Lawrence Livermore National Laboratory (LLNL)
High Performance Computing (HPC)
Sustainability Master Plan – Power Management
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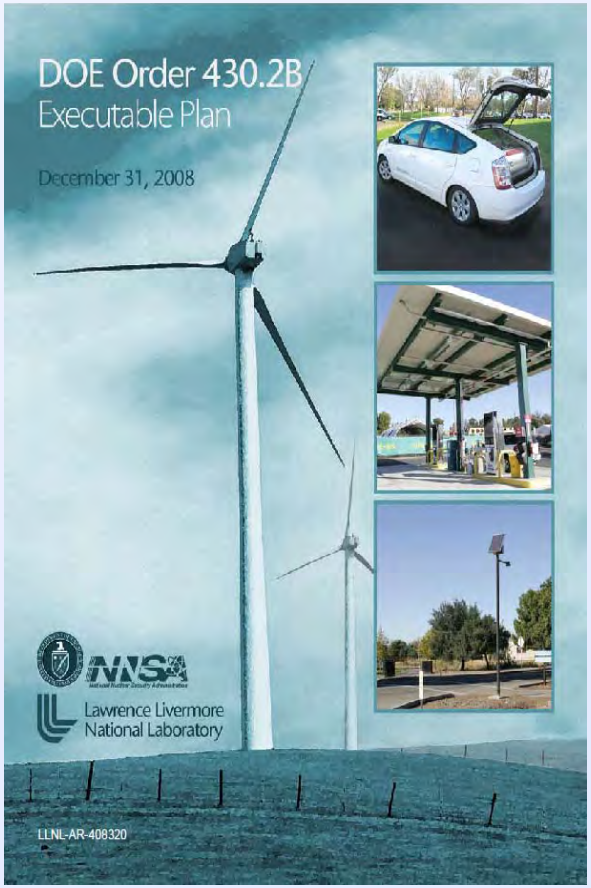
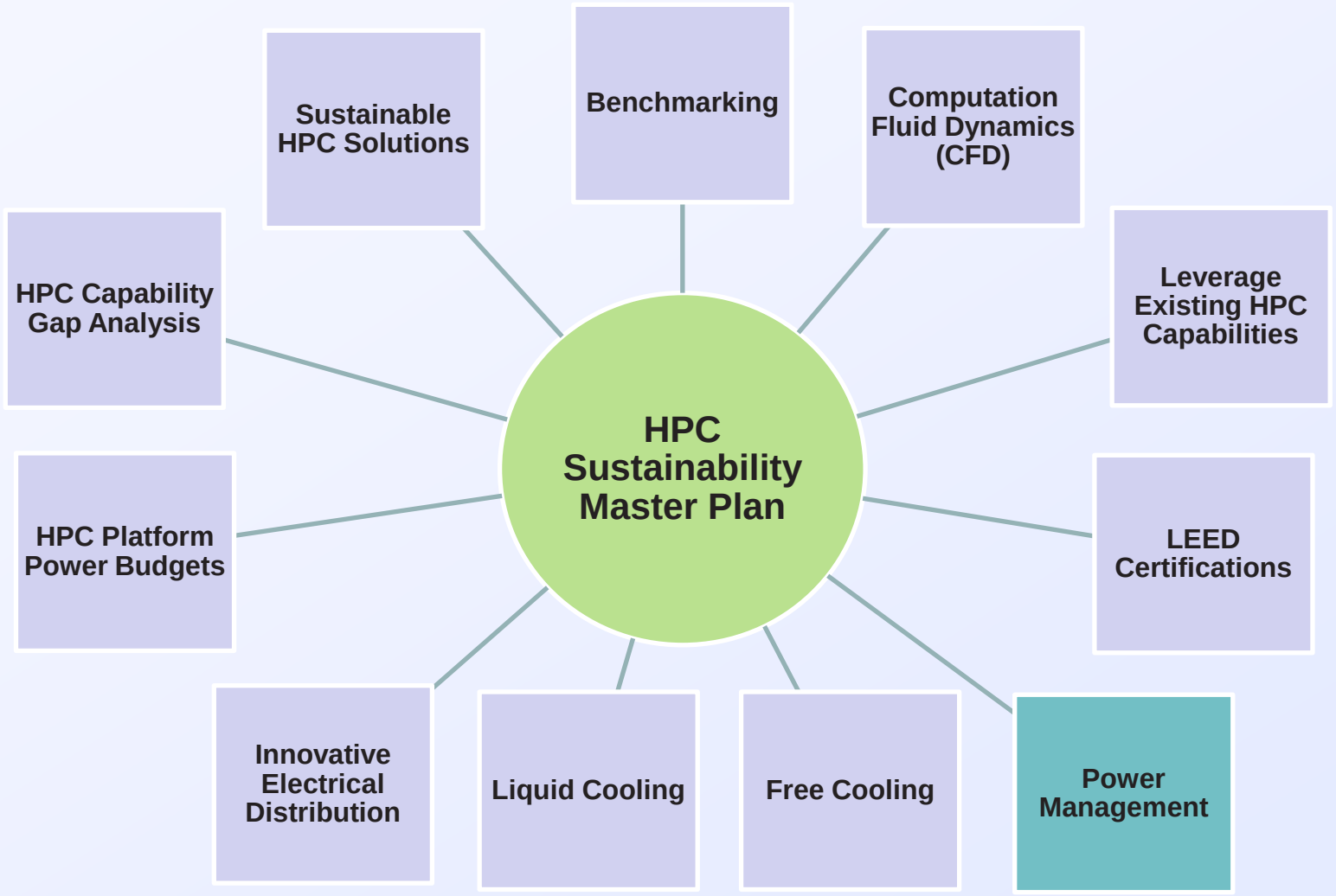
HPC at LLNL strives to reduce energy consumption and ultimately reduce operating costs

- Energy conservation is critical to improve efficiencies and reduce operational costs
  - Operational efficiencies are vital to future of HPC - **Exascale Computing**
- Executive Order DOE 430.2B
  - Reduce energy intensity 30% by 2015 from baseline (FY03)
- Address High Performance Computing (HPC) capabilities and gaps as well as energy impacts site wide
- Developed HPC Sustainability Master Plan to feed into overall LLNL Sustainability Program



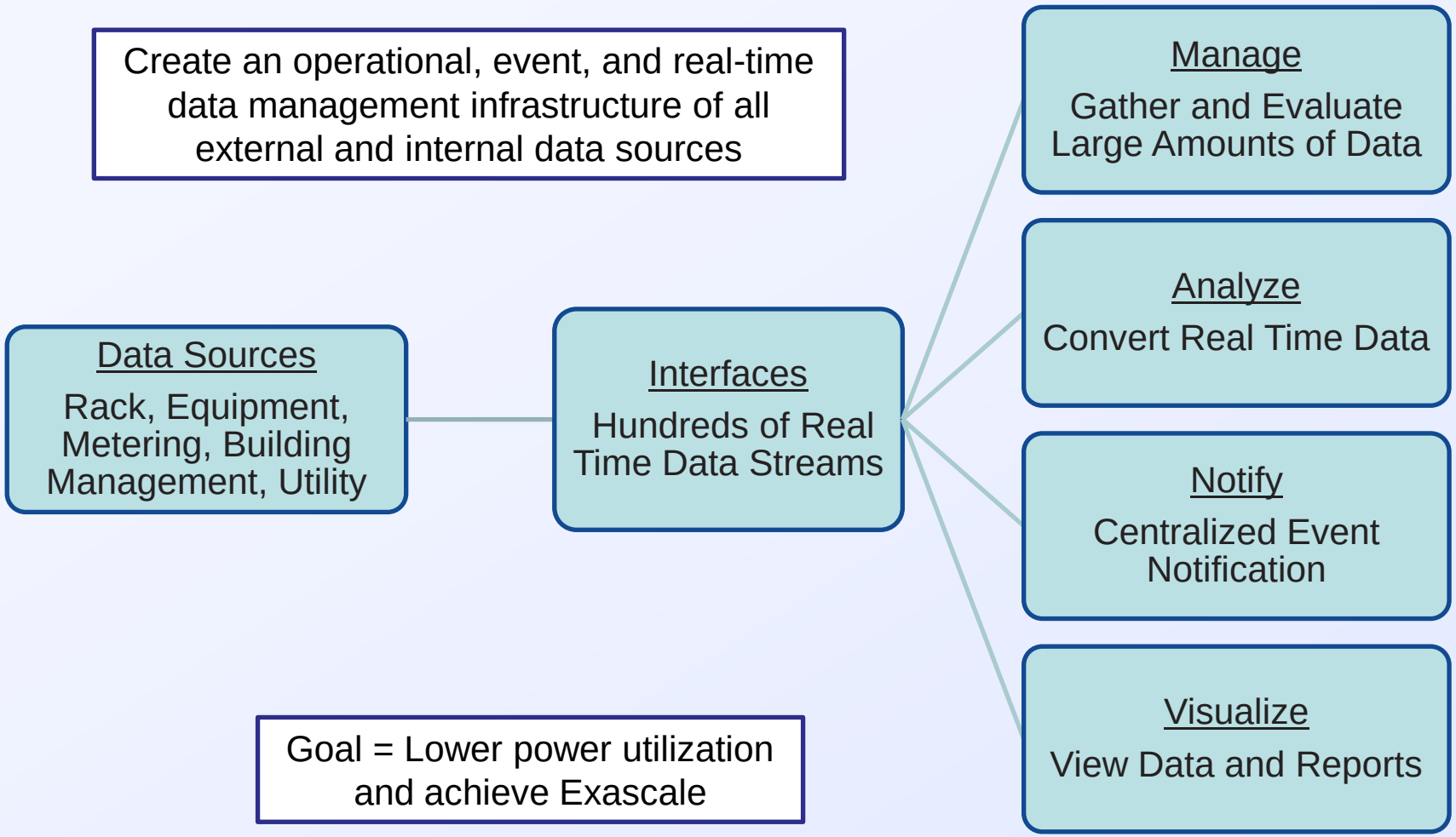
HPC Sustainability Master Plan Core Competencies Drive to Energy Management



