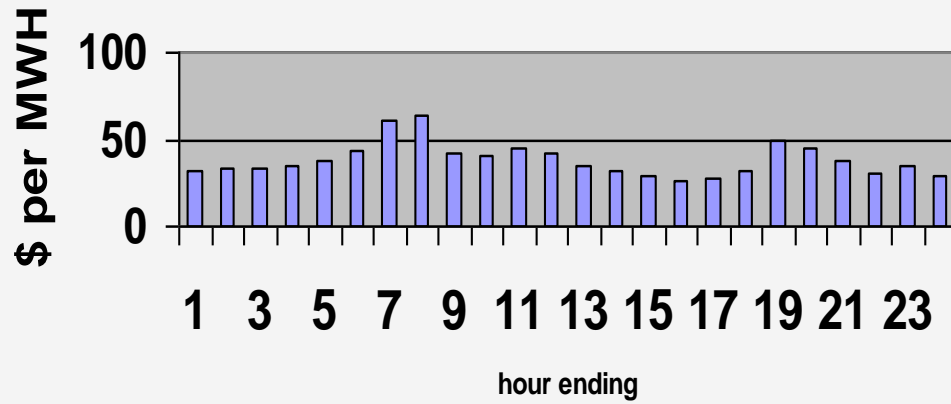


Market Clearing Prices in ERCOT

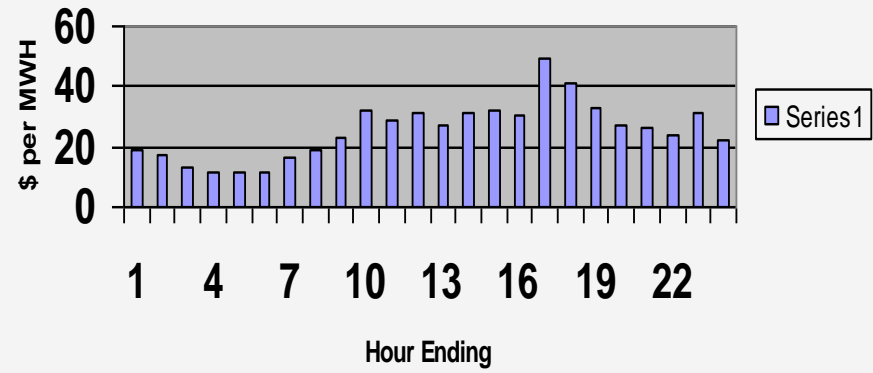
- **723 Hours Prices Negative**
- **550 Hours Prices $>$ \$60 per MWH**
- **243 Hours Prices $>$ \$100 MWH**

