# Data Management for CEC/DOE Energy Storage Demonstration Project

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**Work performed under contract with Sandia National Labs**
**Project Manager: Garth Corey**

Sandia is a multi-program laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

# ACKNOWLEDGMENTS

- Funded in part by the Energy Storage Systems Program of the U.S. Department Of Energy (DOE/ESS), Dr. Imre Gyuk (Mgr), through Sandia National Laboratories (SNL).

# Presentation Outline

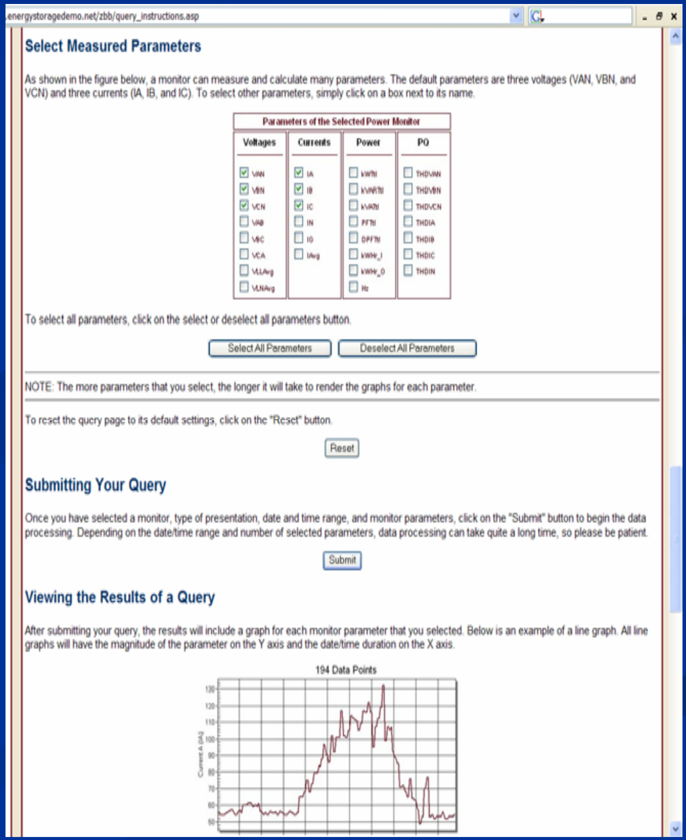
- DAS Overview and Objectives
- Design and Functional Specifications
- Data Acquisition for the three sit
  demo's
- Overview of the Energy Storage Intitiative Website
- Projected Analytical Capabilities
- Project Development Timelines

# Project Objectives

- Promote New Energy Storage Technologies that can achieve California's long range energy goals:
  - Increased energy utilization efficiency
  - Reduced demand for out of state energy procurement
  - Reduced overall energy costs to consumers
  - Total emissions reductions

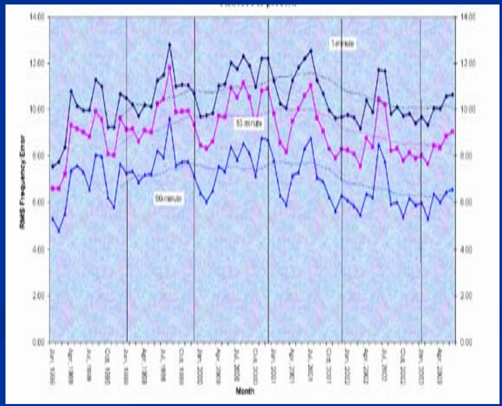
# DAS Objectives

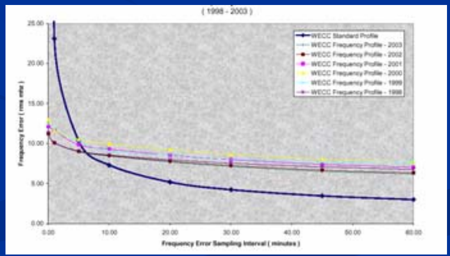
- Develop customized design specifications associated with the DAS for each demonstration
- Provide a safe and secure means of data transmittal, storage, and backup for each demonstration
- Supply a web interface to display system info and provide query-able electric parameter and operational information



# DAS Design Specification

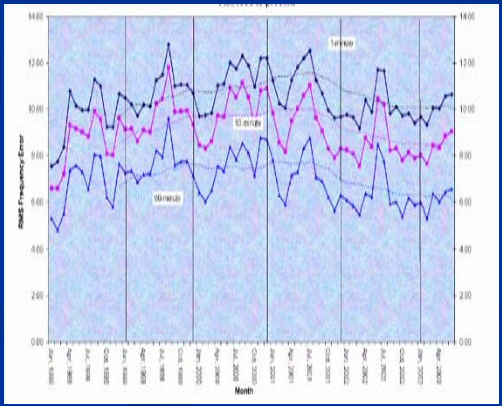
- Must be able to communicate with the on-site data acquisition system at any time during the day to obtain system status info
- Data files will be time stamped, stored on site and downloaded to the central server once daily
- For redundant storage and in the event of a communication problem, the on-site storage must hold a full year of site data
- Acquired data will include power parameters and overall system operational parameters

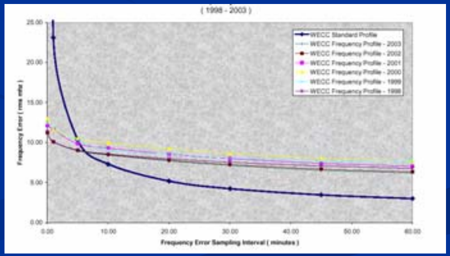




# DAS Design Questions

- Energy or Power Quality
- Time Stamp Source and Resolution
- What is our desired output
- How to Display the Data



