Energy Storage for a Sustainable, Digital Society

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DC 10-31-07

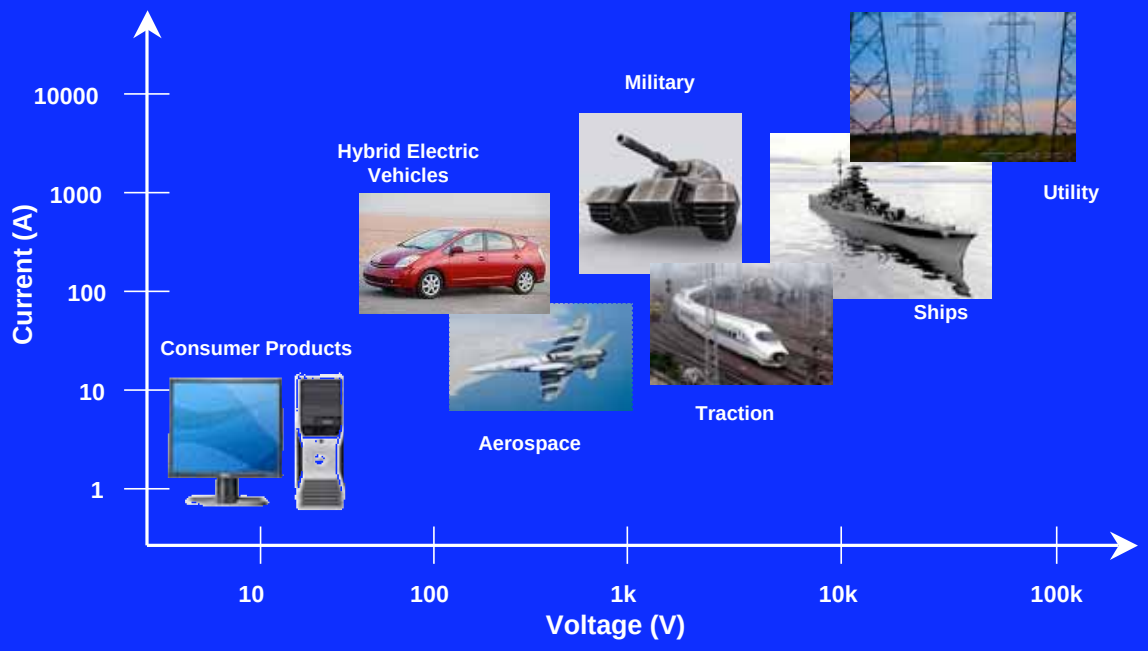
Energy Storage provides Energy

when it is needed

just as Transmission provides Energy

where it is needed

Scales of Power



DRIVERS FOR THE MODERN GRID:

DIGITIZATION OF SOCIETY:
INCREASED POWER QUALITY

ECOLOGICAL CONCERN:
DISPATCHABLE RENEWABLES

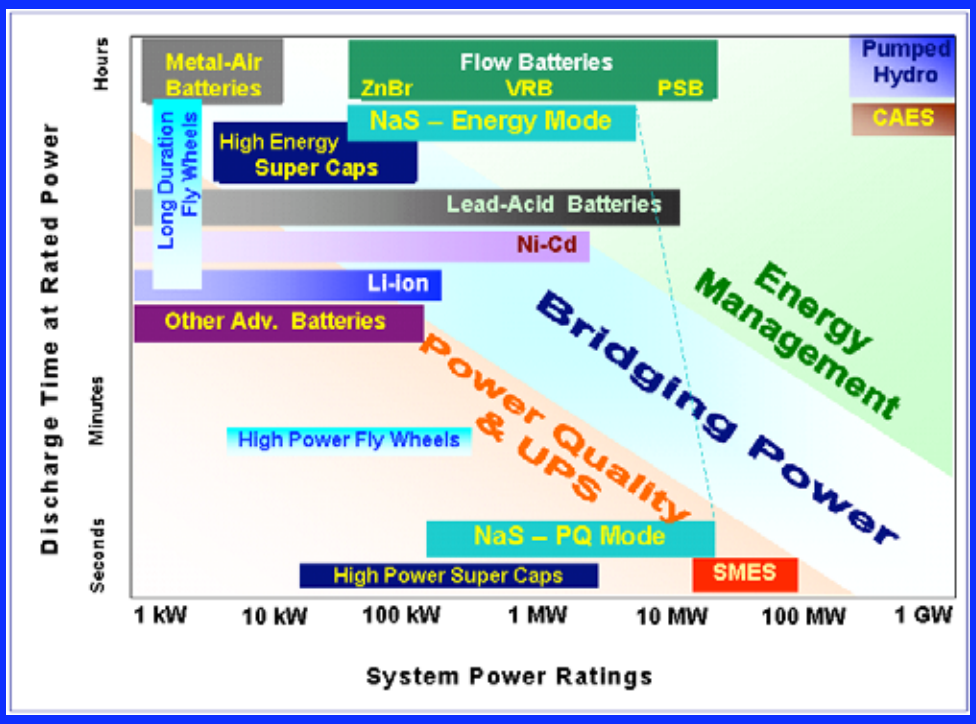
GROWTH IN ENERGY CONSUMPTION:
INCREASED ASSET UTILIZATION

ENERGY STORAGE OFFERS A SOLUTION!

