GLUMAC engineers for a sustainable future

Data Center Efficiency Analysis Study

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Presented by Glumac

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1. EXECUTIVE SUMMARY

Glumac was contracted by the Energy Trust of Oregon (ETO) to perform an analysis of current data center industry trends as they relate to baseline data center energy use in today's market. Energy use in data centers can be generally attributed to three primary types of end use: HVAC or climate conditioning, power distribution, and IT loads. Each of these areas has been addressed in this study.

To meet the project requirements, Glumac assembled a team of in-house staff and data center design partners. The project team, detailed in Appendix D of this report, consisted of IT and HVAC specialist from Glumac, Hoffman Construction, Logicalis, and Rod Legg Consulting. Logicalis and Rod Legg Consulting brought their experience in systems' architecture and data center computing requirements, while Glumac and Hoffman focused on HVAC and power distribution questions. The team was assembled based on the data center clients and technical knowledge of recent data center projects. The diverse experience was leveraged to develop a survey for data center operators to fill out and provide feedback regarding their facility. In addition, the project team also brought their own experiences with data center design and trends to the study, as a secondary source of baseline information. Finally, in case where baseline information was difficult to obtain, reliable third-party resources were consulted to supplement the team's research and create a more complete picture of current and possible future data center trends.

For the purpose of this study and the accompanying survey, the ETO data center baselines were initially divided into 5 sub-markets as a way to compare typical design strategies. However, after some initial investigation and analysis, it was determined by the project team that splitting the smallest (under 500 kW load) data centers in to two distinct sub-markets was needed to better baseline the systems. Therefore, a total of six (6) sub-markets were determined for the purpose of this project.

1. Small Private Data Centers (0-70 kW of load)
    - Small or medium sized business with an onsite data center. Typically no separate IT department, possibly one or two IT staff. Risk averse. Not super sophisticated. Little or no redundancy. Less than70kw IT load (20 tons cooling). Simplified local controls with little or no monitoring. Very cost conscious. Little or no HVAC knowledge.

2. Private Localized Data Centers (70 – 500 Kw).
    - Medium to large business with an onsite data center. Small IT staff and possibly a facility operator. Examples include: Lawyer office, retail business, etc. Low capital cost is still very important. Efficiency measures are driven by meeting energy code only.

3. Mid-Tier, Co-Location Data Centers (0.5-10MW of load);
    - Their business model is selling server rack space or managed server services to businesses which do not want to own and or maintain their own IT equipment. Deferred growth model. HVAC systems are modular to match facility leasing. Low capital cost. As they get larger, they become more interested in annual energy consumption rather than initial capital cost. Lower energy cost allows them to charge lower premiums (competitive rates) or gain higher operating margins. Tenant supplied equipment of all different styles and types.

4. Private, Mid-Tier Data Centers (0.5-10MW of load);
    - IT intensive business such as software developers, computer assisted design companies, health care, insurance companies, etc. Owner purchased equipment allows greater standardization and consideration for energy efficient IT equipment purchases. IT staff typically don't communicate well with facilities about energy. Energy consumption plays a greater role in IT equipment purchases and HVAC equipment design than smaller data

centers, but IT purchase still driven by cost/reliability primarily. Redundancy is included as required to match risk.

5. Enterprise, Co-Location Data Centers (10MW and up of load);
   - Discrete centers often built in modules to match leasing efforts. These operate similar to a number of private mid-tier centers housed in a single facility or site. Larger clients are more aware of energy considerations - attention to energy efficiency helps these facilities with marketing and makes them more competitive to provide greater returns. They often have little control over user supplied IT equipment. Full time IT and facilities staff are on site. These require super redundancy - their clients demand reliability.

6. Private, Enterprise Data Centers (10MW and up of load)
   - Very energy conscious – energy use affects the corporate bottom-line. Having an energy conscious public image is also important. Full time IT and facilities staff on site. Super redundancy required. Total control over IT equipment purchases and HVAC design. . Comfortable operating IT equipment under a wider range of environmental conditions than smaller operators. Examples of this type of data center are companies which offer cloud-based services across the internet.

Although end use percentages vary by data center type, and operational and design characteristics, a breakdown of typical data center energy use is shown below in Figure 1.

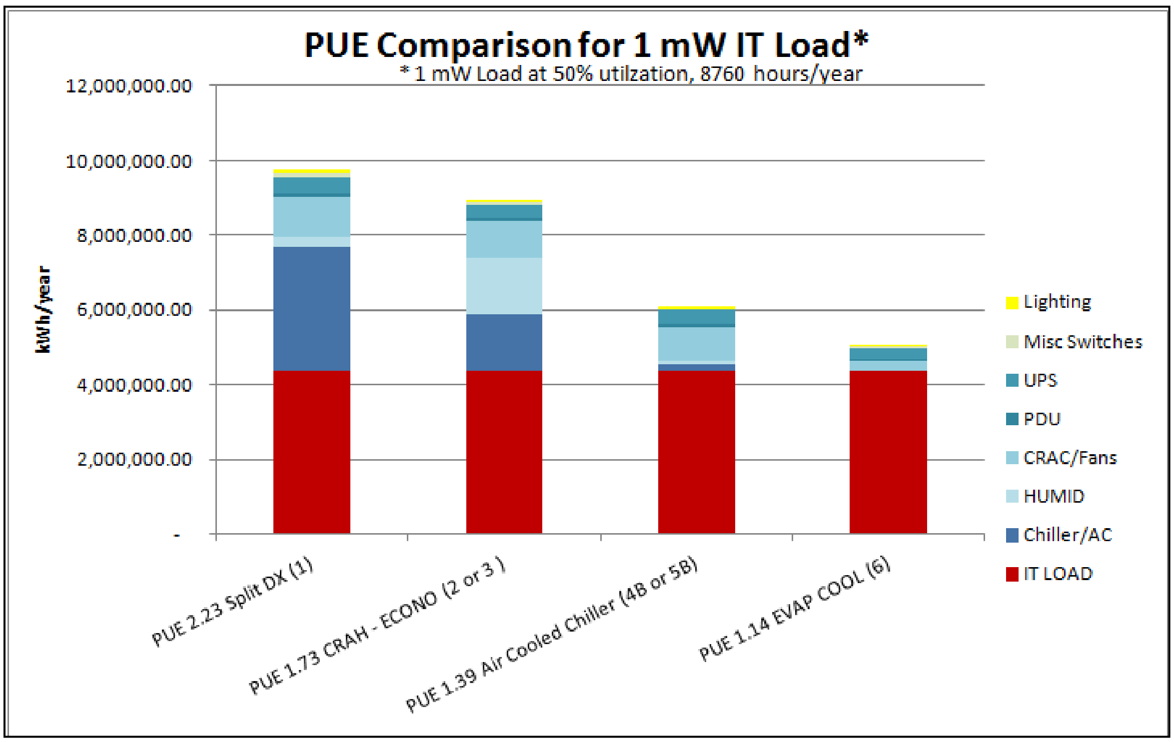


Figure 1-A: Typical Data Center Energy Use

The values for systems 1 – 5 are taken from modeled data from actual data center projects, in which the project team was involved in the design, or construction, which were then analyzed to determine end use values. Known values such as UPS and PDU efficiencies were used in the models, as well as manufacture efficiencies on lighting and climate systems and modeled with a constant 50% server load factor. System 6 values are estimated based on publically available data as part of the FaceBook project (http://www.thefacebookproject.com/). As Figure 1 shows, the end-use profile for data centers of different submarket types (and corresponding typical primary HVAC systems) varies widely. This variance points to different opportunities for energy savings and key areas of focus in design that should be kept in mind when looking at the type of data center.

Each of the submarkets identified above has certain, typical operating patterns and requirements which we believe to be a good starting point for classification of a data center baseline. As such, each of these sub-markets will be used to create a structured group of tables to identify what is baseline practice today for a given sub-market type. The final goal is to provide a “Map to Baseline,” for each market type. This “map” can provide a framework of current practices within the sub-market, yet also include allowances for variations based on factors such as local climate, typical business practices, computing needs, etc. Please see Section 5 for baseline tables.

Based upon the results of our research and analysis, the most typical HVAC systems in new data centers are shown in Table 1.

Table 1: HVAC Systems by Data Center Submarket Type

Data Center Submarket Type	**1** Small Private (0-70kW)	**2** Private, Localized (70-500kW)	**3** MidTier, Co-Lo (0.5-10MW)	**4** Private, Mid-Tier (0.5-10MW)	**5** Enterprise, Co-Lo (10MW+)	**6** Private, Enterprise (10MW+)
Most common HVAC System	CRAC or AHU, DX Air-Cooled	CRAC, DX, with Condenser Water	CRAC, DX, with Condenser Water	CRAH or AHU, (a) Water Economizer or (b) Air Economizer	CRAH or AHU, (a) Water Economizer or (b) Air Economizer	AHU with Evaporative Cooling + Supplemental

As Table 1 shows, small private data centers (Type 1) still commonly are designed with DX systems and should be baselined as such. However, because OESSC requirements limit the size and use of DX cooling, slightly larger, private localized, and mid tier co-location data centers (Types 2 and 3) typically utilize DX CRACs with water cooled condensers and econo coils to meet energy code requirements. Private mid-tier and enterprise co-location data centers (Types 3, 4) are typically built with either air-cooled or water-cooled chilled water systems. Finally, the largest, enterprise data centers (Type 6) are now often being built with evaporative cooling as the primary system as standard practice, with additional chilled water or DX cooling used to supplement if needed. Note that the boundaries between submarket types (size) are not hard and fast, and facilities which operate at the upper end of their submarket may use systems more like their larger counterparts. Engineering judgment should be used when choosing the appropriate baseline system for data centers with server loads near the size boundaries described.

In addition to defining the baseline (common practice) systems shown in Table 1, this study found:

1. Many data center facilities still have a gap between IT staff and Facilities (HVAC/Power) staff communication which results in a lack of comprehensive planning to achieve the best energy savings.
2. Although general conclusions can be drawn for typical or baseline design of data center types, there are enough mitigating factors (climate, location, business needs, etc) to make a simple, prescriptive baseline impossible. However, creating a common starting point based on sub-market, with a series of acceptable variations based on the unique constraints of a given facility should be possible, and is provided in the tables in Section 4.
3. Although few in number, the extraordinary energy use (and savings potential) of very large, enterprise data centers (Types 5 and 6) dictates their inclusion in the ETO data center baseline documentation.
4. For private, enterprise data centers (Type 6) evaporative cooling with climate-driven supplemental air-cooled chillers is standard practice.

5. Although similar in capacity, co-location, enterprise data centers (Type 5) cannot be baselined the same as private, enterprise data centers (Type 6) due to their need for more modular systems architecture and typically phased build business model. In practice, these data centers function closer to a series of mid-tier data centers (Type 3) housed at one site and have a baseline similar to a private mid-tier data center.
6. Due to the similar operational nature of Types 3 and 4, for these two types of data centers, the determining factor when choosing a realistic baseline should be climate and/or air quality concerns which may make the use of outdoor air economization undesirable.
7. VFDs are typically used for cooling tower fans and fluid cooler fans on new construction projects due to their known cost effectiveness.
8. Humidity control ranges are generally close to the ASHRAE T.C.9.9 recommendation of 20-60% RH. Wider tolerances (up to 80% RH) are sometimes seen, but depend on the climate and business requirements to implement safely.
9. Using W/sq-ft to measure server room density is not the preferred metric because aisle width and/or support space provision can distort this value. A better metric of server power density is W/rack. W/sq-ft should be used only in cases where rack layout is unknown.
10. When using full containment, the larger, most sophisticated data centers also implement a proper controls sequence that matches air-handler airflow to server fan airflow via pressure differential to ensure fan energy savings.
11. Although not the norm, it is becoming more common to design power systems to utilize 415V/3Ph distribution rather than 480V/3Ph. This allows the deletion of a 480V/3 to 208V/1 transformer as most IT equipment can operate on a 240V/1. This is an upfront cost savings due to eliminating one transformer, plus an energy savings received from removing the losses associated with transforming the voltage.

Please see subsequent sections for details on the survey findings, as well as conclusions based on both direct interviews and third party published data.

2. ASSUMPTIONS AND LIMITATIONS

The survey completed for this study yielded some interesting results, however in completing the work for the ETO, several challenges were faced which limited the survey's usefulness in understanding the baselines of various types of data centers as specified.

The challenges faced included:

1. Difficulty generating a survey that was both detailed enough to provide useful information per ETO requirements, yet simple enough for busy industry professionals to complete in a timely manner.
2. Low initial response rate to the survey by industry contacts.
3. Limited information by industry contact on certain survey questions that were outside of the respondents' direct area of expertise (IE: Facilities staff who knew HVAC had little knowledge of server power and efficiency requirements).
4. Rapidly changing technologies in IT equipment and its associated power and cooling requirements which make generalizing baseline IT equipment difficult. (i.e.: A moving target.)

As detailed in the next section of this report, the project team was able to find reasonable solutions to these challenges and complete the study through the use of additional sources of information, beyond just what was provided via survey response.

In addition, it is important to clarify that this survey was completely voluntary, and the level of expertise of the survey respondent unknown. For the purpose of this survey, it is assumed that respondents had adequate time and knowledge to accurately answer. Where possible, the project team was tasked to follow-up on survey responses, and to clarify survey responses which appeared to be incongruent with known design information on these data centers. When these differences occurred, the results of follow-up interviews were assumed to be more accurate than corresponding survey data, and were weighted more heavily when drawing conclusions about baseline systems.

As a final note: While obtaining responses proved difficult in this isolated survey, the survey developed for this study may also prove to be useful as a tool to use with incentive recipients to complete at design time and/or again after one year of operation to ensure data for future studies.

3. SUMMARY OF RESEARCH METHODS

To obtain useful information about current trends in data center energy use. Glumac utilized four (4) distinct methods of gathering information on data center power equipment, IT equipment, and HVAC systems and how they contribute to the overall energy use in data centers. The data gathering process began in July, 2012 with the development of an online survey in conjunction with input from ETO representatives, and finished in December 2012 with the supplemental information from third-party sources added to create a more complete picture of industry trends.

The four methods below were used:

1. An online survey using questionPro.com sent to 133 industry contacts.

   The Glumac project team, working with ETO staff from New Buildings, Existing Buildings, Production Efficiency and Planning departments, developed a logic-branched, online survey with up to 112 questions for IT professionals to complete. The survey was meant to be a detailed, yet accessible format that could be completed in approximately 20 minutes by selected respondents.

   The four major topics covered included: General Building/Facility Characteristics, HVAC Equipment (system types, efficiency, capacities, and operation), Electrical/Power Equipment (UPS, connected loads, redundancy, etc), and Server Info (rack configurations, density, load profiles, virtualization). The survey was design with primarily close-ended questions which had answers design to align with exiting ETO datacenter baseline assumptions if possible, plus additional 'new technology' answers available as well. In addition, there were areas of open-ended comments available to clarify or handle unique situations at a given facility.

   The full list of survey questions is included in Appendix A. Although the online survey was sent to a list of industry contacts with whom the project team had existing relationships, the initial response rate to the survey was very low (only 2/133 or 1.5%) and additional methods of obtaining answers needed to be implemented. Follow-up phone calls were made and data entry assistance was offered to clients to increase survey response rate.

2. Phone interviews with non-response recipients plus eleven additional industry contacts to supplement or clarify survey questions.

   To achieve this, Glumac team members conducted an intensive 2-day phone bank on October 24-25, 2012 making calls to clients and industry experts to complete more surveys in the most time effect way possible for the survey respondent. In some cases, survey respondents answered questions on the phone or via email exchange and Glumac staff performed the data entry.

   In other cases where Glumac or its sub-contractors had done the actual design work on the data center, clients simply gave approval for Glumac engineers and Commissioning agents to complete the survey on their behalf. All surveys completed with Glumac staff entering the data are marked as such in the Primary Contact field of the survey data and were input by designers or commissioning agents who had experience at the actual facility.

3. Internal knowledge of the Glumac project team to provide more facilities details.

In cases where survey data was incomplete or insufficient to provide useful information, project team members were tasked with researching recent past project to find representative data in areas such as cooling systems, containment strategies, power supply and distribution schemes, or other relevant areas of the survey. Their input and experience was used, in conjunction with other research methods to provide a backup or 'sanity check' of survey data, to then determine realistic baselines (shown in Section 4 of this report).

The project team who provided feedback and input included:

1. Data Center Architecture and Implementation: Bob Mobach, RCDD-NTS ITIL Senior IT Infrastructure Consultant & Data Center Designer

2. Data Center Architecture and Implementation: Rod Legg, IT Technical Support

3. Data Center Construction and Design: Bart Dickson, LEED AP, Mission Critical Facilities Director, HOFFMAN Construction

4. Data Center Electrical Design: Mike Steinmann, P.E., LEED AP Managing Principal, Glumac Mission Critical Group

5. Data Center Electrical Design: Larry Hengesh, P.E., LEED AP Associate Principal, Glumac Electrical Engineer

6. Data Center Mechanical Design: Brian Johnston, P.E. Mechanical Designer, Glumac Project Manager

7. Data Center Mechanical Design: Mike Nichols, P.E., LEED AP, Principal, Glumac Mechanical Engineer

8. Data Center General Facilities: Jean Ann Krupp, Director of Critical Facilities, Glumac Business Development

Details on the Project Team's data center experience can be found in Appendix D.

4. Third party information services:

As a final check to industry trends (current and future) which affect data center energy use, Glumac staff accessed published studies via the following information services:

Sources accessed and works cited are available in APPENDIX C: Third Party Resources Used.

The research schedule for this study is shown in APPENDIX G

4. FINDINGS

The online survey used for this study was implemented using QuestionPro.com; an industry leader in online survey software. The findings in this section were derived exclusively from the results of the online survey and generalize in Section 3.1. Data pivot tables were done by data center type for survey responses, and used to see general trends. These are shown in Appendix A.

The response rates of the online survey (after intensive phone call follow-up) is summarized in Figure 4-A. Figure 2 shows the relatively small data set generated by the online survey, and the need for supplemental data from phone interviews and third party publications.

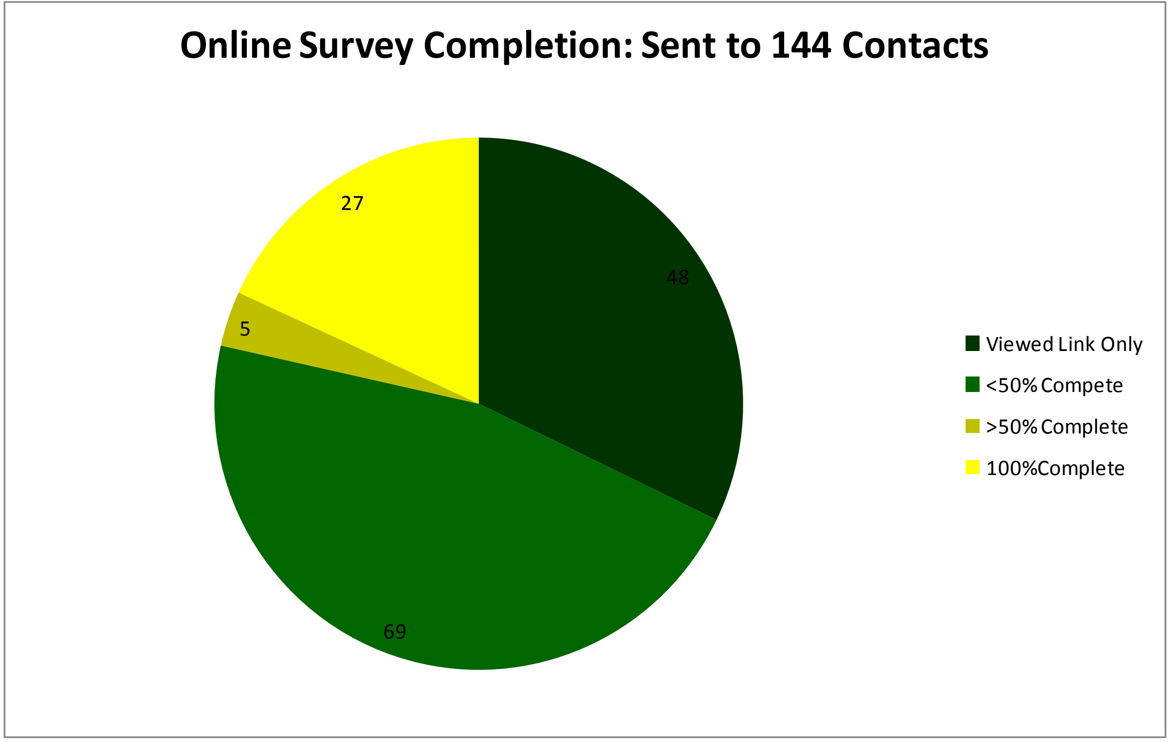


Figure 4-A: Online Survey Completion Rates

According to statistics from the online survey tool, the average time to complete a survey was 19 minutes. Both the <u>100% Complete</u> and the <u>Greater than 50% Complete</u> surveys were used in the analysis of this study. The total number of useable surveys in this study was 32 (a 16% participation rate based upon 133 original email requests sent, plus 11 individual requests for survey completion).

Breakdown of responses by data center type:

- 11 Type 5 (Private Enterprise)
- 2 Type 4 (Collocation Enterprise)
- 8 Type 2 (Private Mid-Tier) (one entered on a separate survey link)
- 10 Type 3 (Collocation Mid-Tier)
- 1 Type 1 (Small Private)

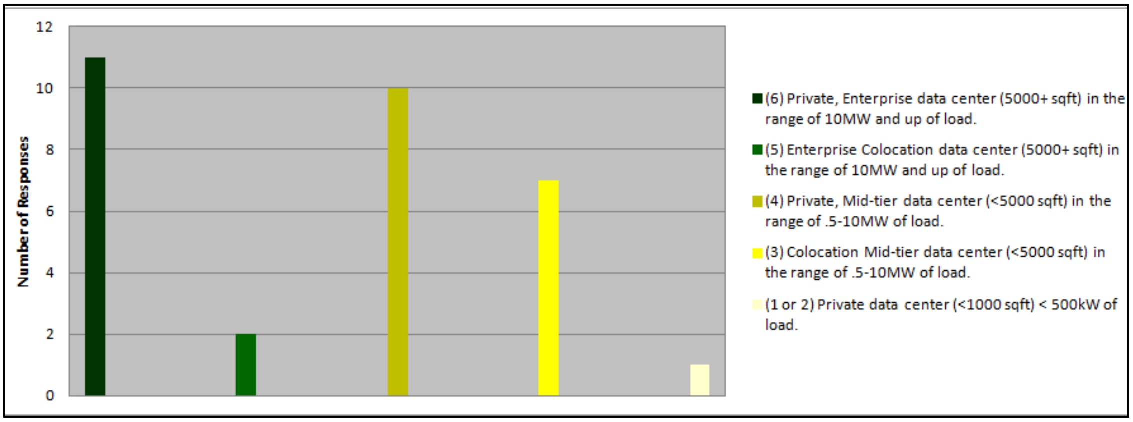


Figure 4-B: Survey Response, by Sub-Market Type

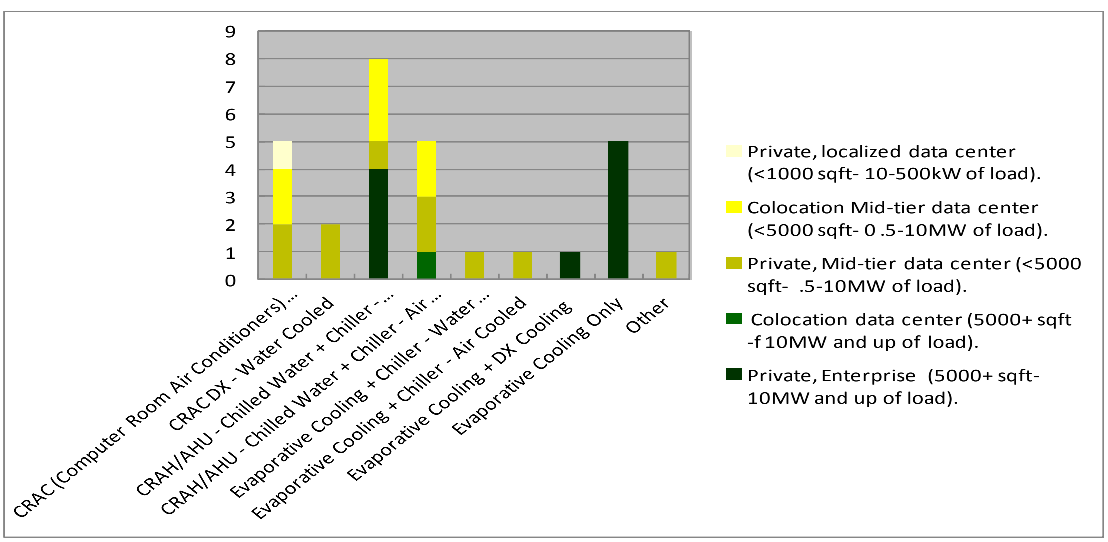
In addition to survey results, three Enterprise Co-Location Data Centers (Sub-market Type 5) were contacted and data from their facilities was used to increase the knowledge base for analysis to five facilities for Type 5 data centers. This phone interview data is not included in the survey results charts in Appendix A, because a complete survey with all 100 questions was not given on the interview. Instead, the comments and information obtained on the phone interviews was used to further understand typical facility operation and draw conclusions regarding systems and energy use in Type 5 facilities.

Finally, in the absence of survey data – specifically for small, private data centers, actual Glumac project data from design and commissioning teams, plus third party case studies and articles were used to identify trends and draw conclusions for sub-market type 1 and 2 data centers

4.1 GENERAL FINDINGS

The graphs below show all responses to the survey questions from total responses, broken out by data center type. The survey data was reviewed and used, along with phone interview data in the analysis and conclusions in this report. Actual response values are shown in Appendix A, however the key findings of the combined survey and interviews can be summarized as:

4.1.1 The sub-market type of the data center was a primary driver in primary cooling system type. Although certainly not definitive, sub-market type, along with the typical server loads associated with it, is a reasonable choice to initially look at baseline trends.



4-C: Cooling Type by Sub Market Type

4.1.2 The survey responses showed a gap in knowledge about server equipment by the facilities staff. It appears that the persons responsible for powering and cooling the data centers and IT staff are not sharing efficiency or energy saving potential with regards to IT equipment installed. The majority of the respondents chose “Don’t Know” on Server Power Supply Efficiency, CPU MIPS, and CPU Power Usage questions. This gap was further substantiated by third party sources such as SearchDataCenter.com and NextGov.com who conducted their own surveys regarding energy efficiency in data centers.

4.1.3 Data Centers in this survey were all from 1995 or later with no mechanical systems installed before 1998. They were equally divided between new, purpose-built and re-purposed buildings. In addition, all data centers surveyed showed at least a partial server refresh within the past 4 years. In other words, IT equipment tends to be updated much more frequently than HVAC equipment.

4.1.4 Small facilities with DX systems did not report better than code minimum efficiencies, however, larger facilities with chilled water systems reported better than code efficiencies. We believe this to be due to the first cost issue, as well as the lack of DX equipment choices that are better than current energy codes.

4.1.5 All facilities with hydronic systems reported VSD use on the fans on heat rejection components.

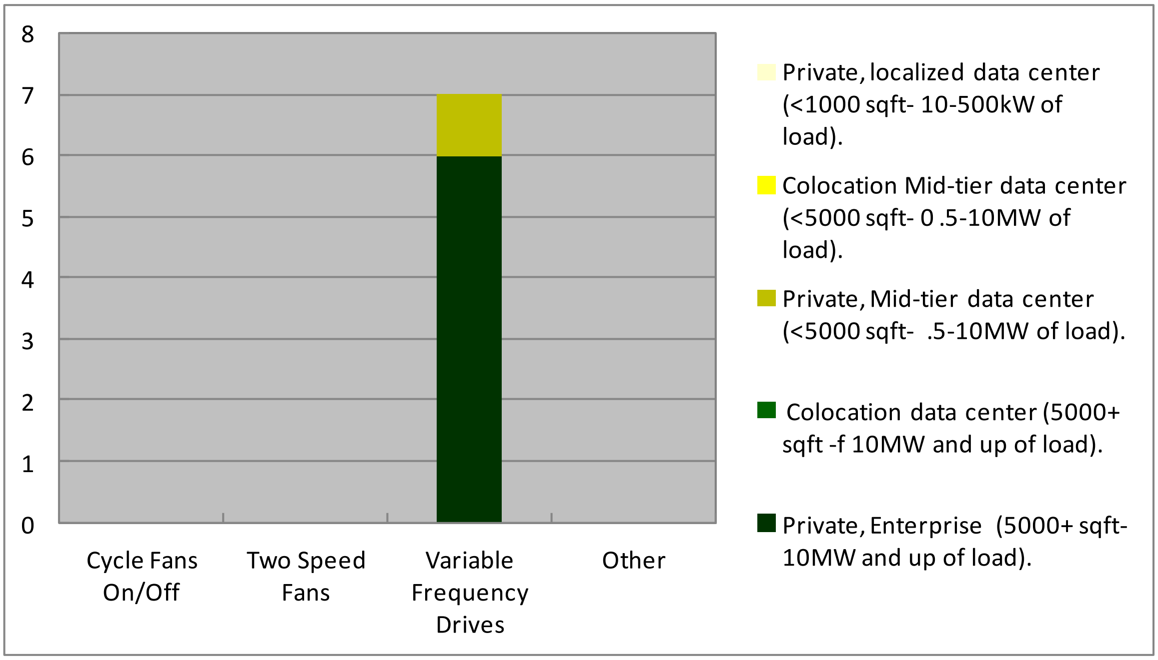


Figure 4-D: Fan Control: Cooling Tower, Fluid Cooler or Evaporator

4.1.6 All but one Enterprise data center reported variable volume supply air, mid and smaller data centers reported mostly constant volume.

