Energy Storage

Status and Progress

(*coming to a grid near you*)

IMRE GYUK, PROGRAM MANAGER
ENERGY STORAGE RESEARCH, DOE

Energy Storage provides Energy

when it is needed

just as Transmission provides Energy

where it is needed

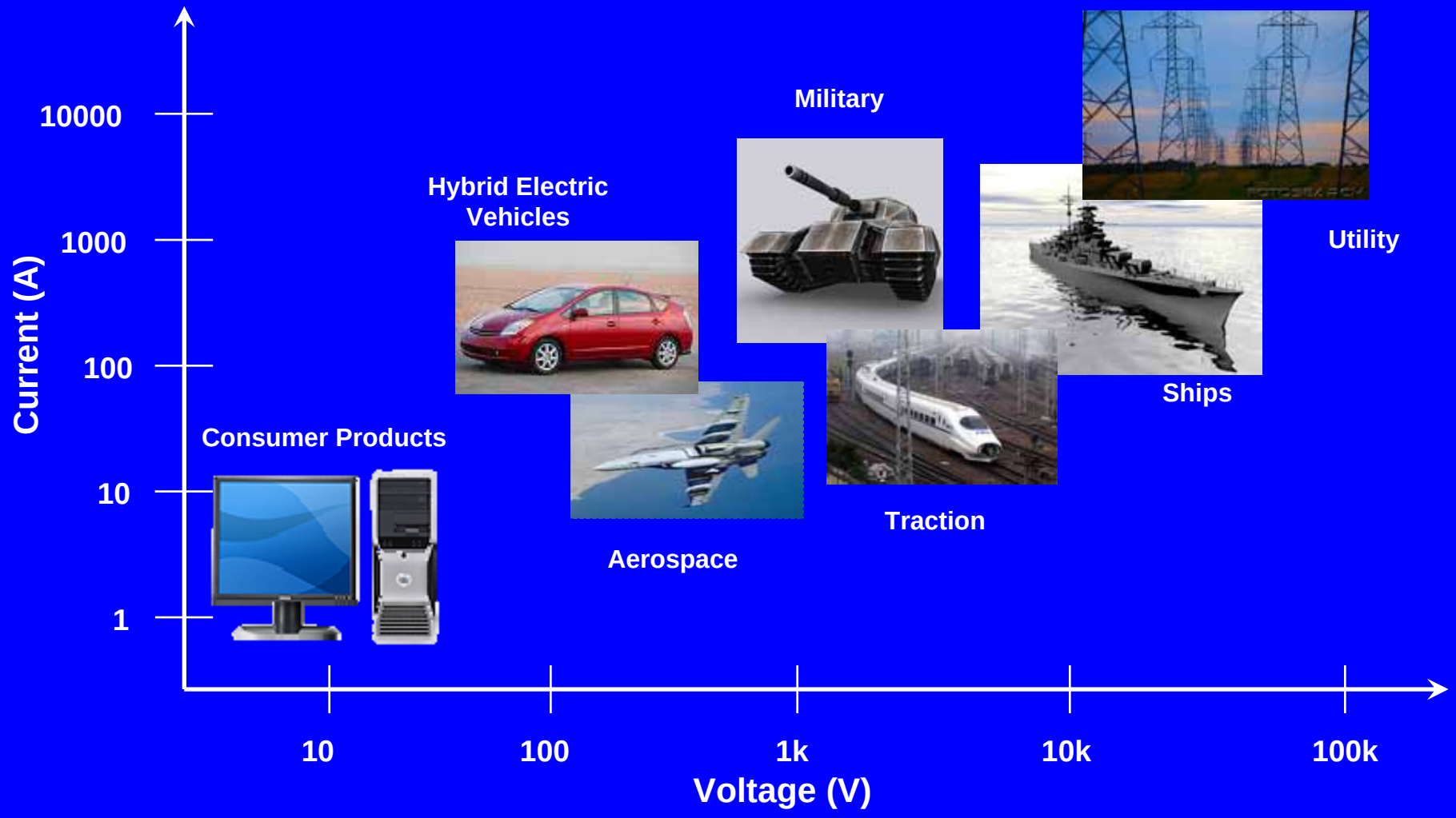
Storage links

Variable Load

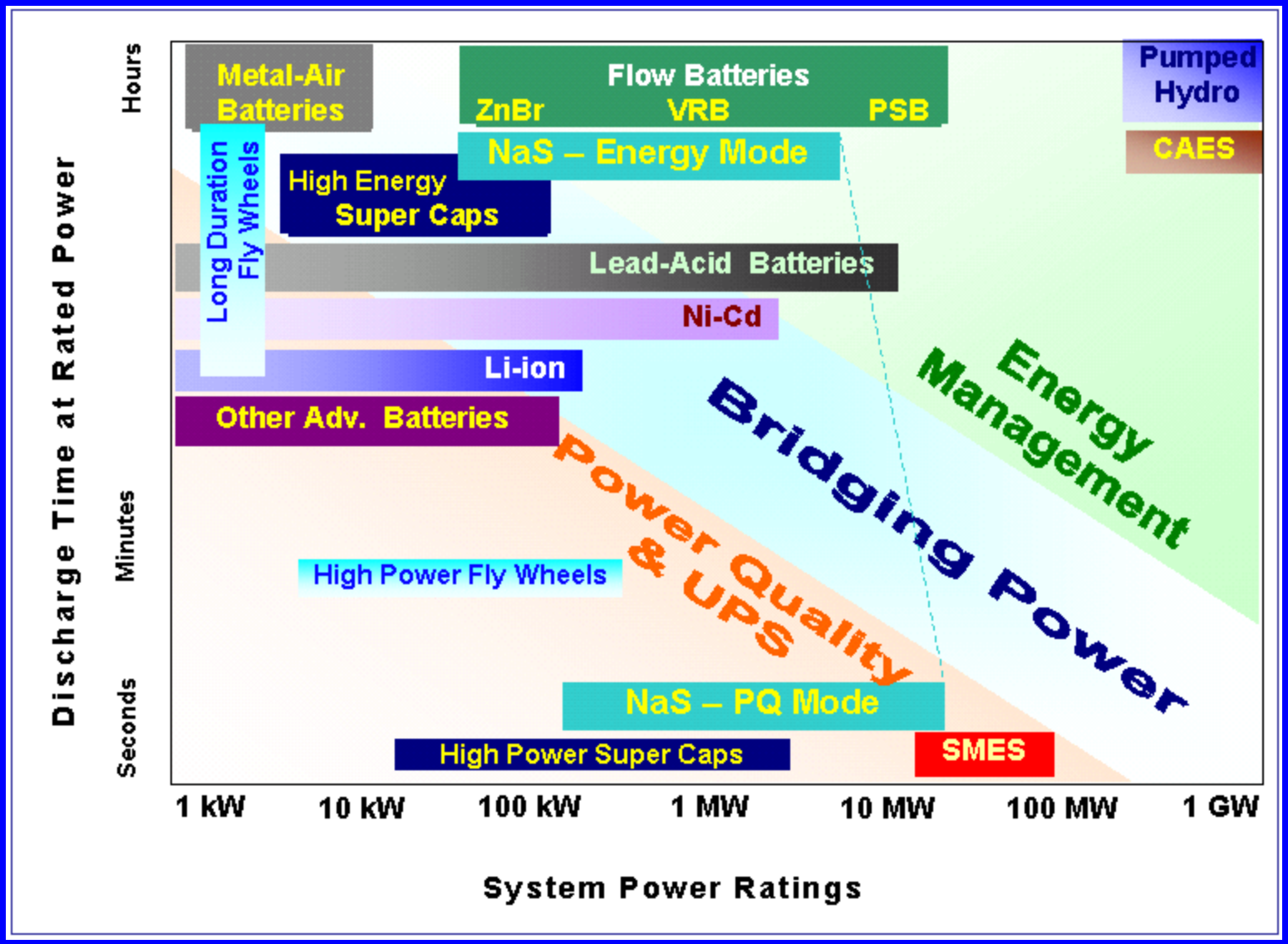
with

Variable Generation

Domains of Power



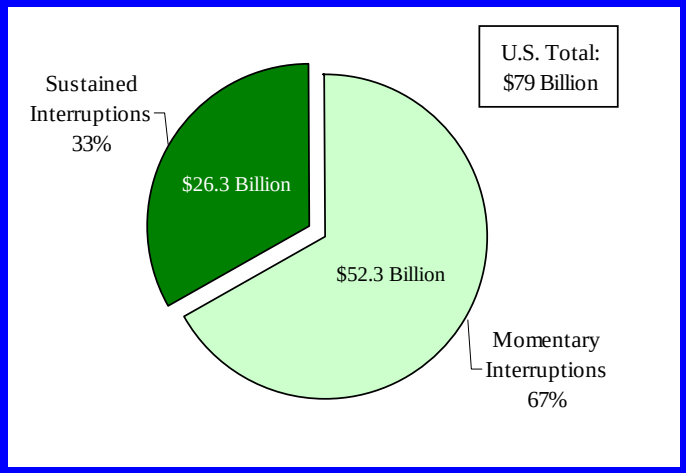
Storage Technologies and Regimes of Application