	POWER Seconds	minutes – hours	*ENERGY* diurnal
LOAD	PQ, Digital Reliability	DER Support for Load Following	Peak Shaving to Avoid Demand Charges
GRID	Voltage Support, Transients	Dispatchability for Renewables, Micro Grids	Mitigation of Transm. Congest. Spinning Reserve

ENERGY STORAGE APPLICATIONS

Storage Technologies and Regimes of Application



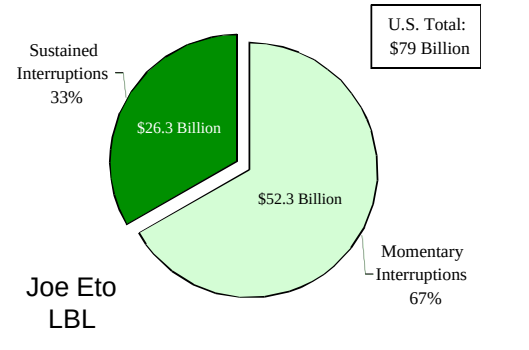
A. Nourai

RELIABILITY AND POWER QUALITY

Has Become a Necessity for the Digital Society

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

Only Energy Storage can provide

seamless Continuity of Power,

eliminate short term Outages

and yield greater Productivity

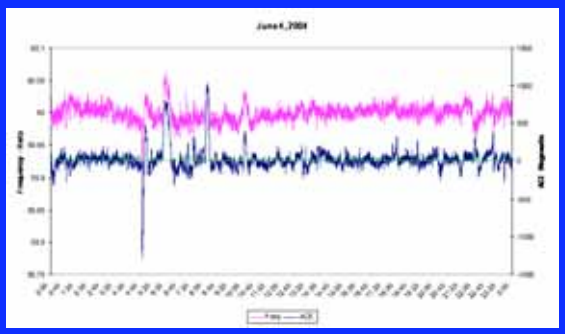
per installed MW of

Generation and Transmission

L/A Battery for Power Quality and Reliability

10 MW - 30 sec System at Microchip Plant

Flywheels
for Grid Frequency Regulation



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

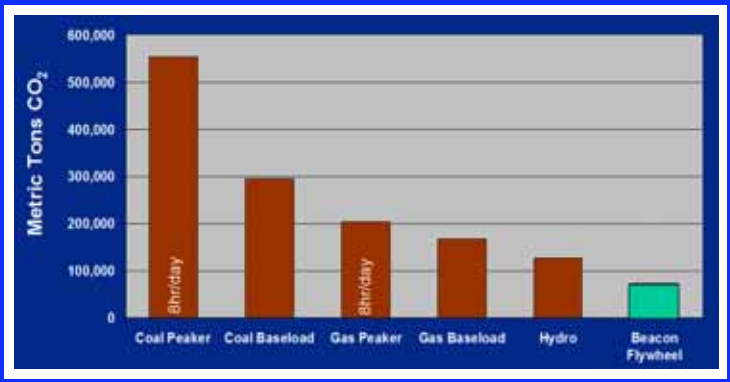
A Beacon Flywheel being assembled

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



Flywheels represent an 80% reduction in CO_2 emission over present methods

In addition, Flywheels are twice as effective as Fossil Generation

100 MW of storage could eliminate 90% of Frequency Variation in California

DG LOAD FOLLOWING

MICROGRIDS

RENEWABLE DISPATCH

Aggressive Renewable Standards:

CA – 20% by 2017
NV – 20% by 2015
NY - 25% by 2013

Kyoto Protocol!!!

