Outline

EE HPC WG resources

Assessing your HPC center
  • Data Center Energy Practitioner
  • DC Pro Tools
  • Assessment protocol

Center of Expertise
  • Update projections
  • Energy Challenge
  • Measure and monitor

Other Resources
  • LBNL (e.g. Case studies, Demonstrations, Wireless test kit)
  • the Green Grid
  • ASHRAE
The EE HPC working group drives energy and computational performance improvement through collective actions.

Members collaborate in areas such as performance metrics, thermal conditions, best practices, etc. as determined by the group. This large market influences manufacturers.
Energy Efficient High Performance Computing Working Group

Purpose:

To drive implementation of energy conservation measures and energy efficient design in high performance computing (HPC).

Goals:

- Reduce expenditure and curb environmental impact through increased energy efficiency in HPC centers.
- Encourage the HPC community to lead in energy efficiency as they do in computing performance.
- Develop and disseminate best practices for maximizing energy efficiency in HPC facilities and systems.
- Serve as a forum for sharing of information (peer-to-peer exchange) and collective action.

Current Activities:

A bi-monthly EE HPC WG membership meeting reviews current team activities led by the Infrastructure, Systems and Conferences Sub-Groups. This meeting is held the second Tuesday of February, April, June, August, October and December. Minutes summarize team activities. For more information, see Meetings and Minutes.
The Data Center Energy Practitioner (DCEP) program qualifies individuals to perform data center assessments.

Developed by DOE in collaboration with Industry

Objective: Raise standards, repeatability, reach large numbers
The DCEP program is administered by Professional Training Organizations – selected through a competitive process.

PTOs license training and exam content from DOE, provide training, administer exams, and issue certificates.

DOE’s goal is to further privatize the program.

Assessing energy performance of your HPC center

- DC Pro assessment tools
  - Energy Profiling Tool V3 release by end of 2013 (V2 retiring)
    - On line
    - Downloadable
    - Provides estimate of PUE and recommendations for improvements
    - Use to track performance

- Air Management spreadsheet tool

- Electrical distribution spreadsheet tool
Saving Energy in Data Centers

Tools and resources are available to help data center owners and operators benchmark data center energy use, identify savings opportunities, and adopt energy efficient practices. The R&D Portfolio includes projects funded by DOE's Industrial Technologies Program (ITP) that can dramatically improve the energy efficiency of the nation's information technology and telecommunications (ICT) industries. On this site you will find information on the following:

- **R&D projects** that advance new ICT technologies in equipment and software, power supply, and cooling.
- **DC Pro Software Tool Suite** includes three tools to measure energy use and identify opportunities for savings in data centers.
- **Data Center Energy Practitioner program** qualifies professionals to evaluate energy use and efficiency opportunities in data centers.
- **Awareness training** on energy efficiency is provided by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
- **Case studies** reveal steps companies are taking to reduce data center operating costs, increase energy efficiency, and regain cooling infrastructure capacity.
- **Partnerships with the Federal Energy Management Program** and other government and industry organizations work to improve data center efficiency and help meet ITP's goals. Contact us for more information.
### 1.1 Data Center General Information

1.1.1 Data Center General Information

1.1.2 Energy Use Systems - Energy Management

1.1.3 Energy Use Systems - IT Equipment

1.1.4 Energy Use Systems - Environmental Conditions

1.1.5 Energy Use Systems - Air Management

1.1.6 Energy Use Systems - Cooling

1.1.7 Energy Use Systems - IT Equipment Power Chain

1.1.8 Energy Use Systems - Lighting

3. Supplied Energy (Optional)

4. Energy Use Distribution (Optional)

5. Results

---

**Power Usage Effectiveness (PUE)**

- **Annual Data Center Site Energy Use**
  - **Usage**
    - Equipment
    - Lights
    - Electric
    - Fans
    - Cooling
  - **Cost**
    - Dollars (Thousands)
    - Electricity: $2,500,000
    - Fuel: $0
    - Steam: $0
    - Chilled Water: $0

---

**Information**

Either click on one of the headers to go to those questions, or click on the 'Continue' button to be taken to the next set of questions.

By clicking on the 'Save and Continue' button, your profile will be saved and you will be able to exit the application without losing your data.

Items with a Light background contribute to the PUE calculation. Please make sure to answer all of them to get a more accurate calculation.

Clicking on a ? will give you more information about the selected row.

A * signifies a required field. This is required in order for the report to save, and only exists in the first section.

Is this a Federal Data Center?

