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- Center for Energy and Environment

Small Embedded Data Centers in Wisconsin

A market characterization study

April 30, 2018

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EXECUTIVE SUMMARY

Seventhwave and the Center for Energy and Environment (CEE) collected information from Wisconsin businesses on characteristics of their business and small embedded data centers (SEDCs). This information will help Focus on Energy address savings opportunities from SEDCs by identifying appropriate program offerings and marketing channels.

The characterization study was comprised of both primary and secondary research. We reviewed studies germane to this project, interviewed Focus on Energy program staff and a select group of IT equipment distributors, surveyed a sample of Wisconsin businesses and conducted a limited number of SEDC site visits. We used the results from the survey of Wisconsin businesses and data gleaned from our literature review to quantify the potential for energy savings from measures targeting SEDCs. We used the results of our site visits to clarify effective approaches for Focus on Energy programs to reach this market segment. Included in the *Quantifying Energy Savings* section are equations for calculating energy savings for specific measures.

SEDC SEGMENTATION

There are approximately 1,600 commercial buildings in Wisconsin with SEDCs. Over half (56%) of these buildings are offices, and nearly one fifth (19%) are non-refrigerated warehouses. Laboratories, education facilities and nursing facilities make up the remainder of building types with a significant number of SEDCs.

There are approximately 14,300 servers in Wisconsin SEDCs. **This equipment consumes approximately 98 GWh annually at a cost to Wisconsin businesses of $10.7 million.**[1,2] Over half (52%) of servers in Wisconsin SEDCs are in offices and 14% in education. Figure 4 shows that nearly half (46%) of Wisconsin servers are in SEDCs that have between 20 and 49 servers, nearly one third (31%) of servers are in SEDCs with between 5 and 9 servers and nearly one sixth of the servers (16%) are in SEDCs that have between 10 and 19 servers. Over half (52%) of SEDCs are in single-story buildings. This means that they have easy access to an exterior surface that could be used for dedicated HVAC equipment that can save energy and money with custom economizer and exhaust settings. The majority (82%) of SEDCs are in buildings built before 2000. This means they are likely in rooms that weren't specifically designed for the type of server equipment in use today, or originally intended to be a server room at all.

FOCUS ON ENERGY PROGRAM AND MEASURE REVIEW

Key takeaways from our interviews with Focus on Energy program staff include:

- Focus on Energy programs serve a wide range of building types with SEDCs including offices, manufacturing, technical and private colleges, K-12, municipalities and government.
- SEDCs operate differently depending on the business needs served, with the three most common being:

[1] Shen et al., "Small Embedded Data Center Program Pilot", COMM-CARD01-20140512-86772, June 2017. Assuming an average demand of 411 W per server and a Mechanical Load Component of 1.9

[2] EIA, Table 5.6.A, Commercial, March 2017, assuming $0.1094/kWh, https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

    - Typical office IT needs and weekday hours
    - Multi-shift manufacturing
    - 24/7 healthcare
- Currently, most SEDC incentives are custom, with rates currently at $0.03/kWh and $100/kW with a requirement that the payback be between 1.5 and 10 years. The few prescriptive measures are for one-for-one HVAC replacements and economizers.
- The majority of SEDCs involved in Focus on Energy programs have dedicated cooling.
- Focus on Energy programs rarely inventory IT equipment or monitor SEDC energy consumption, but will often look at UPS load and utilization server room thermostat setpoint.
- Focus on Energy programs have identified dormant servers as ubiquitous and an opportunity for energy savings.
- The number of SEDC projects is only a few per year.
- Focus on Energy programs have a high level of engagement with the facility (maintenance and operations) staff of buildings, but IT staff are usually only brought into the conversation on an ad hoc basis.
- Primary sources of information for Focus on Energy staff are service providers.
- Barriers
    - First cost
    - Perceived risk of downtime (as no one wants to touch a mission critical system that is working)
    - Disconnect between the staff responsible for energy cost and those that are responsible for IT equipment
    - IT staff turnover can result in missed opportunities
- The primary driver of projects tends to be the customers, who are looking to replace equipment at the end of life, not Focus on Energy program implementers or service providers.

Analysis of Focus on Energy program measures data between 2010 and 2016 showed that the program incentivized upgrades to a total of 96 projects related to data centers (about one a month). This is about 8% of the potential market, a small amount considering that servers have a five-year useful life so that nearly all Wisconsin data centers would be expected to have upgraded or replaced equipment in the seven-year period; fifty-five of these were likely SEDCs. Of the likely SEDC projects, approximately half (51%) were upgrades to IT equipment and half (49%) were upgrades to the HVAC equipment that served the server rooms and closets.

Type of Business Activity

Results of both the survey (n = 48) and the CBECS segmentation by business activity found that nearly half (49%) of survey respondents had SEDCs that serve offices.[3] This outcome agrees with the results of the segmentation exercise. Nearly one quarter (21%) serve manufacturing facilities. Although our segmentation exercise only included commercial buildings, our interviews with Focus on Energy staff indicated that manufacturing was a large and influential sector for data centers. Education also had a sizable number of survey respondents, also in agreement with the results of the segmentation exercise.

[3] Due to the bias inherent in the contact sample for our survey, the responses do not provide a statistically significant representation of activity type of Wisconsin businesses with SEDCs. The segmentation exercise is a more accurate representation of business activity type, as it is based on the statistically significant U.S. Energy Information Administration data from their Commercial Building Energy Consumption Survey

Occupancy Hours

Only one-quarter (26%) of Wisconsin SEDC serve businesses with 24/7 occupancy. This means there is an opportunity for reducing server usage during unoccupied hours in the majority of Wisconsin SEDCs.

Number of Server Racks

The average number of racks per business was 4.3, with a mean and median of 199 and 114 square feet of SEDC per rack, respectively. The number of racks may be a better descriptor of the size of the SEDC, since the rooms that house SEDCs have often been repurposed and may be used for multiple functions. Server rooms typically have two or more racks while network closets will have one or two racks.

Number of Physical and Virtual Servers

Nearly one quarter (24%) of Wisconsin SEDCs had ten or more physical servers. There tended to be more instances of virtual servers in sites with more servers. The average number of physical servers per business was 7.1, with an average of 1.1 physical servers per rack.

Frequency of Planned Upgrades

Almost half (46%) of survey respondents plan to upgrade their servers in the next year and a half. This is a significant opportunity for the Focus on Energy program, if they engage these customers to influence energy-related decisions when upgrades are made.

Approximately two-thirds (61%) of survey respondents monitor UPS utilization. Therefore, they would quickly understand their particular SEDCs need for upgrading if given the right information to act on it. Nearly two-thirds (60%) of survey respondents had UPS utilizations between 0 and 40%.

RECOMMENDATIONS

SEDCs represent an abundant and diverse population of customers with somewhat limited energy usage, a significant challenge for the Focus on Energy program. Focus on Energy could most effectively achieve energy savings by targeting SEDCs that fulfill the minimum requirements that would benefit most from a defined set of effective IT and cooling measures. To assuage IT staff concerns, emphasis should be placed on measures that require minimal non-mission critical capital expenditure and does not result in downtime of IT services.

SEDC Screening Criteria

Table ES 1 provides the screening criteria for identifying SEDCs in existing Focus on Energy customers that would be candidates for achieving significant energy savings.

Table ES 1. Screening Criteria for SEDCs with Good Potential Energy Savings

Priority Level	Type of Need	Characteristic
Required	CRAC	Has a dedicated AC system conditioning the EDC
Required	Servers	Has ten or more physical servers
Required	Electrical	UPS capacity over 4 kVA

Priority Level	Type of Need	Characteristic
Strongly Preferred	Equipment	Age of equipment > 5 years, opportunity for purchasing ENERGY STAR equipment
Strongly Preferred	Equipment	IT staff can provide equipment inventory
Strongly Preferred	Company Size	Has over 80 employees (assuming 8 employees per server)
Preferred	UPS utilization	<40%
Preferred	Server consolidation	Opportunity for virtualization
Preferred	Server consolidation	Opportunity for cloud services or colocation
Preferred	Room set point temperature	<70°F
Preferred	Airflow management	Opportunity to perform hot aisle/cold aisle containment

IT Measures

The following recommended IT measures have the most potential to achieve substantial savings, increasing the likelihood of implementation.

Table ES 2. Recommended IT Measures

Category	Measure
UPS Utilization	1. Increase UPS utilization to 75-80% through UPS consolidation.
Server Consolidation	2. Identify dormant (comatose) servers and turn them off if access to those servers are no longer required.
	3. Reduce the number of physical hosts by employing server virtualization.
	4. Reduce the servers by moving those IT services to the cloud (typically email, file, and database servers).
ENERGY STAR Equipment	5. Purchase ENERGY STAR-certified IT equipment when refreshing.
Storage Reduction	6. Move storage to cloud services.
	7. Archive unused storage onto tape drives and power down unneeded disk drives.

Category	Measure
IT Equipment Scheduling	8. Perform Live Migration or DPM on virtualized servers and place unused physical hosts on standby.
	9. Power down network switches, ports, and/or PoE during non-work hours, such as nights, weekends, and holidays.

Cooling Measures

For SEDCs that have dedicated mechanical systems, two primary measures can be performed:

1. Improving air flow management through:
    a. Cold aisle/hot aisle containment by delivering the conditioned air to the front of the server racks (cold aisle) and exhausting the heated air from the back of the server racks (hot aisle);
    b. Installing blanking panels; and
    c. Performing cable management best practices.
2. Raising the set point temperature in the SEDC to deliver 75°F inlet temperatures at the server racks.

Additional measures that deal specifically with the mechanical system, such as economizing and retrofitting with VFDs, are in the realm of existing utility HVAC recommissioning programs. An exhaust fan installed with hot aisle containment as an alternative to dedicated cooling can be an effective cooling measure for an appropriately sized SEDC.

Quantifying Energy Savings

For Focus on Energy custom rebate programs, Table ES 3 provides some guidance on calculating savings for the above IT and cooling measures. Focus on Energy could additionally use this table to cross-reference against existing measures for future workpaper updates.

Table ES 3. Quantifying SEDC Energy Efficiency Measure Savings

Category	Savings
Server Consolidation	2,891 kWh/yr per server (assuming average power of 330 W/server)
UPS Utilization	kWh/yr = UPS_{load} $*((\eta_1 - \eta_0)/\eta_1 \eta_0)$ * 8760 hr/yr where UPS_{load} is the IT power load read off the UPS (in kVA) and η_0, η_1 are the UPS efficiencies

Category	Savings
	at the initial and increased percent IT loads, respectively (obtained from Figure 20)
Storage Reduction	kWh/yr = ((# of HDDs * 9) + (# of SSDs * 6)) * 8760 hr/yr where # of HDDs are the number of hard disk drives taken off line and # of SSDs are the number of solid state drives taken off line
IT Equipment Scheduling	kWh/yr = ($UPS_{load, on}$ - $UPS_{load, off}$) * $Hours_{off}$) where $UPS_{load,on}$ and $UPS_{load,off}$ are the IT power loads read from the UPS (in kVA) when the devices are scheduled on and scheduled off, respectively; and $Hours_{off}$ is the total number of hours in the year that the equipment is scheduled to be off. For the network switches, a deemed savings approach could also be used to calculate the expected savings. IT staff would need to keep track of the number and type of ports that would be powered on and off as well as any PoE devices (such as phone and access points) that are attached to those ports.
SEDC Setpoint Temperature Adjustment	An estimated 4% cooling energy savings accompanies each 1°F increase in the set point.[4]

COST EFFECTIVENESS

The cost effectiveness of these measures will depend on the realized energy savings versus the cost of implementation. While the above section provides a means to estimate energy savings, the cost of implementing the measures will vary depending on the specific actions that are required. For the most part, these measures require IT staff to take simple actions. The simplest measures would be turning off dormant servers or other IT equipment that is not in use, specifying ENERGY STAR-certified equipment when purchasing new equipment, and raising the SEDC thermostat set point temperature. LBNL identified 14 cost-effective measures for improving EDC energy efficiency, as shown in Table ES 4.[5] The specific cost-effectiveness of these measures will depend on the circumstances of each individual SEDC that define the savings opportunities and the level of staff effort and capital expenditure needed.

[4] http://www.datacenterknowledge.com/archives/2011/03/10/energy-efficiency-guide-data-center-temperature
[5] https://buildings.lbl.gov/sites/default/files/smallserverroomefficiencyfactsheet.pdf

Table ES 4. Top 14 Measures to Save Energy in an SEDC

Category	Measure
Simple, No-Cost, or Very-Low-Cost Measures	Determine computational functions/turn off any unused or dormant servers. (Server Consolidation)
	Increase temperature set points to the high end of ASHRAE's recommended limit (75°F).
	Examine power backup requirements to determine if the UPS is oversized or even needed (UPS consolidation).
	Install blanking panels and block holes between servers in racks to help with airflow management. Practice good cable management at the back of the racks.
A Little More Work, But Still Fairly Simple	Refresh the oldest equipment with the high-efficiency ENERGY STAR-certified models.
	Migrate services to a more energy-efficient internal or external central data center space, or to co-location or cloud solutions (which can permit further server consolidation, UPS consolidation, and storage reduction).
	Provide energy efficiency awareness training for IT custodial and facility staff (IT equipment scheduling).
Higher Investment, But Very Cost Effective	Implement server power management.
	Consolidate and virtualize applications. Turn off unneeded servers (server consolidation).
	Implement rack/infrastructure power monitoring.
	Install variable frequency drives on cooling units (cf. utility HVAC recommissioning programs).
	Install rack- and row-level cooling (Air flow management through hot aisle/cold aisle containment).
	Use air-side economizers (or hot aisle exhaust fans) (cf. utility HVAC recommissioning programs).
	Install dedicated cooling for the room (cf. utility HVAC recommissioning programs).

NONENERGY BENEFITS

Over the coming years, IT workforce will see shifting responsibilities. As IT services increasingly migrate to the cloud, on-site IT staff roles and responsibilities will deal less and less with providing IT services. As IT staff are made responsible for energy efficiency considerations, opportunities could arise for increased energy management role. This would be an ideal fit for the skill sets of this skilled workforce who are literate in reading dashboards, responsible for scheduling automated tasks, and trained with the programming skills needed for building automation systems.

Program Design

For a possible Focus on Energy SEDC program or modifications to existing program, the following four steps are proposed:

1. Education, Training, and Marketing - A significant barrier is that most Wisconsin businesses have no idea how much energy their SEDCs are using.
    a. Programmatic education and outreach to IT staff should focus on the amount of energy typically wasted, potentially opening doors for further efficiency options.
    b. Identifying and working with IT equipment vendors, the most trusted source of information for IT staff, to help embed energy efficiency in their business approach and help overcome barriers to increased program penetration.
2. Pre-Screening - To lower cost and save time during site pre-screening, a phone and online survey could be used to recruit likely candidates for this program. The survey could be adapted from those tested by this project.
3. Field Visit - A follow-up field visit could identify the measures to be taken and determine the necessary steps to enlist the participant in the SEDC program. The audit would be similar to the inventory used for the field visits.
4. Rebates and Incentives - Either through prescriptive measures or custom rebates, incentives should be created to motivate adoption of the most effective IT and cooling energy efficiency measures for SEDCs.

INTRODUCTION

Seventhwave and the Center for Energy and Environment (CEE) collected information from Wisconsin businesses on characteristics of their business and their data centers. This information will help Focus on Energy address savings opportunities from small embedded data centers (SEDCs) by identifying appropriate program offerings and marketing channels for SEDCs.

BACKGROUND

SEDCs are one of the fastest growing end uses of electrical energy in commercial buildings[6] and are estimated to account for nearly one percent of the total electricity use in the U.S. By some accounts, as much as one third of this usage is unnecessary, but this premise has not been addressed by Focus on Energy programs or by most device manufacturers.

A major barrier to realizing the energy savings opportunities in SEDCs is the difficulty in effectively reaching out to a diverse and dispersed customer base. The principal objective of SEDC system administrators is to provide sufficient server availability and capacity to satisfy their business operations and needs. Energy use considerations are not only secondary to IT services but are typically ignored by SEDC system administrators.

To address the opportunities in this market, Focus on Energy needs a better understanding of the number, type, and efficiency level of SEDCs in Wisconsin. Seventhwave and CEE designed and conducted a research study to characterize SEDCs in Wisconsin.

METHODOLOGY

The characterization study was comprised of both primary and secondary research. We reviewed studies germane to this project (summarized in *Appendix A: Literature Review*), interviewed Focus on Energy program staff and a select group of IT equipment distributors, surveyed a sample of Wisconsin businesses and conducted a limited number of SEDC site visits. We used the results from the survey of Wisconsin businesses and data gleaned from our literature review to quantify the potential for energy savings from measures targeting SEDCs. We used the results of our site visits to clarify effective approaches for Focus on Energy programs to reach this market segment.

SEGMENTING EDCS IN WISCONSIN

To begin to understand what SEDCs look like in Wisconsin, we used the U.S. Energy Information Administration's Commercial Building Energy Consumption Survey (CBECS)[7] microdata to quantify the number and types of SEDCs and the buildings they serve.

We limited the dataset to buildings with data centers less than 500 square feet, a number in agreement with the ENERGY STAR definition of server rooms. We then aggregated the data within Wisconsin's census division, East North Central, which also includes Illinois, Indiana, Ohio, and Michigan. To understand Wisconsin's portion of this region's SEDCs, we used population prorating (i.e. Wisconsin has 12 percent of the population of the states in its census division). Finally, the latest CBECS survey was

[6] Jonathan Koomey, 2011. "Growth in Data Center Electricity Use 2005 to 2010," Analytics Press: Oakland, CA. http://www.analyticspress.com/datacenters.html

[7] http://www.eia.gov/consumption/commercial/

completed in 2012. To understand the SEDC population in 2017, we assumed a two percent growth rate in agreement with EIA data for the growth of commercial building area.[8]

SURVEYING AND INTERVIEWING WISCONSIN BUSINESSES WITH EDCS

To further understand the characteristics of SEDCs in Wisconsin, Seventhwave developed an online survey for Wisconsin businesses with questions about the types and quantity of data center equipment, the businesses they serve, and energy savings opportunities and barriers. This survey (*Appendix B: Online Survey Instrument*) was sent to a non-representative sample of 2,800 Wisconsin businesses culled from Seventhwave's contact database. A list of IT professionals from a dataset purchased from Infosource rounded out the group receiving the survey. The results from the survey, while not statistically significant, contributed to the overall picture of SEDCs in Wisconsin businesses.

The results from the surveys were also used to identify IT staff and vendors working with SEDCs in Wisconsin for in-depth interviews. These interviews (*Appendix C: Communications and Outreach Interview Guide*) provided information on how businesses make IT-related decisions, what energy saving measures may be most attractive, and how Focus on Energy program offerings might use communications and outreach strategies to influence their decisions.

REVIEWING FOCUS ON ENERGY PROGRAMS AND MEASURES

Seventhwave conducted interviews with Focus on Energy program staff from the Business Incentive Program (BIP), Agriculture, School and Government Program (ASGP) and the Small Business Program (SBP). These interviews focused on collecting information on projects that addressed energy use in SEDCs to provide insight on a range of business/building characteristics and barriers to implementing efficiency measures.

We also analyzed Focus on Energy program data from 2010 to 2016 for incentives paid for upgrades to SEDCs to get a snapshot of program activity.

SITE VISITS

We supplemented the previous online survey data collection with five site visits to Wisconsin SEDCs. The intent of these site visits was twofold. First, we investigated the SEDCs at these sites in more detail, by:

- Inventorying specific devices and features
- Taking spot measurements of server inlet and thermostat temperatures
- Understanding the SEDCs physical layout and any associated air flow management strategies
- Discussing operational practices, energy savings opportunities and barriers to adoption with facility and IT staff

Second, these site visits served as a preliminary test of a potential program pilot step, namely, conducting site visits to identify energy savings opportunities and to collect information needed to estimate the associated energy savings. Although small in number, working through the process allowed us to identify issues and opportunities for improvement. Key questions we set out to answer included:

1. What level of information was needed to perform reliable screening?
2. What issues arose when attempting to collect the data?

[8] http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx

3. Who was the best person to provide the data?
4. Are site visits necessary to collect the data? Could the data be collected in an alternative method?

For each site visit, we followed a protocol (*Appendix D: Field Study Form*), designed to collect the information needed to meet our goals.

RESULTS

The results are presented below, first with the demographics of SEDCs, followed by a review of Focus on Energy's current programs, and concluding with a summary of the primary data collected in online surveys and site visits. These results lead to recommendations for program design using the best measures for improving their energy performance, and identifying the barriers that need to be overcome.

SEGMENTATION

There are approximately 1,600 commercial buildings in Wisconsin with SEDCs. Over half (56%) of these buildings are offices, and nearly one fifth (19%) are non-refrigerated warehouses. Laboratories, education facilities and nursing facilities make up the remainder of building types with a significant number of SEDCs (Figure 1).

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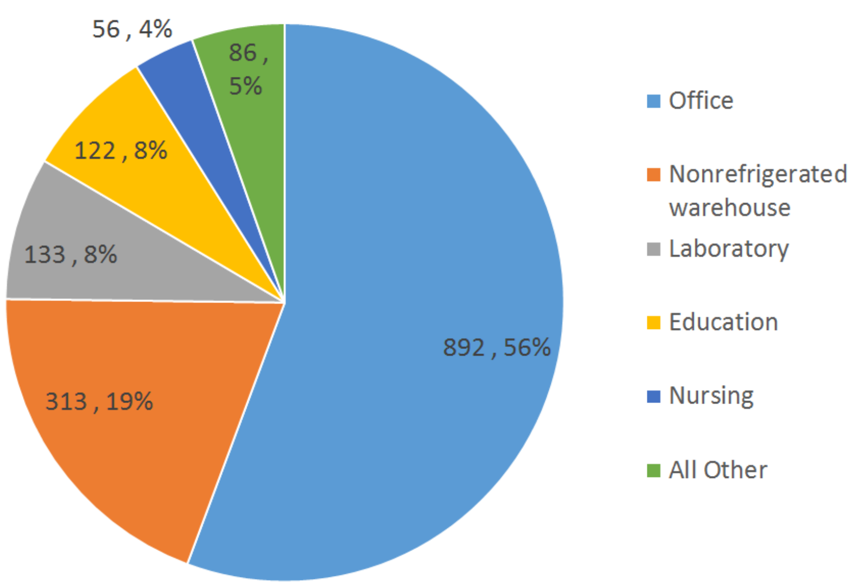
Figure 1. Commercial buildings in Wisconsin with SEDCs



In Figure 2 we show the percentage of buildings within a given building type that have SEDCs. Almost all (94%) laboratories and over half (51%) of inpatient health care facilities have SEDCs. While SEDC penetration in these building types is significant, there are fewer overall facilities, reducing the total number of SEDCs they represent.