Fossil Fuel generation produces Greenhouse Gases

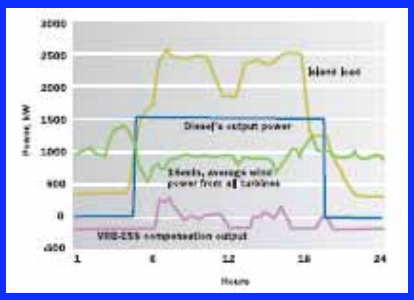
In addition, Coal-fired Generation has adverse Health impacts

Ontario Medical Association estimated such Health effects at $10 Billion annually for Ontario's 3,000 MW of Coal

Diesel / Wind / Battery Hybrid at King Island, Tasmania

1500 kW Diesel
2450 kW Wind
200 kW / 4 hrs
VRB Batteries

Batteries:
Smooth short term Wind
Firm Capacity
Load Shift to optimize Diesel

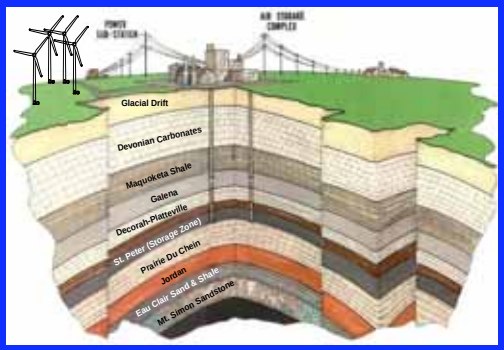


Operation Schematic

COMPRESSED AIR ENERGY STORAGE:

A DOE/ Iowa Muni Project

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

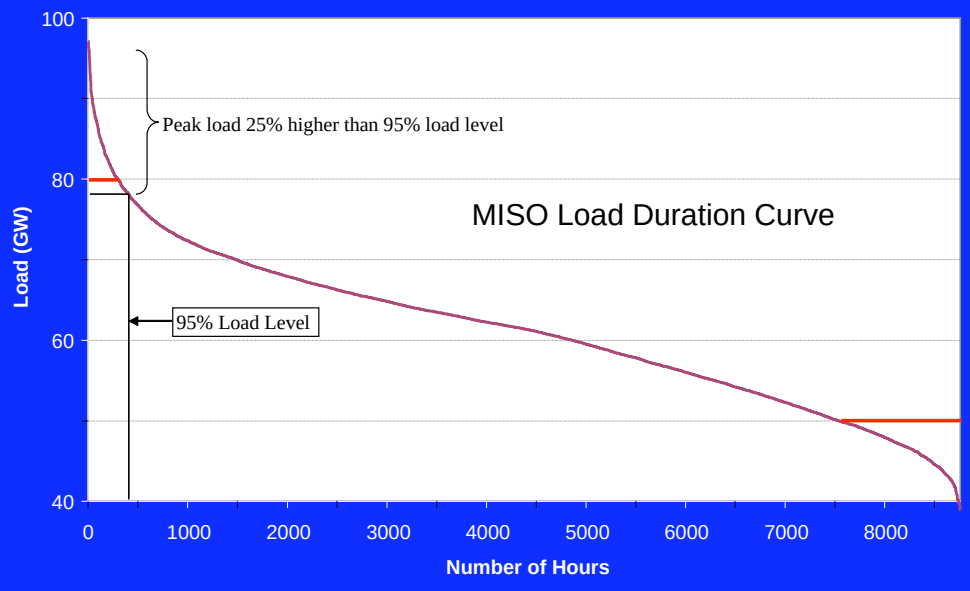


200 MW Aquifer Compressed Air Energy Storage (CAES) with 75 MW of Wind and off-peak Power planned by Iowa Associated Municipal Utilities

PEAK SHAVING

ENERGY MANAGEMENT

UPGRADE DEFERRAL



Energy Storage will allow increased Asset Utilization for Generation and Transmission thereby reducing the Number of Polluting Peaker Plants

1MW NaS Battery to Store Off Peak Power

NYSERDA / DOE PROJECT:

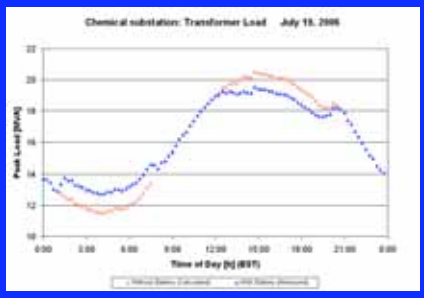
For 1,800HP Natural Gas Compressor in a Long Island NG Refueling Station for 220 Busses

Relieves LIPA Peak Load, Eliminates Night Shift

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



Charleston, WV Appalachian Power Substation

1.2 MW / 6hr NaS Battery for Substation Support:

- First Commercial Application in US.
- Provides Backup during Peak Load
- Defers Upgrade by 5 to 6 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

Energy Storage can:

Provide Power Quality
and Digital Reliability,

Bridge Outages Seamlessly,

Allow Load Following for DG, and
make Renewables Dispatchable

Provide Peak Shaving
and Transmission Upgrade Deferral

Energy Storage
is a Disruptive Technology
whose Adoption will induce a
Paradigm Shift
in the Entire Utility Industry
!!!

RESOURCES

www.sandia.gov/ess

www.electricitystorage.org

EPRI/DOE Energy Storage Handbook