Continue
General information

Profile Name: LBNL Test DC - California-Rod 6/19/13
Department: DOE
Organization: Lawrence Berkeley National Laboratory
Country: United States of America
Address: 5 94720
State/Region: California
County: Alameda
Climate Zone: 3C
Floor Area - Data Center Space: 4000 sq feet
Floor Area - Data Center Support Space: 600 sq feet
Floor Area - Non Data Center Space: 1000 sq feet
Total Facility Space: 5500 sq feet
Type of Data Center: Government
Data Center Tier (Uptime Institute definition): Tier I
Data Center Class: A1

Power Usage Effectiveness (PUE)

1.92

Annual Data Center Site Energy Use

Usage

- Equipment
- Lights
- Electric
- Fans
- Cooling

Cost

- Electricity: $2,500,000
- Fuel
- Steam
- Chilled Water
IT equipment questions

2.2 Energy Use Systems - IT Equipment

- Do you measure and track IT equipment/storage, server and network utilization? 
  - Yes
  - No

- Do you have a process for identifying abandoned/un-used servers and taking them offline? 
  - Yes
  - No

- What is the average age at which you replace your servers? 
  - 4 Years

- Are you using virtualization to consolidate your server workloads? 
  - Yes
  - No

- How extensive is your storage consolidation? 
  - 1% to 50%

- What storage tiers have you implemented? (mark all that apply)
  - More than one production tier
  - Archiving tier
  - Near-line storage

- Have you implemented storage optimization techniques such as thin provisioning, incremental snapshots, or de-duplication? 
  - Yes
  - No
### Environmental conditions

#### What is a typical (average) air temperature leaving the cooling coils (supply)?
- 55°F (13°C)

#### What is a typical (average) air temperature entering the cooling coils (return)?
- Select One
  - 115°F (46°C)
  - 80°F (27°C)
  - 70°F (21°C)

- Per ASHRAE 2011.

- Also include humidity sensors, if any are present.

- Are the cooling system temperature sensors measuring air conditions that are representative of the IT equipment intake air conditions?
  - Yes
  - No

- Does your air management scheme, your economizing system (if present), and your IT equipment allow your data center to operate near the ASHRAE max recommended IT equipment intake temperature, and occasionally between the ASHRAE max recommended and max allowable intake temperature (per your data center Class) during 100% mechanical cooling?
  - Yes
  - No

- Do you have active, working humidification controls?
  - Yes
  - No

- Do you have active, working dehumidification controls?
  - Yes
  - No

- Are the current cooling system high and/or low humidity limit setpoints for the IT intake air tighter than the ASHRAE Recommended limits for your data center Class?
  - Yes
  - No

- Do CRAC units have centralized (networked) or distributed controls?
  - Distributed

- Are CRACs fighting each other (for example, simultaneously humidifying and dehumidifying)?
  - Yes
  - No

- Do the cooling system controls allow you to apply correction factors (Slope and Offset) to the signals from the temperature and humidity sensors?
  - Yes
  - No

---

**Power Usage Effectiveness (PUE)**

1.92

**Annual Data Center Site Energy Use**

- **Usage**
  - Equipment
  - Lights
  - Electric
  - Fans
  - Cooling

- **Cost**
  - Dollars (Thousands)
  - Total: $2,500,000
    - Electricity: $2,000,000
    - Fuel: $10,000
    - Steam: $50,000
    - Chilled Water: $150,000

---

**Assessment Home**: LBNL Test DC - California Profile | Case: LBNL Test DC - California-Rod 6/19/13
Energy end use breakdown

Information
1.1 Data Center General Information
2.1 Energy Use Systems - Energy Management
2.2 Energy Use Systems - IT Equipment

2.3 Energy Use Systems - Environmental Conditions
2.4 Energy Use Systems - Air Management

2.5 Energy Use Systems - Cooling
2.6 Energy Use Systems - IT Equipment Power Chain
2.7 Energy Use Systems - Lighting

3. Supplied Energy (Optional)
4. Energy Use Distribution (Optional)

Use these screens to allocate the annual energy use for each meter identified in Step 3 across the Energy End-Use Breakout Categories. If you do not know what the allocations are for a given meter, it is OK to skip this screen or enter estimates.

All of the energy use for a given meter does not have to be allocated to the breakout categories. If the meter serves more than just the data center, it is OK to leave a portion of the energy in the Remainder column.

Once you have entered values for your breakouts, please click the Recalculate button to get your new Totals for each category.
Potential energy savings

This is your customized DC Pro Summary Report.

