Frequency Regulation using Fast Energy Storage

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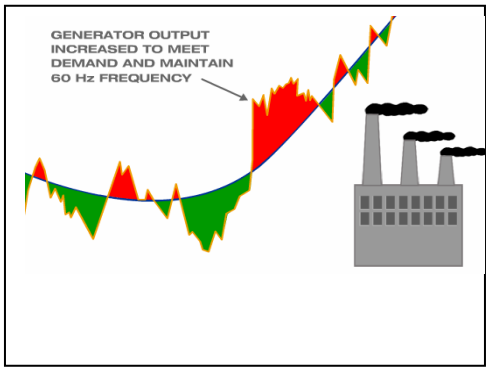
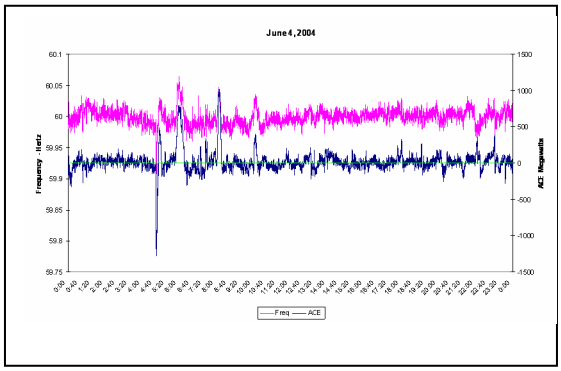
Premise:

The continuous imbalance between Load and Generation is resolved by the ISO by changing frequency. However, frequency has to be brought back to normal periodically. To achieve this, real power has to be inserted into or withdrawn from the grid. Note that this is done for the small flutter on the grid. The overall load curve is met by bringing on new generators.





Current Solution:

The ISO sends out an Area Control Error (ACE) signal which tells participating generators to either increase or decrease generation. In general these generators will be fossil fuel plants (often peakers), though this can be done with dispatchable hydro where available.

Storage Solution:

In response to the ACE signal the electric storage system (ESS) absorbs or injects power into the grid instantaneously. This is essentially a zero sum game so the ESS only uses a small amount of parasitic energy.

Technology:

Flywheels are the storage technology currently under investigation. Flywheels offer fast response, unlimited cycling, deep discharge and adequate power. The relatively low energy content is not a drawback since at most 15 minutes of power are required per cycle. Potentially supercapacitors can do the same job since they have similar characteristics.

Energy Comparison:

Fossil generators take several minutes to respond to the ACE signal. During this time the signal may already have changed so that the generator response may be working against the action required by the grid. A study by CA ISO shows that ESS frequency regulation is twice as effective as regulation by fossil fuel generation. This means that an ESS facility rated at 10MW can do the work of 20 MW of regulation by fossil generation

Carbon Print Comparison:

When fossil fuel generators fluctuate in output, their emission characteristics become non-optimal. A study by KEMA shows that ESS regulation generates 67-89% savings over competing fossil technologies in California. Data for PJM and NE-ISO are comparable.

Research and Demonstrations:

IN addition to studies by KEMA and ISO, there is also analytical work at PNNL funded by BPA. Two scalable demonstration projects have been undertaken on Flywheel Systems with funding from CEC / DOE and NYSERDA / DOE respectively. These pioneering projects are undertaken in the context of separate MOUs between DOE and CEC and NYSERDA. The trailer-mounted 100 kW / 15 min systems each consist of seven 500 lb, 22,000 rpm, magnetically levitated rotors. The two projects are third party monitored and will be analyzed for technical and economical performance. A six month run has been entirely successful showing that the system responds instantaneously to the ACE signal (California) or directly by measuring grid frequency (New York). The CEC unit was tested at PG&E's DUIT facility. An ongoing $1M design study for a 20MW flywheel facility has been funded by DOE. An ongoing $1M design study for a 20MW flywheel facility has been funded by DOE. A 100kW / 15 minute flywheel has been developed by Beacon for such an installation.

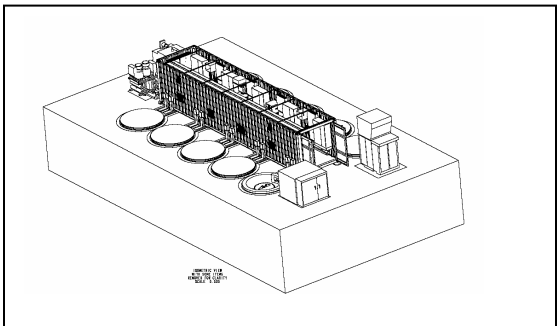
Market Opportunity:

At present only one company, Beacon Inc, has pioneered this technology. Their business plan calls for company owned merchant plants to sell regulation directly to the ISO rather than selling or leasing the technology to individual utilities. ISOs are the obvious market for selling ESS frequency regulation which can be sited anywhere in the region. In fact

CA-ISO has already agreed to buy such ancillary services when available. Contacts with ISO-NE, PJM, and NY-ISO indicate similar willingness. Beacon plans to have their first expandable 1MW plant on line in 2008.

It is estimated that 100MW of ESS can eliminate 90% of the frequency excursions in California. Beacon estimates that the regions where appropriate ancillary markets are already established represent a $600M business opportunity annually.

100 kW / 15m Flywheel



Substation style design with buried flywheels