



**EESAT 2005**



# FLYWHEEL-BASED FREQUENCY REGULATION DEMONSTRATION PROJECTS STATUS

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**NYSERDA**



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# Topics of Discussion

- **What is Frequency Regulation (FR)?**
- **Flywheel Characteristics for FR**
- **CEC/DOE and NYSERDA/DOE Projects**
- **Demonstration System Description**
- **Initial Performance Status**
- **The Future**

# Typical “Regulation” Profile

## ISO Goal:

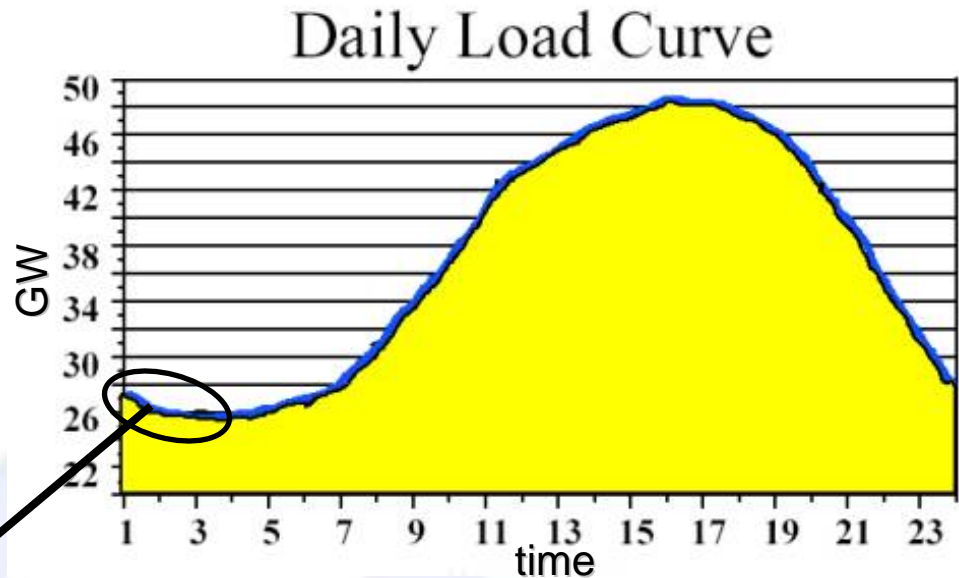
**Load = Power Generated**

**Power < Load:**

– Frequency drops under 60 Hz.

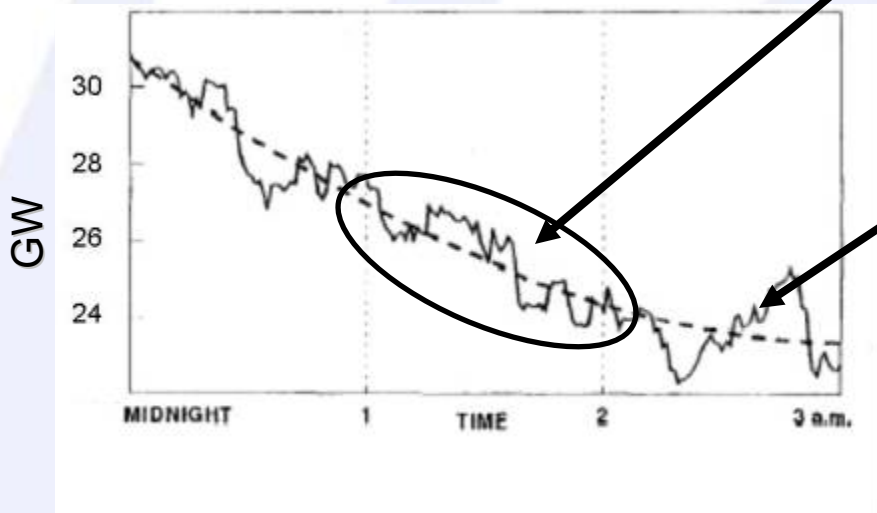
**Power > Load:**

– Frequency rises over 60 Hz.



## Short term variation

- ~ +/-1% to 2% of daily load
- Managed via regulation
- Fluctuation is net zero
- Well suited for energy storage and recycling
- Typical 100-1000MW per control area



# Frequency Regulation Basics

Flash presentation at [www.beaconpower.com](http://www.beaconpower.com)



# Trends in Wind Deployment

- **Today, 1% of power is from wind**
- **By 2020, 6% will be wind generated, driven by state Renewable Portfolio Standards**
- **Wind introduces power fluctuations and intermittencies**
- **Will require more regulation per MW generated (CAISO has indicated as much as 4x)**



# Frequency Regulation Market Dynamics

- **Deployment of wind, driven by Renewable Portfolio Standards, will increase demand**
- **Older fossil fuel-powered plants, frequently used for regulation, are being taken out of service**
- **Emission regulations add equipment that reduces frequency regulation capability**



