

Renewable Integration with Distributed Storage

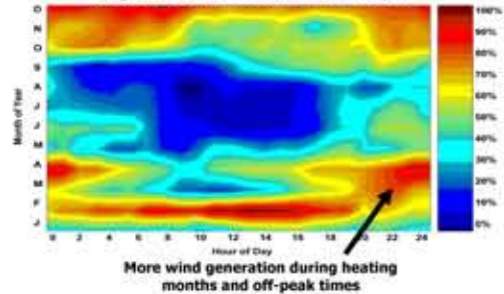
Renewable energy and a smarter grid are keys to managing our nation's energy resources and keeping electric rates low

Renewable Energy

Renewables have a variable generation pattern that can ramp up or down quickly. Low-cost electric storage allows this resource to be fully used.

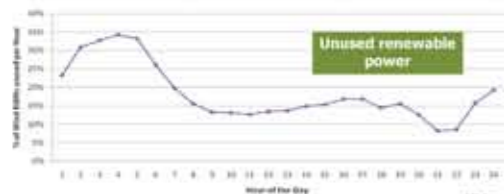


Regional Wind Generation Output



The challenge of effectively utilizing large amounts of renewables and maintaining reliable electric supply is relieved with electric storage.

% of Unusable Wind Energy (Oct-May)
For days with Unused Wind Energy



Assumptions: 25% of total generation is wind and baseload generation is turned down to 25% of capacity.

As renewable generation grows, so does the need for affordable energy storage in order to fully utilize and manage this power supply.

Without storage there will be significant unusable renewable energy.

Grid-Interactive "Thermal Battery"

Low-Cost Distributive Energy Storage

for

- ◆ Renewable Integration
- ◆ Grid Optimization
- ◆ Frequency Control
- ◆ Lower Electric Rates

Hot Water Storage



A 100 gallon water heater stores the equivalent of 26 kWh's to provide year-round energy storage.

Energy is stored in high density ceramic bricks or in domestic water heater.

A distributed array of interactive storage space and water heaters can absorb Gigawatts of power and store many GWh's of energy.

Input and charge levels vary to integrate renewables and for grid optimization while delivering constant comfort.

Energy Storage Cost Comparison

| Technology | Cost | |
|---------------------------|-----------------|-----------------|
| | (\$/kWh) | (\$/kW) |
| Electric Thermal Storage* | \$30 - \$60 | \$100 - \$200 |
| CAES (above-ground) | \$200 - \$250 | \$700 - \$800 |
| ZnBr Flow Cell | \$280 - \$450 | \$425 - \$1300 |
| Pb-Acid Battery | \$330 - \$480 | \$420 - \$660 |
| NaS Battery | \$350 - \$400 | \$450 - \$550 |
| Flywheel | \$1340 - \$1570 | \$3360 - \$3920 |

Source: EPRI 2009 energy storage technology cost estimates
*Source: Steffes Corp.

ETS is a proven, low-cost energy storage solution.

Space Heat Storage



An ETS furnace can store up to 480 kWh of energy and provide continuous comfort for consumers.

ETS allows renewable energy to be used as a dispatchable load

Smart Control

If electric loads can quickly be varied to match current generation mix without inconvenience to the consumer, variable renewable resources can be fully integrated into the grid. A smart control signal can direct low-cost electric storage to productively utilize extra renewable energy when available and supply hot water and space heat energy when renewable energy is not available.

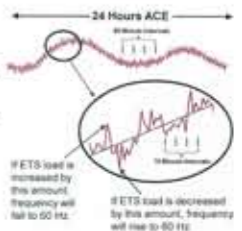
Smart Communication

The communication needed to vary loads for precision load shaping and renewable integration can also be used to optimize existing generation, transmission and distribution assets. In addition, this communication can bring significant monetary and environmental benefit by doing Frequency Control or Regulation without consuming fuel. This provides lower electric costs to the power company and consumer.



Ancillary Value

Fast, smart control signals can quickly ramp space and water heater loads up and down as needed in response to increased or decreased frequency.



This reduces generator fuel consumption and associated emissions, improves grid reliability, and yields significant monetary ancillary payments or reduced cost of regulation.



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Customer-owned electric thermal storage (ETS) space and water heaters along with smart control can integrate renewables at a very affordable cost