

Enabling Renewables with Energy Storage



University of Wisconsin Energy Hub

Greening the Grid: Innovation for our Electricity Infrastructure

November 4, 2011

David Donovan, Manager of Regulatory Policy

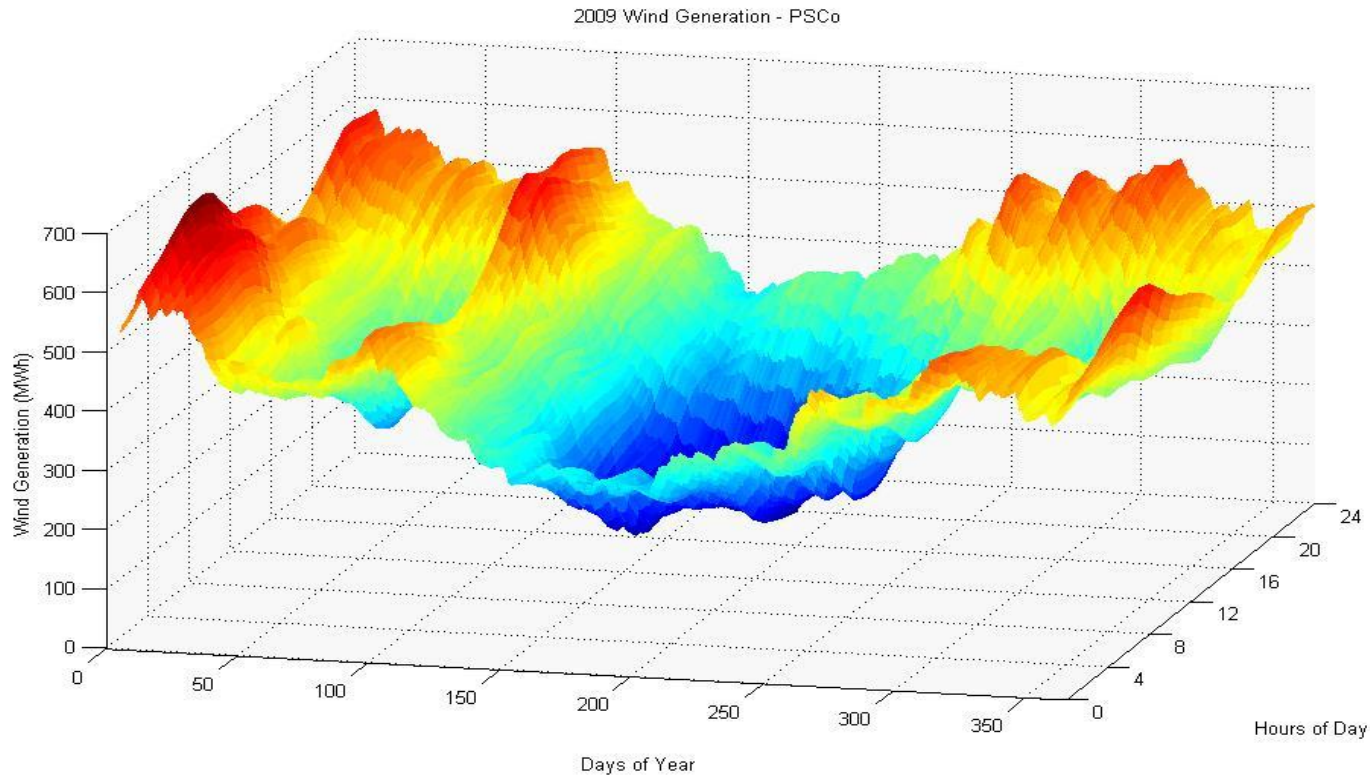
Frank Novachek Director, Corporate Planning