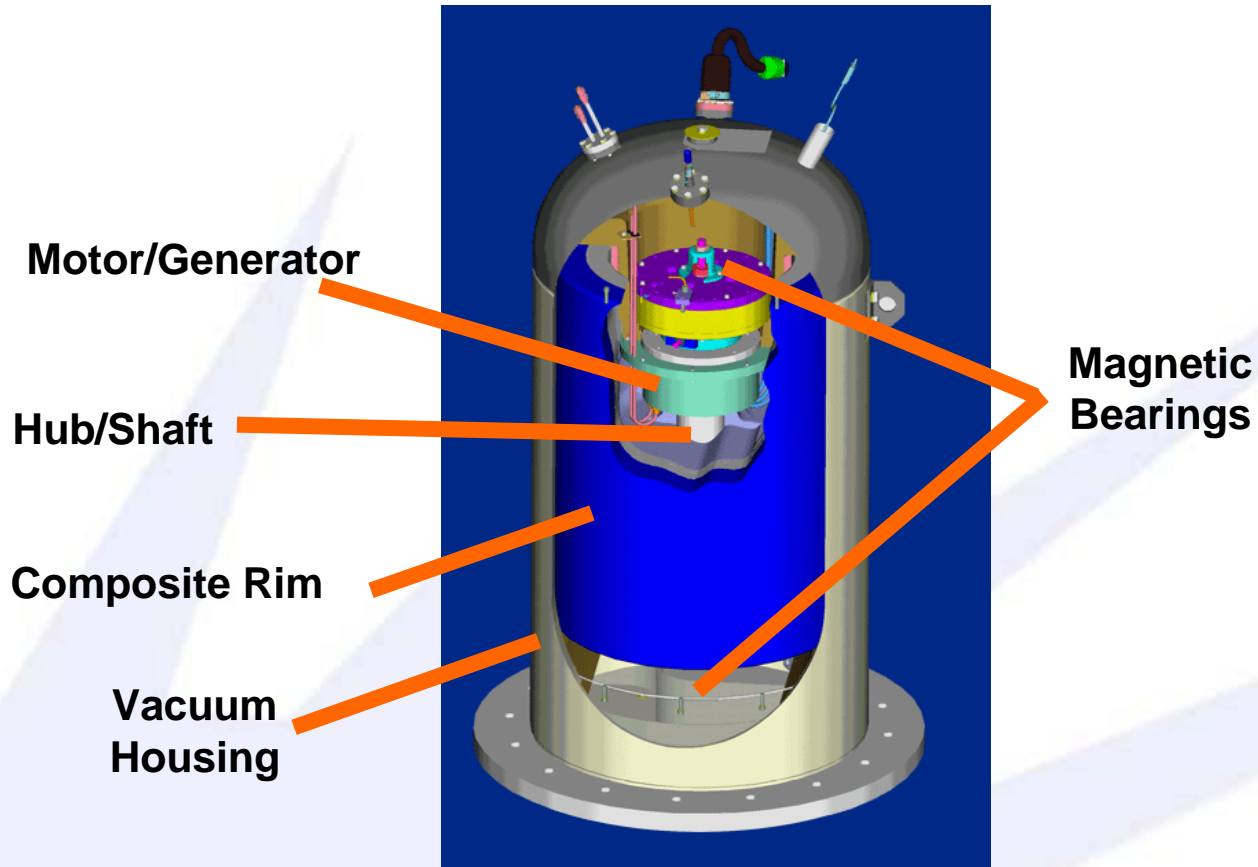
**Regulation  
demand  
increasing**

**while...**



**Regulation  
supply  
decreasing**

# Advanced Flywheel Technology



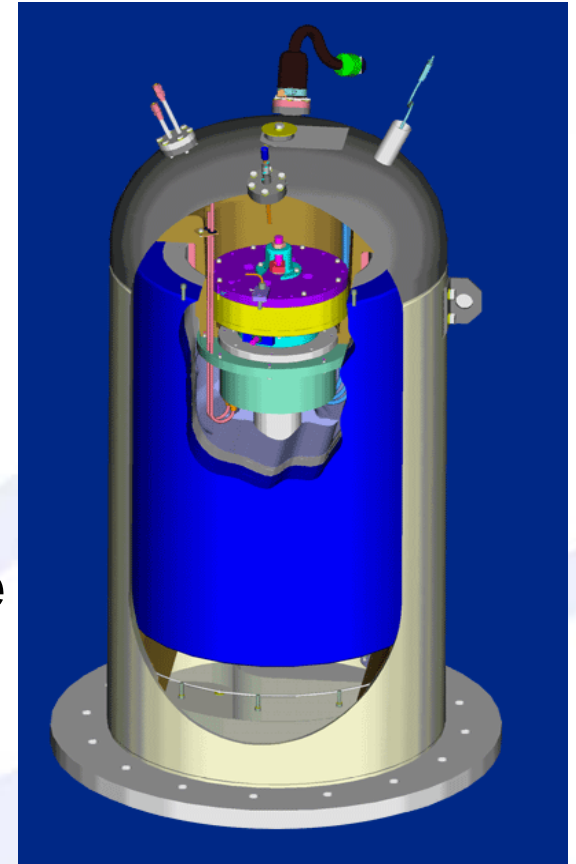
Visit Electricity Storage Association Website  
[www.electricitystorage.org](http://www.electricitystorage.org)





# Critical Design Drivers

- **Output Power (Motor)**
- **Hold-up Time (Stored Energy)**
- **Input/output Voltage**
- **Cyclic Life**
  - Quantity (Total)
  - Depth of Discharge
  - Frequency
- **Continuous vs. Intermittent Duty Cycle**
- **Physical Size & Weight**
- **Environmental**
  - Temperature/Humidity
  - Vibration (Normal Operation)