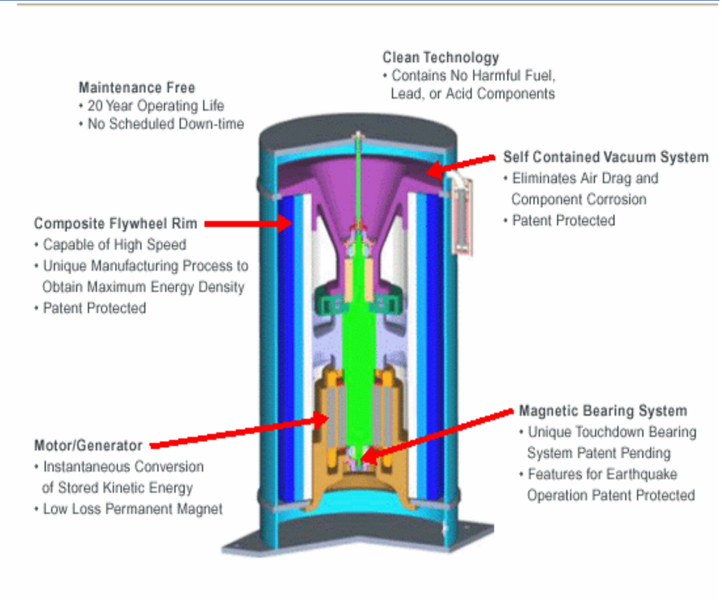



# ZBB Demo Custom DAS Needs

- For the ZBB location system availability information will be a key element of success
- Availability 1 (online ready to discharge/offline for repair)
- Availability 2 Charge state (% available capacity)
- Availability 3 (system status - charging/discharging/idle waiting)
- Availability X (other measurable availability parameters as defined by the project team or during project data analysis)

# FESS Demo Custom DAS Needs

- For the FESS demo key elements of success include:
- Availability 1 (online ready to discharge/offline for repair)
- Availability 2 Charge state (% available capacity)
- Electrical response time to a change of state signal
- Overlays of desired power profile vs actual response
- System Charge/Discharge/Efficiency profile

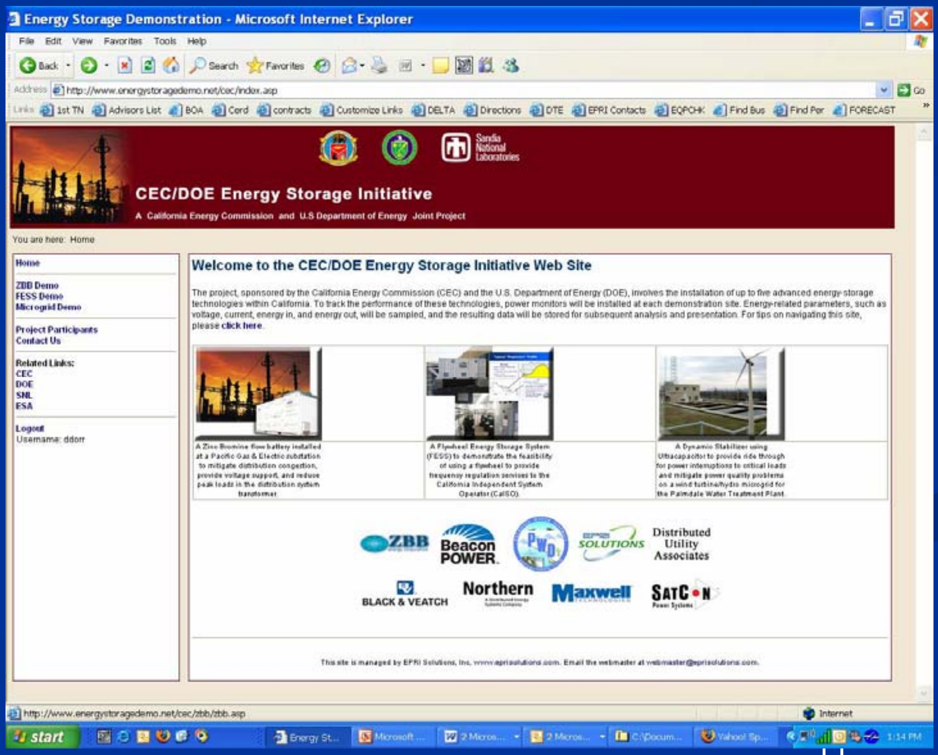


# Palmdale Custom DAS Needs

- For the Palmdale demo – key elements of success will include:
- Ultracapacitor System Availability 1 (online ready to discharge/offline for repair)
- Availability 2 Charge state (% available capacity)
- Power Quality 1 – During power variations did the system continue to support the critical load?
- Power Quality 2 – Was the ultracapacitor system able to improve overall power system interactions between the wind, hydro and other distributed resources

# Energy Storage Demo Website

- Homepage detailing the project and the project objectives
- Separate main-page for each demonstration project
- Electrical configuration information (one line diagrams) detailing each application
- Summary status pages
- Password protected area
  - Analytical Tools
  - Query Help Instructions
  - Saved and Pre-Defined Charts and Graphs



Energy Storage Demonstration - Microsoft Internet Explorer

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# CEC/DOE Energy Storage Initiative

A California Energy Commission and U.S Department of Energy Joint Project

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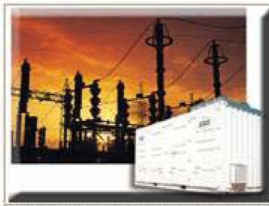
## Welcome to the CEC/DOE Energy Storage Initiative Web Site

The project, sponsored by the California Energy Commission (CEC) and the U.S. Department of Energy (DOE), involves the installation of up to five advanced energy-storage technologies within California. To track the performance of these technologies, power monitors will be installed at each demonstration site. Energy-related parameters, such as voltage, current, energy in, and energy out, will be sampled, and the resulting data will be stored for subsequent analysis and presentation. For tips on navigating this site, please **click here**.



A Zinc Bromine flow battery installed at a Pacific Gas & Electric substation to mitigate distribution congestion, provide voltage support, and reduce peak loads in the distribution system transformer.

A Flywheel Energy Storage System (FESS) to demonstrate the feasibility of using a flywheel to provide frequency regulation services to the California Independent System Operator (CalSO).