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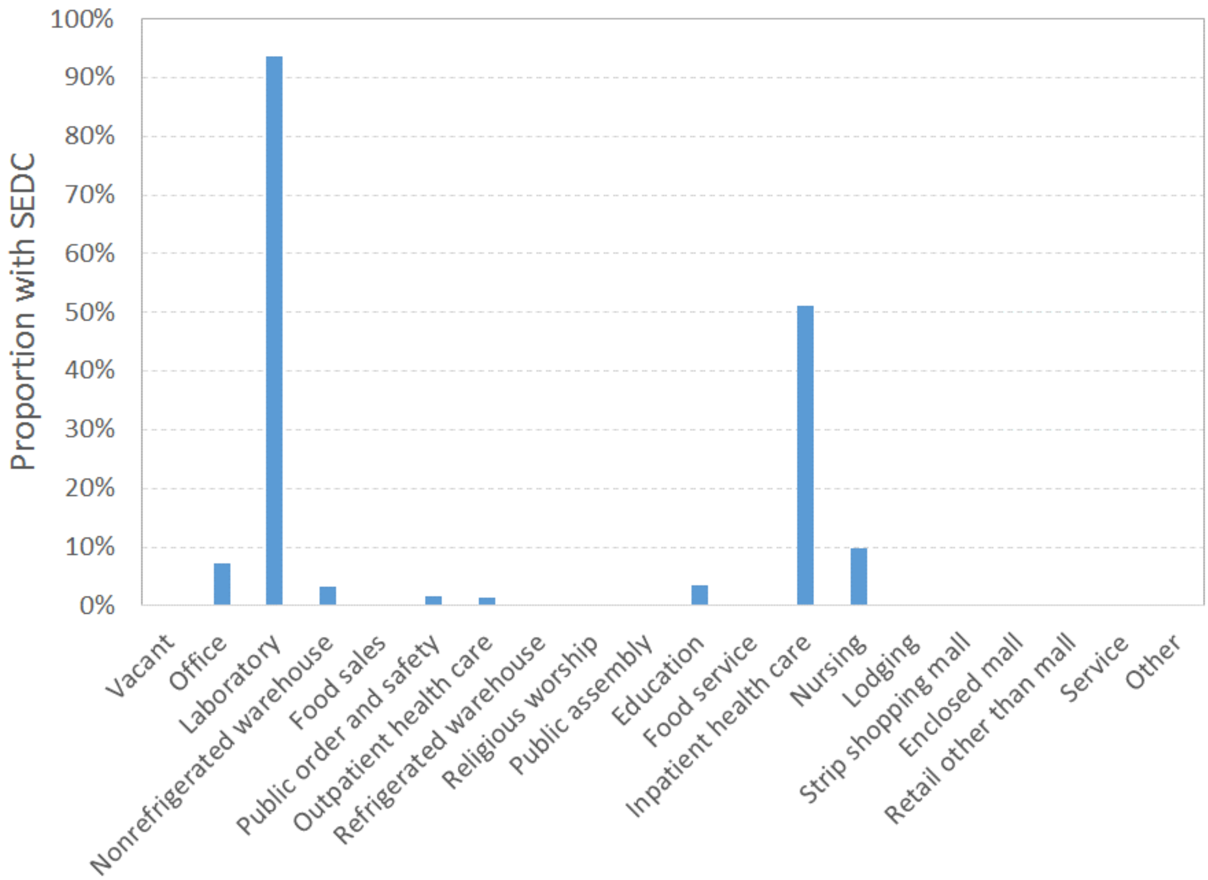
Figure 2. Proportion of Wisconsin commercial buildings within a given building type that have SEDCs



There are approximately 14,300 servers in Wisconsin SEDCs. This equipment consumes approximately 98 GWh annually at a cost to Wisconsin businesses of $10.7 million.[9,10] Figures 3, 4, and 5 show the number of servers (not business); over half (52%) of servers in Wisconsin SEDCs are in offices, while one seventh (14%) are in laboratories and educational facilities. Non-refrigerated warehouses and nursing facilities have a small, but non-negligible share (Figure 3).

[9] Shen et al., “Small Embedded Data Center Program Pilot”, COMM-CARD01-20140512-86772, June 2017. Assuming an average demand of 411 W per server and a Mechanical Load Component of 1.9

[10] EIA, Table 5.6.A, Commercial, March 2017, assuming $0.1094/kWh, https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

Figure 3. Servers by building type in Wisconsin SEDCs

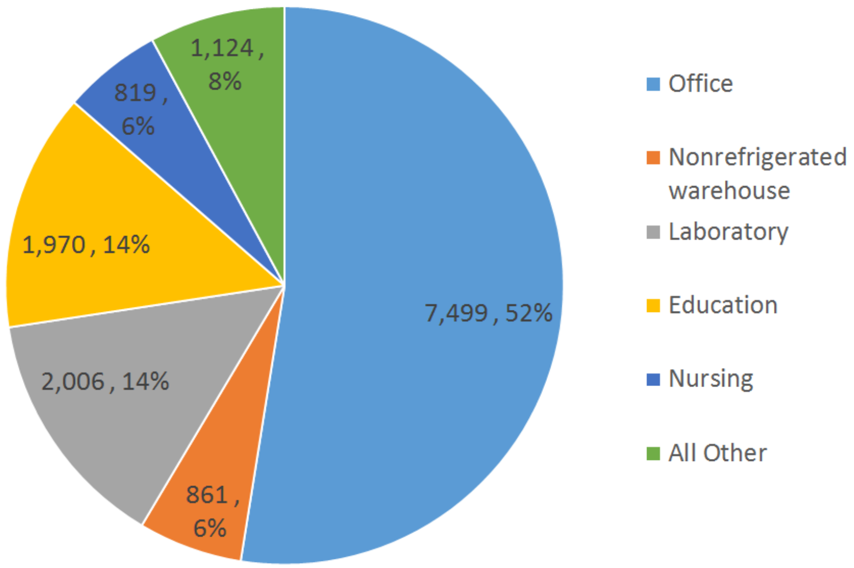


Figure 4 shows that nearly half (46%) of Wisconsin servers are in SEDCs that have between 20 and 49 servers, nearly one third (31%) of servers are in SEDCs with between 5 and 9 servers and nearly one sixth of the servers (16%) are in SEDCs that have between 10 and 19 servers. This is significant since the opportunity for a program to cost effectively serve this market increases as the number of servers in a given data center increases.

Figure 4. Servers by number of servers in Wisconsin SEDCs

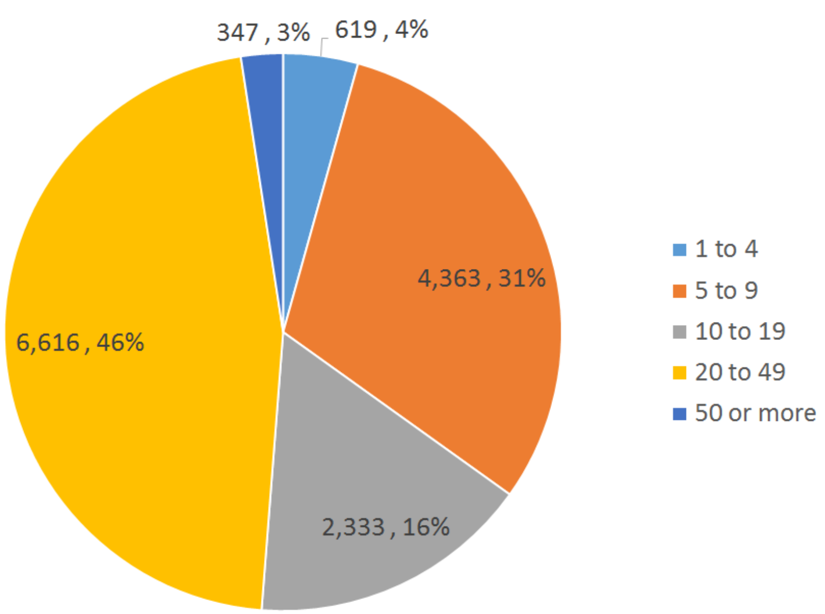


Table 1 summarizes the relationship between computers and servers by building type; this is very useful information for program design as it is often easier to count computers than to get access to and count servers. It is important to note that the number of computers per server does vary by building type.

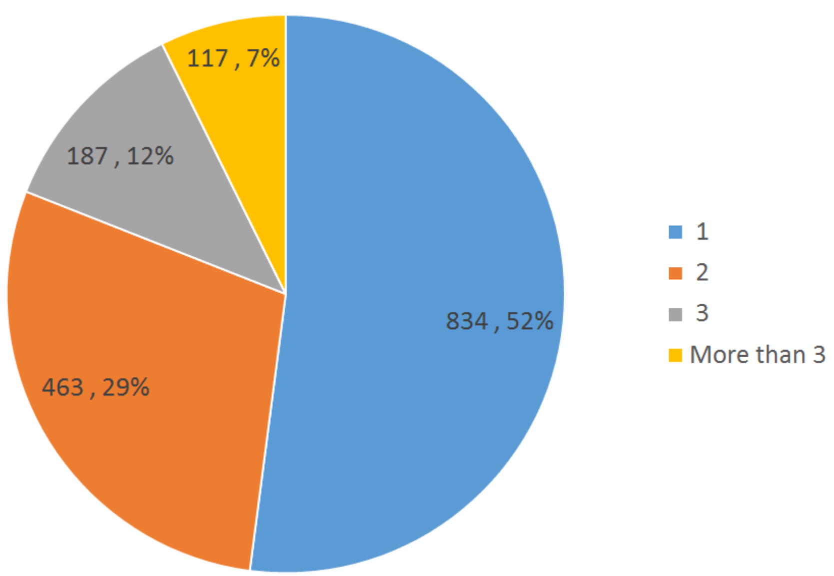
Table 1. Summary of computers by area, workers, and servers.

Building Type	Computers per thousand square feet	Computers per worker	Computers per server
Office	4.2	1.5	9.4
Laboratory	1.3	1.4	6.2
Non-refrigerated warehouse	0.5	1.4	10.1
Public order and safety	2.3	2.5	12.5
Outpatient healthcare	4.7	1.5	24.1
Public assembly	0.4	1.0	8.3
Education	2.7	4.9	38.0
Inpatient healthcare	1.8	1.1	21.5
Nursing	0.9	1.2	7.9
Average	2.2	2.0	13.5

Note that computers include desktops and laptops.

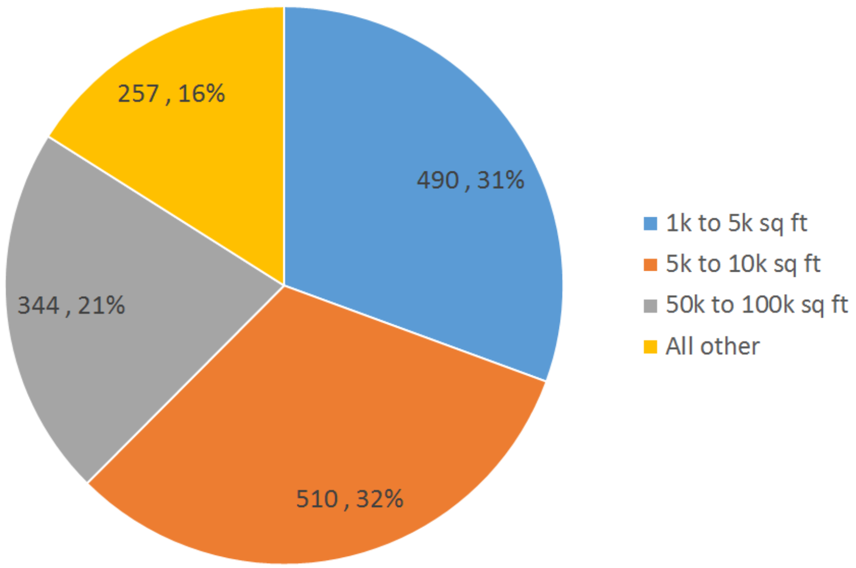
Figure 5 illustrates that over half (52%) of SEDCs are in single-story buildings. This means that they have easy access to an exterior surface that could be used for exhaust and economizer savings.

Figure 5. Number of commercial buildings in Wisconsin with SEDCs by number of floors.



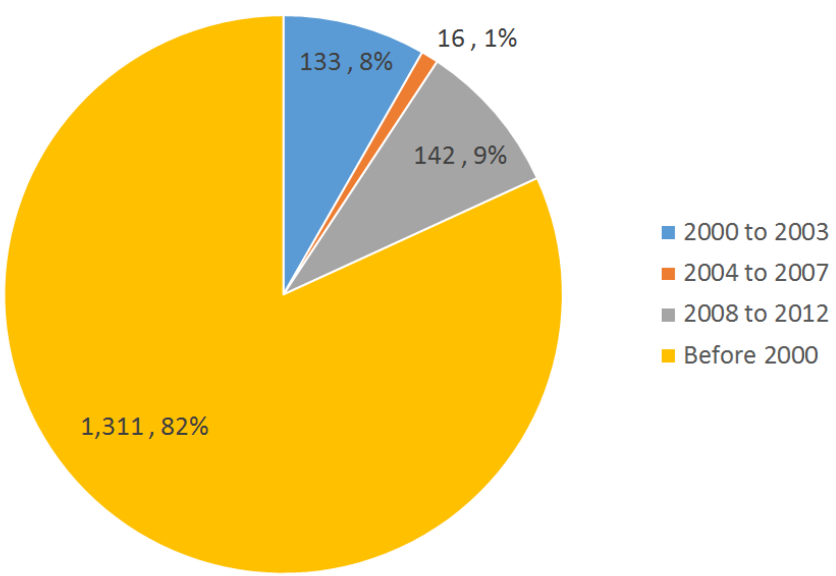
The majority of SEDCs are unsurprisingly in small buildings, with nearly two thirds (63%) in buildings less than 10,000 square feet (Figure 6).

Figure 6. Number of commercial buildings in Wisconsin with SEDCs by area category



As seen in Figure 7, the majority of SEDCs are in buildings built before 2000. This means that they are likely in rooms that weren't specifically designed for the type of server equipment in use today, or originally intended to be a server room at all.

Figure 7. Number of commercial buildings in Wisconsin with SEDCs by year of construction



FOCUS ON ENERGY PROGRAM AND MEASURE REVIEW

Key takeaways from our interviews with Focus on Energy program staff include:

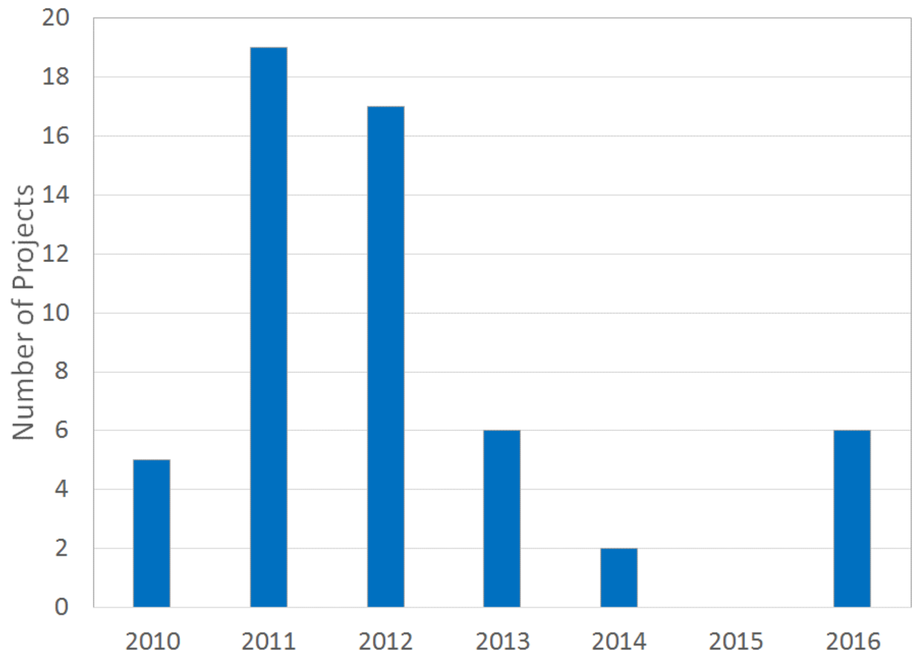
- Focus on Energy programs serve a wide range of building types with SEDCs:
  - Business Incentive Program (BIP): manufacturing and offices
  - Agriculture, Schools and Government Program (ASGP): technical and private colleges, K-12, municipalities and government
  - Small Business Program (SBP): mainly offices
- SEDCs operate differently depending on the business needs served, with the three most common being:
  - Typical office IT needs and weekday hours
  - Multi-shift manufacturing
  - 24/7 healthcare
- The majority of SEDCs serve a single location, but some serve multiple locations. In these instances, the locations are usually all within Wisconsin.
- There is a wide range of ages of SEDCs, including new state-of-the-art systems to legacy systems over 15 years old.
- Currently, most SEDC incentives are custom, with rates currently at $0.03/kWh and $100/kW with a requirement that the payback be between 1.5 and 10 years. The few prescriptive measures are for one-for-one HVAC replacements and economizers.
- The majority of SEDCs involved in Focus on Energy programs have dedicated cooling.
- Focus on Energy programs rarely inventory IT equipment or monitor SEDC energy consumption. If the data is available from the customer, the program will use it to clarify measure savings.
- Focus on Energy programs will often look at UPS load and utilization to clarify energy savings calculations and opportunities.
- Focus on Energy programs will often look at server room air temperature to clarify energy savings calculations and opportunities. This typically involves recording the thermostat set point, but not monitoring the rack inlet temperatures.
- Focus on Energy programs have identified dormant servers as ubiquitous and an opportunity for energy savings.
- While there was a period of several years after 2010, in which the number of SEDC projects increased, recently the number has fallen to only a few per year. This may be due to a programmatic focus on virtualization that has since ended. It’s likely that early adopters have already implemented it, with the remainder finding the main barriers to be cost and fear of change.
- There is a trend towards cloud services. However, it is considered a free rider, and is therefore not incentivized.
- Focus on Energy programs have well established relationships with the facility (maintenance and operations) staff of buildings, which produces a high level of engagement. While it would be ideal for IT staff to be a regular part of the conversation related to energy saving in data centers, they are usually only brought into the conversation on an ad hoc basis.
- Sources of information for Focus on Energy staff
  - BIP: program staff are very knowledgeable, and ask manufacturers for additional information when needed
  - ASGP: rely on service providers
  - SBP: rely on service providers
- Barriers
  - The main barrier is first cost
  - Another significant barrier is perceived risk of downtime, as no one wants to touch a mission critical system that is working

    - There is often a disconnect between the staff responsible for energy cost and those that are responsible for IT equipment
    - IT staff turnover can result in missed opportunities
- The primary driver of projects tends to be the customers, who are looking to replace equipment at the end of life, not Focus on Energy program implementers or service providers, as a result.
    - Case studies may be ineffective since each customer views their own application as unique
    - Service providers don't prioritize energy efficiency, so even when they could promote savings, they don't do so; perhaps there is an opportunity to educate service providers to embed energy efficiency in their value propositions
    - Aside from large energy users, there aren't enough projects to justify investing in program internal resources, knowledge, tools, and recommendations; currently the programs tend to let the customers tell the program what they're doing, instead of the program telling customers what they could do

Analysis of Focus on Energy program measures data between 2010 and 2016 showed that the program incentivized upgrades to a total of 96 projects related to data centers (about one a month). This is about 8% of the potential market, a small amount considering that servers have a five-year useful life so that nearly all Wisconsin data centers would be expected to have upgraded or replaced equipment in the seven-year period. Fifty-five of these were likely SEDCs. Of the likely SEDC projects, approximately half (51%) were upgrades to IT equipment and half (49%) were upgrades to the HVAC equipment that served the server rooms and closets. Of the data center upgrades, nearly four fifths (79%) were for server virtualization, just one was for a UPS upgrade, and the remainder was of unknown upgrades. These projects combined to save 28 kW and 1.2 million kWh. Of the HVAC upgrades, just over half (52%) were for upgrades to cooling equipment, nearly one quarter (22%) were for cold aisle containment, and variable speed drives were applied to fans (11%) and pumps (7%). These projects combined to save 25 kW and 0.6 million kWh.

As seen in Figure 8, other than the years 2011 and 2012, there are only half a dozen projects annually, with none being registered in 2015. The 35 projects in 2011-2012 represent over half of the total projects in this period.

Figure 8. Number of SEDC projects per year



STAKEHOLDER INTERVIEWS

We spoke with IT staff at five Wisconsin businesses/organizations. These staff represented a range of business types, from local government to a firm providing outsourced IT services. Titles of these staff included: IT network system administrator, IT manager, managing partner, IT director and president.

Key takeaways from our interviews with IT staff include:

- Energy use is at best a secondary concern for the IT staff we spoke with: performance is their main concern.
- Decision making on IT equipment in these organizations tends not to reside solely with IT staff but involves others, such as a director of operations or, in the case of local government, committees and the government administrator.
- All the organizations expressed concerns about cloud services—primarily security issues. There was a range of implementation of cloud services from none to an increasing proportion of IT infrastructure, ranging from email services to storage and backup.

Overall, the people we spoke with at these organizations were aware of Focus on Energy but most had not participated in their programs. The one organization that had participated, received rebates for LEDs, not data center improvements. Suggestions for Focus on Energy support included:

- Education, especially material that outlines measures that improve data center performance and energy use and shows the basic economics of each measure.
- Develop simple programs that managed service providers could offer to their clients (these providers have access to many data centers and could use energy reduction as a differentiator for their business). This would include the more prescriptive rebates being made available.

- Target the property owner/building design community to influence data center design in multi-tenant buildings—larger, central data rooms with a rack for each tenant would reduce overall cooling energy, open up more leasable space and increase utilization.

We additionally spoke with five vendors serving Wisconsin SEDCs. These vendors ranged from manufacturers to product wholesalers and distributors and manufacturers' representatives and contractors. Titles of the staff we spoke to included: engineer, sales manager, vice president, vice president of sales, and mechanical contractor.

Key takeaways from our interviews with vendors include:

- Only two of these vendors had suggestions for who were trusted sources of information for IT staff (outsourced IT firms, engineering firms or mechanical contractors), but all indicated they were seeing changes to IT staff roles due to cloud services.
- All of the vendors we spoke with indicated that they use energy efficiency as a selling point with their clients. Most also said they try to influence energy-related decisions.
- However, only one vendor noted sales of ENERGY STAR® equipment.
- All but one vendor were aware of Focus on Energy and three indicated interest in a program promoting SEDC energy efficiency by working through distributors to provide discounts.
- Suggestions for equipment to promote include:
    - Efficient rectifiers
    - Pumped refrigerant
    - Precision air conditioner
    - Optimized rack
    - UPS
    - CRAC

ONLINE SURVEY

Seventhwave received 48 responses to the online survey. The responses provide information on business characteristics, data center characteristics, savings opportunities, and SEDC managers' interaction with Focus on Energy programs.

Business characteristics

The characteristics of the business served by each data center are important factors in the SEDC's energy requirements and performance. The key characteristics include type of business activity, hours of occupancy, business size in terms of number of employees, types of facilities, and types of data centers.

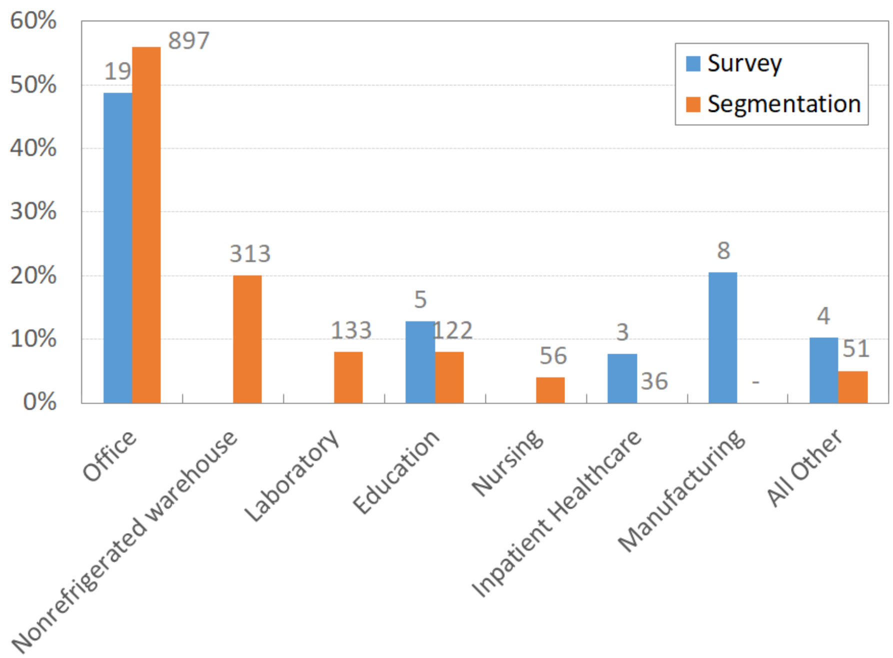
TYPE OF BUSINESS ACTIVITY

Figure 9 shows the results of both the survey and the CBECS segmentation by business activity. Nearly half (49%) of survey respondents had SEDCs that serve offices[11]. This outcome agrees with the results of the segmentation exercise. Nearly one quarter (21%) serve manufacturing facilities. Although our segmentation exercise only included commercial buildings, our interviews with Focus on Energy staff indicated that manufacturing was a large and influential sector for data centers. Education also had a

[11] Due to the bias inherent in the contact sample for our survey, the responses do not provide a statistically significant representation of activity type of Wisconsin businesses with SEDCs. The segmentation exercise is a more accurate representation of business activity type, as it is based on the statistically significant U.S. Energy Information Administration data from their Commercial Building Energy Consumption Survey

sizable number of survey respondents, also in agreement with the results of the segmentation exercise. However, unlike our segmentation results, the survey did not capture any responses from businesses with SEDCs serving warehouses or laboratories.

