Electric Energy Storage and Wind

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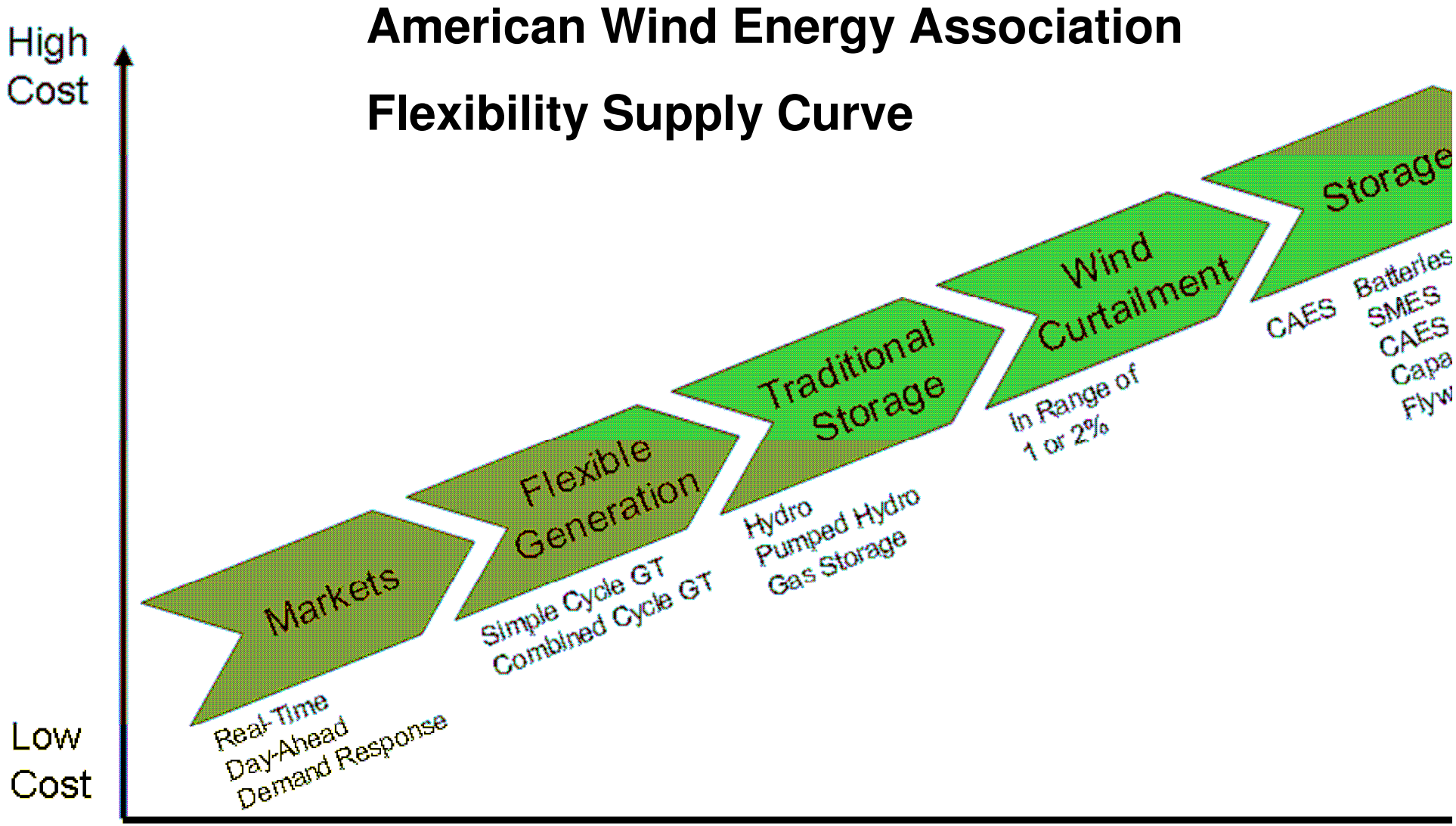
Topics

- AWEA Position on Wind and Storage
- Texas Wind and Power Market
- ERCOT Market Prices and Storage Opportunities
- Ancillary Services Market
- Examples of Integrated Wind and Storage

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**


American Wind Energy Association
Flexibility Supply Curve
High Cost
Low Cost
Markets
Real-Time
Day-Ahead
Demand Response
Flexible Generation
Simple Cycle GT
Combined Cycle GT
Traditional Storage
Hydro
Pumped Hydro
Gas Storage
Wind Curtailment
In Range of
1 or 2%
Storage
CAES
Batteries
SMES
CAES
Capa
Flyw

AWEA Position on Wind and Storage

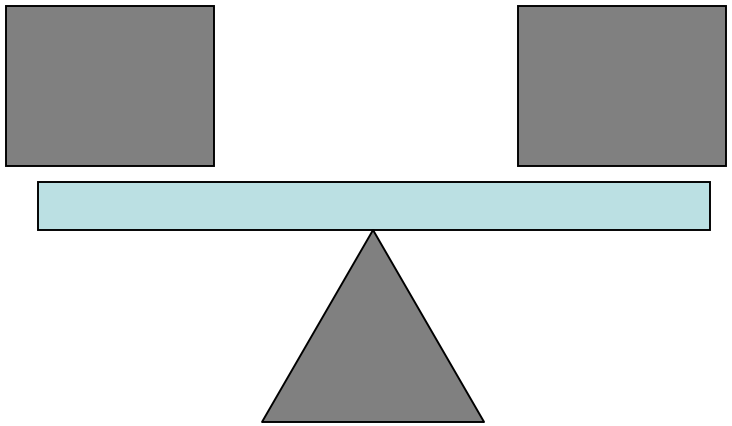
- **As wind penetration continues to grow, at some point in the distant future, the amount of flexibility currently on the grid may be fully tapped.**
- **Wind energy shows very little variability over the minute-to-minute timeframe. Significant changes in wind output tend to occur over time periods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