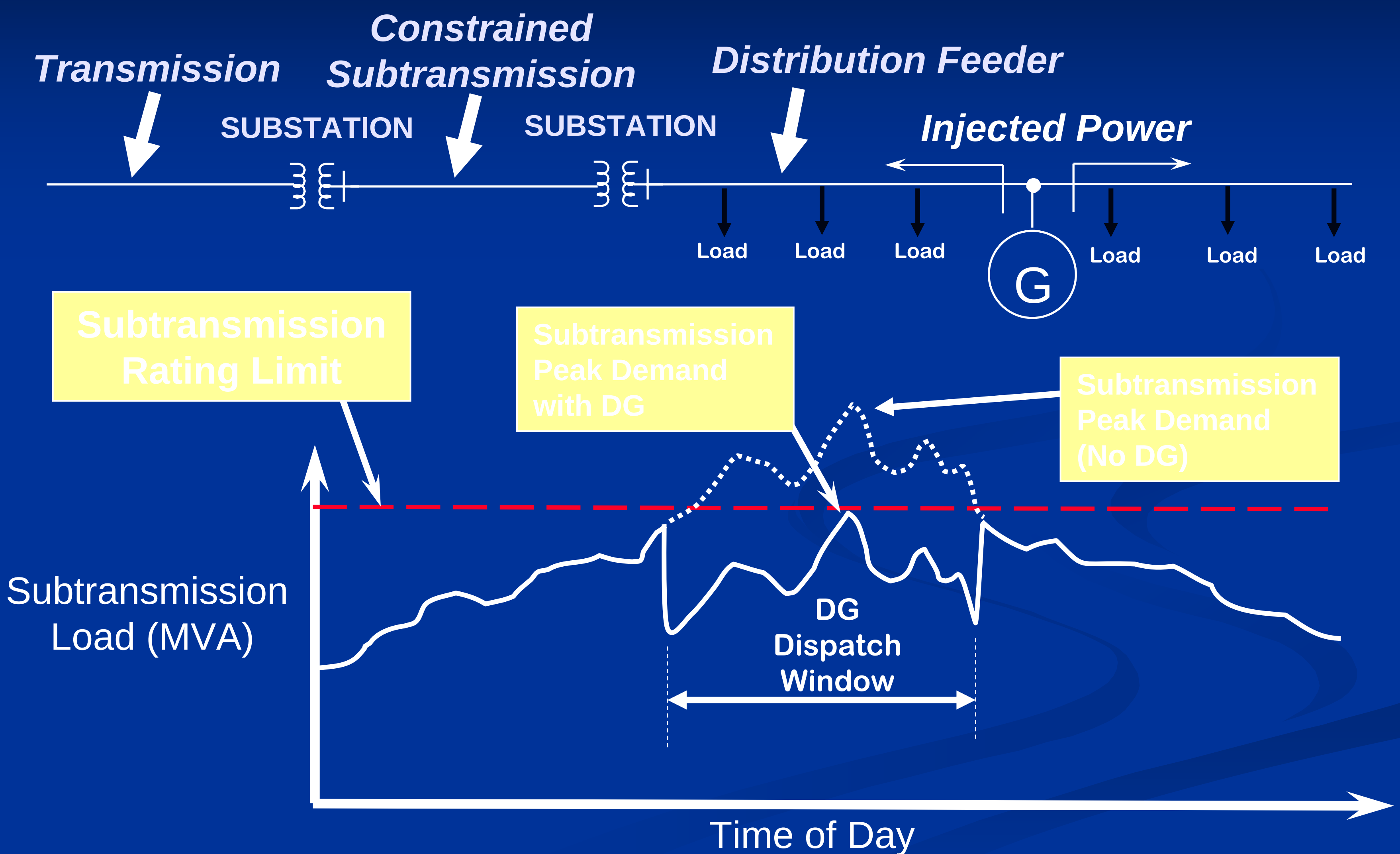
A Dynamic Stabilizer using Ultracapacitor to provide ride through for power interruptions to critical loads and mitigate power quality problems on a wind turbine/hydro microgrid for the Palmdale Water Treatment Plant.

ZBB | Beacon POWER | PWD | EPRI SOLUTIONS | Distributed Utility Associates

BLACK & VEATCH | Northern | Maxwell | SatCon Power Systems

This site is managed by EPRI Solutions, Inc, www.eprisolutions.com. Email the webmaster at webmaster@eprisolutions.com.

# DG Support of T&D System



Zinc Bromine Battery (ZBB) Energy Storage Demonstration - Mozilla Firefox

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http://www.energystoragedemo.net/cec/zbb/zbb.asp

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You are here: Home ■ Introduction to the Zinc Bromine Battery (ZBB) Energy Storage Demonstration



## Zinc Bromine Battery (ZBB) Energy Storage Demonstration



### Project Overview

This demonstration project utilizes a zinc bromine battery storage system installed at an electric utility distribution substation to reduce overloads during peak demand periods. The zinc bromine battery is discharged when the substation circuits exceed a predefined threshold. The objective is to defer a substation transformer upgrade until all associated planning and permitting can be accomplished.

400kWh Zinc Bromine Battery

The California Energy Commission is supplying project implementation funding and the US Department of Energy ESS program is sponsoring and funding the data management, collection and analysis activities. The data management activities are directed by Sandia National Laboratories through contracts with EPRI Solutions Inc and Distributed Utility Associates.

#### Why is CEC/DOE sponsoring this project

This project offers a unique opportunity to demonstrate and better understand the capabilities of a new energy storage system and compare the economics and lifecycle costs to some of the other T&D deferral options available.

#### What are the benefits to California

The benefits to the state of California, based on a successful demonstration of the Zinc Bromine Battery technology would be the ability to reduce peak demand on the electric power system while continuing to support customers loads and allowing those customer that may normal see a blackout with continuing with process operation and production. The technology has the potential to relieve transmission and distribution capacity at needed times. This is also one of the first demonstration projects where real time monitoring and data collection are being used to measure system performance and validate the system performance claims.