- **83% of Year, Prices between
\$0 and \$60 per MWH**

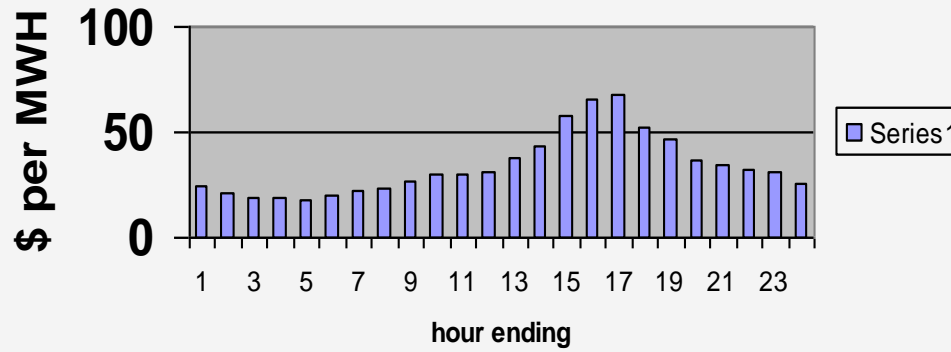
winter



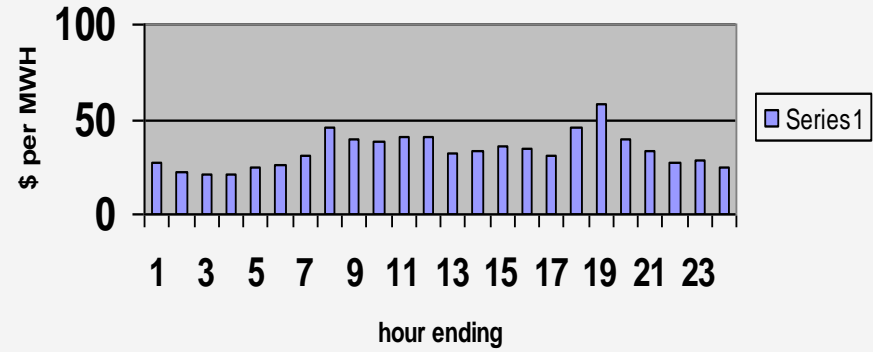
spring



summer

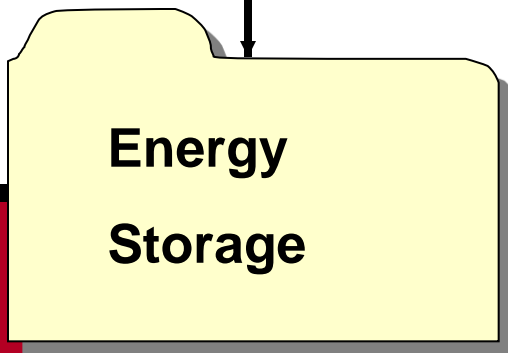
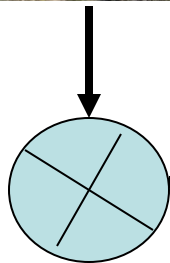