First Principle of Any Electric Power System

MW generated

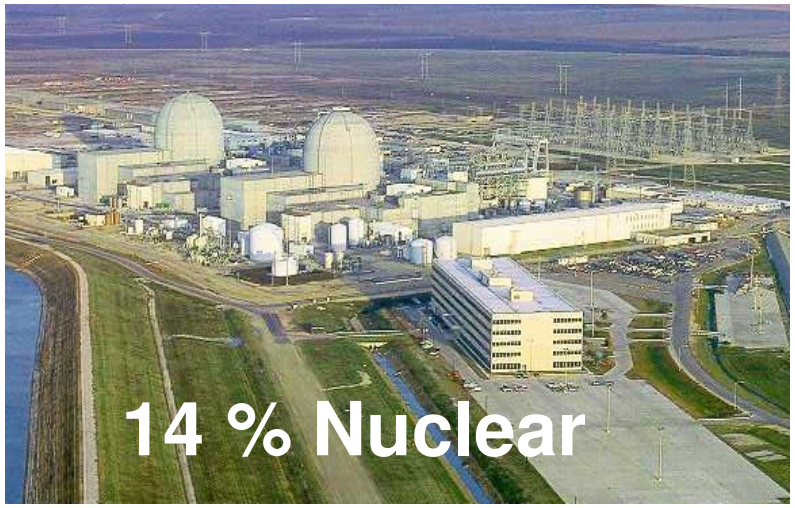


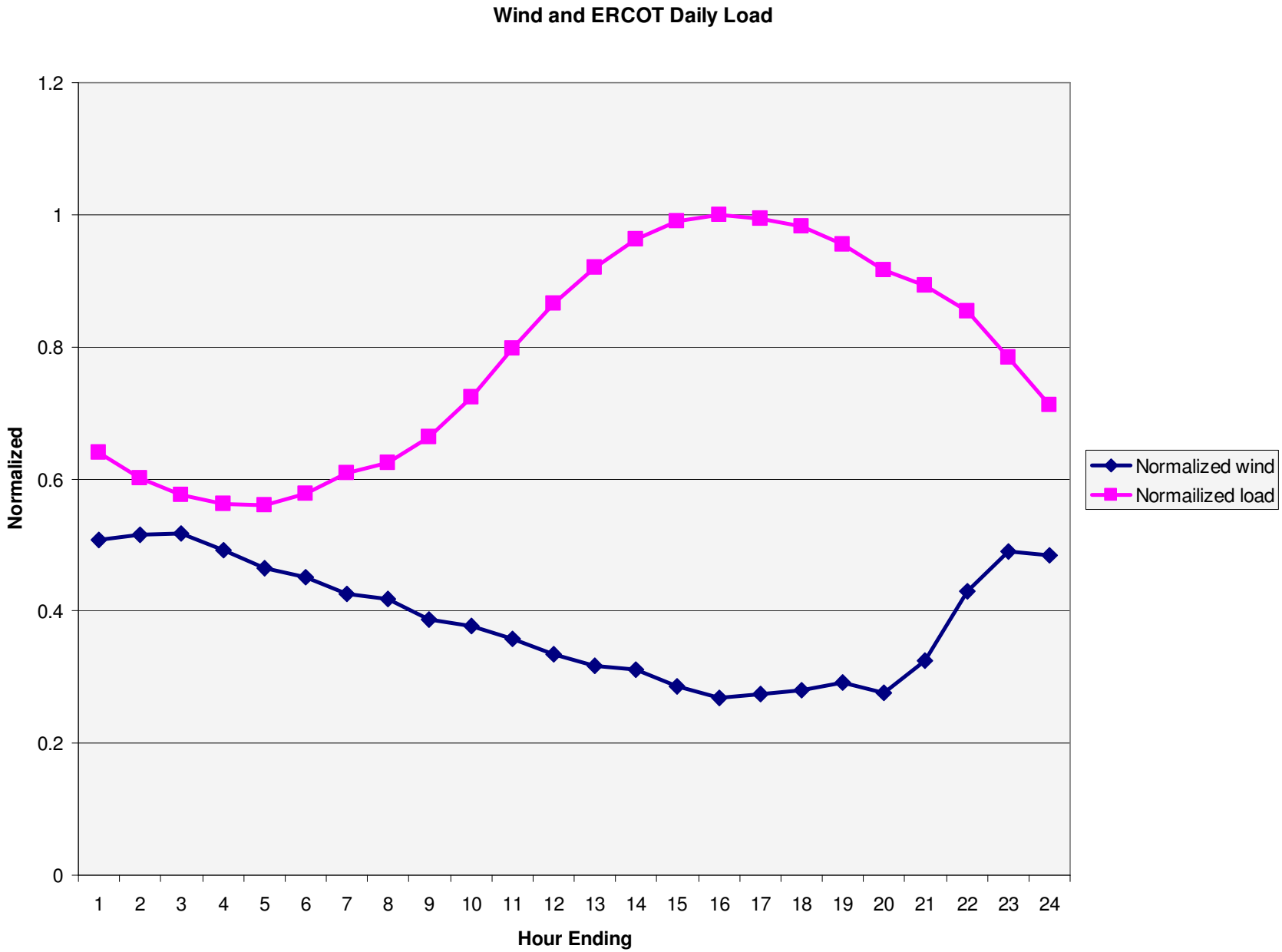
MW consumed

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

Where Does Texas' Electricity Come From Today?




Wind and ERCOT Daily Load
1.2
1
0.8
0.6
0.4
0.2
0
Normalized
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour Ending
Normalized wind
Normailized load

