PEER REVIEW 2007

DOE(SNL)/CEC Energy Storage Program FYO7 Projects

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Presentation Outline

- **DOE(SNL)/CEC Collaboration**
  - **Background of DOE(SNL)/CEC Collaboration**
  - **FY07 Project Review**
    - Zinc Bromine Battery (ZBB) Demonstration
    - Palmdale Super capacitor Demonstration
    - Sacramento Municipal Utility District (SMUD) Regional Transit (RT) Super capacitor demonstration
    - Beacon Flywheel Energy Storage System (FESS)

Background of DOE(SNL)/CEC Collaboration

- **Memorandum of Understanding Between CEC and DOE (SNL).**
  - **In Place since 2004**
  - **Provides support to CEC in the implementation of Electrical Energy Storage Projects.**
    - Project development and coordination
    - Technology transfer
    - Data Acquisition System (DAS) management
      - Monitor and analyze system performance
      - Provide economic evaluation of technology

DOE(SNL)/CEC FY07 Projects
Zinc Bromine Battery (ZBB) Energy Storage Demonstration

- **Overview**
  - **Peak shaving project initiated in 2004**
    - 2 MW/2 MWhr Zinc Bromine Battery demonstration
- **Objective**
  - **Allow for Substation deferral**
    - Demonstrate that Zinc Bromine battery system can cost effectively provide peak shaving
- **Technology**
  - **Presently testing 500-kWh Zinc Bromine battery system**
    - Two strings of five 50-kWh battery modules
    - 500 kWh dc capacity
    - 250 kW ac continuous; 500 kW ac peak

DOE(SNL)/CEC FY07 Projects
Zinc Bromine Battery (ZBB) Energy Storage Demonstration

ZBB's 50 kWh module
(3 stacks in parallel)

ZBB's 500 kWh system (10 - 50 kwh modules)

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DOE(SNL)/CEC FY07 Projects
Zinc Bromine Battery (ZBB) Energy Storage Demonstration

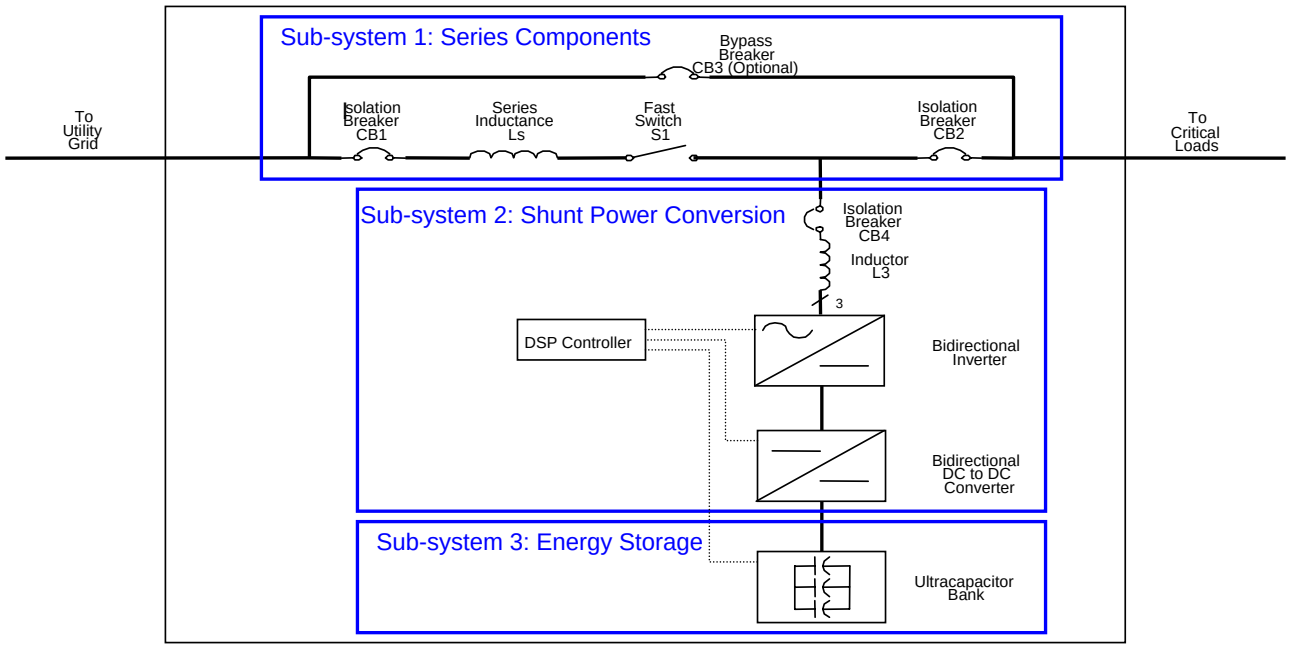
- **Status**
  - **ZBB finished field testing of initial system at the DUIT facility in 2006**
  - **ZBB installed upgraded 500 kWh system at DUIT summer 2007**
  - **Presently system is in 40 day reliability testing**
  - **Upon successful completion of 40 day test, determination will be made whether to install additional 500 kWh systems for further evaluation**
- **DOE/SNL Role**
  - **Collect electrical data during demonstration and provide performance analysis**
  - **Conduct economic evaluation of system**

