Company Logo

**Name of Facility**

Address of facility

**Data Center Energy Efficiency Assessment**

Assessor and affiliation

**Final/Draft Report**

date

Template instructions:

* Highlighted text should be replaced with data center’s actual information
* Ensure formatting, table of contents, and table/figure numbers are updated before submittal
* Results from the Data Center Profiler (DC Pro) Tools and/or the Data Center Master List of Energy Efficiency Actions can inform the recommended energy efficiency measures (EEMs)
  + <datacenters.lbl.gov/dcpro>
  + [datacenters.lbl.gov/resources/data-center-master-list-energy](https://datacenters.lbl.gov/resources/data-center-master-list-energy)

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This report uses preliminary information from vendor data and technical references. The report, by itself, is not intended as a basis for the engineering required to adopt any of the recommendations. Its intent is to inform the site of potential energy saving opportunities and very rough cost savings. The purpose of the recommendations and calculations is to determine whether measures warrant further investigation.

**Authors**

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Table of Contents

List of Abbreviations 4

1. Executive Summary 5

2. Facility Overview 6

3. Facility Energy Use 7

4. Cooling System Description 8

5. Electrical System Description 9

6. Benchmarking 10

7. Recommended Energy Efficiency Measures 14

# List of Abbreviations

**AC** – Alternating Current

**ASHRAE** – American Society of Heating, Refrigerating, and Air-Conditioning Engineers

**BTU/sf-y** – British Thermal Units per square foot per year

**CRAC** – Computer Room Air-Conditioner (with internal refrigerant compressor)

**CRAH** – Computer Room Air Handler (with chilled water coil)

**DC** – Direct Current

**EEM** – Energy Efficiency Measure

**ECM** – Electronically Commutated Motor

**°F** – degree(s) Fahrenheit

**GWh/yr** – GigaWatt Hours per year (millions of kWh/yr)

**HVAC** – Heating, Ventilating, and Air-Conditioning

**IT** – Information Technology

**kV** – kiloVolts (thousands of volts of electrical potential)

**kVA** - kiloVolt-Amperes of apparent power

**kW** – kiloWatts of real power

**kWh** – kiloWatt hour

**PDU** – Power Distribution Unit

**PUE** – Power Usage Effectiveness

**RCI** – Rack Cooling Index

**RTI** – Return Temperature Index

**RH** – Relative Humidity

**sf** – square foot

**TCO** – Total Cost of Ownership

**UPS** – Uninterruptible Power Supply

**V** – Volt(s)

**VFD** – Variable Frequency Drive (for operating motors at variable speed)

**W/cfm** – Watts (of electrical power input) per cubic feet per minute (of air flow)

**W/gpm** - Watts (of electrical power input) per gallon per minute (of water flow)W/sf – watts per square foot

# 1. Executive Summary

Summarize the basic information: who sponsored the energy assessment, purpose of the assessment, the contractor, site name and region it’s located. Also include a brief description of the site including limitations faced when conducting the energy assessment.

### Energy Efficiency Measures

Table 1 summarizes the energy efficiency measures (EEMs), potential savings, and estimated payback identified by the assessment. Further details for each EEM are contained in the report.

Based on an estimated energy cost of $xxxx/kWh, energy cost savings of approximately $xx,xxx/yr are possible through measures that have an average payback period of x.x years and represent approximately x% energy savings in overall data center energy use (relative to the Month/Year baseline).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Grouped Efficiency Measures (EEMs)** | **Estimated Installed Cost**  **($)** | **Estimated Yearly Energy Savings**  **(kWh)** | **Estimated Yearly Dollar Savings**  **($)** | **Estimated Simple Payback**  **(Years)** |
|  |  |  |  |  |
|  |  |  |  |  |
| **Total** | **$** |  | **$** | **Weighted average** |

Table 1 – Saving and Payback Summary

Summarize additional high-level findings and relevant updates since the assessment began

# 2. Facility Overview

Provide a high-level description of facility: embedded vs. standalone data center, date built, square footage, type of equipment present, general layout, and any other noteworthy characteristics. Include data center drawing or image for Figure 1.