A. Nourai

POWER QUALITY,

Commercial



Outage Costs for U.S. Industry estimated at
$79 Billion Annually in a recent study by Joe Eto, LBL

Total U.S. Cost of Electricity
$250 Billion Annually

Momentary Interruptions (<5min)
are More Costly than Sustained Interruptions

High Tech Manufacturing,

Banking, the Internet

Telecommunication

10 MW - 30 sec System at Microchip Plant

Ni-Cd Battery for Voltage Support

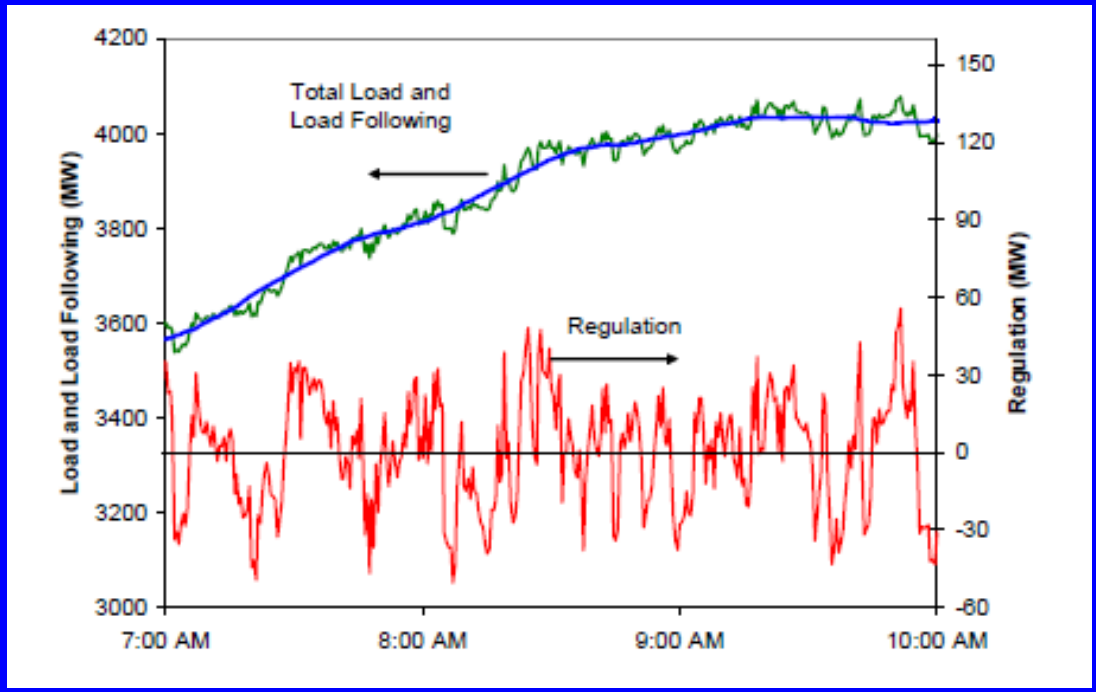
Golden Valley Co-op
World's most Powerful Battery
40 MW in Fairbanks, Alaska!

In 2006: responded to 82 events
preventing 311,000 member outages

VOLTAGE and FREQUENCY REGULATION

Market ready

Grid Frequency Regulation with Fast Storage:



Kirby 2004

Current method to balance constantly shifting load fluctuation is to vary the frequency and periodically adjust generation in response to an ISO signal. Fast storage could respond instantaneously!

A flywheel being assembled

Containerized 7 Flywheel System

CEC / DOE PROJECT:

Beacon Power 100 kW Flywheel System for Grid Frequency Regulation

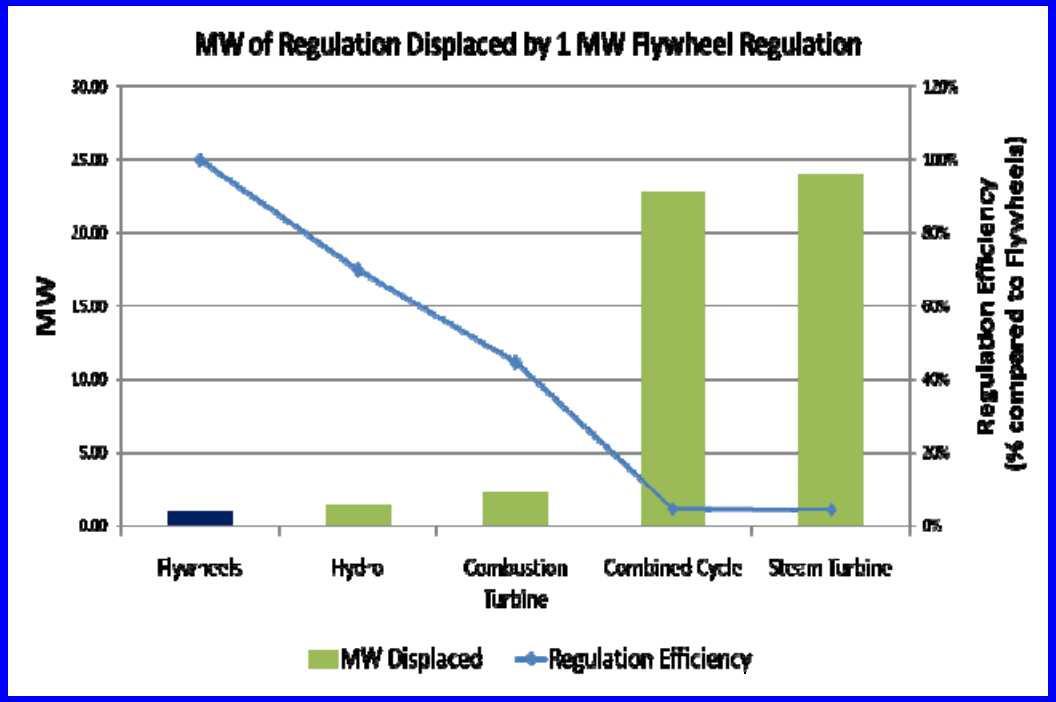
Design for a 20MW Facility with 100kW flywheels funded by DOE

Recent Developments:

AES tests 2 x 1MW / 15min
Altairnano Lithium-Titanate batteries
for regulation services.
Deployed in PJM.
A123 has produced a similar system

1MW / 15 min Flywheel System ready
for installation at New York site

Curently being tested in Massachussets

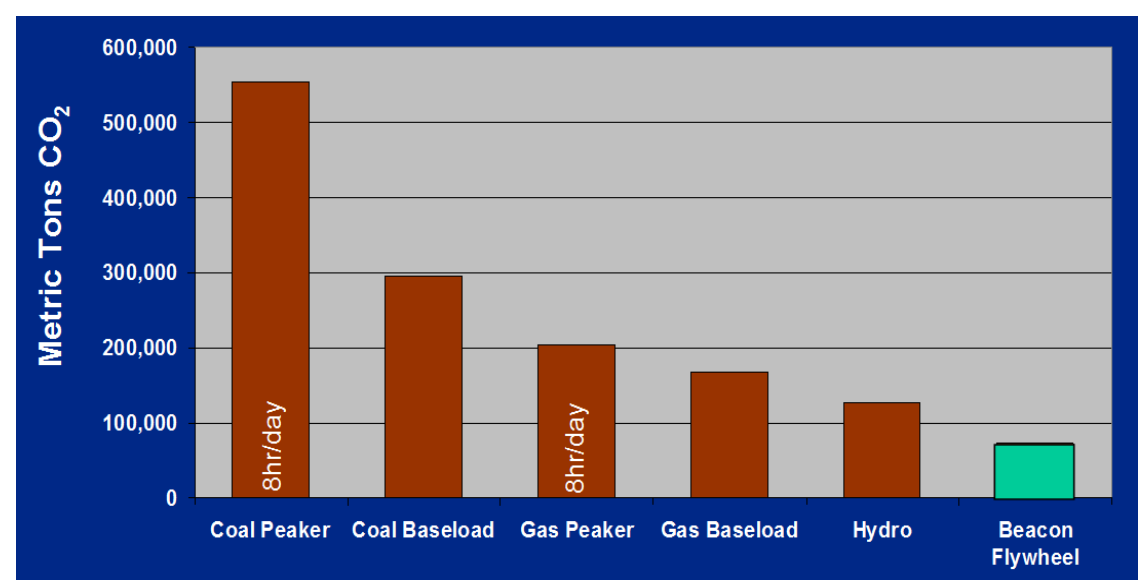


Regulation by fast storage may be twice as effective than gas turbines and 20 times more effective than steam turbines.