DOE(SNL)/CEC FY07 Projects
Palmdale UltraCapacitor Demonstration

- **Overview**
  - **System developed by Northern Power (Distributed Energy Systems) to provide voltage ride through and conditioning**
    - Energy storage
    - PF correction
    - Harmonics
- **Objective**
  - **Develop and demonstrate an ultracapacitor based Electrical Energy Storage System for power reliability and power quality applications**
    - Power outage ride-through capabilities
    - Power factor correction
    - Power conditioning

DOE(SNL)/CEC FY07 Projects
Palmdale UltraCapacitor Demonstration

- **Technology**
  - **Ultracapacitor system provides 450 KW for 30 seconds**



One-line diagram of EnergyBridge system

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DOE(SNL)/CEC FY07 Projects
Palmdale UltraCapacitor Demonstration

One of four ultracapacitor cabinets

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DOE(SNL)/CEC FY07 Projects
Palmdale UltraCapacitor Demonstration

- **Status**
  - **System is assembled at Barre Plant**
  - **Operation acceptance test and factory commissioning completed**
  - **Unit will be shipped to the Palmdale site where a functional acceptance test will take place in Q4 CY07**
- **DOE/SNL Role**
  - **Technical advisor for storage technology**
  - **Collect electrical data during demonstration and provide performance analysis**
  - **Conduct economic evaluation of system**
  - **Conducted Factory commissioning test**

DOE(SNL)/CEC FY07 Projects

SMUD/RT SES demonstration

- **Overview**
  - Voltage stabilization project
    - New power configuration needed to accommodate heavier and more powerful train cars
      - Existing configuration - 1 MW SS located every 2 miles
      - New configuration - 2 MW SS every mile
- **Objective**
  - Avoid cost of new substation by incorporating Static Energy Storage (SES) into existing lines and new expansions
    - Provide Voltage stabilization
      - Estimated 65 VDC increase from 600 V to 665V on 750 VDC system
    - Reduce Energy consumption
      - Estimated 35 – 55kWh energy savings
        - 7-10% energy reduction

DOE(SNL)/CEC FY07 Projects
SMUD/RT SES demonstration

- **Technology**
  - 1MW Siemens Static Energy Storage System SITRAS® SES
    - BCAP 3000 Maxwell UltraCapacitor
    - 1MW for 20 second

Dresden-Hellerau (Container Version)