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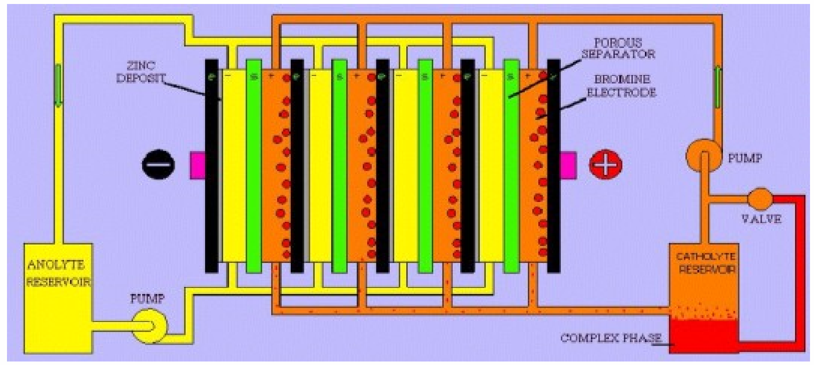
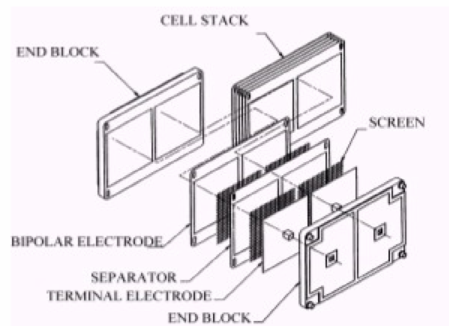
## How it Works

The battery consists of a zinc negative electrode and a bromine positive electrode separated by a microporous separator. An aqueous solution of zinc/bromide is circulated through the two compartments of the cell from two separate reservoirs. The electrolyte stream in contact with the positive electrode contains bromine which is maintained at the desired concentration by equilibrating with a bromine storage medium. The bromine storage medium is immiscible with an aqueous solution containing zinc bromide. All battery components are made from a bromine inert plastic.




Unlike the lead acid and most other batteries, the zinc/bromine battery uses electrodes that cannot and do not take part in the reactions but merely serve as substrates for the reactions. There is therefore no loss of performance, as in most rechargeable batteries, from repeated cycling causing electrode material deterioration. When the zinc/bromine battery is completely discharged all the metal zinc plated on the negative electrodes is dissolved in the electrolyte and again produced the next time the battery is charged. In the fully discharged state the zinc/bromine battery can be left indefinitely.

The zinc/bromine battery offers 2 to 3 times the energy density (75 to 85 watt-hours per kilogram) with associated size and weight savings over present lead/acid batteries. The power characteristics of the battery can be modified, for selected applications. Therefore, the zinc/bromine battery has operational capabilities which make it extremely useful as a multi-purpose energy storage option.

## How It Is Being Applied in This Demonstration

TBD

Flywheel Energy Storage System (FESS) - Microsoft Internet Explorer

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## Demonstration of a Flywheel Energy Storage System for Frequency Regulation Services



### Project Overview

CAISO has indicated that if fast responding regulation systems were added in significant quantity to the electric power grid the total amount of regulation services required would be reduced. One concept to provide this frequency regulation would be the use of flywheel energy storage rather than by cycling the output of a generator. A flywheel would quickly add and subtract power (as directed by Regional Transmission Operator signals) but to have a net zero power consumption. Using this concept, the flywheel recycles energy (store energy when generation exceeds loads; discharge energy when load exceeds generation) instead of trying to constantly adjust generator output.

The California Energy Commission is supplying project implementation funding and the US Department of Energy ESS program is sponsoring and funding the data management, collection and analysis activities. The data management activities are directed by Sandia National Laboratories through contracts with EPRI Solutions Inc and Distributed Utility Associates.

#### Why is CEC/DOE Sponsoring This Project

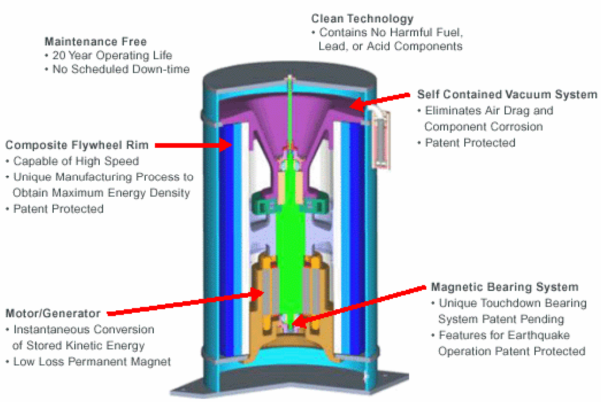
This project is being sponsored to determined the relative benefits of having faster responding generation resources. Additionally, understanding the response time of a flywheel storage system as compared to traditional generator response time will provide a better determination of the required sizing for flywheel and other fast response systems.

#### What are the Benefits to California

When aggregated to reach appropriate output/input levels there are many benefits that a flywheel energy storage system (FESS) can offer to the electric grid. The primary benefits are:

### How the System Will Work

The demonstration FESS is composed of an array of flywheels and motor/generator drives. From each flywheel, two bi-directional inverters are connected back to back to convert the high frequency output/input of the flywheel into a regulated 480 V, 60 Hz input/output that in turn interfaces with a common AC bus. A step-up transformer is required between this common bus at 480 V, and the grid interconnection; since the electrical grid interface is an electrical distribution line at much higher voltage level (i.e. 35, 69, 115 kV). The high voltage side of the transformer is a shunt connected to the high-voltage electric grid bus.




Each flywheel module is associated with an electronic conversion module (ECM). It includes a set of inverters and associated controllers as shown in Figure 5. One inverter will convert the variable speed output form the flywheel Motor /Generator to a D/C buss. The second inverter will convert the D/C buss back to a constant 60 HZ at 480 Vac. The seven ECM's will operate in parallel and either charge or discharge the flywheels at a power level as directed by the master controller.

