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Firming the Future: Cost (Value) of Operating Hydro to Support Other Renewables

NHA Conference
May 11, 2009

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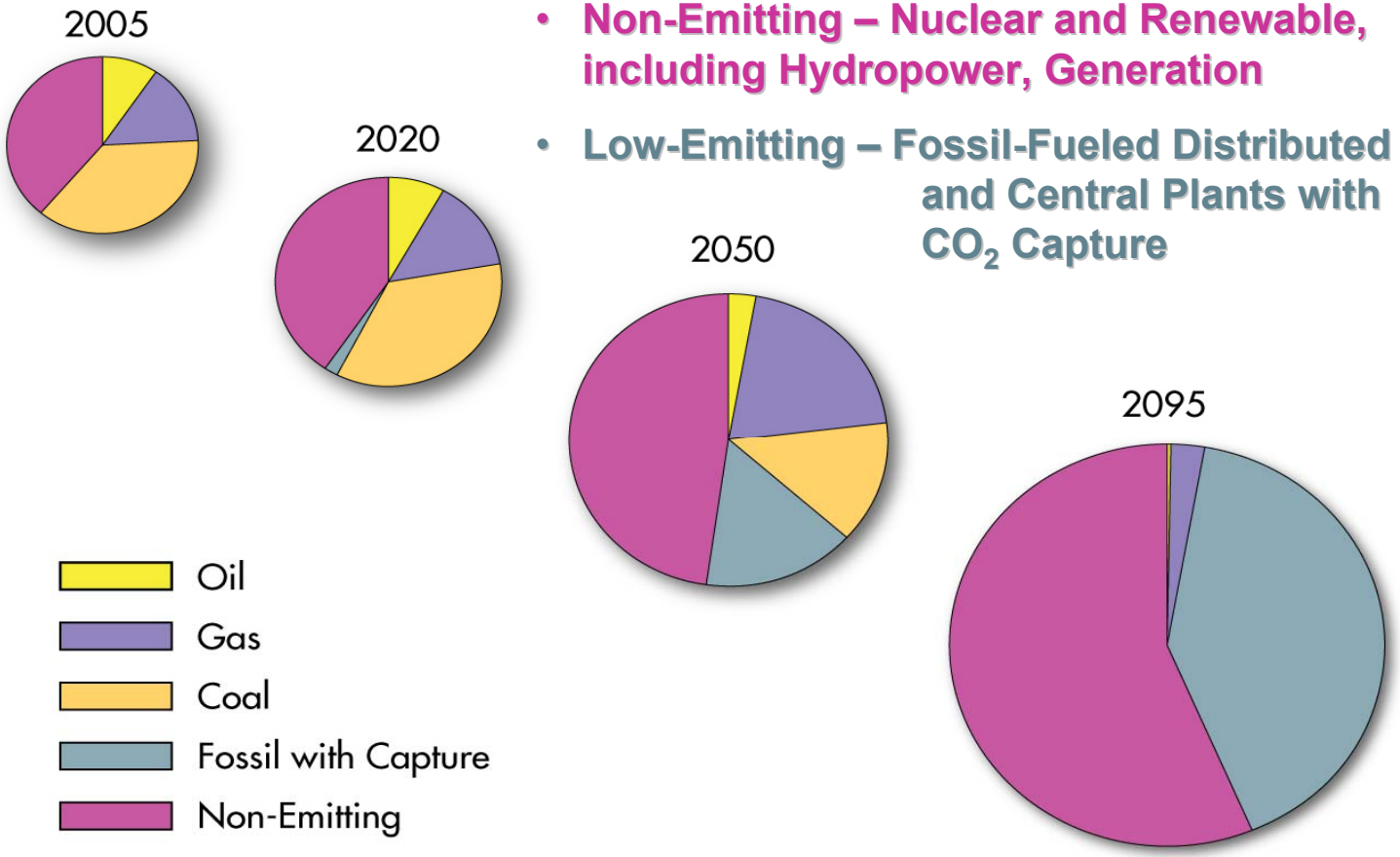
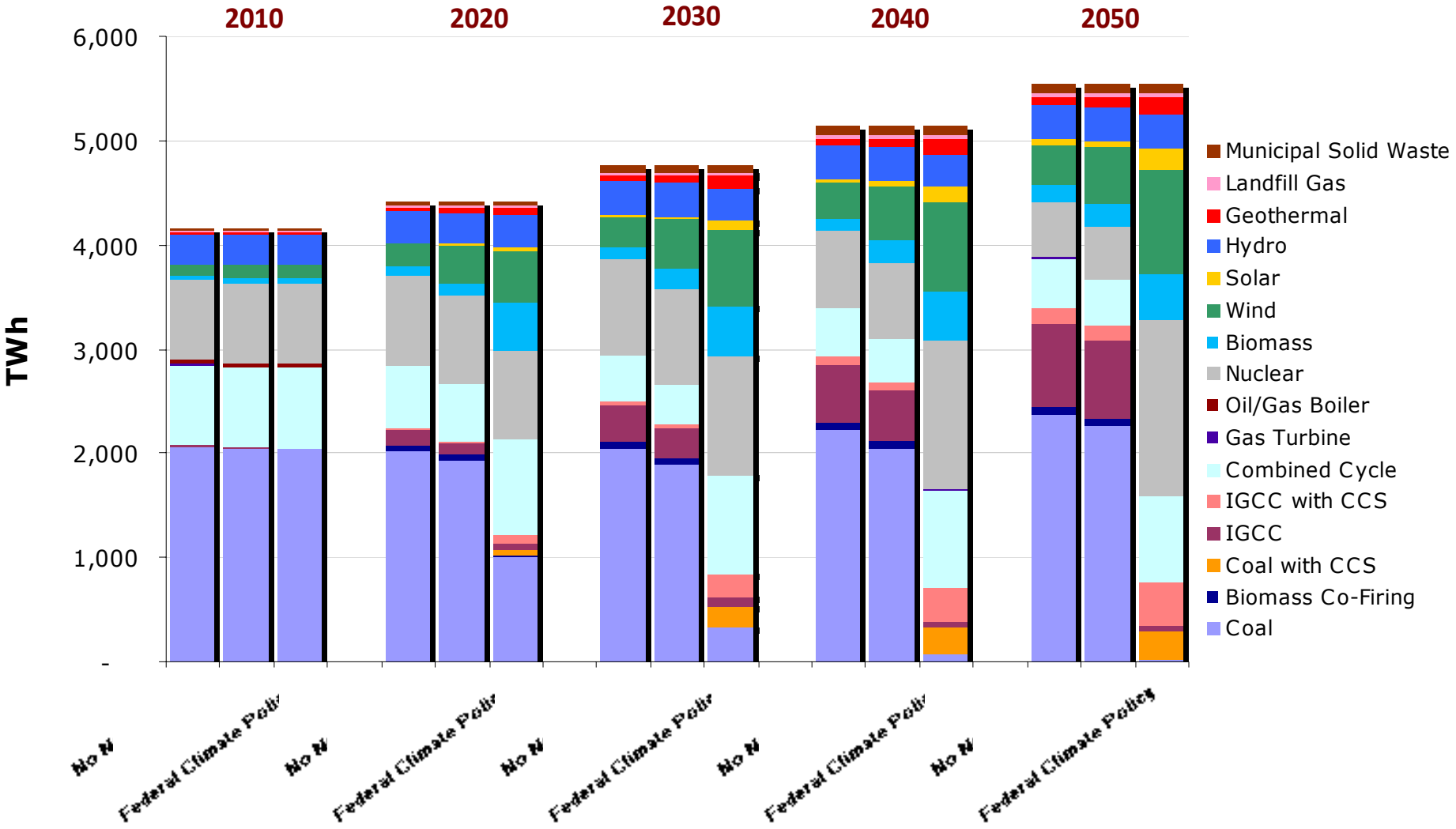
World Electrification Growth and Mix to Stabilize CO_2 Concentrations at 550 ppm