# Beacon's Product Evolution



2000



2kWh  
1 kW

2001



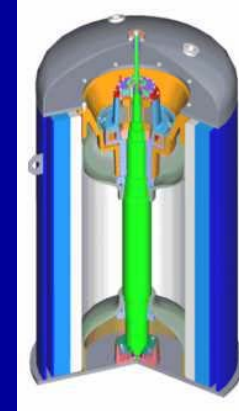
6kWh  
2 kW

2004



6kWh  
15 kW

2006



25kWh  
100 kW

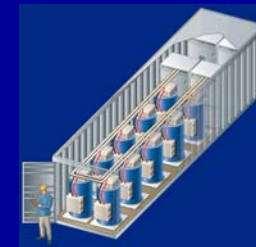
- Telecom applications
- Over 500,000 hours of operation

2005



- 100kW demonstration unit

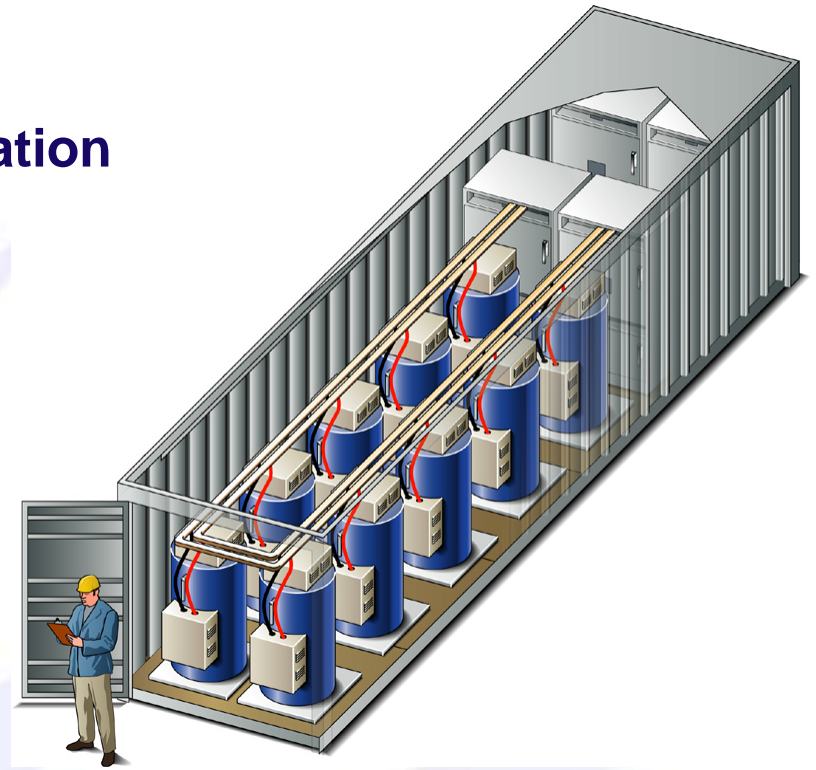
2007



- 1 MW SEM commercial unit

# The Beacon Solution to Freq Regulation

- Ten 25 kWh flywheels / 1 MW of regulation
- Fast response
- High reliability
- Competitive capital cost
- Lowest operational cost
- 20-year life
- Very low maintenance
- Sustainable advantages
- Emission-free, clean technology



**Smart Energy Matrix**  
(13,000lb of composites)



# Demonstration Projects Under Contract

- **California Energy Commission/DOE**
  - 100 kW version of SEM using modified existing flywheels
  - DUIT facility (PG&E Substation R&D facility) in San Ramon, CA
  - Team with Connected Energy for communications
- **NYSERDA/DOE**
  - 100 kW version of SEM using modified existing flywheels
  - Power & Composite Technologies (Industrial Site), Amsterdam NY
  - Team with Connected Energy for communications
- **NYSERDA**
  - Universal Grid Interconnect Device Study for DG “Green Box”
  - Team with Connected Energy
  - Interface between grid and DG assets
  - Scaled lab demonstration



# DUIT Facility in San Ramon, CA

Unloaded from Truck	9/21 7AM
Connected to Grid	9/21 11AM
Check out communications	9/22
Weekend	9/23-25
System checkout	9/26
All flywheels at speed	9/27