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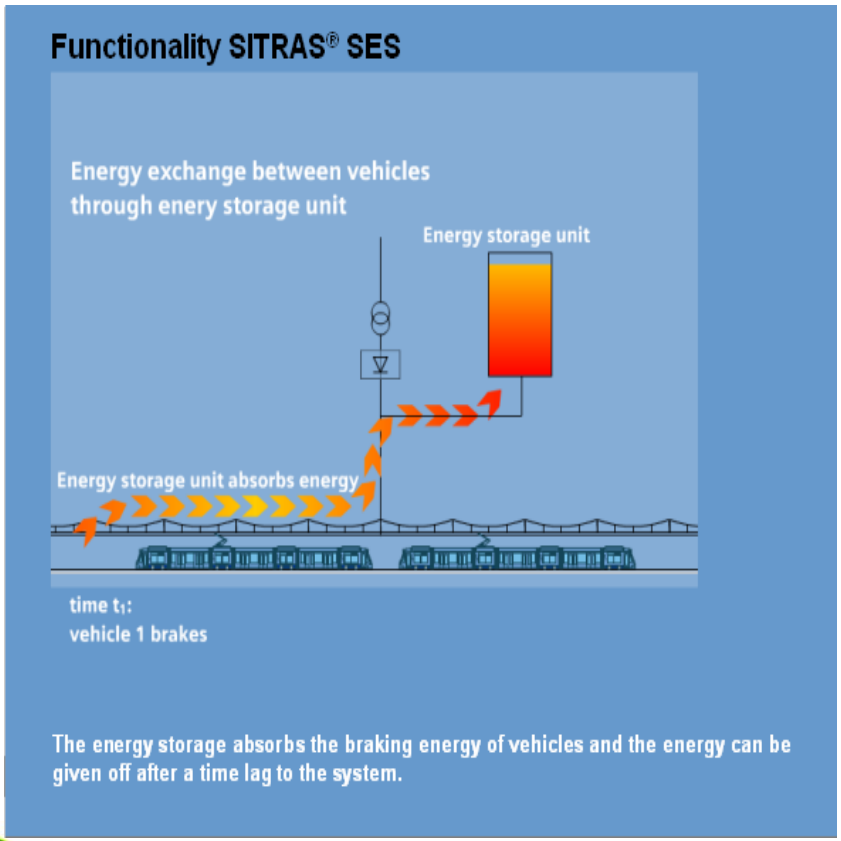
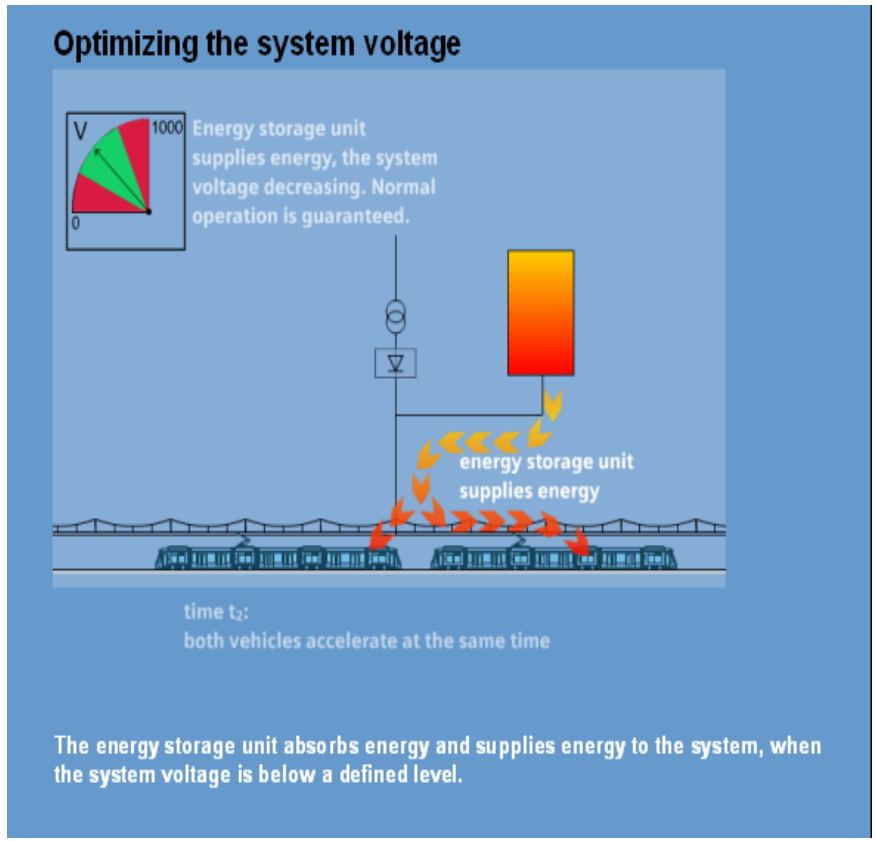
DOE(SNL)/CEC FY07 Projects