Energy Storage at Xcel Energy

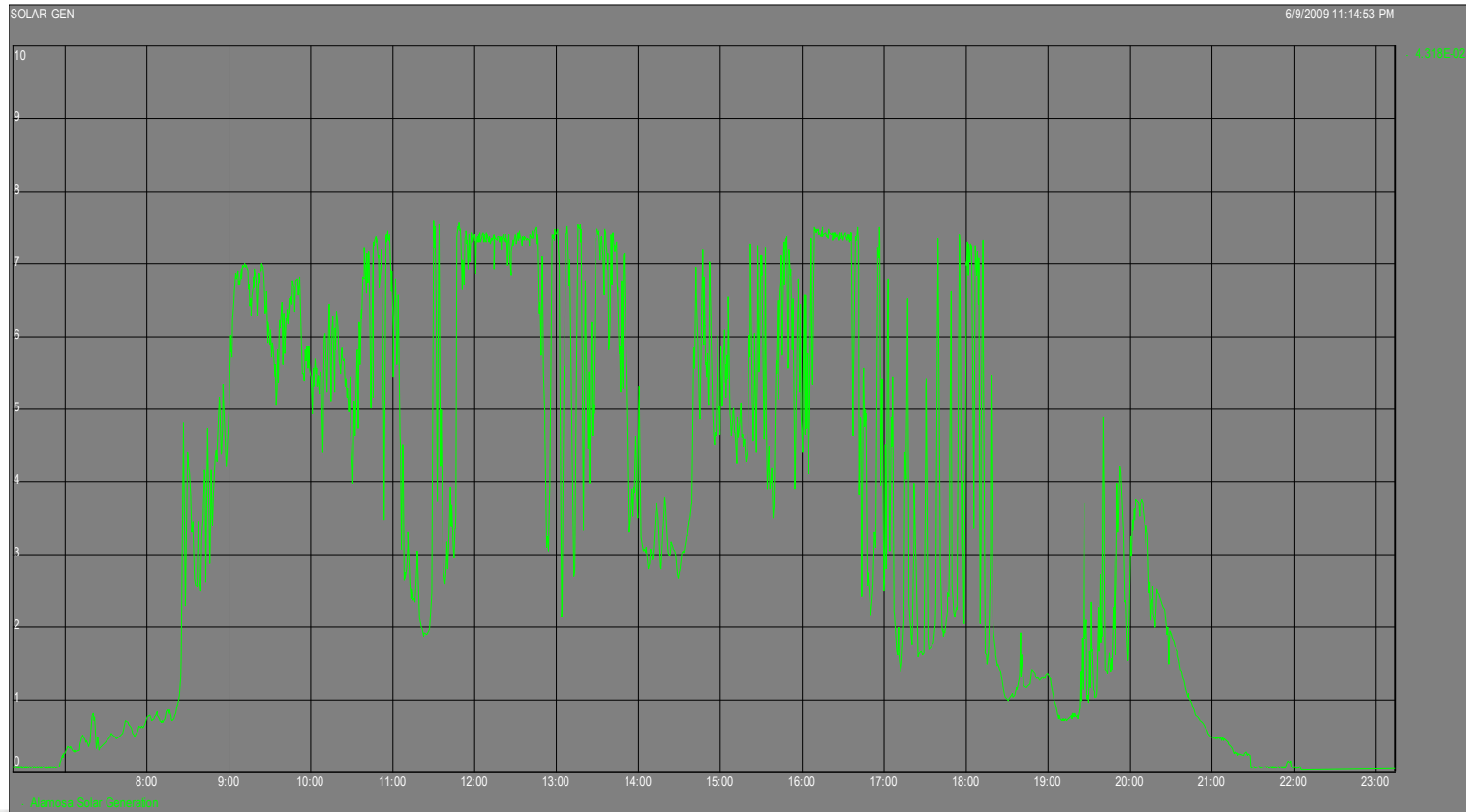
- **Storage is a means to provide more system control, supporting:**
 - Generation – Shifting wind output to minimize impact of renewables variability; reduced wear and tear on conventional generators
 - Transmission – Ancillary services
 - Distribution – Voltage regulation and peak shaving
 - Individual customers – Power quality & peak shaving
- **Strategic to Xcel Energy because of the high wind and solar PV penetrations expected on our operating systems**