**Figure 1– Data Center drawing or image pointing out relevant factors**

# 3. Facility Energy Use

The total electrical demand was on average approximately xxx kW with a yearly energy use of approximately x.x GWh/yr. Approximately xx% of this energy use was related to the IT equipment. The data center was [not] separately sub-metered. The assessment team estimated the data center energy use through a combination of [temporary sub-metering, equipment energy use estimates, spot measurements, and spreadsheet calculations].

### IT Equipment Loads

Summarized in Table 2 below is the IT equipment average power use in kW.

|  |  |  |  |
| --- | --- | --- | --- |
| **Data Center Areas** | **Area (sf)** | **IT equipment load (kW)** | **Power Density (W/sf)** |
|  |  |  |  |
|  |  |  |  |
| **Total** | **x sf** | **X kW** | **x W/sf** |

**Table 2 - IT Equipment Load**

### Data Center Energy End Use

The electrical end use breakdown associated with the data center space was determined and is shown in Table 3 and illustrated in Figure 2. This breakdown is based on Month/Year site visit data [add note if any adjustments made such as increased IT load]. It shows a baseline Power Usage Effectiveness (PUE, the ratio of total data center energy to IT input energy) of approximately x.x, prior to subsequent operational improvements described elsewhere in this report.

Replace end-use categories with data center’s actual breakdown:

|  |  |  |
| --- | --- | --- |
| **Data Center End Use** | **Average Load**  **(kW)** | **Percent of Data Center Total**  **(%)** |
| IT input |  |  |
| CRAH humidity control |  |  |
| CRAH fans |  |  |
| Cooling towers |  |  |
| Condenser water pumps |  |  |
| Chilled water pumps |  |  |
| Chillers |  |  |
| Lighting |  |  |
| UPS loss |  |  |
| Transformer and PDU loss |  |  |
| **Total** | **x,xxx kW** | **x%** |

**Table 3 – Summary of Data Center Electrical End Use**

**Figure 2 – Current Facility Performance (xx Total kW, Month/Year)**

Replace end-use categories with data center’s actual breakdown.

# 4. Cooling System Description

Provide detailed information on cooling system equipment and an overview of the observed readings and measurements such as the return air temperature, supply air temperature, set-points, relative humidity, chilled water, etc.

See Table 4 for ASHRAE’s recommended and allowable temperature and humidity ranges for IT inlet air. Also see EEMS x and x for recommendations related to the cooling system.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Class** | **Dry Bulb (°F)** | **Humidity Range** | **Maximum Dew Point (°F)** | **Maximum Elevation (ft)** | **Maximum Rate of Change**  **(°F/hr)** |
| **Recommended** | | | | | |
| A1 to A4 | 64.4 to 80.6 | 15.8°F DP  to 59**°**F DP and 60% RH | N/A | | |
| **Allowable** | | | | | |
| A1 | 59 to 89.6 | 10.4°F DP and 8% RH to 62.6°F DP and 80% RH | 62.6 | 10,000 | 9\*/36 |
| A2 | 50 to 95 | 10.4°F DP and 8% RH to 69.8°F DP and 80% RH | 69.8 | 10,000 | 9\*/36 |
| A3 | 41 to 104 | 10.4°F and 8% RH to 75.2°F DP and 85% RH | 75.2 | 10,000 | 9\*/36 |
| A4 | 41 to 113 | 10.4°F DP and 8% RH to 75.2°F DP and 90% RH | 75.2 | 10,000 | 9\*/36 |
| B | 41 to 95 | 8% to 82.4°F DP and 80% RH | 82.4 | 10,000 | N/A |
| C | 41 to 104 | 8% to 82.4%°F DP and 80% RH | 82.4 | 10,000 | N/A |
| \*More stringent rate of change for tape drives | | | ©ASHRAE 2015 Thermal Guidelines Table I-P Version (updated to errata issued July 25, 2016). Reformatted by LBNL | | |

**Table 4 – ASHRAE Recommended and Allowable Temperature and Humidity Ranges for IT Inlet Air**

# 5. Electrical System Description

### Utility Feed and General Description

Include basic information about how electricity is fed into the building and to the IT equipment.

