Ex Ante Review Findings

Project Information

IOU	Pacific Gas and Electric
Application ID	NC0096793
Application Date	July 17, 2009 ?
Program Number	
Program Name	Customized New Construction Incentive Program
Program Year	2010
Project ID	99266
IOU Ex Ante Savings Date	August 24, 2010
ED Measure Group Name	CHI 12
IOU Measure Name	Datacenter, Phase II
End Use	HVAC for Data Processing
Date of Review	February 1, 2012
Type of Review	Desk Review
ED Recommendation	Conditional approval – Recommend revise savings estimates as recommended and conduct post-installation M&V

Measure Description

The data center at [redacted] is undergoing a series of retrofits and expansions, broken into three project phases. Each phase will be treated separately by the PG&E incentive program. This report addresses Phase II only.

Phase II will install 6 high density server racks, with a load of 16 kW per rack. Because of the rack equipment density, the baseline HVAC would use Air Management Scheme III, full hot/cold aisle containment. Two computer room air handlers (CRAHs) would condition the racks, and would be provided with chilled-water via the existing campus central chiller plant.

The proposed measure will replace the two baseline CRAH units with passive in-row, rear door heat exchangers. The rear door units will not rely upon self-contained fans, but instead will utilize the existing server fans. The heat exchangers will utilize the central chiller plant for cooling, but will be isolated from the central plant via a water-to-water heat exchanger (Coolant Distribution Unit, or CDU). The CDU utilizes a chilled-water booster pump on the campus side, and a circulation pump on the load side. The secondary loop provided by the CDU limits the racks' exposure to water in the event of a heat exchanger or hose failure, and controls the CHW supply temperature to eliminate coil water condensation.

Energy savings are expected to accrue due to the elimination of the CRAH circulation fans. The rear door units consume essentially no energy, and the pump energy associated with the CDU is small relative to the baseline CRAH fans.

Peak electrical savings are projected to be 10.1 kW, which is the difference between the CRAH fan energy consumption and the CDU pump energy consumption. As this is a data center, savings are expected to be constant 8760 hours/year, or 88,666 kWh/year. The incremental cost is estimated to be $36,784, and the incentive is $14,312.

Summary of Review

Baseline CRAH fan energy was calculated in accordance with "Energy Efficiency Baselines for Data Centers, October 2009", and appears correct. At the time of this review, the current baseline document is "Energy Efficiency Baselines for Data Centers, November 2011, effective January 2012". For air management schemes, the 2012 baseline adds a Scheme IV for very high density racks which requires devices such as rear door units, however this project is below the Scheme IV minimum power density. For Scheme III, assumptions are unchanged between the 2009 and 2012 baselines.

The measure analysis assumes that all CRAH fan energy can be eliminated, and that the increase in static pressure drop due to the rear door coil is negligible compared to the perforated grill that would otherwise exist. Otherwise the server fan energy could increase.

The pump energy calculations for the Coolant Distribution Unit underestimate the pump head of the secondary loop pump. The head of the rear door coils is taken into account, but the head of the CDU's water-to-water heat exchanger is neglected (22.5 psi at a rated flow of 63 gpm). This could decrease savings by as much as 1.6 kW, depending on the unit chosen.

The reduction in load due to fan energy savings will also produce energy savings in the central chiller plant. Depending on the annual load factor assumed for the chiller plant, savings could be on the order of 0.7 kW/ton (per 2012 baseline document), or approximately 2 kW. This effect was not taken into account.

The underestimation of CDU pump energy is roughly offset by the neglected chiller plant energy. Net energy savings are expected to be essentially the same as proposed.

The assumption that server fan energy will not change is important. Server fans are typically low-static and variable flow. Fan speed is controlled by the server to maintain the server temperature setpoint. If the rear door coil were to significantly reduce airflow, or resulted in a higher supply temperature than would otherwise be supplied by the baseline CRAHs, then server fan energy could increase. A rear door coil can also cause recirculation within the rack to increase (depending on rack/server characteristics), further raising the required fan speed. The pressure drop of the proposed rear door coil is 0.11" at 2400 cfm (corresponding to a 21°F rise through a 16 kW rack). The manufacturer claims this is similar to the pressure drop that would otherwise occur through the perforated exhaust grille.

A white paper by Dell estimates that server fan energy might increase in the range of 0-150 W/rack, depending on the rack components, inlet air temperature, and pressure drop of the rear door unit.[1] In the worst case, Dell predicts the increase in server fan energy for six racks would be approximately 900 Watts; or approximately 10% of the projected savings.

An in-house study by LBNL also looked at rear door units, and concluded that the rise in server CPU junction temperature was on the order of 1.8°F, which they concluded should not affect server fan speed as long as the inlet temperature remained in the 74°F-78°F range.[2]

In summary, while there are variances found in the energy consumption of fans, pumps and chillers, we expect the overall energy savings to be close to the proposed savings.