Wind Doesn't Always Blow When Needed

2009 Wind Generation in Colorado



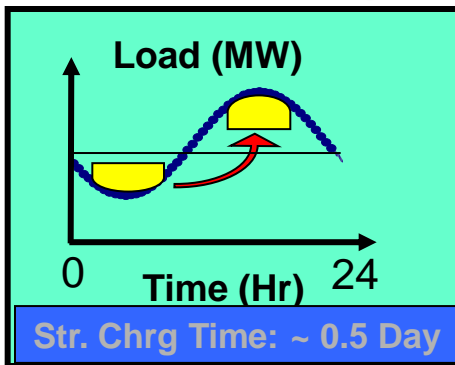
Solar PV Variability



Data from PSCo 8 MW Solar PV Facility in Alamosa, CO

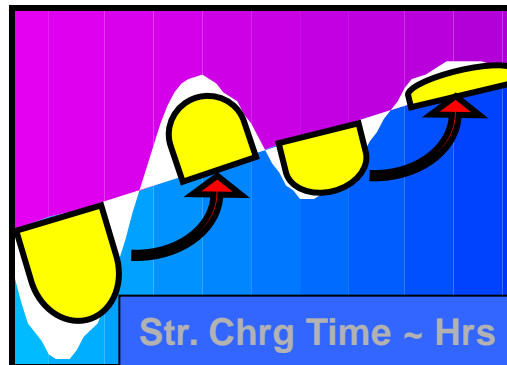
Renewables Integration Value

Time Shifting



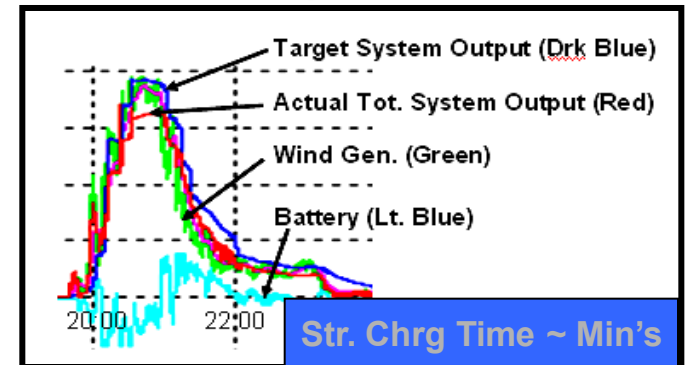
- Arbitrage
- Constraint Relief
- Curtailment Avoidance
- Load/DG Matching
- Peak Shaving

Ramping Control



- Reduced generator cycling
- Reduced reserve requirements (gas & elect)
- Voltage stability (distribution)

Regulation



- Frequency – “Reg Up/Reg Down”
- Voltage/VAR support
- Fast response to system perturbations