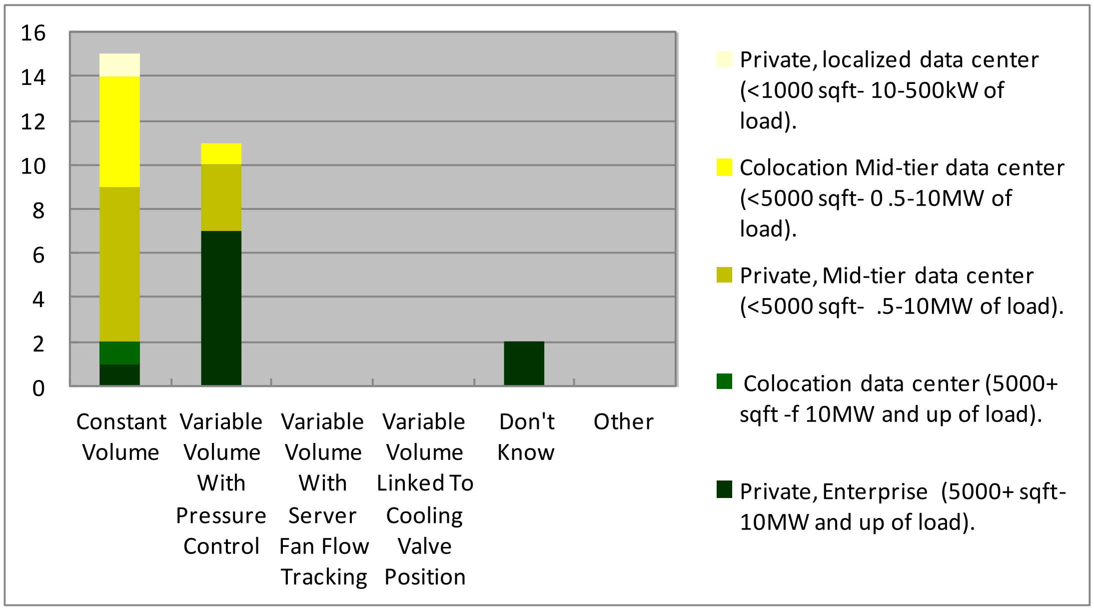


Figure 4-E: Data Center Supply Air

4.1.7 Return Air was typically via room or ceiling plenum. Only 3 of 27 respondents reported ducted return.

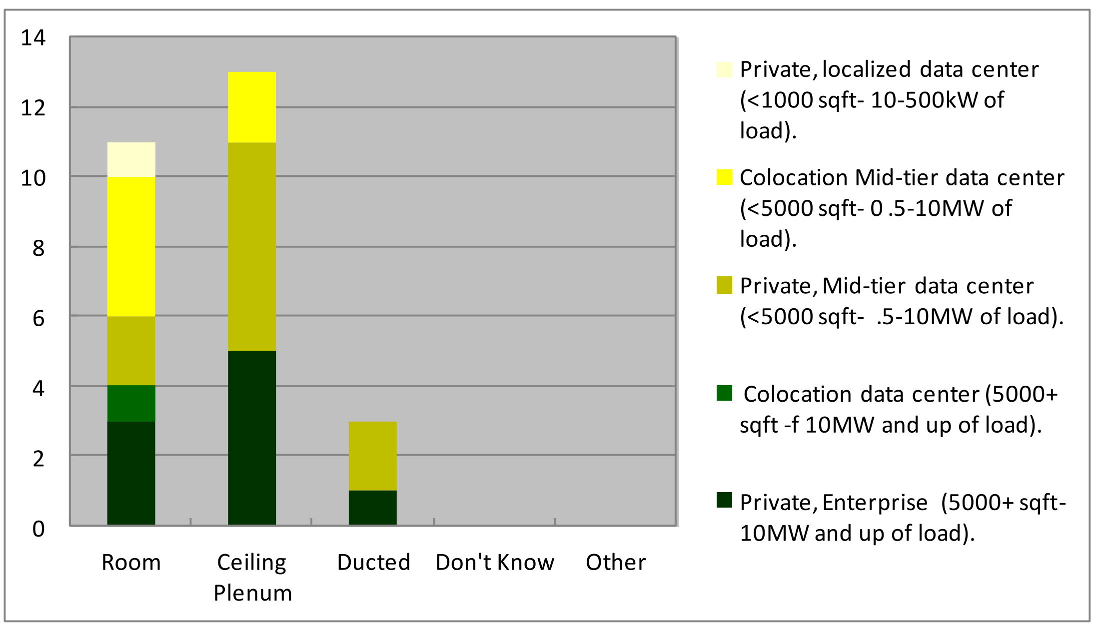


Figure 4-F: Return Air Path

4.1.8 The most common response to allowable humidity ranges was 20-80% RH. With 13 out of 30 respondents choosing this option. However, there was no clear majority.

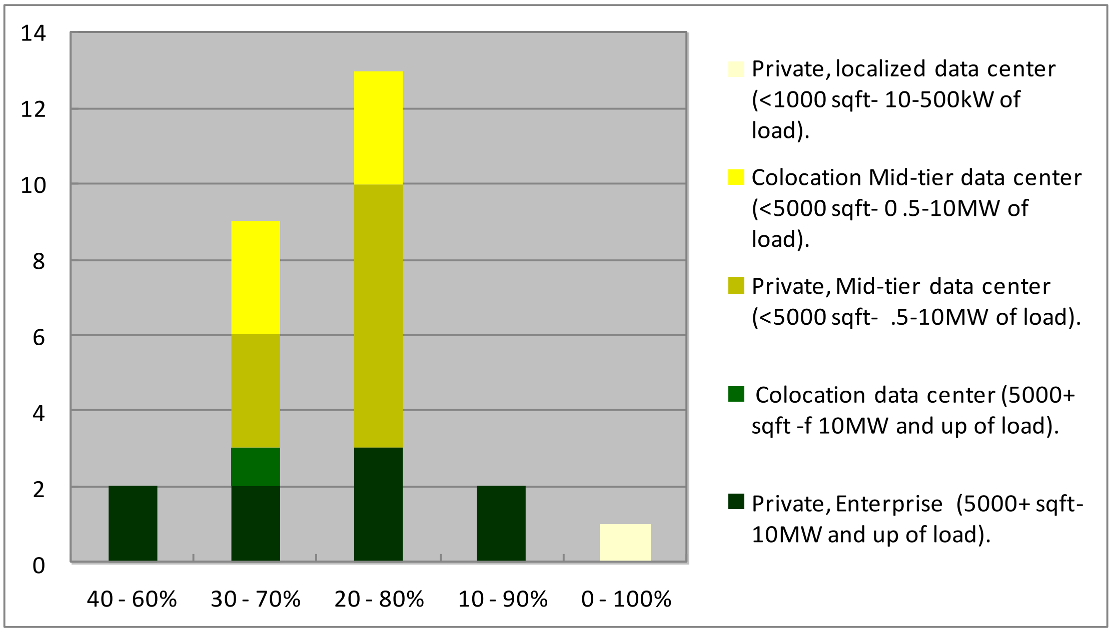


Figure 4-G: Data Center Humidity Range (Allowable)

4.1.9 8 of 22 respondents reported full containment (hot or cold aisle) in their primary area (Area 1) of the facility. 14 of 22 had either full or partial containment implemented.

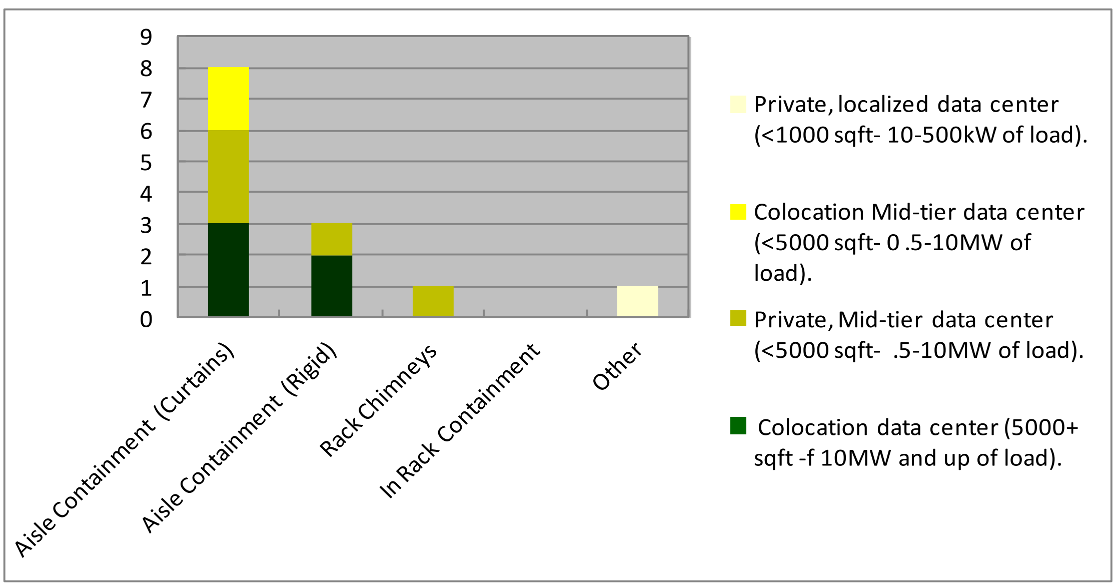


Figure 4-H: Containment Type - Area 1

4.1.10 19 of 24 respondents showed a PDU efficiency of better than 95%. 11 of 24 respondents reported better than 99 efficiency PDUs.

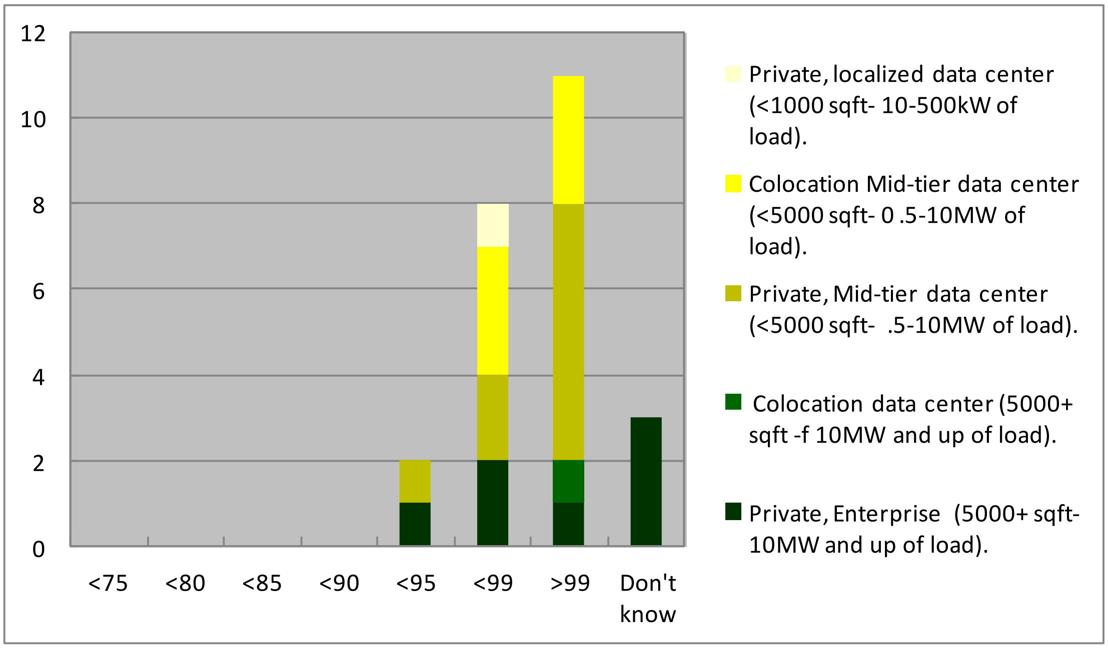


Figure 4-I: Power Distribution Unit (PDU) Efficiency (%)

4.1.11 The most common UPS type was double conversion.

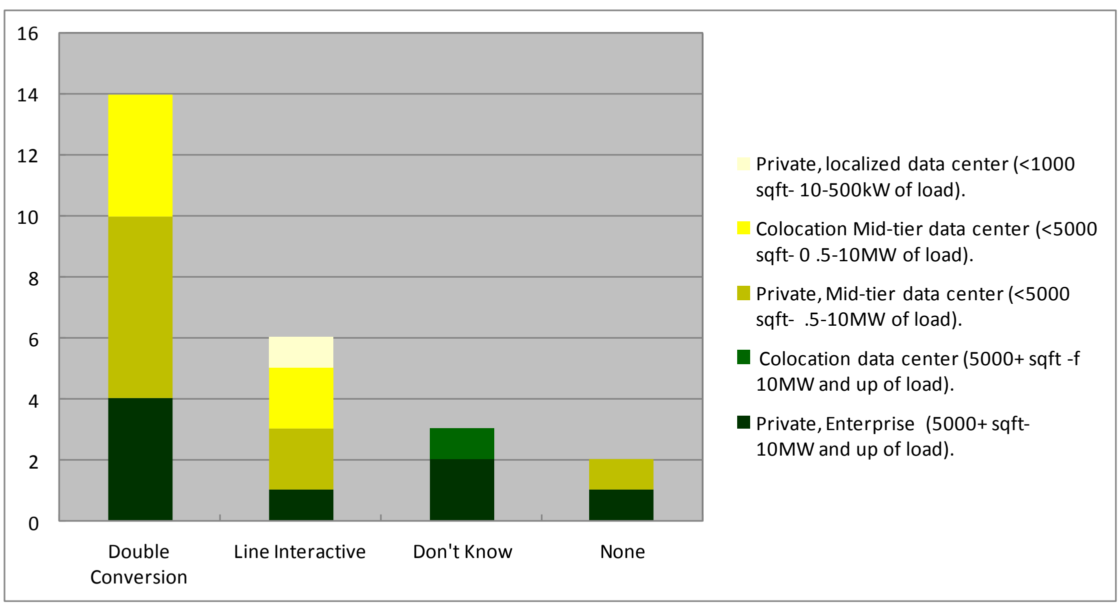


Figure 4-J: Uninterruptable Power Supply (UPS) Type

4.1.12 Data Centers were equally divided between using manual light switches versus occupancy or time delay sensors. Some operators of data centers with vacancy sensors complained of lighting that turned off while IT staff was working on servers.

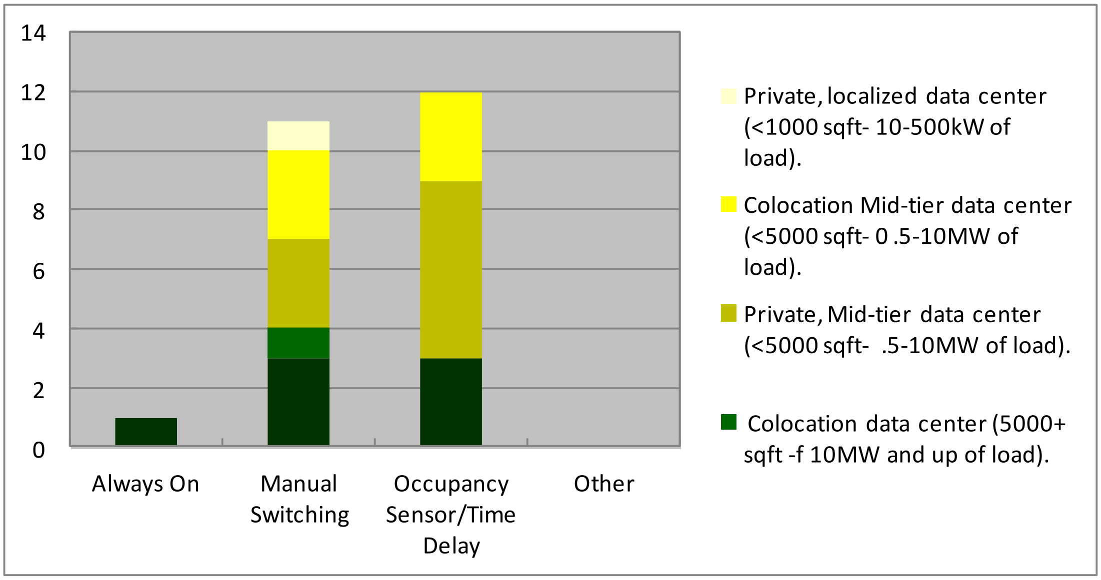


Figure 4-K: Lighting Controls

4.1.13 Less than 25% of respondents knew their server load profiles.

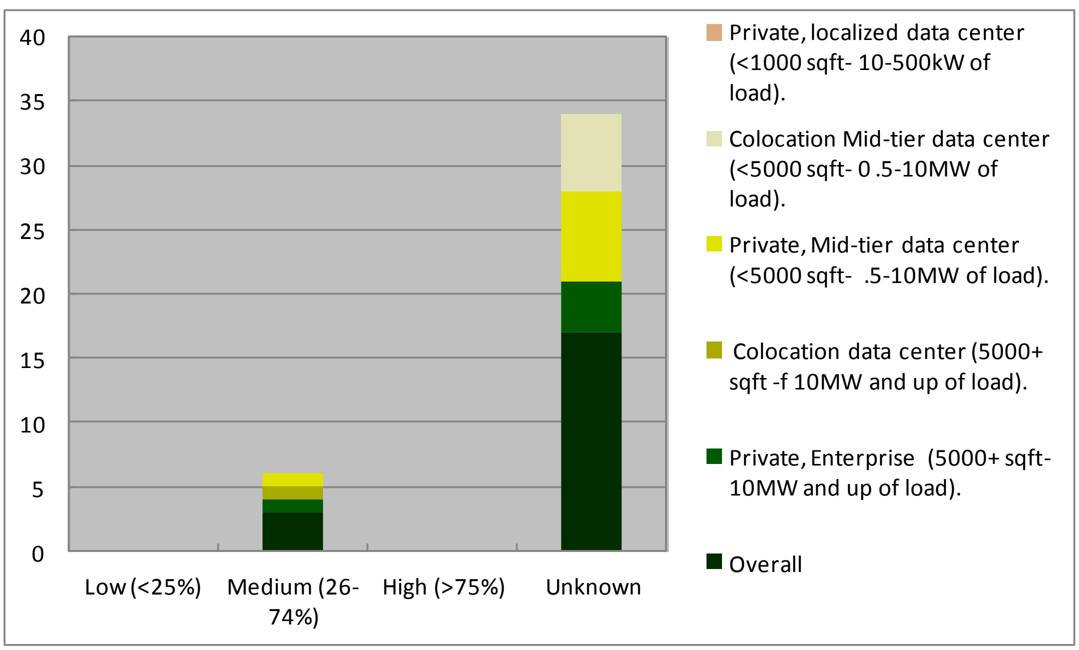


Figure 4-L: Server Load

Complete findings are shown in tables and graphs in **APPENDIX A :** Survey Questions

5. RECOMMENDATIONS

The existing ETO data center baseline document was reviewed and modified based upon the findings of this study. The information in the tables below is derived from a combination of actual survey response data, plus phone interviews and third-party publications to determine typical system and designs in use in today's data centers.

To begin this process, a system type would be selected based on the criteria in Figure 5-A.

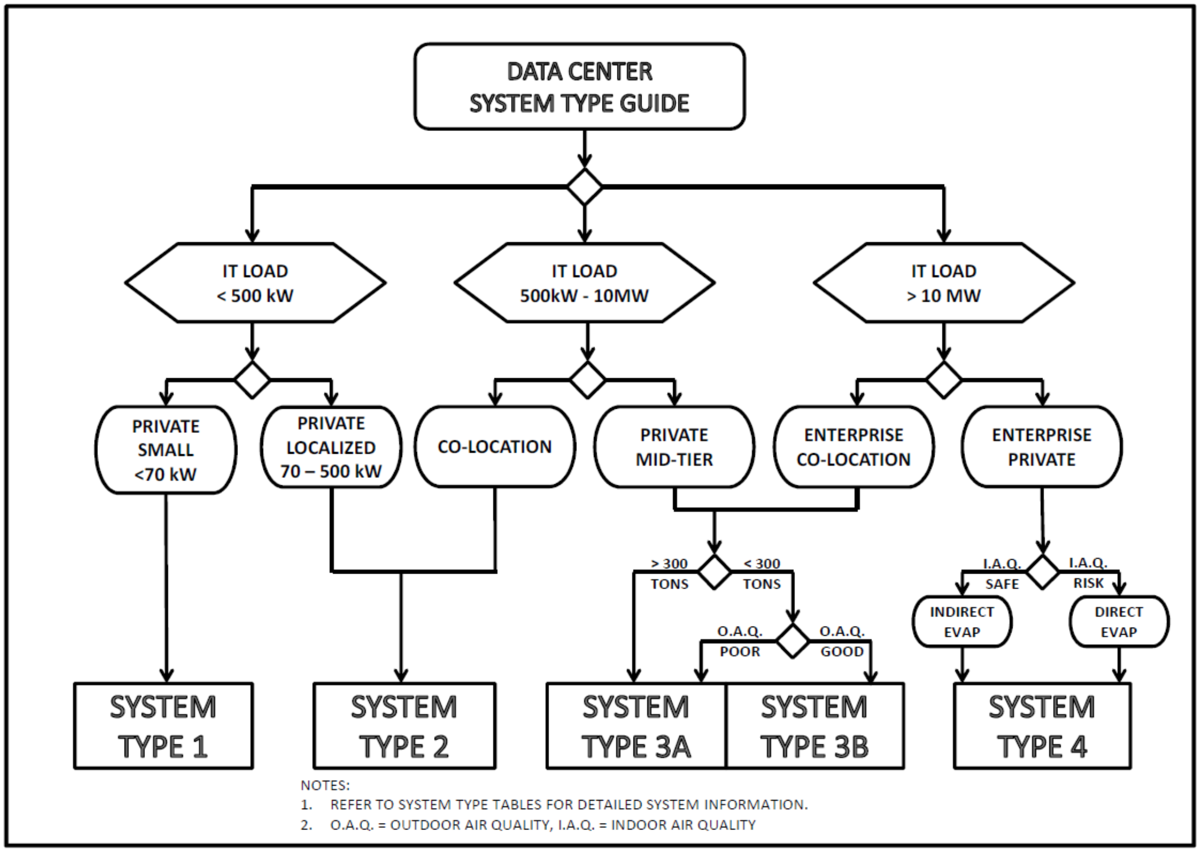


Figure 5-A: Flow Chart of Data Center Baseline Selection

As shown in Figure 5-A, although there are 6 distinct data center submarket types, there is not always a one-to-one correlation between submarket type, and the primary HVAC system type associated with that submarket type. The flow chart in Figure 5-A is designed to direct a user to the appropriate baseline system based upon a mix of IT Load, submarket type, and air-quality or climate issues. Once one of the four appropriate baseline HVAC systems is determined, a specific table of baseline definitions is used to clarify baselines for operation of the chosen system.

BASELINE DEFINITIONS

After a system type has been chosen, the corresponding chart can be used to define a baseline based on the standard HVAC systems in use in today's data centers.

DATA CENTER - SYSTEM TYPE 1		
COMPONENT	**DESCRIPTION**	**NOTES**
COOLING SYSTEM		
Cooling System Type	Split DX or Unitary DX	
EER/SEER/IEER	2010 OEESC	
DX Condenser Selection Point	Design Ambient Dry Bulb Temperature (ASHRAE 0.4% Cooling DB)	
DX Efficiency Curves ('Surfaces')	Derive using varying ambient temperature with constant cooling load	
AIR SYSTEM		
Air System Type	CRAC DX Air-Cooled or AHU DX Air-Cooled	
Fan Energy	2010 OEESC - Section 503.2 SAT/RAT (F, DB): 15 deg delta	1.1
Supply Air Temperature	~55F (DX system - SA Temp not controlled)	1.2
Supply Air Temperature Reset	NO	
Fan Control	Constant Volume (for systems serving process loads only)	
AIRFLOW MANAGEMENT		1.3
0 - 4 KW/Rack Low Density	Hot Aisle/Cold Aisle Configuration Room Supply - Ceiling Plenum Return No Containment	
4.1 - 10 KW/Rack Medium Density	Hot Aisle/Cold Aisle Configuration Room Supply - Ceiling Plenum Return No Containment	
10.1 - 30 KW/Rack High Density	NA	
VENTILATION & ECONOMIZER		
Minimum Ventilation	2010 OSSC and ASHRAE 62-2010: 0.06 CFM / SF + 5 CFM/Person	1.4
Economizer	2010 OEESC, Section 503.4 and Air Side: Full Air Side below SAT plus Integrated cooling from SAT to RAT OSA Except for these systems: 1. Units < 54000 Btu/h: Greater of ≤ 20 tons OR ≤ 10% of total cooling per building 2. New System serving an existing server room, ≤ 50 tons 3. New system, new servers, existing building, ≤ 20 tons	
HUMIDIFICATION & DEHUMIDIFICATION		
Humidification Type	Steam or infrared, 0.33 kWh/lb steam	
Humidification Management	Prohibit dehumidification at cooling coils during operation of humidifiers	
Dehumidification	Cooling Coil	
Dehumidification Reheat	No	
Humidity Control Range (%RH)	20-60	1.5

<table>
<tr><th>HVAC CONTROLS</th><th colspan="5"></th><th></th></tr>
<tr><td>System Controls</td><td colspan="5">Maintain temperature and humidity requirements.
Prevent simultaneous heating and cooling by multiple units.
Prevent simultaneous humidification and dehumidification by multiple units.</td><td></td></tr>
<tr><td>Redundant Equipment</td><td colspan="5">Stand-by Operation</td><td></td></tr>
<tr><td>ELECTRICAL SYSTEMS</td><td colspan="5"></td><td></td></tr>
<tr><td>Server Power Supply Efficiency</td><td colspan="5">80% energy efficiency at 20%, 50%, and 100% of rated load
and
a power factor of 0.9 or greater.</td><td>1.6</td></tr>
<tr><td>Power Distribution Unit Efficiency</td><td colspan="5">DOE and TP-1 Standards</td><td></td></tr>
<tr><td>Server CPU Power</td><td colspan="5">Standard efficiency processors</td><td>1.7</td></tr>
<tr><td>Building Power System</td><td colspan="5">480V from primary transformer passed through UPS system,
stepped down at Power Distribution Units within server room to server power supplies</td><td></td></tr>
<tr><td rowspan="6">UPS Efficiency</td><td colspan="5">Double Conversion UPS Topology</td><td rowspan="6">1.8</td></tr>
<tr><td rowspan="2">UPS Size</td><td colspan="4">% LOAD</td></tr>
<tr><td>25%</td><td>50%</td><td>75%</td><td>100%</td></tr>
<tr><td>kVA, < 20</td><td>86.3</td><td>89.1</td><td>89.6</td><td>89.6</td></tr>
<tr><td>20 < kVA <= 100</td><td>88.5</td><td>90.5</td><td>91.1</td><td>91.1</td></tr>
<tr><td colspan="5">Average Loading on UPS system: Depends on UPS redundancy level (N, 2N, 2(N+1)).
Use following loading ranges: N=35-90%, 2N=10-45%, 2(N+1)=5-15%.</td></tr>
<tr><td>BUILDING ENVELOPE</td><td colspan="5"></td><td></td></tr>
<tr><td>Envelope Requirements</td><td colspan="5">2010 OEESC / SEED</td><td></td></tr>
<tr><td>INTERNAL LOADS</td><td colspan="5"></td><td></td></tr>
<tr><td>Lighting Power Density (W/ft^2)</td><td colspan="5">2010 OSSC</td><td></td></tr>
<tr><td>Lighting Controls</td><td colspan="5">2010 OSSC</td><td></td></tr>
<tr><td>Daylighting Controls</td><td colspan="5">Not Applicable</td><td></td></tr>
<tr><td>Occupancy Density</td><td colspan="5">2010 OSSC</td><td></td></tr>
<tr><td>Server / UPS Load</td><td colspan="5">50% of design IT load expected for first TWO years of operation
(provide supporting documentation for variations)</td><td></td></tr>
</table>

SYSTEM TYPE 1 BASELINE - NOTES:

5.1.1. Respondents stated that they simply follow Oregon Energy Code as needed.

5.1.2. Respondents stated that they simply follow Oregon Energy Code as needed.

5.1.3. Equipment densities based on watts per ft^2 varies widely depending on the building configuration, business type, ramp areas, support areas, etc. Using rack density as the unit of measurement provides a better indication of the true cooling and power requirements. Rack server load, and therefore density within each set of racks, is used for HVAC and electrical design and should also be used to determine containment needs

5.1.4. Based upon simply meeting code requirements.

5.1.5. Humidity limits tend to be based upon ASHRAE T.C 9.9: 2011 Thermal Guidelines for Data Processing Environments. These guidelines expanded the allowable humidity range to 20-80% RH, with a recommended range up of 60%. We see a 20-60% RH baseline range, with certain data centers able to relax controls up to 80% RH depending on climate and business needs.

5.1.6. Server power supply efficiency should include acceptable efficiencies at 20%, 50%, and 100% load, rather than one value of 87%. This is a common way to specify their efficiency in the industry; by using the 80Plus Standard as a minimum (http://www.plugloadsolutions.com). 80Plus Base Level specifies 80% efficiency at each load, however, this varies with higher levels of 80Plus certification. Respondents did not specify at which level they adhered to 80Plus, so the Base Level was chosen as baseline. However based upon the project team's limited experience in this area, an 80Plus Bronze Level (82%, 85%, 82%) may be more appropriate for a baseline. Energy Star 2012 Server Standards are not commonly used yet for purchase decisions according to interviews with IT professionals in Oregon and California.

Parameters	Loading	80 Plus	Bronze	Silver	Gold
Efficiency	20%	80%	82%	85%	87%
	50%	80%	85%	88%	90%
	100%	80%	82%	85%	87%
Power Factor	50%	90% (@100% load)	90% (across the full range)		

Figure 5-B: 80Plus Standard Levels of Certification

5.1.7. Server Processor efficiency baselines are undeterminable at this point. Small to mid-level data center operators interviewed report that processor efficiency is a very small factor in purchase decisions, and not prioritized in the same way that reliability, compatibility with existing systems, and/or cost are. Very large operators were unwilling to share server efficiencies at their data centers, probably for competitive advantage reasons. . Energy Star 2012 Server Standards are not commonly used yet for purchase decisions according to interviews with IT professionals in Oregon and California.

5.1.8. UPS Size versus %Load efficiencies "are averages of published UPS efficiency data compiled from several prominent UPS manufacturers. The data set includes several UPS models in each of the listed UPS size ranges," from the 2011 California Energy Efficiency Baseline report.