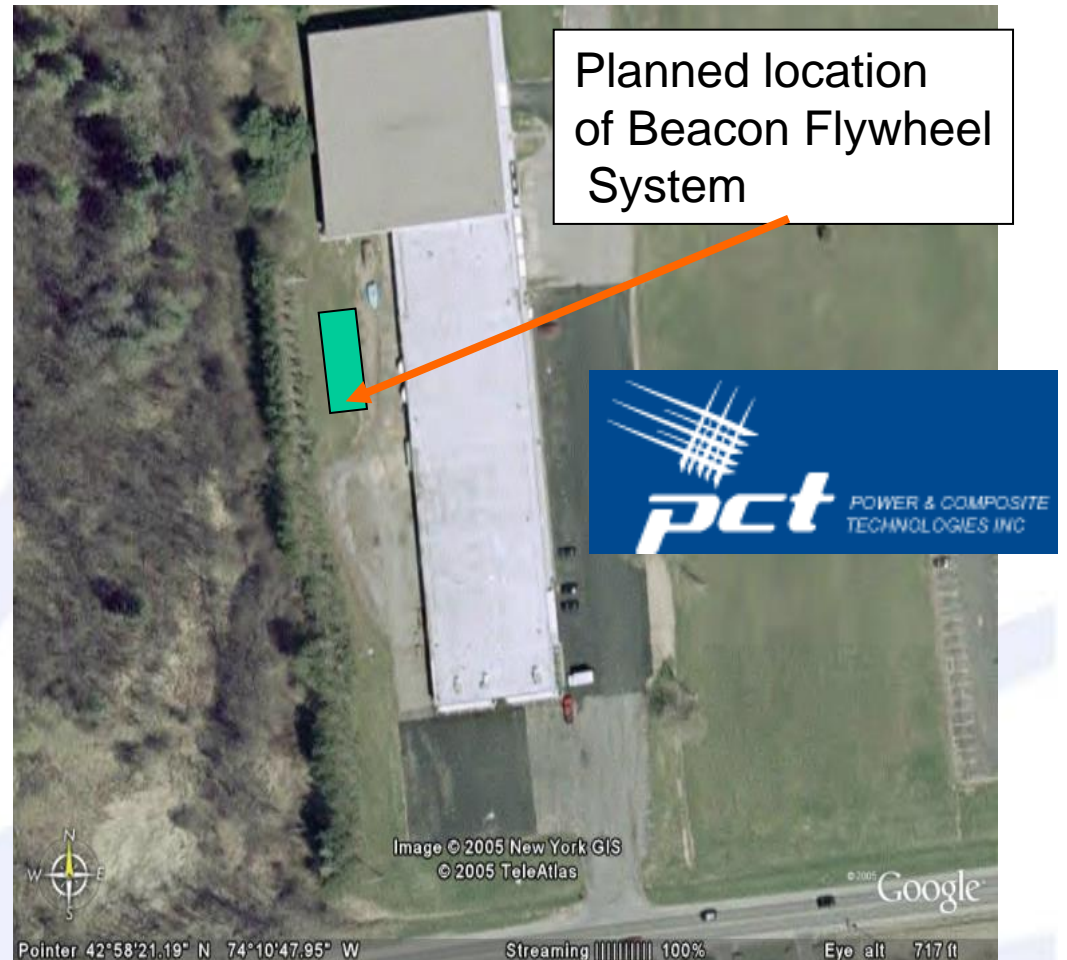
**Very fast, easy installation**

Beacon's Smart Energy Location



# PCT plant in Amsterdam, NY

- **Delivery 4<sup>th</sup> qtr 2005**
- **Installation in “Distribution Cloud”**
- **Demonstrate low cost communication with ISO**
- **Reactive Power testing included in plan**
- **Evaluate using line frequency as regulation signal**