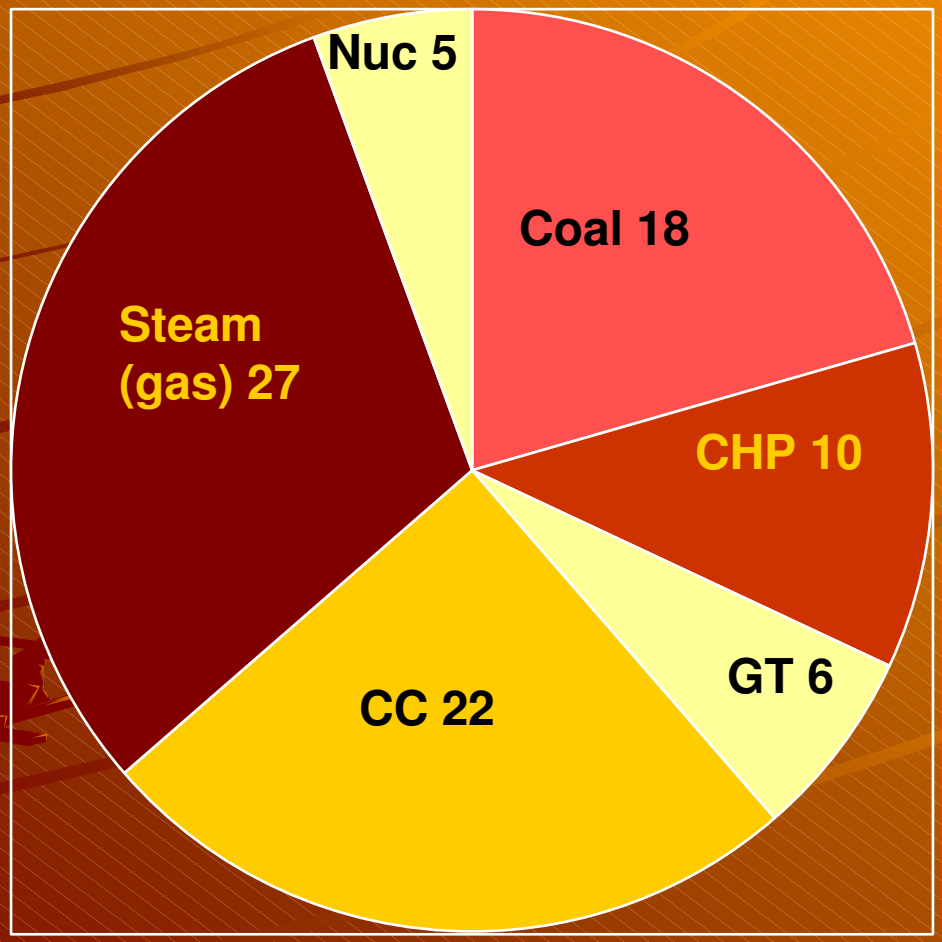
Variability of Wind and Solar

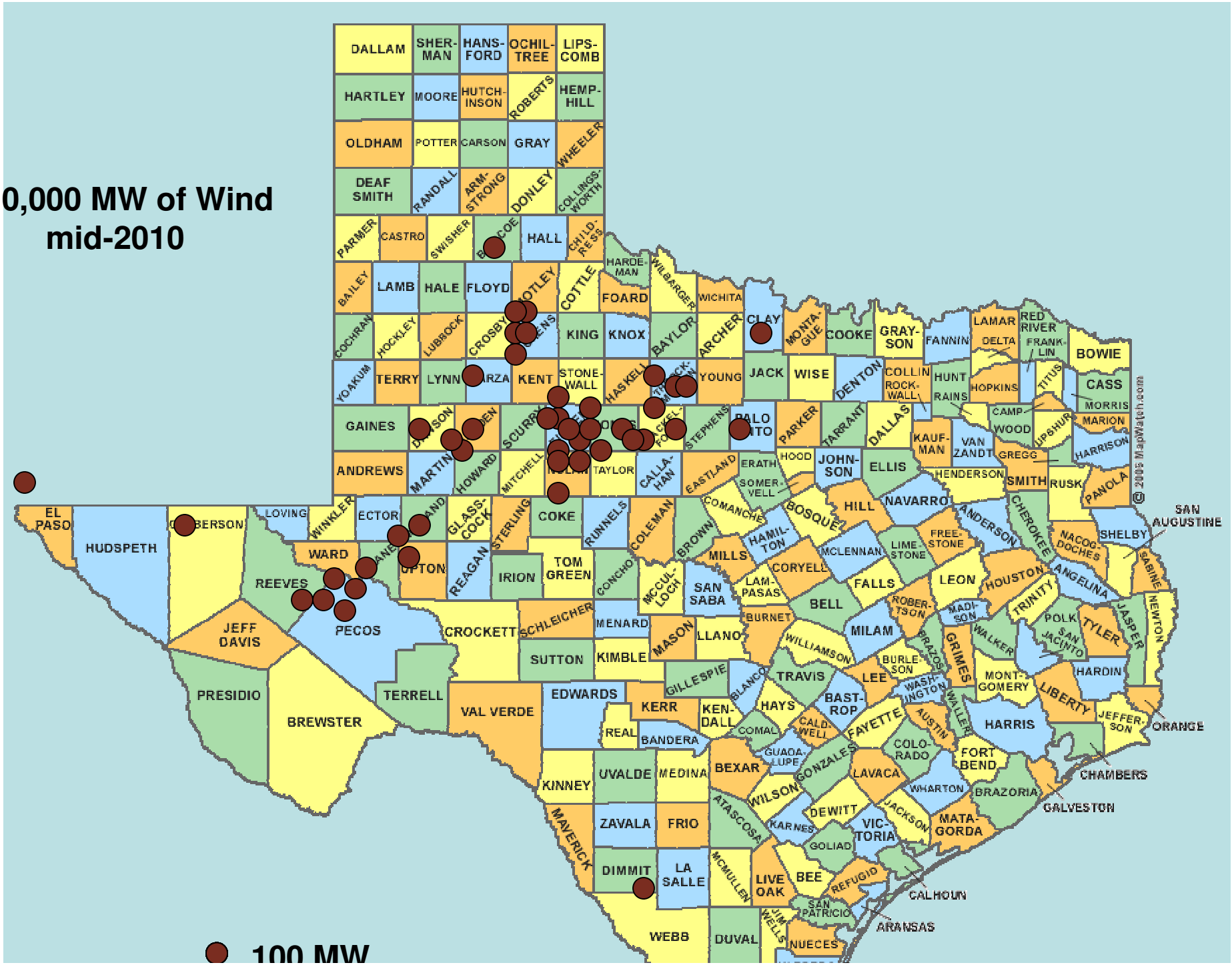
- Thermal Plants will operate at lower capacity factors
- Will be required to ramp more
- Will operate more sporadically
- Increased need for regulation
- Increased need for reserve capacity with good ramping capability