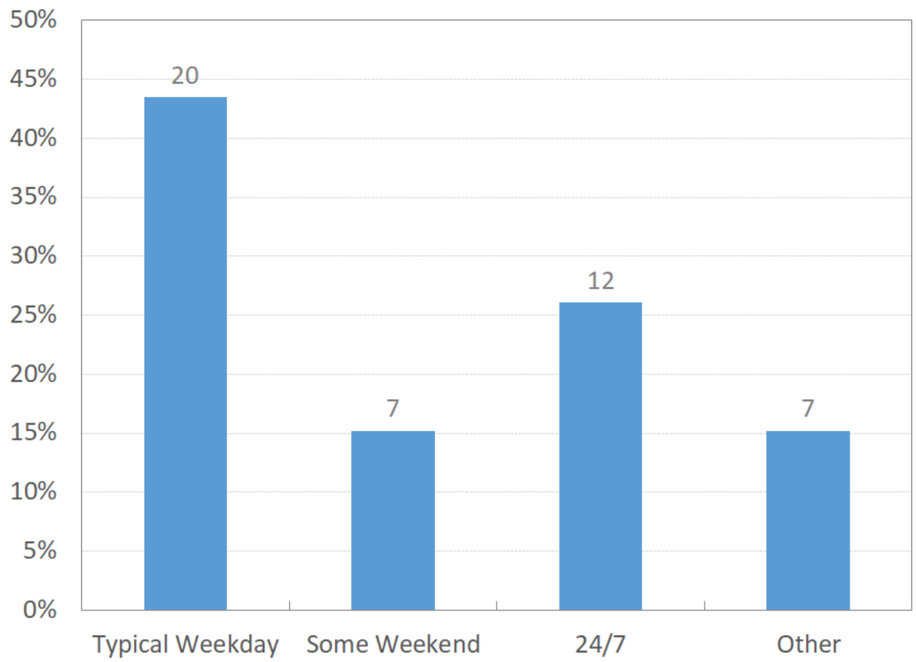
Figure 9. Business activity type of survey respondents



OCCUPANCY HOURS

Figure 10 illustrates the typical hours of occupancy of businesses served by the surveyed Wisconsin SEDCs. Only one-quarter (26%) of Wisconsin SEDCs serve businesses with 24/7 occupancy. This means there is an opportunity for reducing server usage during unoccupied hours in the majority of Wisconsin SEDCs. Note that the Other category included a variety of typical hours of occupancy. However, they all had more hours than a typical weekday, often with expanded evening hours.

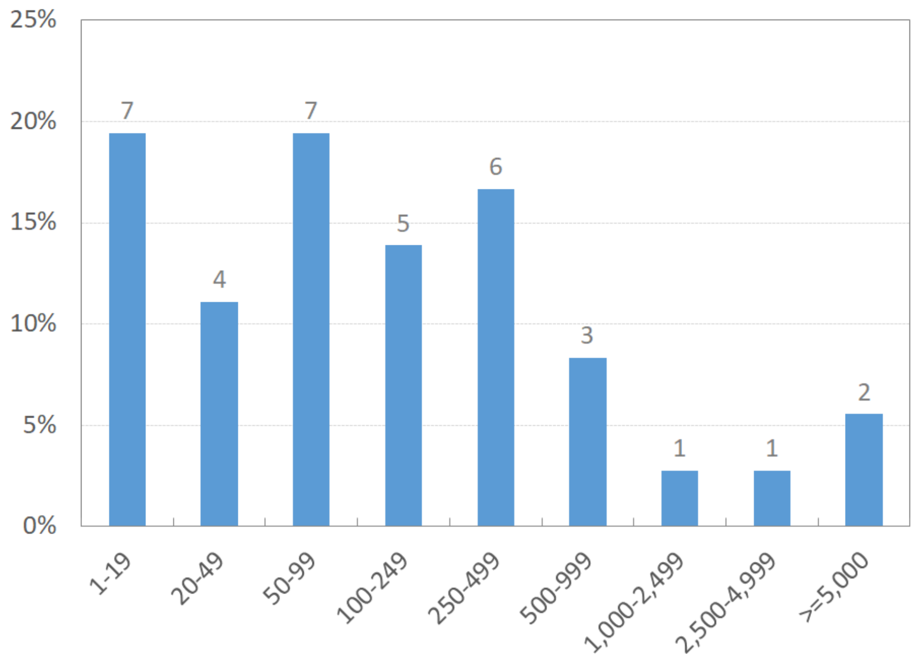
Figure 10. Typical hours of occupancy of businesses served by the surveyed Wisconsin SEDCs



BUSINESS SIZE

Figure 11 illustrates the number of employees of survey respondents' businesses. Individual Wisconsin SEDCs serve a wide range of number of employees, from a few (1-19) to more than 5,000. This further indicates that the SEDCs serve a diversity of businesses in terms of number of employees and operational complexities. The average number of employees per server (including both physical and virtual servers) is 29.

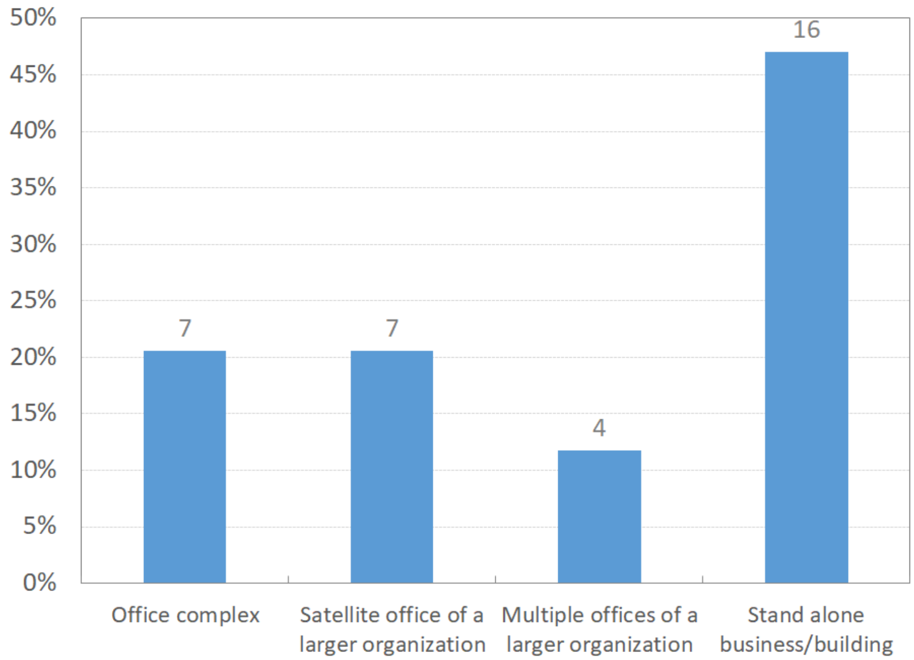
Figure 11. Number of employees served by Wisconsin SEDCs



FACILITY TYPE

There is a range of sizes and complexity of operations for Wisconsin SEDCs as well. This is likely a complicating factor for Focus on Energy as the needs of each SEDC vary. It is further complicated by the fact that we found a wide variation in the sophistication of the associated IT staff. Unfortunately, while the needs of SEDCs tend to fall into distinct groups, these groups are not simply determined by business type. Figure 12 illustrates the types of facilities served by survey respondents. A successful program design will need a method to identify the SEDC server 'group' for a given business using attributes other than business type.

Figure 12. Types of facilities served by the surveyed Wisconsin SEDCs



DATA CENTER TYPE

Figure 13 illustrates the number of Wisconsin SEDCs for survey respondents by data center type.

Figure 13. Number of Wisconsin SEDCs for survey respondents by data center type

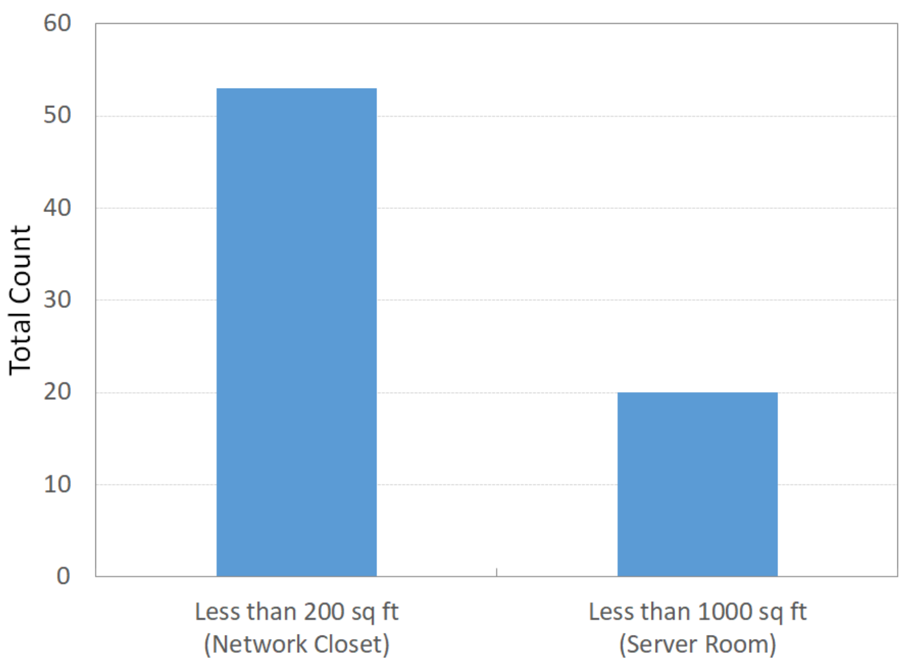


Table 2 further summarizes the number of Wisconsin SEDCs for survey respondents.

Table 2. Summary of the number of Wisconsin SEDCs for survey respondents

	Mean	Standard Error	Maximum	Minimum
Network Closet	1.7	0.3	10.0	0.0
Server Room	0.6	0.2	3.0	0.0

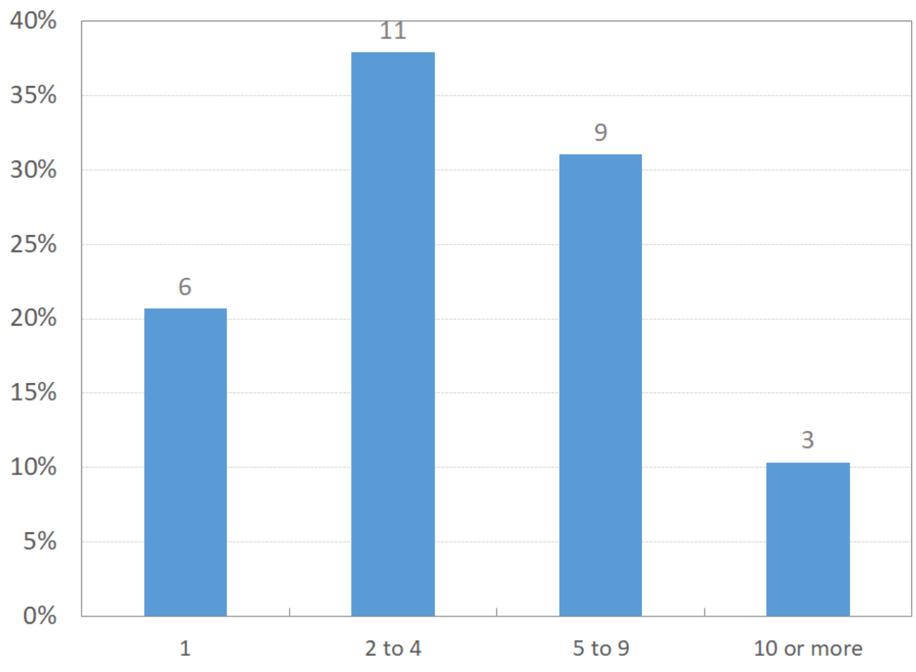
Data Center Characteristics

The characteristics of the data centers themselves help clarify the types and magnitude of energy savings opportunities. These characteristics include number of server racks, number of physical and virtual servers, frequency of planned upgrades, average age of servers, and frequency of refreshing IT equipment.

NUMBER OF SERVER RACKS

The average number of racks per business was 4.3, with a mean and median of 199 and 114 square feet of SEDC per rack, respectively. The number of racks may be a better descriptor of the size of the SEDC, since often the rooms that house SEDCs have been repurposed and may be used for multiple functions. Server rooms typically have two or more racks while network closets will have one or two racks. Figure 14 illustrates the number of server racks in surveyed Wisconsin SEDCs.

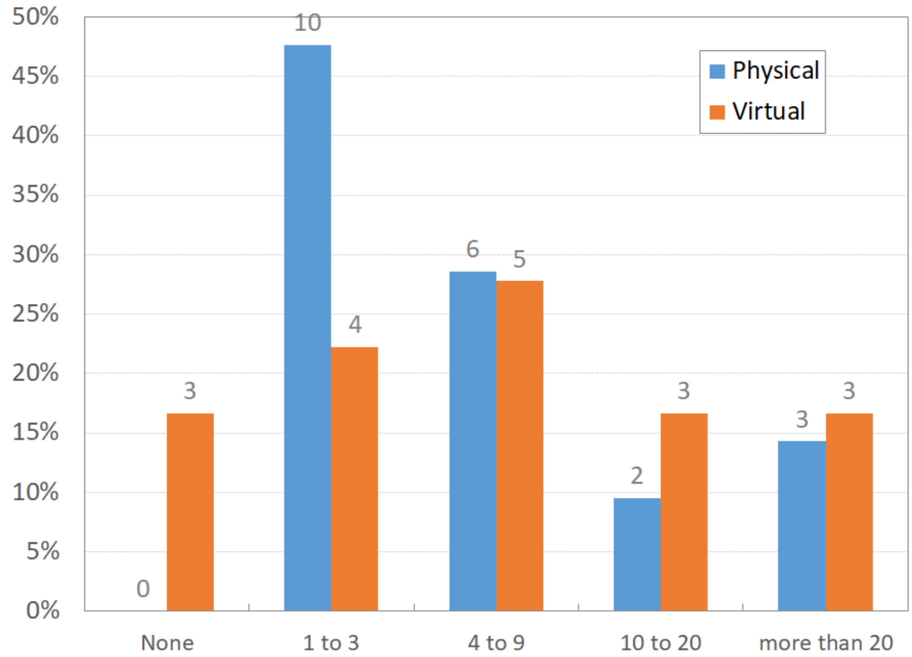
Figure 14. Number of server racks in surveyed Wisconsin SEDCs



NUMBER OF PHYSICAL AND VIRTUAL SERVERS

Nearly one quarter (24%) of Wisconsin SEDCs had ten or more physical servers (Figure 15). There tended to be more instances of virtual servers in sites with more servers. The average number of physical servers per business was 7.1, with an average of 1.1 physical servers per rack.

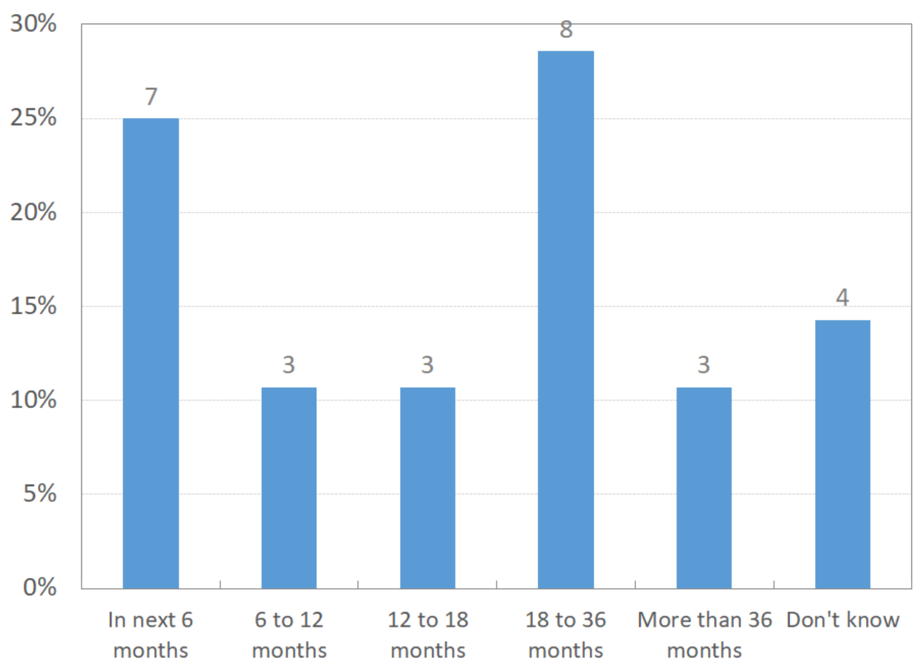
Figure 15. Number of physical and virtual servers in surveyed Wisconsin SEDCs



FREQUENCY OF PLANNED UPGRADES

Almost half (46%) of survey respondents plan to upgrade their servers in the next year and a half (Figure 16). This is a significant opportunity for Focus on Energy programs, if they engage these customers to influence energy-related decisions when these upgrades are made.

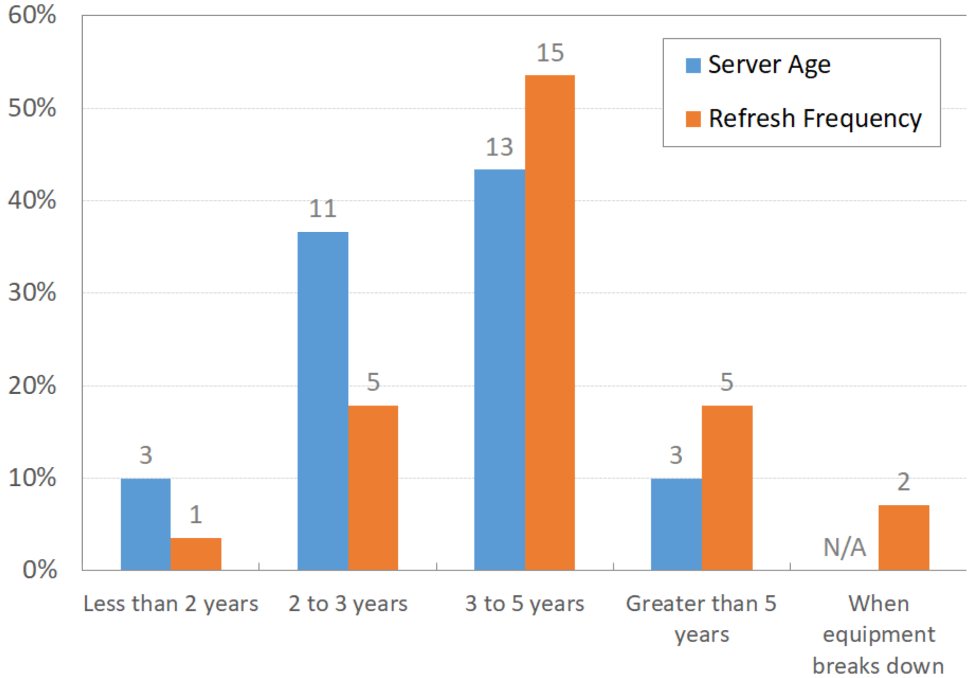
Figure 16. Planned upgrade frequency to servers in surveyed Wisconsin SEDCs



AVERAGE SERVER AGE AND EQUIPMENT REFRESH FREQUENCY

Most of our survey respondents indicated that their servers are more than two years old (Figure 17). Our survey indicates that most IT departments refresh their IT equipment when it is more than three years old. Additionally, the 2015 Uptime Institute Data Center Industry survey reported that “nearly two thirds of their survey respondents install a server in a rack and do not replace it for four or more years.”[12] Businesses with SEDCs often hold on to servers even longer to keep important legacy software running properly, following the adage, “If it ain’t broke, don’t fix it.”

Figure 17. Average age of servers and refresh frequency in surveyed Wisconsin SEDCs



Data Center Energy Savings Opportunities

Multiple energy savings opportunities were addressed in the survey. The following section summarizes these opportunities in more detail.

CLOUD SERVICES

Cloud services and cloud computing can save energy by outsourcing energy intensive computing needs to more energy efficiency enterprise data centers. Nearly two-thirds (61%) of survey respondents currently use some form of cloud services or cloud computing. These cloud services can include a combination of email, file storage, applications such as word processing, spreadsheets, presentations, databases, etc., and other services available remotely in the cloud.

The main barriers to adoption of cloud services were security, privacy and cost (Figure 18). However, only 7% of survey respondents indicated that expanding cloud services would not be useful. If Focus on Energy programs can overcome these barriers, there is an opportunity for additional savings so long as

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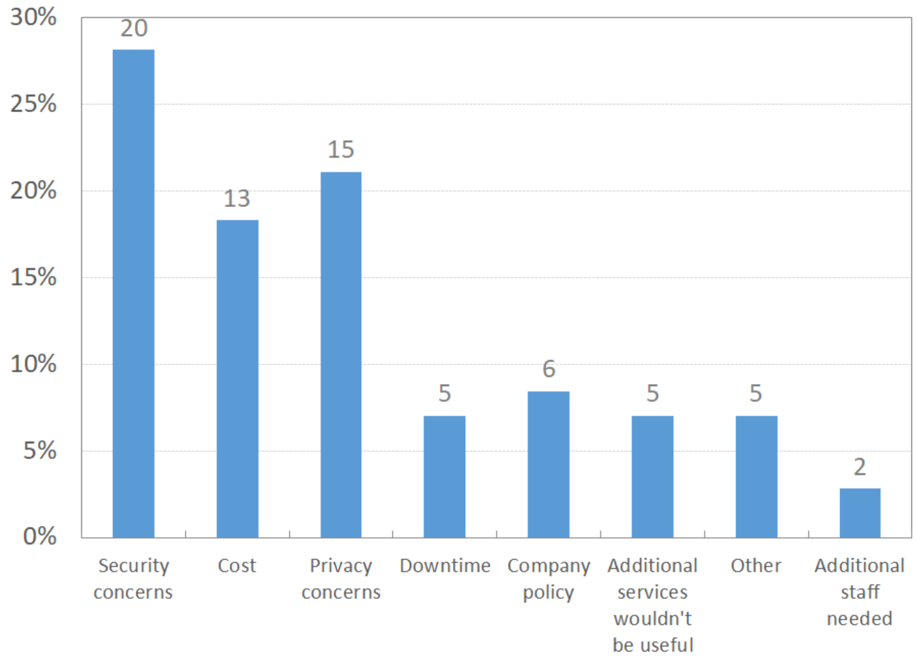
[12] Matt Stansberry, 2015. Uptime Institute Data Center Industry Survey 2015. Uptime Institute LLC. https://uptimeinstitute.com/uptime_assets/08200c5b92224d561ba5ff84523e5fdefeec6b58cbf64c19da7338e185a9c828-survey15.pdf

switching to cloud services is not considered a free rider. This assumes that enterprise data centers are more efficient than the server rooms they replace, which may not necessarily be the case.

Figure 18. Barriers to using cloud services in surveyed Wisconsin SEDCs



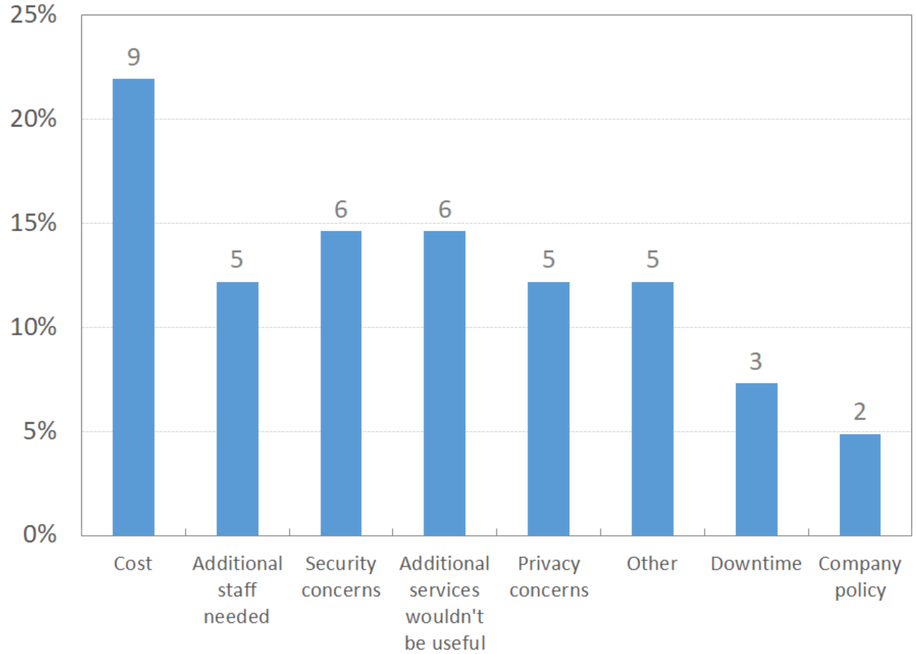
VIRTUALIZATION

Server virtualization allows one physical server to host many virtual machines, or guests, which run their own independent operating systems, applications, and system resources. In other words, several virtual machines/guests can run on a single physical server, reducing the power demand of the SEDC by removing unneeded single application dedicated physical servers. In addition to the virtualization software, or hypervisor, the physical server needs to have a CPU that supports virtualization and sufficient computer resources such as RAM and block storage must be available for all the virtual servers to perform their functions without a performance penalty. ENERGY STAR has provided information on savings, costs, and other considerations for adopting server virtualization.[13]

The main barrier to virtualization for our survey respondents was cost (Figure 19). However, only 15% of survey respondents indicated that expanding virtualization would not be useful. If Focus on Energy programs can overcome these barriers, there is an opportunity for additional savings.

