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

- Sustainable HPC Solutions
- Benchmarking
- Computation Fluid Dynamics (CFD)
- Leverage Existing HPC Capabilities
- LEED Certifications
- Power Management
- Innovative Electrical Distribution
- Liquid Cooling
- Free Cooling
- HPC Capability Gap Analysis
- HPC Platform Power Budgets

HPC Sustainability Master Plan

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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

Create an operational, event, and real-time data management infrastructure of all external and internal data sources

Data Sources
- Rack, Equipment, Metering, Building Management, Utility

Interfaces
- Hundreds of Real Time Data Streams

Manage
- Gather and Evaluate Large Amounts of Data

Analyze
- Convert Real Time Data

Notify
- Centralized Event Notification

Visualize
- View Data and Reports

Goal = Lower power utilization and achieve Exascale
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

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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
- 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
- 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 - B453 TSF Load Graphs
HPC Power Management System - B453 1st Level Machine Room

- Switchgear interface for computational load
- Select #2541A
Phase Data
- Voltage
- Current
- VA
- Watts
- VAR

Total Instantaneous Watts, VARs and VA
HPC Power Management System - B453 Switchboard 2541A
Machine interface for computational load
Select Dawn
# HPC Power Management System - B453 Dawn Platform

## Dawn Cluster Aggregate Watt Hour Pulse

### Time Range Setting

- **Start Date:** 10/5/2011 8:15:00 AM
- **End Date:** 11/4/2011 8:15:00 AM
- **Time Range:** 30 Day(s)

### Statistics

- **Minimum:** 109440 Wh
- **Average:** 206472 Wh
- **Maximum:** 430140 Wh
- **Total:** 1858248 Wh
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