Power Management: Critical to success of energy management of HPC at LLNL and achieving Exascale

- Power management is critical but challenging to implement
  - Numerous data streams
  - Need to aggregate data into single source and view on common dashboard
  - Determining what data is significant
  - Unable to correlate events from various sources
    - Different timestamps and formats

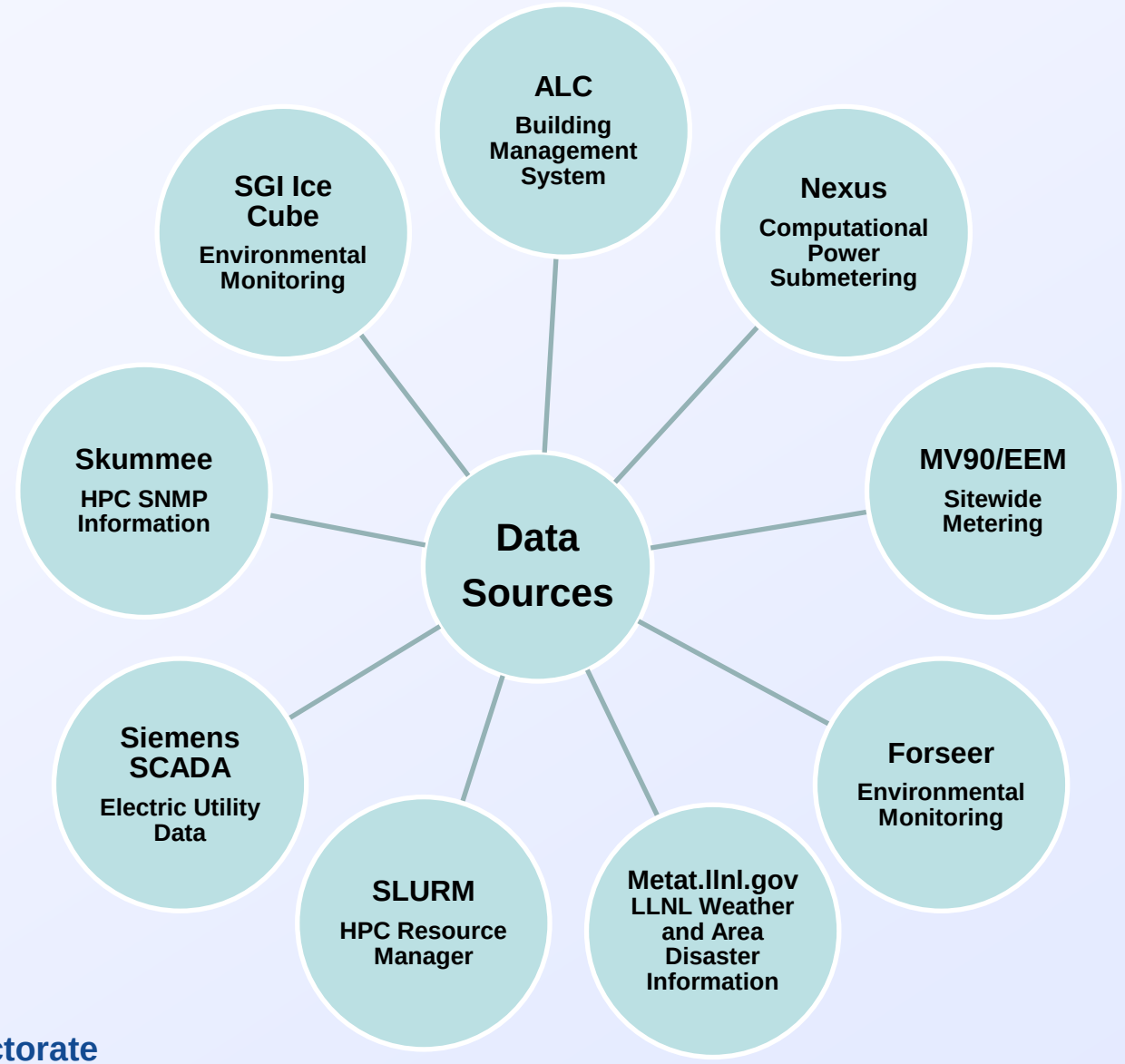
Power Management: Implement centralized system of real time data from the rack to the entire site



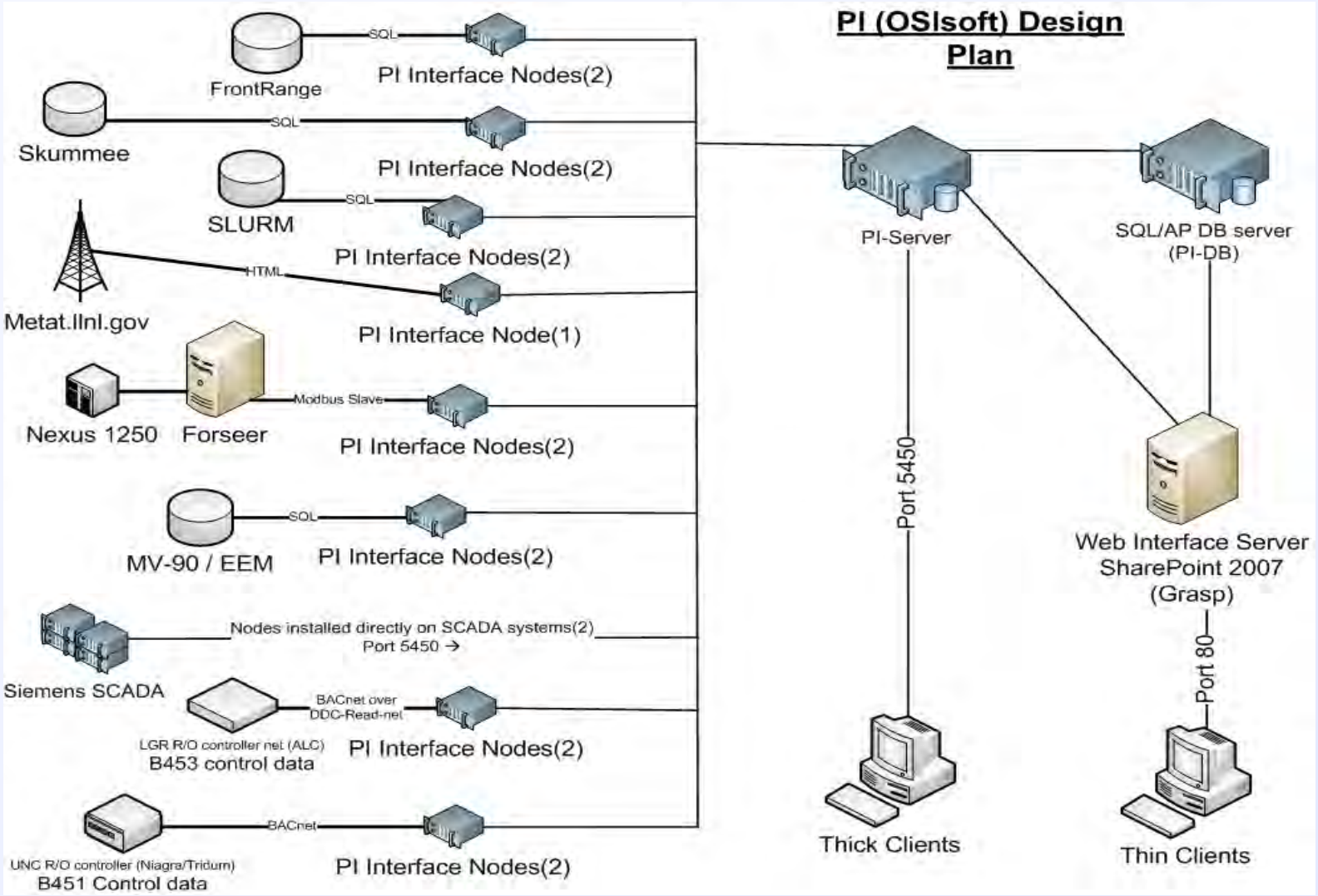
Power Management: Challenges

- Understanding how different types of hardware and software impact power utilization
- Correlating multiple types of data sources
- Coordinating with multiple owners of the data
- Accessing the data
- Selecting the best interface
- Comparing and viewing the data on a common platform
- Creating various dashboards