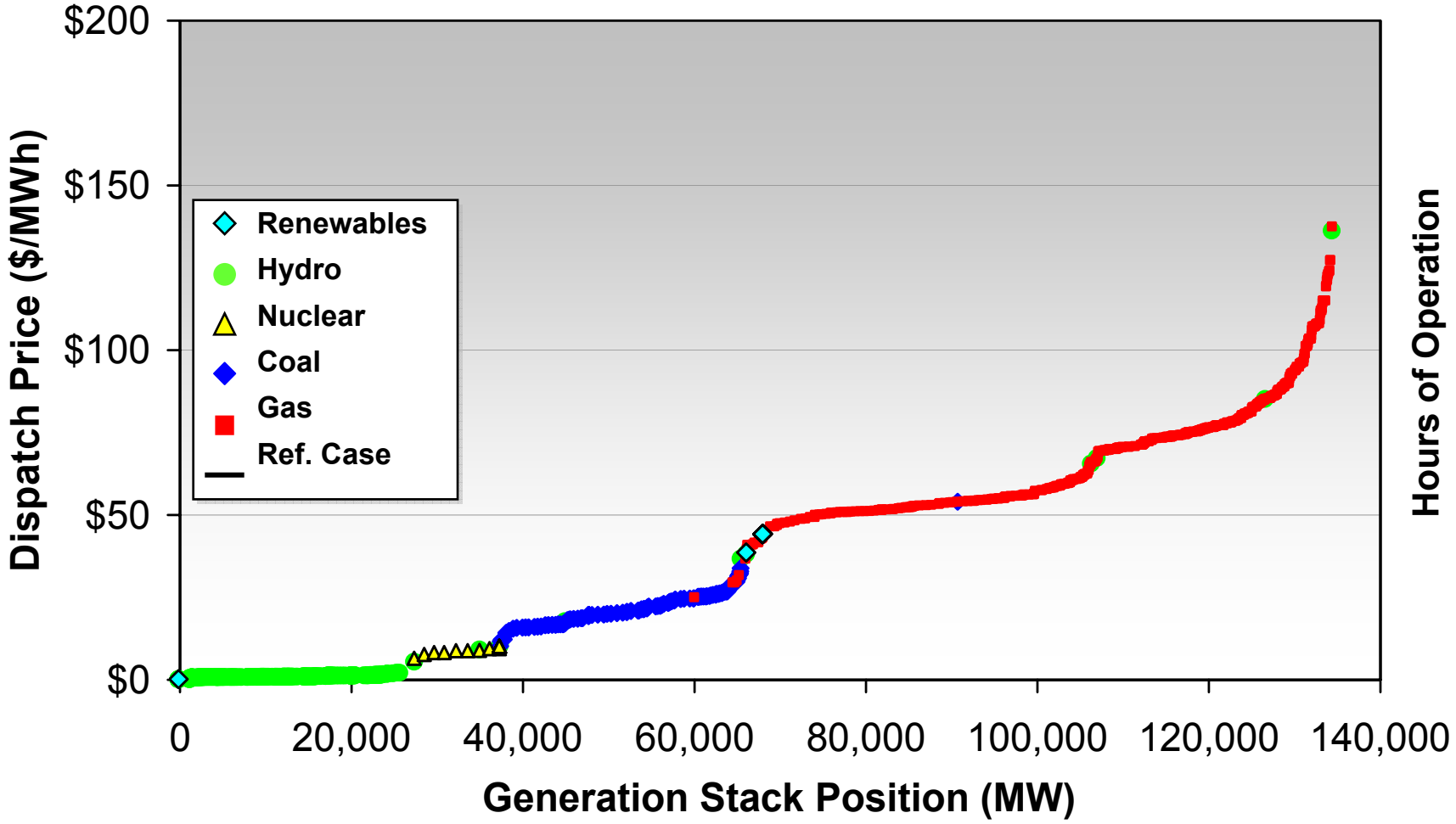
- **Non-Emitting – Nuclear and Renewable, including Hydropower, Generation**
- **Low-Emitting – Fossil-Fueled Distributed and Central Plants with CO_2 Capture**

From T. Wilson, EPRI, etal, "Electrification of the Economy and CO2 Emissions Mitigation," ***Journal of Environmental Economics and Policy Studies*****, Vol. 7/No. 5, 2005**

US Annual Electricity Generation under Three Different Policy Scenarios



Electric Generation Supply, CO_2 $0 per ton



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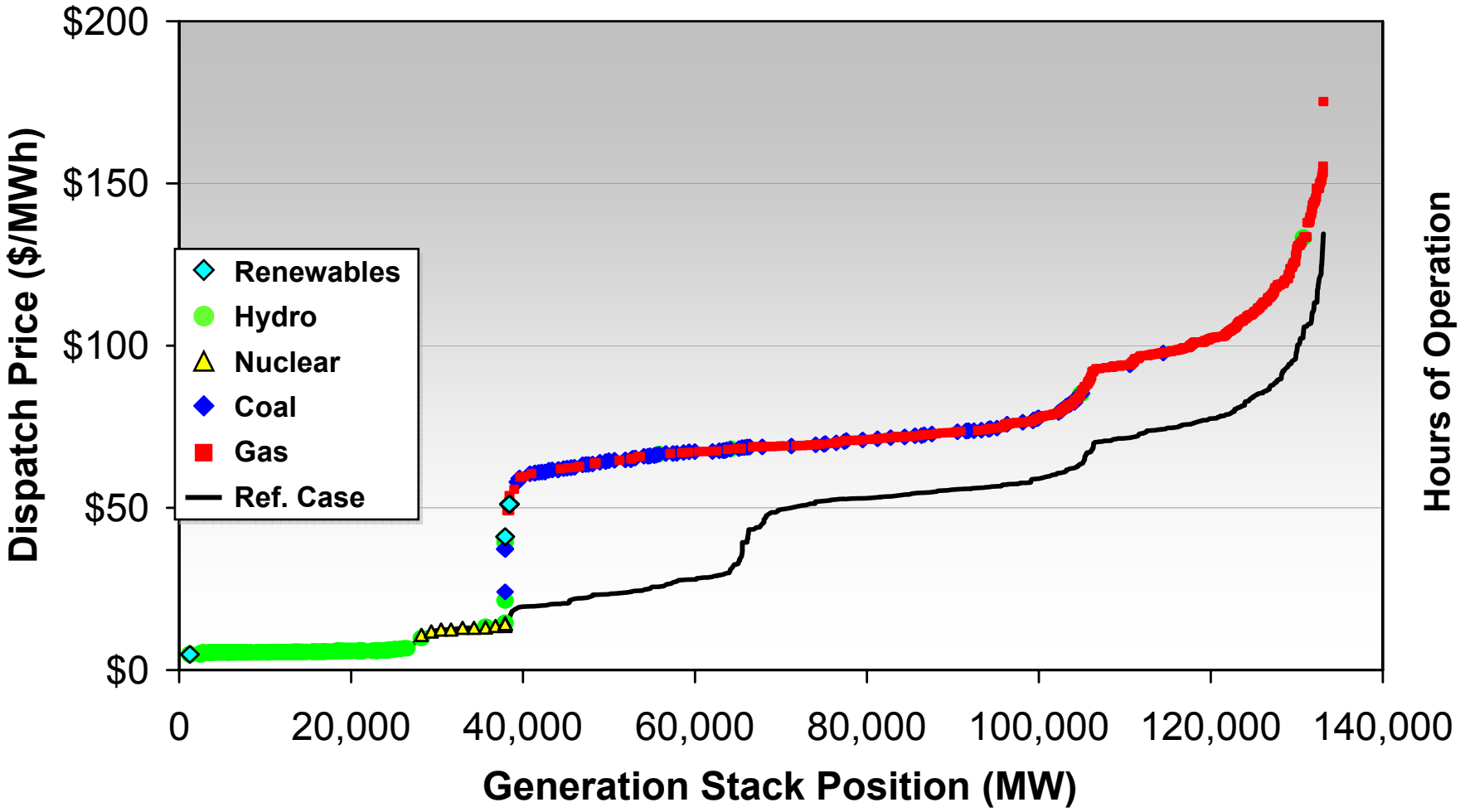
What Happens When CO_2 Has a Price of $40/ton