DATA CENTER - SYSTEM TYPE 2		
COMPONENT	**DESCRIPTION**	**NOTES**
COOLING SYSTEM		
Cooling System Type	Closed Circuit Fluid Cooler(s)	
Fluid Cooler Selection Point	Design Ambient Temperatures (ASHRAE: 0.4% Cooling DB, 0.4% Cooling WB)	
Condenser Water Pump Energy	2010 OEESC Pump operates at head pressure equal to proposed design, meeting minimum efficiency requirements	
Condenser Water Pumping Control	Variable Flow - VFD	
Fluid Cooler Condenser Water Design Temperatures	CWS: Lesser of 85F OR design WB + 10F Fluid Cooler Approach: 10F Condenser Water Temperature Rise: 10F	
Fluid Cooler Fan Energy (W/CFM)	2010 OEESC	
Fluid Cooler Fan Control	Variable Airflow - VFD	2.1

DATA CENTER - SYSTEM TYPE 2		
COMPONENT	**DESCRIPTION**	**NOTES**
Condenser Water Supply Temperature Reset	60F as weather permits, floating up to design temp	
DX Efficiency Curves ('Surfaces')	Derive using varying ambient temperature with constant cooling load	
AIR SYSTEM		
Air System Type	CRAC(s): DX Water Cooled with Economizer Coil	
Fan Energy,	2010 OEESC - Section 503.2 SAT/RAT (F, DB): 15 deg delta	2.2
Supply Air Temperature	~55F (DX system - SA Temp not controlled)	2.3
Supply Air Temperature Reset	NO	
Fan Control	Constant Volume (for systems serving process loads only)	
AIRFLOW MANAGEMENT		2.4
0 - 4 KW/Rack Low Density	Hot Aisle/Cold Aisle Configuration + Room Supply - Ceiling Plenum Return + No Containment	
4.1 - 10 KW/Rack Medium Density	Hot Aisle/Cold Aisle Configuration + Ducted or Floor Plenum Supply, Room Return, Cold Aisle Containment - OR - Room Supply, Ducted or Ceiling Plenum Return, Hot Aisle Containment + Flexible Curtain Containment	
10.1 - 30 KW/Rack High Density	Hot Aisle/Cold Aisle Configuration + Ducted or Floor Plenum Supply, Room Return, Cold Aisle Containment - OR - Room Supply, Ducted or Ceiling Plenum Return, Hot Aisle Containment + Rigid Containment System	2.5
VENTILATION & ECONOMIZER		
Minimum Ventilation	2010 OSSC and ASHRAE 62-2010: 0.06 CFM / SF + 5 CFM/Person	2.6
Economizer	2010 OEESC, Section 503.4 and Air Side: Full Air Side below SAT plus Integrated cooling from SAT to RAT OSA OR: Water Economizer capable of cooling air by direct and/or indirect evaporation and providing 100% of the expected system cooling load at outside air temperatures of 45F dry bulb and 40F wet bulb and below. Except for these systems: New System serving an existing server room, ≤ 50 tons	
Economizer Control	Economizer shall be capable of providing 100% capacity at OAT< 45F DB / 40F WB	
HUMIDIFICATION & DEHUMIDIFICATION		
Humidification Type	Steam or infrared, 0.33 kWh/lb steam	
Humidification Management	Prohibit dehumidification at cooling coils during operation of humidifiers	
Dehumidification	Cooling Coil	
Dehumidification Reheat	No	
Humidity Control Range (%RH)	20-60	2.7
HVAC CONTROLS		
System Controls	Shall maintain temperature and humidity requirements Prevent simultaneous heating and cooling by multiple units Prevent simultaneous humidification and dehumidification by multiple units	
Redundant Equipment	Stand-by Operation	
ELECTRICAL SYSTEMS		

<table>
<tr><th colspan="7">DATA CENTER - SYSTEM TYPE 2</th></tr>
<tr><th>COMPONENT</th><th colspan="5">DESCRIPTION</th><th>NOTES</th></tr>
<tr><td>Server Power Supply Efficiency</td><td colspan="5">80% energy efficiency at 20%, 50%, and 100% of rated load
and
a power factor of 0.9 or greater.</td><td>2.8</td></tr>
<tr><td>Power Distribution Unit Efficiency</td><td colspan="5">DOE and TP-1 Standards</td><td></td></tr>
<tr><td>Server CPU Power</td><td colspan="5">Standard efficiency processors</td><td>2.9</td></tr>
<tr><td>Building Power System</td><td colspan="5">480V from primary transformer passed through UPS system,
stepped down at Power Distribution Units within server room to server power supplies</td><td></td></tr>
<tr><td rowspan="8">UPS Efficiency</td><td colspan="5">Double Conversion UPS Topology</td><td rowspan="8">2.10</td></tr>
<tr><td rowspan="2">UPS Size</td><td colspan="4">% LOAD</td></tr>
<tr><td>25%</td><td>50%</td><td>75%</td><td>100%</td></tr>
<tr><td>kVA, < 20</td><td>86.3</td><td>89.1</td><td>89.6</td><td>89.6</td></tr>
<tr><td>20 < kVA <= 100</td><td>88.5</td><td>90.5</td><td>91.1</td><td>91.1</td></tr>
<tr><td>kVA > 100</td><td>89.4</td><td>92.2</td><td>93.2</td><td>93.3</td></tr>
<tr><td colspan="5">Average Loading on UPS system: Depends on UPS redundancy level (N, 2N, 2(N+1)).
Use following loading ranges: N=35-90%, 2N=10-45%, 2(N+1)=5-15%.</td></tr>
<tr></tr>
<tr><td>BUILDING ENVELOPE</td><td colspan="5"></td><td></td></tr>
<tr><td>Envelope Requirements</td><td colspan="5">2010 OEESC / SEED</td><td></td></tr>
<tr><td>INTERNAL LOADS</td><td colspan="5"></td><td></td></tr>
<tr><td>Lighting Power Density (W/ft^2)</td><td colspan="5">2010 OSSC</td><td></td></tr>
<tr><td>Lighting Controls</td><td colspan="5">2010 OSSC</td><td></td></tr>
<tr><td>Daylighting Controls</td><td colspan="5">Not Applicable</td><td></td></tr>
<tr><td>Occupancy Density</td><td colspan="5">2010 OSSC</td><td></td></tr>
<tr><td>Server / UPS Load</td><td colspan="5">50% of design IT load expected for first TWO years of operation
(provide supporting documentation for variations)</td><td></td></tr>
</table>

SYSTEM TYPE 2 BASELINE - NOTES:

5.2.1 Fluid cooler and cooling tower fans have traditionally had two-speed control, and are still the Oregon Energy Efficiency Specialty Code baseline. However, VFDs are now often cheaper than a traditional motor starter and are definitely less costly than a dual motor drive. VFDs for all fluid coolers and cooling towers are typically used in new construction.

5.2.2 Respondents stated that they simply follow Oregon Energy Code as needed.

5.2.3 Respondents stated that they simply follow Oregon Energy Code as needed.

5.2.4 Equipment densities based on watts per ft^2 varies widely depending on the building configuration, business type, ramp areas, support areas, etc. Using rack density as the unit of measurement provides a better indication of the true cooling and power requirements. Rack server load, and therefore density within each set of racks, is used for HVAC and electrical design and should also be used to determine containment needs.

5.2.5 Servers used in full containment strategies typically have variable speed fans on the processor and chassis which respond to cooling load in the device. Whenever a full containment strategy is in place, a controls sequence which matches server fan and air handler fan flow to maintain a constant pressure differential must be implemented to realize full energy savings (recommended is 0.01" w.g. differential).

5.2.6 Based upon simply meeting code requirements.

5.2.7 Humidity limits tend to be based upon ASHRAE T.C 9.9: 2011 Thermal Guidelines for Data Processing Environments. These guidelines expanded the allowable humidity range to 20-80% RH, with a recommended range up of 60%. We see a 20-60% RH baseline range, with certain data centers able to relax controls up to 80% RH depending on climate and business needs.

5.2.8 Server power supply efficiency should include acceptable efficiencies at 20%, 50%, and 100% load, rather than one value of 87%. This is a common way to specify their efficiency in the industry; by using the 80Plus Standard as a minimum (http://www.plugloadsolutions.com). 80Plus Base Level specifies 80% efficiency at each load, however, this varies with higher levels of 80Plus certification. Respondents did not specify at which level they adhered to 80Plus, so the Base Level was chosen as baseline. However based upon the project team's limited experience in this area, an 80Plus Bronze Level (82%, 85%, 82%) may be more appropriate for a baseline. Energy Star 2012 Server Standards are not commonly used yet for purchase decisions according to interviews with IT professionals in Oregon and California.

5.2.9 Server Processor efficiency baselines are undeterminable at this point. Small to mid-level data center operators interviewed report that processor efficiency is a very small factor in purchase decisions, and not prioritized in the same way that reliability, compatibility with existing systems, and/or cost are. Very large operators were unwilling to share server efficiencies at their data centers, probably for competitive advantage reasons. . Energy Star 2012 Server Standards are not commonly used yet for purchase decisions according to interviews with IT professionals in Oregon and California.

5.2.10 UPS Size versus % Load efficiencies "are averages of published UPS efficiency data compiled from several prominent UPS manufacturers. The data set includes several UPS models in each of the listed UPS size ranges," from the 2011 California Energy Efficiency Baseline report.

DATA CENTER - SYSTEM TYPE 3			
COMPONENT	**DESCRIPTION**		**NOTES**
	3A	**3B**	
	To be used as baseline only when outside air economizer is not feasible due to outdoor air contaminant concerns or humidity concerns.		
COOLING SYSTEM			
Cooling System Type	Chiller(s), Cooling Tower(s)	Air-Cooled Chiller(s)	
Chiller EER/EER - IPLV	2010 OEESC	2010 OEESC	
Chilled Water Pump Energy	Pump operates at head pressure equal to proposed design, meeting minimum efficiency requirements in 2010 OEESC	Pump operates at head pressure equal to proposed design, meeting minimum efficiency requirements in 2010 OEESC?	
Chilled Water Pump Control	Variable primary flow with minimum flow by-pass	Variable primary flow with minimum flow by-pass	
Condenser Water Pump Energy	Pump operates at head pressure equal to proposed design, meeting minimum efficiency requirements in 2010 OEESC	-	
Condenser Water Pumping Arrangement	Constant Volume	-	
Fluid Cooler / Cooling Tower: Condenser Water Design Temperatures	CWS: Lesser of 85F OR design WB + 10F Fluid Cooler Approach: 10F Condenser Water Temperature Rise: 10F	-	
AC Chiller Condenser Fan Control	-	Cycle Condenser Fans	3.1
Cooling Tower Selection Point	Design Ambient Temperature (ASHRAE: 0.4% Cooling WB)		

DATA CENTER - SYSTEM TYPE 3			
COMPONENT	**DESCRIPTION**		**NOTES**
	3A	**3B**	
	To be used as baseline only when outside air economizer is not feasible due to outdoor air contaminant concerns or humidity concerns.		
Cooling Tower Fan Energy (W/CFM)	2010 OEESC	-	
Cooling Tower Fan Control	VFD - Variable Speed to maintain CWS setpoint	-	3.2
Condenser Water Supply, Temperature Control	CW Reset :60F as weather permits, floating up to design temp	-	
DX Selection Point	-	Design Ambient Temperature (ASHRAE: 0.4% Cooling DB)	
Chiller Selection Point (See Cooling Tower for CW Temps)	CHWS: 50F CHWR: 60F	CHWS: 50F CHWR: 60F	
DX/Chiller Efficiency Curves ('Surfaces')	Derive using varying ambient temperature with constant cooling load	Derive using varying ambient temperature with constant cooling load	
AIR SYSTEM			
Air System Type	CRAH(s) or AHU(s) Water Cooled Chiller Waterside Economizer	CRAH(s) or AHU(s) Air Cooled Chiller Airside Economizer	
Fan Energy	2010 OEESC - Section 503.2 SAT/RAT (F, DB): 15 deg delta		
Supply Air Temperature	70F +/- 2F		3.3
Supply Air Temperature Reset	NO		
Fan Control Based on Total System CFM	Constant Volume (for systems serving process loads only)		
AIRFLOW MANAGEMENT			3.4
0 - 4 KW/Rack Low Density	Hot Aisle/Cold Aisle Configuration Room Supply - Ceiling Plenum Return No Containment		
4.1 - 10 KW/Rack Medium Density	Hot Aisle/Cold Aisle Configuration + Ducted or Floor Plenum Supply, Room Return, Cold Aisle Containment -OR- Room Supply, Ducted or Ceiling Plenum Return, Hot Aisle Containment + Flexible Curtain Containment		
10.1 - 30 KW/Rack High Density	Hot Aisle/Cold Aisle Configuration + Ducted or Floor Plenum Supply, Room Return, Cold Aisle Containment -OR- Room Supply, Ducted or Ceiling Plenum Return, Hot Aisle Containment + Rigid Containment System		3.5
VENTILATION & ECONOMIZER			
Minimum Ventilation	2010 OSSC and ASHRAE 62-2010: 0.06 CFM / SF + 5 CFM/Person		3.6
Economizer	2010 OEESC, Section 503.4 Waterside Economizer	2010 OEESC, Section 503.4 Air Side Economizer	
Economizer Control	Capable of providing 100% capacity at OAT< 45F DB / 40F WB	Capable of providing 100% capacity when OAT < SAT Plus Integrated cooling when SAT < OAT < RAT	
HUMIDIFICATION & DEHUMIDIFICATION			

<table>
<tr><th colspan="4">DATA CENTER - SYSTEM TYPE 3</th></tr>
<tr><th>COMPONENT</th><th colspan="2">DESCRIPTION</th><th>NOTES</th></tr>
<tr><td></td><td>3A</td><td>3B</td><td></td></tr>
<tr><td></td><td>To be used as baseline only when outside air economizer is not feasible due to outdoor air contaminant concerns or humidity concerns.</td><td></td><td></td></tr>
<tr><td>Humidification Type vs. design cooling capacity</td><td colspan="2">≤ 200 tons: Steam or infrared, 0.33 kWh/lb steam
≥ 200 tons: Adiabatic (Mist, Wetted-Media or Ultrasonic)</td><td></td></tr>
<tr><td>Humidification Management</td><td colspan="2">Prohibit dehumidification at cooling coils during operation of humidifiers</td><td></td></tr>
<tr><td>Dehumidification</td><td colspan="2">Cooling coil</td><td></td></tr>
<tr><td>Dehumidification Reheat</td><td colspan="2">No</td><td></td></tr>
<tr><td>Humidity Control Range (%RH)</td><td colspan="2">20-60</td><td>3.7</td></tr>
<tr><td>HVAC CONTROLS</td><td colspan="2"></td><td></td></tr>
<tr><td>System Controls</td><td colspan="2">Shall maintain temperature and humidity requirements
and prevent simultaneous heating and cooling by multiple units</td><td></td></tr>
<tr><td>Redundant Equipment</td><td colspan="2">Operate Redundant Equipment at Reduced Load</td><td></td></tr>
<tr><td>ELECTRICAL SYSTEMS</td><td colspan="2"></td><td></td></tr>
<tr><td>Server Power Supply Efficiency</td><td colspan="2">80% energy efficiency at 20%, 50%, and 100% of rated load
and
a power factor of 0.9 or greater.</td><td>3.8</td></tr>
<tr><td>Power Distribution Unit Efficiency</td><td colspan="2">DOE and TP-1 Standards</td><td></td></tr>
<tr><td>Server CPU Power</td><td colspan="2">Standard efficiency processors</td><td>3.9</td></tr>
<tr><td>Building Power System</td><td colspan="2">480V from primary transformer passed through UPS system,
stepped down at Power Distribution Units within server room to server power supplies</td><td></td></tr>
<tr><td>UPS Efficiency</td><td colspan="2">Double Conversion UPS Topology
<table>
<tr><th rowspan="2">UPS Size</th><th colspan="4">% LOAD</th></tr>
<tr><th>25%</th><th>50%</th><th>75%</th><th>100%</th></tr>
<tr><td>kVA, < 20</td><td>86.3</td><td>89.1</td><td>89.6</td><td>89.6</td></tr>
<tr><td>20 < kVA <= 100</td><td>88.5</td><td>90.5</td><td>91.1</td><td>91.1</td></tr>
<tr><td>kVA > 100</td><td>89.4</td><td>92.2</td><td>93.2</td><td>93.3</td></tr>
</table>
Average Loading on UPS system: Depends on UPS redundancy level (N, 2N, 2(N+1)).
Use following loading ranges: N=35-90%, 2N=10-45%, 2(N+1)=5-15%.</td><td>3.10</td></tr>
<tr><td>BUILDING ENVELOPE</td><td colspan="2"></td><td></td></tr>
<tr><td>Envelope Requirements</td><td colspan="2">2010 OEESC / SEED</td><td></td></tr>
<tr><td>INTERNAL LOADS</td><td colspan="2"></td><td></td></tr>
<tr><td>Lighting Power Density (W/ft^2)</td><td colspan="2">2010 OSSC</td><td></td></tr>
<tr><td>Lighting Controls</td><td colspan="2">2010 OSSC</td><td></td></tr>
<tr><td>Daylighting Controls</td><td colspan="2">Not Applicable</td><td></td></tr>
<tr><td>Occupancy Density</td><td colspan="2">2010 OSSC</td><td></td></tr>
<tr><td>Server / UPS Load</td><td colspan="2">50% of design IT load expected for first TWO years of operation
(provide supporting documentation for variations)</td><td></td></tr>
</table>

SYSTEM TYPE 3 BASELINE - NOTES:

5.3.1 Cycling condenser fans for capacity control is standard practice across the industry for all facility types. Variable speed control of the lead condenser fan is available from some air cooled chiller and condenser manufacturers; however they are uncommon in application. We expect that this will change in the future.

5.3.2 Fluid cooler and cooling tower fans have traditionally had two-speed control, and are still the Oregon Energy Efficiency Specialty Code baseline. However, VFDs are now often cheaper than a traditional motor starter and are definitely less costly than a dual motor drive. VFDs for all fluid coolers and cooling towers are primarily used in new construction.

5.3.3 In systems using containment, the target SAT is 70F. However, if there are areas of non containment present, a lower temperature may be needed, and a range of 64-70F is more realistic.

5.3.4 Equipment densities based on watts per ft^2 varies widely depending on the building configuration, business type, ramp areas, support areas, etc. Using rack density as the unit of measurement provides a better indication of the true cooling and power requirements. Rack server load, and therefore density within each set of racks, is used for HVAC and electrical design and should also be used to determine containment needs.

5.3.5 Servers used in full containment strategies typically have variable speed fans on the processor and chassis which respond to cooling load in the device. Whenever a full containment strategy is in place, a controls sequence which matches server fan and air handler fan flow to maintain a constant pressure differential must be implemented to realize full energy savings (recommended is 0.01" w.g. differential).

5.3.6 Based upon simply meeting code requirements.

5.3.7 Humidity limits tend to be based upon ASHRAE T.C 9.9: 2011 Thermal Guidelines for Data Processing Environments. These guidelines expanded the allowable humidity range to 20-80% RH, with a recommended range up of 60%. We see a 20-60% RH baseline range, with certain data centers able to relax controls up to 80% RH depending on climate and business needs.

5.3.8 Server power supply efficiency should include acceptable efficiencies at 20%, 50%, and 100% load, rather than one value of 87%. This is a common way to specify their efficiency in the industry; by using the 80Plus Standard as a minimum (http://www.plugloadsolutions.com). 80Plus Base Level specifies 80% efficiency at each load, however, this varies with higher levels of 80Plus certification. Respondents did not specify at which level they adhered to 80Plus, so the Base Level was chosen as baseline. However based upon the project team's limited experience in this area, an 80Plus Bronze Level (82%, 85%, 82%) may be more appropriate for a baseline. Energy Star 2012 Server Standards are not commonly used yet for purchase decisions according to interviews with IT professionals in Oregon and California.

5.3.9 Server Processor efficiency baselines are undeterminable at this point. Small to mid-level data center operators interviewed report that processor efficiency is a very small factor in purchase decisions, and not prioritized in the same way that reliability, compatibility with existing systems, and/or cost are. Very large operators were unwilling to share server efficiencies at their data centers, probably for competitive advantage reasons. . Energy Star 2012 Server Standards are not commonly used yet for purchase decisions according to interviews with IT professionals in Oregon and California

5.3.10 UPS Size versus % Load efficiencies "are averages of published UPS efficiency data compiled from several prominent UPS manufacturers. The data set includes several UPS models in each of the listed UPS size ranges," from the 2011 California Energy Efficiency Baseline report.

DATA CENTER - SYSTEM TYPE 4		
COMPONENT	**DESCRIPTION**	**NOTES**
COOLING SYSTEM		
Primary Cooling System Type	Direct or Indirect Evaporative Cooling	4.1
Evaporative Cooler Performance	ANSI/ASHRAE 133-2008 Method of Testing Direct Evaporative Air Coolers	
Evaporative Cooling Design Parameters	ASHRAE 0.4% Cooling DB, ASHRAE 0.4% Cooling WB	
Supplemental Cooling System Type	Air Cooled Chiller(s) Limited to a maximum of 200 runtime hours per year.	4.2
Chilled Water Pump Energy	Pump operates at head pressure equal to proposed design, meeting minimum efficiency requirements in 2010 OEESC?	
Chilled Water Pump Control	Variable primary flow with minimum flow by-pass	
AC Chiller Condenser Fan Control	Cycle Condenser Fans	4.3
DX Selection Point	Design Ambient Temperature (ASHRAE: 0.4% Cooling DB)	
Chiller Selection Point (See Cooling Tower for CW Temps)	CHWS: 50F CHWR: 60F	
DX/Chiller Efficiency Curves ('Surfaces')	Derive using varying ambient temperature with constant cooling load	
AIR SYSTEM		
Air System Type	AHU with Primary Evaporative Cooling	
Fan Energy	2010 OEESC - Section 503.2 SAT/RAT (F, DB): 20 deg delta	
Supply Air Temperature	70F +/- 2F	4.4
Supply Air Temperature Reset	No	
Supply Fan Control	Variable Air Flow Differential Pressure Control to match Server Airflow	
AIRFLOW MANAGEMENT		4.5
0 - 4 KW/Rack Low Density	Hot Aisle/Cold Aisle Configuration Room Supply - Ceiling Plenum Return No Containment	
4.1 - 10 KW/Rack Medium Density	Hot Aisle/Cold Aisle Configuration Room Supply, Ducted or Ceiling Plenum Return, Hot Aisle Containment Rigid Containment System	4.6
10.1 - 30 KW/Rack High Density	Hot Aisle/Cold Aisle Configuration Room Supply, Ducted or Ceiling Plenum Return, Hot Aisle Containment Rigid Containment System	4.7
VENTILATION & ECONOMIZER		
Minimum Ventilation	2010 OSSC and ASHRAE 62-2010: 0.06 CFM / SF + 5 CFM/Person	
Economizer	2010 OEESC, Section 503.4 Air Side Economizer:	
Economizer Control	Full Air Side below SAT Plus Integrated cooling from SAT to RAT OSA	
HUMIDIFICATION & DEHUMIDIFICATION		
Humidification Type	Adiabatic (Mist, Wetted-Media or Ultrasonic)	
Humidification Management	Prohibit dehumidification at cooling coils during operation of humidifiers	

<table>
<tr><th colspan="7">DATA CENTER - SYSTEM TYPE 4</th></tr>
<tr><th>COMPONENT</th><th colspan="5">DESCRIPTION</th><th>NOTES</th></tr>
<tr><td>Dehumidification</td><td colspan="5">Cooling coil</td><td></td></tr>
<tr><td>Dehumidification Reheat</td><td colspan="5">NO</td><td></td></tr>
<tr><td>Humidity Control Range (%)</td><td colspan="5">20-60</td><td>4.6</td></tr>
<tr><td>HVAC CONTROLS</td><td colspan="5"></td><td></td></tr>
<tr><td>System Controls</td><td colspan="5">Shall maintain temperature and humidity requirements
and prevent simultaneous heating and cooling by multiple units</td><td></td></tr>
<tr><td>Redundant Equipment</td><td colspan="5">Operate Redundant Equipment at Reduced Load</td><td></td></tr>
<tr><td>ELECTRICAL SYSTEMS</td><td colspan="5"></td><td></td></tr>
<tr><td>Server Power Supply Efficiency</td><td colspan="5">82% energy efficiency at 20% and 100% of rated load
87% at 50% of rated load and
a power factor of 0.9 or greater at 100% load.</td><td>4.8</td></tr>
<tr><td>Power Distribution Unit Efficiency</td><td colspan="5">DOE and TP-1 Standards</td><td></td></tr>
<tr><td>Server CPU Power</td><td colspan="5">Standard efficiency processors</td><td></td></tr>
<tr><td>Building Power System</td><td colspan="5">480V from primary transformer passed through UPS system,
stepped down at Power Distribution Units within server room to server power supplies</td><td>4.9</td></tr>
<tr><td rowspan="7">UPS Efficiency</td><td colspan="5">Double Conversion UPS Topology</td><td rowspan="7">4.10</td></tr>
<tr><td rowspan="2">UPS Size</td><td colspan="4">% LOAD</td></tr>
<tr><td>25%</td><td>50%</td><td>75%</td><td>100%</td></tr>
<tr><td>kVA, < 20</td><td>86.3</td><td>89.1</td><td>89.6</td><td>89.6</td></tr>
<tr><td>20 < kVA <= 100</td><td>88.5</td><td>90.5</td><td>91.1</td><td>91.1</td></tr>
<tr><td>kVA > 100</td><td>89.4</td><td>92.2</td><td>93.2</td><td>93.3</td></tr>
<tr><td colspan="5">Average Loading on UPS system: Depends on UPS redundancy level (N, 2N, 2(N+1)).
Use following loading ranges: N=35-90%, 2N=10-45%, 2(N+1)=5-15%.</td></tr>
<tr><td>BUILDING ENVELOPE</td><td colspan="5"></td><td></td></tr>
<tr><td>Envelope Requirements</td><td colspan="5">2010 OEESC / SEED</td><td></td></tr>
<tr><td>INTERNAL LOADS</td><td colspan="5"></td><td></td></tr>
<tr><td>Lighting Power Density (W/ft^2)</td><td colspan="5">2010 OSSC</td><td></td></tr>
<tr><td>Lighting Controls</td><td colspan="5">2010 OSSC</td><td></td></tr>
<tr><td>Daylighting Controls</td><td colspan="5">Not Applicable</td><td></td></tr>
<tr><td>Occupancy Density</td><td colspan="5">2010 OSSC</td><td></td></tr>
<tr><td>Server / UPS Load</td><td colspan="5">50% of design IT load expected for first TWO years of operation
(provide supporting documentation for variations)</td><td></td></tr>
</table>

SYSTEM TYPE 4 BASELINE NOTES:

5.4.1 The typical cooling system for new construction Type 4 data centers is evaporative cooling in new construction. Data centers of this class use such large quantities of energy that they are often located in climates where evaporative cooling is practical, which coincides with cheaper electricity rates. This makes an evaporative cooling system too cost effective to not be utilized in those climates. Of the 6 Enterprise Level Data Centers the project team interview and/or had direct experience on, 5 out of six utilized evaporative cooling. The one exception was for a very large data center that was built over 4 years ago.

5.4.2 Air cooled chillers to handle limited peak summer temperatures is sometimes included for Type 4 data centers as a supplemental source of conditioning. Modeling to determine hours of mechanical cooling versus evaporative cooling is usually used to determine cost benefit of this hybrid approach.

5.4.3 Cycling condenser fans for capacity control is standard practice across the industry for all facility types. Variable speed control of the lead condenser fan is available from some air cooled chiller and condenser manufacturers; however they are uncommon in application. We expect that this will change in the future.

5.4.4 In systems using containment, the target SAT is 70F. However, if there are areas of non containment present, a lower temperature may be needed, and a range of 64-70F is more realistic.

5.4.5 Equipment densities based on watts per ft2 varies widely depending on the building configuration, business type, ramp areas, support areas, etc. Using rack density as the unit of measurement provides a better indication of the true cooling and power requirements. Rack server load, and therefore density within each set of racks, is used for HVAC and electrical design and should also be used to determine containment needs.

5.4.6 Servers used in full containment strategies typically have variable speed fans on the processor and chassis which respond to cooling load in the device. Whenever a full containment strategy is in place, a controls sequence which matches server fan and air handler fan flow to maintain a constant pressure differential must be implemented to realize full energy savings (recommended is 0.01" w.g. differential).

5.4.7 Humidity limits tend to be based upon ASHRAE T.C 9.9: 2011 Thermal Guidelines for Data Processing Environments. These guidelines expanded the allowable humidity range to 20-80% RH, with a recommended range up of 60%. We see a 20-60% RH baseline range, with certain data centers able to relax controls up to 80% RH depending on climate and business needs.

5.4.8 Server power supply efficiency should include acceptable efficiencies at 20%, 50%, and 100% load, rather than one value. This is a common way to specify their efficiency in the industry; by using the 80Plus Standard as a minimum (http://www.plugloadsolutions.com). Energy Star 2012 Server Standards are not commonly used yet for purchase decisions according to interviews with IT professionals in Oregon and California.

5.4.9 Building power system baseline is still 480V/3Ph, however, an up and coming practice in the industry is to provide 415V/3Ph (based on European voltage standards) at the primary transformer which can then be split down to 240V/1Ph (by phase voltage) *without* the need for a secondary transformer.

5.4.10 UPS Size versus % Load efficiencies "are averages of published UPS efficiency data compiled from several prominent UPS manufacturers. The data set includes several UPS models in each of the listed UPS size ranges," from the 2011 California Energy Efficiency Baseline report.

FUTURE TRENDS

In addition to assessing common practices to determine realistic baseline standards, future trends and/or cutting edge solutions were also looked at. Absolute predictions regarding future developments in this fast-paced, high-dollar industry are nearly impossible to give as new trends occur every 4 to 6 months. Based on the research and suggestions collected, we have determined the following data center trends that should be re-examined for possible updates to the baseline in future.

1. More facilities are moving to no mechanical cooling even in peak times. No backup chiller installed.
2. In addition to the current use of evaporative cooling at the enterprise level, an up and coming trend is to convert to liquid-cooled servers in the data center. Either in a rack-specific system for certain intensive data loads areas, or enterprise wide. We expect to see this trend continue as a primary way of reducing cooling loads

for data centers as it eliminates air handling unit fan power. More details on liquid-cooled servers can be found in the attached article and image in Appendix F.

3. For Sub-Market Types 4 or 5 (data centers that may need to choose between air-cooled and water cooled chillers), a solution that we have seen for locations with rapid changes in outside humidity, fog, dust, smoke, and other air-quality issues, such as in the central Willamette Valley where fog can accumulate faster than the HVAC controls can respond, is to require the use of a 4°F approach to an air-to-air heat exchanger to pre-cool the return air. Thus, one side of the heat exchanger would circulate outside air across the heat exchanger without mixing the air into the air handler supply air while the return air would be cooled prior to entering the supply air path. This would yield greater hours of free cooling than a waterside economizer and sacrifice only a select few hours of the airside economizer operation.
4. Eliminating the need for any ductwork is being done in some enterprise data centers. Greatly reducing the fan static pressure and leading to huge fan savings.
5. Implementing variable condenser water flow for CRAH Systems condenser water loops is not standard today, but is starting to occur.
6. Upgrades to hot/cold thermal separation by either containment for and/or by using increased thermal separations performance of the containment are a trend we expect to grow. For example, duct/plenum insulation in facilities that already use containment, or moving from simple hot-aisle/cold-aisle to a flexible containment system, even at smaller facilities.
7. The utilization of a UPS with eco-mode capability as standard practice.
8. The elimination the UPS through the use of flywheels or grid backup to avoid dual transformation losses that occur with battery backup has been discussed, but is still a very remote trend.
9. Data Center Information Management systems (DCIM) is a growing trend – although cost prohibitive to most smaller centers. The use of these systems to track operation and energy use is continuing to grow in the larger data centers and may provide even more accurate energy use statistics in the future.