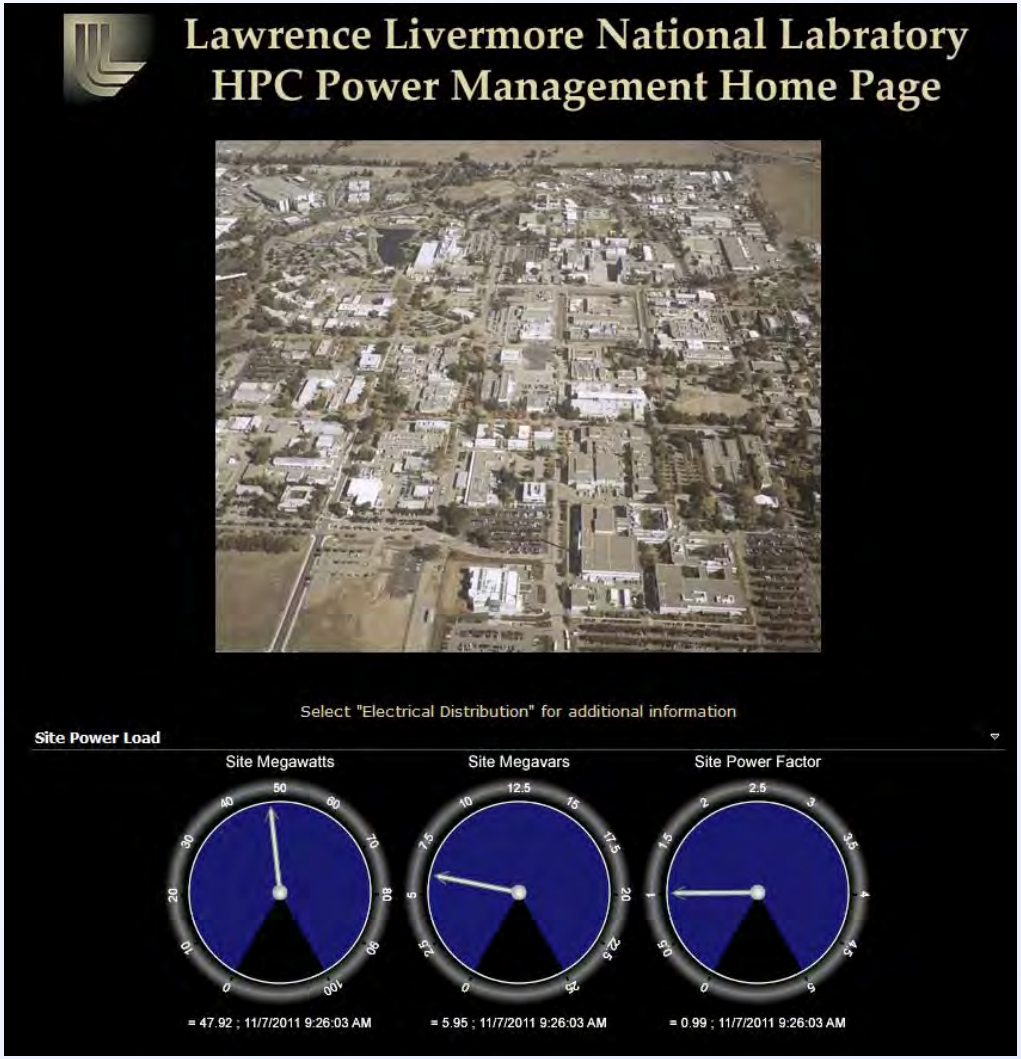
Power Management:
Current data sources are spread across LLNL



Overall Management Architecture

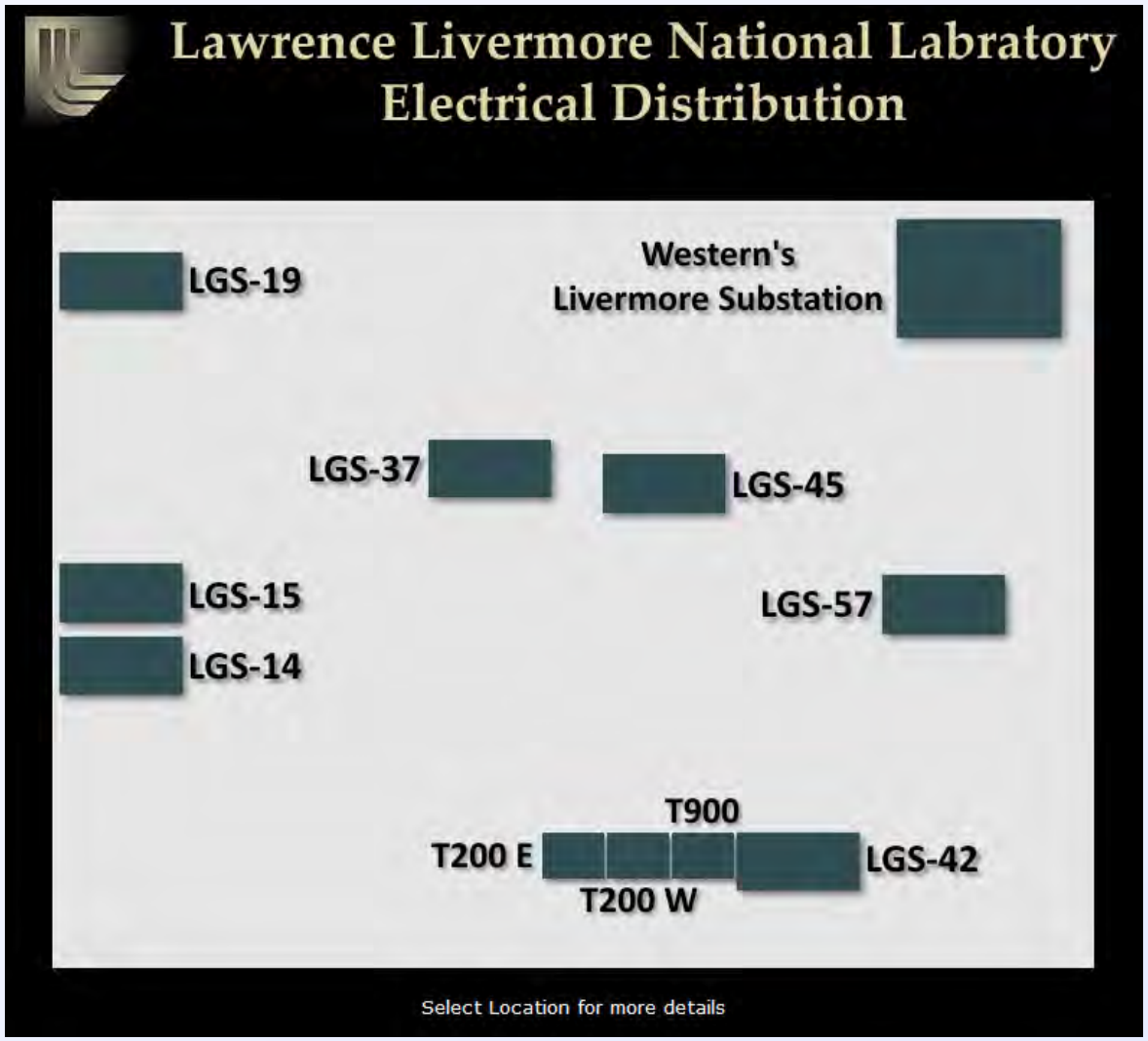


HPC Power Management System
LLNL Electrical Distribution Home Page



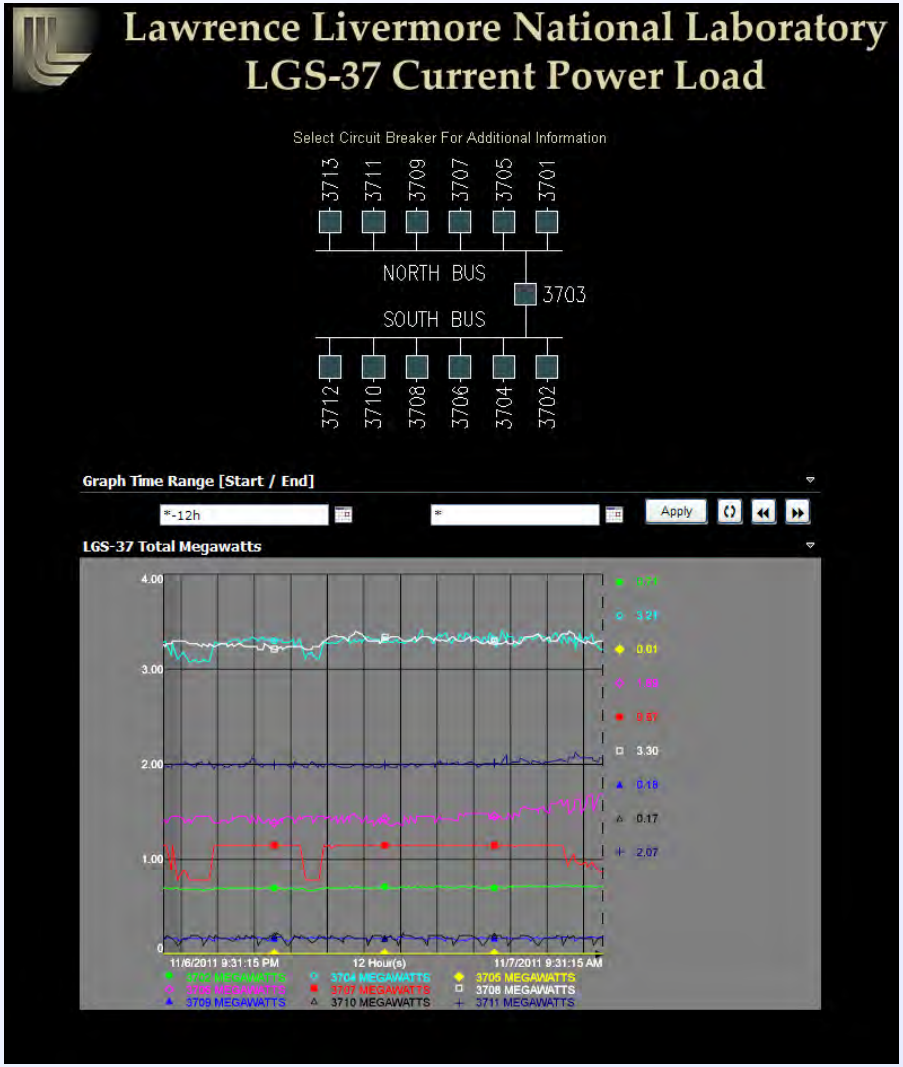
- Understanding entire load flow will be crucial for Exascale
  - Coordinate future data intensive runs with entire site operations
- Instantaneous electrical site information
  - MW
  - MVAR
  - Power Factor