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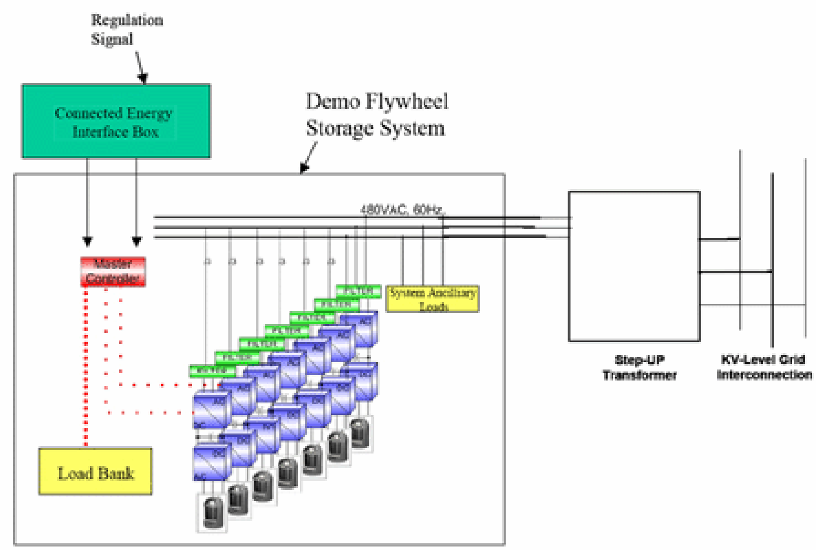
### How the Technology is Being Applied

The Smart Energy Matrix (SEM) consists of an array of flywheel energy storage modules and power conversion electronics packaged in a standard 12' x 40' shipping container. This mobile



## Site and System Summary

The system will be installed and demonstrated at the PG&E DUIT facility in San Ramon, California. It will be run for a period of 3-6 months to demonstrate its ability to interface with the IS signals and grid. Data will independently collected through funding provided by the U.S. DOE and used to estimate the system performance over time. In this demonstration Beacon Power is providing seven 15 kW flywheels in a parallel configuration. This combination is referred to as a Smart Energy Matrix (SEM). The SEM will follow the regulation signal within a fraction of a percent Unlike generation based frequency regulation, no fuel is consumed, and no emissions are generated. Analysis of presently used frequency regulation signals indicates that an energy storage module, which can store or deliver 1 MW for 15 minutes, would provide regulation service superior to services currently provided by generators.




Once installed at the test site the FESS will undergo a series of development test evaluate the system response to various possible regulation signals from the existing signal to much faster changing signals. The system controller will be validated and optimized. Various test signals car be evaluated including typical regulation signals from CAISO or other ISO's. Faster acting signals such as the ACE signal could also be put in to evaluate the FESS response to faster signals. The output power will be plotted and compared to the requested regulation signal. A FESS system model will be completed and correlated with test results so additional variations can be evaluate quickly. After development testing is completed the FESS will be commissioned and put on automatic control.

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Microgrid Energy Storage Demonstration - Microsoft Internet Explorer

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## EnergyBridge-Enabled Microgrid Energy Storage Demonstration

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  - Why is CEC/DOE Sponsoring This Project
  - What are the Benefits to California
- Site and System Summary
- Technology Description
- How the Technology is Being Applied
- Concepts on Use of the Technology

### Project Overview

The Palmdale Water District (Palmdale) in California has installed a variety of new distributed energy resources to supply facility power in an environmentally friendly way. These resources include a 950 kilowatt wind turbine, a 200 kilowatt natural gas generator, and a 250 kilowatt water turbine generator. It is expected that with these new distributed generation sources, the facility will be able to supply the majority of its electric power needs for the near future.

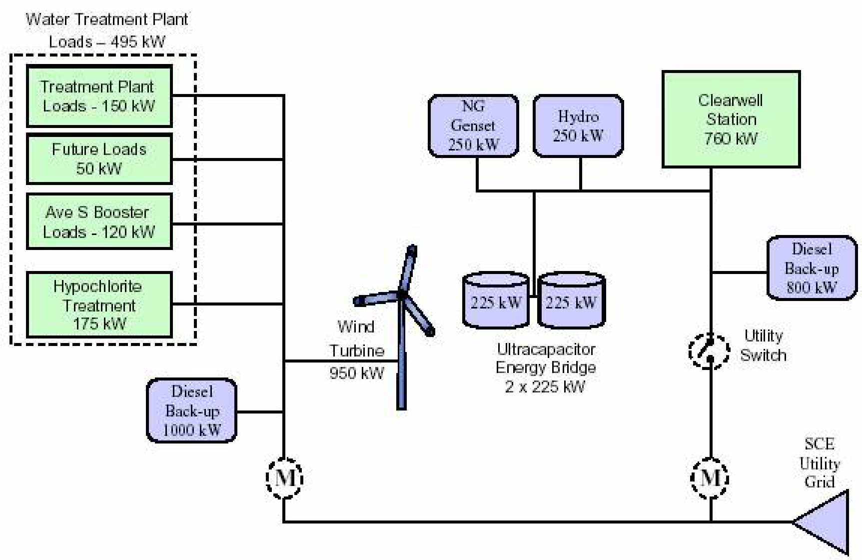
To supplement the electrical performance of these technologies, Northern Power Systems will develop and demonstrate a 450 kilowatt storage system called the EnergyBridge™ electric energy storage system (ESS), using funding from Palmdale and the California Energy Commission (CEC). Data collection and management for this system demonstration is being funded by the U.S. Department of Energy (DOE). The system will be installed at Palmdale's Clearwell Pumping Station (Clearwell). The EnergyBridge™ EES utilizes ultracapacitors coupled with advanced power electronics and controls to maintain electric grid stability even during brief power system variations and momentary power interruptions.