In summary, the challenges with data centers are that due to their intensive power use, owners of these facilities need to be energy conscious in order to remain relevant in the marketplace. Many of the proposed baseline requirements are more stringent than the current 2010 Oregon Energy Efficiency Specialty Code because all data centers can benefit from improvements. Data centers located in office buildings need to be efficient as these are often tied to small-to-medium sized business who benefit from the avoided costs. Collocation and Mid-Tier data centers will not remain cot effective for their clients and/or owners unless they can have efficiency savings to offer cheaper leasable space, and Enterprise data centers require efficiency for public image and minimizing their impact to many of the utility grids to which they are connecting.

Glumac appreciates the opportunity to have participated in this study, and to assist the ETO in further understanding current and potential future energy related trends in the data center industry. We suggest a follow up meeting or phone call to discuss this report to ensure all stakeholders in the project understand the findings and conclusions.

6. APPENDIX A : SURVEY QUESTIONS

Department Of Primary Contact:	Overall	Private, Enterprise (5000+ sqft-10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Data Center Manager	2	0	1	1	0	0
Mechanical Departmer	3	3	0	0	0	0
Electrical Department	1	0	1	0	0	0
IT Department	0	0	0	0	0	0
Other	47	8	0	9	7	1

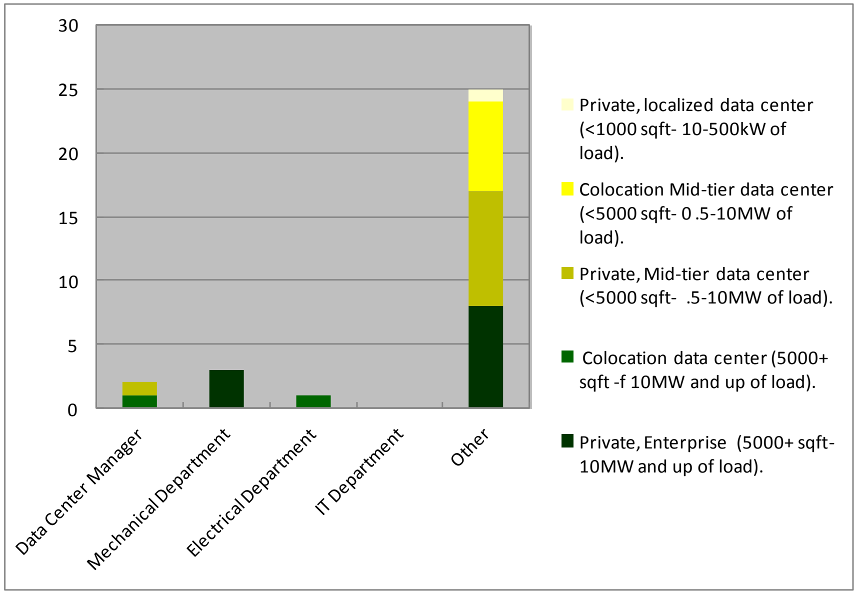


Figure 6-A: Department Of Primary Contact

Do you wish to keep the information you provide anonymous?	Overall	Private, Enterprise (5000+ sqft-10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	24	7	1	9	7	0
No	7	4	1	1	0	1

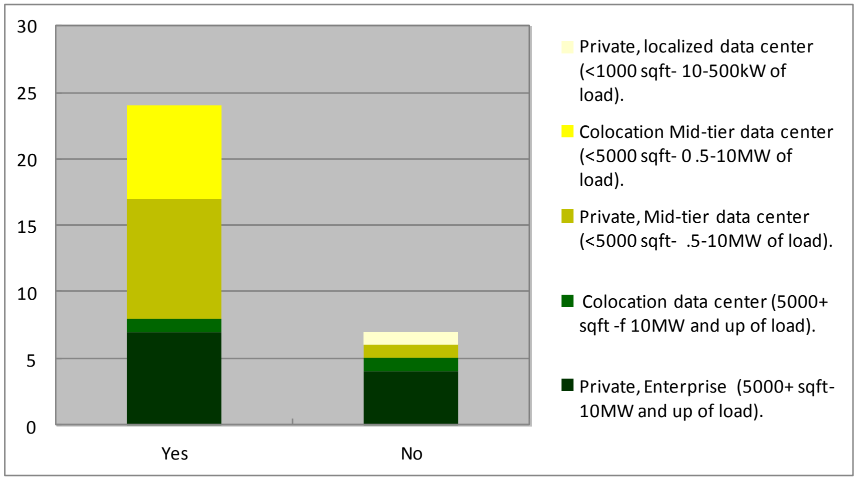


Figure 6-B: Do you wish to keep the information you provide anonymous?

Building Construction Type:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Purpose built data cen	12	9	2	1	0	0
Re-purposed existing b	11	2	0	5	4	0
Fit-out within a larger e	7	0	0	4	2	1

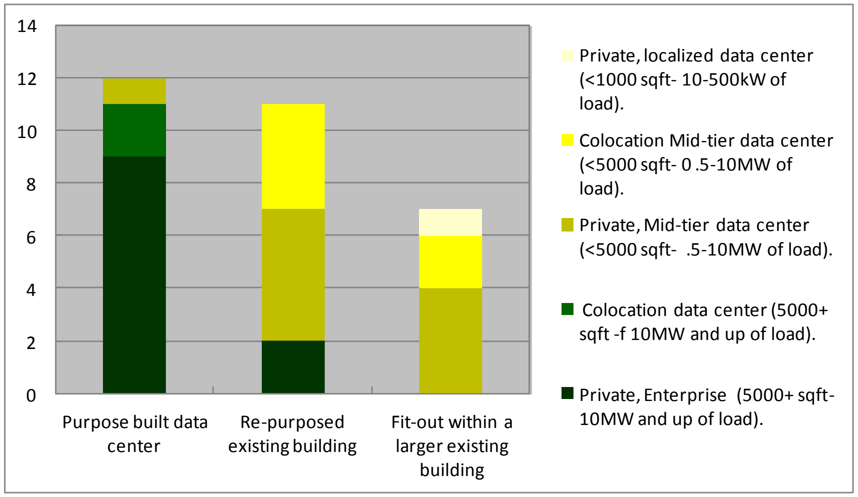


Figure 6-C: Building Construction Type

Data Center Start-Up Year:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
2012	10	7	0	3	0	0
2011	0	0	0	0	0	0
2010	7	0	1	1	5	0
2009	3	2	0	1	0	0
2008	0	0	0	0	0	0
2007	4	1	0	2	1	0
2006	2	0	0	2	0	0
2005	0	0	0	0	0	0
2004	0	0	0	0	0	0
2003	0	0	0	0	0	0
2002	0	0	0	0	0	0
2001	1	0	1	0	0	0
2000	2	0	0	1	1	0
1999	0	0	0	0	0	0
1998	1	0	0	0	0	1
1997	0	0	0	0	0	0
1996	0	0	0	0	0	0
1995	0	0	0	0	0	0
Unknown	0	0	0	0	0	0

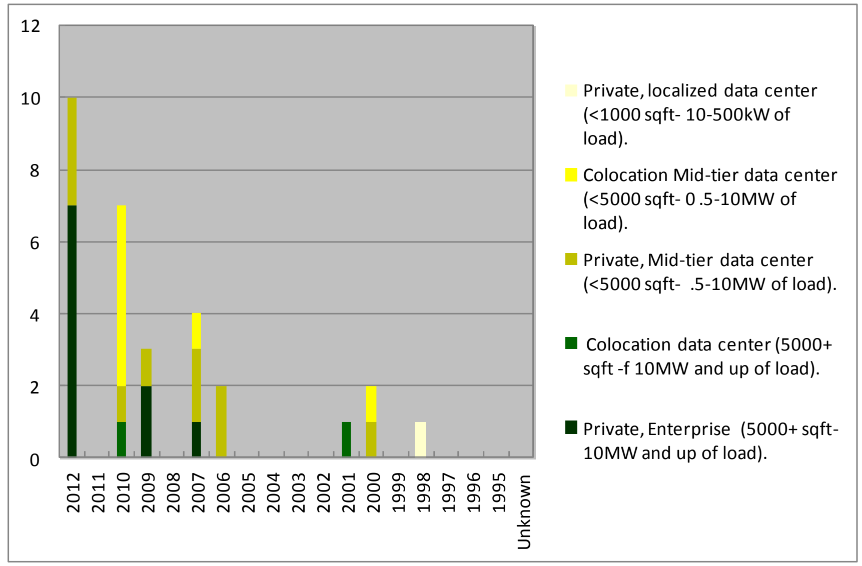


Figure 6-D: Data Center Start-Up Year

Year Of Installation For Current Mechanical System:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
2012	10	6	0	3	1	0
2011	1	1	0	0	0	0
2010	6	0	0	1	5	0
2009	3	1	1	1	0	0
2008	0	0	0	0	0	0
2007	3	0	0	2	1	0
2006	3	1	0	2	0	0
2005	1	0	0	0	0	1
2004	0	0	0	0	0	0
2003	0	0	0	0	0	0
2002	0	0	0	0	0	0
2001	1	0	1	0	0	0
2000	1	0	0	1	0	0
1999	0	0	0	0	0	0
1998	1	1	0	0	0	0
1997	0	0	0	0	0	0
1996	0	0	0	0	0	0
1995	0	0	0	0	0	0

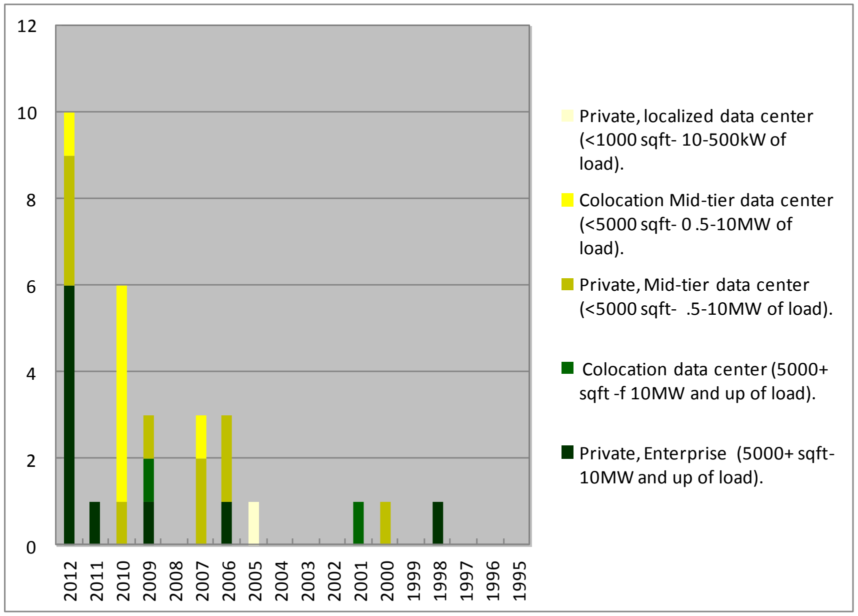


Figure 6-E: Year of Installation For Current Mechanical System

Year Of Last Server Equipment Refresh:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
2012	8	2	2	2	2	0
2011	4	0	0	3	0	1
2010	6	0	0	2	4	0
2009	3	2	0	1	0	0
2008	0	0	0	0	0	0
2007	0	0	0	0	0	0
2006	0	0	0	0	0	0
2005	0	0	0	0	0	0
2004	0	0	0	0	0	0
2003	0	0	0	0	0	0
2002	0	0	0	0	0	0
2001	0	0	0	0	0	0
2000	0	0	0	0	0	0
1999	0	0	0	0	0	0
1998	0	0	0	0	0	0
1997	0	0	0	0	0	0
1996	0	0	0	0	0	0
1995	0	0	0	0	0	0
Unknown	2	1	0	1	0	0

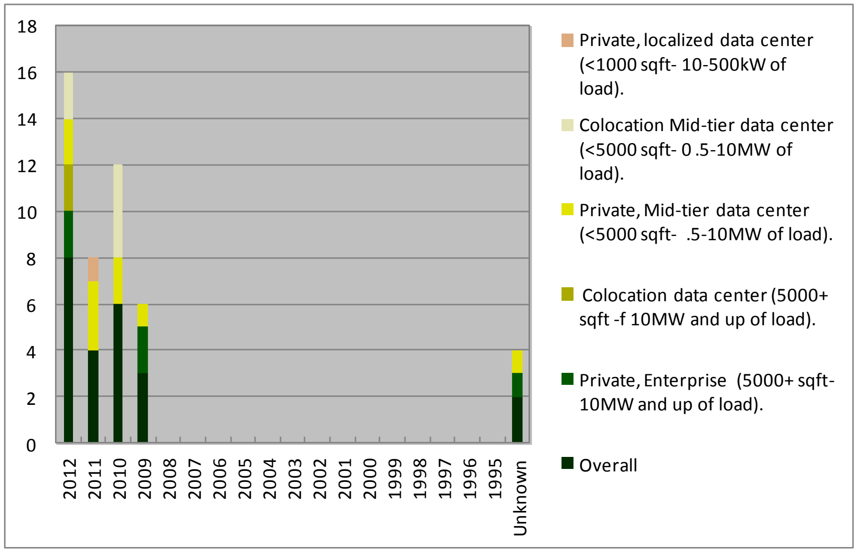


Figure 6-F: Year of Last Server Equipment Refresh

Server Equipment Refresh Was:						
	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
A Full Overhaul	13	5	1	4	3	0
A Partial Overhaul With Percentage Replaced:	10	0	1	5	3	1

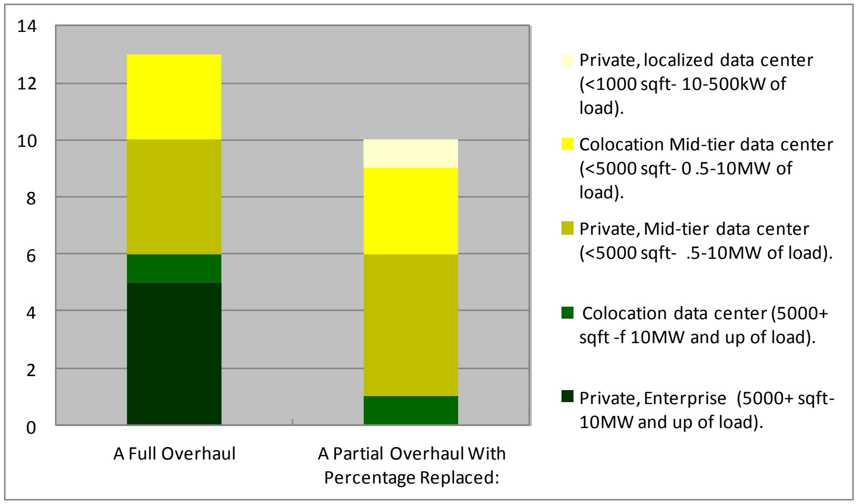


Figure 6-G: Server Equipment Refresh Was

Do You Consider Server Power Supply Efficiency When Purchasing New Server Equipment?						
	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
No	4	0	1	1	2	0
Don't Know	15	6	0	4	4	1
Yes	4	0	1	3	0	0

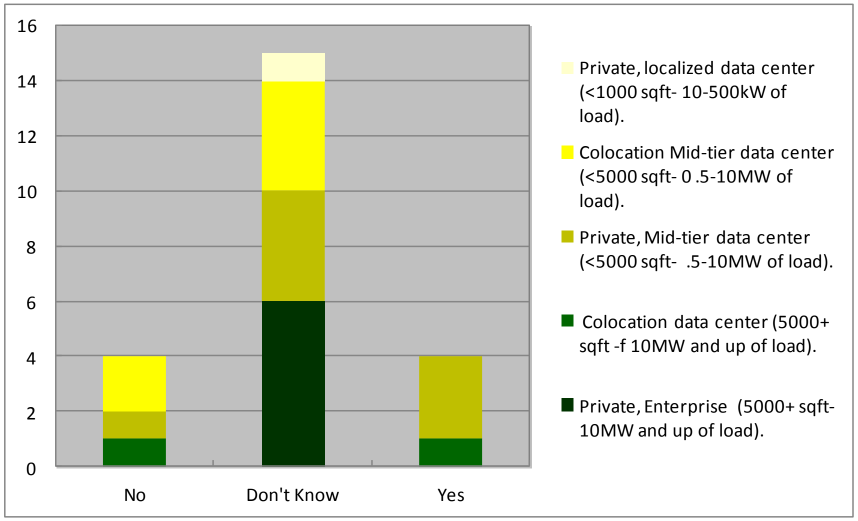


Figure 6-H: Do You Consider Server Power Supply Efficiency When Purchasing New Server Equipment?

Do You Consider CPU Power Usage When Purchasing New Server Equipment?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
No	4	0	1	1	2	0
Don't Know	14	5	0	4	4	1
Yes	7	1	1	5	0	0

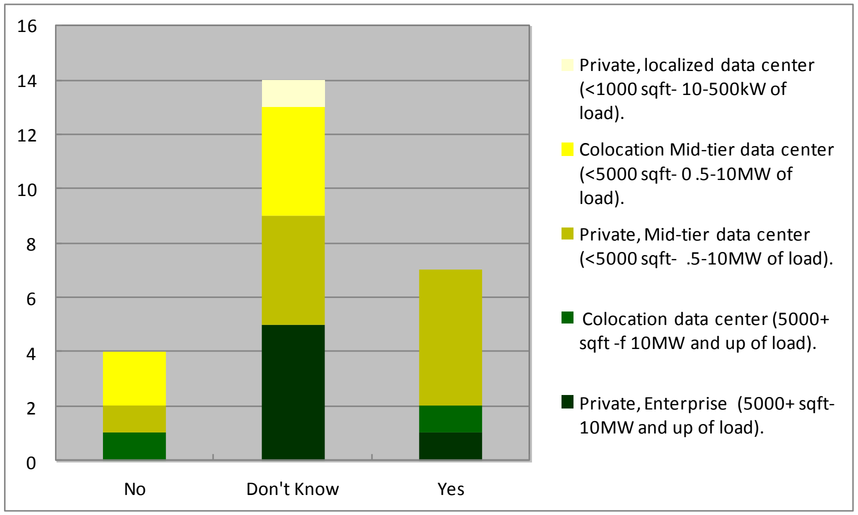


Figure 6-I: Do You Consider CPU Power Usage When Purchasing New Server Equipment?

Do You Consider CPU MIPS (Millions of Instructions Per Second) In Your Purchases?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
No	4	0	0	2	2	0
Don't Know	16	6	1	4	4	1
Yes	4	0	0	4	0	0

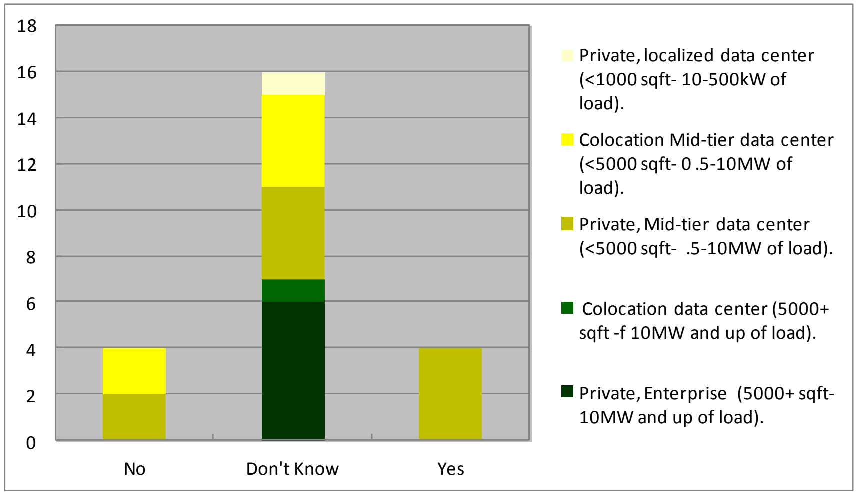


Figure 6-J: Do You Consider CPU MIPS (Millions of Instructions Per Second) In Your Purchases?

Do You Utilize Server Virtualization?						
	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
No	2	0	0	0	2	0
Don't Know	17	8	0	5	4	0
Yes	8	1	1	5	0	1

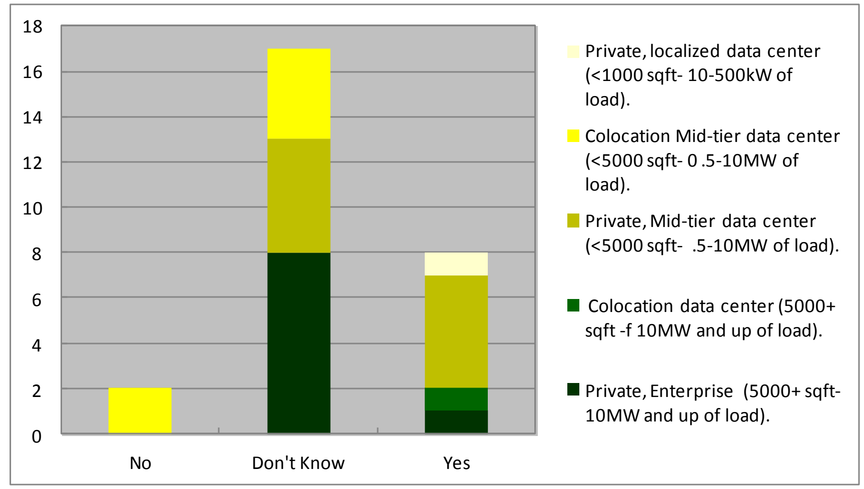


Figure 6-K: Do You Utilize Server Virtualization?

Redundancy In Cooling Equipment?						
	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	30	11	1	10	7	1
No	0	0	0	0	0	0

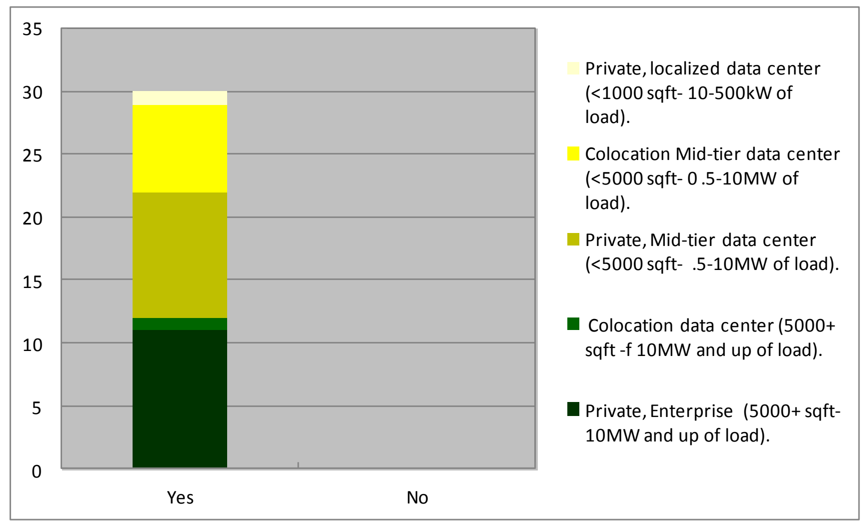


Figure 6-L: Redundancy In Cooling Equipment

Primary Cooling System Type:	Overall	Private, Enterprise (5000+ sqft-10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
CRAC (Computer Roor	5	0	0	2	2	1
CRAC DX - Water Coo	2	0	0	2	0	0
CRAH/AHU - Chilled W	8	4	0	1	3	0
CRAH/AHU - Chilled W	5	0	1	2	2	0
Evaporative Cooling + (	1	0	0	1	0	0
Evaporative Cooling + (	1	0	0	1	0	0
Evaporative Cooling + [	1	1	0	0	0	0
Evaporative Cooling Or	5	5	0	0	0	0
Other	1	0	0	1	0	0

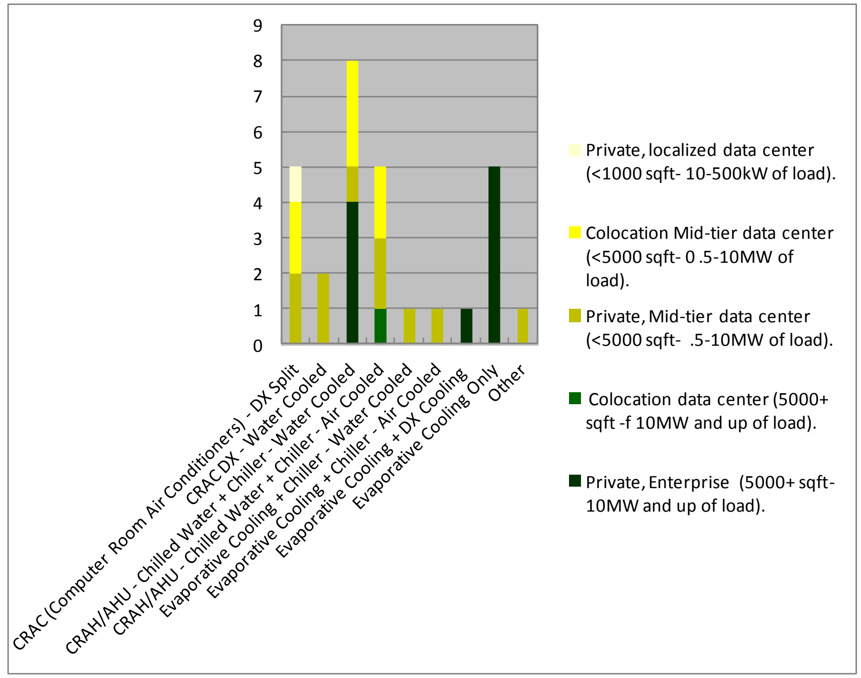


Figure 6-M: Primary Cooling System Type

DX Efficiency (EER/IEER) (Leave Blank If Unknown):	Overall	Private, Enterprise (5000+ sqft-10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Don't Know	2	0	0	1	0	1
Code Minimum	2	0	0	3	1	0
Better Than Code Minii	0	1	0	1	0	0

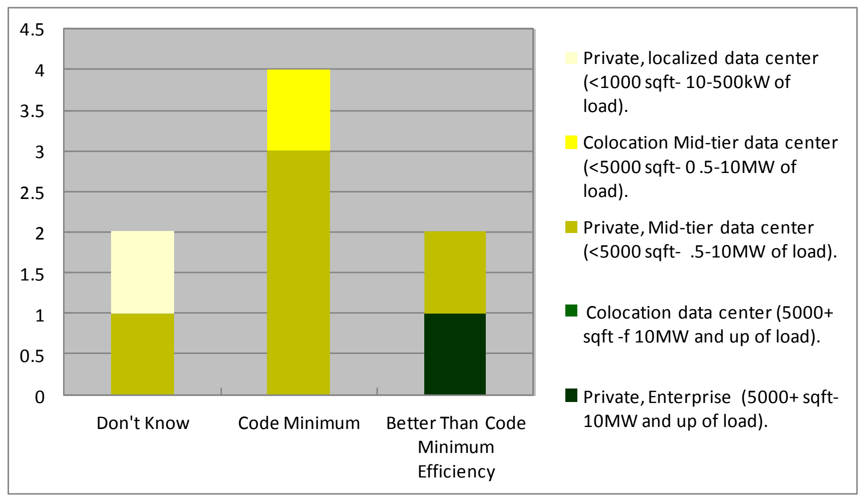


Figure 6-N: DX Efficiency (EER/IEER)

Fan Control: Cooling Tower, Fluid Cooler or Evaporator					
Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Cycle Fans On/Off	0	0	0	0	0
Two Speed Fans	0	0	0	0	0
Variable Frequency Drives	6	0	1	0	0
Other	0	0	0	0	0

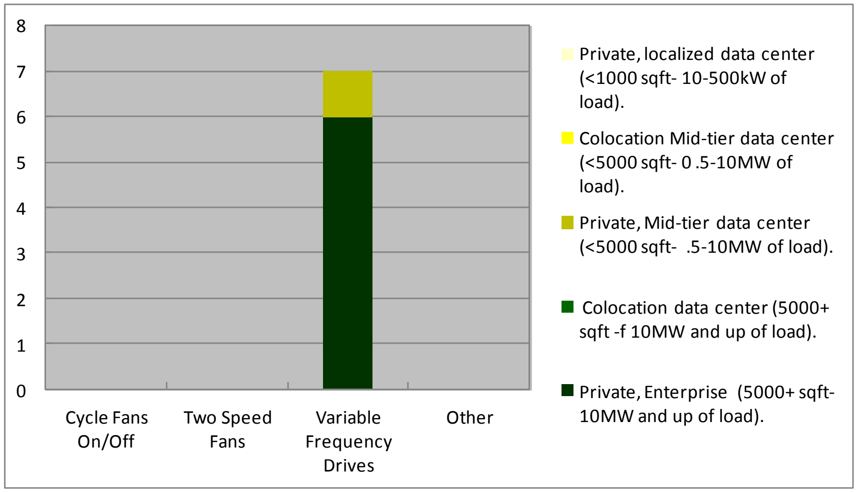


Figure 6-O: Fan Control: Cooling Tower, Fluid Cooler or Evaporator

Fan Energy: Cooling Tower, Fluid Cooler, or Evaporator					
Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Code Minimum	2	0	2	0	0
Don't Know	3	0	1	0	0
Better Than Code Minimum	1	0	1	0	0

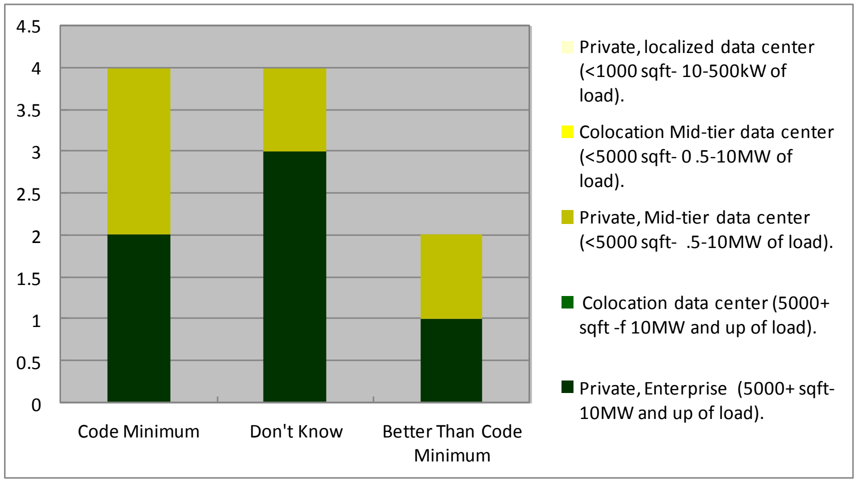


Figure 6-P: Fan Energy: Cooling Tower, Fluid Cooler, or Evaporator

Pump: Condenser Water or Evaporator					
Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Primary - Constant Volume	1	0	3	0	0
Primary - Variable Flow	4	0	1	0	0
Don't Know	0	0	0	0	0
Other	0	0	0	0	0

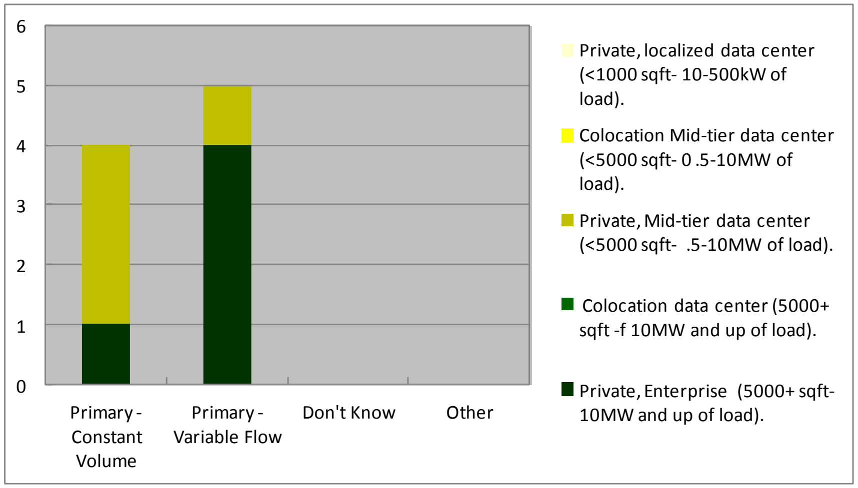


Figure 6-Q: Pump: Condenser Water or Evaporator

Do You Implement Demand Controlled Condenser Water Reset?					
Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	0	0	0	0	0
No	1	0	4	2	0
Don't Know	2	0	1	1	0

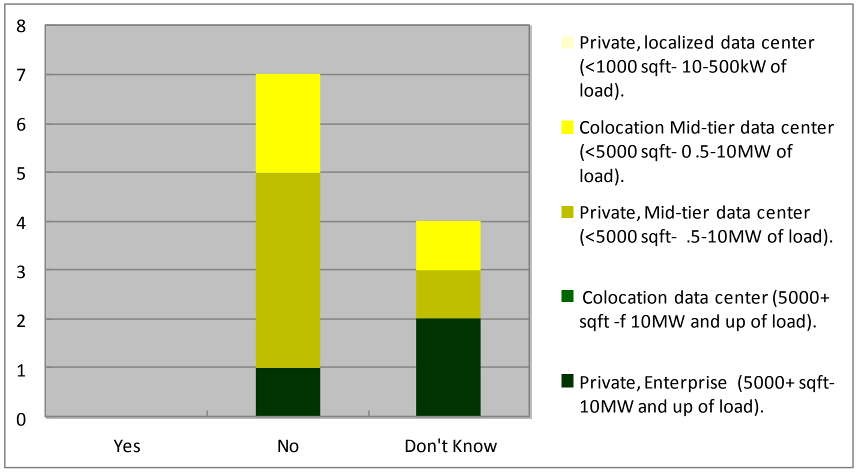


Figure 6-R: Do You Implement Demand Controlled Condenser Water Reset?