HPC Power Management System - LLNL Electrical Distribution



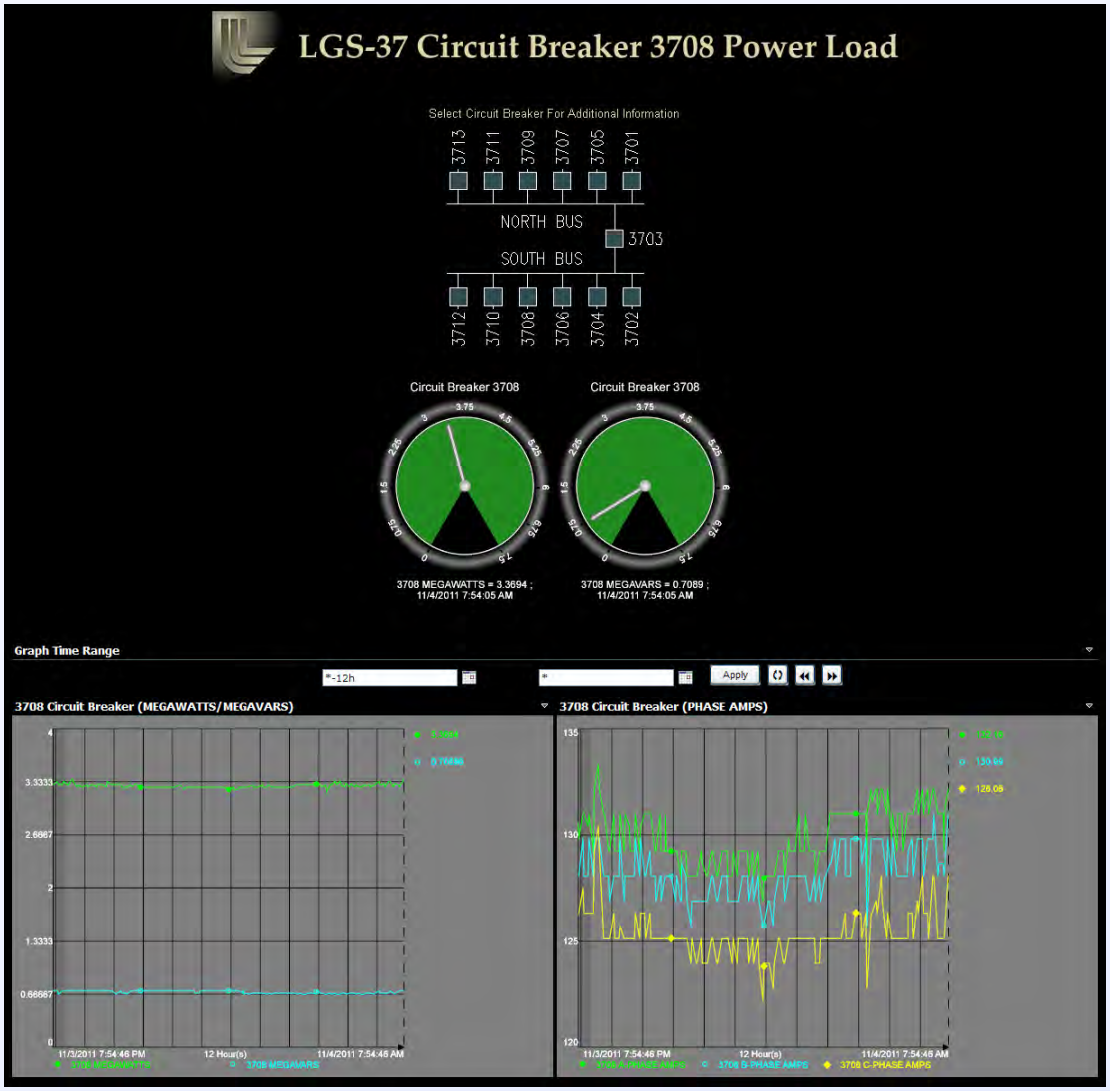
- 115kV Distribution
  - WAPA and PG&E Load Flow
- 13.8kV Distribution Load Flow at Load Grid Switchgear (LGS)
  - LGS-14
  - LGS-15
  - LGS-19
  - LGS-37
  - LGS-42
  - LGS-45
  - LGS-57

HPC Power Management System – LGS-37



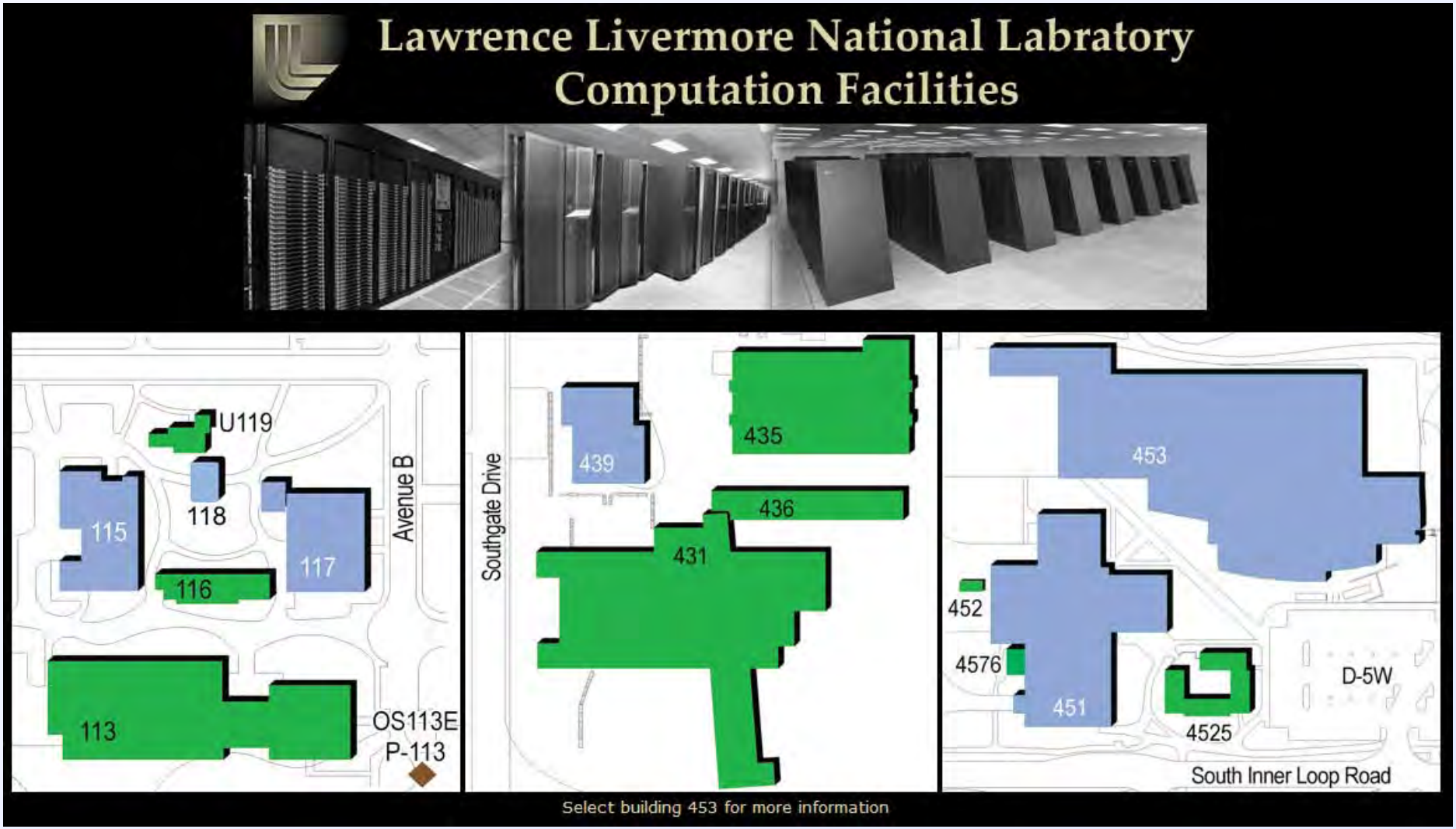
- LGS-37 Example of Load Flow
  - MWs for the entire switchgear and each feeder
- 12 hour window illustrated
  - Window can be modified for different scales