(Y. Makarov, PNNL, 1908)

Flywheels represent a 70-80% reduction in CO2 emission over present methods

(Fioravanti, KEMA, 2007)



PEAK SHAVING

ENERGY MANAGEMENT

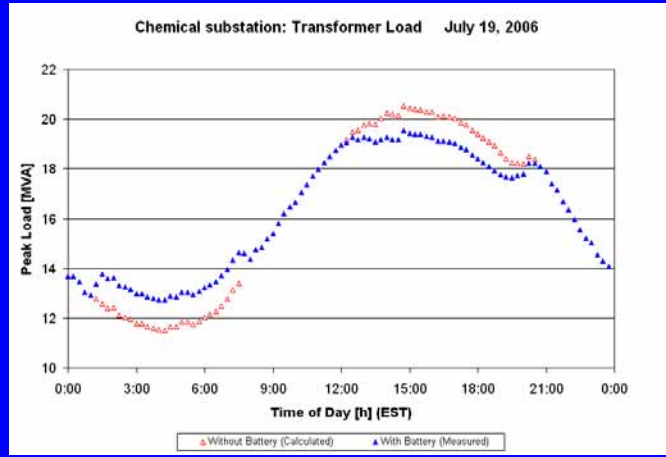
UPGRADE DEFERRAL

Near commercial

CASTLE ROCK, UTAH

VRB TANK INSTALLATION

Peaking Without Upgrade
209 mile feeder
500kW / 2MWh
Vanadium Redox Battery
By VRB Power Systems
5 years unmanned Service



Charleston, WV Appalachian Power Substation

1.2 MW / 6hr NaS Battery for Substation Support:

- First Commercial Application in US.
- Provides Backup during Peak Load
- Deferred Upgrade for 3 Years
- Reduces Transformer Heat up
- Potential Arbitrage Benefits 10K/month

AEP / DOE PROJECT

Generic Design funded by DOE

S&C Power Conditioning System developed with DOE Funding (R&D 100)

Commissioned June 26, 2006

1MW NaS Battery to Store Off Peak Power

NYSERDA / DOE PROJECT:
For 1,800HP Natural Gas Compressor in a Long Island NG Refueling Station for 220 Busses

Relieves LIPA Peak Load, Eliminates Night Shift at Plant

Partnership with NYPA

Costshares from NY ISO, TVA, EPRI, Southern, First Energy, ComEd, PSE&G, APPA, LIPA, Hydro Quebec, San Diego G&E

Three 600-HP compressors + 1 MW NaS battery

Several similar projects coming up:

AEP: 3 projects @ 2MW each (NaS)

PG&E: 6 MW (NaS)

Duke: 1 MW (ZnBr, Premium Power)

Delhi Co-op (NY): 500 kW (Axion; Zebra)

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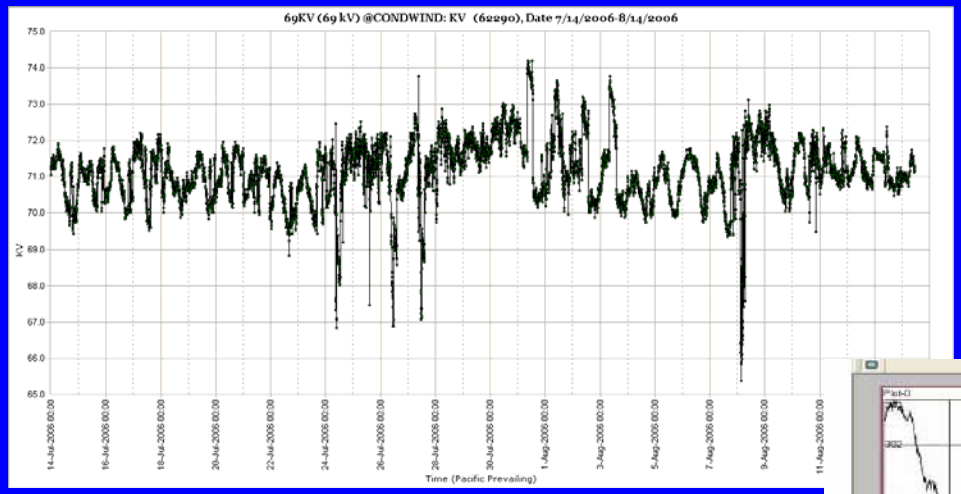
RENEWABLES DISPATCH