Chiller Efficiency (IPLV):	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Don't Know	0	0	1	0	0	0
Code Minimum	2	1	0	3	0	0
Better Than Code Minimum	5	2	0	3	5	0

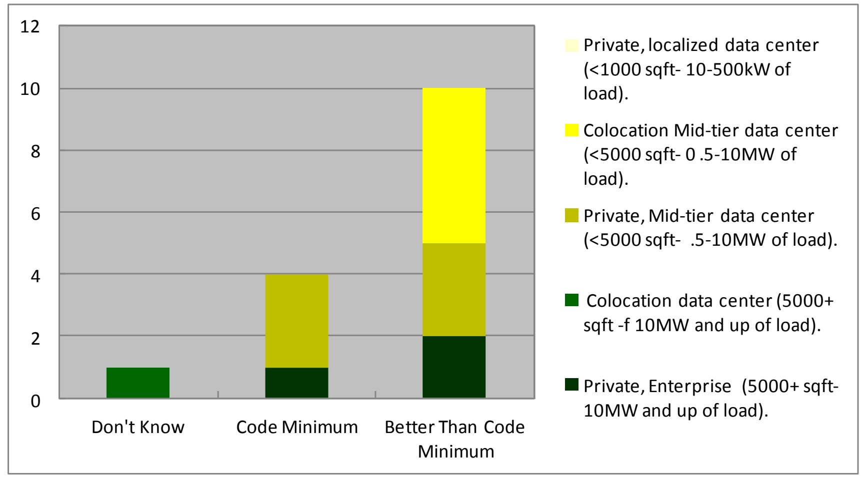


Figure 6-S: Chiller Efficiency (IPLV)

Chilled Water Pump Arrangement:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Primary - Constant Volume	0	0	0	0	0	0
Primary - Variable Flow	4	1	0	2	2	0
Primary/Secondary - Constant Volume	0	0	0	1	0	0
Primary/Secondary - Variable Flow	4	3	1	3	3	0
Don't Know	0	0	0	0	0	0
Other	0	0	0	0	0	0

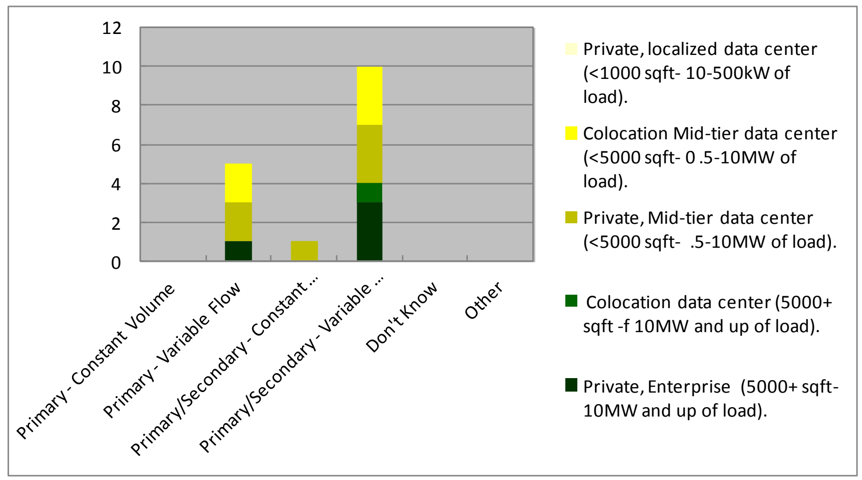


Figure 6-T: Chilled Water Pump Arrangement

Do You Implement Demand Controlled Chilled Water Reset?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	1	1	0	1	0	0
No	4	1	0	2	2	0
Don't Know	3	2	1	2	3	0

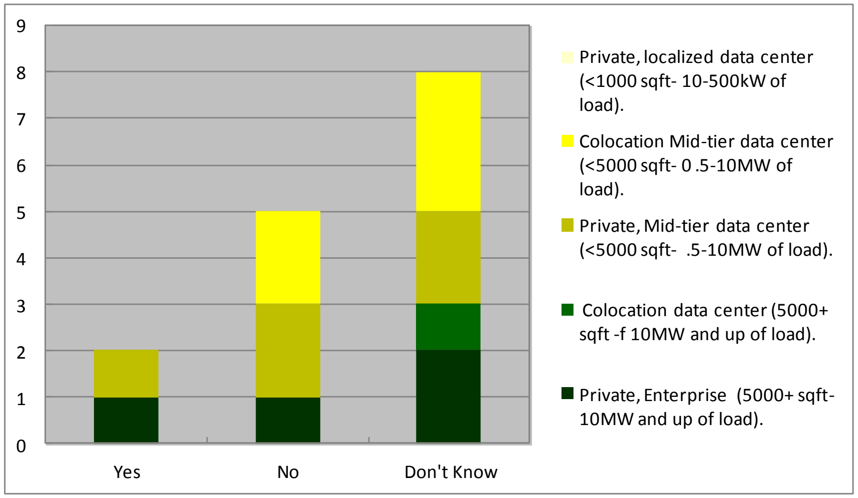


Figure 6-U: Do You Implement Demand Controlled Chilled Water Reset?

Data Center Supply Air:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Constant Volume	15	1	1	7	5	1
Variable Volume With Pressure Control	11	7	0	3	1	0
Variable Volume With Server Fan Flow Tracking	0	0	0	0	0	0
Variable Volume Linked To Cooling Valve Position	0	0	0	0	0	0
Don't Know	2	2	0	0	0	0
Other	0	0	0	0	0	0

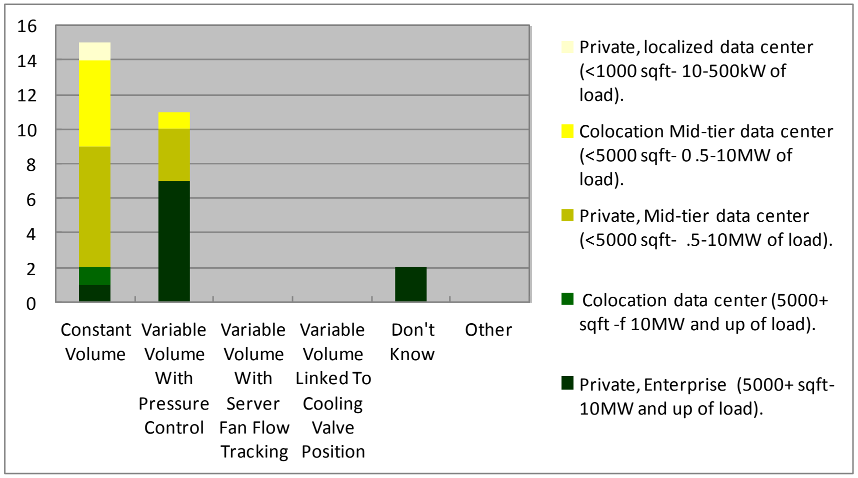


Figure 6-V: Data Center Supply Air

Do You Implement A Supply Air Temperature Reset?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	5	3	0	1	1	0
No	13	2	0	7	3	1
Don't Know	9	4	1	2	2	0

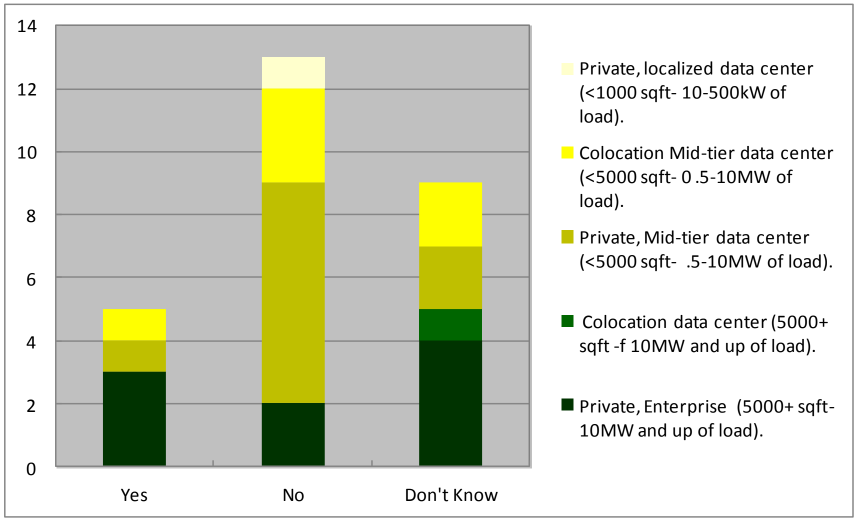


Figure 6-W: Do You Implement A Supply Air Temperature Reset?

Return Air Path:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Room	11	3	1	2	4	1
Ceiling Plenum	13	5	0	6	2	0
Ducted	3	1	0	2	0	0
Don't Know	0	0	0	0	0	0
Other	0	0	0	0	0	0

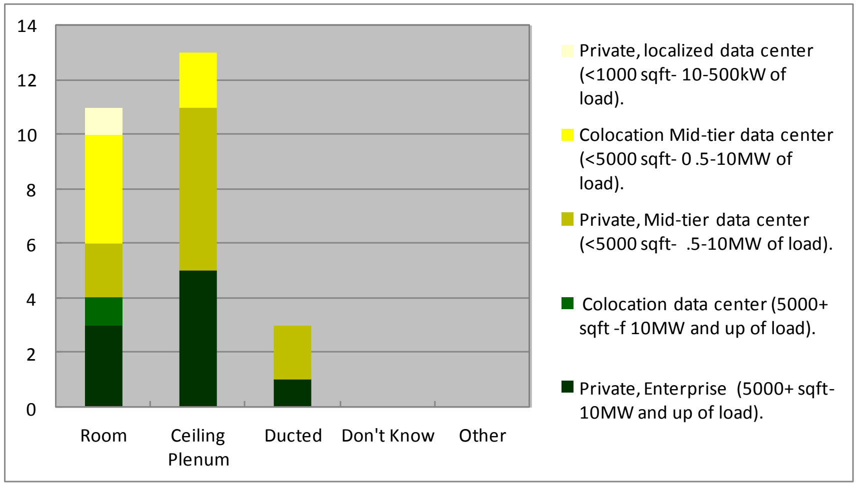


Figure 6-X: Return Air Path

Supply And/Or Return Fan Energy:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Fan Power Meets Energy Code Minimum	12	4	0	5	3	0
Better Than Energy Code Minimum	11	4	0	4	3	0
Don't Know	3	1	0	1	0	1

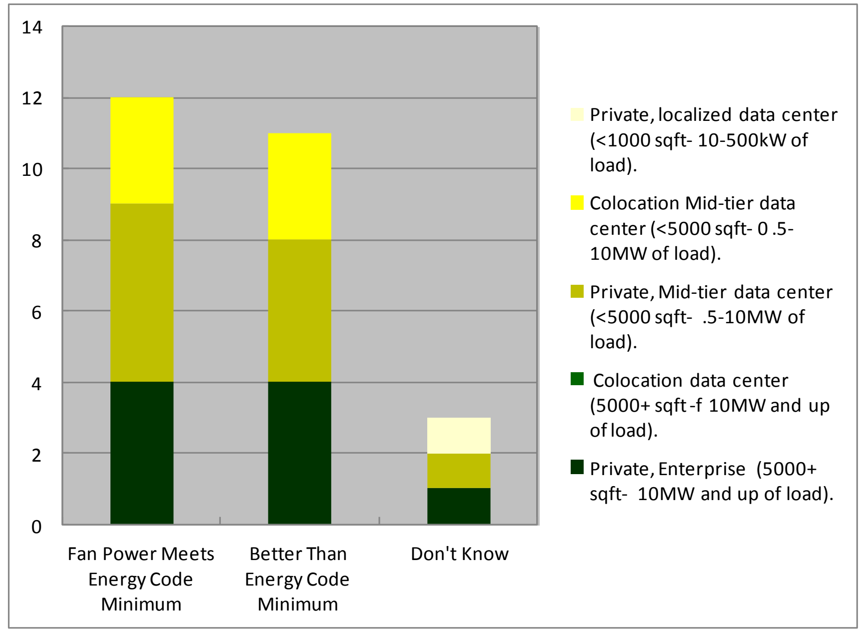


Figure 6-Y: Supply And/Or Return Fan Energy

Data Center Humidity Range (Allowable):	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
40 - 60%	2	2	0	0	0	0
30 - 70%	9	2	1	3	3	0
20 - 80%	13	3	0	7	3	0
10 - 90%	2	2	0	0	0	0
0 - 100%	1	0	0	0	0	1

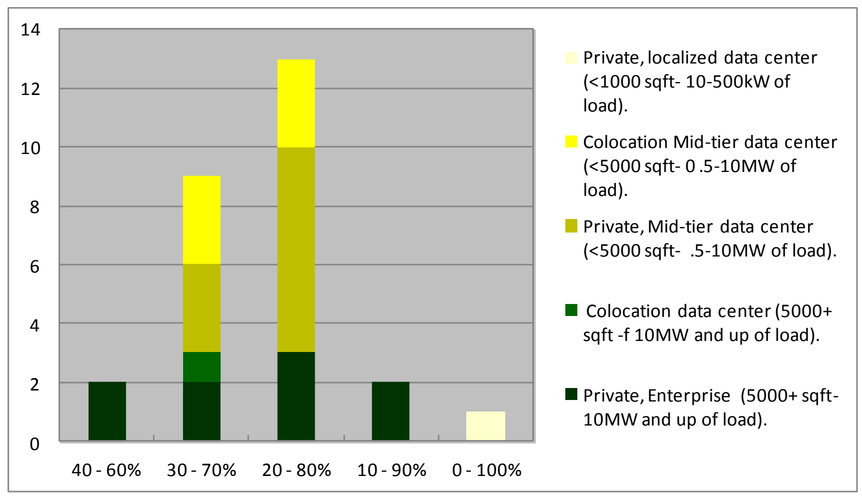


Figure 6-Z: Data Center Humidity Range (Allowable)

Humidification?	Overall	Private, Enterprise (5000+ sqft-10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	21	4	1	10	6	0
No	6	5	0	0	0	1
Don't Know	0	0	0	0	0	0

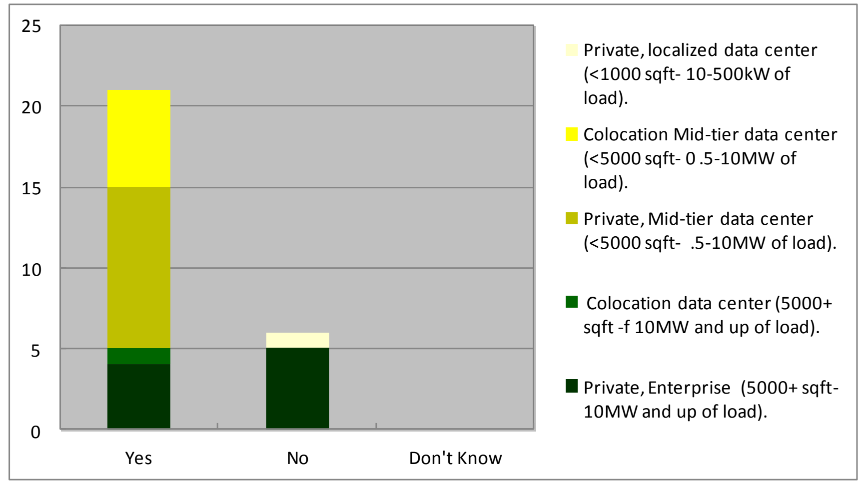


Figure 6-AA: Humidification

Humidification Type?	Overall	Private, Enterprise (5000+ sqft-10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Steam	9	0	0	6	3	0
Atomization	0	0	0	0	0	0
Ultrasonic	10	3	1	3	3	0
Wet Pad	2	1	0	1	0	0
Other	0	0	0	0	0	0

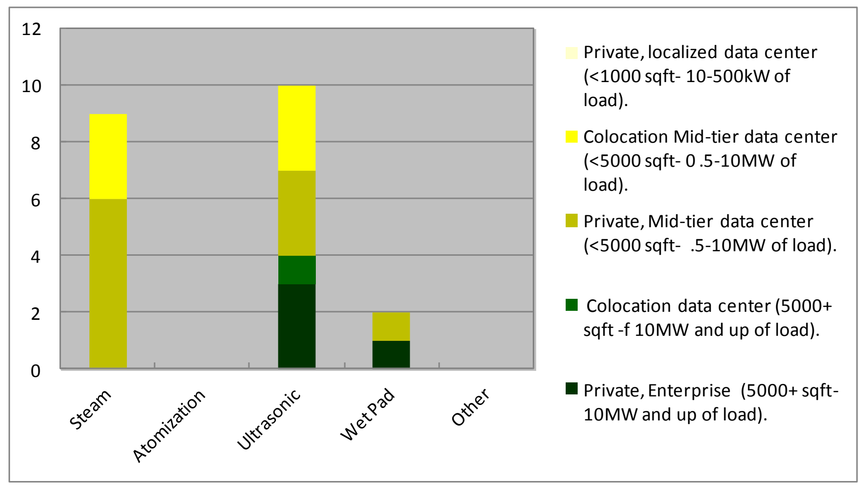


Figure 6-BB: Humidification Type

Dehumidification?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	9	3	0	3	3	0
No	16	6	0	7	3	0
Don't Know	2	0	1	0	0	1

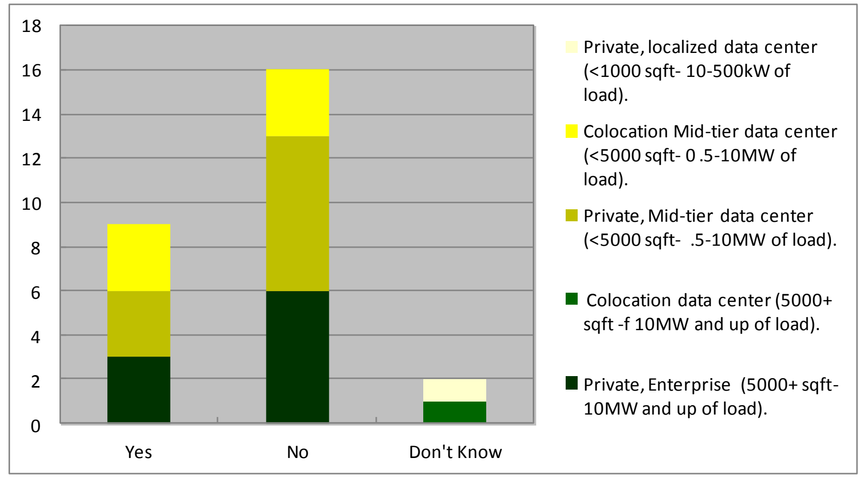


Figure 6-CC: Dehumidification

Dehumidification Lock-Out?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	1	0	0	1	0	0
No	2	0	0	1	1	0
Don't Know	6	3	0	1	2	0

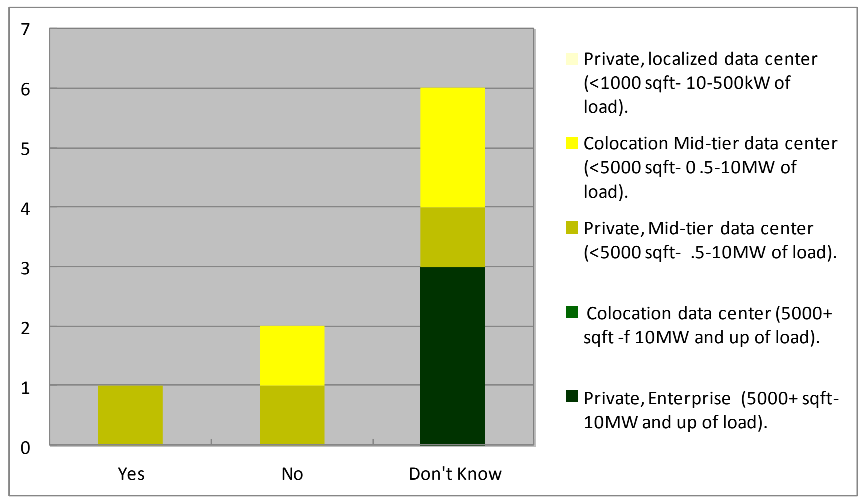


Figure 6-DD: Dehumidification Lock-Out

Dehumidification type:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Electric Reheat	8	2	0	3	3	0
Hot Water Reheat	0	0	0	0	0	0
Don't Know	1	1	0	0	0	0

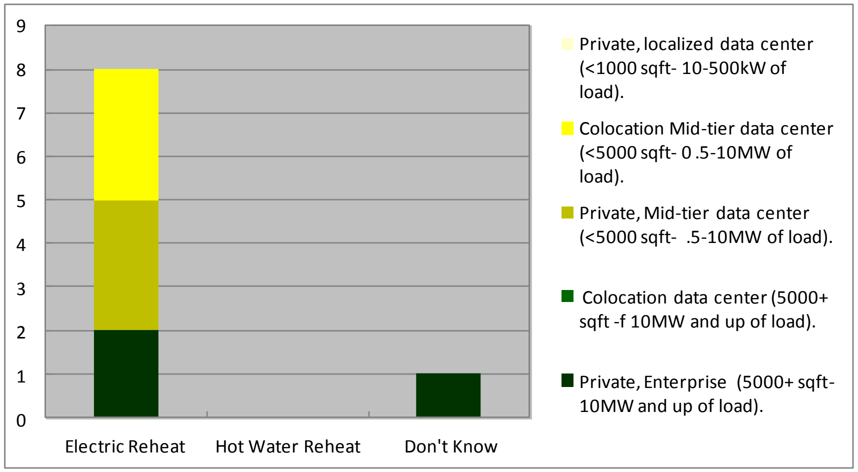


Figure 6-EE: Dehumidification Type

Do You Use A Free Cooling Economizer?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	20	9	1	6	4	0
No	7	0	0	4	2	1

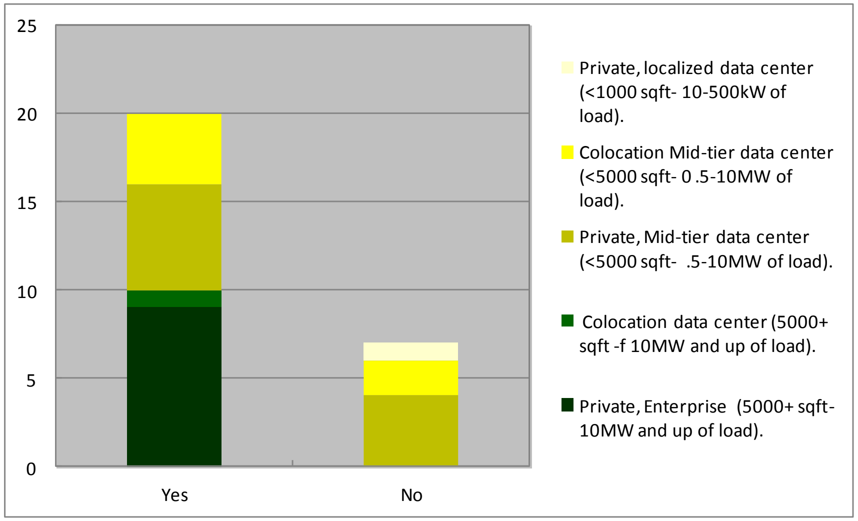


Figure 6-FF: Do You Use A Free Cooling Economizer?

What Type Of Economizer Equipment Is Used?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Outside Air Economizer With Mixing Box	7	4	0	2	1	0
Outside Air Economizer With Heat Wheel	0	0	0	0	0	0
Outside Air Economizer With Heat Pipe	0	0	0	0	0	0
Outside Air Economizer With Plate Frame Heat Exchanger	3	2	0	1	0	0
Hydronic Plate Frame Heat Exchanger	7	3	0	1	3	0
CRAC Unit Econocoil	2	0	0	2	0	0
Don't Know	1	0	1	0	0	0
Other	0	0	0	0	0	0

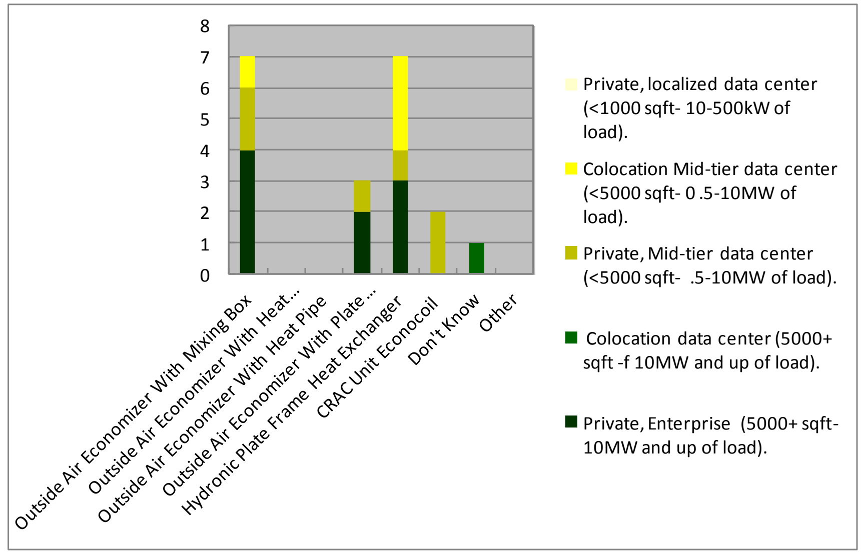


Figure 6-GG: What Type Of Economizer Equipment Is Used?

Do You Have Integrated Economizer Operation?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
No (Economizer and Mechanical Cooling Do Not Operate At The Same Time)	4	1	0	1	2	0
Yes (Economizer and Mechanical Cooling Can Operate Simultaneously)	16	8	1	5	2	0
Don't Know	0	0	0	0	0	0

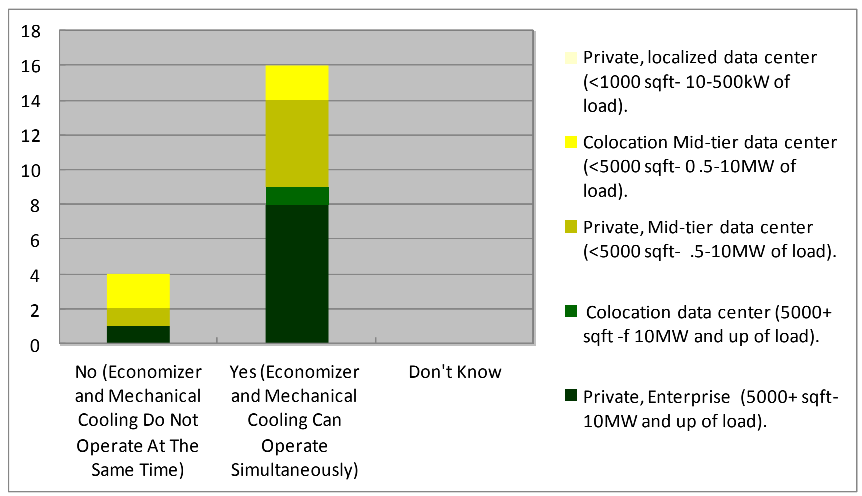


Figure 6-HH: Do You Have Integrated Economizer Operation?