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Costs of Ancillary Services and Plant Cycling

Hydropower Technology Roundup Report: Accommodating Wear and Tear Effects on Hydroelectric Facilities Operating to Provide Ancillary Services

TR-113584-V4

1004047

Final Report, August 2001

Methodology for Costing Ancillary Services From Hydro Resources

Case Study and Guidelines

1004604

Final Report, October 2001

Damage to Power Plants Due to Cycling

1001507

Final Report, July 2001

Implications of Energy and Ancillary Service Market Structure for Hydroelectric Generation

A Survey of US ISOs

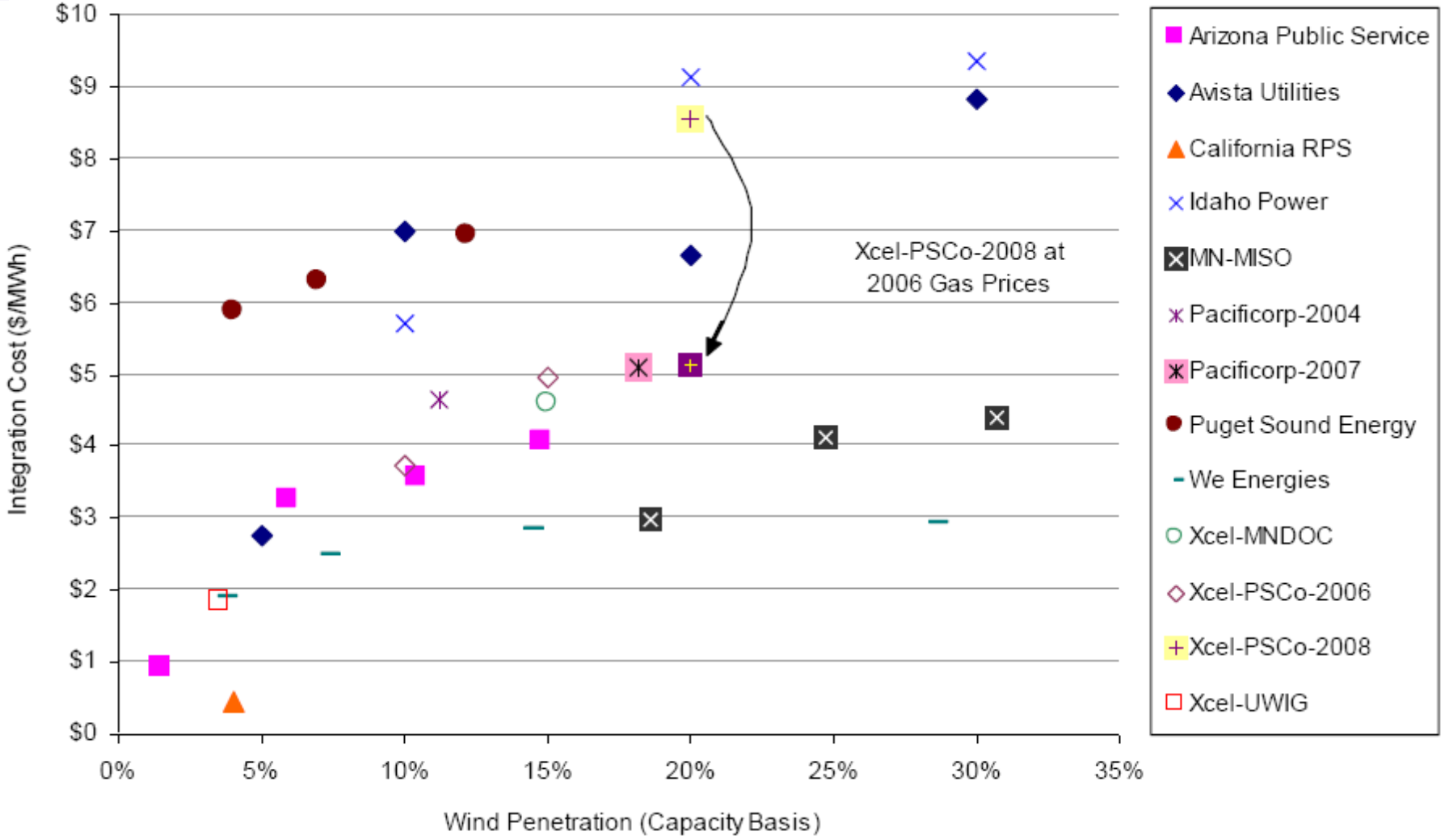
1006277

Final Report, September 2001

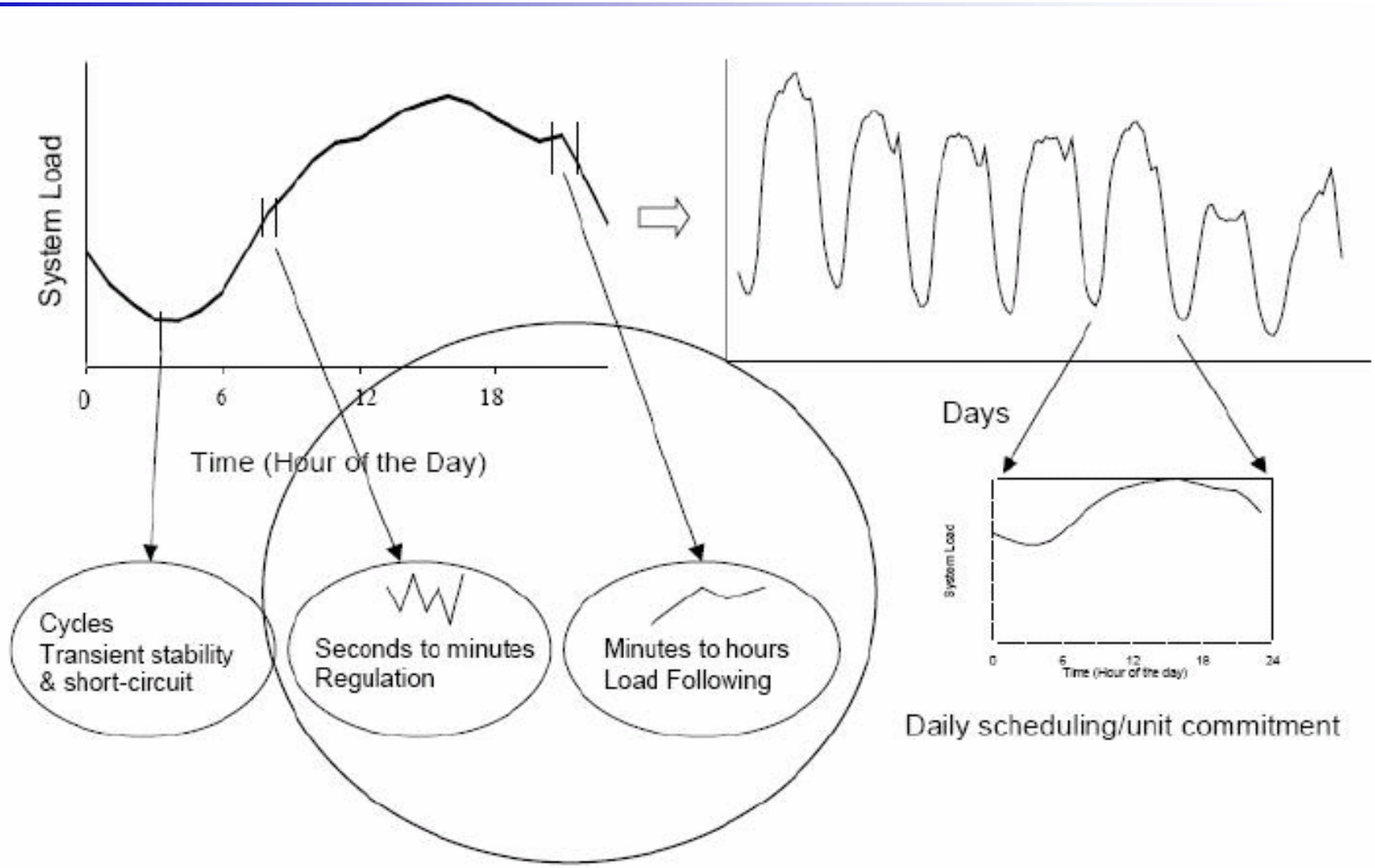
Sample of wind plant grid impact….very location and system specific