The California Energy Commission is supplying project implementation funding and the US Department of Energy ESS program is sponsoring and funding the data management, collection and analysis activities. The data management activities are directed by Sandia National Laboratories through contracts with EPRI Solutions Inc and Distributed Utility Associates

## Site and System Summary

The 450 kW EnergyBridge component includes the development and integration of two ultracapacitor modules, a static isolation switch, system monitoring/controls, data acquisition, and human interface. The power network will combine power generation, advanced load management and critical energy storage elements utilizing advanced controls and switching technologies.

Power sources include a 950 kW wind turbine, a planned 250 kW hydroelectric plant, an existing 250 kW natural gas generator, and existing 800 kW and 350 kW diesel generators. The total load at the site is approximately 1.25 MW. The EnergyBridge™ system will be designed to operate in parallel with the utility as a line interactive device, continuously providing voltage support, power factor correction, harmonic improvement, and transient mitigation. This architecture will not only facilitate integration of backup generators, but also allow for easy integration of additional distributed generation (DG) devices such as fuel cells, microturbines, and wind turbines into advanced power networks.




Palmdale Energy Bridge Project Electrical One Line Diagram

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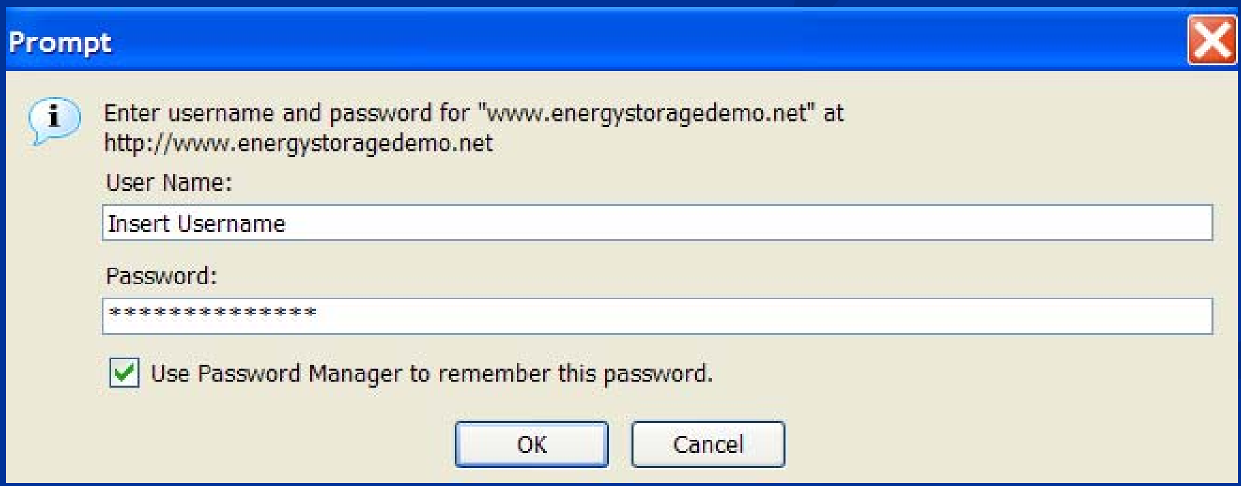
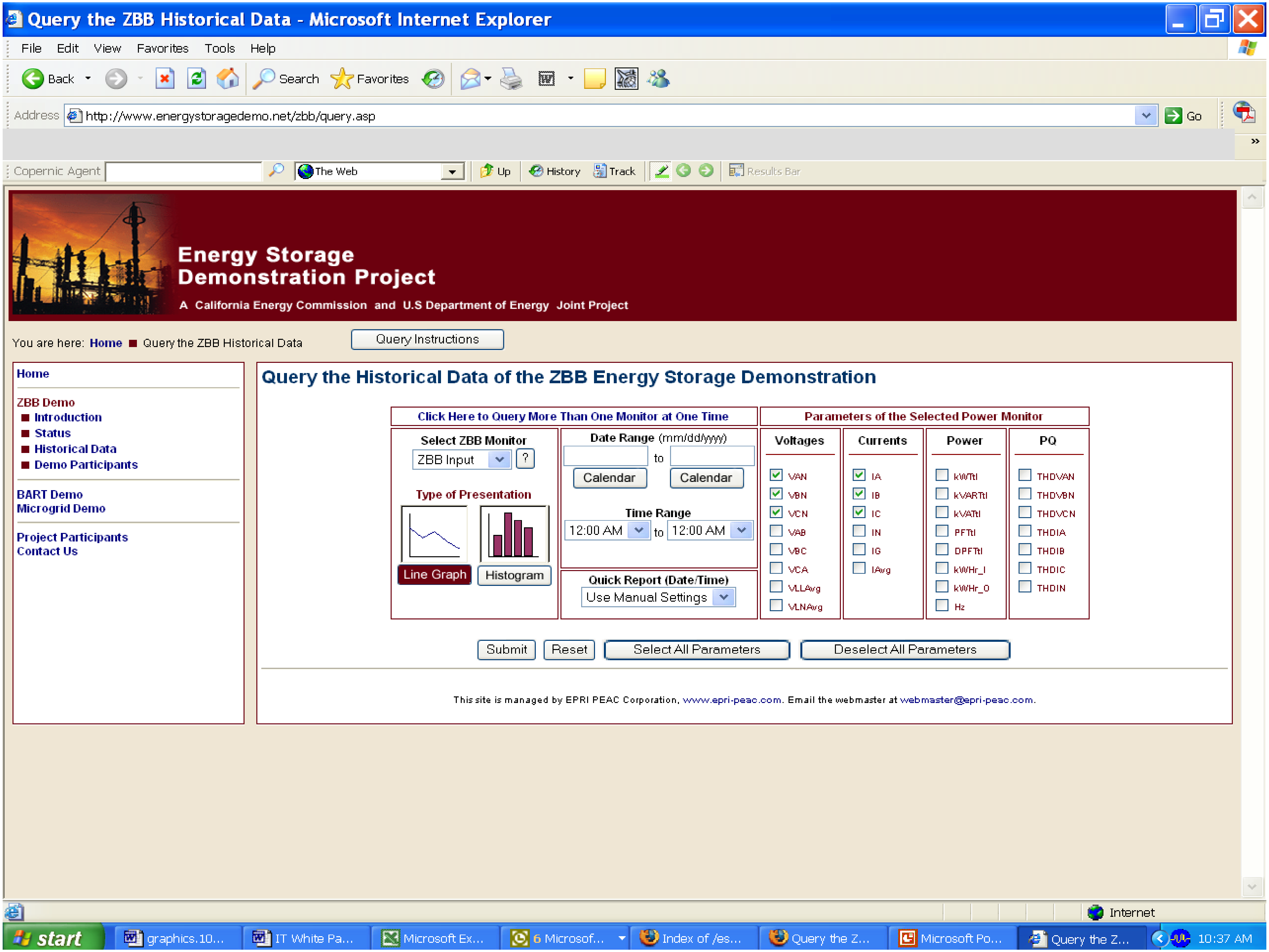
## Technology Description