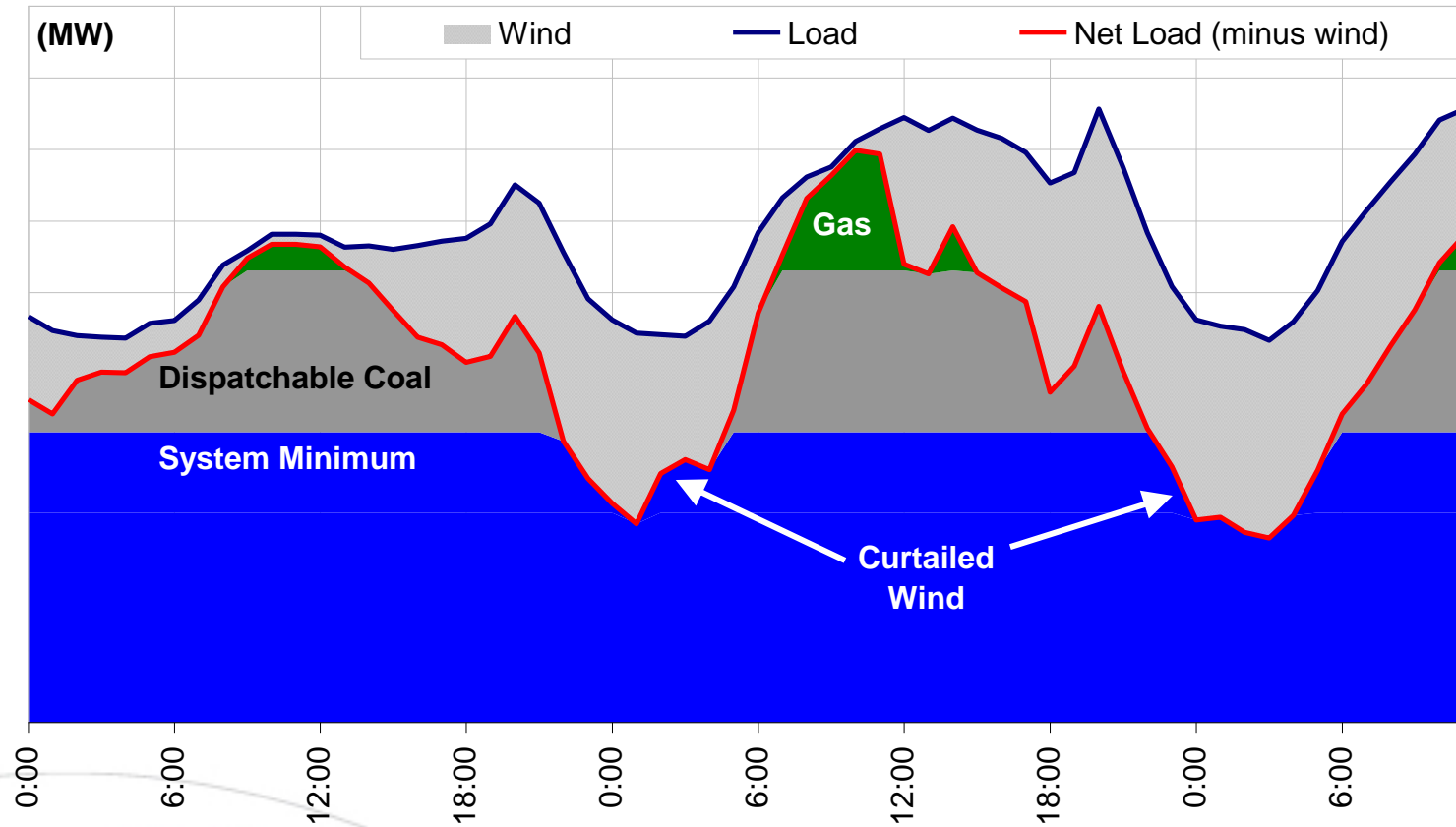
Source: EPRI

Minimum Generation Limits

– Largest Current Issue With Wind Energy

- **Typical Off-Peak Generation Supply Conditions**
 - **Most gas plants are turned off at night**
 - **Coal plants are cycled to minimum levels**
 - **Nuclear production is held constant**
- **If wind is blowing during these hours:**
 - **Potential exists for wind curtailment**
 - **Potential for more frequent coal cycling**

System Bottoming Effects (No Storage) System with Coal Baseload



Baseload Minimum Generation Mitigation

- **Lower the Floor**
 - Lower plant minimum capacity (*e.g. modern gas turbines*)
 - Decommit - Reevaluate “must run” status (*contract changes*)
 - Decommission baseload (*e.g. coal plant retirements*)
- **Increase Off-Peak Load**
 - Add new storage resources (*when price is right*)
 - Dispatchable loads (*e.g., Demand Response Resources*)
- **Make Wind Play Nicely**
 - Implement set point/ramp control at wind plants (*current technology in more recent wind resource additions*)
 - Better forecasts = Better planning (*actively in development*)

Storage Expensive Now

... But There's Promise

- System does not currently have much wind curtailment exposure that could be cured by energy storage
- Considering only the “generation” value of storage, current competition for bulk energy storage is a device that is between a CT and a CCGT (4-6 Hrs of on peak use per day)
- Commercially available storage technologies have a higher capital cost today than those alternatives
- Storage has the potential to provide other difficult to value services
 - Both load and a generation source providing operational flexibility
 - Quick response – though value is system dependent
 - Smaller, distributed systems can serve multiple functions (case specific)
 - Distribution voltage support & congestion relief
 - Solar PV variability mitigation
 - Aggregation to serve bulk storage functions, including time shift and wind energy curtailment avoidance

Luverne Distributed Energy Storage System – Sodium Sulfur Battery

- 1 MW / 7 MWh NaS Battery System
- Power Conditioning Equipment (PCS)
- Wind farm/grid interconnection
- Partnerships
 - NGK/S&C
 - MinWind LLC
 - NREL
 - U of Minnesota
 - Great Plains Institute