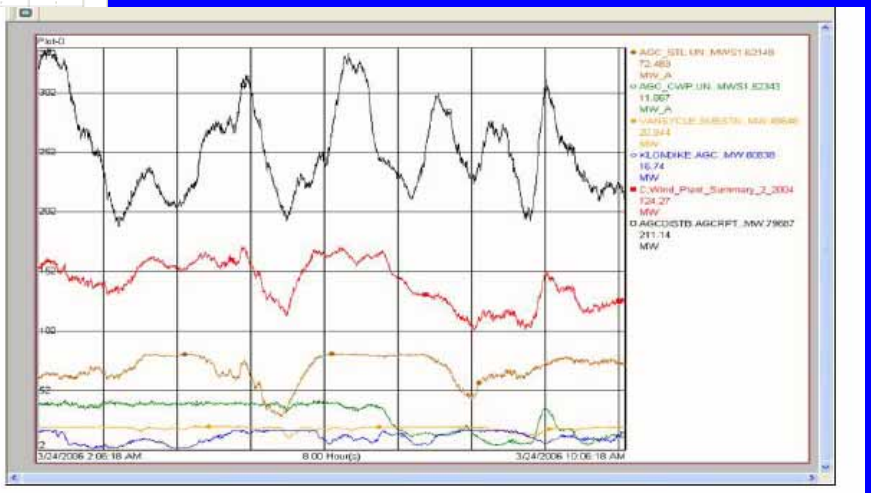
SMOOTHING, RAMPING,

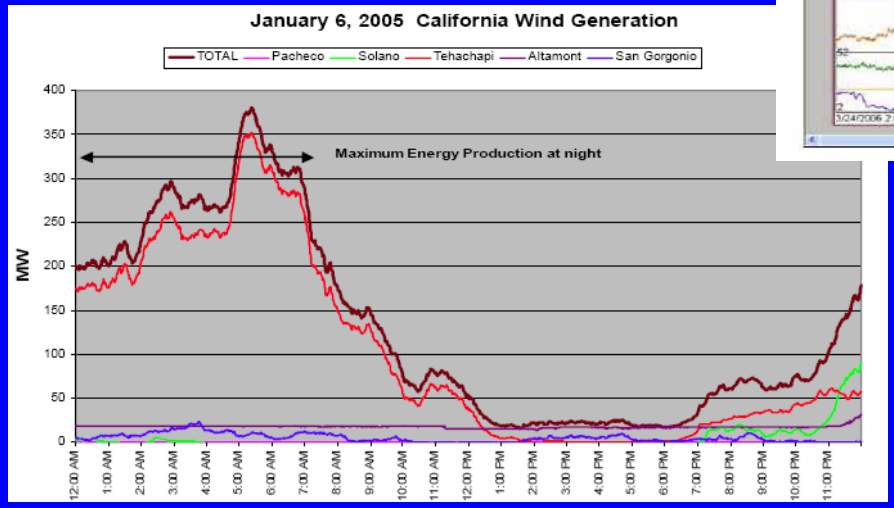
and PEAK SHIFTING

Grid Voltages near Condon, OR, Windfarm



Wind Ramps in BPA Territory





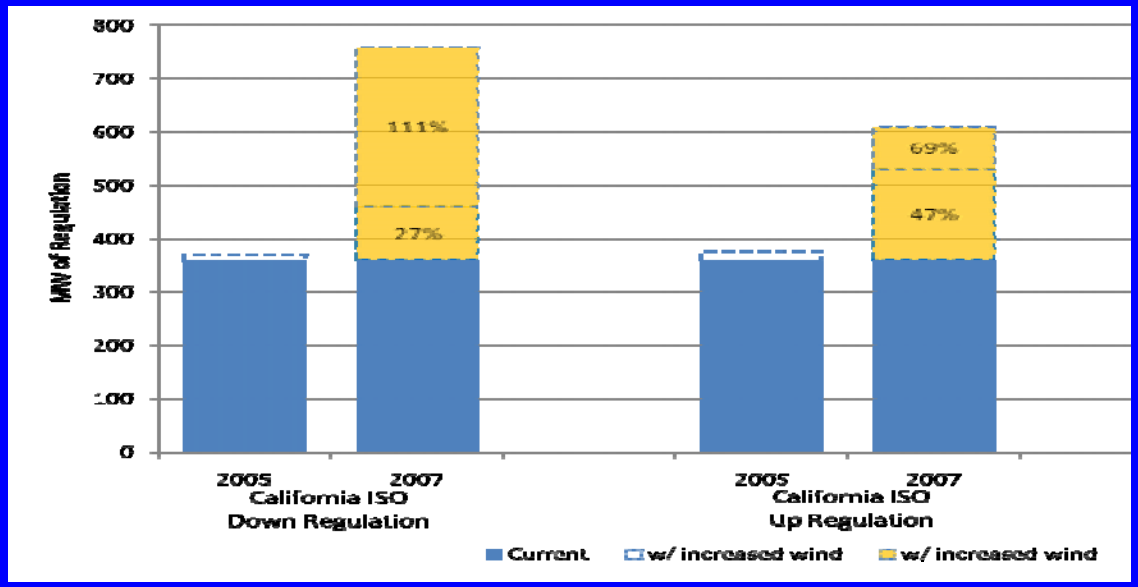
Diurnal Pattern in California & Texas

Variable Renewable Generation will increase the Need for Grid Regulation

20% Renewables expected in CA by 2012

47 - 138% Increase in Regulation expected

(Hawkins, CA-ISO, 2007)



Extra Regulation can be handled by Fast Storage and Demand Response

In Texas on Feb. 26, 2008 Wind Power dropped 1200MW in 10 Minutes.
The Disturbance was registered throughout the U.S.
and as far as Manitoba!

Blackouts were avoided by massive Load shedding by industrial customers.

NYSERDA / DOE Project
CUNY La Guardia Campus,
100kW PV + 150kW / 2hr Storage
Axion Lead / Carbon Battery