The EnergyBridge™ EES utilizes ultracapacitors coupled with advanced power electronics and controls to maintain electric grid stability even during brief power system variations and momentary power interruptions.

# Password Protected Area

- Provides project participants with secure area access to the raw data and the analytical tools necessary to evaluate and understand the acquired site information





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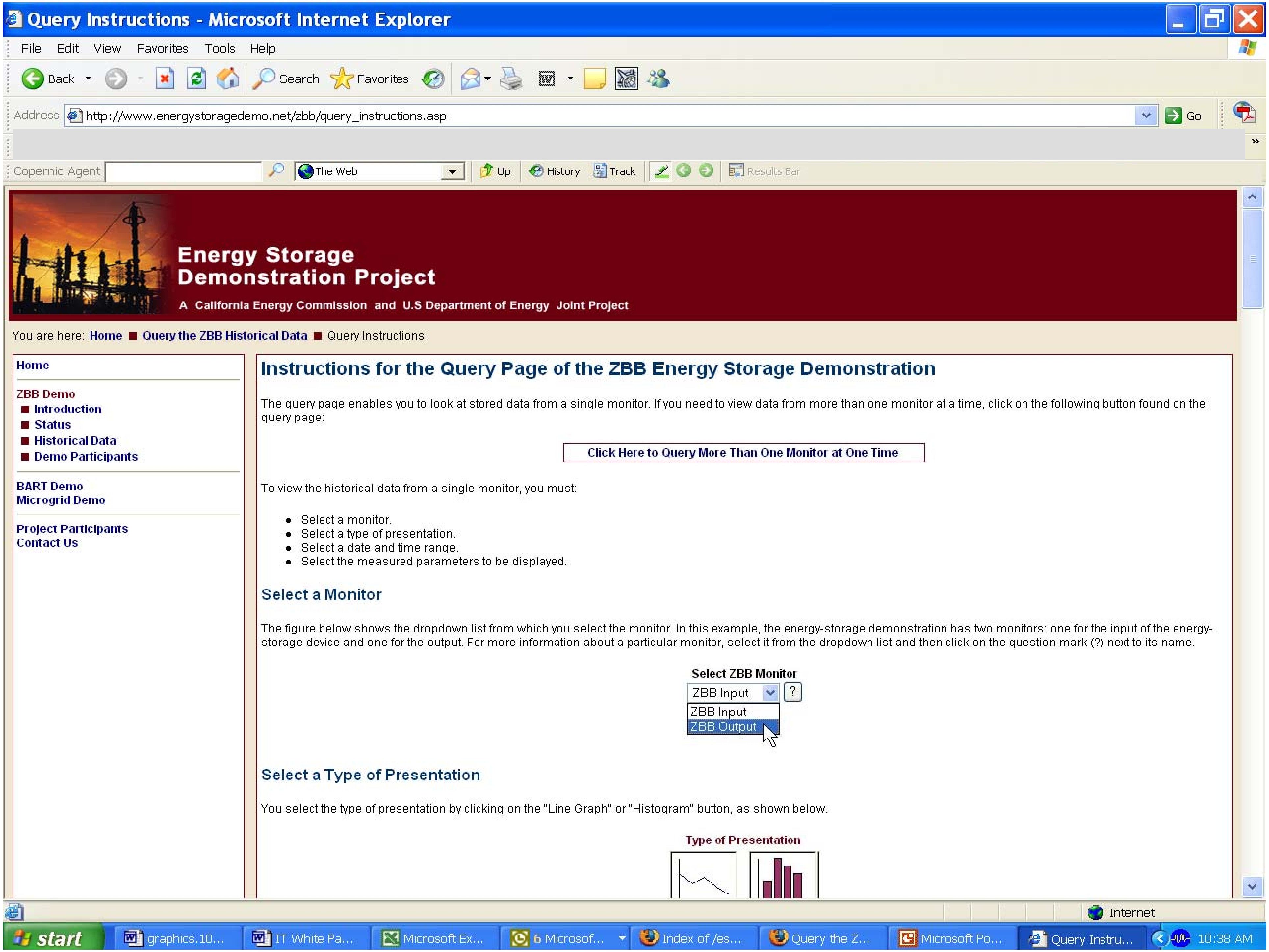

Query Instructions - Microsoft Internet Explorer

http://www.energystoragedemo.net/zbb/query_instructions.asp

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## Instructions for the Query Page of the ZBB Energy Storage Demonstration

The query page enables you to look at stored data from a single monitor. If you need to view data from more than one monitor at a time, click on the following button found on the query page:

Click Here to Query More Than One Monitor at One Time

To view the historical data from a single monitor, you must:

- Select a monitor.
- Select a type of presentation.
- Select a date and time range.
- Select the measured parameters to be displayed.

### Select a Monitor

The figure below shows the dropdown list from which you select the monitor. In this example, the energy-storage demonstration has two monitors: one for the input of the energy-storage device and one for the output. For more information about a particular monitor, select it from the dropdown list and then click on the question mark (?) next to its name.