[13] ENERGY STAR. "Server Virtualization." energystar.gov. https://www.energystar.gov/products/low_carbon_it_campaign/12_ways_save_energy_data_center/server_virtualization (retrieved December 17, 2017)

Figure 19. Barriers to using virtualization in surveyed Wisconsin SEDCs



ENERGY STAR EQUIPMENT

Since September 2013, EPA ENERGY STAR has been certifying energy efficient IT equipment. This equipment includes servers, data storage, and large network equipment (LNE) which include switches, routers, and UPSs. There are currently no tiers for these equipment types. Product specifications for the major SEDC IT equipment include:

- Servers - efficiency and power factor requirements on power supply units (PSUs) and base idle power state allowances;[14]
- Storage Equipment - efficiency and power factor requirements on PSUs, the use of variable speed fans for equipment cooling, capacity optimizing methods;[15]
- LNE (i.e., switches and routers) - efficiency and power factor requirements on PSUs;[16] and
- UPSs - minimum average efficiency requirements.[17]

All the major manufacturers of data center IT equipment now offer ENERGY STAR certified equipment.

The overwhelming majority (93%) of survey respondents purchase ENERGY STAR equipment when possible. However, there currently is not significant market penetration of these more efficient pieces of equipment due to the rating being relatively new. Further, purchasing ENERGY STAR equipment is company policy for only 15% of our survey respondents. Taken together, this limits the risk of free

[14] ENERGY STAR. "Enterprise Server Key Product Criteria." energystar.gov. https://www.energystar.gov/products/office_equipment/enterprise_servers/key_product_criteria (retrieved April 28, 2017)

[15] ENERGY STAR. "Data Center Storage Key Product Criteria." energystar.gov. https://www.energystar.gov/products/office_equipment/data_center_storage/key_product_criteria (retrieved April 28, 2017)

[16] ENERGY STAR. "Purchasing More Energy-Efficient Servers, UPSs, and PDUs." energystar.gov. https://www.energystar.gov/products/office_equipment/large_network_equipment/key_product_criteria (retrieved April 28, 2017)

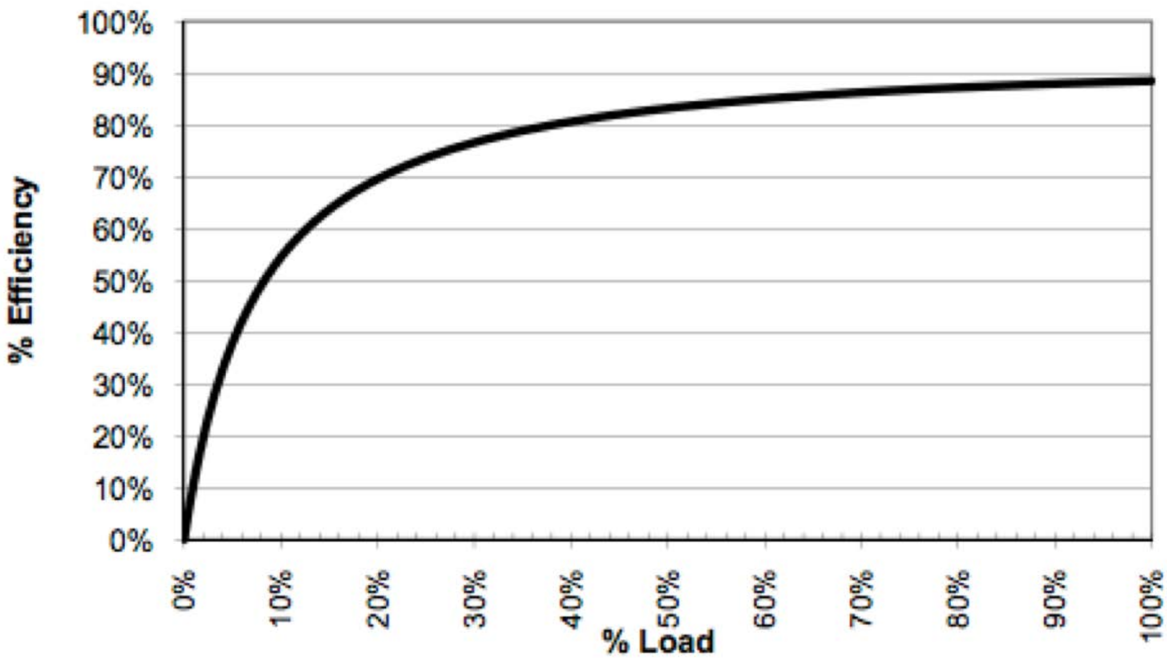
[17] ENERGY STAR. "Uninterruptible Power Supplies Key Product Criteria." energystar.gov. https://www.energystar.gov/products/office_equipment/uninterruptible_power_supplies/key_product_criteria (retrieved April 28, 2017)

ridership. Focus on Energy programs could capture energy savings by offering prescriptive rebates for ENERGY STAR equipment such as servers and UPS.

UPS UTILIZATION AND LOADS

The size or capacity of the UPS can affect the overall efficiency of the data center. The efficiency of the UPS is dependent on the magnitude of the IT load relative to the capacity of the UPS. The greater the percent load of the battery capacity, the greater the efficiency of the UPS. Figure 20 shows a typical UPS efficiency curve.

Figure 20. Typical UPS Efficiency Curve[18]



A choice then must be made when sizing the UPS. If a power outage does occur, how much battery capacity is required to keep mission critical services running? Typically, battery capacity is designed to allow IT equipment to gracefully shut down or to allow sufficient time for power to be restored via backup generation or resumption of service. The rule of thumb for sizing a new UPS is to plan the capacity to be 20-25% greater than the load.

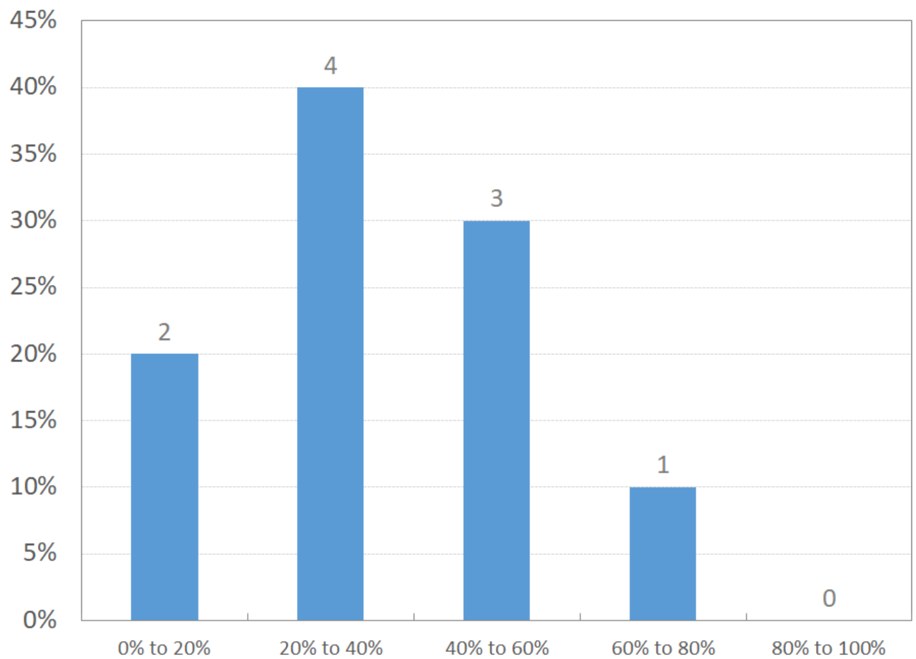
Fortunately, approximately two-thirds (61%) of survey respondents monitor UPS utilization. They therefore would quickly understand their particular SEDCs need for upgrading if given the right information to act on it.

Nearly two-thirds (60%) of survey respondents had UPS utilizations between 0 and 40% (Figure 21). Increasing UPS utilization from a 10% utilization to a 40% utilization can raise the efficiency from about 50% to 80%. This efficiency increase has a proportionate decrease in electrical energy consumption. A more modest utilization increase from 40% to 80% (the maximum reported in our survey) would have a smaller, but still significant, improvement in efficiency from about 80% to 87%. Often sites have more than one UPS, all operating at low utilization, and consolidating them into one UPS with higher

[18] Sawyer, R.L. 2012. Making Large UPS Systems More Efficient. White Paper 108, Revision 3. APC by Schneider Electric. http://www.apc.com/salestools/VAVR-6LJV7V/VAVR-6LJV7V_R3_EN.pdf (retrieved April 28, 2017)

utilization not only increases the efficiency of the one remaining UPS but also allows the other UPSs to be powered down. However, this wouldn't be possible if the UPSs were redundant by design. Replacing older UPSs with properly sized ENERGY STAR UPSs will increase efficiency in two ways: (1) a more efficient UPS efficiency curve and (2) greater efficiency as a result of increased utilization.

Figure 21. Range of UPS utilization in surveyed Wisconsin SEDCs

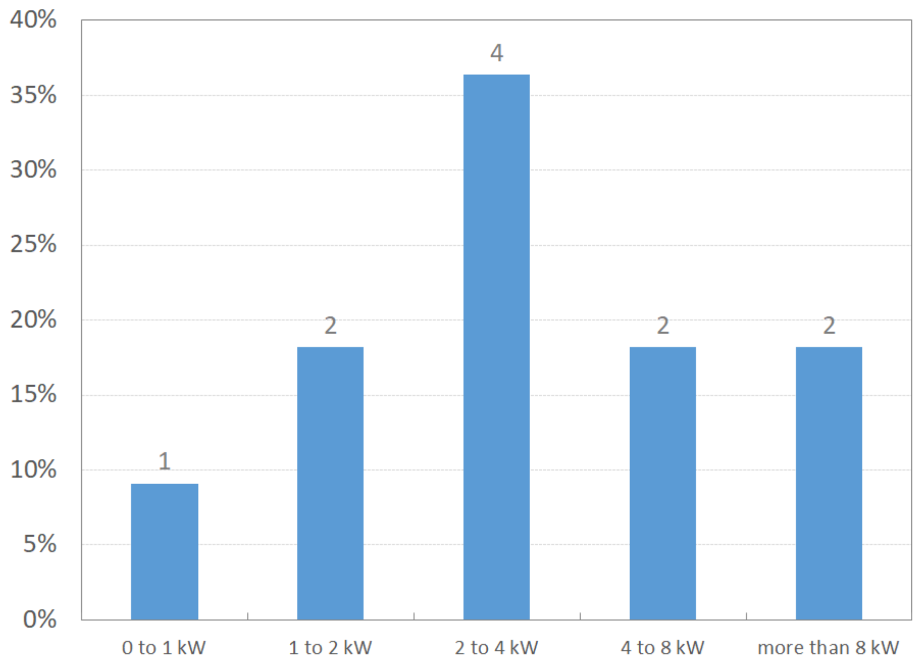


Survey respondents reported that over nearly three-quarters (73%) of their UPS loads are over 2 kW (Figure 22). This is a good measure of the total power load of the SEDCs. A load of less than 2 kW likely represents network closets and greater than 2 kW probably represents a server room. This self-reporting, however, may be an underestimate because:[19]

1. Actual server utilization is typically "embarrassingly bad,"
2. Scheduled auditing to actually identify this issue is not performed, and
3. There is no accountability for the costs associated with poor utilization.

[19] Stansberry, op. cit.

Figure 22. Range of UPS loads in surveyed Wisconsin SEDCs



SERVER CONSOLIDATION

A study by NREL estimated that 30% of all servers are "comatose" – they are powered on but are not serving any useful information or computing services.[20] This often occurs when an application is no longer used, or migrated to the cloud. However, no IT personnel are willing to take ownership and actually unplug the associated server. A smaller proportion of Wisconsin servers (9%) were reported to be "on" but that have host applications that are not being used. There is therefore significant opportunity for server consolidation in Wisconsin. Additionally, when present, it is a low-cost savings opportunity with minimal barriers to implementation.

HVAC ENERGY SAVINGS OPPORTUNITIES

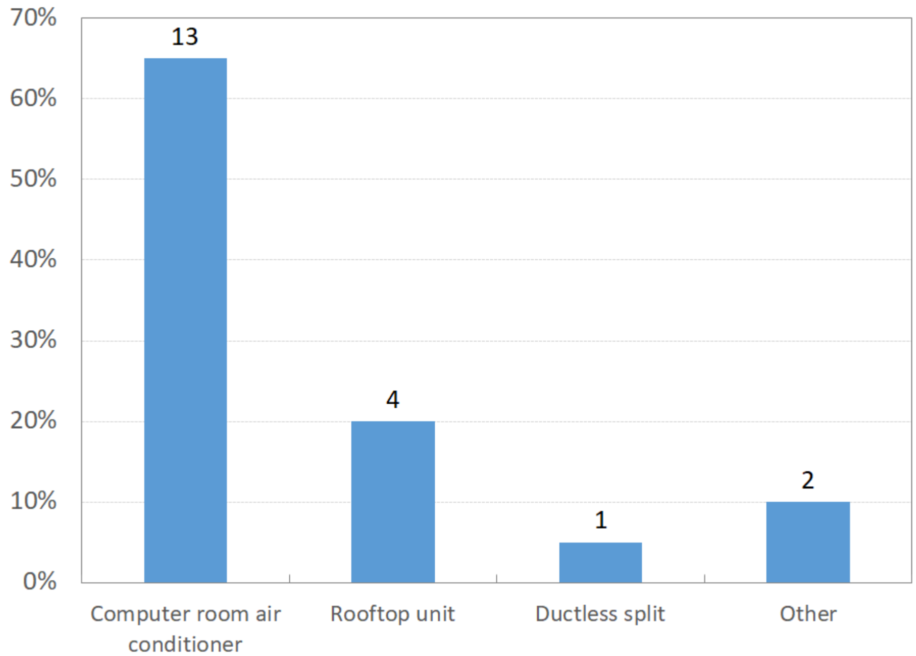
The energy used to cool SEDCs is a significant component of their overall energy consumption. The following sections outline additional energy savings opportunities related to the HVAC systems that serve SEDCs.

COOLING EFFICIENCY

Over three-quarters (77%) of Wisconsin SEDCs have dedicated cooling. These SEDCs are served by a variety of cooling equipment (Figure 23).

[20] Jon Koomey and Jon Taylor. 2015. "New data supports finding that 30 percent of servers are 'Comatose', indicating that nearly a third of capital in enterprise data centers is wasted." Anthesis Group, June. http://anthesisgroup.com/wp-content/uploads/2015/06/Case-Study_DataSupports30PercentComatoseEstimate-FINAL_06032015.pdf (retrieved April 28, 2017)

Figure 23. Cooling equipment type in surveyed Wisconsin SEDCs



Of SEDCs with dedicated cooling, two-thirds (65%) are served by computer room air conditioners (CRAC) units. CRAC units are specialty equipment; designed, sold and maintained by specialty vendors. There is a programmatic opportunity to work with these vendors to embed energy efficiency in their services.

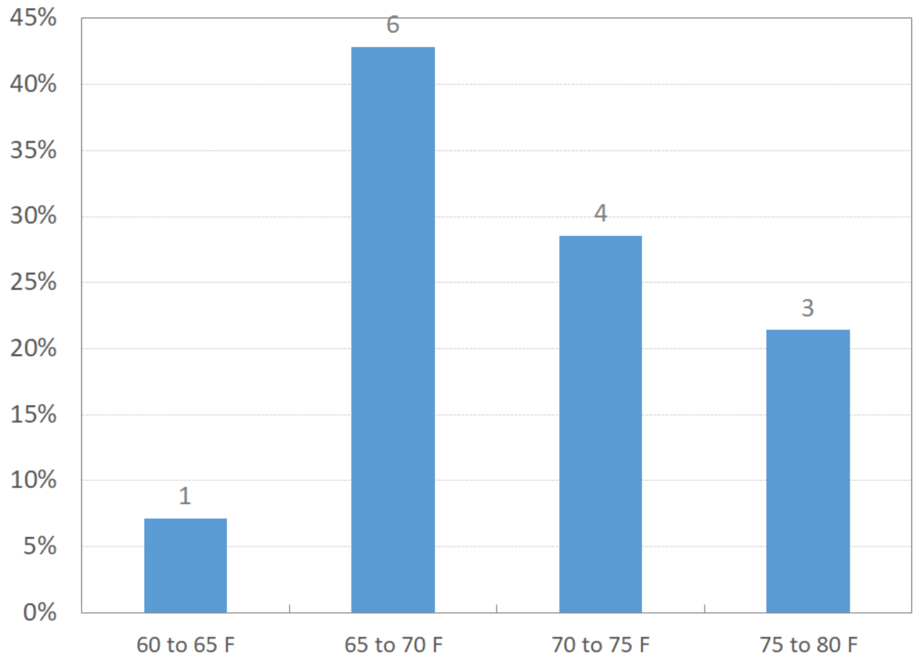
Additionally, one-fifth (20%) of Wisconsin SEDCs are served by RTUs. Energy savings could be captured through increased cooling efficiency and economizer controls. Both of these are currently included as prescriptive HVAC measures within Focus on Energy. However, the prescriptive incentives are too low for this application as they do not reflect the 24/7 operation of SEDC cooling loads. Targeted, and therefore higher, incentives towards SEDCs could facilitate these savings.

TEMPERATURE SETPOINT ADJUSTMENT

The temperature setpoint in SEDCs is a factor in the amount of cooling energy they require. The higher the setpoint, the less energy is needed. Manufacturer's recommended operating temperature ranges for servers have increased over the years, but the observed SEDCs rarely reflect these changes. While there is an upper limit to the setpoint, set points can generally be increased by about 5 degrees. Cooling systems remain necessary as data center equipment performance can be compromised by high temperatures; ASHRAE recommends that server inlet air temperature be between 64.4 and 80.6 °F. Note that this recommended temperature is different than the thermostat setpoint, which is often several degrees lower.

The average thermostat temperature setpoint was 69.8 °F (Figure 24). Simply increasing this towards the high end of the ASHRAE recommended range would result in cooling energy savings.

Figure 24. Thermostat setpoint temperature in surveyed Wisconsin SEDCs

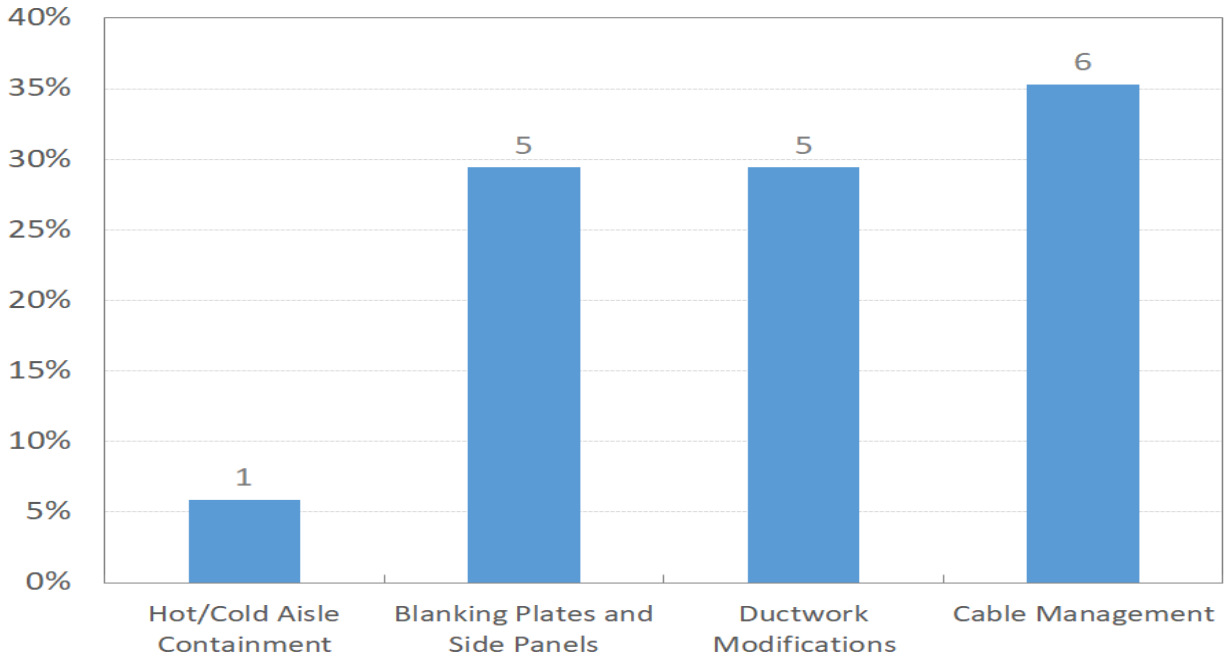


AIRFLOW MANAGEMENT STRATEGIES

In SEDCs, air flow management can save cooling energy by separating the cool inlet air from the hot outlet air for the server racks. This reduces mixing and increases the effectiveness of the cooling system.

Nearly half (48%) of survey respondents had no air flow management strategies employed in their SEDCs (Figure 25). Any measures that are implemented will reduce cooling energy requirements.

Figure 25. Air flow management strategies in surveyed Wisconsin SEDCs



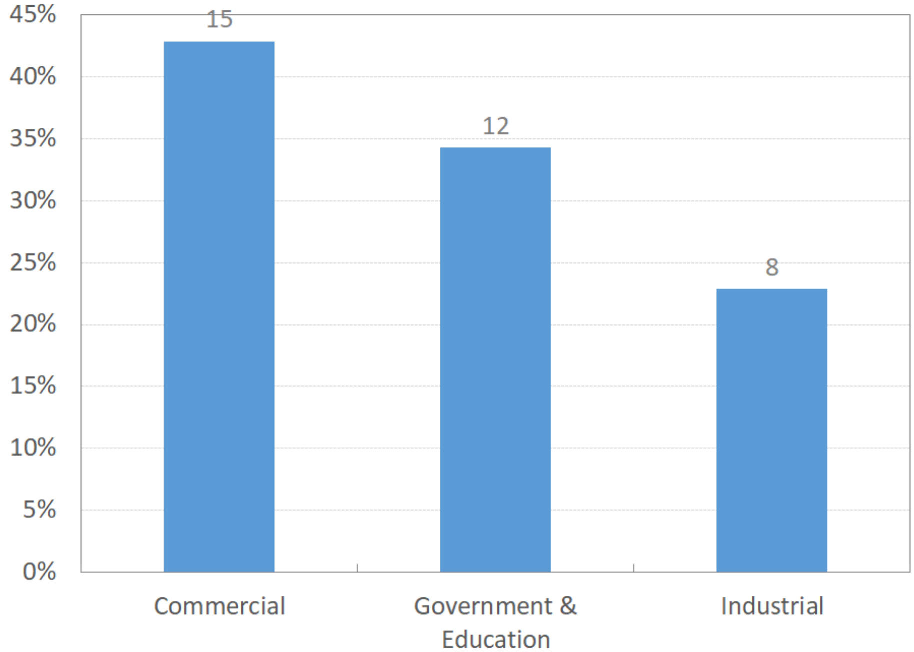
Of those that did have some air flow management strategy, there is still a significant opportunity. Particularly with respect to the low penetration of hot/cold aisle containment. Simple plastic curtains have been shown to be an effective method to implement this measure for SEDCs.

Interaction of SEDCs and energy efficiency

Additionally, we gathered information relevant to how those who manage SEDCs interact with Focus on Energy programs and how they consider energy efficiency in their decisions on equipment upgrades or replacement.

Although we couldn't map each survey respondent to a specific Focus on Energy program, Figure 26 suggests that SEDCs may be found in significant numbers across Focus on Energy with Commercial, Government & Education and Industrial roughly aligning with the BIP, ASGP and Large Energy User programs, respectively. Although opportunities exist across Focus on Energy programs, survey data indicated a low awareness of and participation in current, applicable Focus on Energy custom and prescriptive programs. Over four-fifths (83%) were unaware of rebates or incentives from Focus on Energy for purchasing energy efficient equipment. Additionally, only one-quarter (25%) have received a rebate or incentive within last 2 years for upgrading data center. Since the mean reported equipment lifetime was about five years, participation approaching 100% is possible.