Note: The 'Annual Energy Use' and 'Potential Annual Energy Savings' tables will only have data if you entered data into Sections 3 and 4 (Supplied Energy and Energy Use Distribution).

However you can still generate the recommended actions by clicking 'Finish with the Profile' button and making sure the checkbox is checked.

### Annual Energy Use

<table>
<thead>
<tr>
<th></th>
<th>Total Amount ($)</th>
<th>$/yr</th>
<th>$/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>7963000.00</td>
<td>$2,560,000.06</td>
<td>$0.31</td>
</tr>
<tr>
<td>Fuel</td>
<td>0</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>Steam</td>
<td>0</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>Chilled Water</td>
<td>0</td>
<td>$0.00</td>
<td>$0.00</td>
</tr>
<tr>
<td>Totals</td>
<td>7963000.00</td>
<td>$2,560,000.06</td>
<td>$0.31</td>
</tr>
</tbody>
</table>

![Energy Comparison Chart]

![Power Usage Effectiveness (PUE)]

**Usage**

- Equipment
- Lights
- Electric
- Fans
- Cooling

**Cost**

- Electricity
- Fuel
- Steam
- Chilled Water

2,560,000
0
2,560,000
4,000
2,000
0
4,000

 Finish with the Profile | Print Profile | Archive Profile | Generate Recommended Tasks
Potential energy savings

Assessment Home: LBNL Test DC - California Profile | Case: LBNL Test DC - California-Rod 6/19/13

### Potential Annual Energy Savings

<table>
<thead>
<tr>
<th>Breakout Category</th>
<th>Current Energy Use</th>
<th>Potential Energy Use</th>
<th>Potential Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kWh/yr</td>
<td>kWh/yr</td>
<td>kWh/yr</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td></td>
<td>$</td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>IT Equipment</td>
<td>4150000</td>
<td>4150000</td>
<td>0</td>
</tr>
<tr>
<td>Data Center Lights</td>
<td>83000</td>
<td>91208.79</td>
<td>-8208.79</td>
</tr>
<tr>
<td>Electric Distribution Losses</td>
<td>332000</td>
<td>0</td>
<td>332000</td>
</tr>
<tr>
<td>Fans</td>
<td>913000</td>
<td>91208.79</td>
<td>821791.21</td>
</tr>
<tr>
<td>Cooling</td>
<td>2490000</td>
<td>228021.96</td>
<td>2261978.02</td>
</tr>
<tr>
<td>Totals</td>
<td>7563000</td>
<td>4560438.56</td>
<td>3487560.44</td>
</tr>
<tr>
<td>PUE</td>
<td>1.92</td>
<td>1.1</td>
<td></td>
</tr>
</tbody>
</table>

**Total Savings** - $1,056,344

- Equipment: $102,920.00
- Cooling: $254,755.28
- Data Center: $701,213.19

Power Usage Effectiveness (PUE) - 1.92

Annual Data Center Site Energy Use

**Usage**

<table>
<thead>
<tr>
<th>Component</th>
<th>Energy Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment</td>
<td>2500000</td>
</tr>
<tr>
<td>Lights</td>
<td>2500000</td>
</tr>
<tr>
<td>Electric</td>
<td>2500000</td>
</tr>
<tr>
<td>Fans</td>
<td>2500000</td>
</tr>
<tr>
<td>Cooling</td>
<td>2500000</td>
</tr>
<tr>
<td>Total</td>
<td>100000000</td>
</tr>
</tbody>
</table>

**Cost**

- Electricity: $2,500,000
- Fuel: $2,500,000
- Steam: $2,500,000
- Chilled Water: $2,500,000

Finish with the Profile | Print Profile | Archive Profile | Generate Recommended Tasks
“While information technology (IT) is improving the efficiency of government, energy use in data centers is growing at a significantly faster rate than any other building segment...”

A new Department of Energy-led CENTER of EXPERTISE will demonstrate national leadership in decreasing the energy use of data centers. The Center will partner with key influential public and private stakeholders. It will supply know-how, tools, best practices, analyses, and the introduction of technologies to assist Federal agencies with implementing policies and developing data center energy efficiency projects.

Initiatives

The Data Center Energy Challenge will require participating Federal agencies and other data center owners to establish an efficiency goal for their data centers...

MORE DETAILS

Resources

The Center’s activities will include establishing metrics, providing technical assistance to agencies piloting innovative measurement and management approaches...