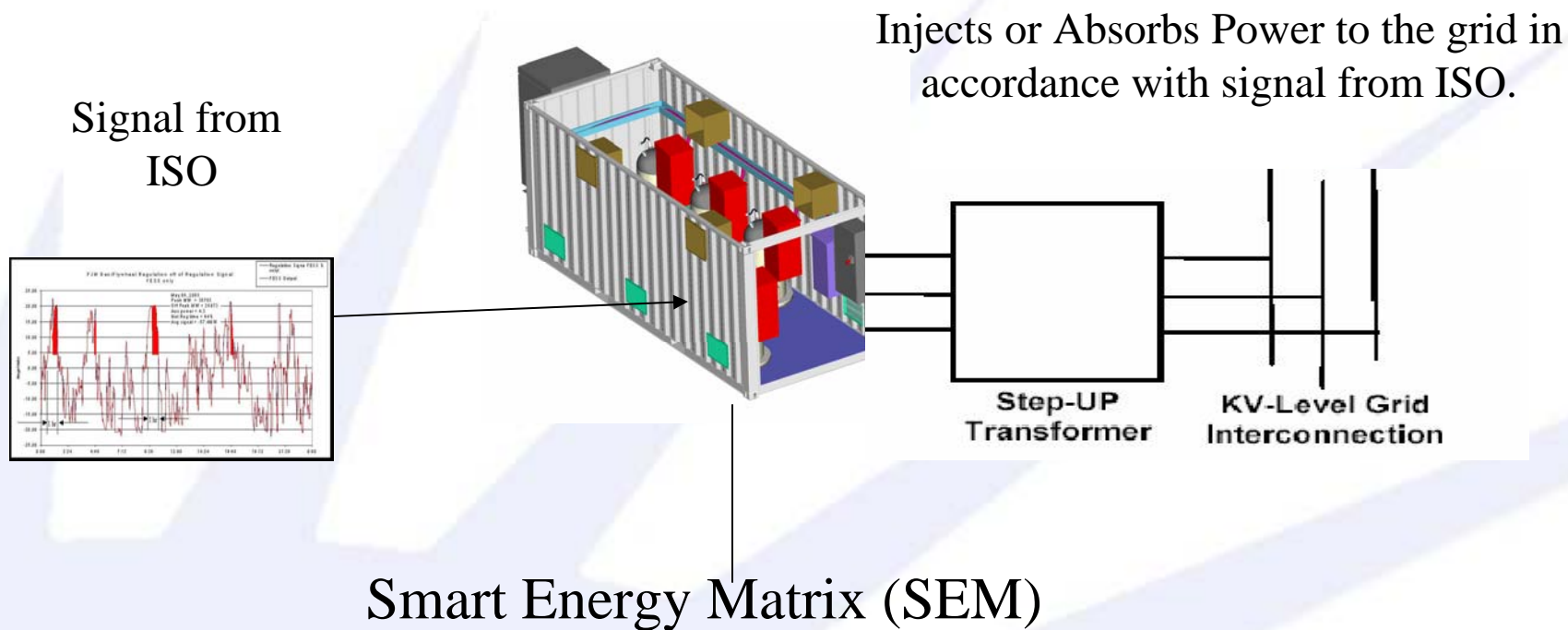


# Objectives of Demonstration Projects

- **Proof of concept on ~1/10<sup>th</sup> power scale**
- **Show ability to follow fast changing Frequency Regulation signals**
- **Demonstrate anti-islanding**
- **Validate interconnection capability**
- **Demonstrate performance & economic value**
- **Develop and demonstrate communications with grid operators**
- **Collect data for product specifications**
- **Gain industry confidence**
- **Report results to the industry**