Study	Penetration Level (%)	Regulation	Intra-Hour Load Following	Inter-Hour Load Following	Scheduling/Unit Commitment	Total
NYSERDA-NYISO	10	-	-	-	-	
Xcel-280	0.3	-	0.41	1.44		1.85
Xcel-1500	15	0.23	0.00	4.37		4.60
AESO	13	7.37	-	3.64	-	11.01
BPA	11	0.19	0.28	-	1.00	1.47
SPS	20	1.00 - 2.25	0.01	-	-	1.01 - 2.26
WE	14	1.08	0.14	-	1.61	2.83
GRE	16.6	1.28	0.18	-	3.08	4.54
Pacificorp	20	-	-	2.50	3.00	5.50

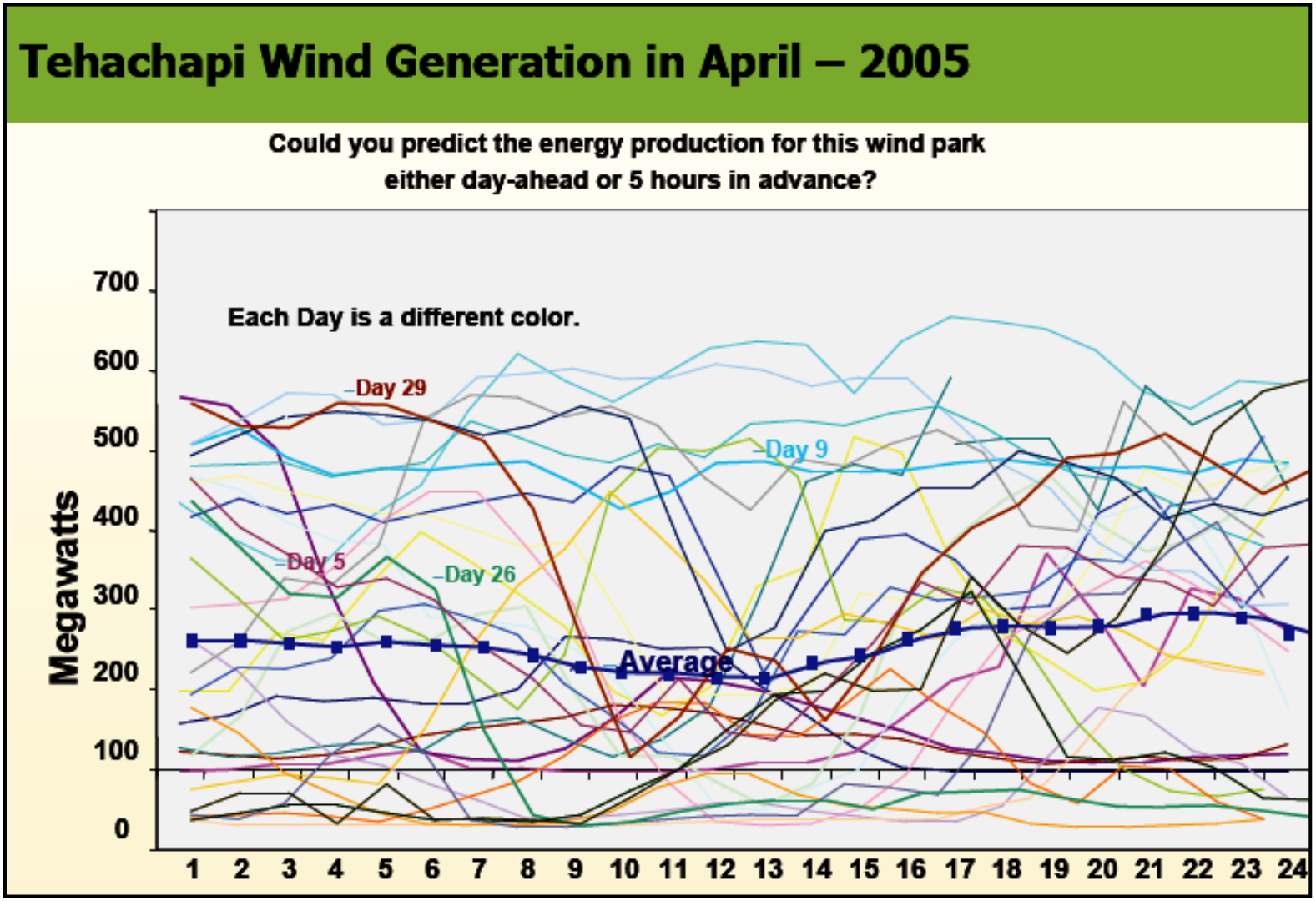
Cost of integration as a function of penetration