**UPS System**

Count, topology, whether meters were present and working.

Table 5 shows the loading of the A and B UPS systems. Briefly explain where data in table came from.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Units** | **UPS-A** | **UPS-B** | **Combined** |
| UPS Input | kW | xx | xx | xx |
| UPS Output | kW | xx | xx | xx |
| Losses | kW | xx | xx | xx |
| Efficiency | % | xx | xx | xx |
| Load Factor | % | xx | xx | xx |

**Table 5 – UPS Electrical Measurements**

**Distribution Transformers/PDUs**

Provide a count and basic description of PDUs used to distribute electrical power to the IT equipment including kVA, meters present and data they provide, and whether all metering work properly.

### Lighting

Cover type, count, and any other relevant information.

# 6. Benchmarking

The purpose of this section is to summarize the metrics that were calculated as part of the assessment process and compare them to data from other facilities, where available.

### Overall Efficiency Metric

The PUE (total energy/IT energy) metric was calculated based on the Month/Year data and found to be x.x, which is better/worse than average. See Figure 3.

**Figure 3 – PUE (total energy/IT energy) Add line and text box to show your data center’s PUE and goal (if different than federal goal).**

### Air Management and Air Distribution Metrics

Representative IT equipment intake and exhaust temperatures were collected from a sample of IT equipment in the main data center. In addition, measurements of supply and return air temperatures were taken from the CRAC/CRAH units and perforated tiles. The goal was to establish an understanding of the air management performance, identify any issues such as hot spots or inadequate airflow. From these temperature measurements, the following indices were calculated:

#### Rack Cooling Index (RCI)

RCI is a dimensionless measure of how effectively the IT equipment is cooledwithin the desired intake temperature specification range (ASHRAE recommended values- see Table 4). It provides a measure of the conditions at the high (HI) end and at the low (LO) end of the specified temperature range. RCIHI=100% means that no intake temperature is above the maximum recommended, and RCILO=100% means that no intake temperature is below the minimum recommended. Using ASHRAE Class A1 temperature specification, “poor” conditions are ≤90% whereas “good” conditions are ≥96%.

#### Return Temperature Index (RTI)

The Return Temperature Index (RTI) is a dimensionless measure of the actual temperature differential in the equipment room as well as a measure of net by-pass or net re-circulated air in the data center. 100% is generally the target; >100% → recirculation air; <100% → by-pass air.

Table 6 summarizes and interprets metrics calculated from data taken Month/Year.

|  |  |  |  |
| --- | --- | --- | --- |
| **Metric Name** | **Unit** | **Value** | **Interpretation** |
| CRAC/CRAH/AHU Temperature Differential | F | x |  |
| Average Rack Temperature Rise | F | x |  |
| Return Temperature Index (RTI), measure of by-pass air and recirculation air | % | x |  |
| Rack Intake Temperatures (average) | F | x |  |
| Rack Cooling Index-High (RCIHI), measure of conformance with ASHRAE recommended intake temperature specification, high end of temperature range | % | x |  |
| Rack Cooling Index-Low (RCILO), measure of conformance with ASHRAE recommended intake temperature specification, low end of temperature range | % | x |  |
| Airflow Efficiency | W/cfm | x |  |
| Ratio of Total System/CRAH Flow to Total Rack Flow | None | x |  |
| Fan motor efficiency | % | x |  |
| Econ Utilization Factor | % | x |  |

**Table 6 – Air Management and Air Distribution Metrics**

### Cooling Plant Metrics

This section is relevant only if the data center is served by a cooling plant, if not delete this entire section and remember to align table and figure numbers. Table 7 summarizes the cooling plant metrics and Figure 4 compares the chiller plant wires to water efficiency and chiller rated efficiency at design to other data centers.