MORE DETAILS
Center of Expertise – Energy Challenge

- Federal and Private industry Energy Challenge being developed
- Goal – lead to continual improvement
- Possible elements:
  - PUE – best, most improved
  - Utilization
  - Site generation
  - Benchmarking data base
- Your ideas are welcomed
Most Federal centers are not adequately metered

Many “enterprise” data centers are not adequately metered

Initiative will provide guidance and best practices in collaboration with industry groups

Your input is welcome
Center of Expertise

• Update data center projections originally presented in 2007 EPA report to Congress
Energy benchmarking reveals wide variation

High Level Metric: Power Utilization Effectiveness

(PUE) = Total Energy/IT Energy
End use breakdowns can be instructional

- HVAC Cooling: 23%
- HVAC Fans: 8%
- Lighting: 4%
- UPS: 8%
- Other: 11%
- Servers: 46%
Resources

Federal Programs

Federal Energy Management Program (FEMP)
- Assessment tools
- Data Center Energy Practitioner Program
- Data Center Challenge
- Industry Projections
- Measure and monitor
- Case studies

General Services Administration (GSA)

Environmental Protection Agency (EPA)
- Energy Star Buildings
- Energy Star Products

Federal Data Center Consolidation Initiative

Industry Organizations

The Green Grid

ASHRAE

7 X 24 Exchange

Uptime Institute

AFCOM

ITIC

Silicon Valley Leadership Group

Critical Facilities Roundtable
LBNL developed resources

Wireless Test Kit developed with goal of quickly capturing 75-80% of assessment data

GSA Green Proving Ground reported on the technology: http://www.gsa.gov/portal/content/140959
the Green Grid Maturity Model

The Data Center Maturity Model (DCMM) touches upon every aspect of the data center including power, cooling, compute, storage, and networking. In addition, the levels of the model outline current best practices and a 5-year roadmap for the industry. You and your colleagues can use the DCMM Assessment Tool to evaluate your data center and IT portfolio against the DCMM, get access to your personal DCMM equalizer, and obtain benchmarking results.*

*Time to complete assessment: 20-30 mins for summary level, 60 minutes for those unfamiliar with DCMM.

Downloads:
DCMM - Full Model
DCMM - All Individual Sections in Zip File
DCMM - Compute Section
DCMM - Cooling Section
DCMM - Management Section
DCMM - Network Section
DCMM - Other Facility Section
DCMM - Other IT Section
DCMM - Power (Standard E)
DCMM - Power (A0)
DCMM - Power Section
DCMM - Storage Section

Related Content:
- Climate Savers White Paper - Motherboard Power Efficiency Measurement Process
- Climate Savers White Paper - Power Management for Networking Devices
- Climate Savers White Paper - Power Management System Design Guide
Maturity Model promotes continual improvement
Green Grid Free Cooling Map

Map Courtesy of The Green Grid

http://cooling.thegreengrid.org/namerica/WEB_APP/calc_index.html
Wireless Sensor Networks
Findings, March 2012

“By most standards, this data center is an efficient facility. The fact that a wireless sensor network helped it significantly reduce its energy profile speaks volumes for the technology.”

Ron Jones
Facility Manager, Office of the Chief Information Officer, USDA

Wireless Sensors Help Decrease Data Center Energy Consumption

Data centers consume roughly two percent of all energy used in the United States, and their carbon footprint is projected to exceed that of the airline industry by 2020\(^1\). Nearly 50 percent of the facility energy typically goes to run IT loads, such as cooling and power conditioning. In
Federal Energy Management Program resources

- Best Practices Guide
- Benchmarking Guide
- Data Center Programming Guide
- Technology Case Study Bulletins
- Process Manuals
- Procurement Specifications
- Report Templates
- Quick-Start Guide
ASHRAE data center book series

3. Design Considerations for Datacom Equipment Centers (2009)
8. Particulate & Gaseous Contamination in Datacom Environments (2009)
ASHRAE guidelines apply to HPC systems

Provides common understanding between IT and facility staff.

Developed with IT manufacturers

Recommends temperature range up to 80.6°F with “allowable” much higher.

Six classes of equipment identified with wider allowable ranges to 45°C (113°F).

Provides wider humidity ranges

Provides more justification for operating above the recommended limits
In summary, the infrastructure tool kit includes resources to help improve energy efficiency in HPC centers.

Assessment tools and resources are available

Keep your eye on FEMP’s “Center of Expertise”

Existing guides and technical resources provide direction

There is always more that can be done

Questions?
Break