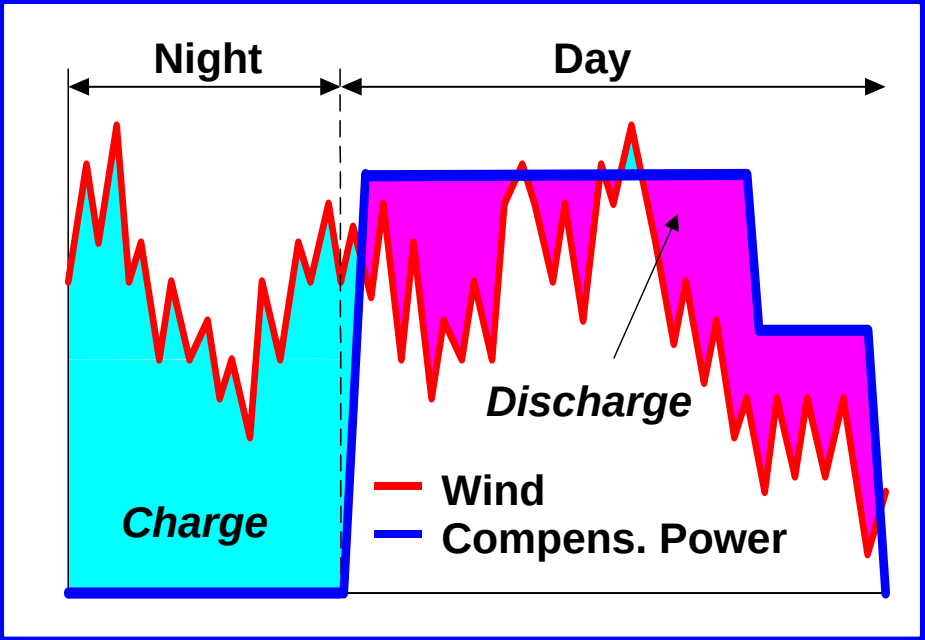
Intended to provide
250kW Peaking
as Part of NYCity
8 MW Solar Target
Kickoff Oct. 2, 2008

Storing the Wind in Minnesota

Xcell's 1MW / 6hr
Sodium-Sulfur Facility
Luverne, Minn.
Complementing 11MW Wind
Ready in April 2009

Wind:
1000 MW in 2009
3000 MW by 2020 …..

Rokkasho Windfarm in Northern Japan



Japan Target:

3,000 MW Wind by 2010

Rokkasho:

51 MW Wind

34 MW / 7 hr NaS Storage

24 Hour Advance Planning depending on Wind and Load Forecast

Compressed Air Energy Storage CAES

Inexpensive Off-Peak Power
is used to Compress Air for Storage
in Aquifers, Salt Domes or Caverns.
On-Peak, Compressed Air is used as
Input for Gas Turbine Compressor,
increasing Efficiency

Huntdorf, Germany, 290 MW

McIntosh, Alabama, 110 MW

New Ventures:

Iowa Energy Park, Norton OH

Texas, New York ….