Select ZBB Monitor
ZBB Input ?
ZBB Input
ZBB Output

### Select a Type of Presentation

You select the type of presentation by clicking on the "Line Graph" or "Histogram" button, as shown below.

Type of Presentation

## Select Measured Parameters

As shown in the figure below, a monitor can measure and calculate many parameters. The default parameters are three voltages (VAN, VBN, and VCN) and three currents (IA, IB, and IC). To select other parameters, simply click on a box next to its name.

**Parameters of the Selected Power Monitor**

| Voltages | Currents | Power | PQ |
|---|---|---|---|
| ☑ VAN | ☑ IA | ☐ kWTtl | ☐ THDVAN |
| ☑ VBN | ☑ IB | ☐ kVARTtl | ☐ THDVBN |
| ☑ VCN | ☑ IC | ☐ kVATtl | ☐ THDVCN |
| ☐ VAB | ☐ IN | ☐ PFTtl | ☐ THDIA |
| ☐ VBC | ☐ IG | ☐ DPFTtl | ☐ THDIB |
| ☐ VCA | ☐ IAvg | ☐ kWHr_I | ☐ THDIC |
| ☐ VLLAvg | | ☐ kWHr_O | ☐ THDIN |
| ☐ VLNAvg | | ☐ Hz | |

To select all parameters, click on the select or deselect all parameters button.

[Select All Parameters] [Deselect All Parameters]

NOTE: The more parameters that you select, the longer it will take to render the graphs for each parameter.

To reset the query page to its default settings, click on the "Reset" button.

[Reset]

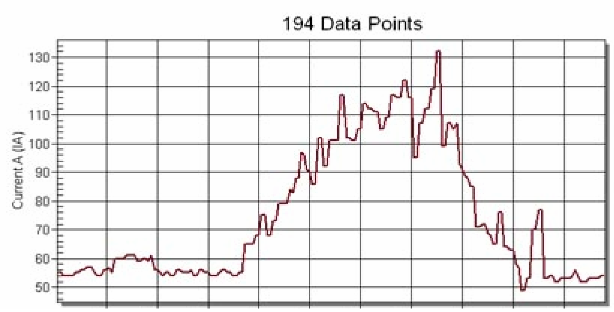
## Submitting Your Query

Once you have selected a monitor, type of presentation, date and time range, and monitor parameters, click on the "Submit" button to begin the data processing. Depending on the date/time range and number of selected parameters, data processing can take quite a long time, so please be patient.

[Submit]

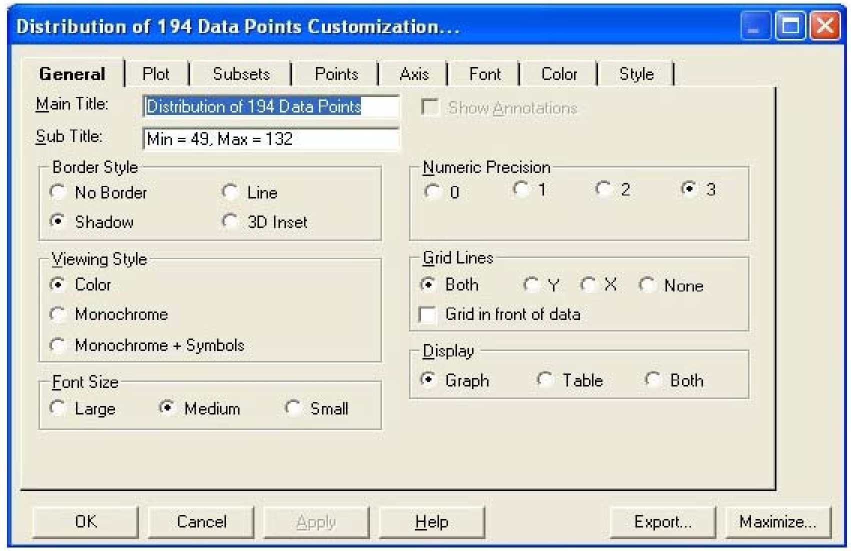
## Viewing the Results of a Query

After submitting your query, the results will include a graph for each monitor parameter that you selected. Below is an example of a line graph. All line graphs will have the magnitude of the parameter on the Y axis and the date/time duration on the X axis.



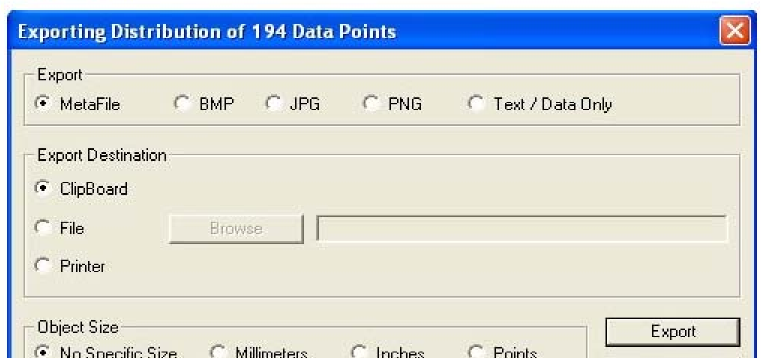
## Customizing a Graph

Each graph on the query-results page can be customized. Simply double-click on the graph, and a customization window will pop up, as shown in the figure below. To learn about the customizing choices, click on the "Help" button.




## Saving a Graph

To save a graph to your hard drive, double click on the graph and click on "Export..." from the pop-up window. The resulting pop-up menu enables you to select the type of file, the destination, and the size.



# Summary and Conclusions

- Website is operational – pre-demonstration data is being collected for the Palmdale Site and the FESS Demo – http://www.energystoragedemo.net/cec
- Web based data acquisition system is structured for security, redundancy, availability and expandability
- There is no such thing as a "simple data acquisition system" – Functional and design/performance specifications are an integral component of the measurement of success for energy storage projects