Load-Generation Balancing and Scheduling



Wind Variability & Predictability



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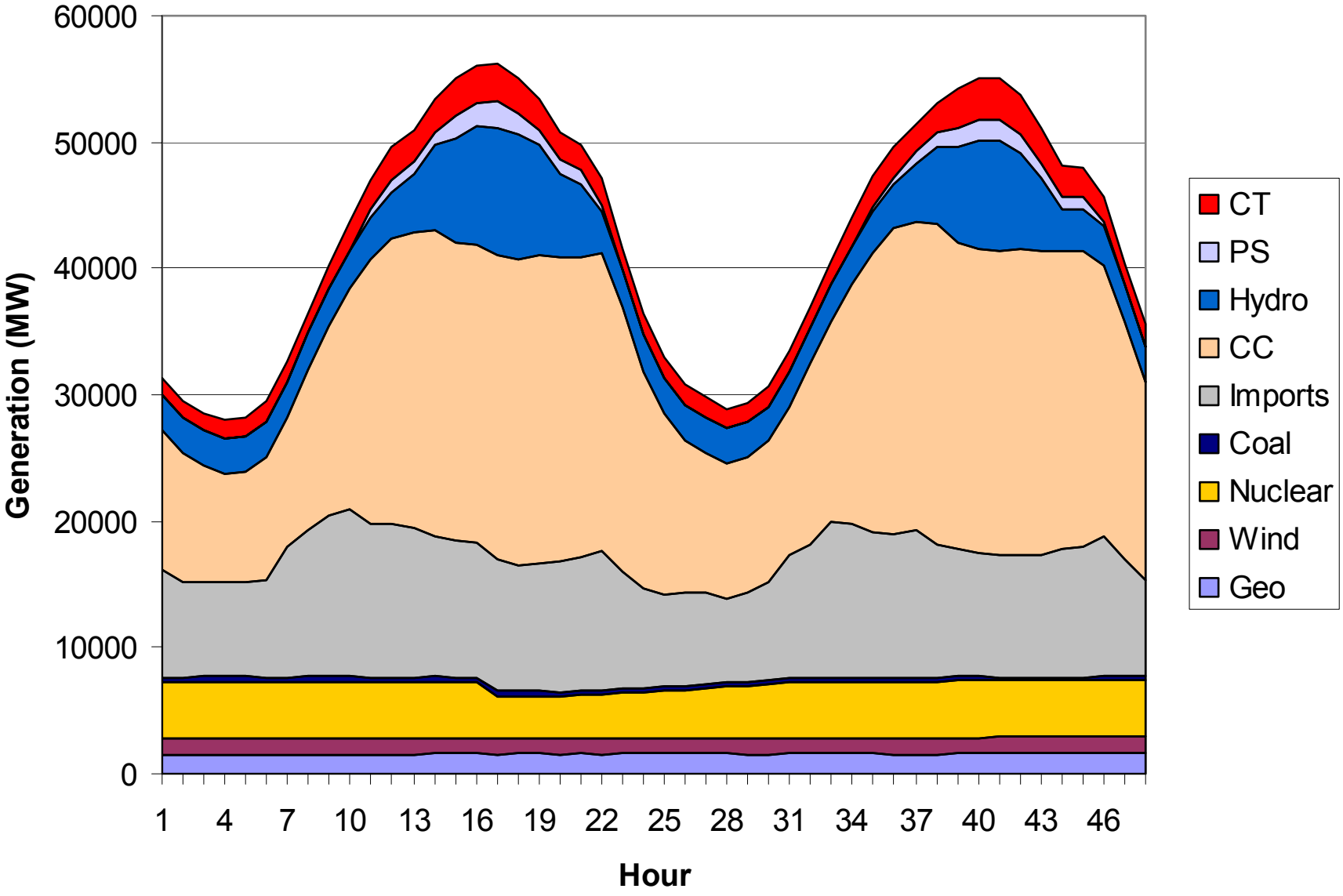
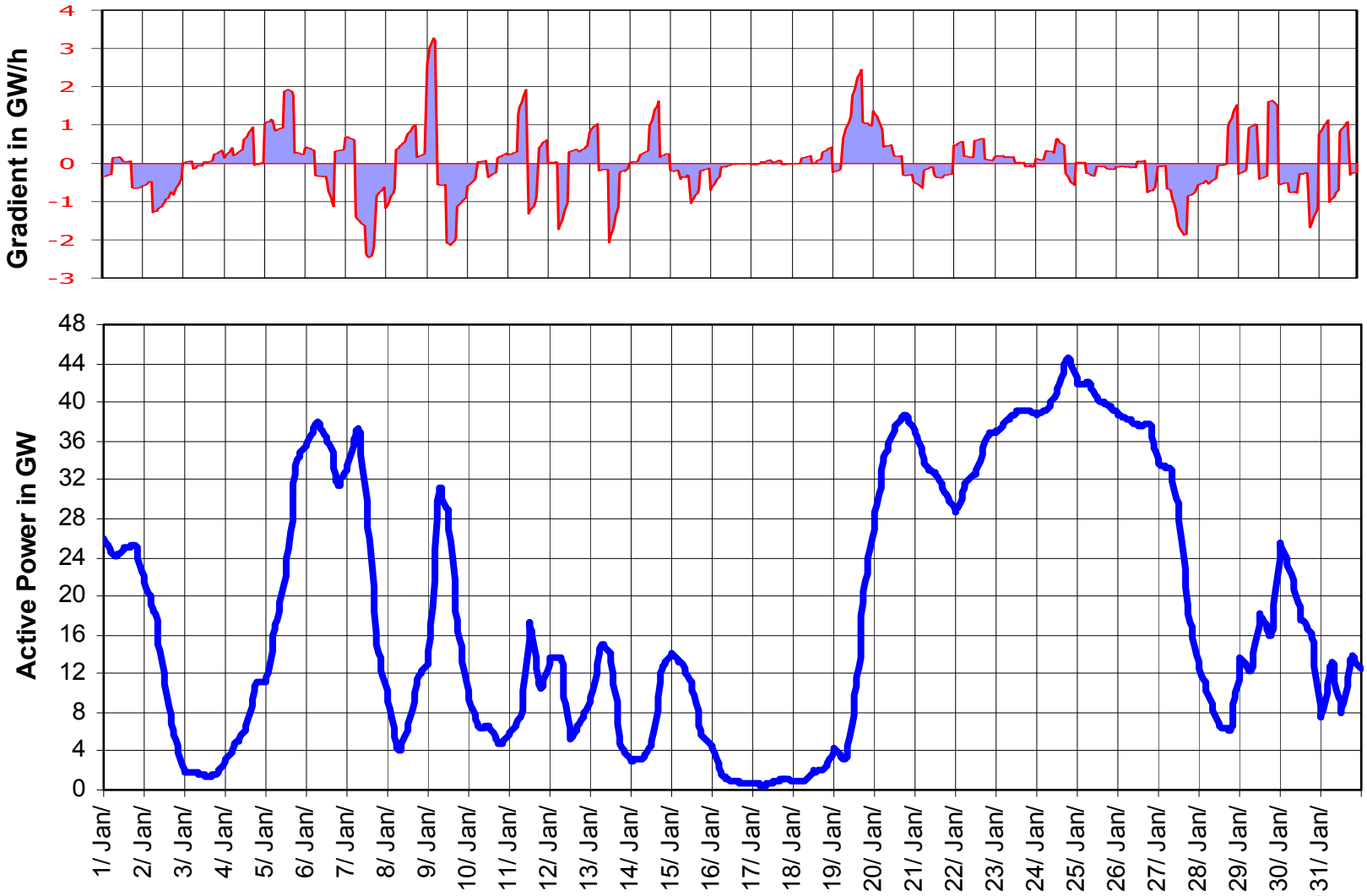
Electric Dispatch Example – Two Summer Days in California



GERMANY – Expected Variation based on projected 48 GW Installation (balancing duty)