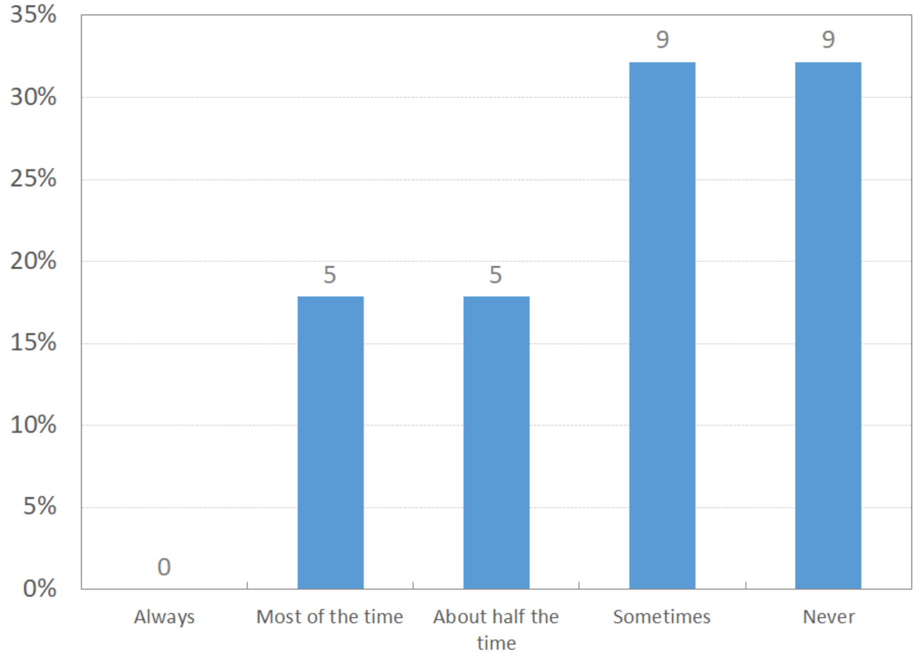
Figure 26. Business activity type generally mapped to Focus on Energy programs



Despite this, survey data indicated that energy efficiency is an important factor when considering upgrades or changes to SEDCs.

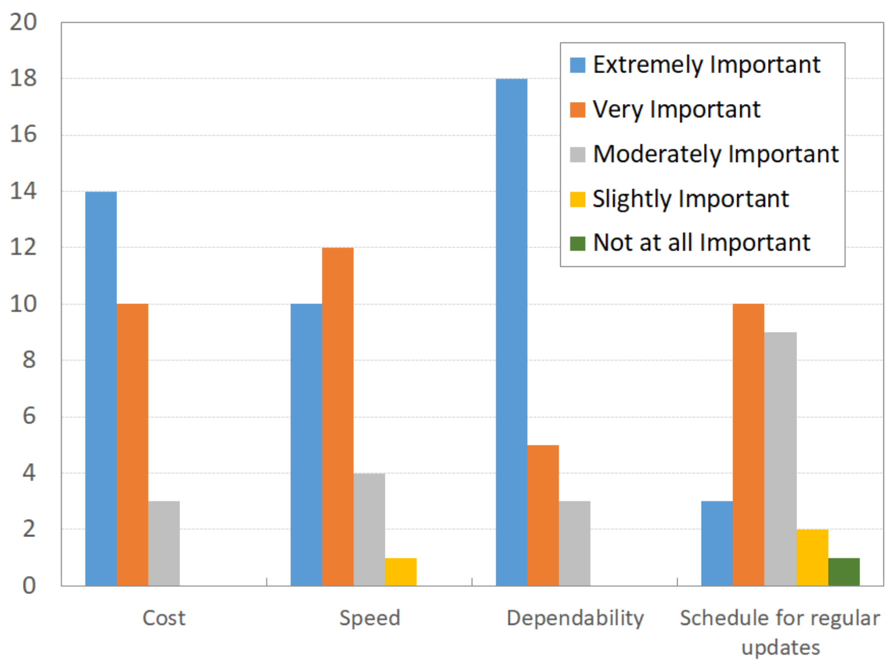
Over two-thirds (68%) of IT staff in Wisconsin SEDCs are considering energy efficiency (Figure 27). In addition, almost all (94%) of businesses pay their own energy bills, meaning they will realize the benefits of energy efficiency. Although it is an important factor, energy efficiency is not the primary factor. Nearly two-thirds (62%) of survey respondents indicated that energy efficiency was one factor among many that they considered.

Figure 27. Frequency that energy efficiency factored into decisions in surveyed Wisconsin SEDCs



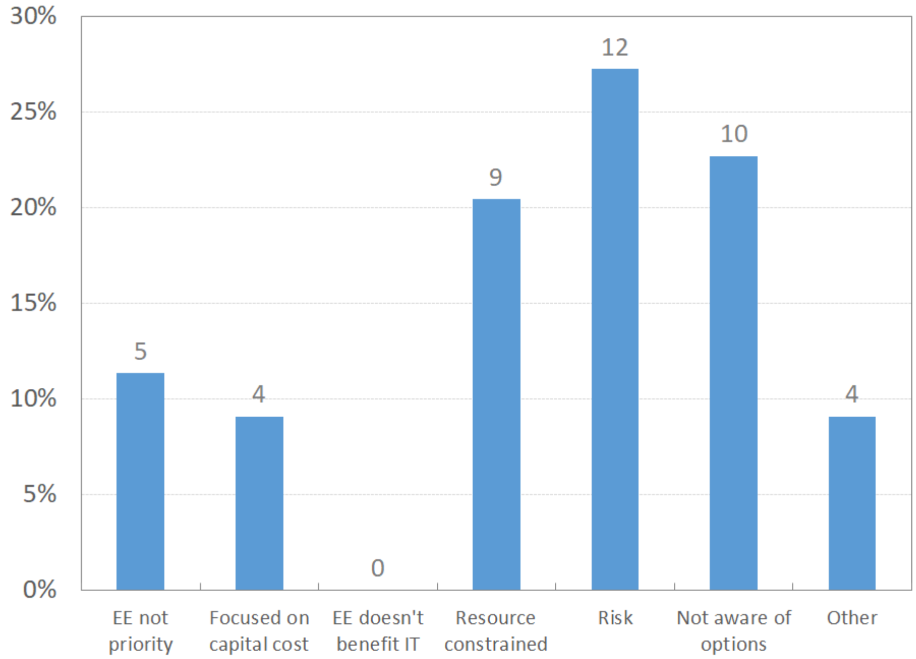
Survey respondents consistently ranked dependability as extremely important when making decisions about SEDC upgrades (Figure 28). Capital cost was similarly extremely important, and speed was ranked as very important. Taken together, this suggests that companies are open to energy efficiency, when these other factors are also met. Unfortunately, a variety of barriers still stand in the way of improved SEDC energy performance.

Figure 28. Relative importance of factors when considering SEDC upgrades



Survey respondents consistently indicated that risk was a significant barrier (Figure 29). IT staff are reluctant to change mission critical systems. This barrier will be difficult for a program to overcome. Case studies may help, although as mentioned previously IT staff tend to view their SEDC as unique. Energy advisor expertise would likely be the best way to overcome this barrier. Constrained resources are also a significant barrier that can be partially offset by incentives. Surprisingly no one mentioned that energy efficiency doesn't benefit IT.

Figure 29. Barriers to pursuing energy efficiency in surveyed Wisconsin SEDCs

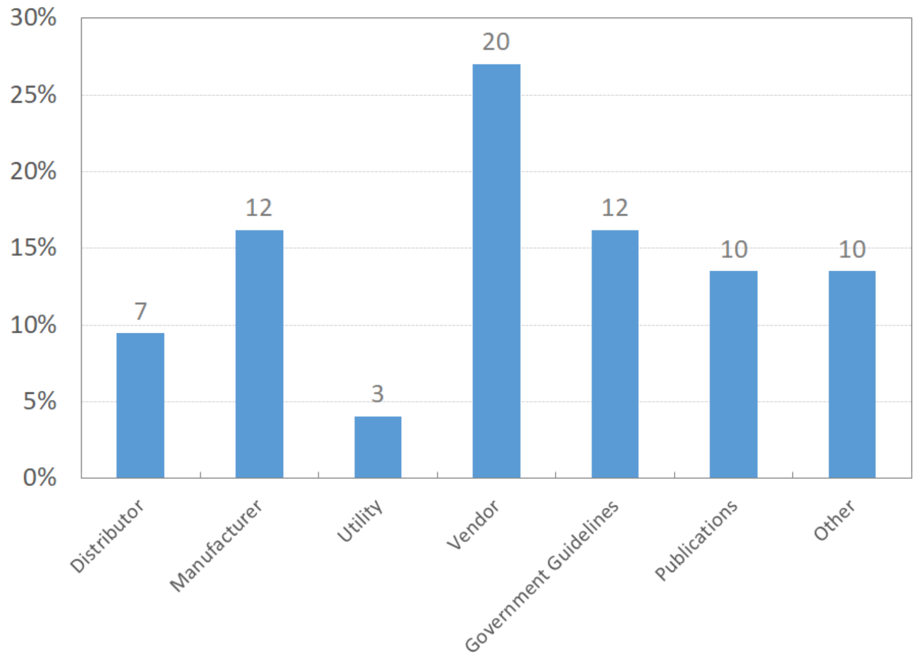


An additional barrier is that most Wisconsin businesses have no idea how much energy their SEDCs are using. Over two-thirds (70%) of data center power usage is not monitored. However, 26% of these respondents at least knew their UPS load, meaning they had some understanding of their SEDCs electric demand and therefore energy consumption. Programmatic education and outreach could focus on the amount of energy typically wasted, potentially opening doors for further efficiency options.

A lack of awareness of energy efficient options can be dealt with programmatically through targeted outreach and training. Identifying the sources of information of Wisconsin IT staff is an important first step.

The most trusted source of information were vendors. Identifying and working with vendors to help embed energy efficiency in their business approach may be one way to overcome barriers to increased program penetration. The following vendors were listed by survey respondents: Access Incorporated, Meraki, School Tech Supply, Source One Technology and Swick Technologies (Figure 30).

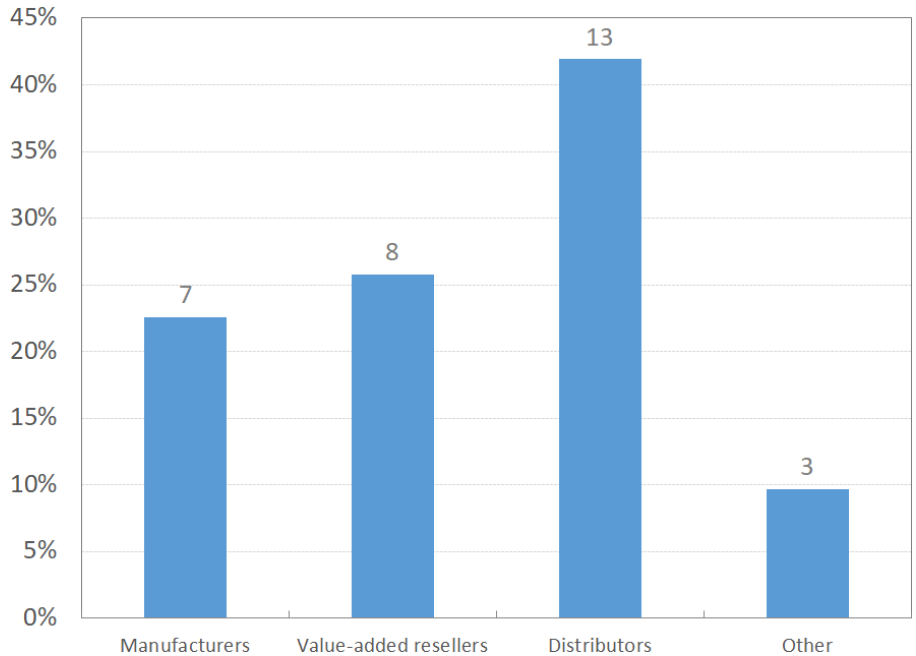
Figure 30. Sources of information of Wisconsin IT staff



Other important sources were manufacturers, government guidelines and publications (such as industry magazines). A significant number of "Other" responses were corporate IT staff. In fact, this may be a barrier for Focus on Energy programs, in that it is often difficult to reach these decision makers, on the other hand, because corporate IT managers rely heavily on their peers to learn of the newest best practices, reaching them should remain a goal for programs.

There may be an opportunity to work upstream by providing incentives to vendors and manufacturers to promote energy efficient equipment and to promote energy saving practices. Wisconsin IT staff predominately purchase data center equipment from distributors. However, manufacturers and value-added resellers are also important (Figure 31).

Figure 31. Who Wisconsin IT staff purchase data center equipment from



The following distributors were listed by survey respondents: Swick Technologies, Simple Network Consulting, Envision IT LLC, Presidio, Heartland, CDWG and Sophos.

The following manufacturers were listed by survey respondents: Microsoft, Dell, Cisco, CDW, Lenovo, Hewlett Packard and Apple.

FIELD STUDY

The five sites varied in both the size of the SEDC and sophistication of staff. On the lower end was an SEDC with 1 rack and outsourced IT, on the higher end was an SEDC with multiple racks and sophisticated in-house IT staff. The following are the conclusions reached, organized by the sections of our protocol.

Interview

We began each site visit with an interview of either facility or IT staff, depending on their availability. Having both present would have been preferable, as there were often gaps in knowledge on specific subjects. This portion of the site visit could have been conducted entirely remotely over the phone. Collecting this data via an online survey would likely lose the potential for follow-up or clarification that a conversation allows. However, pre-screening sites via a short online survey that contains the most important drivers would be a reasonable preliminary step.

SCHEDULING

A stated barrier to server power management is scheduled backups and updates, as well as flexible worker schedules necessitating servers be accessible by remote employees during off hours. However, a more significant barrier is lack of awareness and experience with this control. None of the staff knew about server power management, nor how to access the settings.

CLOUD SERVICES

Similar to the findings of the online survey, the onsite interviews revealed a perception that expanding cloud services would be beneficial. However, security remained a concern, even prompting one organization to not use any cloud services.

Equipment Status

Interviewees often did not know the age of their equipment, requiring email follow-up to obtain it. A process improvement would be to send a list of questions beforehand, so that the interviewee could look-up information prior to the visit.

The more sophisticated IT staff had a planned equipment renewal schedule, as well as allocated budget for making upgrades. The less sophisticated IT staff bought replacement equipment when failures occurred. Since these businesses did not have an equipment replacement/upgrade plan or budget, replacement decisions were made quickly based on availability to restore capabilities and minimize downtime, without thinking about energy efficiency.

WORKSTATIONS

Computer power management was a consistent opportunity, although the trend in newer operating systems has these settings enabled by default. However, a significant opportunity still remains.[21] The main barrier is pushback from users. Focus on Energy could develop educational material, stepping IT staff through the process of rolling out computer power management that minimizes user pushback.

MOTIVATIONS TO TAKE ACTION

Generally, the larger organizations had more sophisticated IT staff, which reported being directed to reduce operating costs. However, the SEDCs were never metered separately. Without energy consumption data, IT staff could never prove the success of energy reduction initiatives, nor understand the magnitude of the SEDC energy consumption. Focus on Energy could develop simple calculators for approximating SEDC annual energy consumption and energy cost based on a few easy inputs. They could additionally incentivize newer, less expensive wireless metering solutions such as Packet Power.[22]

Walkthrough

The second part of the site visit was a walk-through of the SEDCs including inventory of the equipment. Similar to the interview, this inventory could have generally been done remotely by providing tables of the type of equipment that were to be included. When dealing with a "walk-in" visitor, IT and facility staff often did not know the desired information about their equipment, nor could we find it on nameplates because they were often either inaccessible or nonexistent. For all site visits, the interviewee had to follow-up after they had time to access their equipment inventory spreadsheets, equipment spec sheets, or invoices. This could have been done in advance.

COOLING

Besides the inventory of cooling equipment, we also measured the air temperature at both the thermostat and the server inlets. We found that the thermostat setpoint could generally be increased and still meet the recommended server inlet temperature of 75 °F. Note that this recommendation still leaves a 5 °F safety margin to the upper limit of ASHRAE recommended server inlet temperature range. It is interesting to note that one SEDC was registering server inlet temperatures above 82 °F. When this was mentioned to the facility personnel, they remembered that the servers had overheated on at least one occasion and

[21] Hackel et al., "Impacts of Office Plug Load Reduction Strategies", COMM-20140512-87091, October 2016.

[22] www.packetpower.com

needed to be rebooted. This anecdotally shows that the upper limit of ASHRAE's recommendations is correct. This situation arose because the thermostat controlling the space conditioning in the SEDC was located in an adjacent, perimeter office. This space's cooling loads were drastically different from the SEDC, meaning it was not receiving the cooling it needed. We recommended installing an exhaust fan to draw adjacent conditioned air into the server room.

Measuring air temperatures was an aspect of the site visits that would be difficult to conduct remotely. However, the same Hobo temperature sensors that we used during the site visits could be mailed to prospective sites. Simple instructions could be included for how to place each at server inlets and the thermostat for a specified period of time. Once the period was over, the sensors could then be mailed back to Focus on Energy for analysis. Including the packaging for mailing the equipment back, as well as pre-launching the sensors would minimize the time requirement of the IT personnel. Note that since the sensors would be recording temperature data during shipping, only the temperature data during the prescribed measurement time period should be analyzed.

Another potential energy savings opportunity was air flow management. During the walk through we attempted to understand the SEDC layout, in order to identify opportunities for improved air flow management. This aspect of the site visits would be very difficult to conduct remotely. This is especially compounded by the fact that IT and facility staff were often reluctant to give permission for us to take photographs. This reluctance was driven by security concerns. So, a program design that required staff to send pictures and drawings of the SEDC would face a significant barrier. To determine if an opportunity existed for air flow management, simple screening questions could be used to understand the extent or previous air flow management efforts. If none had previously been undertaken, an opportunity probably exists that would warrant further investigation on site.

While the majority of the SEDCs we visited had typical cooling systems, one SEDC used a unique liquid cooled approach. This system, from LiquidCool,[23] uses a dielectric fluid to remove heat from servers, then reject that heat to an adjacent printer room. Small variable speed pumps efficiently move the liquid. Due to the improved efficiency of removing heat in this way, this SEDC was able to dramatically reduce the cooling energy it required, achieving a measured PUE of 1.03. Other manufacturers with similar systems are Ebullient[24] and 3M.[25]

IT EQUIPMENT

When inventorying the IT equipment, several specific data points were particularly difficult to locate without follow-up. They included whether a server was categorized as 1S and 2S+ (number of sockets for processors in the server), the port speed of the network switches, and UPS utilization.

When we were able to identify the UPS utilization, it was typically very low, ranging from 15% to 40%. We even found one UPS that was reading 0% utilization. This confirmed that smaller sizing when purchasing replacement UPS or UPS consolidation are opportunities for programs that would increase utilization and improve efficiency.

Another frequent opportunity was purchasing ENERGY STAR equipment. However, IT and facility staff often lacked knowledge about the equipment types for which ENERGY STAR equipment was available. Focus on Energy could develop a fact sheet describing which IT equipment had ENERGY STAR equipment options, and a list of best practices when ENERGY STAR was not available. Additionally,

[23] http://www.liquidcoolsolutions.com/

[24] http://ebullientcooling.com/

[25] https://www.3m.com/3M/en_US/novec-us/applications/immersion-cooling/

Focus on Energy could develop template purchasing policy language that companies could incorporate into their own purchasing policies. This template language could reflect the fact sheet, specifying ENERGY STAR equipment where applicable or best practices where it is not.

We did not see significant external storage on our site visits, but where there was external storage there was usually an opportunity to switch from Hard Disk Drive to Solid State Drive.

Increasing virtualization was definitely an opportunity for improved energy performance in our walk throughs. However, this measure is harder to implement, often occurring at server refresh; it also has limitations due to security concerns and policies of some customers.

MISCELLANEOUS LESSONS LEARNED

Interviewees often reiterated our previous findings that budgets are tight. Internal payback thresholds for purchases also tended to be low, often less than 1 or 2 years. Similarly, they reiterated that their staff was busy, not having the time to thoroughly consider efficiency nor to work with Focus on Energy. They worried that the rebate may be not be large enough to justify their time commitment. They instead relied on vendors or outsourced IT to provide recommendations. Focus on Energy could work with these trade allies to help them embed energy efficiency in their business model.

We were also able to confirm that the data provided via the survey was accurate, strengthening the case that data could be collected remotely without site visits.

CONCLUSIONS AND RECOMMENDATIONS

As a result of our work on this project, we found that:

1. Wisconsin has a large number of businesses with SEDCs (approximately 1,600 commercial buildings), resulting in an annual energy consumption of approximately 98 GWh.
2. The majority of SEDCs can be found in offices, manufacturing, and education.
3. Most SEDCs have dedicated cooling.
4. Current practices offer the opportunity for significant energy savings through both IT equipment and cooling measures.

The biggest challenge for a Focus on Energy SEDC program is to optimize its efforts to identify and recruit the most likely businesses that would participate in the program and achieve good energy savings. Finding the right businesses is a challenge because we are dealing with an abundant and diverse population of customers with somewhat limited total energy usage. A Focus on Energy program could most effectively achieve energy savings by targeting SEDCs that fulfil specific requirements that would benefit most from a defined set of effective IT and cooling measures.

SEDC SCREENING CRITERIA

Table 3 provides the screening criteria for identifying SEDCs in existing Focus on Energy customers that would be candidates for achieving significant energy savings.

Table 3. Screening Criteria for SEDCs with Good Potential Energy Savings

Priority Level	Type of Need	Characteristic
Required	CRAC	Has a dedicated AC system conditioning the EDC
Required	Servers	Has ten or more physical servers
Required	Electrical	UPS capacity over 4 kVA
Strongly Preferred	Equipment	Age of equipment > 5 years, opportunity for purchasing ENERGY STAR equipment
Strongly Preferred	Equipment	IT staff can provide equipment inventory
Strongly Preferred	Company Size	Has over 80 employees (assuming 8 employees per server)
Preferred	UPS utilization	<40%
Preferred	Server consolidation	Opportunity for virtualization
Preferred	Server consolidation	Opportunity for cloud services or colocation
Preferred	Room set point temperature	<70°F
Preferred	Airflow management	Opportunity to perform hot aisle/cold aisle containment

IT MEASURES

The following recommended IT measures have the most potential to achieve substantial savings, increasingly the likelihood of implementation.

Table 4. Recommended IT Measures

Category	Measure
UPS Utilization	1. Increase UPS utilization to 75-80% thru UPS consolidation.
Server Consolidation	2. Power down any unused (comatose) servers.
	3. Reduce the number of physical hosts by employing server virtualization.
	4. Reduce the servers by moving those IT services to the cloud (typically email, file, and database servers).
ENERGY STAR Equipment	5. Purchase ENERGY STAR-certified IT equipment when refreshing
Storage Reduction	6. Move storage to cloud services

Category	Measure
	7. Archive unused storage onto tape drives and power down unneeded disk drives.
IT Equipment Scheduling	8. Perform Live Migration or DPM on virtualized servers and place unused physical hosts on standby.
	9. Power down network switches, ports, and/or PoE during non-work hours such as nights, weekends, and holidays.

COOLING MEASURES

We recommend two primary measures for SEDCs that have dedicated mechanical systems:

1. Improve air flow management through:
    a. Cold aisle/hot aisle containment by delivering the conditioned air to the front of the server racks (cold aisle) and exhausting the heated air from the back of the server racks (hot aisle),
    b. Installing blanking panels, and
    c. Performing cable management best practices.
2. Raise the set point temperature in the SEDC to deliver 75°F inlet temperatures at the server racks.

Additional measures that deal specifically with the mechanical system such as economizing and retrofitting with VFDs are in the realm of existing utility HVAC recommissioning programs. An exhaust fan installed with hot aisle containment as an alternative to dedicated cooling can be an effective cooling measure for an appropriately sized SEDC.

QUANTIFYING ENERGY SAVINGS

For Focus on Energy custom rebate programs, Table 5 provides some guidance on calculating savings for the above IT and cooling measures. Focus on Energy could additionally use this table to cross-reference against existing measures for future workpaper updates. One important note is that typically the Power Usage Effectiveness (PUE) of SEDCs is about 2 which means that the cooling power load is about equal to the IT power load. If we can assume that this stays constant over the range of operation of the SEDC, any IT savings that are achieved will result in a cooling energy savings of the same magnitude.