SMUD/RT SES demonstration





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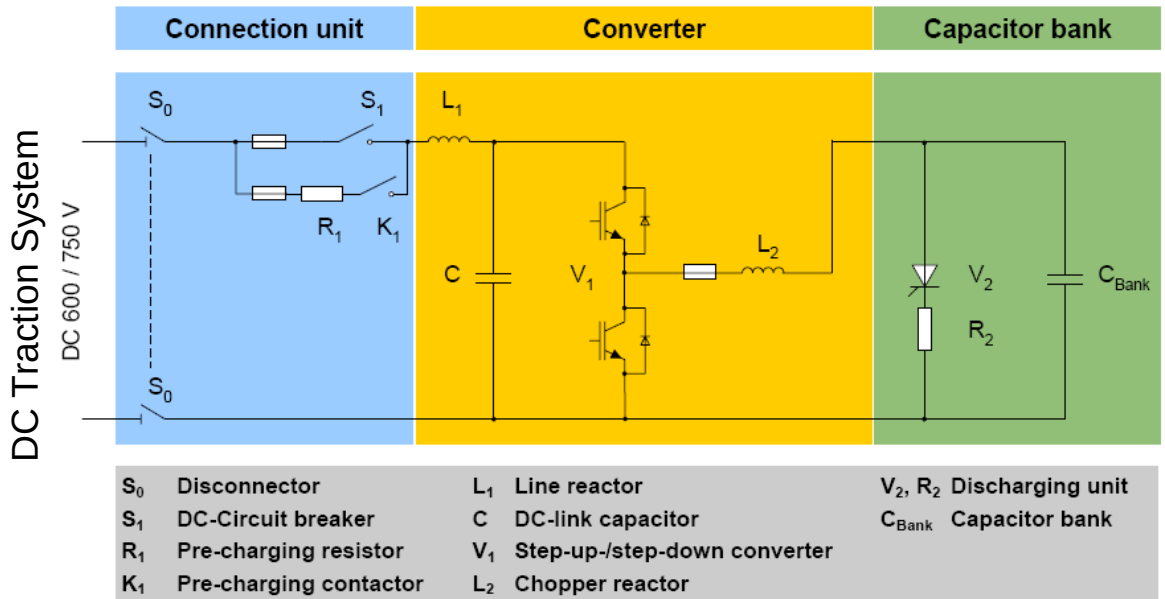
DOE(SNL)/CEC FY07 Projects