Economizer Operates With Outside Air Conditions Less Than:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
40DB / 35WB	0	0	0	0	0	0
45DB / 40WB	3	0	0	3	0	0
50DB / 45WB	5	2	0	1	2	0
55DB / 50WB	1	1	0	0	0	0
60DB / 55WB	0	0	0	0	0	0
65DB / 60WB	0	0	0	0	0	0
70DB / 65WB	2	2	0	0	0	0
Higher?	3	2	0	1	0	0

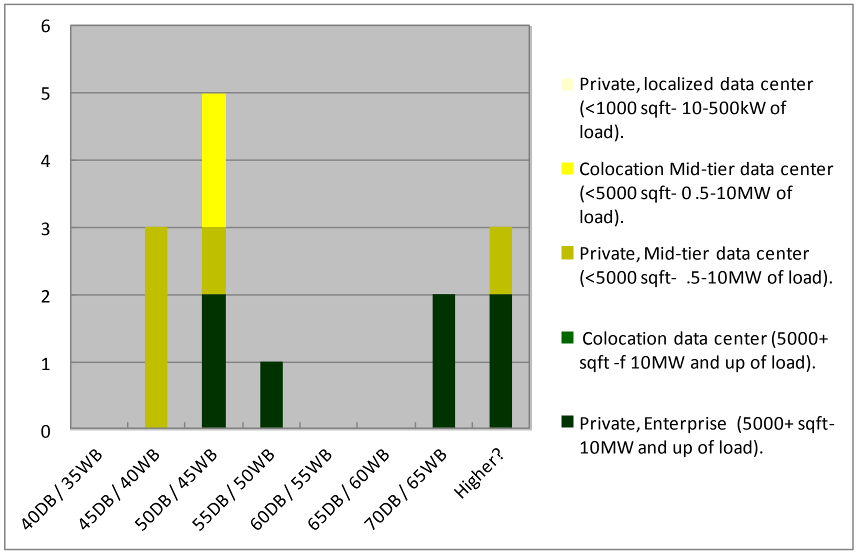


Figure 6-II: Economizer Operates With Outside Air Conditions Less Than

Is Evaporative Cooling Used?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Direct	5	4	0	1	0	0
Indirect	5	3	0	2	0	0
None	16	2	0	7	6	1

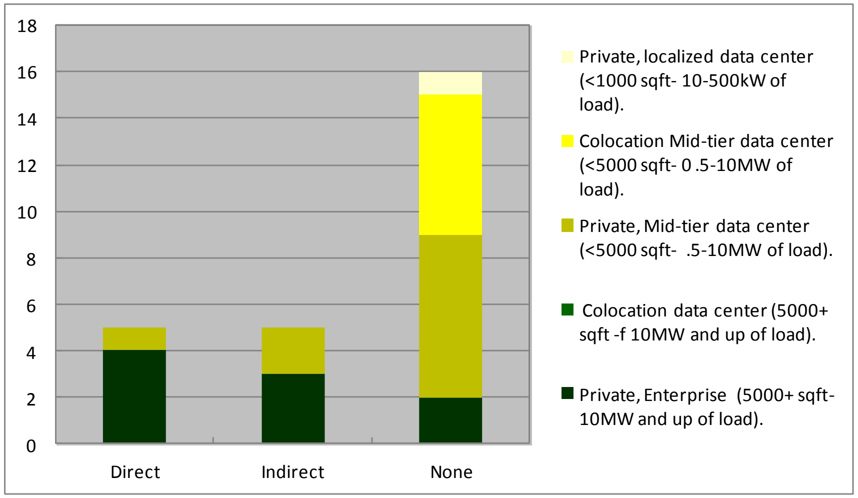


Figure 6-JJ: Is Evaporative Cooling Used?

Evaporatie Cooling Operation At Outside Air Conditions Less Than:

	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
50DB / 45WB	2	0	0	2	0	0
55DB / 50WB	0	0	0	0	0	0
60DB / 55WB	1	1	0	0	0	0
65DB / 60WB	0	0	0	0	0	0
70DB / 65WB	0	0	0	0	0	0
75DB / 70WB	0	0	0	0	0	0
80DB / 75WB	2	1	0	1	0	0
Higher	2	2	0	0	0	0

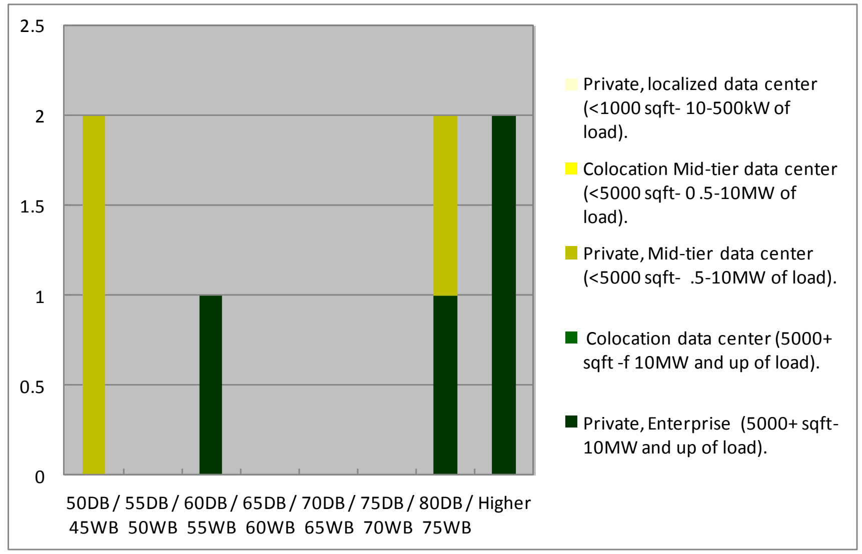


Figure 6-KK: Economizer Operates With Outside Air Conditions Less Than

Evaporatie Cooling Operation At Outside Air Conditions Less Than:

	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
50DB / 45WB	2	0	0	2	0	0
55DB / 50WB	0	0	0	0	0	0
60DB / 55WB	1	1	0	0	0	0
65DB / 60WB	0	0	0	0	0	0
70DB / 65WB	0	0	0	0	0	0
75DB / 70WB	0	0	0	0	0	0
80DB / 75WB	2	1	0	1	0	0
Higher	2	2	0	0	0	0

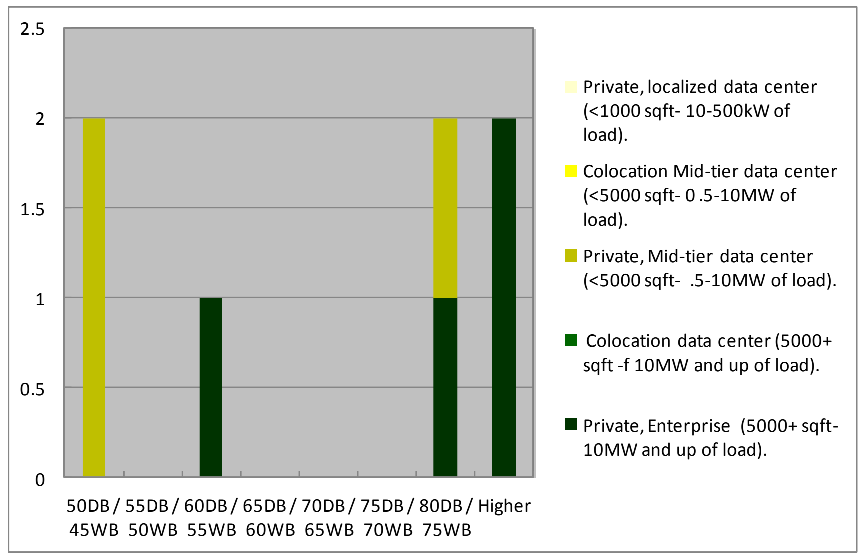


Figure 6-LL: Evaporative Cooling Operation At Outside Air Conditions Less Than

Primary Electrical Metering - Data Center Total:

	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Incoming Service	23	7	1	9	6	0
None	0	0	0	0	0	0
Don't Know	2	1	0	0	0	1
Other	0	0	0	0	0	0

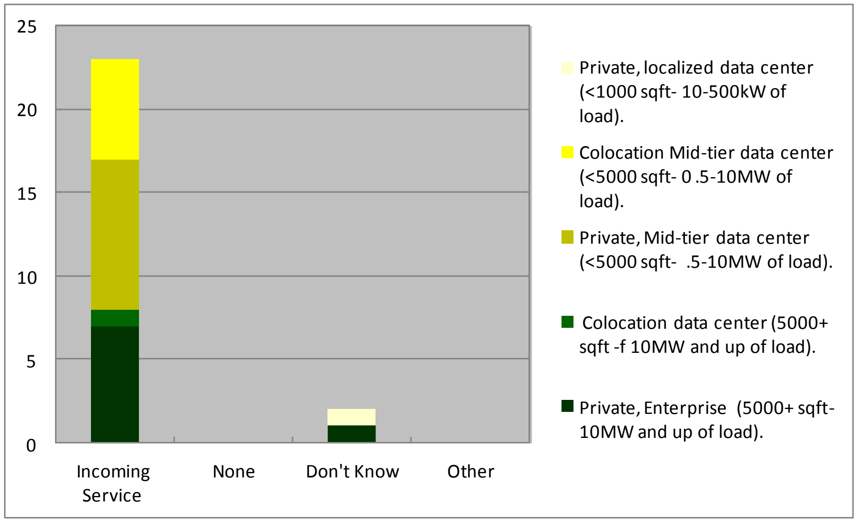


Figure 6-MM: Primary Electrical Metering - Data Center Total

Electrical Metering - IT Load:

	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
UPS Input	0	0	0	0	0	0
UPS Output	9	2	0	3	3	1
Rack	11	2	1	5	3	0
None	1	0	0	1	0	0
Don't Know	3	3	0	0	0	0
Other	1	1	0	0	0	0

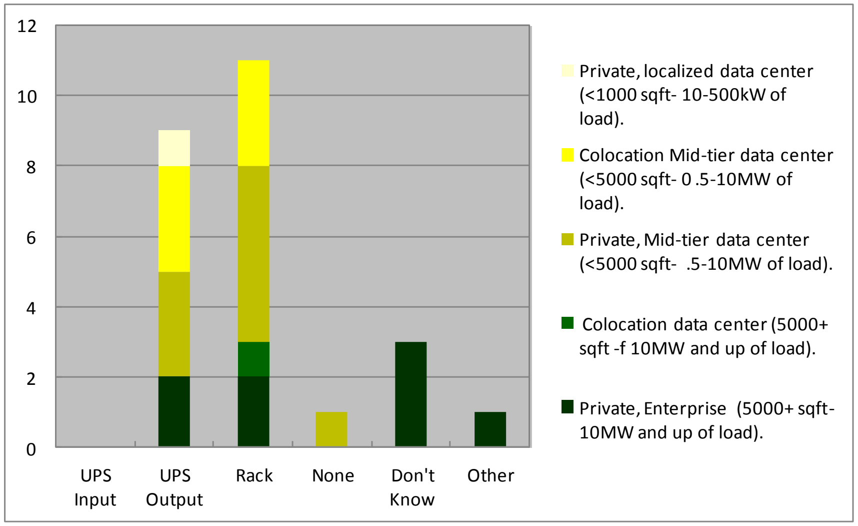


Figure 6-NN: Electrical Metering - IT Load

Power Distribution Unit (PDU) Efficiency (%):	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
<75	0	0	0	0	0	0
<80	0	0	0	0	0	0
<85	0	0	0	0	0	0
<90	0	0	0	0	0	0
<95	2	1	0	1	0	0
<99	8	2	0	2	3	1
>99	11	1	1	6	3	0
Don't know	3	3	0	0	0	0

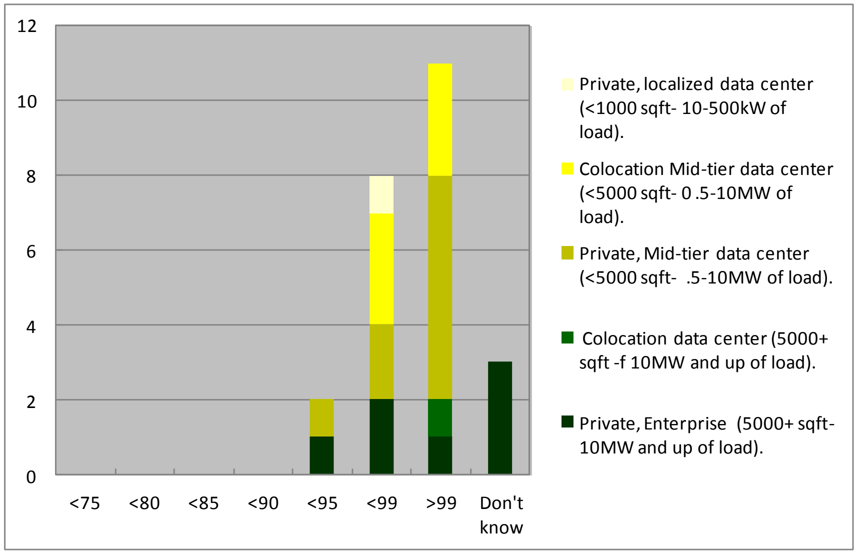


Figure 6-OO: Power Distribution Unit (PDU) Efficiency (%)

Uninterruptable Power Supply (UPS) Type:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Double Conversion	14	4	0	6	4	0
Line Interactive	6	1	0	2	2	1
Don't Know	3	2	1	0	0	0
None	2	1	0	1	0	0

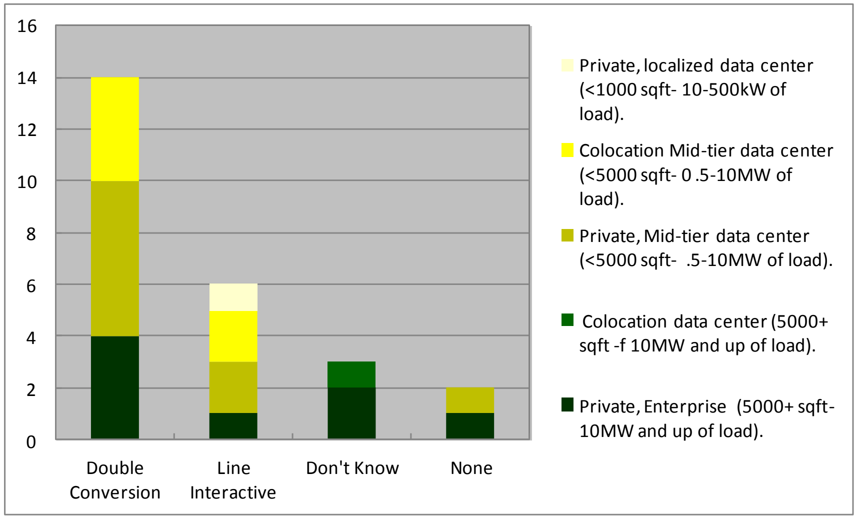


Figure 6-PP: Uninterruptable Power Supply (UPS) Type

Redundancy In UPS Equipment?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	24	8	1	8	6	1
No	0	0	0	0	0	0

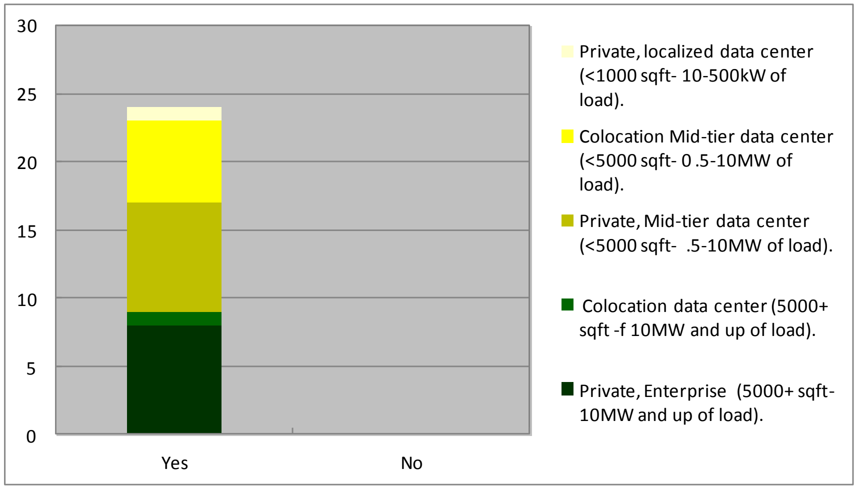


Figure 6-QQ: Redundancy In UPS Equipment

Lighting Controls:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Always On	1	1	0	0	0	0
Manual Switching	11	3	1	3	3	1
Occupancy Sensor/Time Delay	12	3	0	6	3	0
Other	0	0	0	0	0	0

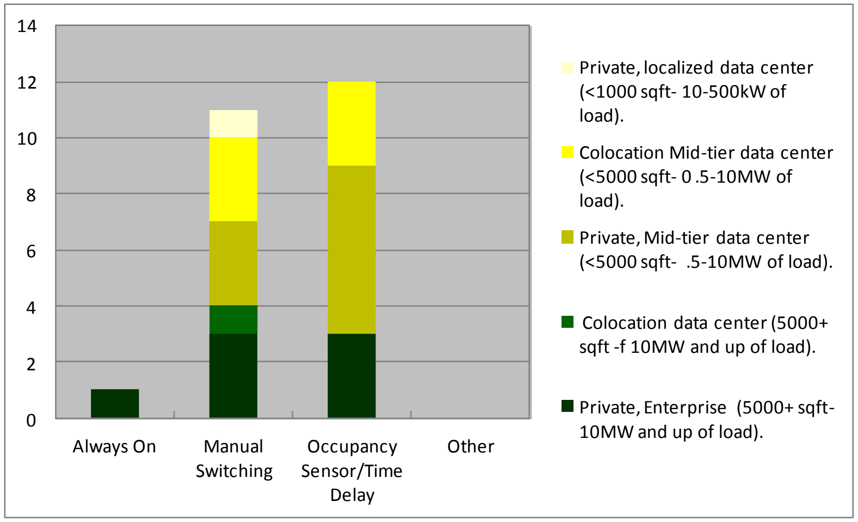


Figure 6-RR: Lighting Controls

Typical Server Rack Load - Area 1:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
<4 kW/Rack	6	0	1	2	3	0
4-10 kW/Rack	13	6	0	4	3	0
>10 kW/Rack	2	0	0	2	0	0

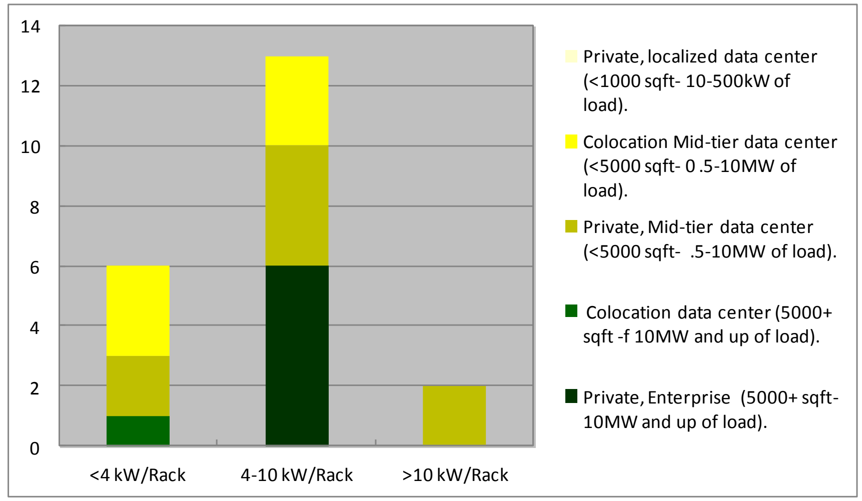


Figure 6-SS: Typical Server Rack Load - Area 1

Morning Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	3	1	1	1	0	0
High (>75%)	0	0	0	0	0	0
Unknown	17	4	0	7	6	0
Mean	3.70	3.60	2.00	3.75	4.00	0.00

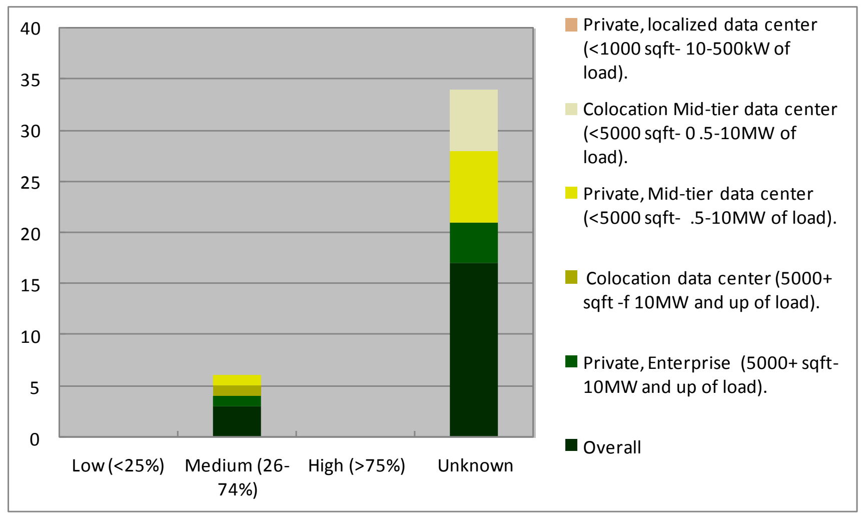


Figure 6-TT: Morning Server Load

Midday Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	3	1	1	1	0	0
High (>75%)	0	0	0	0	0	0
Unknown	17	4	0	7	6	0
Mean	3.70	3.60	2.00	3.75	4.00	0.00

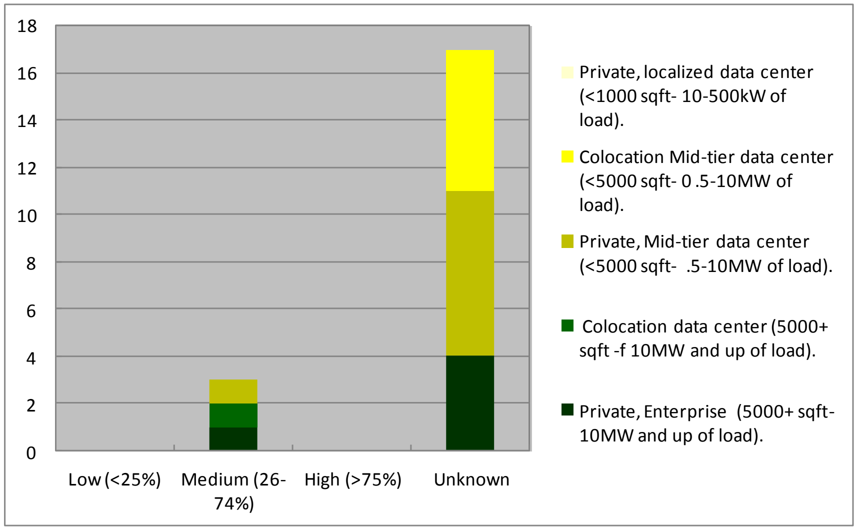


Figure 6-UU: Midday Server Load

Afternoon Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	3	1	1	1	0	0
High (>75%)	0	0	0	0	0	0
Unknown	17	4	0	7	6	0
Mean	3.70	3.60	2.00	3.75	4.00	0.00

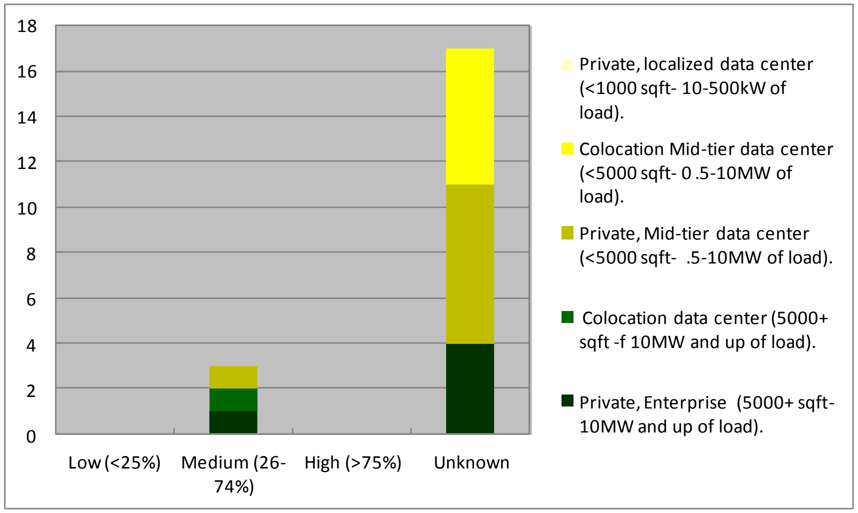


Figure 6-VV: Afternoon Server Load

Evening Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	1	0	0	1	0	0
Medium (26-74%)	2	1	1	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	16	4	0	7	5	0
Mean	3.63	3.60	2.00	3.63	4.00	0.00

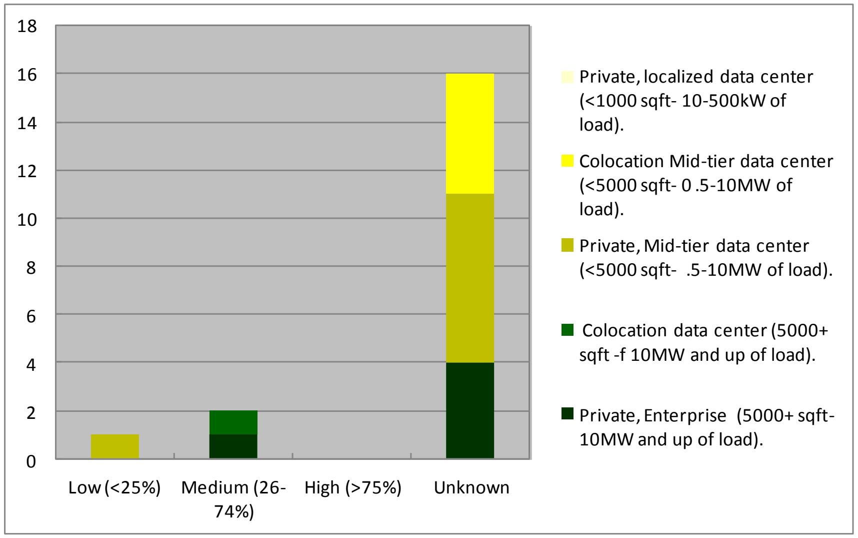


Figure 6-WW: Evening Server Load

Nighttime Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	1	0	0	1	0	0
Medium (26-74%)	2	1	1	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	17	4	0	7	6	0
Mean	3.65	3.60	2.00	3.63	4.00	0.00

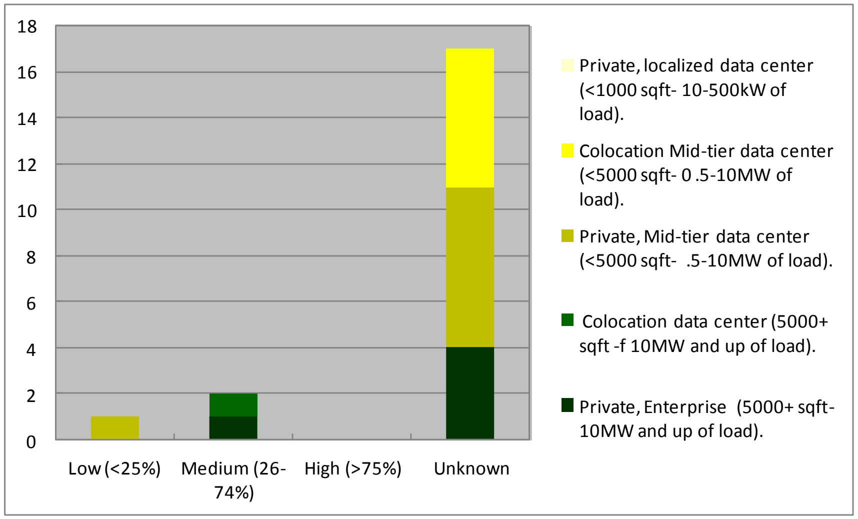


Figure 6-XX: Nighttime Server Load

Weekday Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	3	1	1	1	0	0
High (>75%)	0	0	0	0	0	0
Unknown	17	4	0	7	6	0
Mean	3.70	3.60	2.00	3.75	4.00	0.00

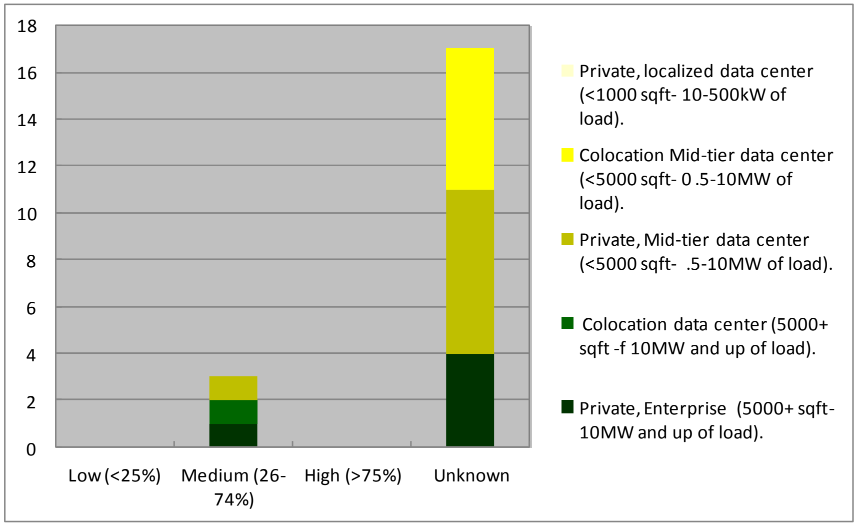


Figure 6-YY: Weekday Server Load

Saturday Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	1	0	0	1	0	0
Medium (26-74%)	2	1	1	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	17	4	0	7	6	0
Mean	3.65	3.60	2.00	3.63	4.00	0.00