HPC Power Management System – LGS-37 Feeder 3708



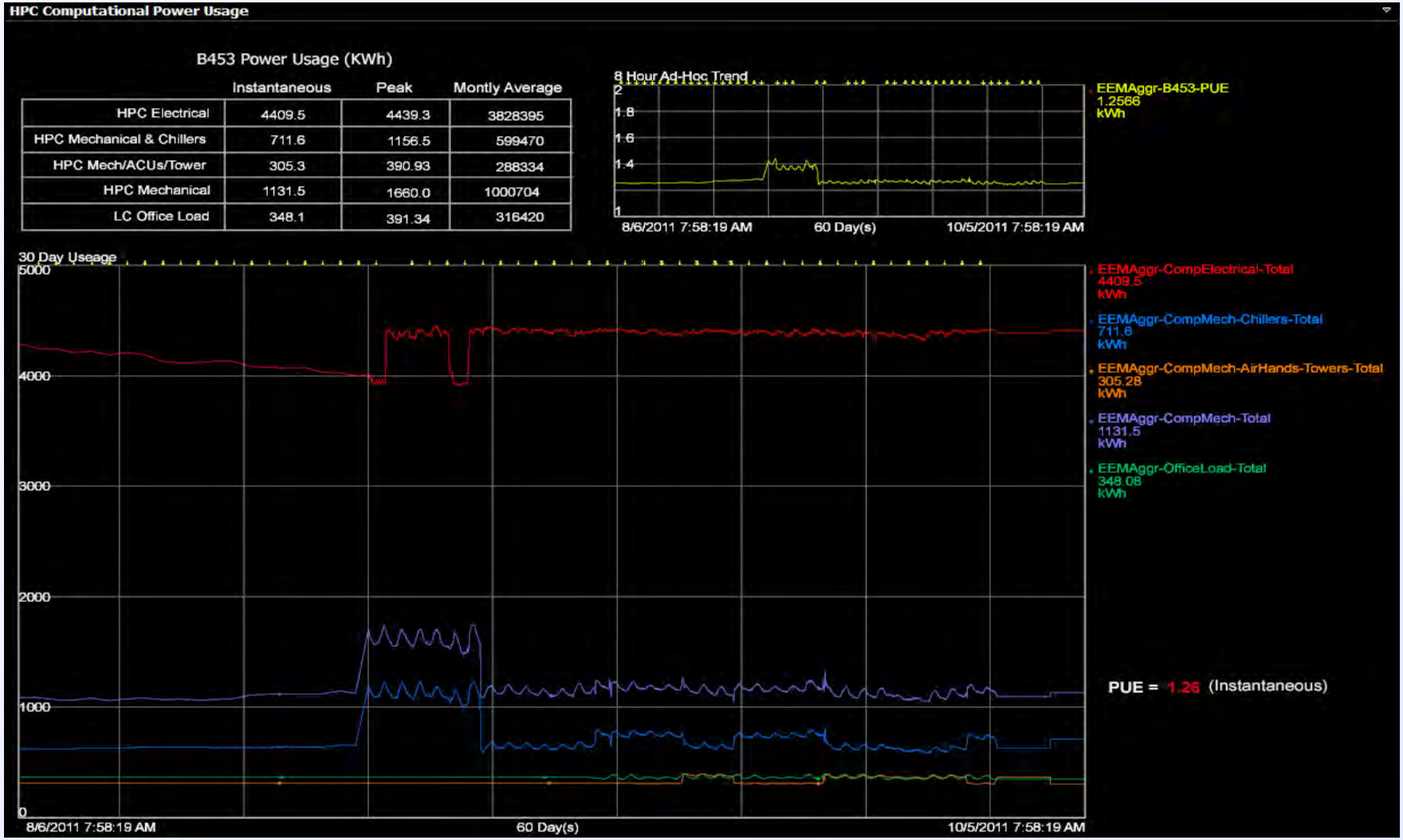
- LGS-37 Feeder 3708 Example of Load Flow
  - MW
  - MVAR
  - Phase Amps
- Trending historical data will provide the ability to determine system capabilities

