

Energy Storage for Grid and RTO Management

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What is 'Electricity' Storage?

1. Electricity itself cannot be stored. Therefore it is converted into another energy form (mechanical, chemical, or fluid energy), stored, then converted back when needed.

What is ‘Electricity’ Storage?

(cont.)

2. Electricity, usually low-cost off peak such as available at night or from low cost generation (hydro, nuclear), is converted to another form, then re-injected onto the grid as a higher value electricity “product,” as necessary service to maintain grid stability and reliability (ancillary services), or as capacity downstream of a “transmission constraint.”

What is ‘Electricity’ Storage?

(cont.)

3. Unlike traditional assets, storage assets respond extremely fast (which qualifies them for ancillary services) and can incur lower “variable costs” when cycled and dispatched

Need for Energy Storage

- **ARBITRAGE**
 - Competitive, commodity markets need storage and inventory management to function efficiently
- **STABILITY**
 - Electricity grids require ‘ancillary services’ for reliability and stability

Need for Energy Storage

(cont.)

- **VALUE CREATION**
 - Storage transforms low-value *unscheduled* power—characteristic of renewables—into high value product that can be scheduled into the market, taking advantage of dynamic pricing
- **SECURITY**
 - Electricity infrastructure can be reinforced with large quantities of ‘stored’ energy and provides more options

US Electricity Storage Situation

- **ERODING CAPACITY**

- Storage embodies 2.7% of nation's electricity capacity and is declining as new capacity comes on-line and no large-scale storage facilities added!

- **COMPARATIVELY LOW**

- Other 'Western' energy-intensive countries have larger percentage of capacity as storage. Examples: Japan, 10%; UK, 4%; South Africa, 5%

- **LIMITED OPTIONS**

- Virtually all large-scale storage to date is pumped storage hydroelectric for which expansion capability is almost non-existent

Energy Storage Attributes

- **OPTIMIZES EXISTING INFRASTRUCTURE**
 - *Average* utilization of generation and transmission assets is only around 50%. Storage leverages assets up from the average and towards their peak capacities—with lower overall emissions
 - Reserve margins—which have declined to 16% in recent years—can be better managed when storage is used judiciously
 - Transmission lines can be more highly loaded during off-peak periods.
 - Fossil power plants can operate in base load as they were designed to do and emissions are lower when they operate at rated load
 - Renewable facilities can transform their low-value unscheduled power into high-value scheduled power

Energy Storage Attributes (cont)

- **AVOIDS UNNECESSARY ADDITIONS**
 - Hundreds of millions of dollars spent on peaking and dispatch plants (gas-fired turbines and combined cycles) to exploit transmission constraints. Storage can alleviate such constraints more efficiently
 - Reserve margins are increasing again because of price and reliability concerns and a slow economy. Storage helps manage reserve margins at lower and less costly levels. *Industry needs better way of balancing supply with demand than just “build more power stations.”*
 - Mitigates need for new transmission lines by raising the overall productivity of the existing lines

Energy Storage Attributes (cont)

- DOE estimates a total savings of \$32-billion through use of “high-density storage devices to...store power during off-peak periods and deliver it when loads exceed generating capacity
- DOE estimates an economic benefit of \$1.4-billion through use of high-density storage in conjunction with renewable energy

Energy Storage Attributes (cont)

- **FACILITATES BULK TRANSFERS**

- RTOS and ISOs face limited transfer capabilities among/between regions. Large-scale storage provides that capability without adding more G&T capacity.

- **TEMPERS PRICE VOLATILITY**

- Without storage, electricity grid is one gigantic “just-in-time” inventory system, which results in higher volatility than other commodity markets
- Moving electricity long distances is a “promising way” of addressing price volatility
- Avoiding dependence on short-term contracts through use of storage could also moderate volatility
- Cutting the last one percent of supply (I.e. most expensive peakers) can potentially cut prices by 10% (General economic rule)

Energy Storage Attributes (cont)

- **PROVIDES ANCILLARY SERVICES**
 - Can ancillary services be profitably supplied by the “market” or will RTOs eventually be responsible? Ancillary services may be treated like “taxes.”
 - Six ancillary services are defined as necessary to a properly (efficiently and reliably) functioning electricity grid
 - Reactive supply and voltage control from generation sources
 - Regulation
 - Contingency reserve-spinning
 - Contingency reserve-supplemental
 - Load following
 - System black start

Energy Storage Attributes (cont)

- **ALLEVIATES SYSTEM CONSTRAINTS**
 - Independents and merchants are installing new plants near pinch points to take advantage of locational pricing opportunities. This could raise prices to end-users
 - Competition currently is inhibited because utilities can legally ‘game the system’ by declaring must run plants and by requiring certain plants to operate to maintain reliability
 - *Solution: Locate storage after bottlenecks and “must-run” plants*

An Example: PJM

- **PJM represents imbalanced resources reflected in electricity prices**
 - Western area (mostly coal and nuclear) average prices (June 2000 to March 2001)-\$32-39/MWh
 - Eastern area (mostly gas and oil) average prices (June 2000 to March 2001)-\$52-59/MWh
 - Storage has opportunity to “arbitrage” this price difference and move lower cost coal and nuclear power into the higher priced area of PJM

The Natural Gas “Analogy”

- **Electricity storage will likely follow a similar development path as natural gas storage.**
 - Pre-natural-gas deregulation (1986) and FERC order 636, very little gas storage existed and most of it controlled by local distribution companies (LDC)
 - Today, gas storage has expanded substantially and continues to do so. Independent and merchant storage companies are an important balancing mechanism in the market and have been credited with minimizing supply/demand and price dislocations

