Small Embedded Data Centers

Energy Efficiency Program Recommendations for ComEd

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Claire Cowan, Director of Program Design & Delivery, Slipstream

Scott Schuetter, Senior Research Engineer, Slipstream

Andrew Kotila, Program Manager, Slipstream

431 Charmany Drive
Madison, WI 53719
608.210.7117
slipstreaminc.org

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Project Manager:
Claire Cowan

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Executive summary

This report evaluates energy efficiency opportunities for small embedded data centers (SEDCs) in ComEd territory. Unlike large enterprise operations which are dedicated exclusively to data center functions and are separately located from the businesses and organizations they serve, small embedded data centers (SEDCs) are located within business and institutional facilities such as offices, hospitals, schools, warehouses and laboratories. This study focuses on the smallest end of the data center spectrum: server rooms and network closets less than 500 sf, consistent with the ENERGY STAR definition of server rooms.

SEDCs represent an energy-intensive space type that is challenging for energy efficiency programs to address. IT system administrators focus primarily on operational priorities like reliability and performance. IT departments may have decision-making authority over equipment purchases but in many cases the operating costs associated with SEDC energy consumption are born by other departments. IT service providers working to upgrade equipment in SEDCs may be unfamiliar with energy efficiency programs. The energy savings associated with individual data center efficiency measures is relatively small at SEDC scale, making it challenging for utilities to offer significant incentives for efficiency improvements.

Multiple studies have been done on SEDC efficiency, and many of them mention "midstream" or "upstream" incentive strategies as a potentially viable pathway for aggregating savings across a number of SEDCs, improving program cost-effectiveness. Both program approaches target the supply chain rather than end use customers. Midstream programs typically target equipment distributors and installers, where upstream programs typically target manufacturers. This study assesses the viability of a midstream program approach for capturing SEDC savings in ComEd territory. This assessment includes the following elements: (1) characterization of the SEDC market in ComEd territory; (2) identification of SEDC energy efficiency measures; (3) estimation of energy savings potential; and (4) analysis of program opportunity.

This study employed the following research methods:

- Review of relevant energy efficiency program literature.
- Research on data center efficiency programs with focus on initiatives targeting small to medium-sized data centers as well as initiatives targeting the data center supply chain.
- Analysis of data from the U.S. Energy Information Administration's 2012 Commercial Buildings Energy Consumption Survey (CBECS) to estimate the total number of SEDCs in ComEd territory, identify the market segments and building types where SEDCs are most prevalent, and estimate energy savings potential per SEDC and in aggregate.
- Interviews with IT and HVAC service providers active in the SEDC market in ComEd territory and neighboring states, soliciting input on efficiency opportunities, sales strategy, customer priorities and challenges, and interest in participating in a midstream program pilot.

Key findings from this research include:

- There are approximately 2500 SEDCs in ComEd territory. Over half (56 percent) of these buildings are offices, and nearly one fifth (19 percent) are non-refrigerated warehouses. Laboratories, education facilities and healthcare/skilled nursing facilities make up the remainder of building types with a significant number of SEDCs.
- Typical annual electricity consumption of SEDCs in ComEd service territory is estimated at 107,000 kWh per year per facility, and 267,500,000 kWh per year in aggregate.
- Major energy efficiency opportunities in SEDCs include:
    - Increasing UPS utilization