Ramp Rates
in % of Capacity per Minute

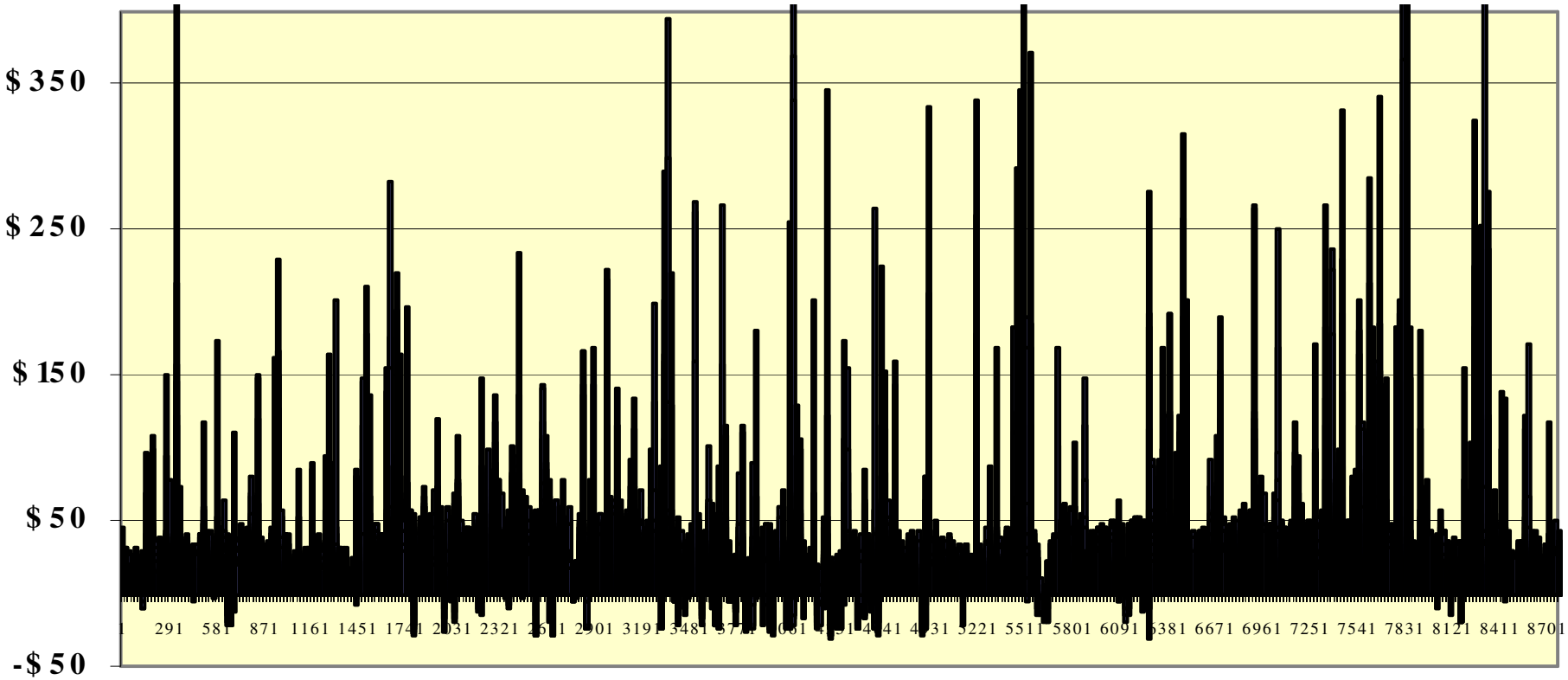
- Nuclear 0
- Coal 2.5% per minute
- Combined Cycle 2.5%
- Gas-fired Steam 3.0%
- Gas Turbine 20%