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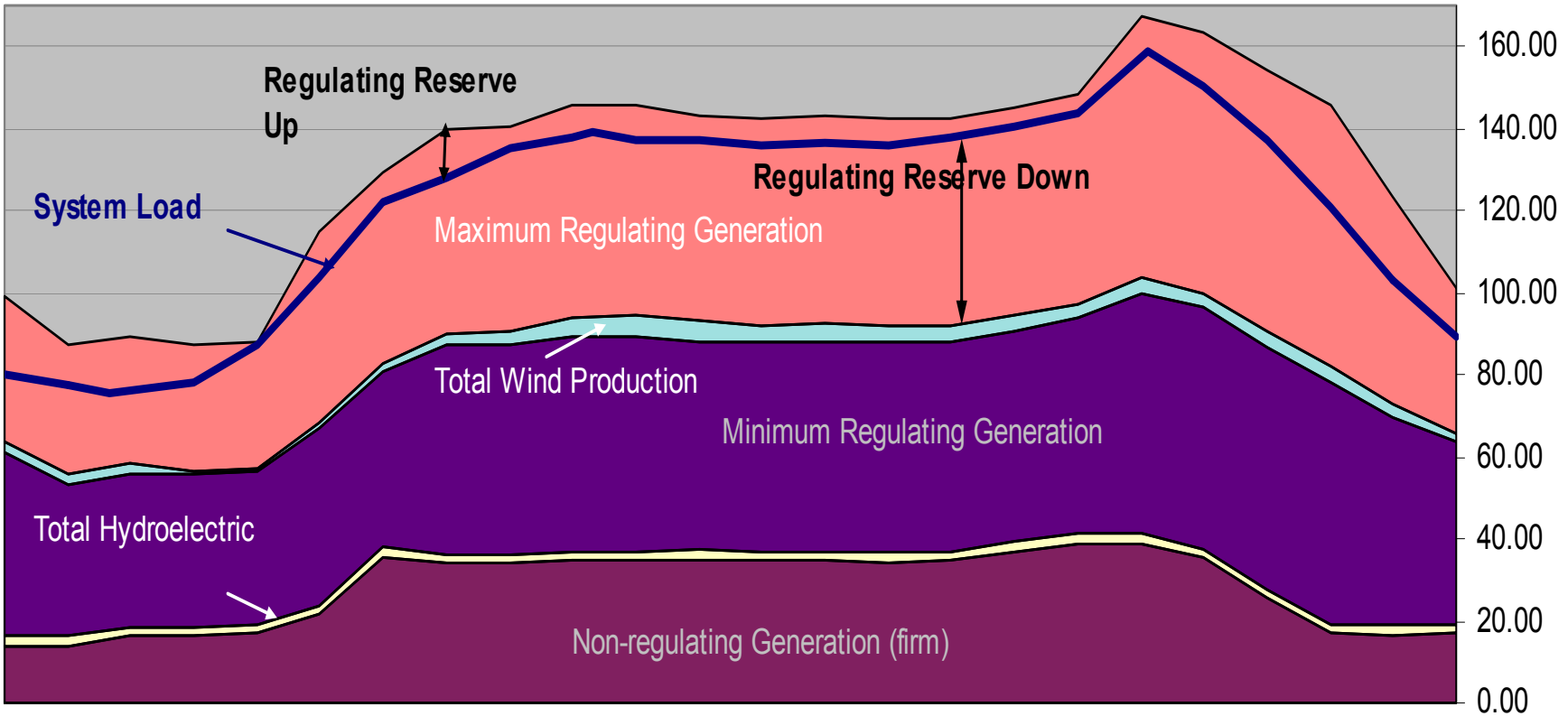
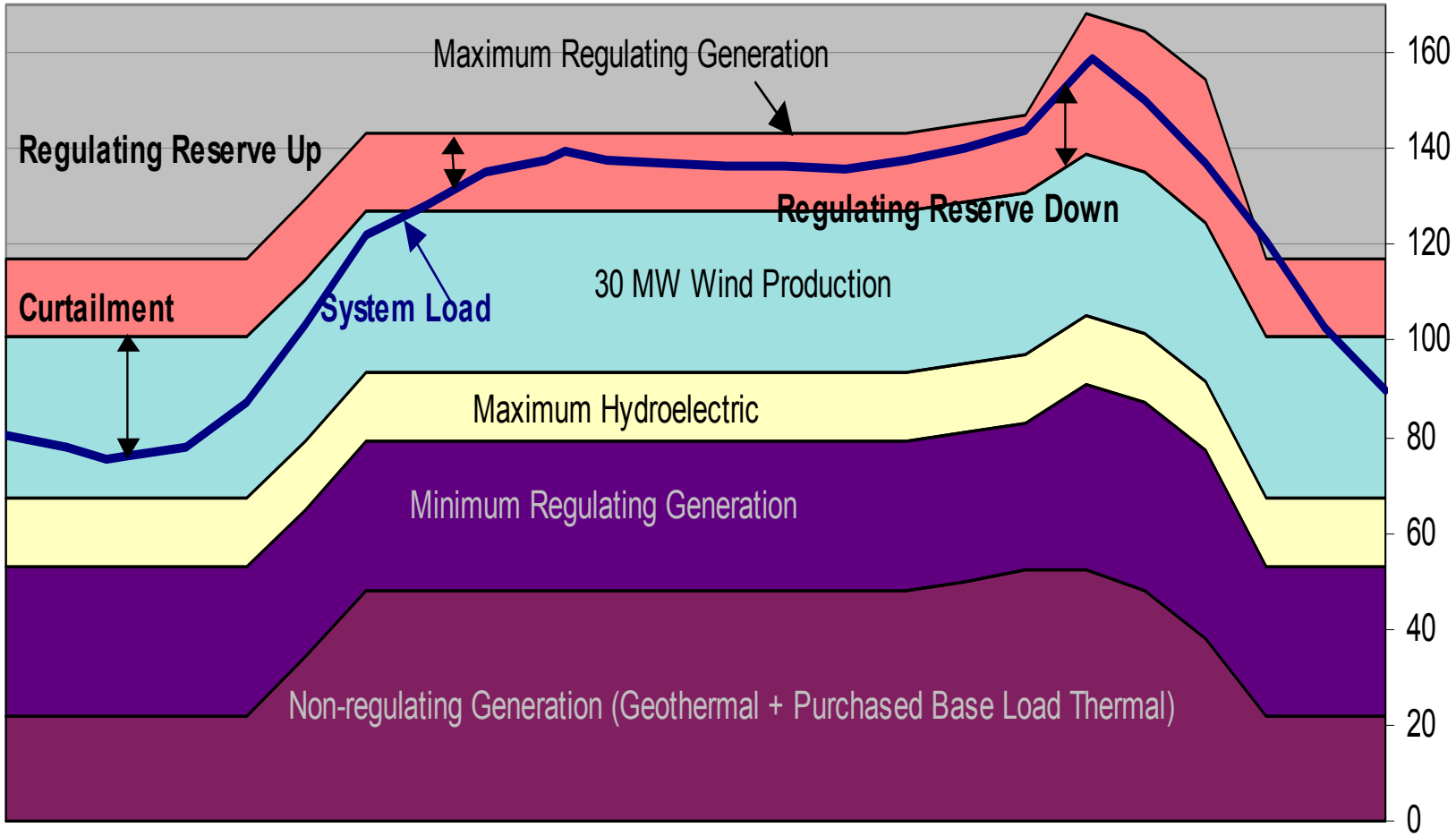
Daily Challenge for Helco's System Operators