    - Replacing older servers with current generation models
    - Removing dormant servers
    - Increasing data center temperature set points
    - Cooling efficiency upgrades at end of equipment life
- Technology trends are driving SEDCs to use less energy because there is less equipment required and the major components of data center infrastructure are becoming more energy efficient. Server virtualization and cloud storage are important factors driving future increases in SEDC efficiency.
- The energy efficiency measures focused on in this report have the potential to reduce SEDC energy consumption by 8-20 percent. Applying a 20 percent reduction to the annual energy usage of 2500 SEDCs in ComEd territory generates an estimated energy savings potential of 53.5 million kWh.
- We estimated that a ComEd SEDC initiative could potentially achieve market penetration of 2 percent, which would produce annual savings of 420,000-1,070,000 kWh at an 8-20 percent savings rate per SEDC.
- Ninety two percent of the savings potential in SEDCs are associated with efficiency improvements that would be delivered by a service provider including UPS utilization, server and storage consolidation, migration of data to the cloud, and airflow management. Thus, a midstream program leveraging service providers would likely capture more savings than an upstream program strategy targeting manufacturers of efficient products such as ENERGY STAR qualified UPS, server, and data storage equipment (8 percent of potential savings).
- Service providers expressed support for a midstream program approach but did not feel that proposed incentive rates between $0.05-0.12/kWh would have much impact on customer decision-making. ComEd's current incentive range for data center measures is $0.10-0.12/kWh.
- Targeting SEDCs is not without risk. PG&E and National Grid programs serving small to medium-sized data centers have been discontinued or scaled back due to low participation.

Service providers made a number of recommendations on how to successfully engage their efforts: in a midstream program approach:

- Keep participation process simple, minimize paperwork requirements.
- Develop prescriptive incentives to provide certainty on what incentives will be from the outset—before the customer has made the decision to move ahead.
- Provide co-marketing support, allowing service providers to leverage the ComEd brand.
- Provide a dedicated point of contact for program questions.
- Provide education about optimal thermostat set points in data centers.

There are significant challenges facing successful deployment of an SEDC initiative in ComEd territory. With low savings per measure and per facility as noted above, achieving robust participation and cost-effectiveness will be difficult. ComEd has some existing service provider relationships that could be leveraged to deploy an SEDC pilot, but does not have an established network of engaged IT service providers. Major investments would be needed to build these relationships and the infrastructure needed to run a successful midstream programs. We estimate that within four years of launch, an SEDC offering could generate annual savings of 2 million kWh per year and garner participation from 10% of SEDCs in ComEd territory at a non-incentive cost of $0.10 per first year kWh. This level of investment may not be warranted by the level of potential savings in ComEd territory. There is also free ridership risk stemming from the fact that the SEDC market is undergoing a transformation driven by the transition to cloud computing and computing technology that

becomes more efficient with each new generation of product. Companies like Microsoft, Amazon and Google are aggressively promoting cloud solutions in the SEDC market.

Despite these challenges, there are some incremental steps short of a full-scale midstream offering that can be taken to capture more savings from the SEDC market. Developing work papers for SEDC measures to get them included in the Illinois Technical Reference Manual (TRM) would allow ComEd to confidently increase the number of prescriptive incentive offerings available to service providers working in SEDCs. Packages of SEDC measures could be promoted to service providers in a targeted fashion—starting with firms that are already engaged in supporting ComEd programs like the ones interviewed for this study. There may also be opportunities for bundling SEDC measures into projects participating in other ComEd programs like Retrocommissioning (RCx).

Background

Data centers are estimated to account for nearly one percent of the total electricity use in the U.S.[1] . Over half of this usage is associated with small server rooms and IT equipment closets.[2] By some accounts, as much as one third of SEDC usage is unnecessary, but energy efficiency programs have struggled to capture cost-effective savings from this segment.

A major barrier to capturing the energy savings opportunities in SEDCs is the challenge of cost-effectively reaching out to a diverse and dispersed customer base to identify and implement energy efficiency improvements. 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. At the same time, IT service providers, HVAC contractors and engineering firms are actively completing projects in SEDCs that reduce energy consumption: equipment replacement, server consolidation, migration of data and applications to the cloud. Leveraging these providers could be a strategy for energy efficiency programs to gain traction in the SEDC market. However, maintaining cost-effectiveness will be a major challenge as individual measures and projects involve significant implementation costs and relatively low savings.

To better understand the challenges and opportunities in the SEDC market, ComEd engaged Slipstream to interview service providers, quantify market potential, characterize the market, and review energy efficiency program best practices. Evaluating the potential for leveraging service providers to recruit projects and lower implementation costs was an important research priority.