ERCOT Generating Capacity in GW

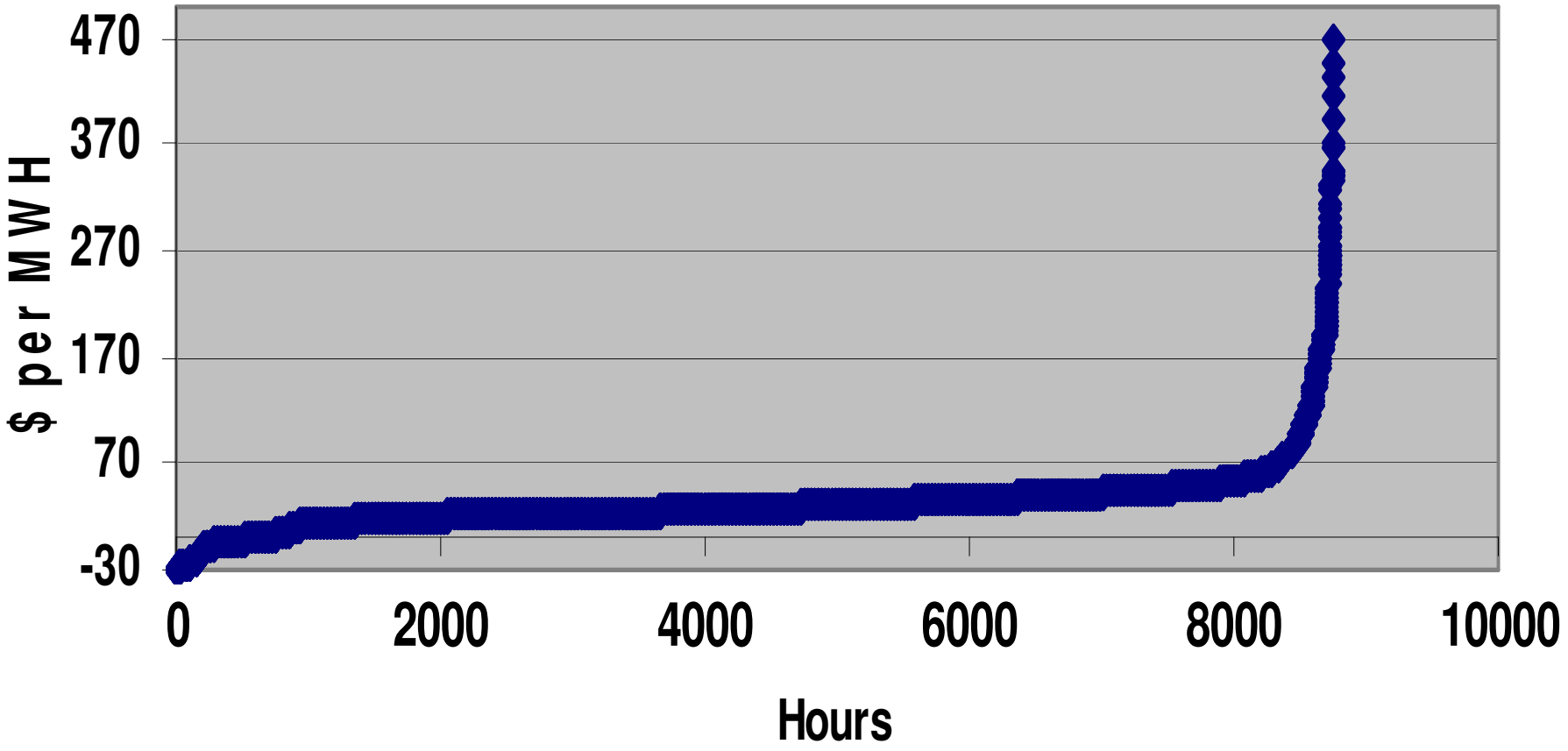



10,000 MW of Wind
mid-2010
100 MW

Hourly MCPE in ERCOT West Zone



MCPE

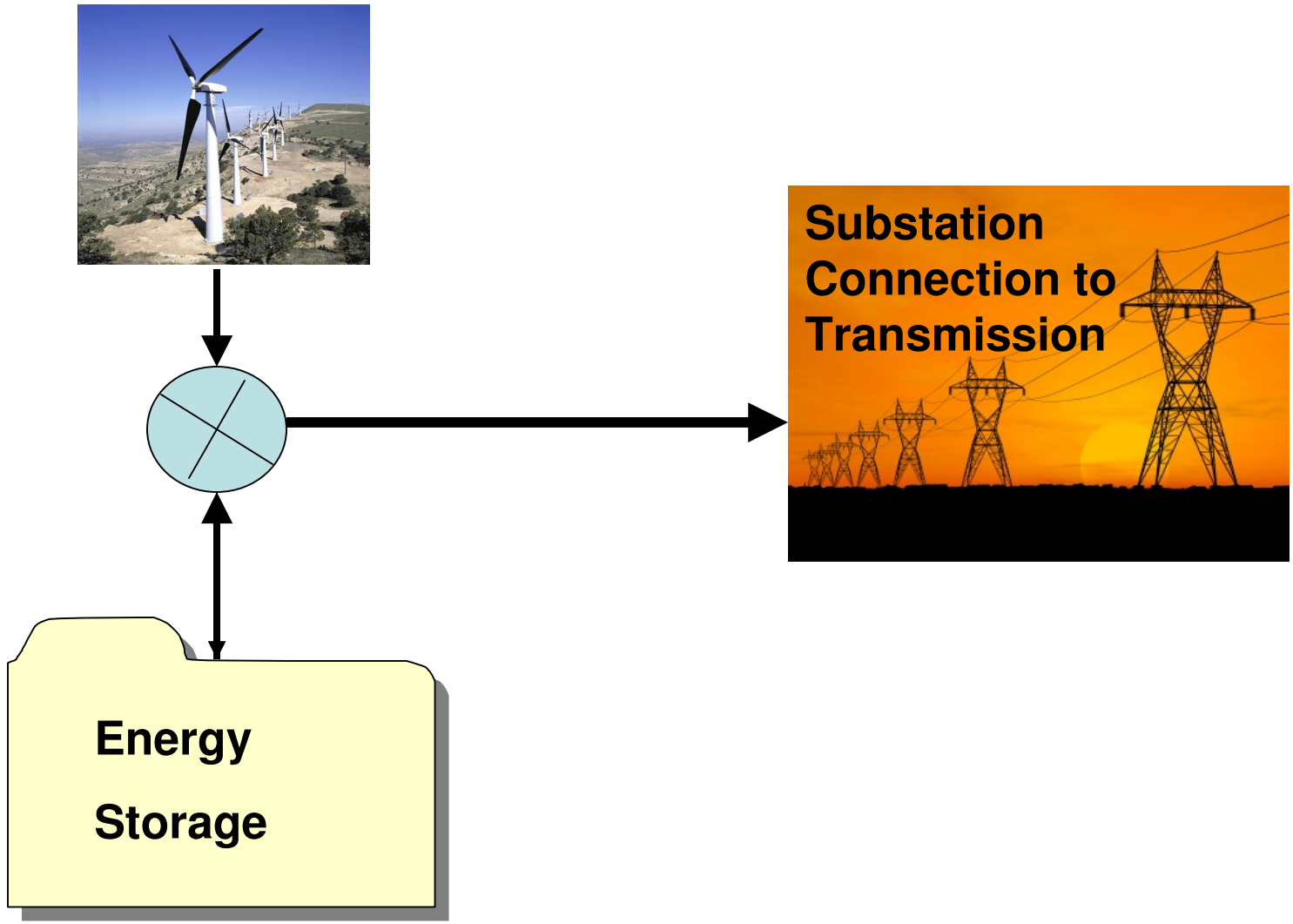


Market Clearing Prices in ERCOT

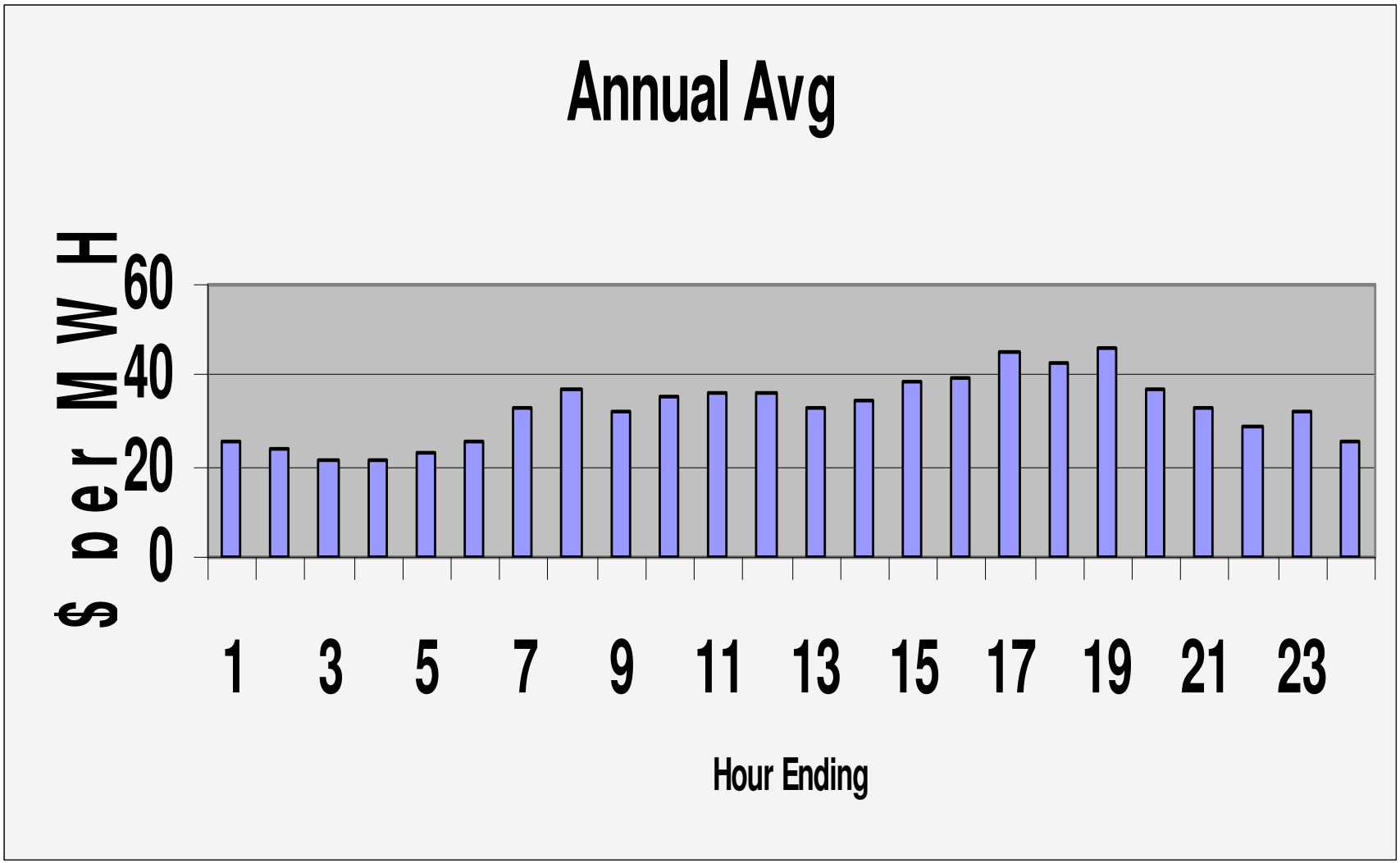
- 723 Hours Prices Negative
- 550 Hours Prices > $60 per MWH
- 243 Hours Prices > $100 MWH