Table 5. Quantifying SEDC Energy Efficiency Measure Savings

Category	**Savings**
Server Consolidation	2,891 kWh/yr per server (assuming average power of 330 W/server)

Category	Savings
UPS Utilization	kWh/yr = $UPS_{load} * ((\eta_1 - \eta_0) / \eta_1 \eta_0) * 8760$ hr/yr where UPS_{load} is the IT power load read off the UPS (in kVA) and η_0, η_1 are the UPS efficiencies at the initial and increased percent IT loads, respectively (obtained from Figure 20)
Storage Reduction	kWh/yr = ((# of HDDs * 9) + (# of SSDs * 6)) * 8760 hr/yr where # of HDDs are the number of hard disk drives taken off line and # of SSDs are the number of solid state drives taken off line
IT Equipment Scheduling	kWh/yr = $(UPS_{load, on} - UPS_{load, off}) * Hours_{off}$) where $UPS_{load,on}$ and $UPS_{load,off}$ are the IT power loads read from the UPS (in kVA) when the devices are scheduled on and scheduled off, respectively; and $Hours_{off}$ is the total number of hours in the year that the equipment is scheduled to be off. For the network switches, a deemed savings approach could also be used to calculate the expected savings. IT staff would need to keep track of the number and type of ports that would be powered on and off as well as any PoE devices (such as phone and access points) that are attached to those ports.
SEDC Setpoint Temperature Adjustment	An estimated 4% cooling energy savings accompanies each 1°F increase in the set point.[26]

COST EFFECTIVENESS

The cost effectiveness of these measures will depend on the realized energy savings versus the cost of implementation. While the above section provides a means to estimate energy savings, the cost of implementing the measures will vary depending on the specific actions that are required. For the most part, these measures require IT staff to take simple actions. The simplest measures would be turning off dormant servers or other IT equipment that is not in use, specifying ENERGY STAR-certified equipment when purchasing new equipment, and raising the SEDC thermostat set point temperature. LBNL identified 14 cost-effective measures for improving EDC energy efficiency, as shown in Table 6.[27] The specific cost-effectiveness of these measures will depend on the circumstances of each individual SEDC that define the savings opportunities and the level of staff effort and capital expenditure needed.

[26] http://www.datacenterknowledge.com/archives/2011/03/10/energy-efficiency-guide-data-center-temperature
[27] https://buildings.lbl.gov/sites/default/files/smallserverroomefficiencyfactsheet.pdf

Table 6. Top 14 Measures to Save Energy in an SEDC

Category	Measure
Simple, No-Cost, or Very-Low-Cost Measures	Determine computational functions/turn off any unused or dormant servers. (Server Consolidation)
	Increase temperature set points to the high end of ASHRAE's recommended limit (75°F).
	Examine power backup requirements to determine if the UPS is oversized or even needed (UPS consolidation).
	Install blanking panels and block holes between servers in racks to help with airflow management. Practice good cable management at the back of the racks.
A Little More Work, But Still Fairly Simple	Refresh the oldest equipment with the high-efficiency ENERGY STAR-certified models.
	Migrate services to a more energy-efficient internal or external central data center space, or to co-location or cloud solutions (which can permit further server consolidation, UPS consolidation, and storage reduction).
	Provide energy efficiency awareness training for IT custodial and facility staff (IT equipment scheduling).
Higher Investment, But Very Cost Effective	Implement server power management.
	Consolidate and virtualize applications. Turn off unneeded servers (server consolidation).
	Implement rack/infrastructure power monitoring.
	Install variable frequency drives on cooling units (cf. utility HVAC recommissioning programs).
	Install rack- and row-level cooling (Air flow management through hot aisle/cold aisle containment).
	Use air-side economizers (or hot aisle exhaust fans) (cf. utility HVAC recommissioning programs).
	Install dedicated cooling for the room (cf. utility HVAC recommissioning programs).

NON ENERGY BENEFITS

Over the coming years, IT workforce will see shifting responsibilities. As IT services increasingly migrate to the cloud, on-site IT staff roles and responsibilities will deal less and less with providing IT services. As IT staff are made responsible for energy efficiency considerations, opportunities could arise for increased energy management role. This would be an ideal fit for the skill sets of this skilled workforce who are literate in reading dashboards, responsible for scheduling automated tasks, and trained with the programming skills needed for building automation systems.

PROGRAM DESIGN

We propose the following components for a possible Focus on Energy SEDC program or modifications to existing programs:

1. Education, Training, and Marketing - A significant barrier is that most Wisconsin businesses have no idea how much energy their SEDCs are using. Programmatic education and outreach to IT staff should therefore focus on the amount of energy typically wasted, potentially opening doors for further efficiency options. This outreach should also involve IT equipment vendors, the most trusted source of information to IT staff. Identifying and working with vendors to help embed energy efficiency in their business approach would help overcome barriers to increased program penetration.
2. Pre-Screening - To save cost and time during site pre-screening, a phone and online survey could be used to recruit likely candidates for this program. The survey could be adapted from those tested by this project.
3. Field Visit - A follow-up field visit could identify the measures to be taken and determine the necessary steps to enlist the participant in the SEDC program. The audit would be similar to the inventory used for the field visits.
4. Rebates and Incentives - Either through prescriptive measures or custom rebates, incentives should be created to motivate adoption of the most effective IT and cooling energy efficiency measures for SEDCs.

APPENDIX A: LITERATURE REVIEW

Embedded Data Center Literature Review
Lester S. Shen
Center for Energy and Environment

Since 2011, the principal research studying small embedded data centers (SEDCs) have been performed by the following sources:

1. Natural Resources Defense Council (NRDC) led by Pierre Delforge,
2. Lawrence Berkeley National Laboratory (LBNL),
3. Pacific Gas and Electric (PG&E),
4. Stanford University's Jonathan Koomey, and
5. The State of Minnesota Department of Commerce Division of Energy Resources (DER) Conservation Applied Research and Development (CARD) Program.

This literature review identifies the main reports published by these sources and provides a synopsis of the principal findings produced regarding EDCs.

I. Natural Resources Defense Council (NRDC)

A. **Small Server Rooms, Big Energy Savings** by Drew Bennett and Pierre Delforge[28] – The NRDC survey obtained 30 responses from a wide range of businesses and organizations including "consulting, law, telecommunications, online advertising, public radio, biopharmaceutical, architecture, local government, religious organizations, non-profits, education, and many others." Of the respondents, the number of employees on site ranged from 3 to 750 and the number of servers ranged from 1 to 55. The survey focused on virtualization and cloud computing since those two strategies would likely provide server rooms with the greatest and most cost-effective energy savings. An EPA report to Congress in 2007 found that the average server in the U.S. operates at 5 to 15 percent utilization, suggesting an excellent opportunity for server consolidation and virtualization and/or cloud computing.[29]

Findings

NRDC learned the following lessons:

1. There was a wide variation in ownership configurations with 13 percent of the respondents not owning servers and using cloud computing services, 20 percent having at least one server in the cloud, and 23 percent either renting servers off-site or hosted at a co-location.
2. Only 37% of small organizations surveyed by NRDC had virtualized at least one server and only 26% of all server stock of small and medium businesses (SMBs) had been virtualized. Only 23% of the small companies planned to increase their virtualization in the next 12 months.
3. Lack of information and misaligned incentives are the primary barrier to adoption of virtualization. The survey revealed that 54% of the organizations do not pay their utility bill based on kWh (e.g. the rent includes a fixed fee for utilities). For 58% of the

[28] Drew Bennett and Pierre Delforge, Small Server Rooms, Big Energy Savings: Opportunities and Barriers to Energy Efficiency on the Small Server Room Market, NRDC Issue Paper, February 2012.
[29] U.S. EPA ENERGY STAR Program, Report to Congress on Server and Data Center Energy Efficiency Public Law 109-431, August 2, 2007.

organizations the IT managers did not have regular access to energy use data, and 93% of the organizations did not have ready access to the data center energy use.

4. Half of the small businesses surveyed said that they planned to upgrade their server room within the next year, indicating that opportunity for adopting ECOs exists in these small organizations.

In addition to lack of information and misaligned incentives, NRDC noted the following barriers to adoption of cloud computing and virtualization:

- Energy savings was lower on the list of business priorities and the benefits were not great enough to overcome the corporate inertia;
- Privacy and data security was a barrier with company restrictions in place to prevent cloud computing or virtualization;
- Software and hardware costs are a greater priority to IT managers than energy costs; and
- Technology is not a barrier.

NRDC provided the following policy recommendations:

- Communication and education should be used to promote the use of cloud services, especially dealing with the issues of logistics, benefits, and data security.
- Increased marketing and outreach, along with training and education of IT managers and service providers, will abet the use of virtualization.
- Incentives such as rebates coupled with highlighting other benefits besides energy savings can overcome the issue of split incentives. Demand aggregation can also make small server rooms an attractive market for manufacturers and service providers.
- Timely marketing during the periods when new investments in technology occur will lead server room managers to greater adoption. Incentives to IT resellers and service providers can provide the leverage point to monitor those windows of opportunity.

B. **Utility Energy Efficiency Program Design: Server Room Assessments and Retrofit** by Mark Bramfitt and Pierre Delforge[30] – This NRDC study developed a set of recommendations for utility programs and services to target the server room market.

Findings

The study lists the following as the ECOs that are most cost-effective:

- Server virtualization and consolidation (optimizing server utilization);
- ENERGY STAR servers (purchasing highly efficient equipment);
- Equipment refresh (replacing equipment that is over five years old with more efficient servers and refreshing with updated equipment every two years after);
- Server power management (varying power settings as needed);
- Use of centralized or cloud services (increasing server utilization and the use of more efficient equipment and infrastructure);

[30] Mark Bramfitt, P.E., and Pierre Delforge. 2012. Utility Energy Efficiency Program Design: Server Room Assessments and Retrofit, NRDC, April 11.

- Cooling (using more efficient HVAC equipment and airflow management, which may actually be less applicable for small server rooms and closets); and
- Power conditioning (using high efficiency UPSs and maximized loading, both of which are limited for server rooms).

This report suggests three components that should be included in a utility program targeted for server rooms:

- Education Materials and Evaluation Tools – Provide web-based marketing and outreach materials with an online energy savings calculation tool and enlist the vendor community to assist in outreach.
- On-Site Evaluations – Partner with IT service providers who can assess opportunities on site and help recruit for the program.
- Prescriptive Incentive Programs – Establish an incentive program targeted at server rooms that includes the participation of qualified IT service firms.

NRDC has developed a template for creating this program:

Program Design and Delivery Checklist

Activity	Planning	Launch	Delivery
Prepare work papers for server virtualization and consolidation and premium efficiency server rebate measures and submit to regulators for approval			
Meet with program evaluators to review design and implementation plan			
Identify potential vendor partners			
Prepare education and marketing materials			
Post marketing and education materials and evaluation tools to web site			
Hold internal stakeholder (account representatives, program managers, etc.) training event			
Hold vendor training event			

Activity	Planning	Launch	Delivery
Hold customer events (or integrate into other outreach activities)			
Participate in vendor-sponsored outreach activities			
Monitor program results			

The elements of a prescriptive rebate program for virtualization and consolidation could follow these recommendations:

Essential Elements of a Prescriptive Rebate Program Design

Measure Name	Small-scale server virtualization and consolidation
Measure Description	Installation of software allowing consolidation of IT workloads on fewer physical servers, and removal of unneeded servers
Program Applicability	May be limited by project size or by customer class
Base Case Description	Servers dedicated to single IT workloads, typically at utilization rates below ten percent become more energy efficient when servers are virtualized and consolidated.
Base Case Energy Consumption	On average, “volume” servers (single or dual-core machines manufactured three to six years ago) draw 225 Watts with little or no power management based on IT workload variability, resulting in annual consumption of about 1,970 kWh. If a new replacement server is purchased, both demand and energy use would be lower, as the latest generation servers draw only about 125 to 150 Watts on average, corresponding to annual consumption of 1,100 to 1,300 kWh.

Energy Savings	Demand: 0.125-0.225 kW per server removed (net) Energy: 1100-1970 kWh/yr per server removed (net)
Base Case Equipment Cost	Not Applicable
Measure Cost	Approximately $2000 per server removed, including software license and services, and assuming new servers
Measure Incremental Cost	Same as above
Effective Useful Life	5 years (could be higher)
Net To Gross Ratio	0.8

C. **Is Cloud Computing Always Greener?** by Josh Whitney, Jessica Kennedy, and Pierre Delforge[31] – This NRDC Issue Brief was published in 2012 to report on the findings of their analysis with WSP Environment and Energy on whether cloud computing could provide more energy and carbon efficient technology solutions for small- and medium-sized organizations.

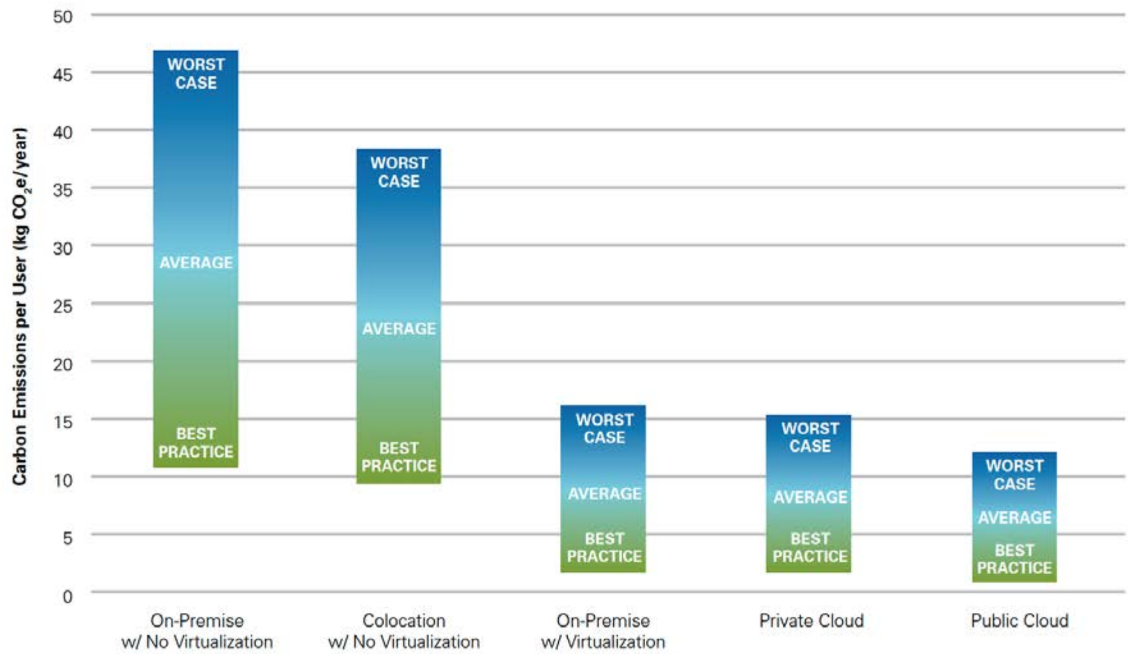
Findings

The authors reported the following findings:

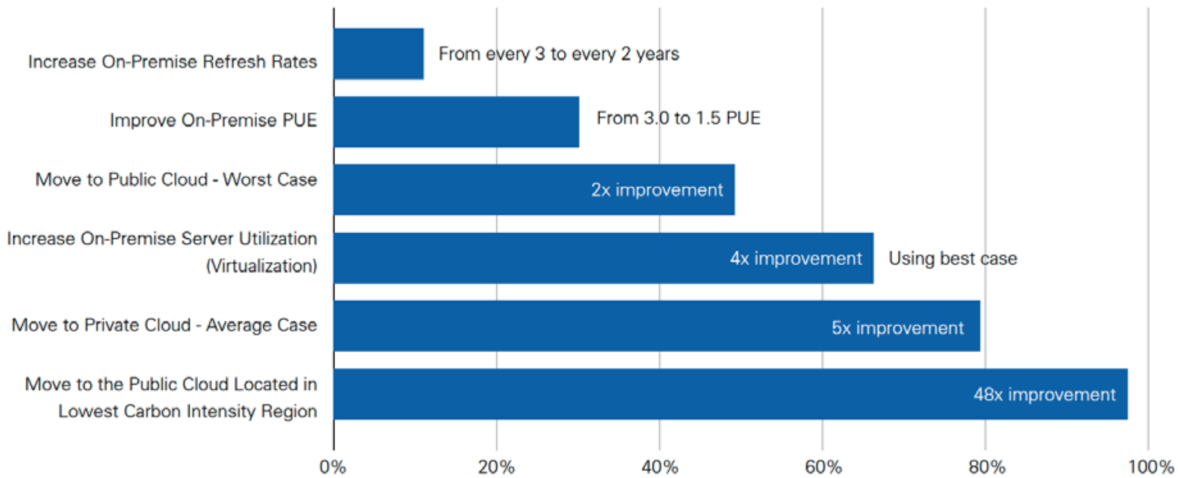
1. Cloud computing is generally more energy efficient with a small carbon footprint than EDCs but all clouds are greener than others, and
2. An EDC that performs and implements energy efficiency best practices can perform more sustainably than a "brown" cloud.

The following figure compares the five scenarios they studied.

[31] Josh Whitney, Jessica Kennedy, and Pierre Delforge. 2012. Is Cloud Computing Always Greener?, NRDC Issue Brief IB: 12-10-A, October.



The figure below shows the carbon reduction potential from measures ranging from increasing on-premise IT equipment refresh rates to moving to the public cloud.



Moving IT services from a non-virtualized EDC to an efficient public cloud could bring a 48 times reduction in carbon.

D. Data Center Efficiency Assessment by Josh Whitney and Pierre Delforge[32] – This 2014 NRDC Issue Paper describes the results of a study conducted by Anthesis to assess the progress of

[32] Josh Whitney and Pierre Delforge. 2014. Data Center Efficiency Assessment, NRDC Issue Paper IP: 14-08-A, August.

energy efficiency in the data center industry. They focused on three issues for their survey and literature review:

1. The level of IT equipment utilization;
2. The impact of and potential for efficiency opportunities through multi-tenant data centers via colocation, managed hosting, or cloud computing; and
3. The extent to which the industry's technology and delivery model is driving energy efficiency.

Findings

The large "cloud" computer server farms like Google, Apple, Facebook, Amazon, Microsoft, and others lead the way in providing efficient services. Because these companies own and operate their data centers, cost, publicity, and pressure from environmental organizations drive their efficiency efforts. However, these types of data centers represent less than 5% of the the total energy use of data centers. For the remaining 95% of the energy users (of which EDCs represent 49% of the total electricity share), broad adoption of energy and carbon efficiency best practices lags behind.

IT efficiency was identified as the most important issue to focus on for overall energy and carbon efficiency. IT efficiency can be increased through higher server utilization, performance improvements, and purchase of efficient hardware. Average server utilization is about 12 to 18% and the factors for this include:

1. vast over-provisioning of IT resources;
2. limited deployment of virtualization despite its broad penetration;
3. unused ("comatose") servers;
4. inherent limitations to high utilization levels outside of public cloud computing;
5. under-deployment of server power-management solutions;
6. procurement practices focused on initial cost instead of total cost of ownership; and
7. lack of a common, standardized server utilization metric.

The report developed the following recommendations to address these issues and "accelerate the known mechanisms of efficiency and enable faster adoption of efficiency-focused technologies, metrics, and initiatives":

1. Adopt a simplified CPU utilization metric that can be measured and reported,
2. Increase disclosure of data center energy and carbon performance (benchmarking) using available data center infrastructure management (DCIM) tools, and
3. Align incentives between IT and facilities, the decision makers on data center efficiency.

II. Lawrence Berkeley National Laboratory (LBNL)

A. Energy Efficiency in Small Server Rooms – Lawrence Berkeley National Laboratory (LBNL) performed a California Energy Commission (CEC) Public Interest Energy Research (PIER) Program-funded project looking at the energy efficiency issues of small server rooms, with the final report being published in the Spring of 2013.[33,34] This project also produced the fact sheet[35] and its longer version.[36] For this project, 30 small server rooms across eight different institutions were surveyed. A 30-minute walkthrough assessment was developed and conducted at each site. A walkthrough assessment protocol and tool was developed to document the server room, management, IT equipment, and HVAC equipment. A more detailed study of four of these sites was also performed.

Findings

LBNL identified 14 cost-effective measures for improving EDC energy efficiency, as shown in Table 1.[37]

Top 14 Measures to Save Energy in an SEDC

Category	Measure
Simple, No-Cost, or Very-Low-Cost Measures	1. Determine computational functions/turn off any unused servers.
	2. Increase temperature set points to the high end of ASHRAE's recommended limit.
	3. Examine power backup requirements to determine if the UPS is oversized or even needed.
	4. Install blanking panels and block holes between servers in racks to help with airflow management.
A Little More Work, But Still Fairly Simple	5. Refresh the oldest equipment with the high-efficiency models.
	6. Move to a more energy-efficient internal or external central data center space, or to co-location or cloud solutions.
	7. Provide energy efficiency awareness training for IT custodial and facility staff.
	8. Implement server power management.

[33] H.Y. Iris Cheung, Steve E. Greenberg, Roozbeh Mahdavi, Richard Brown, and William Tschudi. (Lawrence Berkeley National Laboratory, 2013. Energy Efficiency in Small Server Rooms. California Energy Commission. Publication number: CEC-XXX-2013-XXX.

[34] Iris (Hoi Ying) Cheung, Steve Greenberg, Roozbeh Mahdavi, Richard Brown, and William Tschudi. 2014. "Energy Efficiency in Small Server Rooms: Field Survey and Findings," Proceedings, 2014 ACEEE Summer Study on Energy Efficiency in Buildings, paper 9-109, August.

[35] Mark Bramfitt, Rich Brown, Hoi Ying (Iris) Cheung, Pierre Delforge, Joyce Dickerson, Steve Greenberg, Rod Mahdavi, and William Tschudi. 2012. Improving Energy Efficiency for Server Rooms and Closets. Lawrence Berkeley National Laboratory, October.

[36] Hoi Ying (Iris) Cheung, Rod Mahdavi, Steve Greenberg, Rich Brown, William Tschudi, Pierre Delforge, and Joyce Dickerson. 2012. "Fact Sheet: Improving Energy Efficiency for Server Rooms and Closets." Lawrence Berkeley National Laboratory, LBNL-5935E, September.

[37] Bramfitt, et al., op. cit.

Category	Measure
Higher Investment, But Very Cost Effective	9. Consolidate and virtualize applications.
	10. Implement rack/infrastructure power monitoring.
	11. Install variable frequency drives on cooling units.
	12. Install rack- and row-level cooling.
	13. Use air-side economizers.
	14. Install dedicated cooling for the room.

The following observations were made based on the surveys and assessments:

- Most rooms that house EDCs were typically not intended for that purpose (particularly for cooling) and so are less than optimal for energy efficiency considerations.
- EDC energy costs are not paid by the larger organization and therefore the EDC is not be submetered, meaning that little to no feedback is provided to IT managers on EDC energy use or costs and there is little incentive for energy efficiency.
- Business operations, as opposed to energy efficiency, are the priority of IT managers.
- For IT ECOs,
    - Limited IT budgets and a lack of regular hardware updates means that IT equipment often is older and less energy efficient;
    - Server utilization is often low and is not often tracked, providing a good opportunity for server consolidation and virtualization; and
    - Colocation and cloud migration are obvious energy efficiency opportunities, but IT managers often prefer to keep servers in close proximity for possible power outages and data security considerations.
- For HVAC ECOs, when the EDC is separately zoned or has a dedicated computer room air conditioner (CRAC) or computer room air handler (CRAH),
    - Small server room set point temperatures are often lower than needed and this overcooling is a good opportunity for savings;
    - EDCs often do not have hot/cold air separation that can reduce cooling requirements; and
    - Scheduling and use of economizers can reduce EDC HVAC energy use.

In this study PUEs were calculated for the four sites studied in the detailed assessments. Because of site constraints, estimates were made when specific loads could not be measured. This reinforces the issue that PUE may not be a good benchmarking metric for EDCs.

Most of the barriers observed by the Lawrence Berkeley National Lab researchers were the result of organizational disincentives, rather that the result of technical reasons. Utility incentive and educational programs could be effective in overcoming these barriers. Furthermore, a lack of information prevented the adoption of some obvious ECOs. Measuring server power draw and utilization would help assess needs and opportunities.

B. United States Data Center Energy Usage Report – This 2016 report[38] published by LBNL used historical data of data center electricity consumption back to 2000 to forecast data center energy use out to 2020, based on new trends and the most recent data available.