HPC Power Management System - Livermore Computing

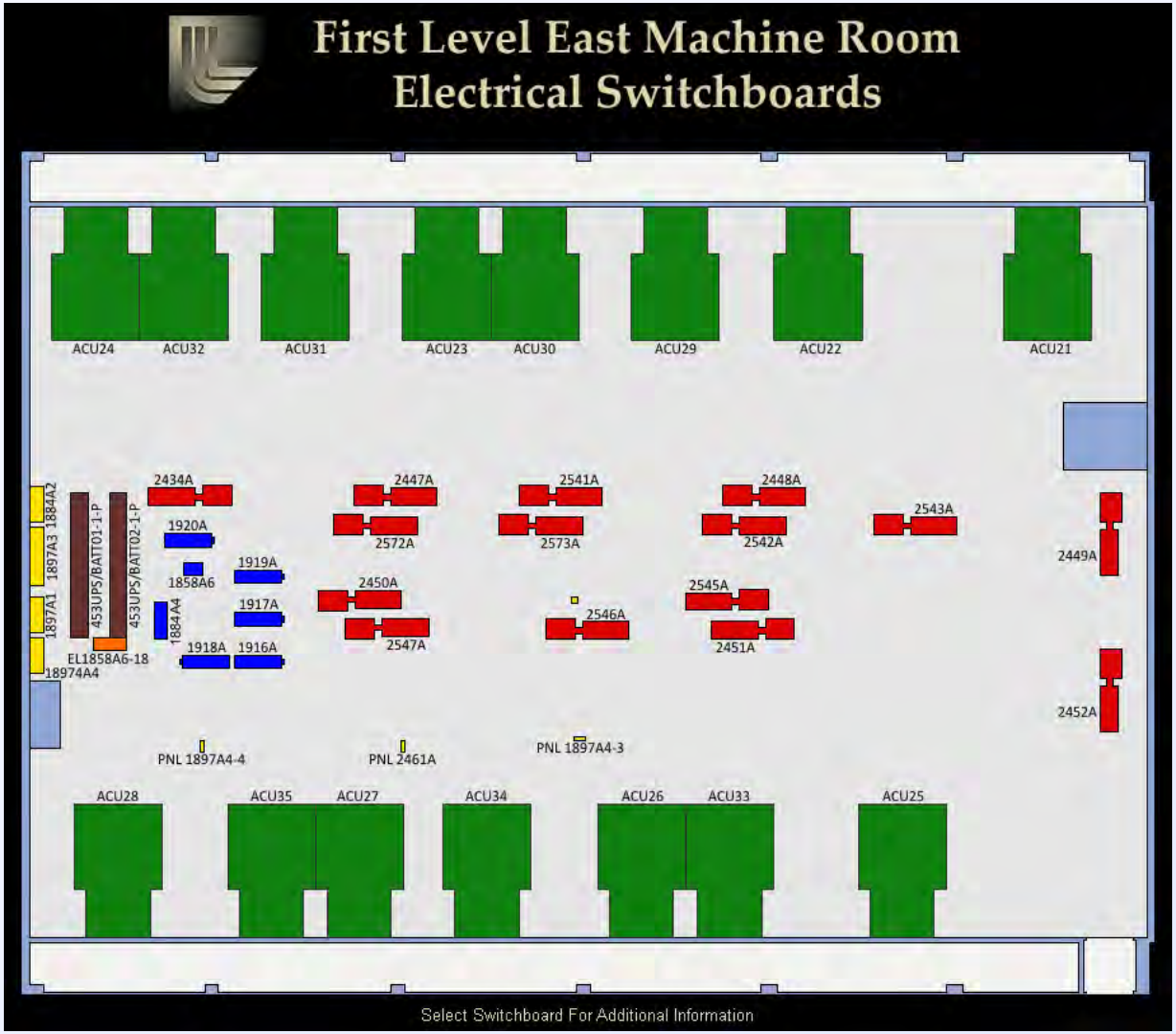


HPC Power Management System - B453 TSF Overview

HPC Power Management System - B453 TSF Load Graphs

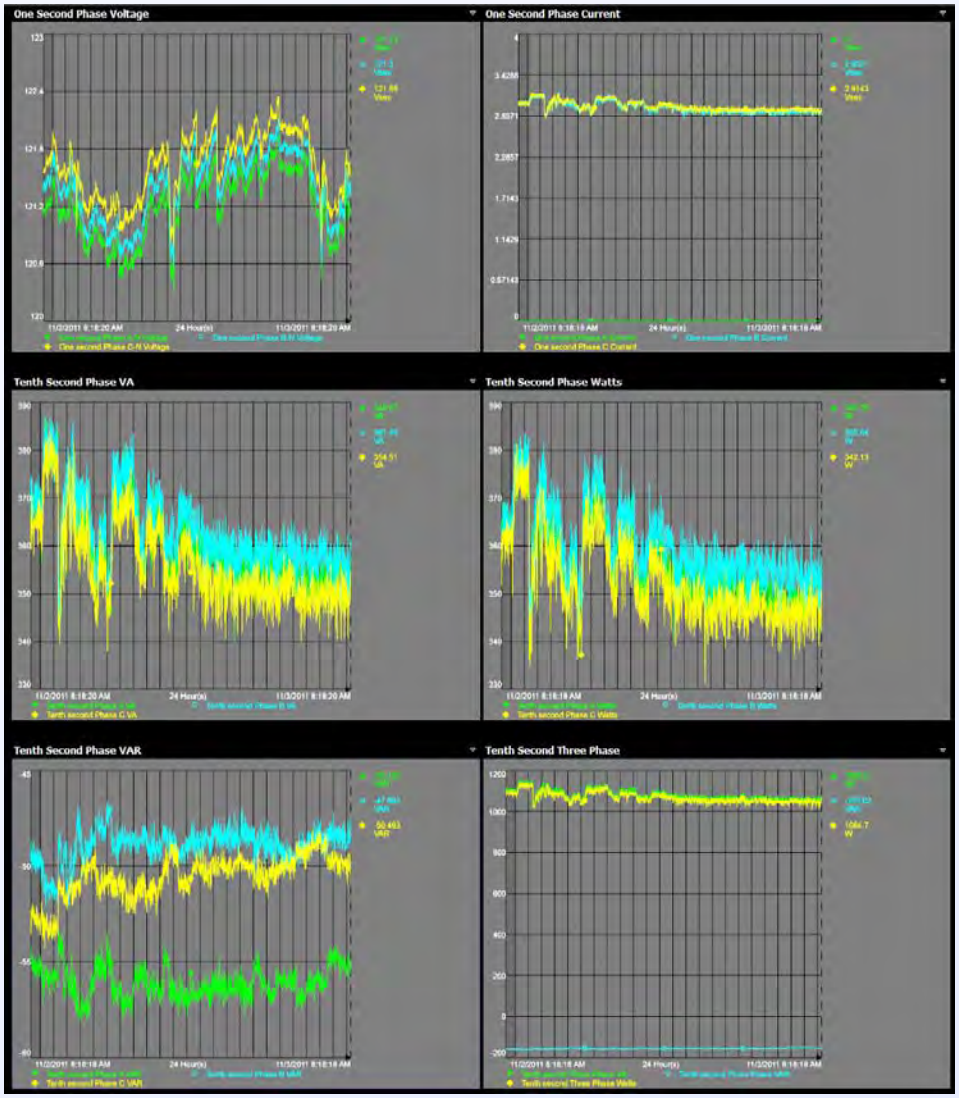


HPC Power Management System - B453 1st Level Machine Room



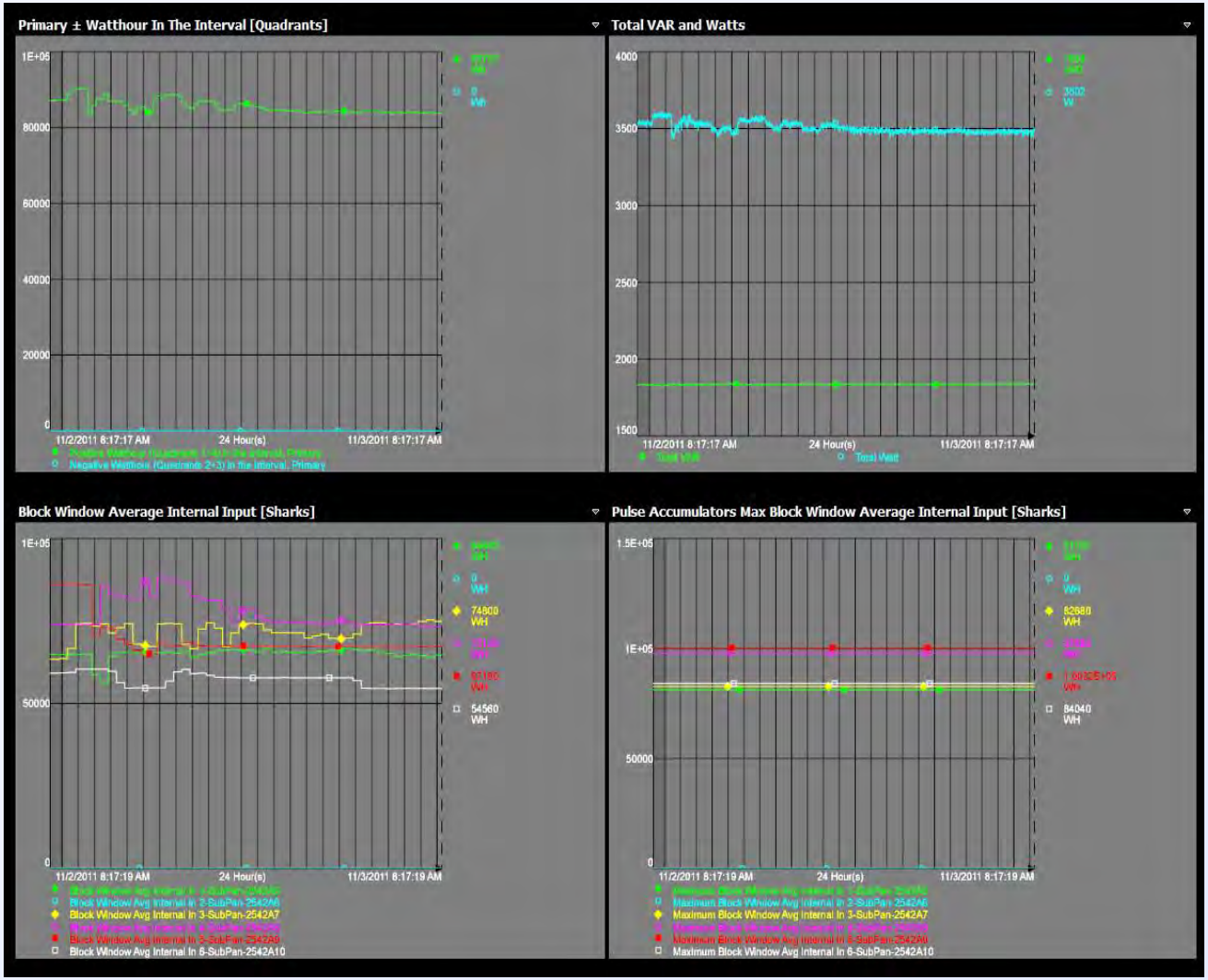
- Switchgear interface for computational load
- Select #2541A

HPC Power Management System - B453 Switchboard 2541A

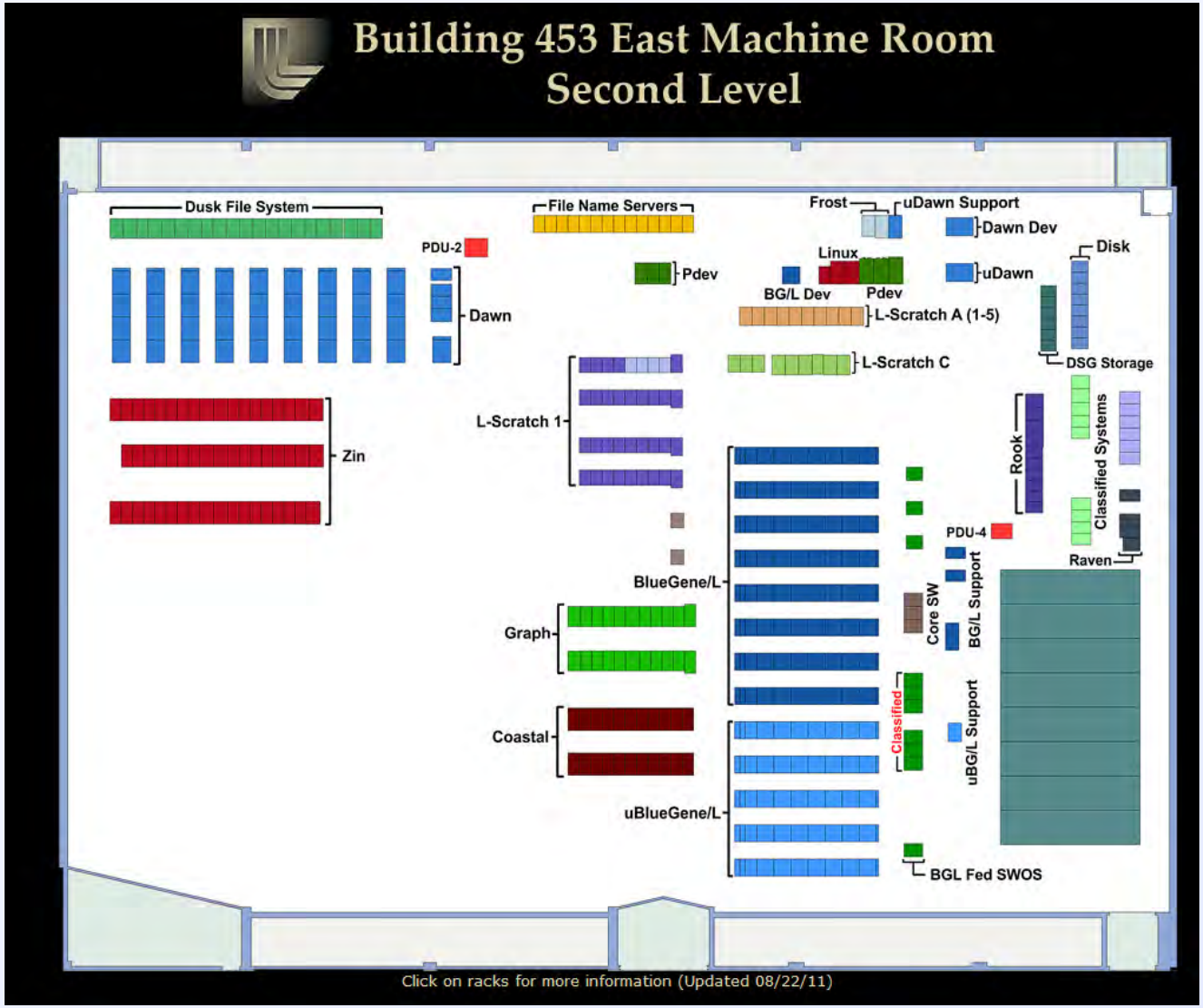


- Phase Data
  - Voltage
  - Current
  - VA
  - Watts
  - VAR
- Total Instantaneous Watts, VARs and VA

HPC Power Management System - B453 Switchboard 2541A



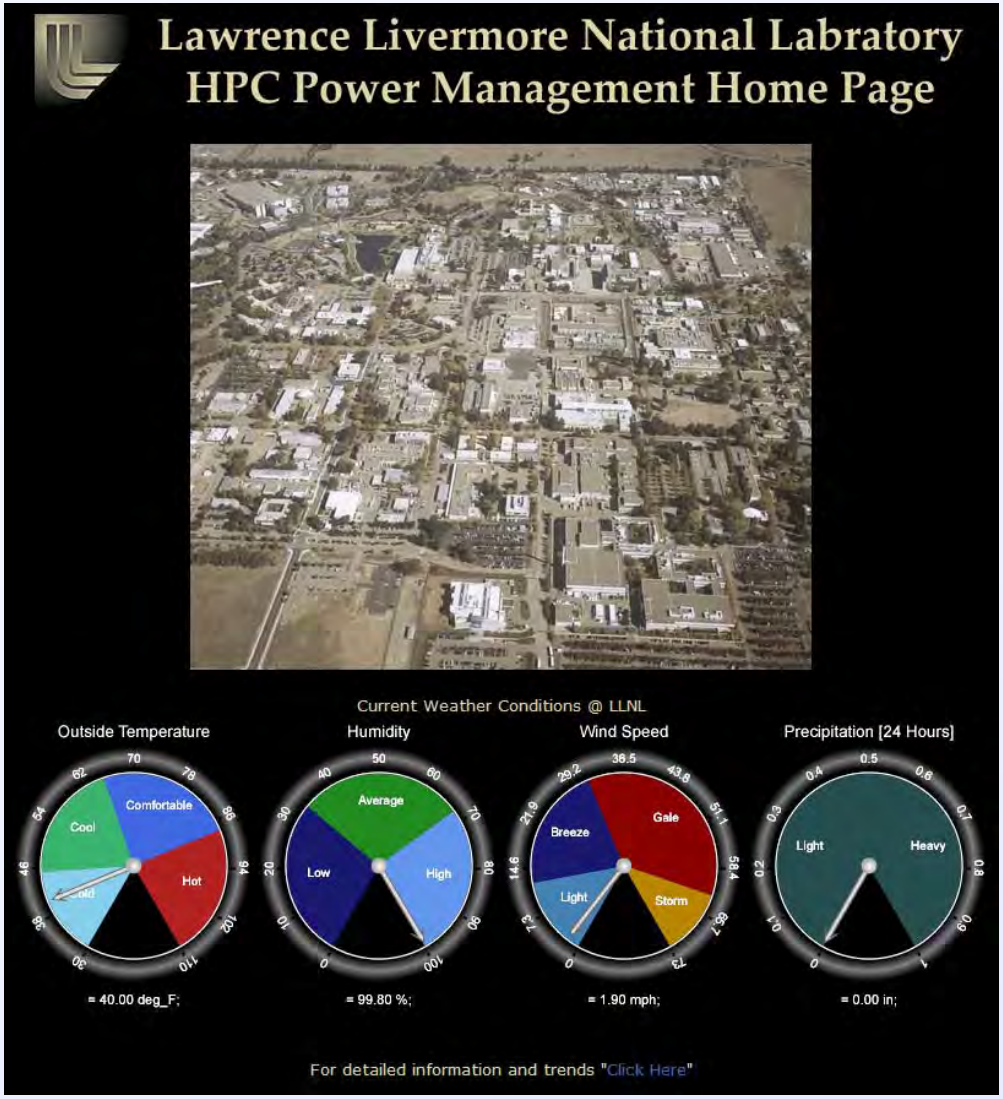
HPC Power Management System
B453 2nd Level East Machine Room