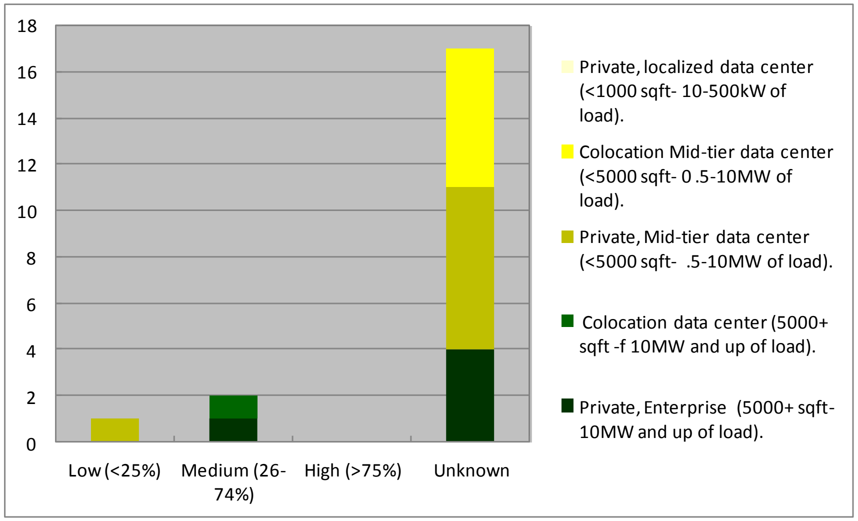


Figure 6-ZZ: Saturday Server Load

Sunday Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	1	0	0	1	0	0
Medium (26-74%)	2	1	1	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	17	4	0	7	6	0
Mean	3.65	3.60	2.00	3.63	4.00	0.00

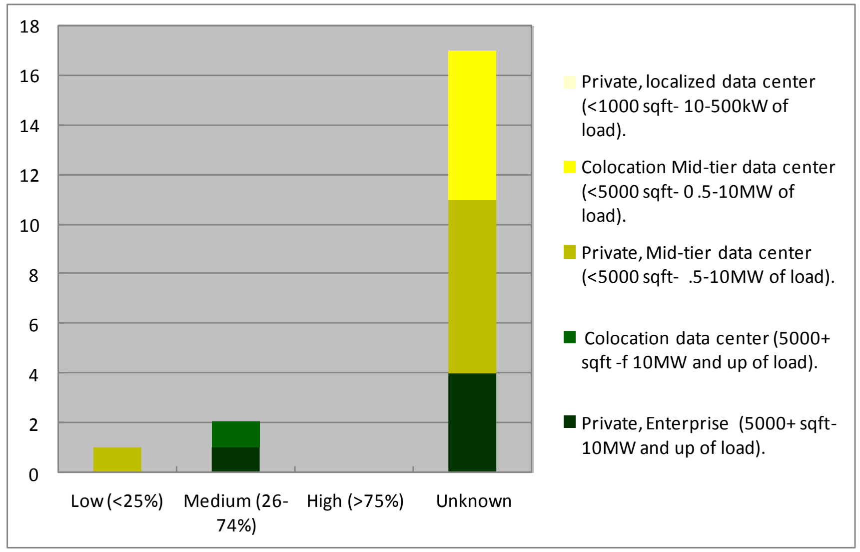


Figure 6-AAA: Sunday Server Load

Spring Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	3	1	1	1	0	0
High (>75%)	0	0	0	0	0	0
Unknown	17	4	0	7	6	0
Mean	3.70	3.60	2.00	3.75	4.00	0.00

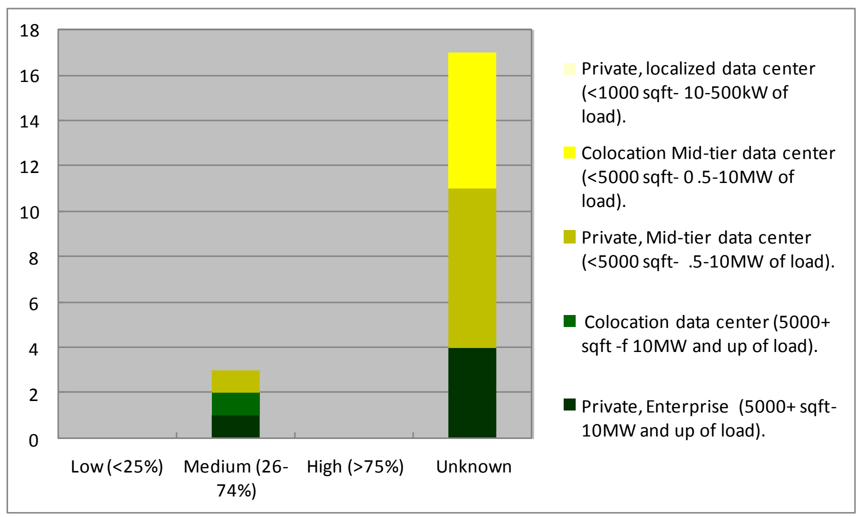


Figure 6-BBB: Spring Server Load

Summer Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	3	1	1	1	0	0
High (>75%)	0	0	0	0	0	0
Unknown	15	4	0	5	6	0
Mean	3.67	3.60	2.00	3.67	4.00	0.00

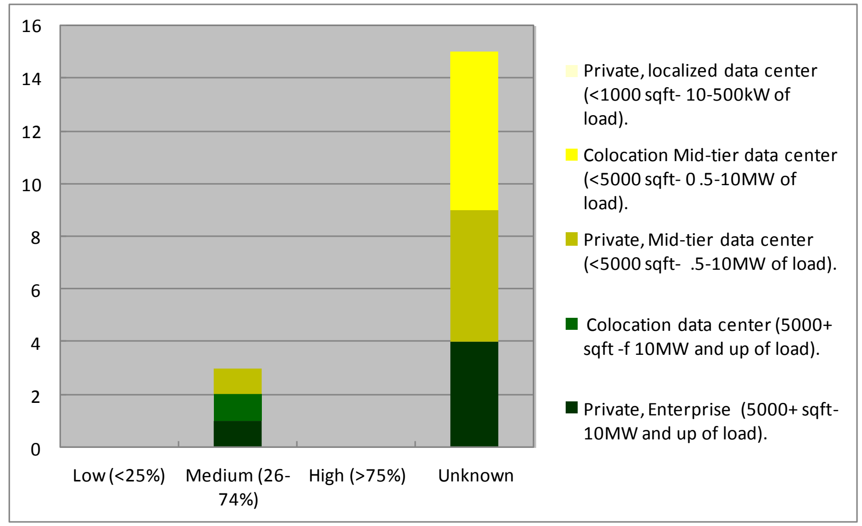


Figure 6-CCC: Summer Server Load

Fall Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	3	1	1	1	0	0
High (>75%)	0	0	0	0	0	0
Unknown	14	4	0	5	5	0
Mean	3.65	3.60	2.00	3.67	4.00	0.00

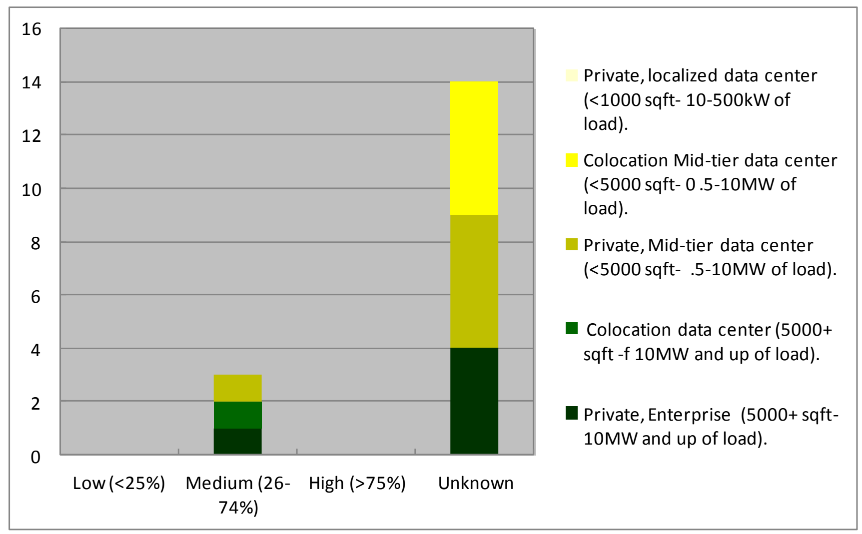


Figure 6-DDD: Fall Server Load

Winter Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	3	1	1	1	0	0
High (>75%)	0	0	0	0	0	0
Unknown	15	4	0	5	6	0
Mean	3.67	3.60	2.00	3.67	4.00	0.00

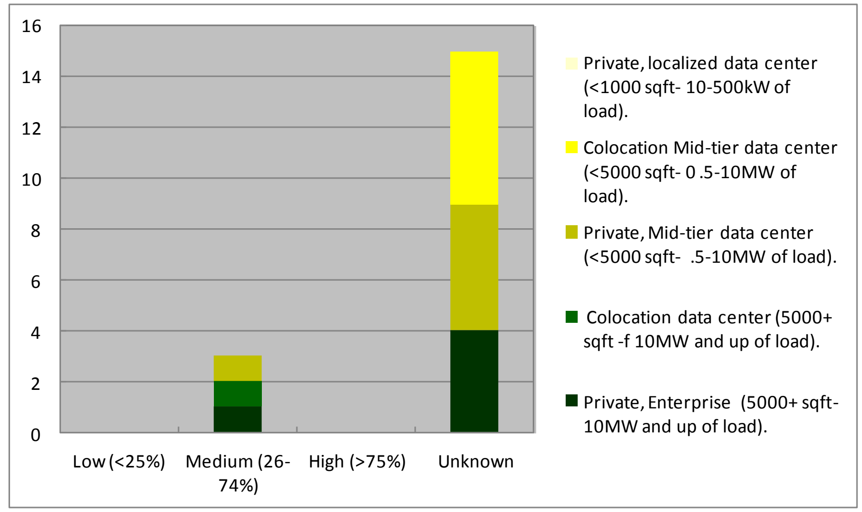


Figure 6-EEE: Winter Server Load

Cooling System Type - Area 1:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
AHU/RTU	4	2	0	2	0	0
CRAC (Computer Room Air Conditioner)	5	0	0	3	1	1
CRAH (Computer Room Air Handler)	14	5	1	3	5	0
In Row Cooler	1	0	0	1	0	0
In Rack Cabinet Cooler	0	0	0	0	0	0
Other	0	0	0	0	0	0

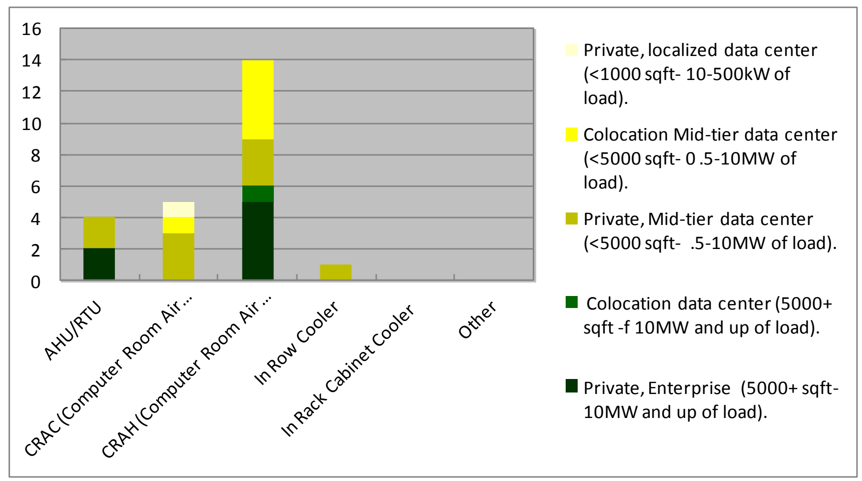


Figure 6-FFF: Cooling System Type - Area 1

Raised Floor Supply - Area 1?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	13	4	1	5	3	0
No	10	3	0	3	3	1
Don't Know	0	0	0	0	0	0

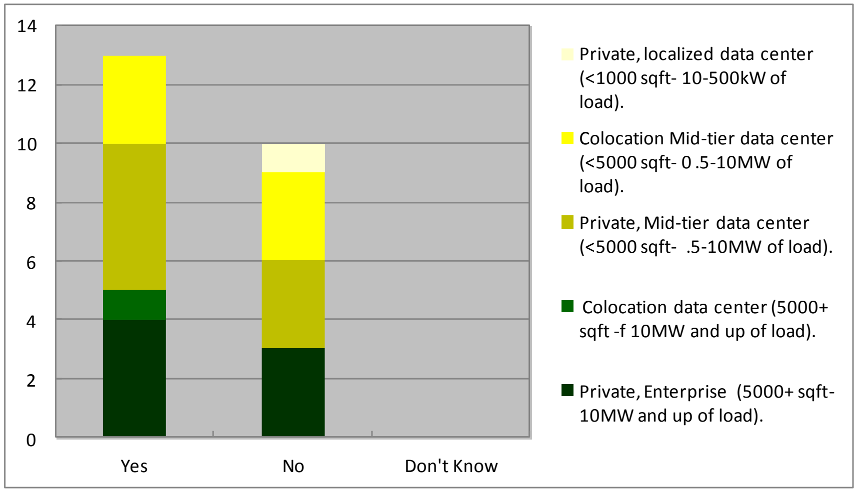


Figure 6-GGG: Raised Floor Supply - Area 1

Do Server Racks Employ Hot Aisle/Cold Aisle Configuration In Area 1?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes, Partial Hot Aisle Containment	3	1	0	1	1	0
Yes, Partial Cold Aisle Containment	3	1	0	1	0	1
Yes, Full Hot Aisle Containment	6	3	0	3	0	0
Yes, Full Cold Aisle Containment	2	1	0	0	1	0
No	5	1	0	2	2	0
Don't Know	3	0	0	1	2	0

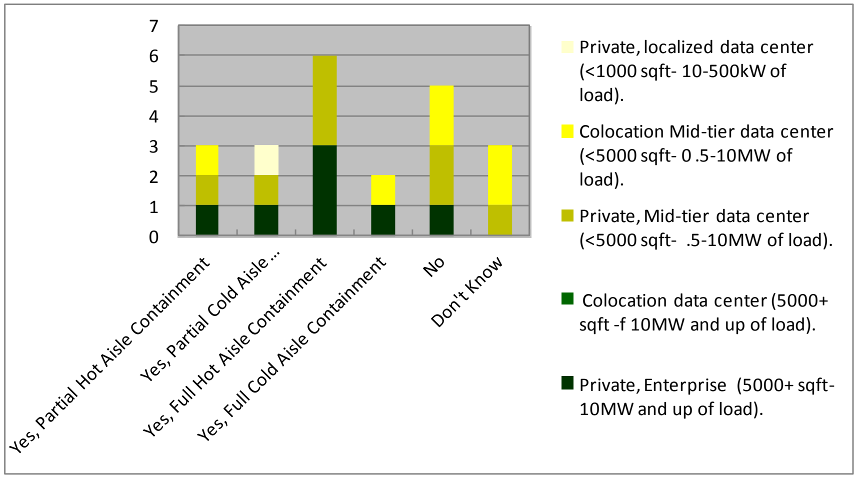


Figure 6-HHH: Do Server Racks Employ Hot Aisle/Cold Aisle Configuration In Area 1?

Containment Type - Area 1:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Aisle Containment (Curtains)	8	3	0	3	2	0
Aisle Containment (Rigid)	3	2	0	1	0	0
Rack Chimneys	1	0	0	1	0	0
In Rack Containment	0	0	0	0	0	0
Other	1	0	0	0	0	1

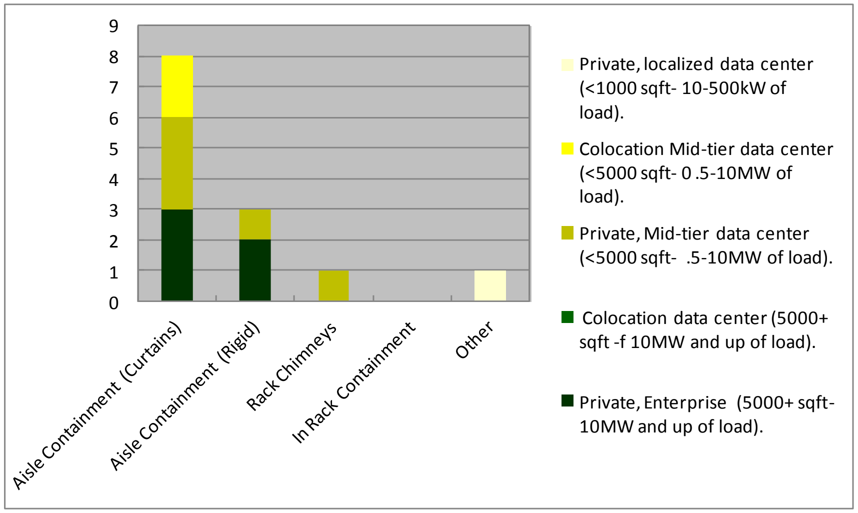


Figure 6-III: Containment Type - Area 1

Do you have a second unique data center area to report?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes, Proceed to Data Center Area 2	3	1	0	2	0	0
No, Proceed to Final Section of the Survey	22	7	1	7	6	1

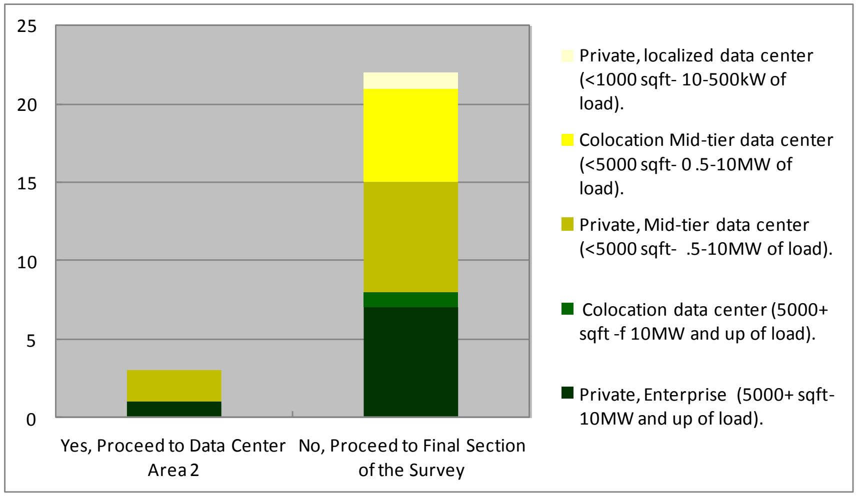


Figure 6-JJJ: Do You Have A Second Unique Data Center Area To Report?

Typical Server Rack Load - Area 2:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
<4 kW/Rack	0	0	0	0	0	0
4-10 kW/Rack	1	1	0	0	0	0
>10 kW/Rack	2	0	0	2	0	0