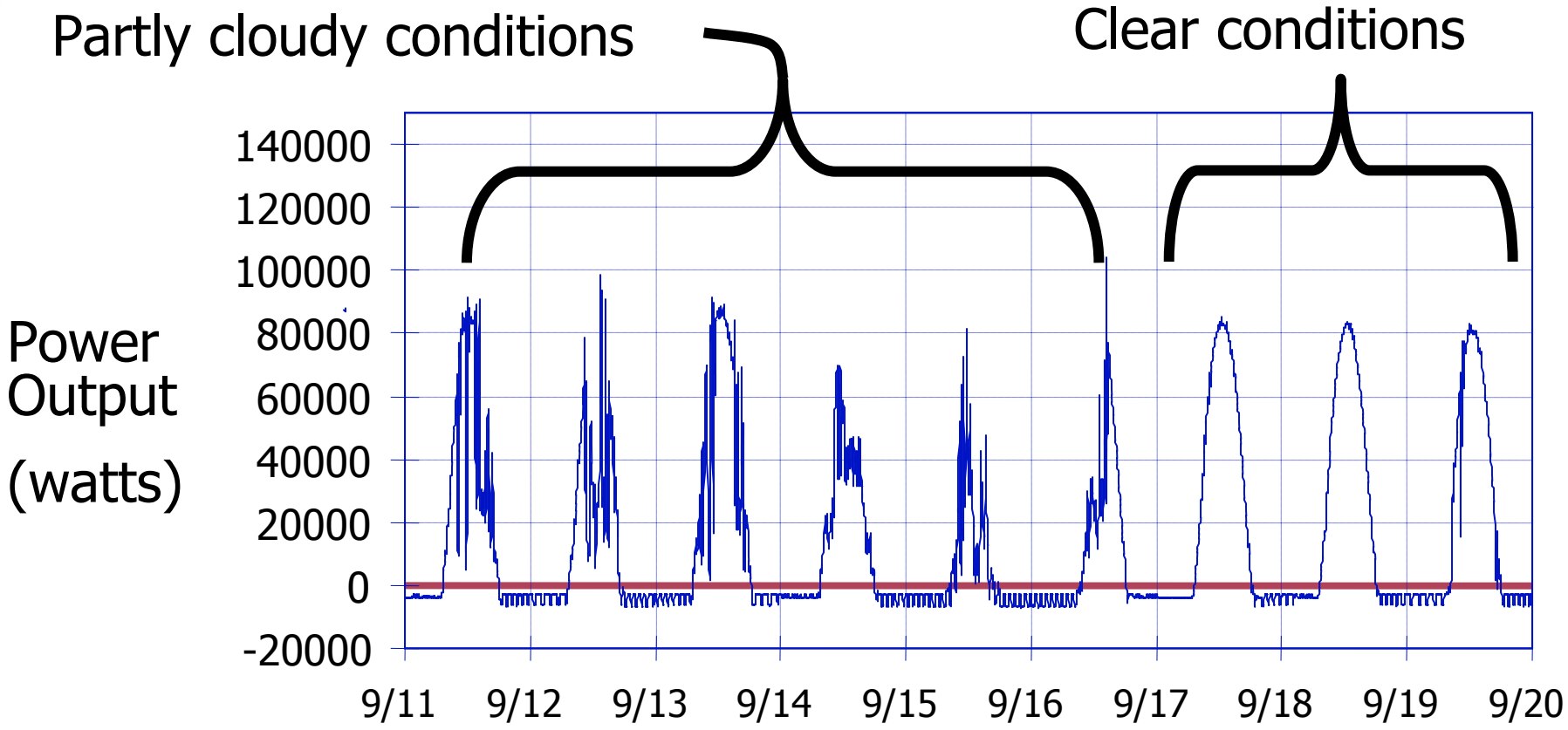
Daily, 24 hour, Load Profile and Generating Resource Allocation

Expected Situation with 30 MW of Wind Power Generation



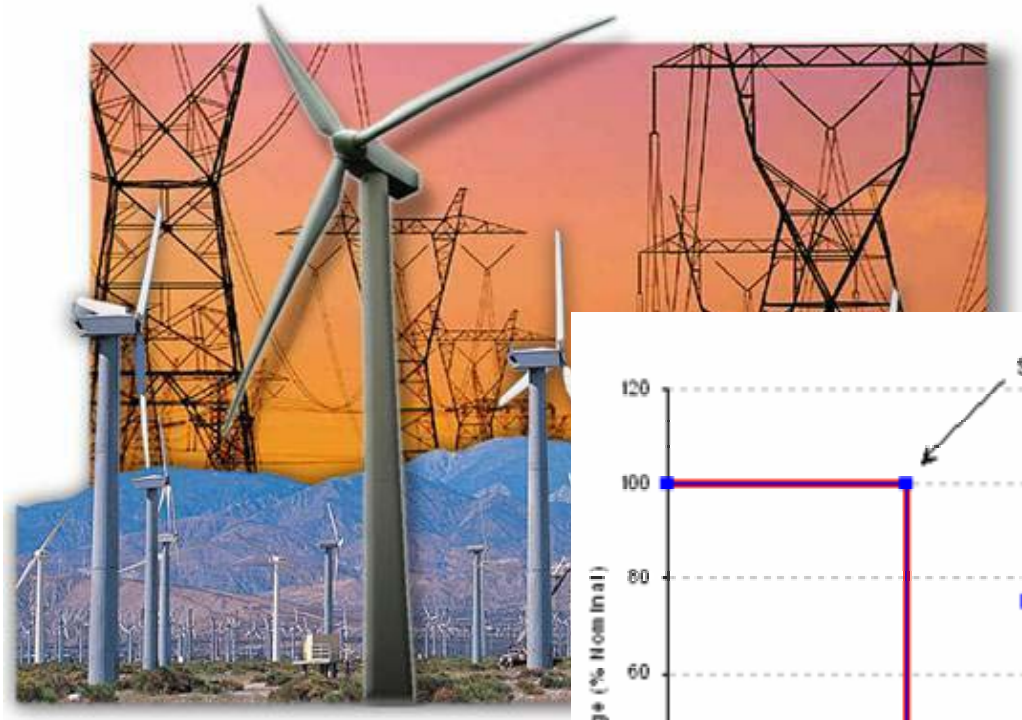
Projected Load Profile and Generating Resource Allocation

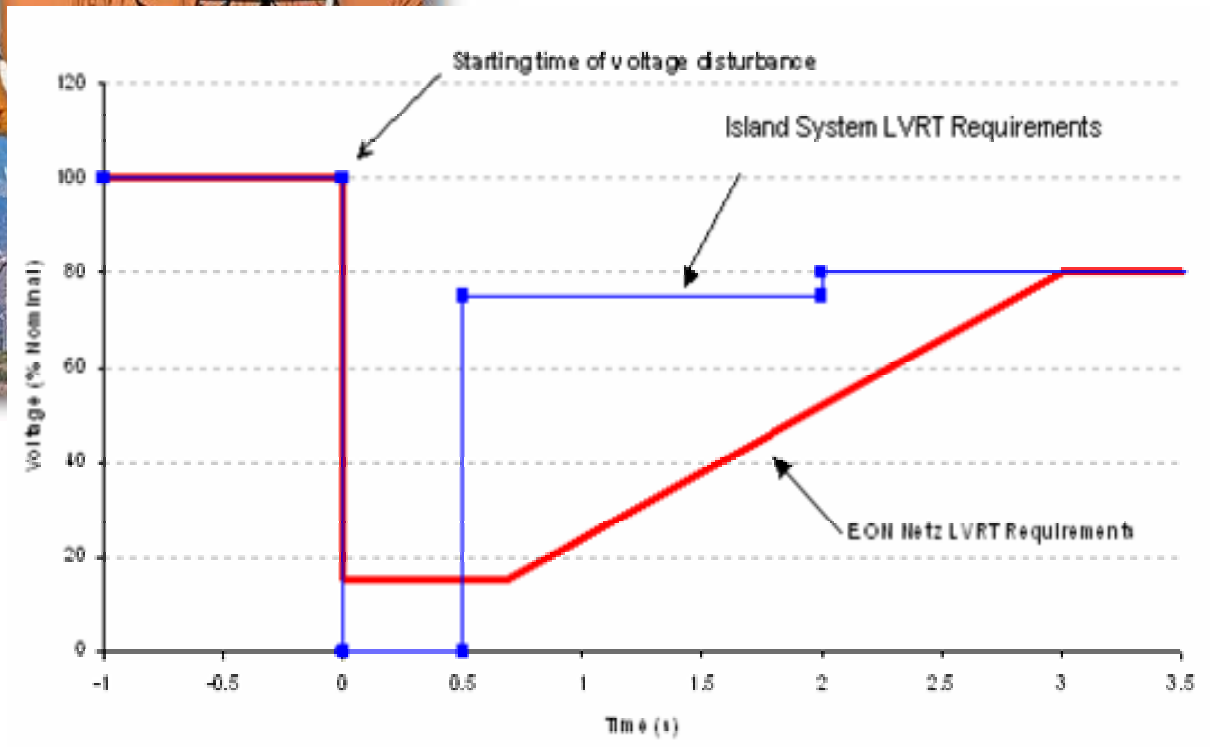
Hourly variation of solar PV system output over a few days