Note that the proposed savings are for Phase II, which is a pilot project for a much larger Phase III installation. Fan energy savings cannot be directly extrapolated from Phase II to Phase III. This is because Phase II requires two air handlers in the baseline to satisfy airflow and redundancy requirements, and as a result operates with an airflow TD of 11°F. As Phase III is much larger, the number of redundant units in the baseline will be significantly smaller, and the TD significantly higher. Baseline fan energy savings will therefore be significantly smaller. In addition, a few CRAHs may still be required to provide filtration and possibly dehumidification.

References

[1]"IT EQUIPMENT RESPONSE TO EXTERNAL PRESSURE", Dell 2009

http://i.dell.com/sites/content/business/solutions/whitepapers/zh/Documents/server-response-to-pressure_cn.pdf

[2]"Demonstration of Rack-Mounted Computer Equipment Cooling Solutions, Lawrence Berkeley National Laboratory, September 2010"

hightech.lbl.gov/documents/data_centers/chill-off2-final-rpt.pdf

Description	IOU Proposed Ex Ante Data	ED Recommended Changes
Project Baseline (Early Replacement, Normal Replacement, Capacity Expansion)	Capacity Expansion	Accept
Project Cost Basis (Full Cost, Incremental Cost)	Incremental Cost	Accept
RUL	Not applicable	

Description	IOU Proposed Ex Ante Data	ED Recommended Changes
EUL	Not stated	Provide EUL and report savings in terms of EUL
kWh Savings through RUL	Not applicable	
KW Savings through RUL per CPUC Definition	Not applicable	
Therms Savings through RUL	Not applicable	
kWh Savings through EUL	88,666 kWh/year	EUL not reported; adjust this figure by EUL. Measure pump energy is underestimated, and chiller plant energy savings are not considered. Savings should be revised to include these parameters.
KW Savings through EUL	10.1 kW	See above
Therms Savings through EUL	Not applicable	
Lifetime Savings kWh		
Lifetime Savings KW	10.1 kW	See above
Lifetime Savings Therms	Not applicable	
Secondary Impact kWh	Not calculated	Only fan energy savings and pump energy costs were calculated; credit should also be taken for chiller energy savings due to reduced fan heat.
Secondary Impact KW per CPUC Definition	Not calculated	See above
Secondary Impact Therms	Not applicable	
Interactive Effects kWh	Not applicable	

Description	IOU Proposed Ex Ante Data	ED Recommended Changes
Interactive Effects Therms	Not applicable	
Net-to-Gross Ratio		

Detailed Review Findings

Reviewed Parameter	Analysis
Project Baseline	IOU Proposal: Phase II load consists of 6 server racks at 16 kW per rack. The load density requires Data Center Air Management Scheme III (hot and cold aisles), consisting of two airhandlers providing (N+1) redundancy. The baseline fan energy is calculated using "Energy Efficiency Baselines for Data Centers, October 2009".
	ED Assessment: CRAH fan energy was calculated in accordance with 2009 Data Center Baseline document, but methodology is unchanged in 2012 Baseline document.
	ED Recommendation: Accept as proposed.
Project Cost Basis	IOU Proposal: The baseline cost is estimated based on RS Means 2010, 23.81.23.10.2520 for two CRAH units. Hot/cold aisle containment is estimated at $10,000. The proposed system cost is based on a quote from Coolcentric, and includes both labor and equipment
	ED Assessment: Baseline and proposed costs appear reasonable. Note that incentive payment is less than 50% of the incremental cost, and so it not limited by the cost basis.
	ED recommendation: Accept as proposed

Reviewed Parameter	Analysis
RUL	IOU Proposal: Not applicable
	ED Assessment:
	ED Recommendation:
EUL	IOU Proposal: Not defined
	ED Assessment:
	ED Recommendation: EUL should be stated.
Savings Assumptions	IOU Proposal: The baseline has more fan energy; the measure has more pump energy. Peak savings are projected to be 10.1 kW, constant for 8760 hours. Overall savings are 88,666 kWh/year
	ED Assessment: The measure pump energy costs are underestimated by as much as 1.6 kW. However, the central chiller plant energy savings are not accounted for, and may be on the order of 2 kW (per the 2012 Baseline document). Overall energy savings should be similar.
	ED Recommendation: Correct calculations for pump and chiller energy.

Reviewed Parameter	Analysis
Calculation Methods/Tool review	IOU Proposal: Spreadsheet calculations assuming constant energy usage all hours.
	ED Assessment: Savings are principally due to the elimination of CRAH fans. Savings are expected to be relatively independent of the weather, and relatively constant.
	ED Recommendation: Accept as proposed.
Pre- or Post-Installation M&V Plan	IOU Proposal: Primary loop supply temperature, flow and pump power. Secondary loop supply temperature, flow and pump power. Rack power demand
	ED Assessment: These parameters are sufficient to establish pump power, but do not assess whether the server fan energy has increased due to the airflow resistance imposed by the rear door coil.
	ED Recommendation: If data is available from within the server and from the manufacturer, also record server fan speed(s) and compare to manufacturer's stated speed for the given server load(s) and inlet temperature(s). Also gather maximum possible server fan energy consumption to establish the upper limit.
Net-to-Gross Review	IOU Proposal: Not provided
	ED Assessment: Not Reviewed

Reviewed Parameter	Analysis
	ED Recommendation: None