Findings

A number of scenarios were modeled and the following results were obtained:

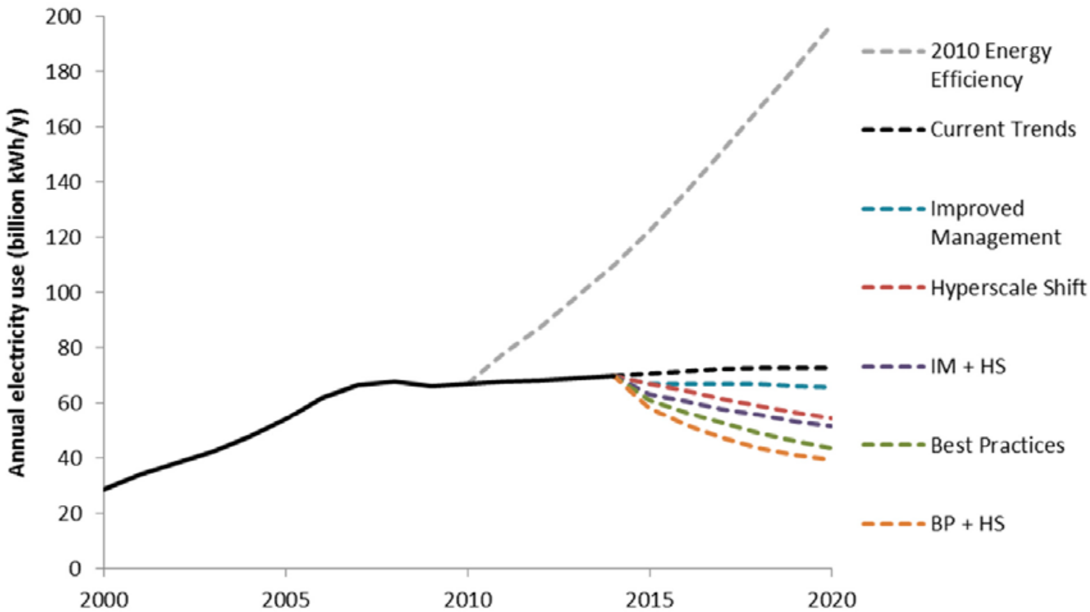


Figure ES-1 Projected Data Center Total Electricity Use

Estimates include energy used for servers, storage, network equipment, and infrastructure in all U.S. data centers. The solid line represents historical estimates from 2000-2014 and the dashed lines represent five projection scenarios through 2020; Current Trends, Improved Management (IM), Best Practices (BP), Hyperscale Shift (HS), and the static 2010 Energy Efficiency counterfactual.

The study shows that data center electricity use increased by nearly 90% from 2000 - 2005, falling to about a 24% increase from 2005 - 2010, and falling further to about 4% from 2010 - 2014. Energy use is expected to continue to increase at about 4% from 2014 - 2020. Based on projections, U.S. data centers are predicted to use about 73 billion kWh in 2020.

The reduced growth in the number of servers operating in data centers is the most important factor that impacts on the overall data center energy use trends. Virtualization, colocation, and cloud services are the reasons for this server reduction. Reduced server power draws and

[38] Armin Shehabi, S. Smith, D. Sartor, R. Brown, M. Herrlin, J. Koomey, E. Masanet, N. Horner, I. Azevedo, and W. Lintner. 2016. United States Data Center Energy Usage Report. Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-1005775.

efficiency improvements in storage, network , and infrastructure also have an important influence.

As part of their work in developing their forecasts, average power draws of common data center equipment and the installed base of that equipment were compiled and published in the report. This equipment included servers, storage devices, and network equipment. This data could be a useful guide for estimating data center power draws.

III. Pacific Gas and Electric Company (PG&E)

A. Small Data Center Market Study – In 2013 the Cadmus Group performed a market study for Pacific Gas and Electric (PG&E) on small data centers (EDCs) in which they surveyed over 320 PG&E small and medium business (SMB) customers and performed in-depth interviews with select IT vendors and EDC managers.[39,40]

Findings

Classifications - Based on interviews, the Cadmus report classified server closets as EDCs of less than 200 square feet floor area with one server rack and classified server rooms as EDCs with floor area of 200 to 500 square feet with three server racks. A typical server had two processors and six cores. Most of the EDCs (over half surveyed) were found to be server closets.

Major segments with EDCs - From vendor interviews and the EDC manager survey, Cadmus found that EDCs were most often present in the following segments:

- government,
- schools,
- healthcare,
- financial services,
- professional services,
- manufacturing, and
- high tech and biotech.

Interestingly, the vendors saw little difference in the energy efficiency opportunities between EDCs in satellite offices of large organizations and stand-alone SMBs. Their interviews also revealed the major reasons that EDCs were kept on-site:

- inertia,
- security requirements (e.g., Sarbanes-Oxley, HIPPA),
- reliability (not dependent solely on connectivity), and
- better speed/performance.

Barriers - The primary barriers that Cadmus cited are:

[39] Allison Bard, Robert Huang, Mark Bramfitt, Kerstin Rock, and Michelle Lichtenfels. 2013. Pacific Gas and Electric Company Small Data Center Market Study, The Cadmus Group, Inc., December 27.
[40] Allison Bard, Robert Huang, Rafael Friedmann. 2014. "From Our Closet to Yours: Fashioning Energy Efficiency Programs for Small Data Centers," Proceedings, 2014 ACEEE Summer Study on Energy Efficiency in Buildings, paper 6-232, August.

- Energy efficiency is not a priority for EDC managers and is typically not part of the decision-making process. The top priorities are uptime, limiting costs, and data security.
- EDC managers and IT vendors are typically unable to even estimate their IT load, even though they knew the number of servers in their EDC (median = three).
- Resource constraints, upfront costs, and aversion to risk are other commonly cited barriers.

ECOs - The energy efficiency measures most often implemented in EDCs were IT measures. Most EDCs are not connected to HVAC controls, so HVAC ECOs happened less frequently. The most often implemented IT ECOs were reported to be: installation of energy efficient servers and UPSs, unused servers decommissioning, data storage management, and server utilization. More than half of the EDCs surveyed used some virtualization and nearly half were virtual servers.

Both IT vendors and EDC managers listed server virtualization, data storage management, and migration to the cloud as the best energy efficiency opportunities. Opportunity for cloud migration is limited as they lack some of the need that on-site EDCs provide in security, bandwidth, and control.

Decision-making - Cadmus found that vendors were an important part of the decision-making process as they provide a source of information, recommendations, and quotes. The final approval of the products and system lies with the internal IT manager, IT director, or the VP and the CFO or CEO approval of the final budget.

Recommendations to Utilities - Cadmus developed the following recommendations for utilities in dealing with EDCs:

- Programs should focus on IT systems rather than HVAC systems.
- Targeted incentive programs should be made available to alleviate high upfront costs and lack of funding for ECOs.
- Prescriptive incentives should be used to promote the implementation of ENERGY STAR UPSs, storage, and servers.
- A targeted server virtualization program to customer groups that are unlikely to implement server virtualization on their own should be provided through education, services, and incentives.
- Incentives should be provided for cloud migration or co-location.
- IT vendors, OEMs, and value-added resellers should be used to effectively reach EDC managers.
- Pilot projects should be considered that deal with the following:
    - different outreach approached to reach EDC managers,
    - testing specific ECOs,
    - alternative program designs, and
    - EDC metering to quantify energy savings.

B. Embedded Data Centers – Since 2013, PG&E has been studying embedded data centers as part of the Data Center Research Partnership which also include the Northwest Energy Alliance (NEEA), Silicon Valley Power, the City of Palo Alto, and LBNL. Two reports were published in

2016. Embedded Data Centers by NEEA[41] describes the 2014 - 2015 Data Center Research Partnership research activities and PG&E produced the 2016 PG&E Data Center Baseline Measurement and Verification (M&V) Guidelines.[42] Embedded data centers are defined by PG&E as "server rooms, closets, and localized data centers embedded in other commercial and institutional buildings—often (but not always) less than 5000 ft2 in size or less than 50 kW in load."[43]

Findings

The NEEA report defines three market interventions with the greatest potential of increasing energy efficiency in embedded data centers. These are:

1. Exploration and refinement of prescriptive measures, including efficient servers, utilization and/or virtualization, and efficient uninterruptible power supplies (UPS)
2. A website "clearinghouse" specific to embedded data centers that would serve as an unbiased source of information related to energy efficiency and function as a gateway to link customers to contractors and utility incentives
3. Promotion of efficient colocation data centers and incentivized movement of the data center function from the smaller and less efficient data center to the larger and more efficient colocation data center

The PG&E document "specifies a standard of care for estimating savings from installation of mechanical and electrical systems in data centers, and recommends baselines for modifying or installing energy-efficient equipment in data centers." The guidelines are applicable to a facilities with a total IT load of at least 30 kW which could include larger EDCs.

IV. Stanford University

A. Growth in Data Center Electricity Use 2005 to 2010 – In 2011, at the request of the New York Times, this report was completed to assess the growth in data center electricity use from 2005 to 2010. [44]

Findings

Some of the key results of the analysis were:

- Electricity used in U.S. data centers in 2010 accounted for between 1.7 and 2.2% of total electricity use.
- By early 2007 the growth of the install base of servers in data centers had begun to slow because of virtualization and other factors.
- Growth in electricity used per server probably accounted for a larger share of demand growth from 2005 to 2010 than it did in 2000 to 2005.

The following figure shows the results of the scenarios that were modeled.

[41] G. Wickes and M. Lichtenfels. 2016. Embedded Data Centers. Report #E16-295. Northwest Energy Efficiency Alliance. January 14.
[42] J. Stein and B. Gill, P.E. 2016. 2016 PG&E Data Center Baseline Measurement and Verification (M&V) Guidelines. CALMAC ID: PGE0369.01. Pacific Gas and Electric Company, PG&E Data Center Baseline, February.
[43] M.D. Barr and C.E. Harty. 2016. Embedded Data Centers Workshop: Final Report. Pacific Gas and Electric Company.
[44] J. Koomey. 2011. "Growth in Data Center Electricity Use 2005 to 2010," Analytics Press: Oakland, CA.

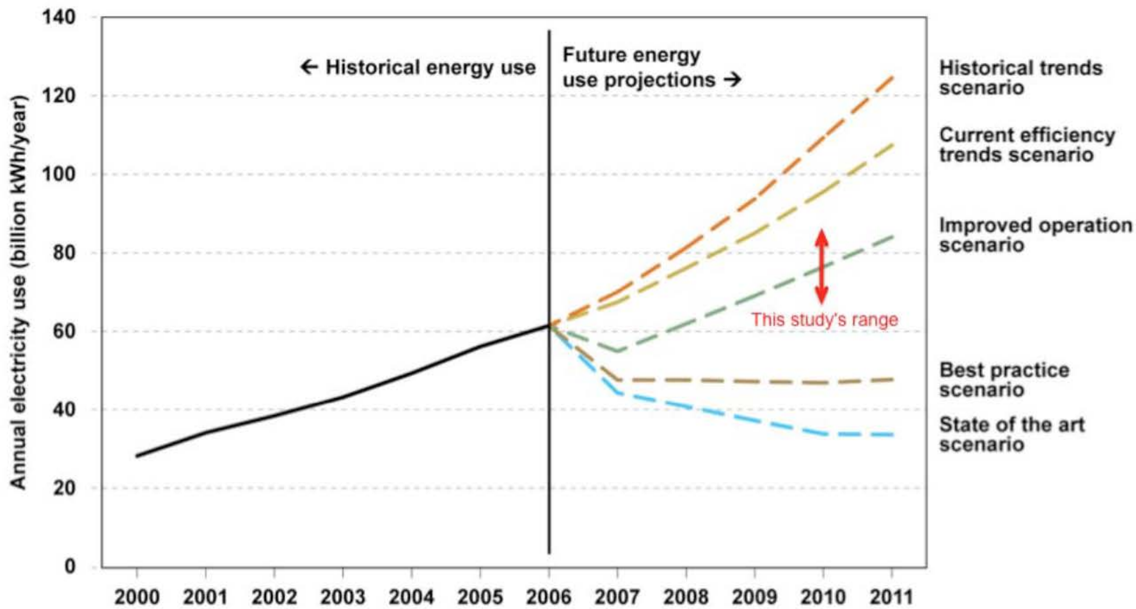


Figure ES-1: Predicted US electricity use for data centers from the EPA report to Congress (EPA 2007) and the range estimated in this study

B. Comatose servers –In 2015 this study summarizes their analysis of available data on comatose servers that reside in data centers.[45] Comatose servers are servers that use electricity but do not deliver any useful IT services. Often these are servers that are running older applications that are nol onger used by staff but continue to be powered on "just in case."

Findings

Using data from TSO Logic's North American installed base of nearly four thousand servers y, the authors report that 30% of the physical servers in the sample were comatose. This was true for both virtualized and non-virtualized environments. These findings supported the results published in two previous studies by the Uptime Institute and McKinsey and Company, respectively. The report estimates that there are approximately 3.6 million comatose servers in the U.S.

V. Minnesota Department of Commerce, Division of Energy Resources, Conservation Applied Research & Development (CARD)

A. MnTAP White Paper: Energy Conservation Potential at Minnesota Data Centers – The white paper Energy Conservation Potential at Minnesota Data Centers: Identifying the

[45] J. Koomey and J. Taylor. 2015. "New data supports finding that 30 percent of servers ate 'Comatose', indicating that nearly a third of capital in enterprise data centers is wasted." Anthesis Group, June.

Opportunity[46] is an analysis of the data center energy efficiency opportunities and challenges in Minnesota. It covers the full range of data centers from server closets with a floor area less than 200 ft^2 to enterprise-class data centers with a floor area greater than 15,000 ft^2. Since this project is only concerned with embedded data centers (EDCs), only the findings of the white paper with respect to server rooms and server closets will be reviewed.

Findings

Barriers – MnTAP points out that the issue for data center energy efficiency is not that technical solutions aren't available, it is that the lack of awareness, education, and management priorities hinder adoption of these practices and solutions. With regard to EDCs, MnTAP found three major barriers to improving data center efficiency:

1. Without monitoring through submetering, decision makers and managers are unaware of the power demands of their data center and the EDC's energy use (and the associated costs) with respect to the entire enterprise. Since some data centers may need to be taken offline in order to install monitoring equipment, and that involves risks and hassles that may impact the productivity and reliability of the data center.
2. Because of split incentives, IT managers and financial officers make business decisions independently of, and perhaps against, each other with regard to cost and energy use decisions for the company. The IT manager's priority is to deliver 24/7 reliability and high computational performance. The financial officer looks at the bottom line and high return on investment.
3. A general resistance to change or inertia within the organization is often at odds with the continuous improvement approach needed to achieve EDC energy efficiency improvements. If business operations are moving smoothly the attitude is often, "why fix what's not broken?" Changes in the form of new approaches and technologies mean an increase in the level of complexity and the need for more training and education, and MnTAP observed that "fear of change, loss of control, and loss of reliability" are seen as major issues.

Energy Conservation Opportunities (ECOs) – MnTAP has defined five categories of ECOs: Environmental, Electronic, Electrical, Educational, and Elimination, which they denote as the five "E's" and describe as:

- Environmental includes air flow, temperature, and humidity.
- Electrical is the infrastructure that provides power and lighting.
- Electronic includes consolidation, virtualization, and energy efficient equipment.
- Education is informing clients how they can contribute to a data center's efficiency.
- Elimination is migrating data center operations to an external service provider.

MnTAP notes that while environmental ECOs typically have the largest impact on improving data center energy efficiency, EDCs generally do not have the heat density needed for dedicated

[46] J. Vanyo, R. Lundquist, and L. Babcock. 2014. Energy Conservation Potential at Minnesota Data Centers: Identifying the Opportunity, Minnesota Department of Commerce, Division of Energy Resources, COMM-03192012-53916, September.

cooling equipment. In these cases, cooling will come from the conditioned air of the entire space and from fans used to circulate air or exhaust heat from the server closet/room. In their report, MnTAP created a matrix of ECOs vs. data center types. Below are their findings on opportunities for server rooms and closets:

ECO Type	**ECO**	**Server Rooms/Closets**
Elimination	Out source	X
Electronic	Cabling	-
	Virtualize	-
	Consolidation	X
	High-Efficiency Servers	X
Environmental	High-Efficiency Cooling Equipment	-
	Hot/Cold aisles	-
	Space heating	-
Electrical	Efficient Power System	-
	High-Efficiency Lighting System	X
Education	Tenant Education	X

Benchmarking – Of the benchmarking tools reviewed by MnTAP, ISO 50001[47] and vendor specific tools like the IBM Data Center Operational Efficiency Self-Assessment online tool[48] were identified as being useful for EDCs. ISO 50001 is an energy management standard based on a process of continuous improvement. DOE has an online toolkit to assist an organization in the implementation process.[49] MnTAP suggests the ISO 50001 will be useful for EDCs "as a starting point to indicate direction for energy efficiency effort." The IBM self-assessment is an online tool that leads the user through six pages of survey questions in order to rank the data center. It defines four stages that can be used to characterize a data center based on efficiency, availability, and flexibility. These are:

1. Basic: The environment is relatively stable and is maintained based on short-term objectives, with standalone infrastructure as the norm. Companies at this stage have the advantages of server consolidation, but have not implemented availability levels, which vary widely from application to application and site to site.
2. Consolidated: Server virtualization and site consolidation are used to take out sizable numbers of systems and facilities and thereby lower capital costs. At this level, server and storage technologies are well utilized and possibilities for improving availability through virtual machine (VM) mobility are beginning to be realized.
3. Available: IT infrastructure is treated as a general resource "pool" that can be allocated and scaled freely to meet the changing demands of workloads, and to ensure uptime and performance while providing high rates of utilization. The focus at this stage is on measuring and improving service levels while building out governance procedures that capture business requirements.
4. Strategic: Widespread adoption of policy-based information tools lowers the manual complexity of the data center and ensures availability requirements and dynamic movement of applications and data. At this stage instrumentation and metrics are constantly used to validate compliance with governance policies.

MnTAP believes that the IBM tool would be both relevant and useful to EDCs as a benchmarking tool. There are also other benchmarking tools available that could be tested for EDCs and could help in creating social norms to help convince IT managers and financial officers to take action towards reducing energy use of EDCs. It is important to keep in mind that at a minimum, when utilizing benchmarking tools, baseline energy use and server utilization need to be monitored in order to determine the need and return on investment for possible energy efficiency measures.

Utility incentives – Utility programs in the form of rebates can incentivize organizations that employ EDCs to implement ECOs. MnTAP has created a table showing data center efficiency incentives for select Minnesota utilities. This table is reproduced below:

[47] International Organization for Standardization, ISO 50001 - Energy Mangement webpage, http://www.iso.org/iso/home/standards/management-standards/iso50001.htm.
[48] IBM, Data Center Operational Efficiency Self Assessment online tool, IBM Data Center Study webpage, http://www-935.ibm.com/services/us/igs/data-center/assessment.html.
[49] U.S. DOE, DOE eGuide for ISO 50001 webpage, https://ecenter.ee.doe.gov/EM/SPM/Pages/home.aspx.

Utility	Service Territory	Data Center Incentives Offered
Austin Utilities	City of Austin	Prescriptive rebates on cooling equipment, servers, and clients.
Dakota Electric Association	Dakota county	Low interest energy efficiency loans, rebates on cooling equipment, audits, consulting and monitoring.
Minnesota Power	Northeastern Minnesota	Offer standard rebates, performance rebates, etc.
Otter Tail Power Co	Western Minnesota	Grants available for conservation and efficiency improvements based on demand and kwh saved.
Owatonna Public Utilities	Owatonna area	Prescriptive rebates on cooling equipment, servers, and clients.
Rochester Public Utilities	City of Rochester	Prescriptive rebates on cooling equipment, servers, and clients.
Xcel Energy	St. Paul/Minneapolis and suburbs	Specific Data Center Efficiency rebate program involving an energy study, cost estimates of energy saving measures, and rebate information. Study rebates up to 75% or $25,000, and rebates of

With regard to implementation, MnTAP found that utilities often rely on "vendors and consultants to work with the client to develop and implement energy efficient technologies and procedures. The utility only becomes involved at the beginning to approve proposed work and when it comes time to evaluate the project for rebate purposes."

Conclusions – With respect to the objectives of the white paper, MnTAP found the following answers to the questions they posed:

- How aware are data center managers of the available energy efficiency opportunities? *Overall it was observed that data center staff members have an understanding of energy conservation opportunities at their facilities.*

- How much energy do data centers located in Minnesota consume? *Many data center managers do not measure their power consumption and do not know how efficient they are. Any ECOs available to a center may not be considered because there is no measured baseline energy use from which to calculate a rate of return to justify a specific investment. Based on site visits completed for this grant, the measurement of electrical consumption of data centers in general is lacking. Managers do not know the data center's PUEs at any level. In addition, data center managers view the installation of monitor control systems (MCSs) as a major inconvenience, since their operation may be off-line during the installation. Measuring efficiency and/or improving it takes a back seat to reliability. Therefore, managers must be convinced that the energy efficiency benefits associated with MCS installation outweighs the perceived risk or hassle of the installation itself.*
- Do data center managers realize the impact improving the efficiency of their data center could have on their organization's budget? *At best, [IT managers] make broad statements about the percentage they think the data centers use compared to the entire building, but they do not know how much the entire building uses. Some have implemented specific energy efficient technologies and methods, but they do not know how much energy or money they saved, if any.*
- Are Minnesota utilities fully aware of data center operations and energy consumption across the state and in their territories? *For electric utilities, the data center sector is part of their overall commercial building CIPs.*
- Do CIP program managers have relevant information on options for improving the energy efficiency of data centers? *There is little focus on the unique energy conservation needs of data centers relative to a typical commercial building*
- Will a focus on improving the energy efficiency in Minnesota data centers contribute significantly to utilities meeting their State energy savings goals? *A more targeted focus may be justified to demonstrate the opportunity for state energy conservation available through data center energy management.*

And finally MnTAP drew these conclusions:

- Minnesota data center staff are aware of the energy efficiency options available; however, it is still unknown how much power Minnesota data centers demand or consume.
- Many Minnesota data center managers do not know the impact implementing ECOs will have on their organizations' bottom line.
- Minnesota electrical utilities may have limited awareness of the data center operations in their area even though data center ECOs can have an impact on facility energy efficiency.

B. **CEE: Small Embedded Data Center Pilot Program** – In 2017 CEE published the findings from their CARD project which developed, implemented, and assessed a pilot program targeting small embedded data centers (SEDCs) in Minnesota.[50] In partnership with the Wisconsin Energy

[50] L. S. Shen, J. Lynch-Eisenhut, and J. Vanyo. 2017. Small Embedded Data Center Program Pilot, Minnesota Department of Commerce, Division of Energy Resources, COMM-CARD01-20140512-86772, June.

Conservation Corporation (WECC) and the Minnesota Technical Assistance Program (MnTAP), the project performed two main tasks:

1. The market characterization of SEDCs in Minnesota, and
2. The field study to assess energy use at selected sites and measure savings of installed measures.

Findings

Electronic survey – WECC developed an electronic survey to help discern the IT services of SEDCs for various business types in Minnesota and identify opportunities for energy savings. The goals of the survey were to:

- Define the major sectors in Minnesota that employ SEDCs and the common types and sizes of those businesses;
- Assess the nature and variety of SEDCs in Minnesota and the common IT practices employed;
- Survey stakeholder perceptions and gain an understanding of their support network; and
- Determine opportunities and barriers to implementing energy efficiency measures for SEDCs.

Outreach efforts of the project team resulted in 134 responses from around the state, representing a range of data center types from server closets with floor areas less than 200 square feet to enterprise data centers greater than 15,000 square feet. Of the survey responses, 35 were server rooms under 200 to 1,000 square feet (26%) and 47 were data closets under 200 square feet (35%). Since the focus of the study was SEDCs, the discussion is focused on the responses from data closets and server rooms.

Many of the survey respondents had already adopted some energy efficiency measures. Sixty-six percent of respondents replied that server virtualization was in place at their site, while 18% responded no and the remaining 18% did not know. With regard to cloud services and cloud computing, 62% of survey respondents shared they were using some close services, while 33% responded no and 5% did not know. Nearly half (48%) of the respondents had already taken advantage of both virtualization and cloud services. For those that had not, the main barriers to adopting virtualization were cost and maintenance/staffing while the main barriers to adopting cloud services were security and cost.

Utilities throughout Minnesota offer incentives, rebates, and loans that can be applied to data center energy efficiency measures. These include measures dealing with IT equipment and cooling, as well as services such as monitoring and consulting. Some are prescriptive based while others are performance based. Of note, only 2% of respondents were aware that utility rebates and incentives were even offered for data centers. The survey found that vendors are an important source of information to SEDC IT managers, and they could have a significant role in both outreach to SEDC IT managers and in advocating for energy efficiency measures. It also suggests that a midstream strategy with incentives to vendors could be very effective.

Field Study – A total of eleven sites representing commercial, institutional, and industrial sectors were recruited to participate in the field study. The sites included a total of 24 SEDCs (10 server rooms and 14 network closets). Nine of the ten sites had dedicated cooling equipment while one remaining site had an exhaust fan that removed the heated air from the server room, typical configurations for SEDCs. Energy use was monitored at the sites over several months to acquire a baseline and recommend possible energy efficiency measures. The project team then worked with IT staff at each of the sites to plan and test experimental strategies to reduce SEDC energy use and performed post-measure monitoring to assess the energy saving impacts.