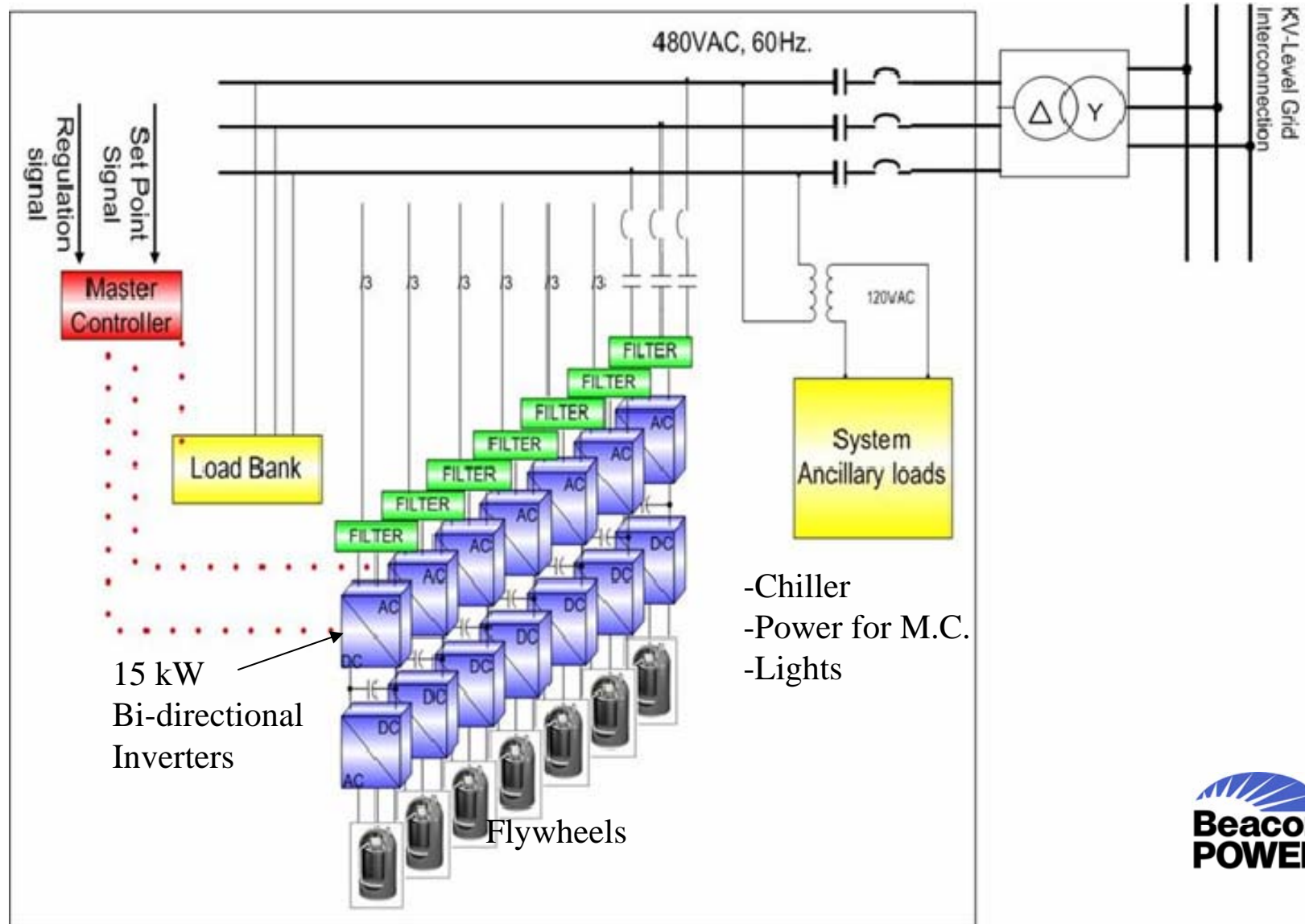


# System Operation





# Demo Schematic



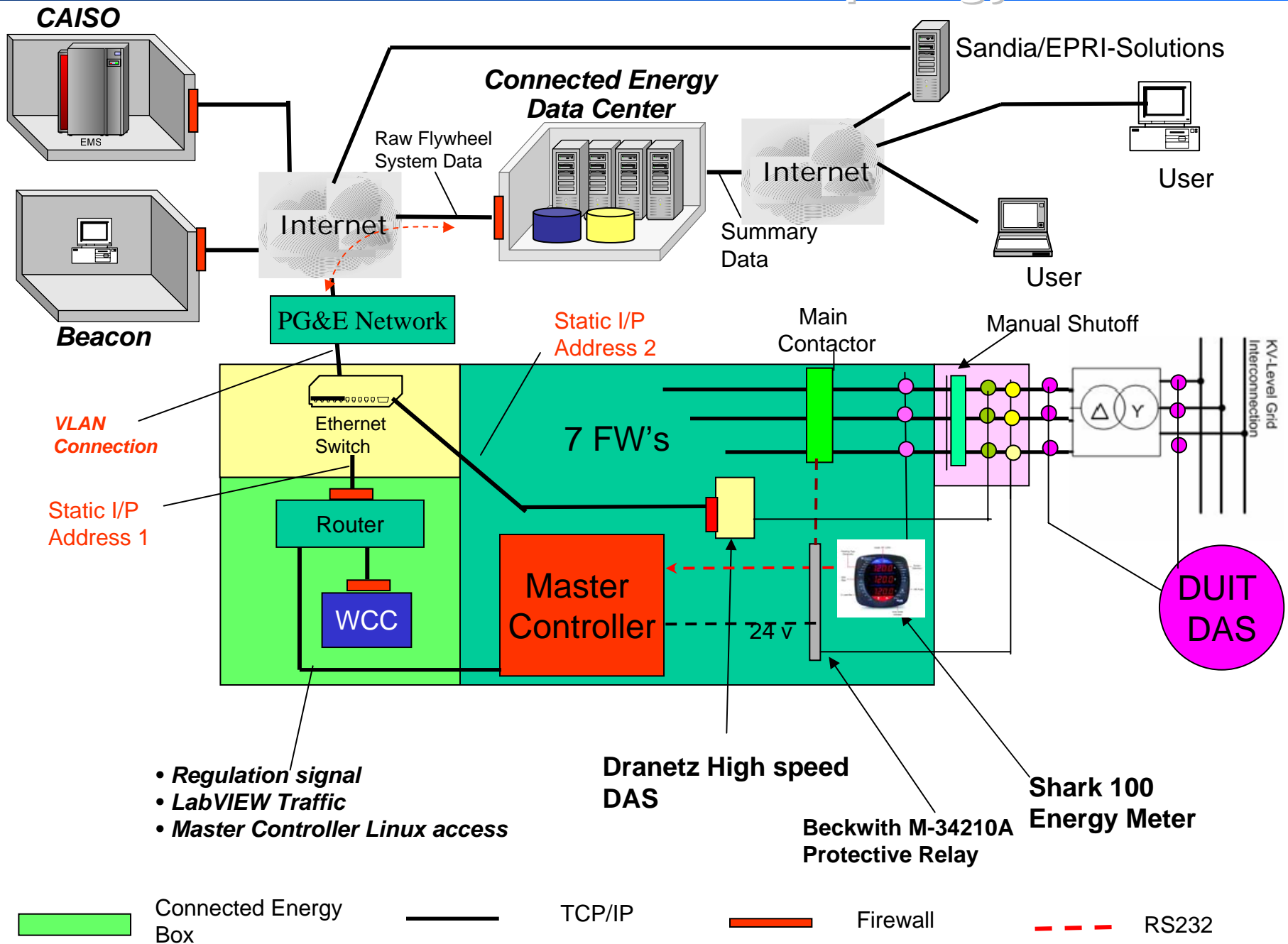
# Outside view of System



# Inside view of system



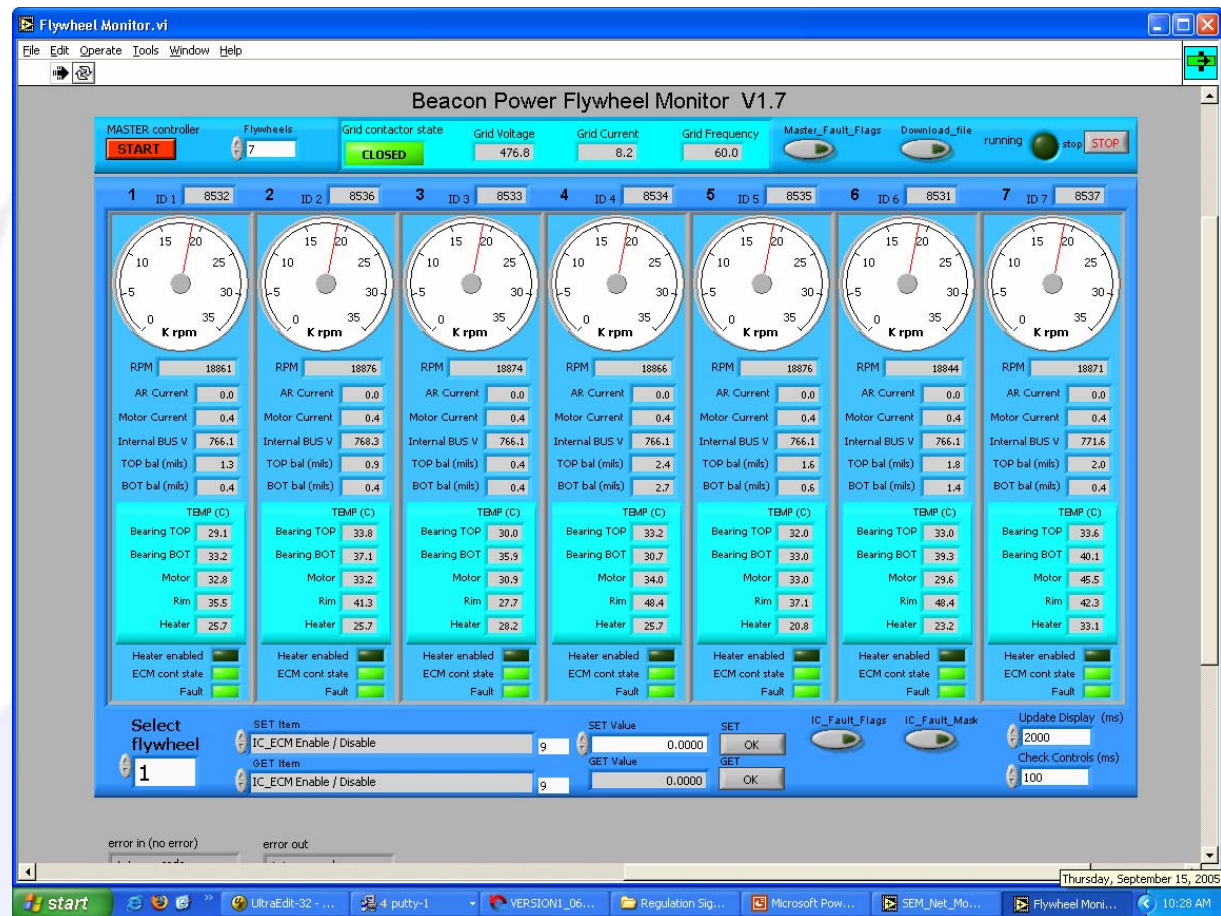