Natural Gas Analogy (cont)

- Underground gas storage in depleted reservoirs, aquifers, and salt domes represents more than 3 Tcf, or approximately 15-20% of annual gas demand
- Storage capacity (volume) has grown 6% since 1993, with deliverability increasing by 15% as a result
- Gas storage has reduced the amount of new gas transmission pipeline required by 50%!
- In many demand regions, gas withdrawn from storage can accommodate up to 30% of daily demand in the winter months

Gas/Electric Corollary: Ancillary Services

- **Natural gas**
 - High deliverability, storage demand, inventory drawdown
 - Gas parking, line packing
 - Local pressure regulation
 - Emergency exchange and supply balancing
 - Scheduling, system control and dispatch service
 - Lost/unaccounted for gas
 - Gas quality control
- **Electricity**
 - Regulation, frequency response (load following)
 - Energy imbalance services
 - Reactive power supply, voltage control
 - Operating reserve
 - Scheduling, system control and dispatch service
 - Real power losses
 - Frequency regulation

Electricity Storage Lacks Visibility

- **INSTITUTIONAL BARRIERS**
 - As vertically integrated electric utilities are ‘unbundled,’ storage does not fall within existing boundaries—generation, transmission, distribution, etc
- **ENTRENCHED INDUSTRIES**
 - US Energy Association National Energy Strategy does not address energy storage for electricity markets
- **LACK OF POLITICAL SUPPORT**
 - Bush Energy Plan did not mention storage
 - FERC and RTOs/ISOs have not focused on role of energy storage
- **HERD MENTALITY**
 - Industry converged on high-cost gas-fired peaking and ‘dispatchable’ power to balance supply with demand, meet ‘marginal pricing’

Addressing these Issues

- **FORMATION OF THE ENERGY STORAGE COUNCIL**
 - Represents the energy storage industry before governmental, public, and quasi-governmental bodies.
 - Supports the deployment of energy storage options both in terms of technology development and applying new competitive business models based on dynamic electricity pricing and cost measures.
 - Recommends that FERC, DOE, and others evaluate the benefits of a greater role for energy storage in the nation's electricity infrastructure
 - Seeks to define a national goal for energy storage to make electricity markets efficient and infrastructure more reliable and *drive the industry towards that goal*

Addressing these Issues (cont)

- **ENERGY STORAGE COUNCIL ACTIVITIES**
 - Fast growth trajectory--Five members within two months
 - Meetings with DOE Offices of Fossil Energy and Energy Efficiency and Renewables
 - Meetings with Members of House Energy and Commerce Committee, allied industry organizations (American Wind Energy Assoc.)

ENERGY STORAGE COUNCIL

- www.energystoragecouncil.org

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- Current members
 - Ridge Energy Storage and Grid Services, Houston, Tex
 - Haddington Ventures Ltd, Houston, Tex
 - Alstom Power, Richmond, Va
 - Decker Energy International, Winter Park, Fla
 - MAN Turbomachinery Inc, Houston, Tex

Addressing these issues (cont)

- **COMMERCIAL OPTIONS AVAILABLE**
 - ESC member companies and others ready to develop, finance, and participate in commercial projects
 - Project developers willing to pursue merchant-like facilities independent of utilities, with suitable off-take agreements, etc, to support financing
 - Several options available depending on capacity needs
 - Options span the range of facility sizes contemplated (unit sizes can range from 1 MW to several hundred MW)

Bulk Energy Storage Options

- **COMPRESSED AIR ENERGY STORAGE (CAES)**
 - Similar to pumped storage, except air is compressed and stored underground, then released when needed through turbine/generators
 - Only current option that can replace pumped storage for largest-capacity facilities—above 100 MW. Several US commercial projects now in development—Texas, Ohio, etc
 - Can also be designed for smaller “sub-surface” installations using buried pipe instead of underground geologic formations
 - Compared to peaking gas turbines, CAES avoids 60% loss of energy input to just compress the air, but does require some fuel input. Heat rate ~ 4300 Btu/kWh (HHV)
 - Demonstrated at large scale
 - 110-MW facility, Alabama Electric Cooperative, operating 10 years
 - 290-MW facility operating in Germany for 25 years
 - Large facilities planned for Japan, Israel, Korea, Morocco

Bulk Energy Storage Options (cont)

- **PUMPED STORAGE HYDROELECTRIC**

Last unit installed in US 1991

- Limited sites available and contemplated projects difficult to permit
- Significant efficiency gains through use of advanced pump/turbines and variable-speed drives
- Virtually all facilities affiliated with utilities
- Alta Mesa, Calif project—70-MW pumped storage + large wind turbine project
- Potential to site on high coastal areas using seawater
 - Japanese installation has employed this concept-30MW demonstration at Okinawa

Bulk Energy Storage Options

- **BATTERIES AND REGENERATIVE FUEL CELLS**
 - Suitable for 1-100 MW capacity range
 - Commercial projects and demonstrations
 - 10 MW lead/acid battery facility operating in Chino, Calif for Edison International
 - 12 MW lead/acid facility operating in Puerto Rico
 - 15 MW regenerative fuel cell facility commencing operations in UK, similar facility (12 MW) being built in Mississippi for TVA
 - 6 MW Sodium/sulfur battery facility operating in Japan, with development interest of American Electric Power

Action Plan

- FERC, RTOs, and transmission sector stakeholders need to evaluate the role of energy storage seriously
- Energy storage advocates need to quantify the magnitude of the conceptual benefits articulated here and understand economic implications
- Electricity industry, with government support, should define a national goal for energy storage and drive towards that goal