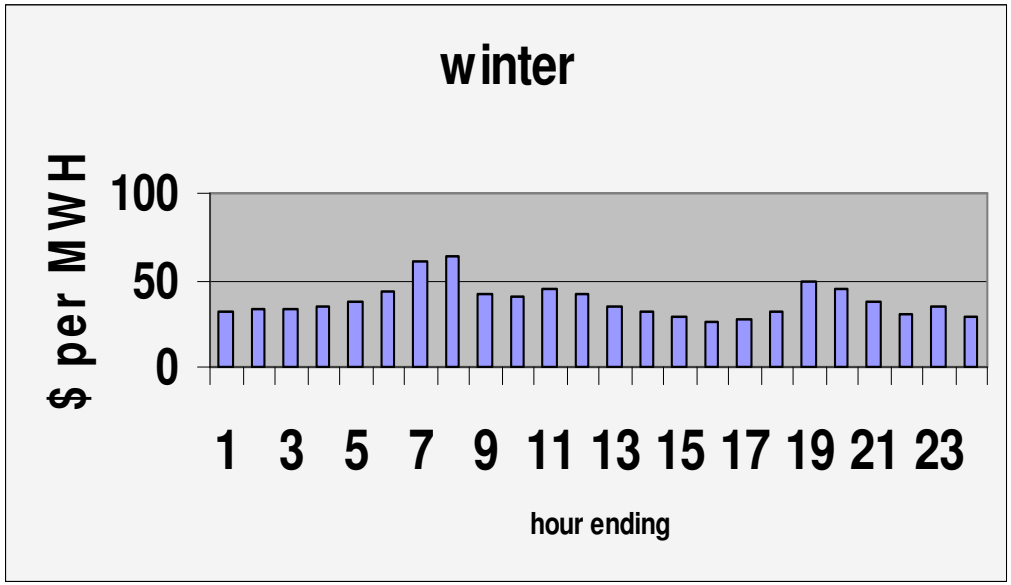
- 83% of Year, Prices between
  $0 and $60 per MWH