Located in Luverne, MN; connected to Minwind Energy LLC wind facility (11.5 MW)

SolarTAC Battery Project

XP Dynamic Power Resource™

- 1.5 MW / 1 MWh Standard Module
- Turn-key - Storage, PCS, Controls, Enclosures, and Interconnection
- Primary Applications for Xcel Energy
 - Solar PV Integration
 - Distribution Grid Reliability
 - Solar Peak Time Shift
 - Ancillary Services
- Partnerships
 - Xtreme Power
 - EPRI
 - Possibly NREL & Amonix



Recent Installation at SolarTAC





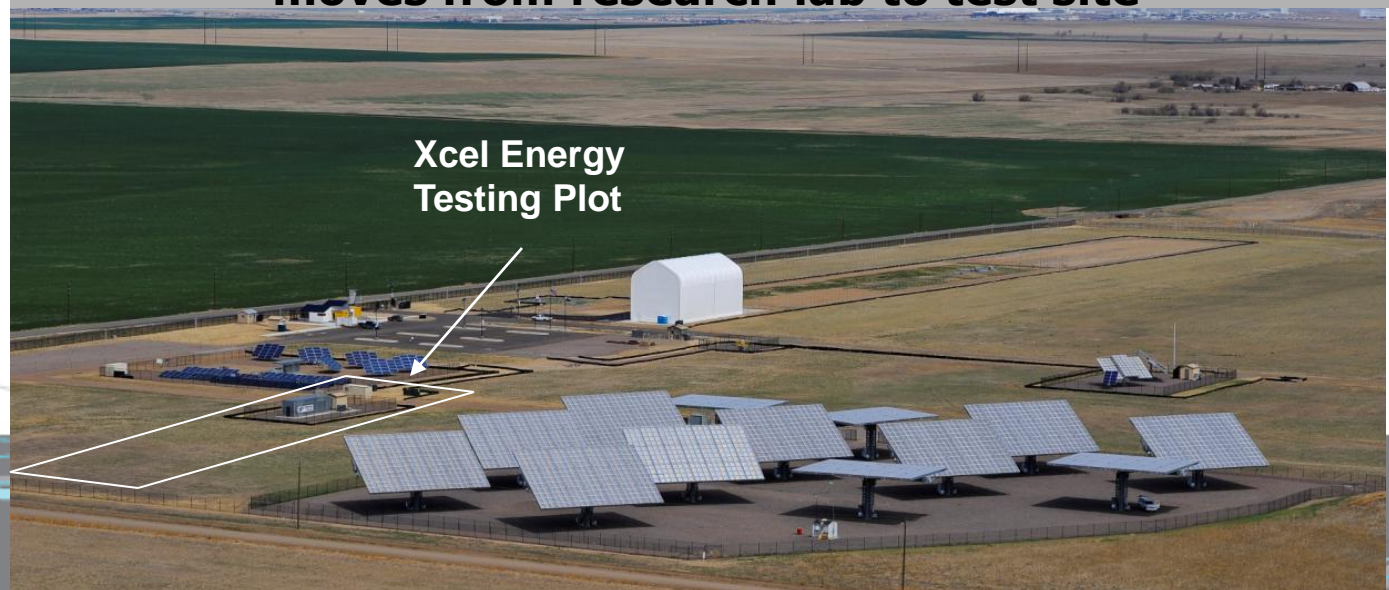
SolarTAC Entrance

1 MW “Solar2Battery” Project



A world-class facility where solar technology moves from research lab to test site

Site Aerial View
(as of April, 2011)