# Data Communication Topology



- Regulation signal
- LabVIEW Traffic
- Master Controller Linux access

# System Graphical User Interface

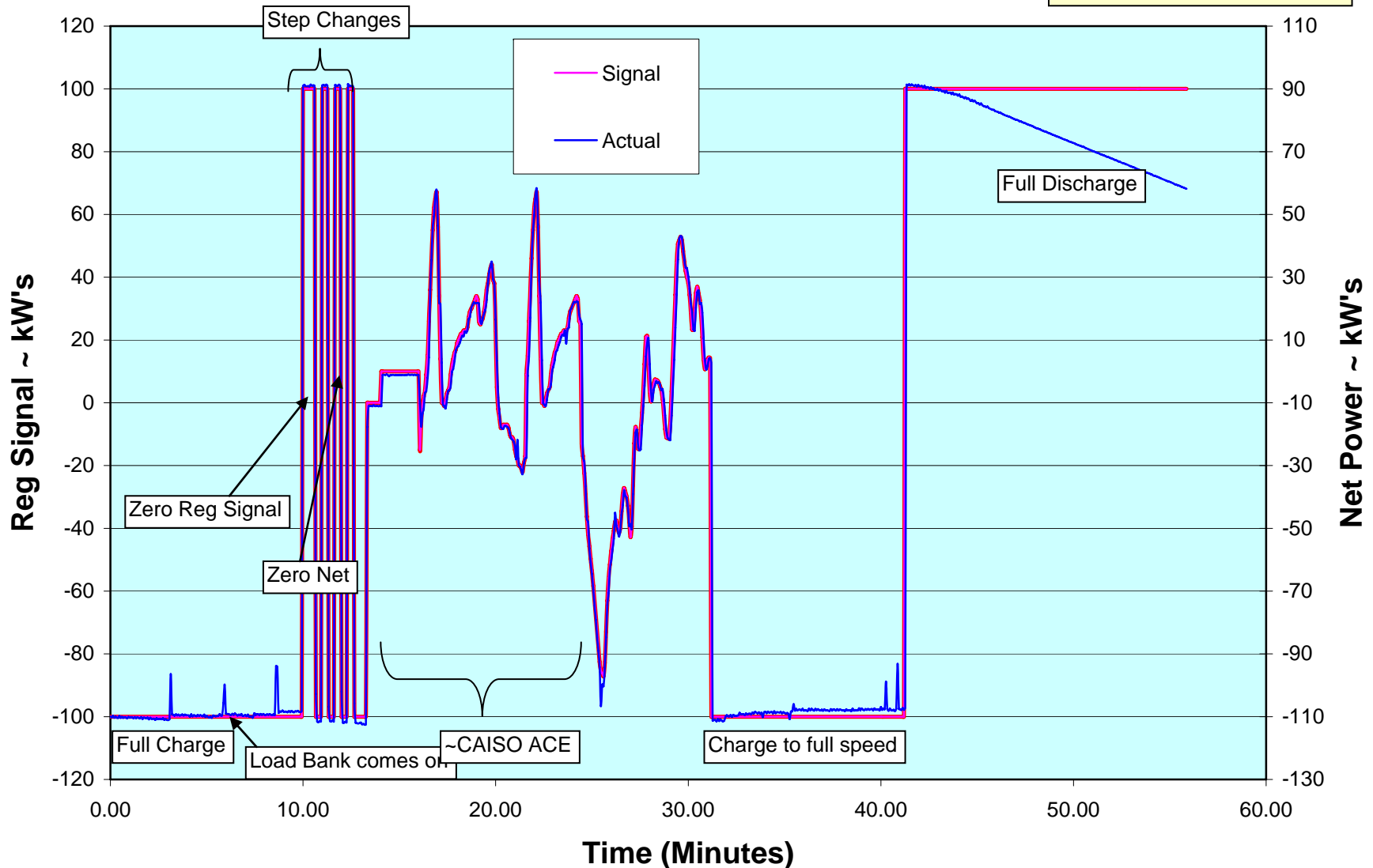
Remote Monitoring  
and Control of  
Flywheel and  
System Parameters