|  |  |  |  |
| --- | --- | --- | --- |
| **Metric Name** | **Unit** | **Value** | **Notes/Interpretation** |
| Chiller Plant Wire to Water Efficiency | kW/ton | x |  |
| Chiller Rated Efficiency at Design | kW/ton NPLV | x |  |
| Cooling Tower Design Efficiency | gpm/HP | x |  |
| Cooling Tower Design Approach | F | x |  |
| Condenser Approach Temperature | F | x |  |
| Chilled Water Pumping Efficiency | W/gpm | x |  |
| Condenser Water Pumping Efficiency | W/gpm | x |  |
| Pump and fan motor efficiency | % | x |  |
| Chiller Water-Side Econ Utilization Factor | % | x |  |

**Table 7 – Cooling Plant Metrics**

### 

**Figure 4 – Chilled water plant and chiller rated efficiency** Add line and text box to show your data center’s chiller plant efficiency and chiller rated efficiency

### Electrical Power Chain Metrics

The UPS system typically represents an efficiency opportunity in most data centers. In this data center, the UPS was on an average loaded to approximately xx% of its rated capacity. Since UPS efficiency is higher at higher load factors, loading to 50% total for 2N system or 40% for each module is good from an efficiency point of view. The efficiency at the units at xx% load factor is approximately xx% according to the manufacturer. This means that the UPS efficiency is better than average for all systems benchmarked at this load factor.

Table 8 summarizes the metrics that were collected. Figure 5 plots observed UPS efficiency. Figure 6 compares observed load factor to other data centers, and figure 7 shoed measures IT load density.

**Figure 5 – UPS Load Factor Add line and text box to show your data center’s UPS Load Factor**

**Figure 6 – Measured IT Load Density Add line and text box to show your data center’s Measured IT load density**

# 7. Recommended Energy Efficiency Measures

Below is a summary and detailed information on the energy efficiency measures (EEMs) recommended for further consideration. Guidance and language for best practice EEMs are outlined in the Data Center Master List of Energy Efficient Actions on the Center of Expertise for Energy Efficiency in Data Centers website: datacenters.lbl.gov/tools/8-data-center-master-list-efficiency-actions

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Grouped Efficiency Measures (EEMs)** | **Estimated Installed Cost**  **($)** | **Estimated Yearly Energy Savings**  **(kWh)** | **Estimated Yearly Dollar Savings**  **($)** | **Estimated Simple Payback**  **(Years)** |
|  |  |  |  |  |
|  |  |  |  |  |
| **Totals** | **$** |  | **$** | **Weighted average** |

**Table 8 – Saving and Payback Summary**

**EEM 1**

List EEM in more detail including why the measure is being recommended and helpful information for decision-making and implementation.

**EEM 2**

List EEM in more detail including why the measure is being recommended and helpful information for decision-making and implementation.

### Additional Measures or Strategies

Include additional guidance on overall strategies or things to consider going forward.

The pie charts below show the current data center energy breakdown (Figure 7) and the projected energy breakdown after the implementation of recommended measures (Figure 8). The estimate of the absolute number of xx average kW in Figure 8 assumes the IT load stays constant. As the IT load grows, the absolute total number will grow, and the absolute energy use of the electrical and cooling infrastructure will grow, but the PUE typically decreases since the infrastructure generally gets more efficient as the load increases.

**Figure 7 – Current Facility Performance (xx total kW as of Month/Year)**

**Figure 8 – Potential Facility Performance (xx total kW as of Month/Year)**

# Appendix A: DC Pro or PUE Estimator Inputs and Outputs

# Appendix B: Electrical Single Lines

# Appendix C: Electrical Power Measurements / Readings

# Appendix D: Mechanical Flow Diagram / P&IDs

# Appendix E: Mechanical System Measurements / Readings

# Appendix F: Other Field Data and Calculation Details

# Appendix G: Assessment instrumentation