SMUD/RT SES demonstration

Static Energy Storage System SITRAS® SES

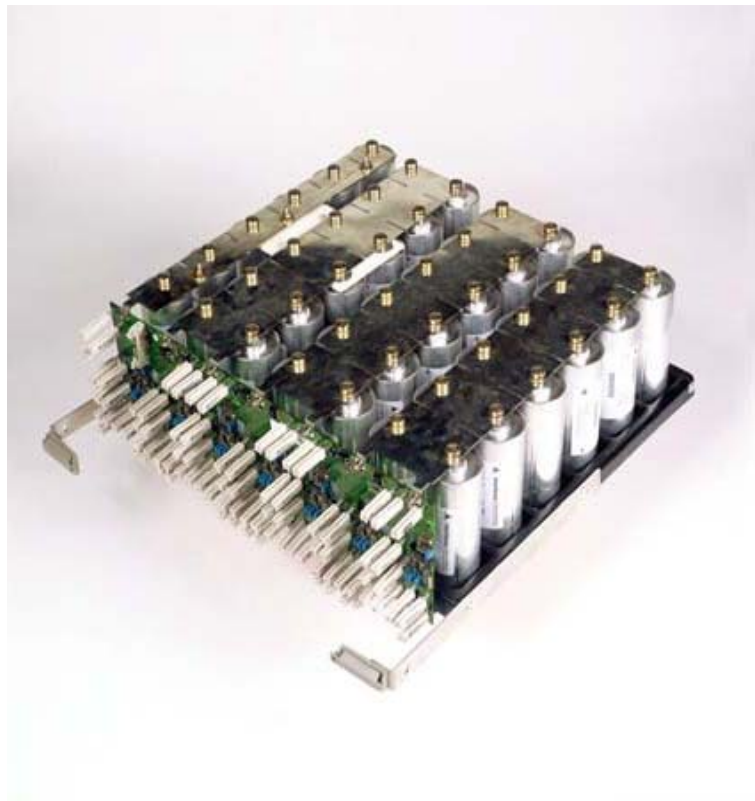
Design: Single-line diagram



DOE(SNL)/CEC FY07 Projects

SMUD/RT SES demonstration

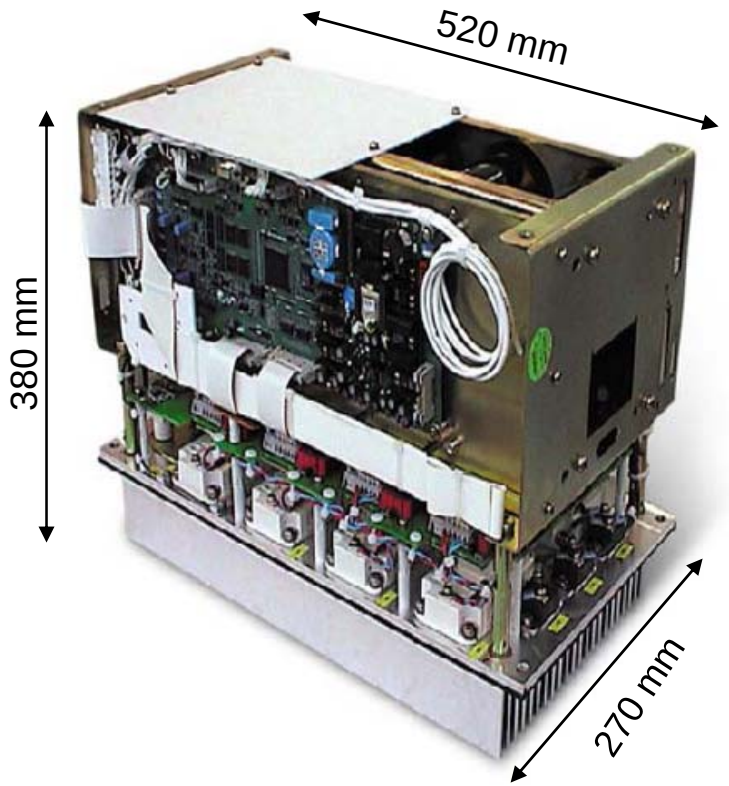
- **Static Energy Storage System SITRAS® SES**
  - **Capacitor bank consist of 30 Watchdog modules**
    - Each module consists of 7 function blocks supervising capacitors connected in parallel.
  - **Technical data of the capacitor**
    - Voltage 2.7 V; capacity 3,000 F
    - Double-layer capacitors



DOE(SNL)/CEC FY07 Projects

SMUD/RT SES demonstration

- Static Energy Storage System SITRAS® SES
  - **Converter: IGBT converter module**



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DOE(SNL)/CEC FY07 Projects

SMUD/RT SES demonstration

- **Status**
  - **Phase I started in 2005 and included:**
    - RT light rail system model simulation by Siemens Transportation Systems started in 2006 that analyzes the potential benefit of SES at specific locations
      - Detailed data collection and analysis by RT for input to the Siemens model
      - Detailed billing study by SMUD for all 34 RT substations
  - **Phase II started in 2007 and includes:**
    - Additional Data collection and cost analysis
    - SES operational for summer/Fall 2008
    - 15 month demonstration of SES System on Sacramento RT Light Rail Folsom Line

DOE(SNL)/CEC FY07 Projects

SMUD/RT SES demonstration

- **DOE/SNL Role**
  - **Technical advisor for storage technology**
  - **Collect electrical data during demonstration and provide performance analysis**
  - **Conduct economic evaluation of system**

DOE(SNL)/CEC FY07 Projects
Beacon Flywheel Energy Storage System (FESS)

- **Overview**
  - **100 KW 15 minute Power unit successfully demonstrated over 18 month test period (2005/06)**
    - **7 ea. 15 KW flywheel units**
- **Objective**
  - **Show efficacy of flywheel technology for grid-scale frequency regulation**
- **Technology**
  - **Kinetic Energy Flywheel**
    - Fast response
      - Full “up” or “down” regulation < 4-seconds vs. 5-minutes for conventional technology