- Machine interface for computational load
- Select Dawn

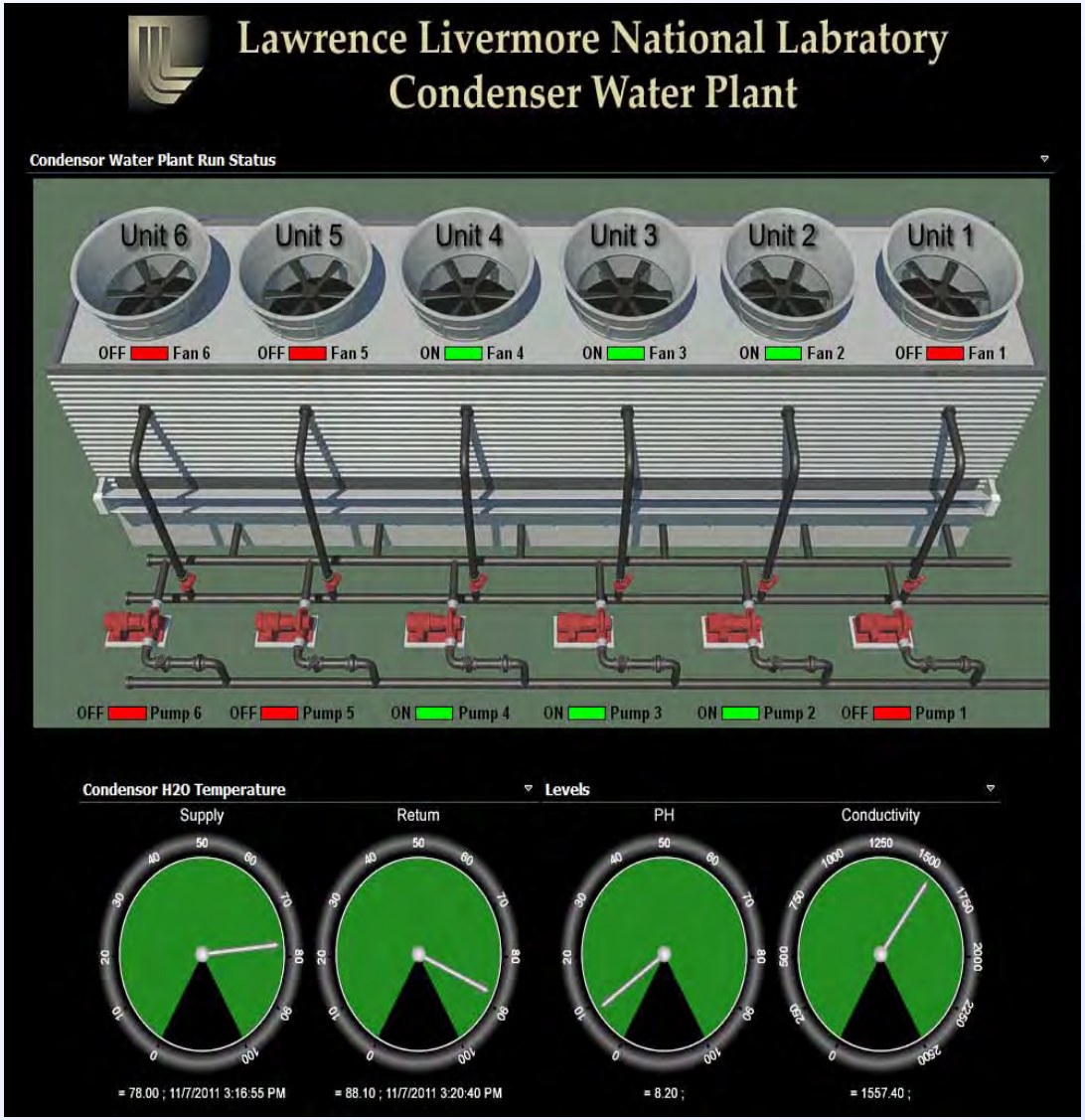
HPC Power Management System - B453 Dawn Platform

HPC Power Management System
LLNL Mechanical Distribution Home Page



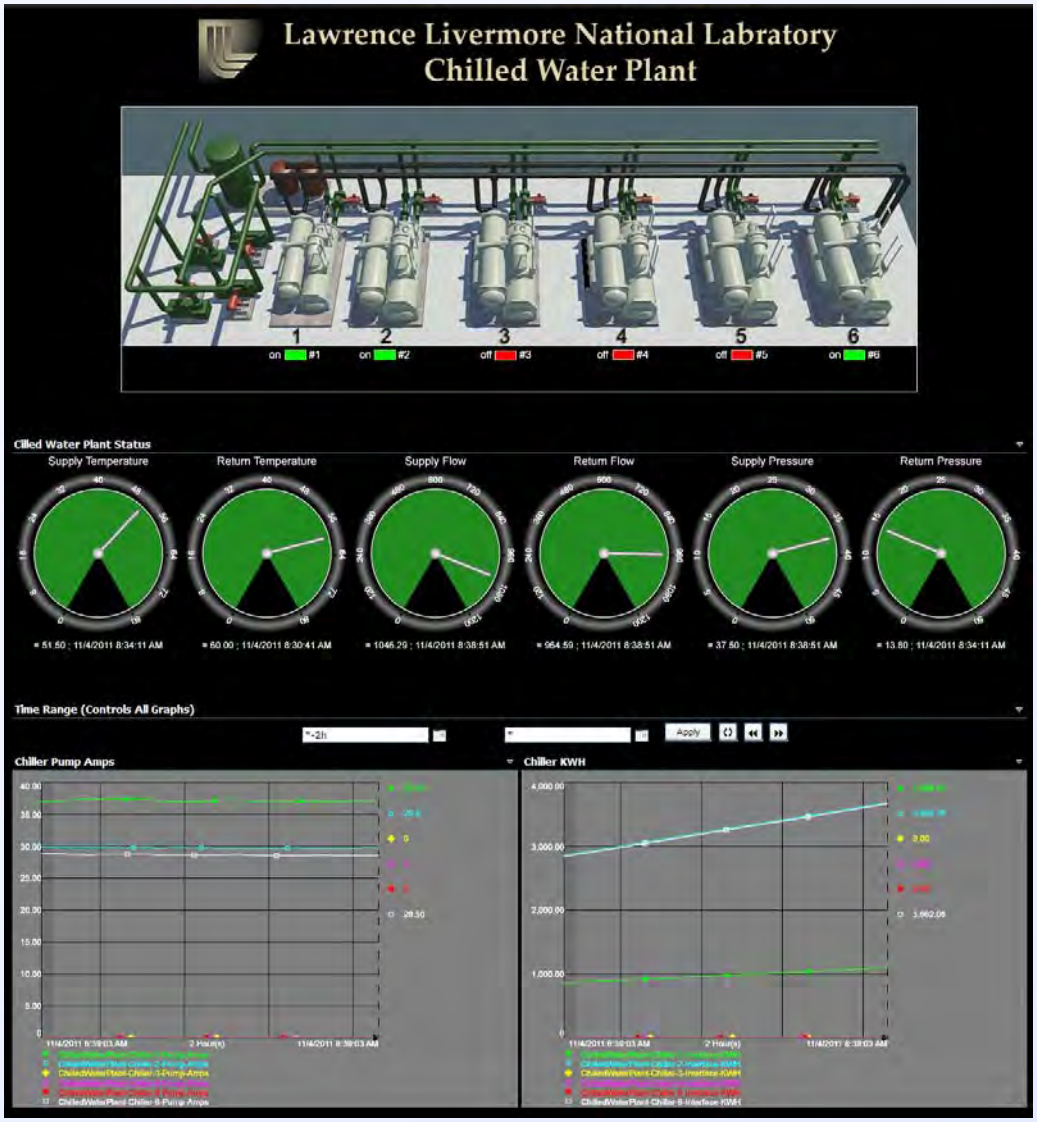
- Key to implement more energy efficient mechanical solutions through historical trending of environmental conditions
- Instantaneous Environmental Conditions
  - Outside Temperature
  - Humidity
  - Wind Speed
  - Precipitation