fall



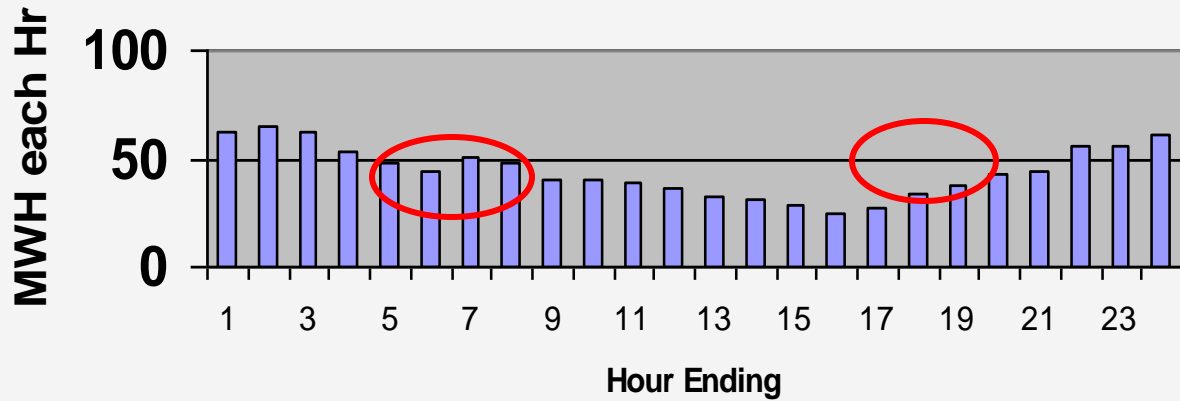


Simplified Control System

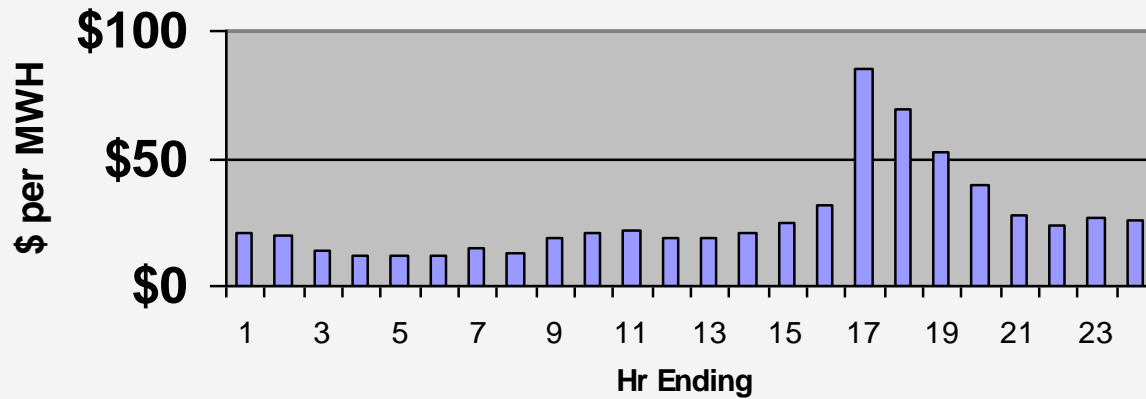




Hackberry Wind Farm Avg Hourly Production - May

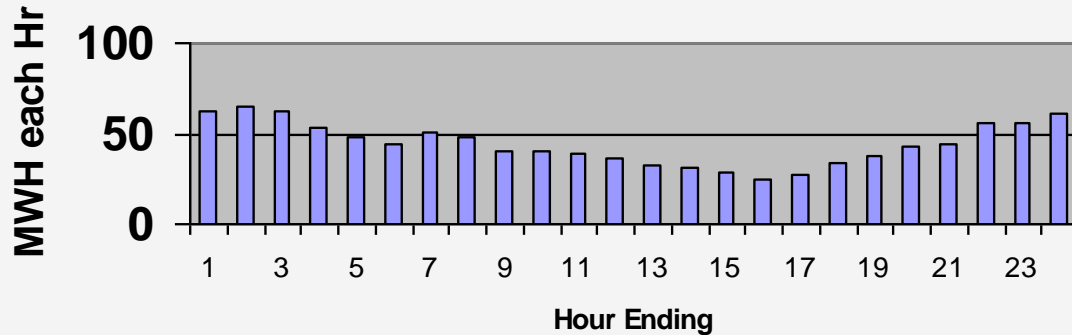


Avg Hourly MCPE - May





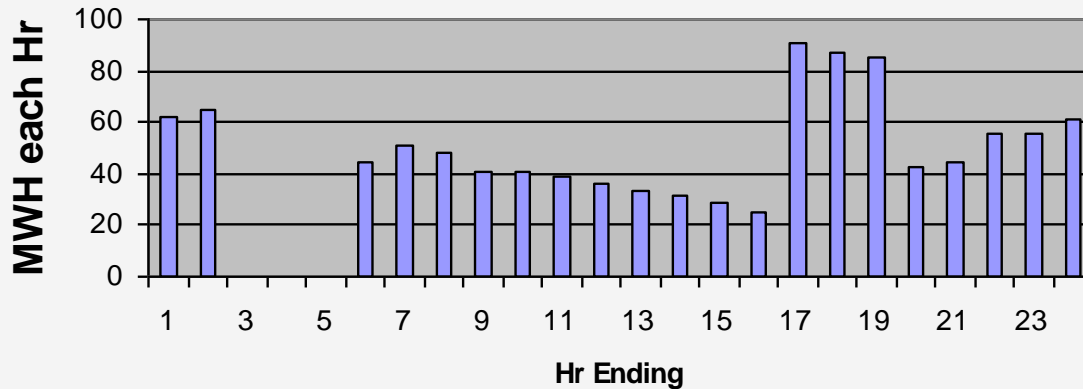
Hackberry Wind Farm Avg Hourly Production - May



Revenue \$786,000

For month of May

Production Profile -Combined Wind and Storage



Revenue \$1,068,000

For month of May

36% more

**\$1900 per MWH of
storage for May**



Questions ?

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Variability of Wind and Solar

- **Thermal Plants will operate at lower capacity factors**
- **Will be required to ramp more**
- **Will operate more sporadically**
- **Increased need for regulation**
- **Increased need for reserve capacity with good ramping capability**