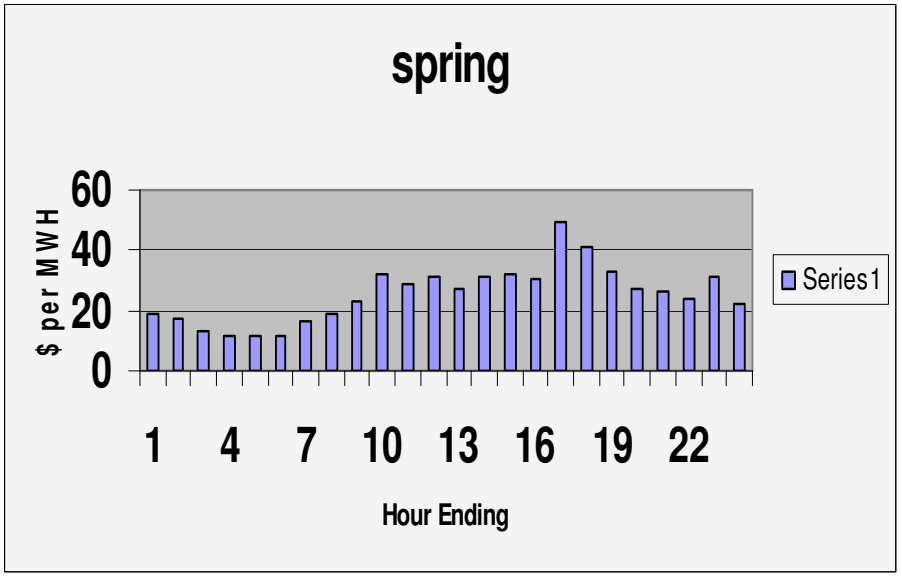
Simplified Control System

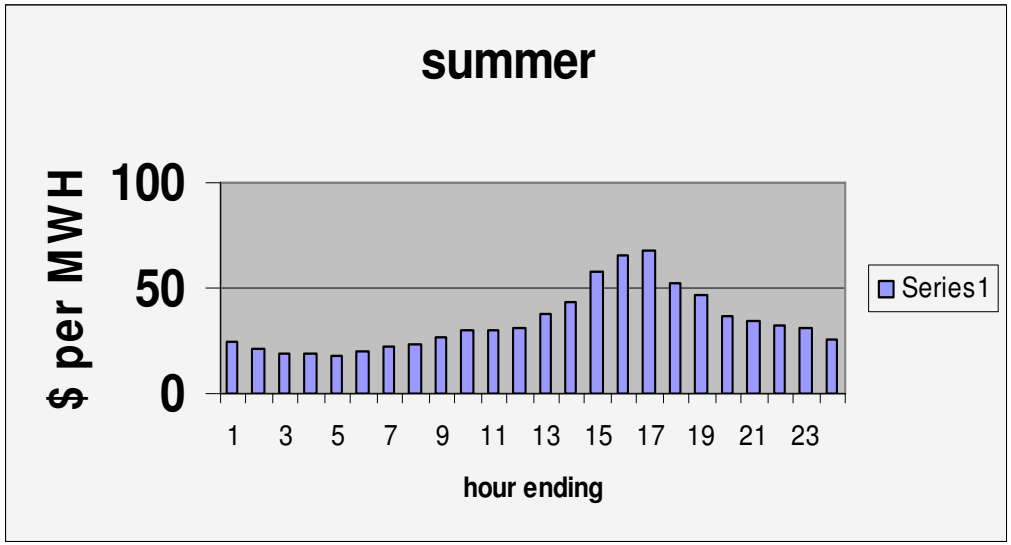


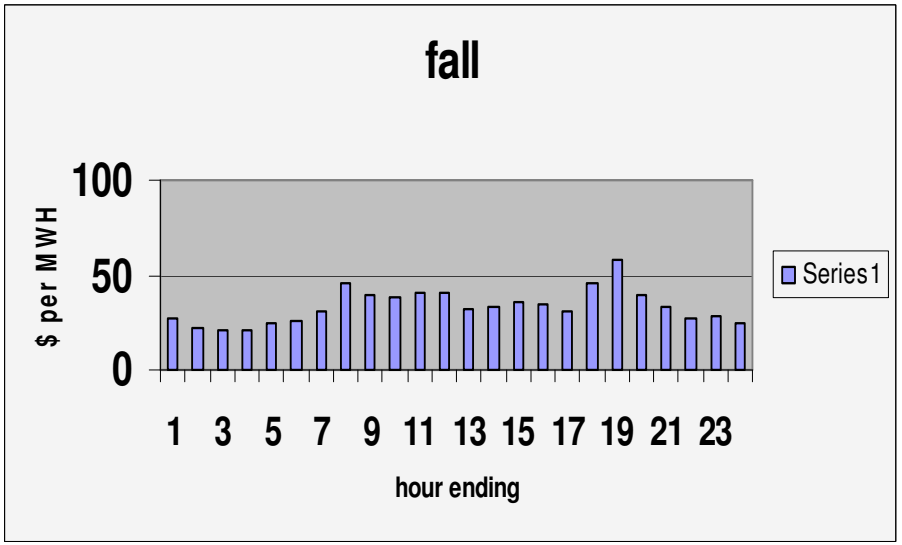
Hourly MCPEs

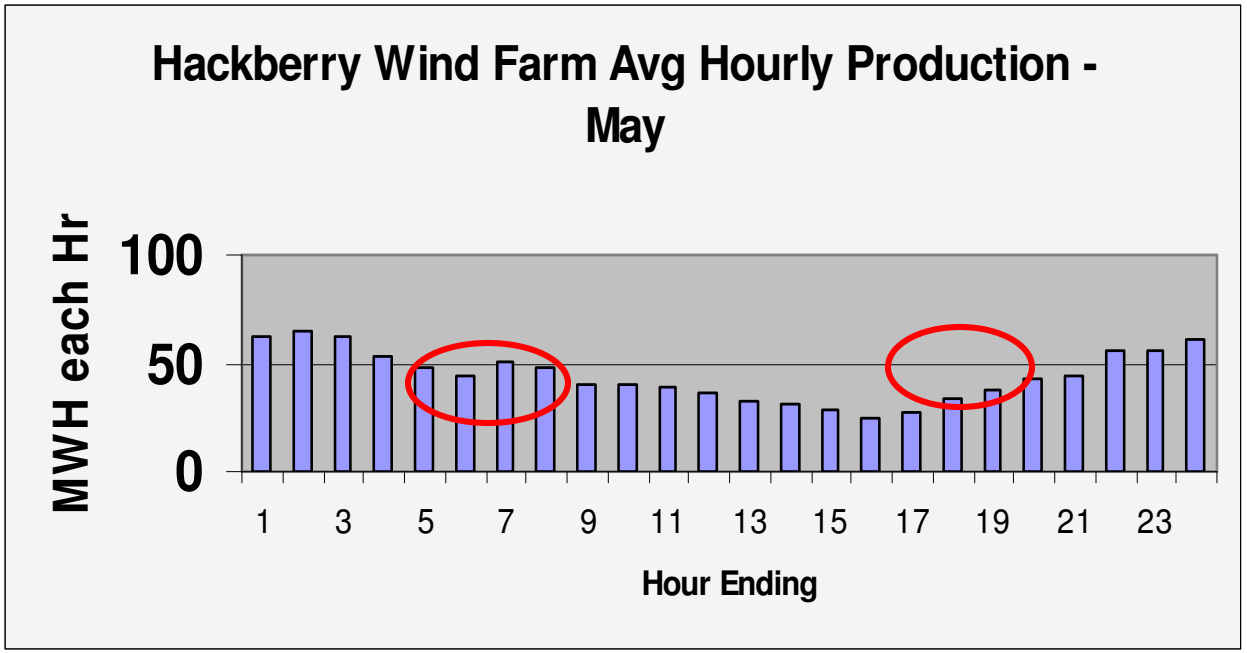


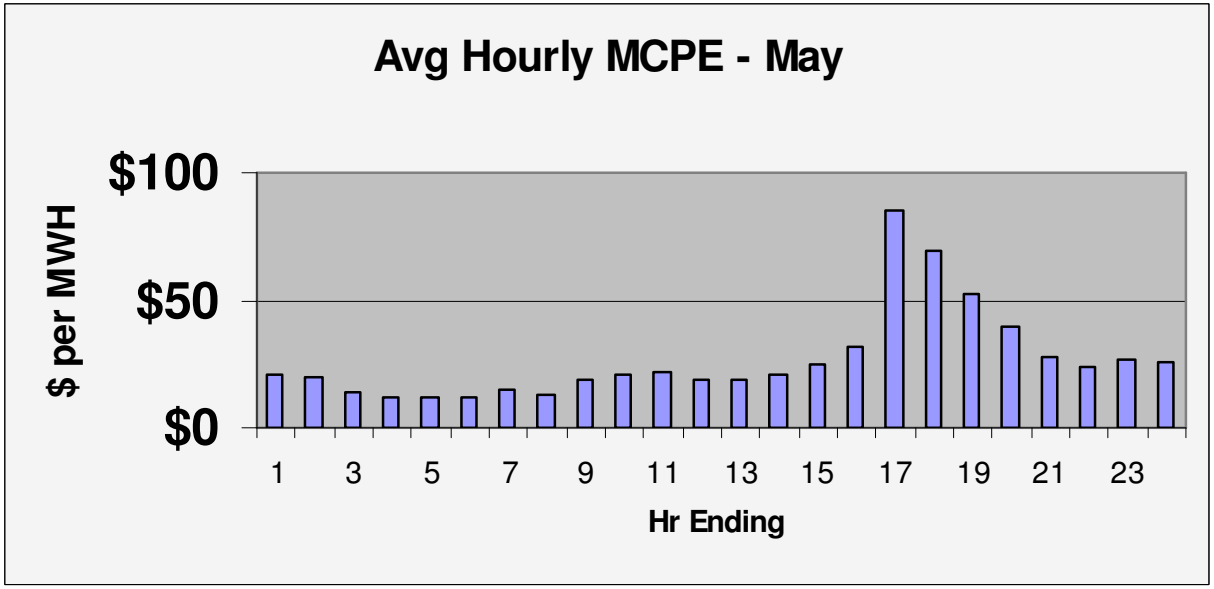

winter
$ per MWH
100
50
0
1 3 5 7 9 11 13 15 17 19 21 23
hour ending

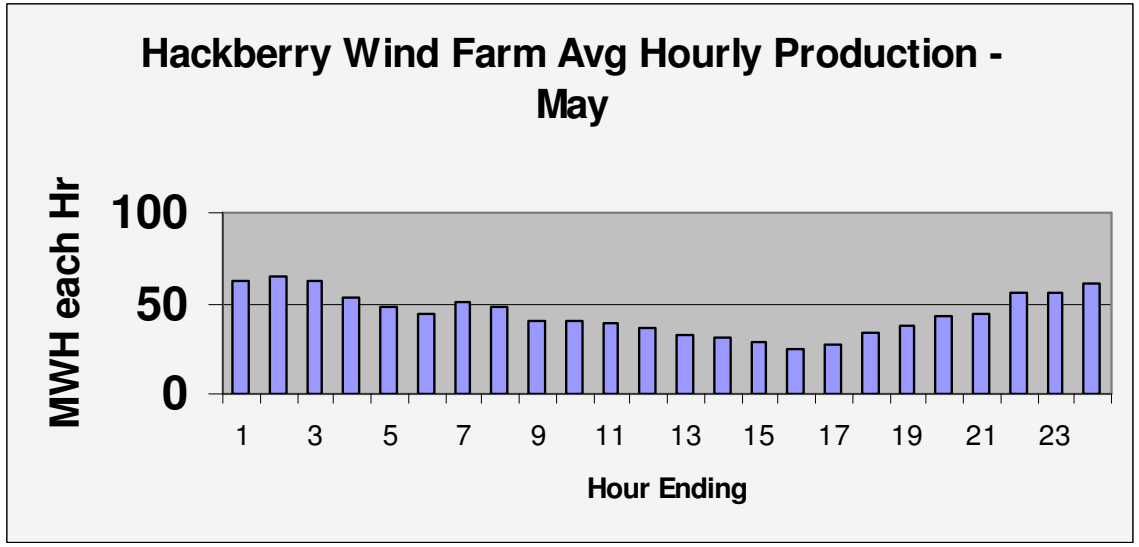

spring
$ per MWH
60
40
20
0
1 4 7 10 13 16 19 22
Hour Ending
Series1


summer
$ per MWH
100
50
0
1 3 5 7 9 11 13 15 17 19 21 23
hour ending
Series1


fall
$ per MWH
100
50
0
1 3 5 7 9 11 13 15 17 19 21 23
hour ending
Series1

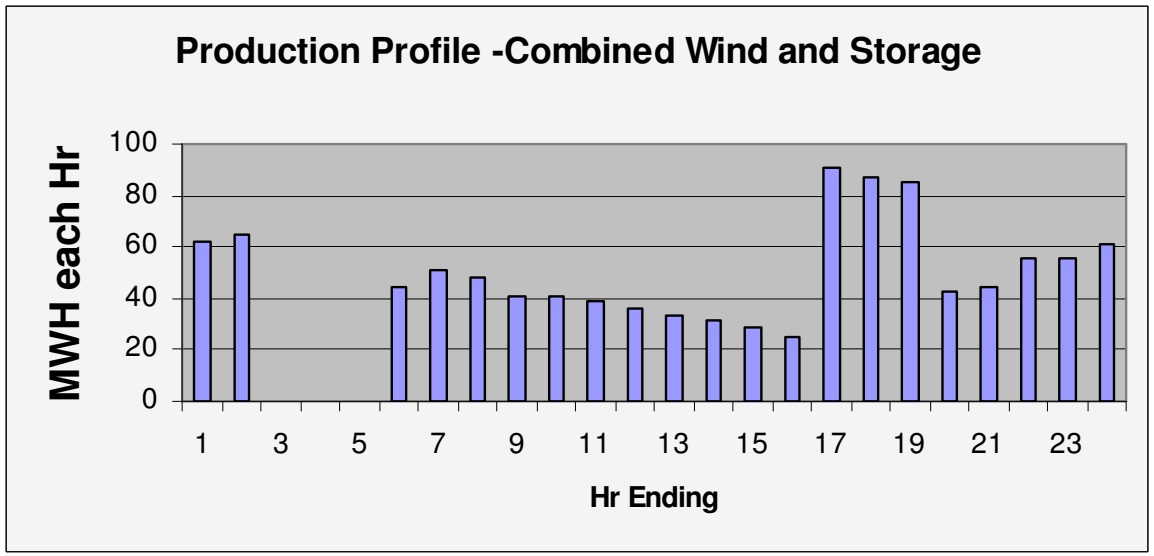

Hackberry Wind Farm Avg Hourly Production - May
MWH each Hr
100
50
0
1
3
5
7
9
11
13
15
17
19
21
23
Hour Ending


Avg Hourly MCPE - May
$ per MWH
$100
$50
$0
1
3
5
7
9
11
13
15
17
19
21
23
Hr Ending



Revenue $786,000

For month of May



Revenue $1,068,000

For month of May

36% more

$1900 per MWH of storage for May

Example 1- Xcel Energy

- 11 MW wind farm in Luverne, MN
- Sodium Sulfur Battery (NGK Insulators, Japan)
- 1.0 MW / 7 MWH
- use price signal from Midwest ISO to control charge/discharge.
- Testing dynamic response to system changes
- RT efficiency = 75%
- In Operation

Example 2 – Hawaiian Electric Co.

- 30 MW wind farm on Oahu (First Wind)
- Xtreme Power (Kyle, TX) Advanced Lead Acid Battery
- 15 MW / 10 MWH
- Primary purpose – Frequency Regulation
- Secondary purpose – arbitrage
- In construction

Example 3 – Ford / Detroit Edison

- 500 kW solar PV system, Wayne, MI
- 750 kW Lead Acid Battery
- Xtreme Power

Questions ?

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