HPC Power Management System - Condenser Water Plant



- Equipment Status
- Environmental Conditions
  - Supply Temperature
  - Return Temperature
  - PH
  - Conductivity

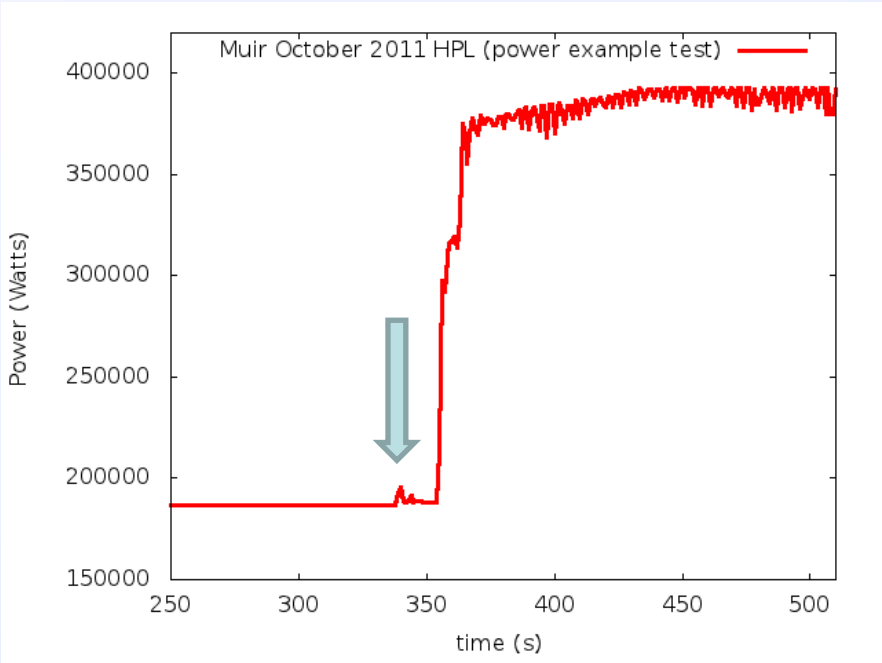
HPC Power Management System - Chilled Water Plant

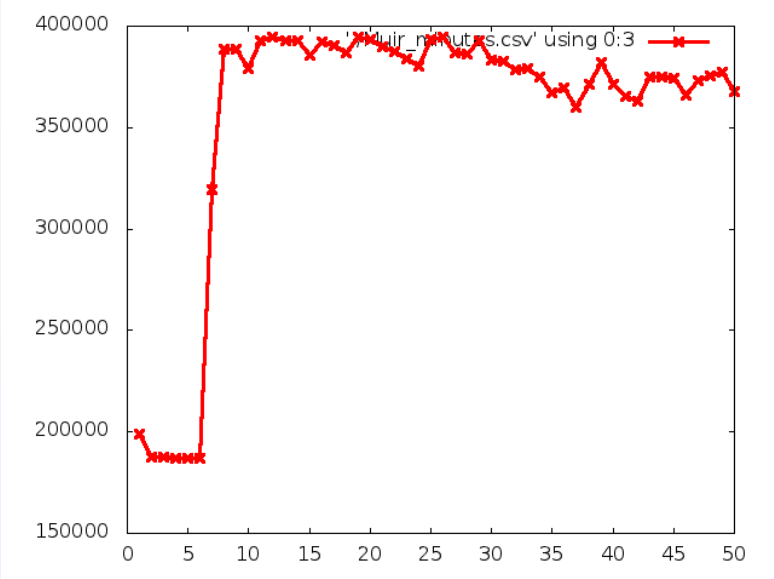


- Equipment Status
- Environmental Conditions
  - Supply Temperature
  - Return Temperature
  - Supply Flow
  - Return Flow
  - Supply Pressure
  - Return Pressure

Test Case - Analyzing Power of a HPC Run

- Power profile
  - 1 minute vs. 1 second power measurements
  - Provided case study information for the EEHPC System Metrics analysis





Path Forward

- Review the usefulness of the data streams
- Continue to evaluate the data through test cases
- Validate and improve the use of the dashboards

Questions

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Back-up Slides

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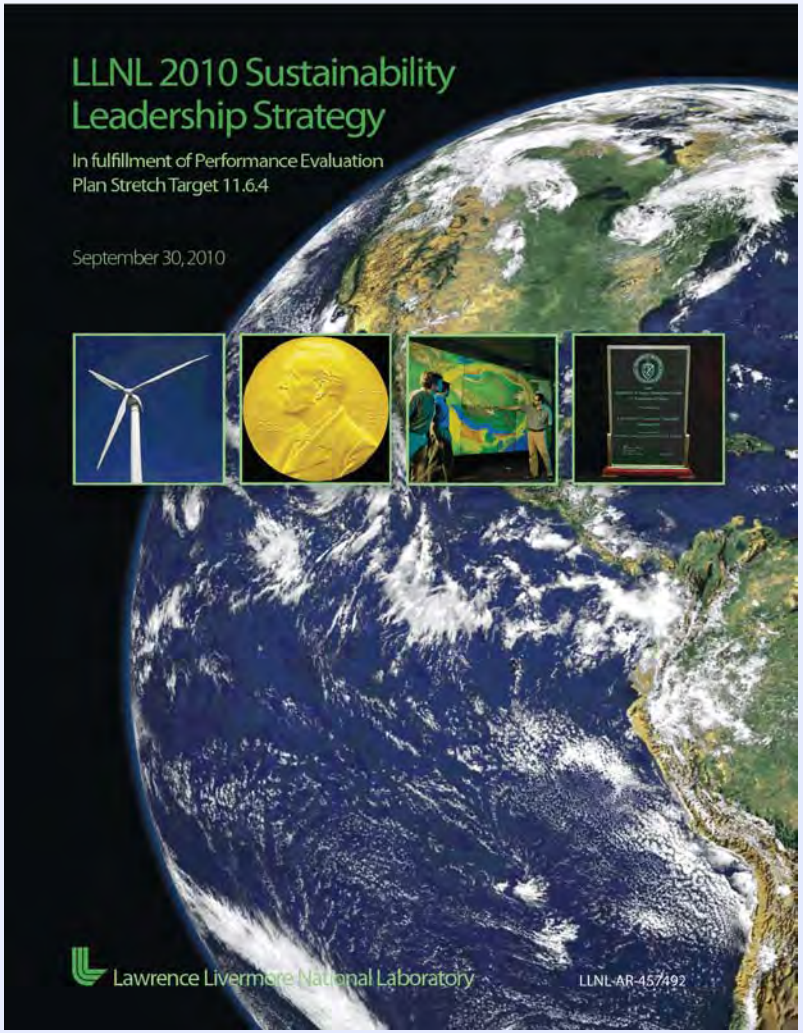
LLNL's Sustainability Leadership Strategy

- Developed a Strategic Plan
  - Sustainability is integral to the Laboratory's mission success
- Developed key points of integration
  - Facilities and infrastructure management
  - Mission and program engagement
  - Workforce involvement
  - External stakeholder relations.
- Creating synergy to foster sustainability and mission success
- Integrating a process for the entire organization

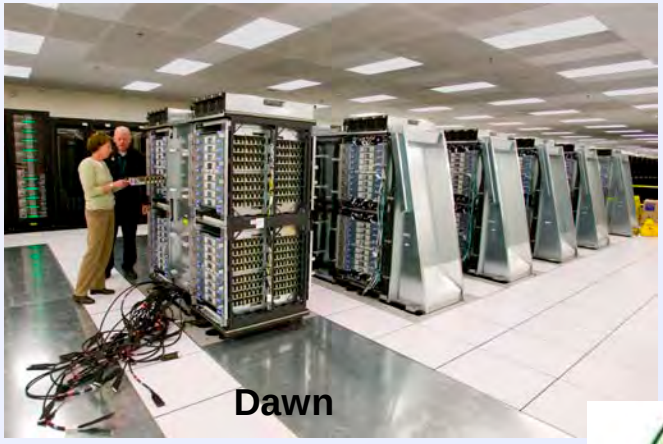
Sustainability Program Vision at LLNL

- Create governance process
  - Sustainability Advisory Board (SAB) and Sustainability Working Group (SWG)
- Leverage current successes
- Track metrics
- Communicate strategies and successes to employees
- Outreach programs to the community

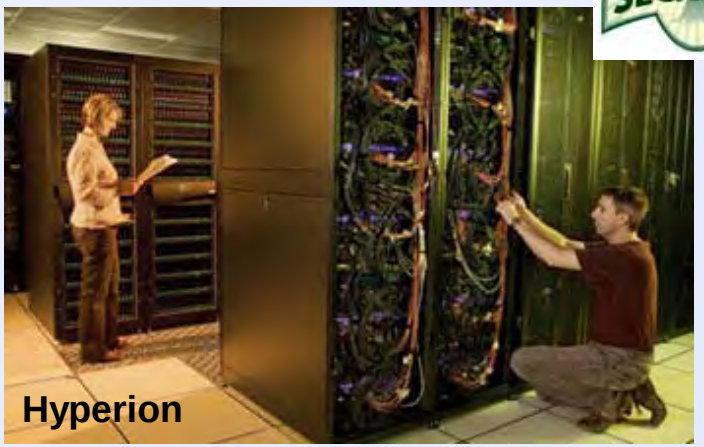


HPC's goal is to develop efficiencies across TSF complex "Turn Megawatts into PetaFLOPS and ExaFLOPS"

- Highlights:
  - Capitalized on flexible and scalable infrastructure of the facility and computational platforms
  - Performed extensive benchmarking
  - Prepared comprehensive computational fluid dynamics (CFD)
  - Improved operational efficiencies
    - DOE FEMP 2009 Energy Award
    - B-453 LEED Gold Certified Awarded on December 2009 and B-451 LEED Silver April 2011


Dawn

SEQUOIA


Hyperion