Xcel Energy
Testing Plot

Other Energy Storage Activities

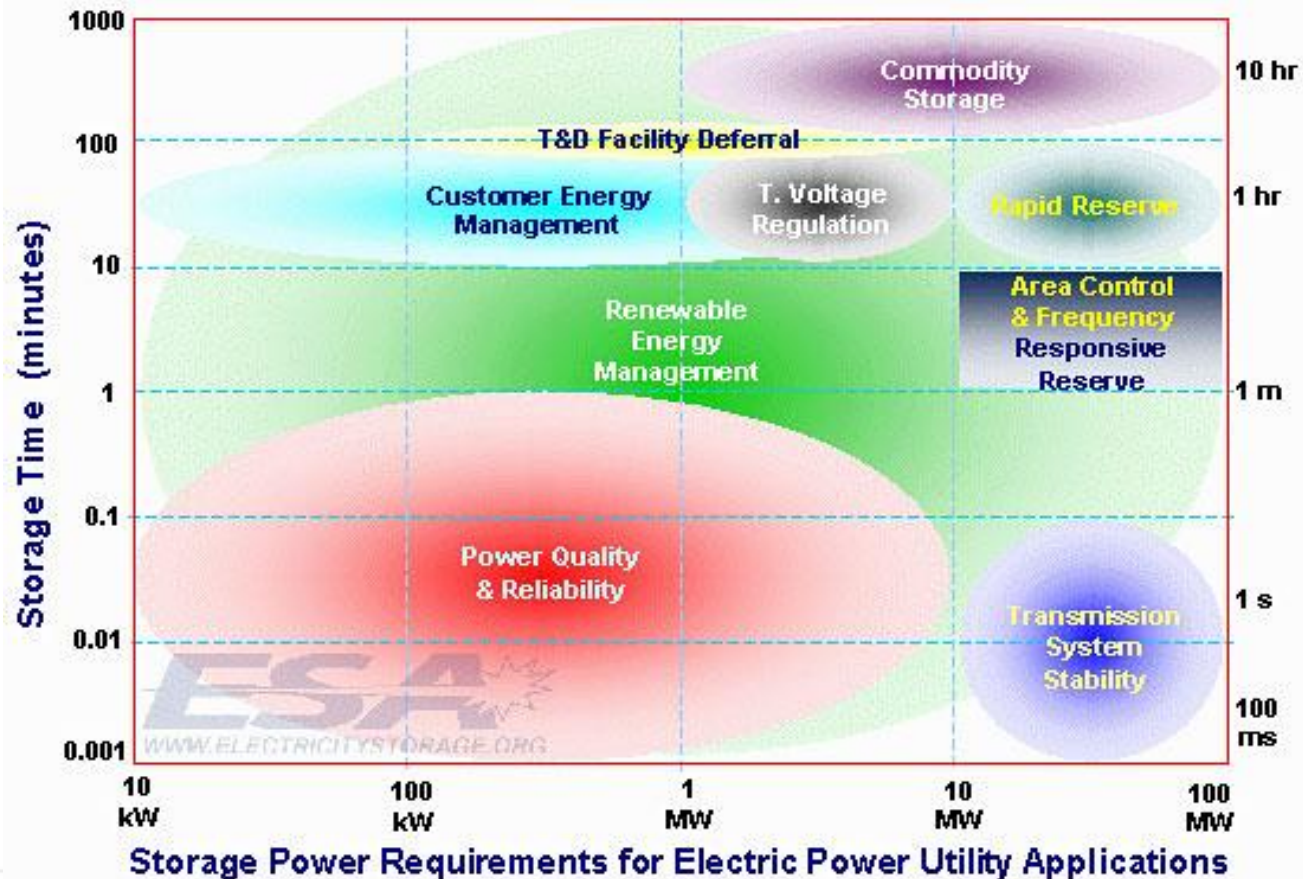
- **Wind-To Hydrogen Project (2006 – Present)**
 - Two electrolyzers powered by wind and solar energy at NREL to produce and store hydrogen during off-peak hours for use in operating a 50 kW hydrogen internal combustion engine (HICE) generator set during on-peak hours
 - System has been expanded to include a hydrogen fueling station (for hydrogen powered vehicles at NREL) and a 5 kW stationary fuel cell to operate in parallel with the HICE generator set.
 - Location: Golden, Colorado – NREL's National Wind Technology Center
 - Partners: NREL, DOE, EPC, Proton Energy, Teledyne
- **Compressed-Air Energy Storage Study (2009-2010) :**
Contracted with EPRI to examine the economics and technical issues of siting a CAES plant in Colorado – On Hold



Xcel Energy[®]

RESPONSIBLE BY NATURE[™]

Utility Applications for Storage



Data from Sandia Report 2002-1314

System Ratings

Installed systems as of November 2008