A number of measures were identified and verified that increase the energy efficiency of SEDCs without introducing the need for large capital expenditures. Most of the measures deal with operational changes that can be performed by IT staff.

Operational Efficiency Measures

Opportunities are available to achieve energy savings in SEDCs through simple changes in operation based on activity or inactivity. These opportunities are typically overlooked due to the priority of maintaining mission critical services, and the lack of energy management training and awareness of IT staff, building facilities personnel, and the accounting staff who pay the energy bills. Energy savings can be obtained fairly quickly and at low cost with routine operational changes that have no impact on user needs for IT services. It is possible to achieve energy savings by powering down IT equipment during non-work hours or during times of non-utilization, and this can account for about 60% of the work week (including overnight hours and weekends). IT staff are typically more open to these operational efficiency measures since they avoid the capital expenditures involved with purchasing new equipment. These simple scheduling changes also avoid any downtime in IT services and can be easily implemented and reversed if issues arise.

The best candidates for scheduling changes are network switches. Network switches are found in both server rooms and network closets. Scheduling server status using currently available software already installed on the server can reduce the server power draw during low-utilization periods. During off hours, a bare bones number of physical hosts can be kept awake while the remainder are put on standby. Then when services are in demand, additional hosts can be brought online as needed, without any interruption of service. The magnitude of savings depends on how many servers are placed on standby through scheduling.

Airflow and Cooling Opportunities

For SEDCs with dedicated cooling systems, poor operations translate into energy inefficiencies. Relying on the thermostat set point to deliver cooling often results in overcooling. Monitoring air temperatures at the server inlets can now be done with inexpensive temperature monitors, which allow for more precise and efficient cooling strategies.

Airflow management can reduce cooling loads by minimizing the mixing of cooled and heated air in the server room. This creates more uniform temperatures along the inlet of the server racks and makes it possible to deliver conditioned air in the upper range of the ASHRAE recommended indoor air temperature of 64.4°F to 80.6°F. Hot aisle and/or cold aisle containment can provide significant savings by minimizing airflow.

Equipment Upgrades

Monitoring important operational data ensures that systems are working properly and operations are performed without unnecessary and excessive use of energy. Most sites made very little effort to monitor energy use, even though it can be easily and inexpensively done.

It is often assumed that energy efficiency improvements are a byproduct of normal equipment upgrades. While this may be true for large data centers with two- to three-year cycles for equipment upgrades, refresh rates for the SEDCs in this study were generally much longer, often two to three times that of larger data centers. Equipment upgrades can bring greater energy efficiency as new models and improved technologies provide more capabilities per unit, and as data center equipment certifications like ENERGY STAR allow for more informed energy choices. With time, equipment refreshes naturally lead to higher energy efficiency.

The following two tables list the study's suggested energy efficiency measures to reduce the IT and cooling power loads for SEDCs, respectively. Most of the operational measures can be performed immediately at very little cost.

Measures to Reduce IT Power Loads in SEDCs

Category	Measure
Simple, No-Cost, or Very-Low-Cost Measures	1. Consolidation: Power down any unused (comatose) servers.
	2. Consolidation: Examine power backup requirements to determine if the UPSs are underutilized and consolidate if possible.
	3. Scheduling: Power down network switches, ports, and/or PoE during non-work hours such as nights, weekends, and holidays.
A Little More Work, But Still Fairly Simple	4. Power Reduction: Refresh IT equipment with high-efficiency ENERGY STAR models.

Category	Measure
	5. Power Reduction: Upon UPS refresh, resize UPS to better match power loads of the SEDC to result in UPS utilizations in the range of 60-80%. Replace with ENERGY STAR UPS models.
	6. Power Reduction: Move IT services (applications, storage, etc.) to more energy-efficient external central data center space, co-location, or cloud solutions employing SaaS.
Higher Investment, But Can Be Cost Effective	7. Consolidation: Reduce the number of physical hosts by employing server virtualization.
	8. Consolidation: Archive unused storage onto tape drives and power down unneeded disk drives.
	9. Scheduling/Consolidation: Perform live migration or DPM on virtualized servers and place unused physical hosts on standby. This could require software upgrade, additional storage, or CPU replacement.

Measures to Reduce Cooling Loads in SEDCs

Category	Measure
Simple, No-Cost, or Very-Low-Cost Measures	1. Mechanical System: Increase temperature set points so that server rack inlet temperatures are at the high end of ASHRAE's recommended limit (~77°F).
	2. Airflow management: Install blanking panels and block holes between servers in racks.

Category	Measure
	3. Mechanical System: Set air handler fan to AUTO instead of ON (i.e., running continuously), if allowed by code.
	4. Monitoring: Install low-cost Bluetooth temperature monitors to track rack inlet temperatures and SEDC thermostat setpoint.
A Little More Work, But Still Fairly Simple	5. Airflow management: Arrange or orient server racks so that distinct cold aisles and hot aisles are created.
	6. Airflow management: Perform cold aisle and/or hot aisle containment using drapes or other air barriers.
	7. Airflow management: Properly manage server cables by tying or clipping cords together.
Higher Investment, But Can Be Cost Effective	8. Mechanical System: Depending on power load of SEDC (<4 kW), consider installing an exhaust fan in hot aisle (to avoid need for dedicated cooling and provide CHP opportunities with the rest of the building).
	9. Mechanical System: Re-duct supply and return vents to promote rack- and row-level cooling (hot and cold aisles).

Recommendations

For IT Staff:

1. It is important to monitor data center power loads and server air temperatures to determine how much additional energy your data center is using to deliver your mission critical services. This would include monitoring UPS power loads and server inlet temperatures.

2. Efforts to reduce baseload IT power or phantom loads can be taken by identifying and turning off comatose servers, consolidating servers through virtualization, and reducing unnecessary storage. During times when mission critical services are not in demand, operational efficiency measures through scheduling and energy management can be employed.
3. When the time comes for equipment to be updated or replaced, more efficient models should be purchased such as ENERGY STAR™ rated equipment and proper equipment sizing should be specified.
4. Options such as cloud services or colocation should be considered. The PUE of SEDCs are typically on the order of about 2 while cloud services are reporting PUEs as low as 1.1 to 1.2.

For Utility Programs:

1. Since the electronic survey results found that only 2% of IT staff were aware of utility rebates and incentives, there is a clear need for utilities to raise awareness of IT staff responsible for SEDCs.
2. The ease of monitoring SEDC power draws into the UPS provide an approach for measured savings and a basis for a Pay for Performance program. In addition, the typical power load numbers presented by the LBNL study[51] can provide a good basis for deemed savings of energy measures like server consolidation or network switch scheduling. These numbers can also be updated over time as more measured savings data is collected.
3. The survey also found that the trusted sources of information for IT staff were vendors and service providers. Midstream approaches that take advantage of these information channels as well as incentive energy efficiency choices could be effective.
4. Along these lines of midstream approaches, an SEDC design assistance program could be delivered to architectural and engineering design firms to help guide the design and construction of more energy efficient server rack layouts and CRAC systems.
5. Utilities currently have recommissioning programs and the HVAC measures that can be used to deliver more efficient cooling in SEDCs could fall under these programs for custom rebates.

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APPENDIX B: ONLINE SURVEY INSTRUMENT

Focus on Energy is conducting research to better understand Wisconsin businesses' use of embedded data centers (including network closets and server rooms). We hope you are able to give us 15 minutes of your time to complete this survey, which will inform Focus on Energy's energy efficiency program designs to better serve these facilities in Wisconsin. Randomly selected survey participants will be offered a free on-site assessment. This assessment will include a short description of identified energy savings opportunities.

All individual responses will be kept confidential with survey results reported in aggregated form only. Please respond by [DATE].

If you are not the appropriate contact, please forward this survey link to your Systems Administrator, IT Manager or Network Engineer for your Wisconsin location.

Thank you in advance for providing this important information. If you have questions or comments about this survey, please contact Peggy Heisch (pheisch@seventhwave.org).

If you have any additional questions about Focus on Energy, the EERD program, or this project, they can be directed to Joe Fontaine (Joe.Fontaine@wisconsin.gov), Focus on Energy Performance Manager at the Public Service Commission of Wisconsin.

Filtering

First, please answer the following questions so we can ensure that your company meets the criteria for this survey.

1. Are you knowledgeable about a network closet, server room, and/or data center located in one of your business' buildings that serves your business' IT needs? ***Yes/No***

If No: ***Thank and Terminate***

2. Is the network closet, server room, and/or data center that you are responding about located in Wisconsin? ***Yes/No***

If No: ***Thank and Terminate***

In answering the following questions please think of data centers as including network closets and/or server rooms.

Building Information

Now we have a few questions about the building(s) served by the data center.

1. Which of the following best describes the business activity served by the data center? ***Select one***
    a. Advertising/Marketing
    b. Financial Services
    c. Government
    d. Inpatient healthcare
    e. Outpatient healthcare
    f. Nursing
    g. Manufacturing
    h. Education
    i. Laboratory
    j. Other

2. Which best describes the typical hours of occupancy at buildings served by the data center? ***Select one***
    a. Weekdays (8 hour workday); Weekends (none)
    b. Weekdays (8 hour workday): some weekend occupancy
    c. Two shifts
    d. Three shifts
    e. 24/7
    f. Don't know
3. Estimate the number of employees served by the data center: ***Select one***
    a. None
    b. 1 to 20
    c. 20 to 49
    d. 50 to 99
    e. 100 to 249
    f. 250 to 499
    g. 500 to 999
    h. 1,000 to 2,499
    i. 2,500 to 4,999
    j. 5,000 or more
4. Building type served by the data center: ***Select one***
    a. Office complex
    b. Satellite office of a larger company
    c. Stand alone business/building
    d. Other

<u>Data Center Information</u>

The following questions will help us to understand your data center characteristics and needs, and determine how Focus on Energy programs might better serve businesses such as yours.

3. Is your company responsible for paying for electricity and natural gas use at your location? ***Yes/No/Don't know***
4. How many of each size of network closets, server rooms, and/or data centers does your location have? ***Enter integer for each***
    a. < 200 sq ft (i.e: a Network Closet that provides network connections to workstations, office equipment, and phones, usually one or two server racks)
    b. <1000 sq ft (i.e. a Server Room that provides IT services such as servers, data storage, and security; in addition to network services, often 2 to 10 racks)
    c. 1000-5000 sq ft (i.e. a Localized Data Center)
    d. 5000-15000 sq ft (i.e. a Mid-tier Data Center)
    e. > 15000 sq ft (i.e. an Enterprise Data Center)
5. Does your server room or data center serve one location or multiple business locations? ***Select one***
    a. One location only
    b. Multiple business locations in Wisconsin
    c. Multiple business locations (not all in Wisconsin)
6. How many server racks are in your server room? ***Select one***
    a. 1
    b. 2-4
    c. 5-9
    d. 10+

7. What is the average age of your servers? ***Select one***
    a. Less than 1 year old
    b. 1 year old
    c. 2-3 years old
    d. 3-5 years old
    e. 5+ years old
8. Do you monitor power usage of your data center? ***Yes/No/Don't Know***
9. Does your data center have dedicated cooling?
    a. Yes
    b. No
    c. Don't know
10. Approximately what percentage of your servers are currently powered "on" but have host applications that are not being used? ***Enter percentage***
11. Do you use any cloud services or cloud computing? ***Yes/No/Don't know***
12. What are the barriers to additional cloud services or cloud computing (select all that apply) ***Select multiple***
    a. Cost
    b. Downtime
    c. Additional need for Maintenance/Staffing
    d. Policy
    e. Privacy
    f. Security
    g. Further cloud services wouldn't be useful for us
    h. Not sure what cloud services are
    i. Other

Data Center Purchasing Information

Thank you. Now we have a few more questions about how your business makes purchasing decisions for IT equipment.

13. Who are your trusted sources of information for making IT decisions? (select all that apply) ***Select multiple***
    a. Distributor
    b. Manufacturer
    c. Utility
    d. Vendor
    e. Government Guidelines
    f. Publications (i.e. magazines or other media)
    g. Other
14. How often does energy efficiency factor into your IT decisions? ***Select one***
    a. Always
    b. Sometimes
    c. Never

If 14 = a or b:

14a. Please describe: ***Text***

15. What are the barriers to pursuing energy efficiency technologies for your company? (select all that apply) ***Select multiple***
    a. Energy efficiency not a priority
    b. Focused on up-front costs, not long-term payback
    c. No benefit to IT, a facility benefit
    d. Resource constraint
    e. Risk: focused on up-time/performance
    f. Lack of information
    g. Other
16. When do you plan to make upgrades to your servers? ***Select one***
    a. Next 6 months
    b. 6 – 12 months
    c. 12 – 18 months
    d. 18 – 36 months
    e. 36 months +
17. When do you typically refresh your IT equipment? ***Select one***
    a. Less than every 2 years
    b. Every 2-3 years
    c. Every 3-5 years
    d. Over 5 years
    e. When equipment breaks down
18. Please rank each of the following motivations as to their importance to your decisions for making server upgrades: ***Select one (1 = Very Important…5 = Not Important)***
    a. Cost
    b. Speed
    c. Dependability
    d. Part of regular updates
    e. Other
19. If you rely on specific vendors, distributors, value-added resellers (VARs) or manufacturers, please provide their names. ***Text***
20. Are you aware of any rebates or incentives from Focus on Energy to purchase energy efficient equipment for your data center? ***Yes/No***
21. Have you upgraded your data centers and received a rebate or incentive from Focus on Energy in the last 24 months? ***Select one***
    a. Yes (no rebate)
    b. Yes (received rebate)
    c. No
    d. Don't know
22. If the option exists to purchase ENERGY STAR equipment, do you choose it? ***Select one***
    a. Yes (because of personal choice)
    b. Yes (because of purchasing policies)
    c. No
    d. Don't know

Optional Information

23. *A team will be performing free on-site energy assessments of data centers for a sample of survey participants. Would you like to be added as an interested business that may benefit from this activity?* ***Yes/No***

Business Name/Address

1. Business Name: ***Text***
2. Street Address (location of data center): ***Text***
3. City: ***Text***
4. Zip Code: ***Text***
5. Phone Number: ***Text***

Contact Information

1. Full Name: ***Text***
2. Title/Role: ***Text***
3. Email Address: ***Text***

24. *Does your organization take steps to lower utility bills through increasing energy efficiency?* ***Yes/No/Don't know***
25. *Do you have an inventory of the IT equipment in your data center?* ***Yes/No/Don't Know***
26. *How many physical servers does your location host? (based on address provided)* ***Select one***
    a. *1-3*
    b. *4-9*
    c. *10-20*
    d. *20+*
27. *How many virtual servers does your location host? (based on address provided)* ***Select one***
    a. *1-3*
    b. *4-9*
    c. *10-20*
    d. *20+*
    e. *None*
28. What are the barriers to additional virtualization (select all that apply) ***Select multiple***
    a. Cost
    b. Downtime
    c. Additional need for Maintenance/Staffing
    d. Policy
    e. Privacy
    f. Security
    g. Capacity
    h. Further virtualization wouldn't be useful for us
    i. Not sure what virtualization is
    j. Other
29. *What range of UPS utilization do you see at your location?* ***Select one***
    a. *0 to 20%*
    b. *20 to 40%*
    c. *40 to 60%*
    d. *60 to 80%*
    e. *80 to 100%*
    f. *Don't know*
30. *What range of total UPS loads do you see at your location?* ***Select one***
    a. *0 to 1 kW*
    b. *1 to 2 kW*
    c. *2 to 4 kW*
    d. *4 to 8 kW*
    e. *Over 8 kW*
    f. *Don't know*

If 9 = Yes:

9a. What is the thermostat set point temperature in your data center? ***Enter float***

9b. What type of cooling equipment do you have? ***Select multiple***

1. *Computer Room Air Conditioner*
2. *Rooftop Unit*
3. *Ductless Split*
4. *Other*

31. *What air flow management strategies do you do or have you performed?* ***Select multiple***
    a. *Partitions/drapes for hot/cold aisle containment*
    b. *Blanking plates and side panels*
    c. *Ductwork modifications*
    d. *Cable management*
    e. *None*
32. *Do you monitor server utilization?* ***Yes/No***
33. *Who do you purchase data center equipment from? (controls/monitoring, racks/infrastructure, IT equipment)* ***Select multiple***
    a. *Manufacturers*
    b. *Value-added resellers (VARs)*
    c. *Distributors*
    d. *Other*

Thank you for taking the time to complete the survey. Your responses have been recorded.

APPENDIX C: COMMUNICATIONS AND OUTREACH INTERVIEW GUIDE

IT Staff

1. What roles do you perform at your organization? [select multiple]
    a. Data center operation and maintenance
    b. Network administration
    c. Work station management/maintenance
    d. Office equipment management/maintenance
    e. IT help desk
    f. IT training
    g. Phone management/maintenance
    h. Other?
2. What are your communication channels with your clients? Of these channels, which do they prefer and what is the most successful on a regular basis?
3. What are the most frequently-implemented energy saving measures by your clients in their data centers?
4. In your experience, who within your client organizations is most frequently making energy-related decisions? How are those decisions made?
5. Is this decision making different when the energy equipment services your clients' data center? If so, how?
6. In your opinion, what is the best way to influence your clients to implement energy savings measures in their data centers?
7. Do you see a changing role for IT staff as cloud services become more and more standard?
8. How frequently do you work with facilities staff? What issues have they raised related to their data center operations?
9. Are you responsible for paying for energy use of your data center? If not who does?
10. Is there pressure on you to reduce operating costs of the data center?
11. How does energy efficiency influence how you operate your data center?
12. Before this interview, were you aware of Focus on Energy incentives available for reducing energy use of data centers? If so, have you received any to help from Focus to offset costs?
13. Aside from increasing incentive rates, what kind of support could Focus on Energy provide to help businesses in making their data centers more energy efficient?

Vendors

1. What roles do you perform at your organization?
    a. Data center operation and maintenance
    b. Network administration
    c. Work station management/maintenance
    d. Office equipment management/maintenance
    e. IT help desk
    f. IT training
    g. Phone management/maintenance
    h. Other?
2. What are your communication channels with your clients? Of these channels, which do they prefer and what is the most successful on a regular basis?
3. Do you ever try to influence IT energy-related decisions? If so, how?
4. What are the main types of inquiries that you get from IT staff?
5. Do you influence data center operations? If so, how?
6. Who do you think are the trusted information sources for IT staff?
7. Energy efficiency can reduce IT operating costs. Is this ever used as a selling point with your clients? If not, why?
8. Has the role of IT staff changed with cloud services becoming more and more prevalent? If so, how?

9. How would you promote energy efficiency in data centers?
10. What capital improvements would you suggest to reduce data center energy use?
11. What operational strategies would you suggest to reduce data center energy use?
12. What portion of your equipment sales are ENERGY STAR certified?
13. Before this interview, were you aware of Focus on Energy incentives available for reducing energy use of data centers? If so, do you promote these when working with your clients to help offset costs?
14. Would it be beneficial if Focus on Energy were to create a program to promote SEDC energy efficiency by working through distributors to provide discounts? Why do you say that?
15. If so, what equipment would you like to see incentivized through this type of program?

APPENDIX D: FIELD STUDY FORM

Focus on Energy Small Embedded Data Center Characterization
Site Visit Protocol

General Information

Site Name: ________________________________ Date:________

Pre-visit

- ☐ Address, contact name and phone number, directions
- ☐ Review available information
- ☐ Bring hard copy of site visit protocol, Hobo Temp loggers (~5), extra batteries, fasteners, USB cord, post-it notes and computer with power cord
- ☐ Lester Shen: 612-558-1413

IT Staff Interview (15-30 minutes)

Name: ________________________________

Scheduling

14. What roles do you perform at your organization? [select multiple]
    a. Data center operation and maintenance
    b. Network administration
    c. Work station management/maintenance
    d. Office equipment management/maintenance
    e. IT help desk
    f. IT training
    g. Phone management/maintenance
    h. Other? ______________________
15. What are the typical hours of occupancy at buildings served by the data center
    a. Weekday start and end time:
    b. Weekend start and end time:
16. Is IT equipment kept running 24/7? If so, does it need to be kept running constantly during unoccupied periods? Please explain.
17. When are updates and backups performed?
18. What Power Over Ethernet devices are on site?
19. Do you power down any equipment during off hours?
20. Do you put servers to sleep when not needed, such as those which are spare capacity to handle peak traffic a few hours a year or little used applications and which remain idle or underutilized the rest of the time?
21. Do you perform distributed power management with your virtualized servers?

Cloud Services

1. What applications do you run in the cloud?
2. Are you planning to move any additional servers to the cloud? If so, how many?
3. Do you use cloud storage? Are you planning to and if so, when and how much?

Equipment Status

1. What is the oldest piece of equipment that you have and how old is it?
2. What is the average age of your IT equipment?
3. What is the typical refresh rate of your IT equipment?
4. What is the main reason to do this refresh?
5. Do you look for ENERGY STAR equipment when replacing IT equipment?
6. Are the server power management options enabled?
   a. Yes
   b. No, is there a reason that they were disabled?
   c. Don’t Know, can they check the settings and get back to us after?

Workstations

1. Do you employ computer power management at the workstations?
2. Do employees use their workstations to connect in remotely to work off-site or after hours?
3. Does your company use thin-client or zero-client workstations?

Motivations to Take Action

1. Are you responsible for paying for energy use of your data center? If not, who is?
2. Is there pressure on you to reduce operating costs of the data center?
3. How does energy efficiency influence how you operate your data center?
4. Are you aware of Focus on Energy incentives for data centers? If so, have you taken advantage of any?

Walkthrough (~1 hour)

Cooling

1. Temperature sensors
   a. Install and launch Hobo temperature sensors to record on 1 minute intervals at thermostat and inlet of each server rack
   b. Remove and download data at end of walkthrough
2. What is thermostat setpoint temperature?
3. Fill out cooling equipment inventory

Equipment Type [CRAC, RTU, Split, In-Row, or Exhaust Fan]	**Make**	**Model Number**

IT Equipment

1. Fill out IT equipment inventory with input from IT personnel

Equipment Type	**Equipment Subtype**	**Total Number**
Racks	None	
Servers	1S	
	2S+	
External Storage	HDD	
	SDD	
Switches	100 MB Ports	
	1000 MB Ports	
	10 GB Ports	

	40 GB Ports	
	100 GB Ports	
Routers	None	
Modems	None	
Appliances Such as firewall, video equipment, security cameras…	None	

5. Fill out UPS table

UPS Description	**Load (%)** Read from display	**Total Capacity (kVA)** From nameplate

6. Ask IT staff
    a. How many servers are dedicated to single applications?
    b. How many physical servers host virtualized servers?
    c. How many physical servers are comatose or dormant?
    d. How many Power over Ethernet phones?
    e. How many Power over Ethernet access points?
    f. How many other Power over Ethernet devices? description

Photograph

- ☐ Entire Room
- ☐ Racks
- ☐ Servers
- ☐ External storage
- ☐ Switches
- ☐ Partitions
- ☐ Routers
- ☐ Modems
- ☐ Appliances
- ☐ Cooling equipment and nameplate
- ☐ Thermostat

Wrap-Up (~15 minutes)

1. Suggest operational and capital improvement measures identified during walk through. Could include the following:
   a. Increase thermostat setpoint (as high as 80 F inlet temperature)
   b. UPS consolidation to increase total utilization > 60-70%
   c. Power down dormant servers
   d. Virtualize servers, where possible
   e. Migrate IT services to the cloud - email, applications, storage
   f. Power down equipment during non-work hours
      - Schedule the powering down of non-essential ports or data and PoE on network switches
      - Schedule distributed power management with virtualized servers
      - Schedule power down of SSD storage equipment
   g. Capital improvement recommendations
      - Purchase Energy Star equipment
      - Replace UPS with properly sized UPS with total utilization > 60-70%
      - Replace HDD storage with SSD storage
      - Purchase server and storage equipment that allows increased virtualization
      - New, high efficient cooling equipment with variable speed control
2. What are the main barriers to implementing each? i.e. costs, staff time/capabilities, mission critical risks
3. Describe Focus on Energy program
   a. Prescriptive Incentives (https://focusonenergy.com/sites/default/files/inline-files/2018_HVAC_Plumbing_1.26.18.pdf) are available for increasing cooling equipment efficiency, implementing and optimizing economizer control and implementing VFD fan motor control. Incentives based on size and number of equipment purchased.
   b. Custom incentives (http://focusonenergy.com/business#program-custom-projects) are also available for a variety of energy savings measures. Incentives based on energy savings calculation.
4. Reinforce benefits of implementing energy savings upgrades
5. Reminder that we will follow-up with a short summary of opportunities in a couple weeks