Recorded Data for a 100 kW Site Near Albany, NY, 1998

Wind Events – Denmark Example





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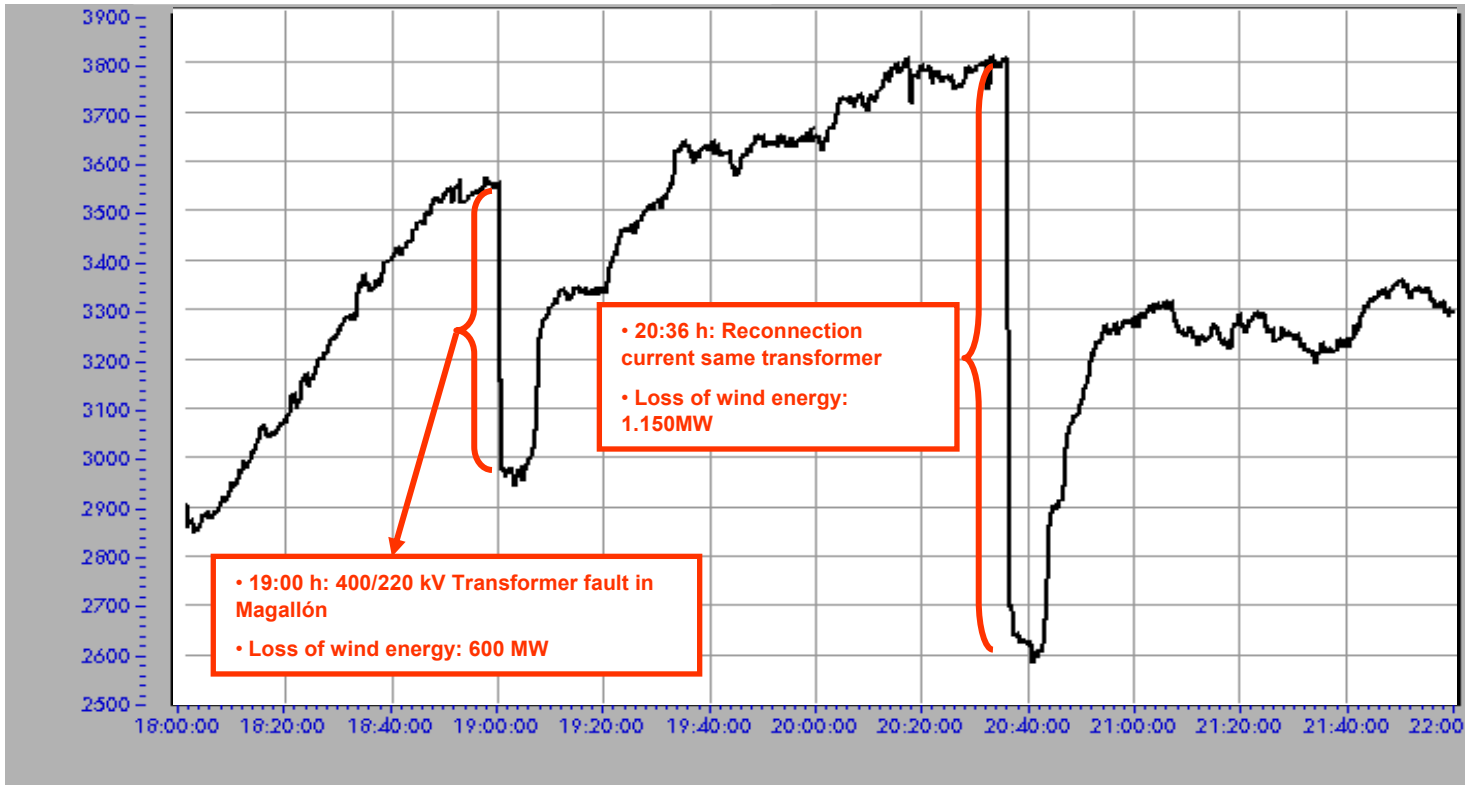
SPAIN (Plot from Ref [2]) – Sensitivity to Voltage Dips

- Large installed capacity of older Wind Turbine Generators without low-voltage fault ride-through



Functions and Services Provided by Generation (in energy markets)

Functions and Services	**Short Description**	**Time Frame**
Base load units (non-regulating)	**Energy** (firm) scheduled well in advance, based on availability, price, and long-term contracts.	**Long-term** commitments
Committed units (usually with regulation capacity)	**Energy** (firm) scheduled based on availability and price to meet block load, with LOLE[1] and load forecasts considered.	Day before plan, **hourly** resolution
Load-following or energy-balancing units	**Energy** ramping to follow the load, met by adjusting generation schedules and the imbalance energy market.	Hourly plan with **5- to 10-minute** resolution
Frequency regulation (regulating reserves)	**Service** provides capacity based on a signal from dispatcher, with AGC[2] to meet CPS 1 and CPS2[3] and no net energy[4].	Every few minutes, **minute-to-minute** resolution
Reactive supply and voltage control	**Service** of injecting or absorbing of reactive power to control local transmission voltages (usually provided with energy).	Continuous with response in **seconds**
Spinning operating reserves	**Service** to provide energy in response to contingencies and frequency deviations.	Begin within **10 sec** full power in **10 min**

Value of Ancillary Services and Energy Storage

- *Load following*
- *Regulation*
- *Reserves*
- *Black start*

Revenues from Ancillary Services and the Value of Operational Flexibility

1004413

Final Report, November 2002

Dynamic Operating Benefits of Energy Storage

A Survey of US ISOs

AP 4875

Final Report, October 1986

Quantifying the Value of Control System Performance Improvements

1009844

Final Report, December 2004

Mechanisms for Evaluating the Role of Hydroelectric Generation in Ancillary Services Markets

TR-111707

Final Report, November 1998

Value of Operational Flexibility to Portfolios of Generating Units

1004819

Final Report, November 2003

Recommendations

1. *Improve our Analysis and Communication for Valuing Hydro Power Assets*
   - Regulation Value Assessment
   - Contingency Reserve Value Assessment
   - Load Following and Dispatch Value Assessment
   - Energy Arbitrage Value Assessment
   - Black Start

2. *Break-thru market and regulatory challenges for aggregate hydro values to recognize cost/benefits*

Questions

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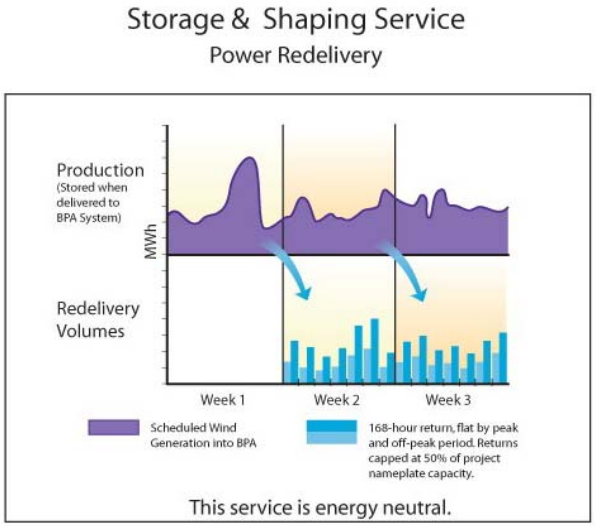
Bonneville Power Administration Wind Integration Services

Contact: Elliott Mainzer, eemainzer@bpa.gov

BPA Storage and Shaping Service

- For wind projects that deliver power to the BPA system.
- Peak and Off-Peak blocks redelivered a week later at $6.00/MWh before transmission.



BPA Network Wind Integration Service

- For customers in BPA Control Area who wish to purchase wind from a project selling into BPA Control Area.
- Tariff is $4.50/MWh before transmission.