# Preliminary Demo Performance Data

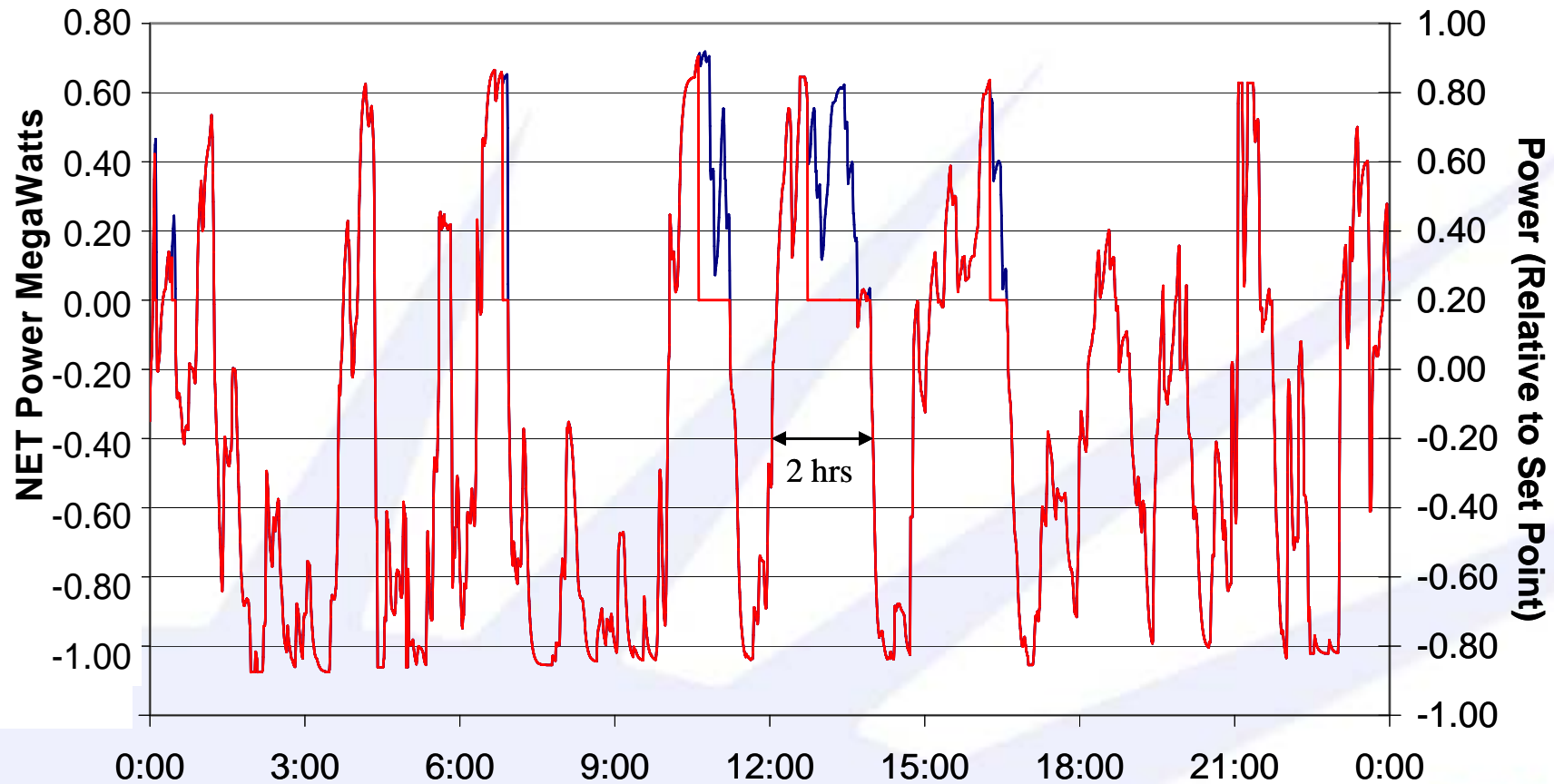
## 100kW Acceptance Test Signal

Set Point = -10 kW  
Max Reg = 100 kW  
Flywheels start @ 19,000 RPM



# Preliminary Product Analysis

## Performance vs. existing PJM Signal



Evaluating System Operation in different Interconnects



# The Future-Flywheels are here to stay!

- **Flywheels are an ideal technology for Frequency Regulation**
- **Frequency Regulation requirements should increase**
  - Renewable Portfolio Standards
  - Generator assets targeted for retirement are generally today's source of lower cost regulation
- **New application potentials:**
  - Growth of Distributed Generation will need high cyclic energy storage capability
  - Residential renewables should benefit from no-maintenance, "green", working energy storage
  - UPS functions

**Join the DUIT tour to see Demo System in operation**