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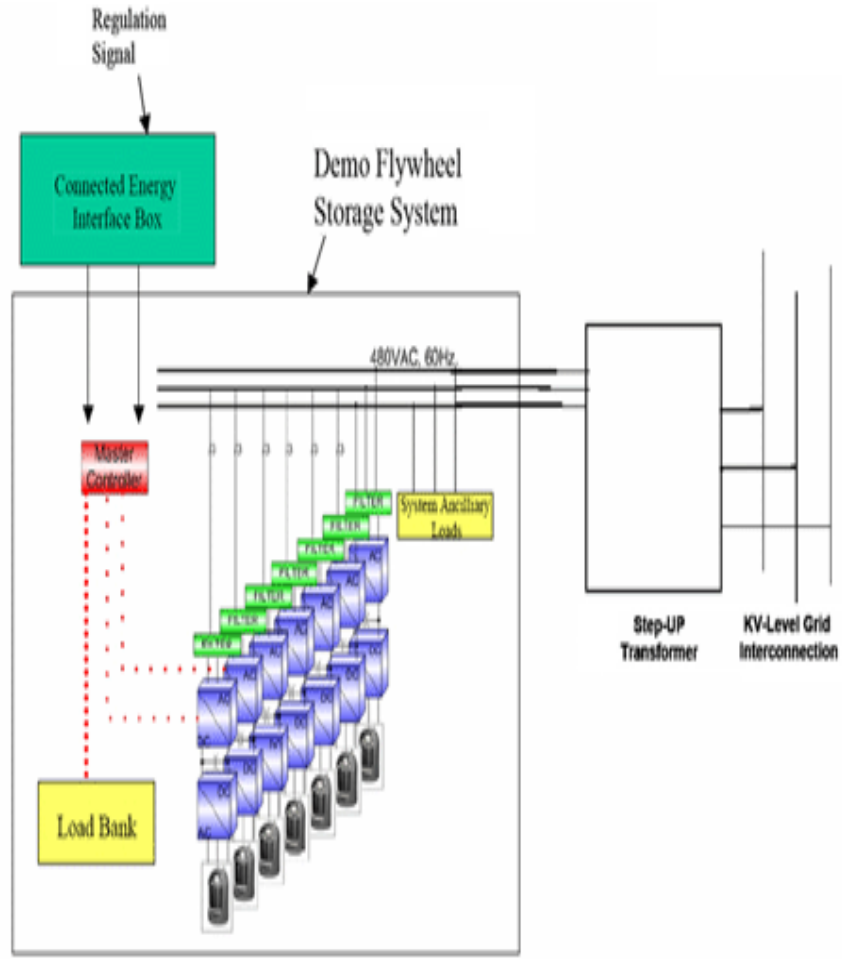
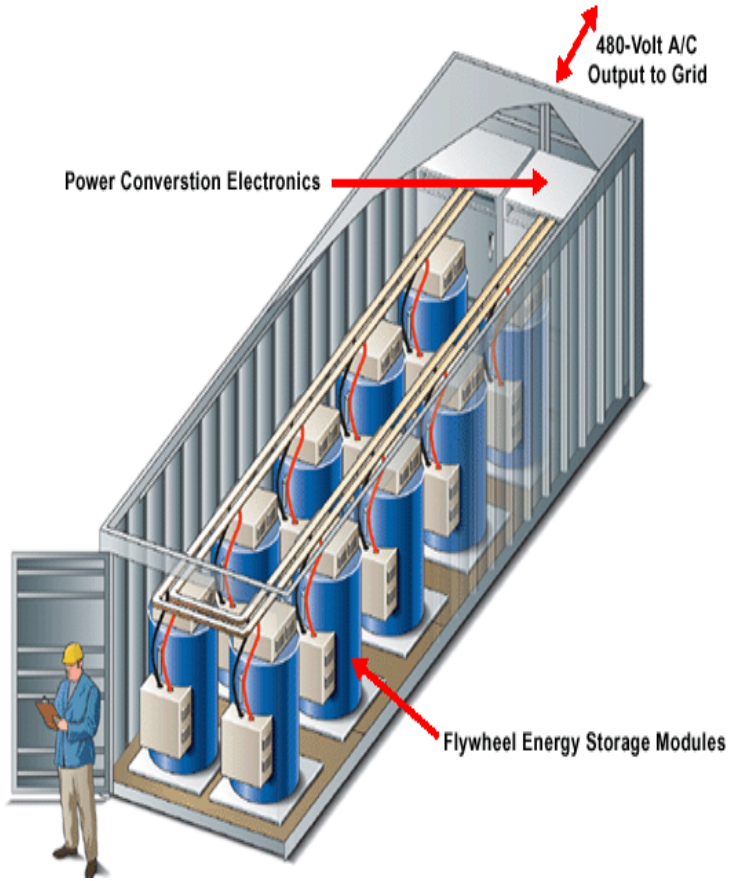
DOE(SNL)/CEC FY07 Projects
Beacon Flywheel Energy Storage System (FESS)





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DOE(SNL)/CEC FY07 Projects
Beacon Flywheel Energy Storage System (FESS)

- **Status**
  - **Demonstration of 100 KW system successfully completed Dec 2006**
  - **Final reports in progress**
- **DOE/SNL Role**
  - **Technical advisor for storage technology**
  - **Capture electrical data during testing, provide performance analysis**
  - **Economic benefit/cost evaluation of commercial-scale plant**
  - **Facilitate commercialization**

DOE(SNL)/CEC FY07 Projects Summary

- **DOE/SNL continues to provide support to new and ongoing energy storage businesses and technologies**
  - **Technical performance and economic feasibility analysis**
  - **Technical consulting and advisory role**
- **Upcoming Projects**
  - **NaS battery installation**
    - CEC/PG&E collaboration
  - **VRB Battery**
    - CEC/SMUD/Sprint Collaboration