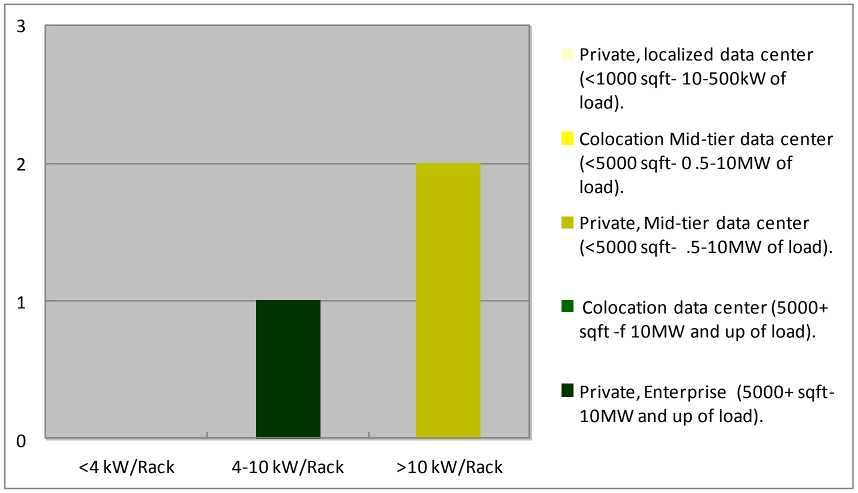


Figure 6-KKK: Typical Server Rack Load - Area 2

Morning Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

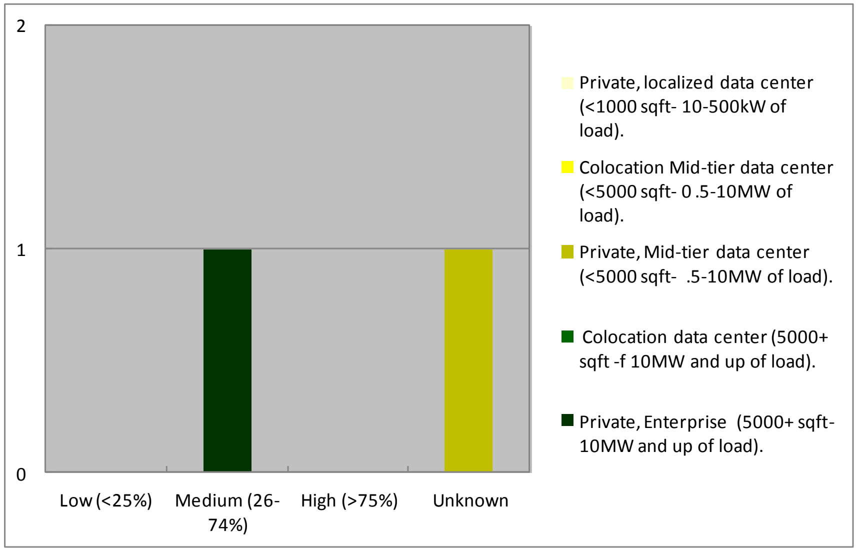


Figure 6-LLL: Morning Server Load

Midday Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

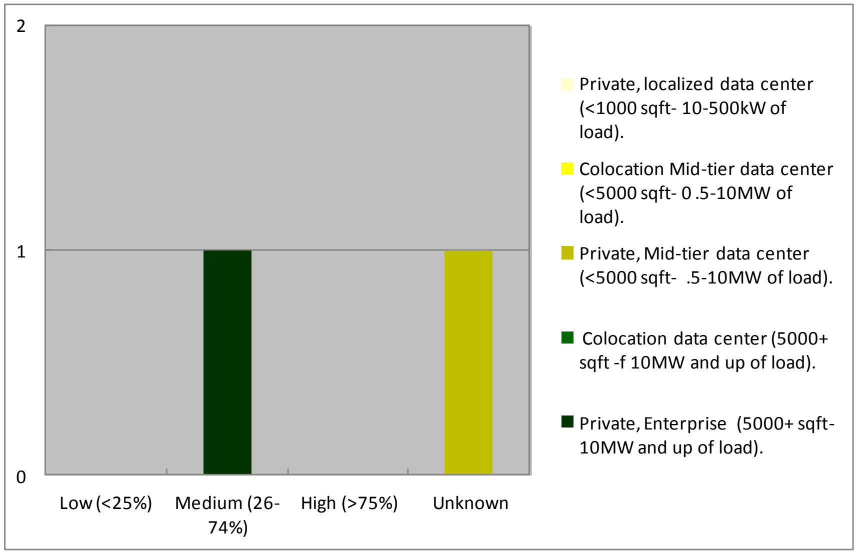


Figure 6-MMM: Midday Server Load

Afternoon Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

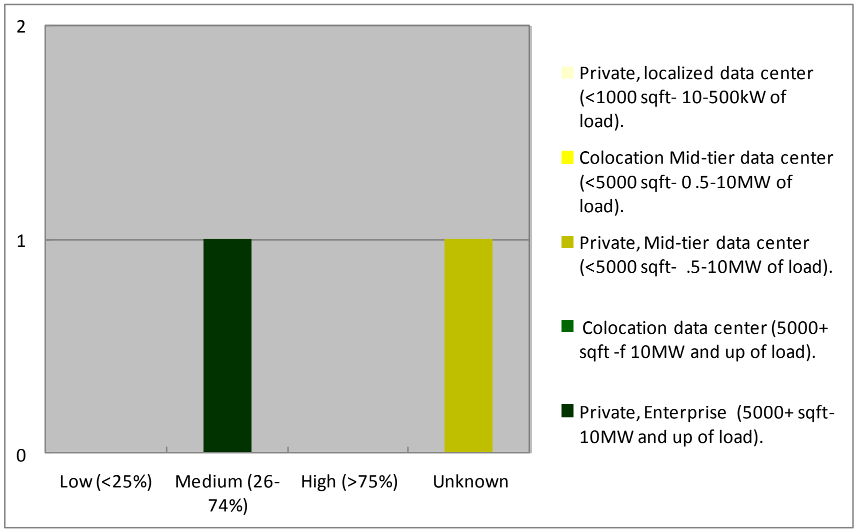


Figure 6-NNN: Afternoon Server Load

Evening Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

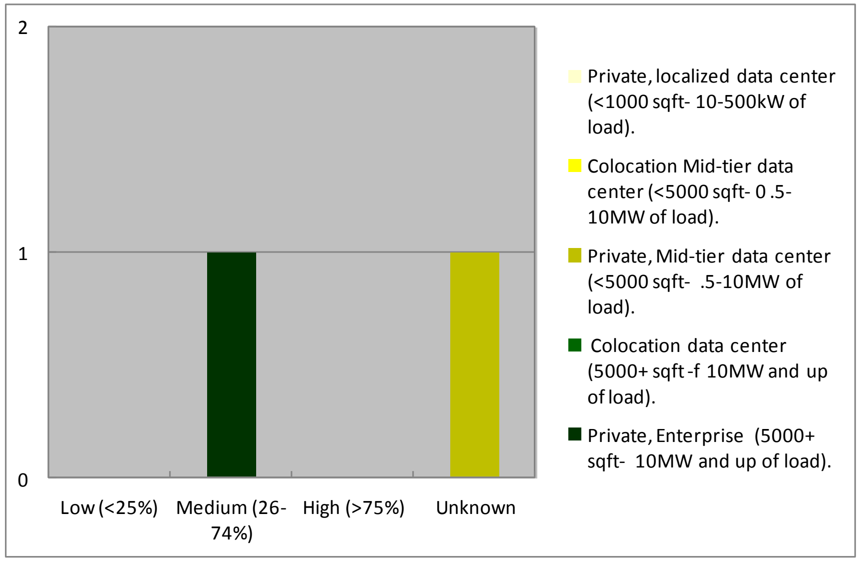


Figure 6-OOO: Evening Server Load

Nighttime Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

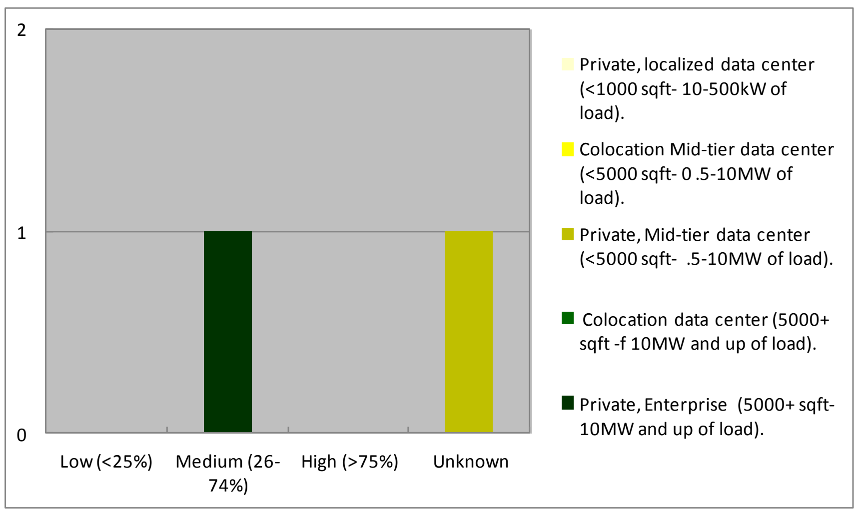


Figure 6-PPP: Nighttime Server Load

Weekday Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

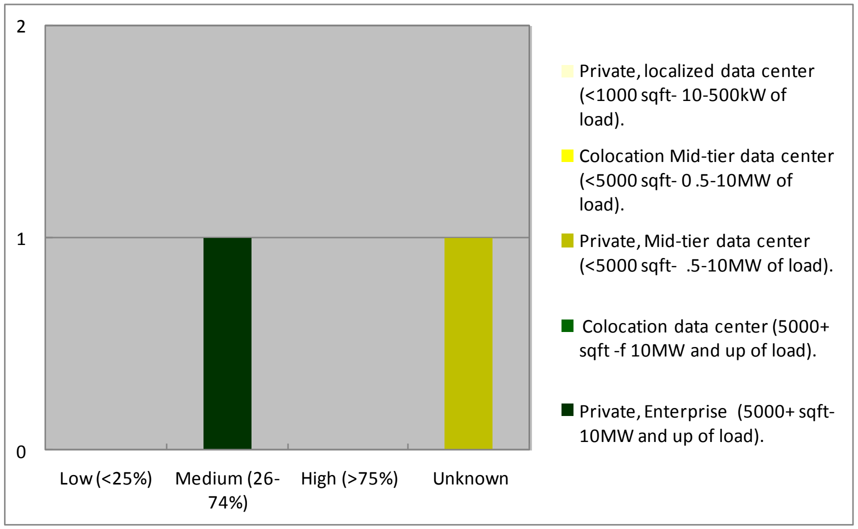


Figure 6-QQQ: Weekday Server Load

Saturday Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

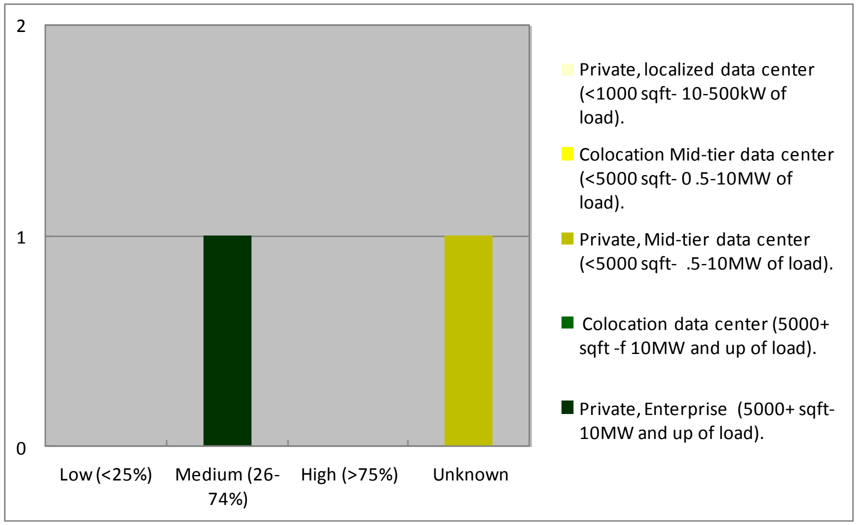


Figure 6-RRR: Saturday Server Load

Sunday Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

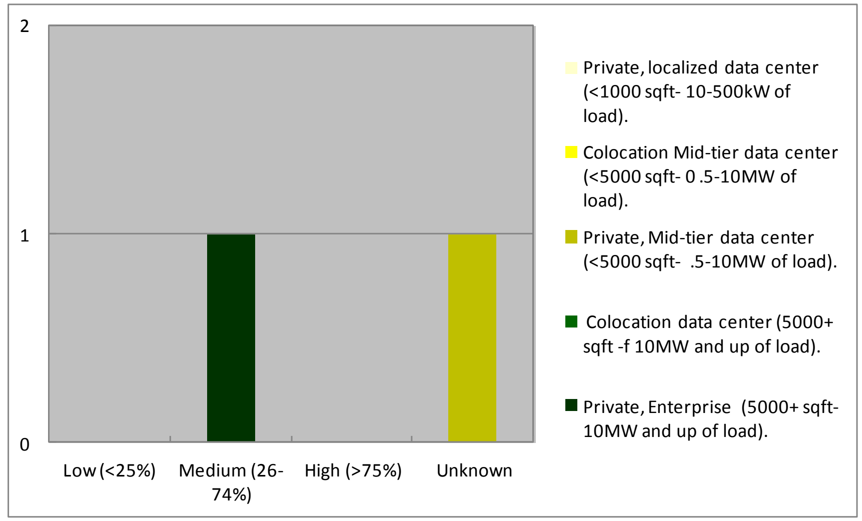


Figure 6-SSS: Sunday Server Load

Spring Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

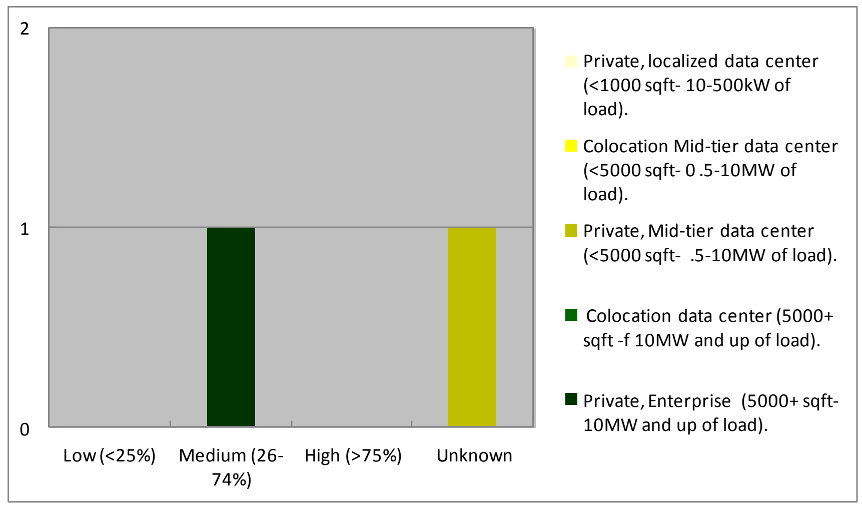


Figure 6-TTT: Spring Server Load

Summer Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

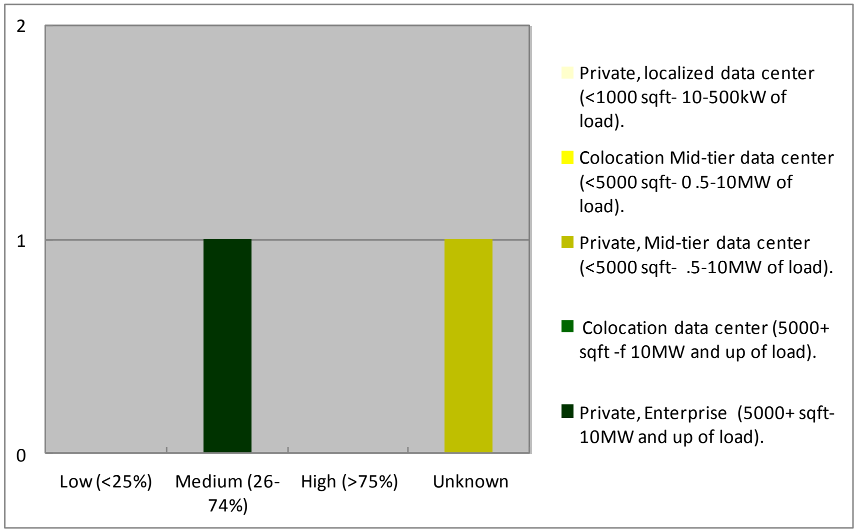


Figure 6-UUU: Summer Server Load

Fall Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

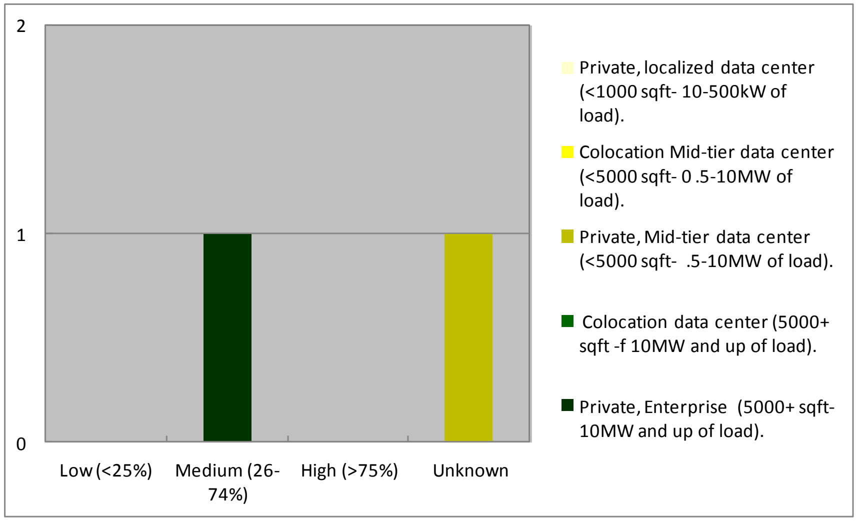


Figure 6-VVV: Fall Server Load

Winter Server Load	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Low (<25%)	0	0	0	0	0	0
Medium (26-74%)	1	1	0	0	0	0
High (>75%)	0	0	0	0	0	0
Unknown	1	0	0	1	0	0
Mean	3.00	2.00	0.00	4.00	0.00	0.00

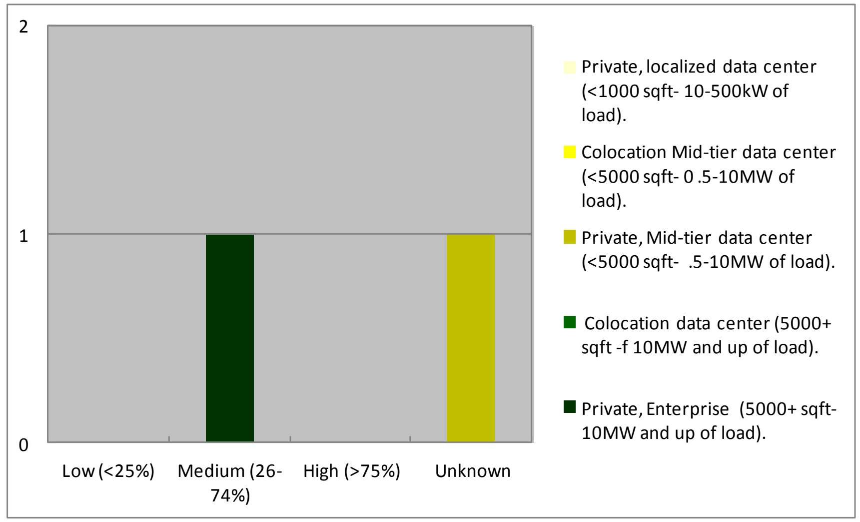


Figure 6-WWW: Winter Server Load

Cooling System Type - Area 2 (Select One Or More Cooling Types):	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
AHU/RTU	1	0	0	1	0	0
CRAC (Computer Room Air Conditioner)	0	0	0	0	0	0
CRAH (Computer Room Air Handler)	1	0	0	1	0	0
In Row Cooler	2	1	0	1	0	0
In Rack Cabinet Cooler	0	0	0	0	0	0
Other	1	1	0	0	0	0

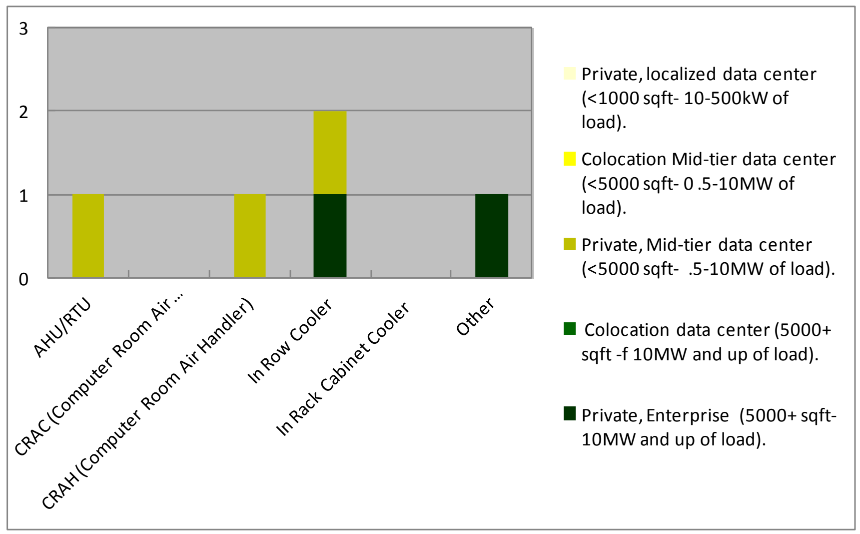


Figure 6-XXX: Cooling System Type - Area 2 (Select One Or More Cooling Types)

Raised Floor Supply - Area 2?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes	0	0	0	0	0	0
No	3	1	0	2	0	0
Don't Know	0	0	0	0	0	0

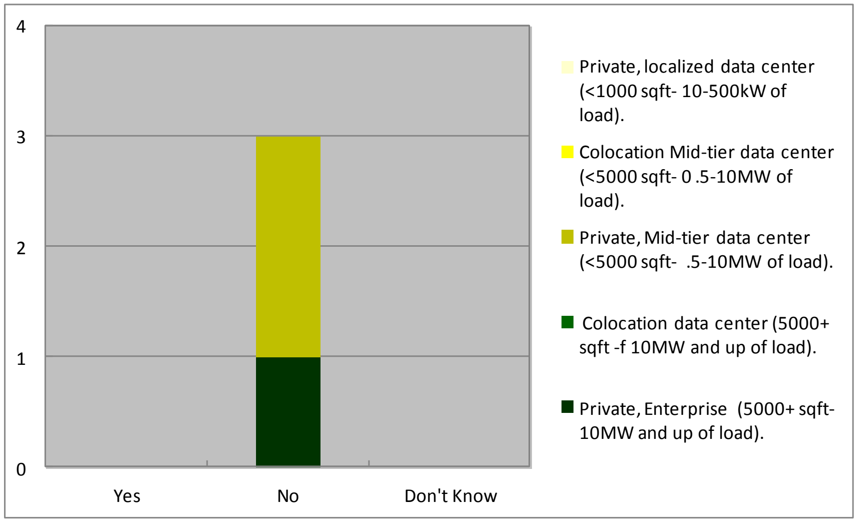


Figure 6-YYY: Raised Floor Supply - Area 2

Do Server Racks Employ Hot Aisle/Cold Aisle Configuration In Area 2?	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Yes, Partial Hot Aisle Containment	0	0	0	0	0	0
Yes, Partial Cold Aisle Containment	0	0	0	0	0	0
Yes, Full Hot Aisle Containment	1	0	0	1	0	0
Yes, Full Cold Aisle Containment	1	1	0	0	0	0
No	1	0	0	1	0	0
Don't Know	0	0	0	0	0	0

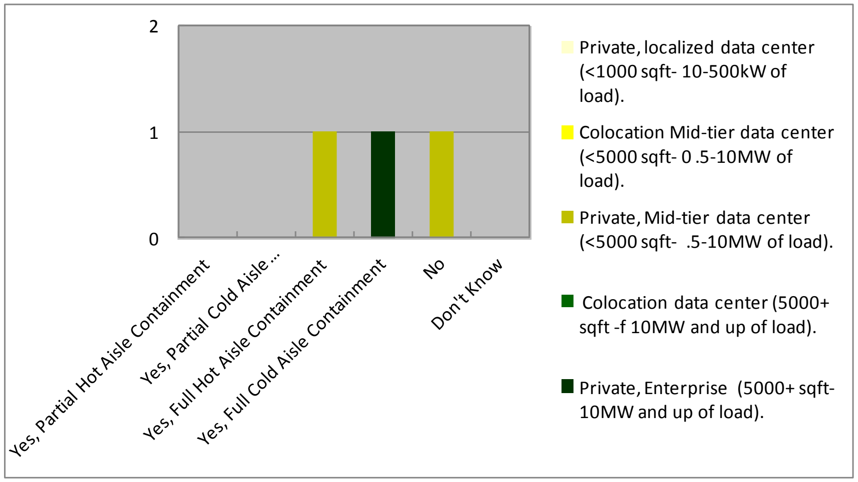


Figure 6-ZZZ: Do Server Racks Employ Hot Aisle/Cold Aisle Configuration In Area 2?

Containment Type - Area 2:	Overall	Private, Enterprise (5000+ sqft- 10MW and up of load).	Colocation data center (5000+ sqft -f 10MW and up of load).	Private, Mid-tier data center (<5000 sqft- .5-10MW of load).	Colocation Mid-tier data center (<5000 sqft- 0 .5-10MW of load).	Private, localized data center (<1000 sqft- 10-500kW of load).
Aisle Containment (Curtains)	0	0	0	0	0	0
Aisle Containment (Rigid)	1	1	0	0	0	0
Rack Chimneys	1	0	0	1	0	0
In Rack Containment	0	0	0	0	0	0
Other	0	0	0	0	0	0

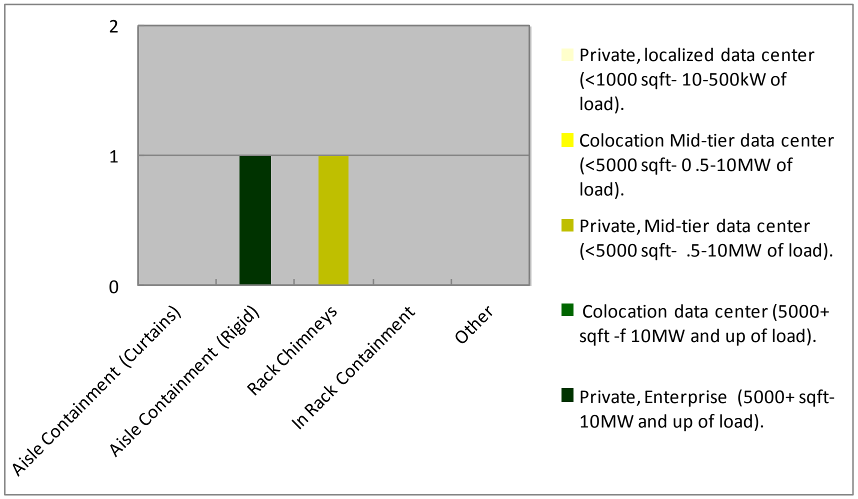


Figure 6-AAAA: Containment Type - Area 2

7. APPENDIX B: PARTICIPANT STATISTICS

Question Pro Software provided statistic on participation, and drop-out rates for the survey. Note: 2 additional surveys were completed using an earlier (but idendical) link and their statistics are not included in these participant statistics. Thus, values in the Overall Participant Statistis are off by 2 participants.

Drop-out analysis numbers are correct.

Overall Participant Statistics

	Count
Viewed (Reset)	98
Started	63
Completed	25
Completion Rate	39.68%
Drop Outs (After Starting)	38
Validation Errors	31

Drop-Out Analysis

Last Completed Question	Count	Base %	Cumulative %
2. [Q25] Dear Data Center Owner/Operator/Industry Expert; Energy Trust o ...	2	5%	5%
3. [Q91] Please make sure to be certain of your responses before clicking ...	8	21%	26%
7. [Q10] First Name	22	56%	82%
25. [Q43-C57] Do You Consider CPU MIPS (Millions of Instructions Per Second) I ...	1	3%	85%
32. [Q5-C57] Primary Cooling System Type:	1	3%	87%
94. [Q24-C57] Do You Implement A Supply Air Temperature Reset?	1	3%	90%
101. [Q32-C57] Humidification?	1	3%	92%
113. [Q21-C57] Evaporative Cooling Operation At Outside Air Conditions Less Tha ...	1	3%	95%
125. [Q39-C57] Lighting Controls:	1	3%	97%
141. [Q83] Do you have a second unique data center area to report?	1	3%	100%
Total	39	100%	100%

8. APPENDIX C: THIRD PARTY RESOURCES USED

The following sources of information were accessed to research areas needing additional information.

1. Green Grid
2. Data Center Knowledge
3. Uptime Institute
4. Tech Target
5. ASHRAE
6. Mission Critical (Magazine)
7. U.S. Environmental Protection Agency

Works Used to support recommendations:

Bigelow, S. J. (2013, January). The Data Center of the Future. *Modern Infrastructure* , pp. 14-22.

Kirby, L. (2012, Sept/Oct). The Next Generation Modular Data Center: Efficient, Agile, Sustainable. *Mission Critical: Data Center and Emergency Backup Soutions* , pp. 34-42.

Myatt, B. (2012, March/April). Super Computing Advances Will Change Our Power and Cooling Strategies. *Mission Critical: Data Center and Emergency Backup Solutions* , pp. 20-24.

U.S. Environmental Protection Agency. (2012, November). *Understanding and Designing Energy-Efficiency Programs for Data Centers.* Retrieved December 18, 2012, from www.energystar.gov: http://www.energystar.gov/ia/products/power_mgt/ES_Data_Center_Utility_Guide.pdf

9. APPENDIX D: PROJECT TEAM DETAILS

Data Center General Facilities: Jean Ann Krupp, Director of Critical Facilities, Business Development

- Director of Mission Critical Services, Ledcor
- VP of Real Estate and Construction, Base Partners, Inc.
- Director of Real Estate and Construction at Cable & Wireless (Digital Island/Exodus)

Data Center Mechanical Design: Mike Nichols, P.E., LEED AP, Principal, Mechanical Engineer

- Agilent Technology Campus Upgrade, Santa Clarita, CA
- Applied Materials Corporate Data Center, Austin, TX
- Ascent
  - CH2 Data Center, Chicago, IL
  - Northlake Data Center, Chicago, IL
  - Reuters Data Center, Saint Louis, MO
- Dell Data Center Optimization Northern Europe (7-sites)
- Intuit, Quincy, WA
  - MTV-4, Upgrade / Modernization
  - MTV-14, New MEP Infrastructure & TI
- Level (3) Communications
  - Anaheim, CA
  - Gateway, San Diego, CA
  - Los Angeles, CA
  - San Francisco, CA

Data Center Mechanical Design: Brian Johnston, P.E. Mechanical Designer, Project Manager

- Easy Street, data center addition conceptual design, Beaverton, OR
- Laika, Rondler Center RC4 Data Center, Hillsboro, OR
- Legacy Health System, Portland, OR
  - Conway Collocation Data Center
  - Data Center Design
  - Lovejoy Data Center HVAC Upgrades
- Nova Corporation, data center site evaluations, AZ and NM
- IBM, 14523 Milikan Way, Beaverton, OR
- Infinity Internet, site assessment and conceptual design, Portland, OR and Vancouver, WA
- McAfee Data Center, Beaverton, OR
- Mentor Engineering Data Center Transformation, Shannon, IRE
- Mentor Graphics, Wilsonville, OR
  - Engineering Data Center (EDC), 400 Kw
  - Building C & E Infrastructure Assessment
  - Colo C Data Center, 320 Kw
  - Calibre Lab Data Center (300 Kw) Upgrade
  - Central Plant – Utility Building
  - Network Control Center

Data Center Electrical Design: Larry Hengesh, P.E., LEED AP Associate Principal, Electrical Engineer

- American Presidents Line, Data Center, Rancho Cordova, CA*
- CNF Transportation – Corporate Data Center in new 240,000 sf Corporate Headquarters and AdTech Center, Portland, OR, winner of 2001 Portland BEST Award

- Columbia Sportswear, Beaverton, OR and Henderson, KY
- First Interstate Bank, Data Center, Folsom, CA*
- Hewlett-Packard, Roseville R21, New Construction, Roseville, CA
    - Emergency Generator Design and Full Kitchen, Energy Center, Laboratory, Data Center
- IBM Data Center, 250 kW, Beaverton, OR
- Infinity Internet Colo Data Center Facility, 900 kW, Vancouver, WA
- Legacy Health System Data Center Upgrade, 400 kW, Portland, OR
- Mentor Graphics, Wilsonville, OR
    - Building “E” Service Upgrade and EDC Data Center
    - Calibre Lab Data Center (300 Kw) Upgrade
    - Colo C Data Center, 320 Kw
    - DPC Data Center Upgrade
    - EDT Worldwide Data Center, 1800kW
    - NCC Data Center Upgrade

- Mentor Graphics, EDT Worldwide Data Center, 1200 kW, Shannon, IRE
- Nike, Mike Schmidt Data Center, Portland, OR
- Nova Corporation, Data Center Site Evaluations, AZ and NM
- Providence St. Vincent Medical Center, Portland, OR
- Generator Paralleling System – Eight 1250kW units with ring bus
- Standard Insurance Data Center Upgrade, Portland, OR
- ViaWest data centers, Hillsboro, OR - 1800 kW, and Salt Lake City, UT - 1200 kW
- Collocation centers with raised floor, N+1 water-cooled chiller plant, 50-ton CRAH units, 120W/sf
- Wells Fargo Bank, Data Center, Concord, CA*
- World Savings, Data Center, San Antonio, TX*

Data Center Electrical Design: Mike Steinmann, P.E., LEED AP Managing Principal, Mission Critical Group

- 201 Mission, Cogeneration, sustainable design, San Francisco, CA
- ADC Green 1 Data Center, Commissioning, McClellan, CA
- Agilent Technologies, Design & Commissioning, Santa Clara, CA
- Allegiance Telecom, San Francisco and Sunnyvale, CA
- Applied Materials Arques Technology Center, Sunnyvale, CA
- Applied Materials Corporate Data Center, Austin, TX
- Ascent CH1 and CH2, Design & Commissioning, Northlake, IL
- CaISO Data and Command Center, Commissioning, Folsom CA
- Clorox, Pleasanton, CA
- Dell Data Center Optimizations, Various US locations
- Digital Island Data Center/Web Hosting 24/7 Facilities, Design and Commissioning, Multiple Locations, Worldwide
- Exodus/Cable & Wireless, SC-6 Data Center, Santa Clara, CA
- Intel, Santa Clara, CA
- Intuit Data Center, Commissioning, Quincy, WA
- Looking Glass Networks, Santa Clara and Los Angeles, CA
- One Market Plaza, Cogeneration, San Francisco, CA
- Pokka Beverages, Cogeneration, sustainable design, American Canyon, CA
- Reuters, St. Louis, MO
- Savvis SC-7 Data Center, Commissioning, Santa Clara, CA
- Scottrade, St. Louis, MO
- Sun Microsystems, Santa Clara, California
- Terremark, Santa Clara, CA
- T-Mobile Data Canter, Commissioning, Wenatchee, WA

Data Center Construction and Design: Bart Dickson, LEED AP, Mission Critical Facilities Director, HOFFMAN Construction

- PDX1 Data Center, VADATA, Boardman, OR
- PDX2 and PDX4 Data Centers, VADATA, Boardman, OR
- Bend BroadBand Vault Data Center, Bend, OR
- Regence Healthcare Data Center, Salt Lake UT
- Hayward SFO-9 Data Center, Hayward, CA
- MCI Network Information Center, Prototype, Hillsboro, OR
    - With eight more in Oregon, Washington, California, Colorado, Utah and Missouri

Data Center Architecture and Implementation: Rod Legg, IT Technical Support

- State of Oregon, Cloud Computing, Technical Support Programs, Salem, OR
- United States and Asia Pacific, Technical Support for Fortune 500 Companies and Public Sector Accounts
- IBM PC Company, China
- IBM Global Technology Services, Worldwide

Data Center Architecture and Implementation: Bob Mobach, RCDD-NTS ITIL Senior IT Infrastructure Consultant & Data Center Designer, LOGICALIS

- Bend BroadBand Vault Data Center, Bend, OR
- North County Transit District, San Diego County, CA

10. APPENDIX E: POWER DISTRIBUTION EXAMPLE

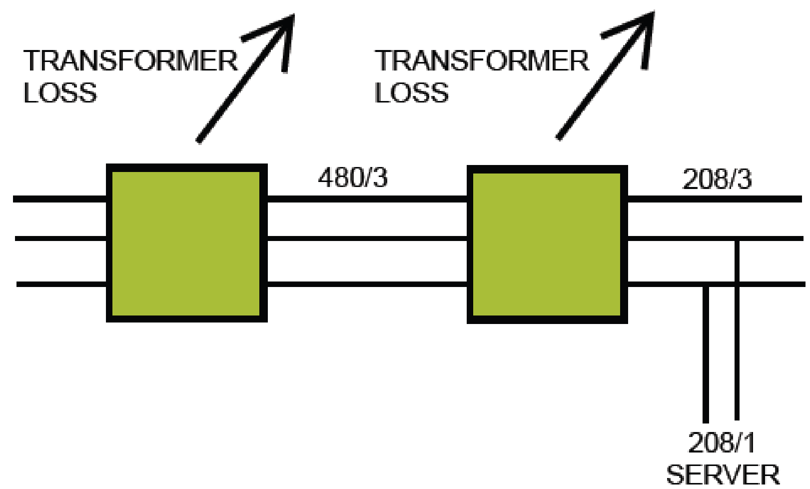


FIGURE 1. TYPICAL 208/1 DISTRIBUTION

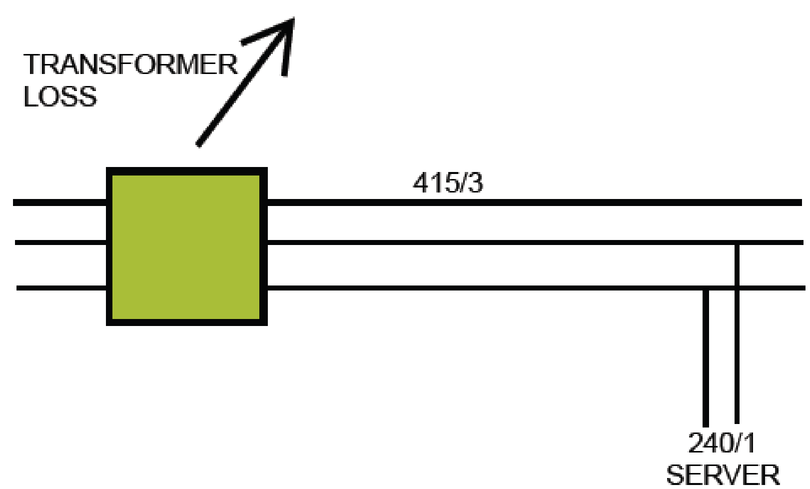


FIGURE 2. TYPICAL 415V DISTRIBUTION

11. APPENDIX F: LIQUID COOLING EXAMPLE

This is one example of Liquid Cooling. This system, made by Asetek, is scheduled to be installed at NREL's Skynet HPC Cluster at the Energy Systems Integration Facility (ESIF) in Golden, Colorado.

RackCDU™ Liquid Cooling

Hot Water Liquid Cooling for Data Centers.

RackCDU is a hot water, direct-to-chip, data center liquid cooling system that enables cooling energy savings up to 80% and density increases of 2.5x when compared to modern air cooled data centers. RackCDU removes heat from CPUs, GPUs, memory modules and other hot spots within servers and takes it all the way out of the data center using liquid.

Free ambient outdoor air cools the water returning to the data center, meaning no power is used to actively chill the water. The water leaving the data center is hot enough to enable waste heat recycling, further increasing energy cost savings, reducing carbon footprint and resulting in cooling EREs (Energy Reuse Efficiencies) below 1!

RackCDU is deployed at a rack/server level providing maximum scalability. The system consists of a zero-U rack level CDU (Cooling Distribution Unit) mounted in a 10 inch (250mm) rack extension that includes space for 3 additional PDUs, and direct-to-chip cooling loops within each server. The direct-to-chip cooling loops are drop in replacements for the existing air heat sinks, with tubes exiting through an unused PCIe slot. This enables RackCDU deployment as a retrofit during server refresh cycles and in new builds.

Benefits:

- Cooling energy savings exceeding 50%.
- Rack level density increases of 2.5x.
- Server level density (higher TDP CPU/GPUs in smaller form factors).
- Waste Heat Recycling achieving ERE < 1.
- Immediate to 1 year payback cycles typical.
- Enables high temperature data centers.
- Full surveillance/alarm system monitoring temperatures, pressure, flow and leaks.

Click to Calculate RackCDU Savings

Figure 11-A: Astek Liquid Cooling

12. APPENDIX G: SURVEY SCHEDULE

Table A.2: Survey Development and Follow-up Timeline:

DATE	TASK	COMMENTS
7/18/2012	Initial Survey Review with ETO	First version, in Excel format, rejected.
8/7/2012	Second Survey Review with ETO	New online format and questions reviewed
8/22/2012	Final Survey approval by ETO	Minor edits requested before sending out, but OK per ETO
8/28/2012	First Survey Email Sent	Sent to 133 contacts' email addresses
9/6/2012	Initial Survey Results Assessment	2 responses
9/11/2012	Hoffman Phone Follow-up #1	2 responses
9/14/2012	Glumac Phone Follow-up #1 by admin staff	No additional responses
10/4/2012	Follow-up results review	
10/19/2012	Sur vey Follow-up strategy session	Glumac to increase intensity of appeal to contacts to complete survey
10/24/2012	Glumac Intensive 2-day phone follow-up with contacts	Glumac team works closely with contacts to assist in survey completion.
11/14/2012	ETO/Glumac Meeting and Results Presentation	
11/26/2012	Glumac Third-Party Research Begins*	Phone calls, articles, interviews to fill in missing data from survey
12/17/2013	Research Consolidation and Report Writing Begins	
12/19/2012	Baseline Recommendations Development Begins	Additional interviews and third party research
01/30/2013	Final Report, First Draft Presented to ETO	
3/01/2013	Final Report, review comment response back to ETO	Significant updates requested. Additional staff scheduled.
4/5/2013	Final Report, V2 Version to ETO	Several updates requested
4/24/2013	Final Report: FINAL Version to ETO	