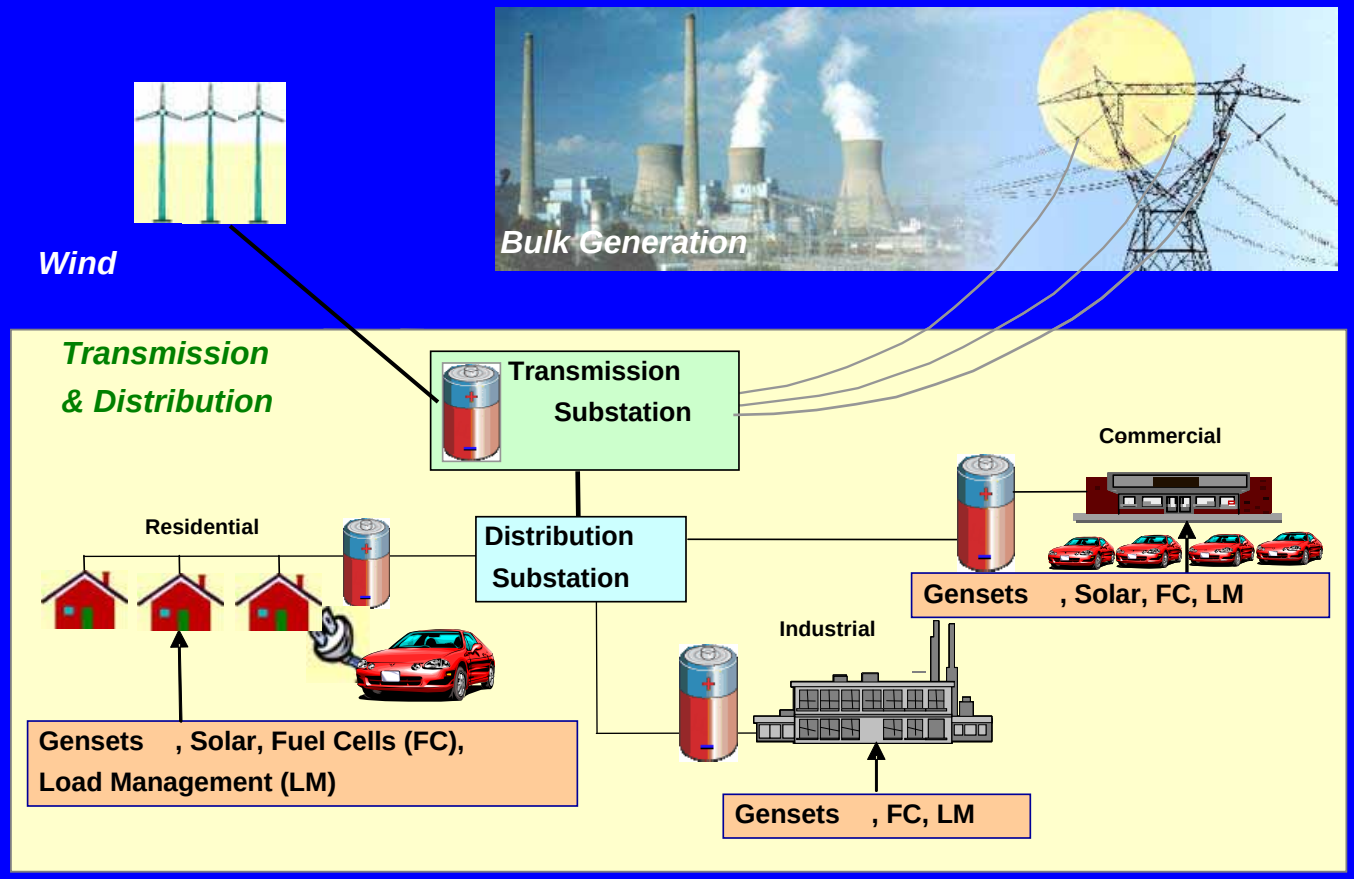
Energy Storage can:

Provide Power Quality and Digital Reliability,

Provide Voltage and Frequency Regulation
and smooth Renewable Contributions

Allow better Asset Utilization
of Generation and Transmission

Provide Spinning Reserve
and Energy Management
to Accommodate Renewables Resources



Nourai, AEP

Distributed Storage, Distributed Generation, and Distributed Intelligence will be essential for the Grid of the Future

RESOURCES

http://www.sandia.gov/ess/

http://www.electricitystorage.org/

EPRI/DOE Energy Storage Handbook

ESA (DC, May ‘09), EESAT (Seattle,Oct. 09)