Objectives

The SEDC research project for ComEd has three key objectives:

- Characterize the SEDC market, including estimating the number of SEDCs in ComEd service territory and identifying the market segments and building types that are most likely to contain SEDCs.
- Estimate the energy savings potential associated with SEDCs in ComEd territory.
- Assess the viability of an energy efficiency program targeting SEDCs, with a particular focus on midstream or upstream program strategies.

[1] Koomey (2011). *Growth in Data Center Electricity Use 2005 to 2010.*

[2] Bramfitt & Delforge. (2012) *Utility Energy Efficiency Program Design: Server Room Assessments and Retrofits*. Prepared on behalf of the Natural Resources Defense Council.

Approach

We conducted primary and secondary research as part of this study. Beginning with a literature review, we summarized other studies that have specifically addressed SEDC energy efficiency opportunities both in the Midwest and other regions. We reviewed energy efficiency program offerings to identify other utilities and program administrators that have targeted efficiency opportunities in SEDCs. We also interviewed one energy efficiency program manager who has invested significant resources to develop program strategies for the data center market, including SEDCs. Lastly, we conducted two conference calls with ComEd program implementation staff to gather information about historical data center initiatives, current program changes, service provider engagement. The ComEd team also provided input on the SEDC efficiency measure framework.

To characterize the magnitude of the SEDC opportunity in ComEd territory, we leveraged microdata from the U.S. Energy Information Administration's 2012 Commercial Buildings Energy Consumption Survey (CBECS).[3] This allowed us to estimate the total number of SEDCs, identify the market segments and building types where SEDCs are most prevalent, and estimate energy savings potential per SEDC and in aggregate.

Lastly, we conducted two rounds of interviews with vendors and service providers that perform HVAC and IT upgrades in the SEDC market. An initial round of scoping interviews focused on understanding key elements of the service provider's business: type of services delivered to SEDCs, energy efficiency measures most applicable to the SEDC market, completive landscape and customer priorities. We also assessed the service provider's interest in a midstream incentive approach. In the second round of interviews we solicited service provider feedback on individual measures that could be targeted by a SEDC program strategy: applicability, customer decision process, estimated savings, cost, and barriers to implementation. We solicited input on several questions relevant to program design such as feedback on potential incentive ranges for each measure, the degree to which an energy efficiency program could influence a purchasing decision at the specified incentive levels, and programmatic support that would be most valued by the service provider. Three interviews were completed in Round 1 and five interviews were completed in Round 2.[4]

Research findings

Market segmentation

We used 2012 CBECS microdata to quantify the number and types of SEDCs in ComEd territory and the types of buildings they serve.[5]

We limited the dataset to buildings with data centers less than 500 square feet, a threshold aligned with the ENERGY STAR definition of server rooms. We then aggregated the data within ComEd service territory's census division, East North Central, which also includes Wisconsin, Indiana, Ohio, and Michigan. We used population prorating to quantify the portion of the region's SEDCs that are within ComEd's service territory (i.e. ComEd service territory has 19 percent of the population of the states in this Census region). Since the latest CBECS survey was completed in 2012, we estimated the SEDC population in 2018 by assuming a two percent annual growth rate which aligns with EIA data for the growth of commercial building area.[6]

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[3] U.S. Energy Information Administration (2012). *U.S. Commercial Buildings Energy Consumption Survey*. Available at: http://www.eia.gov/consumption/commercial/

[4] Four companies were interviewed in Round 2 but one firm provided both IT and HVAC interviewees.

[5] U.S. Energy Information Administration (2012). *U.S. Commercial Buildings Energy Consumption Survey*. Available at: http://www.eia.gov/consumption/commercial/

[6] U.S. Department of Energy (2011). *Building Energy Data Book*, Chapter 3.

There are approximately 2,500 commercial buildings in ComEd service territory with SEDCs. Over half (56 percent) of these buildings are offices, and nearly one fifth (19 percent) are warehouses. Laboratories, education facilities and healthcare/skilled nursing facilities make up the remainder of building types with a significant number of SEDCs (Figure 1).

Figure 1: Commercial buildings in ComEd service territory with SEDCs

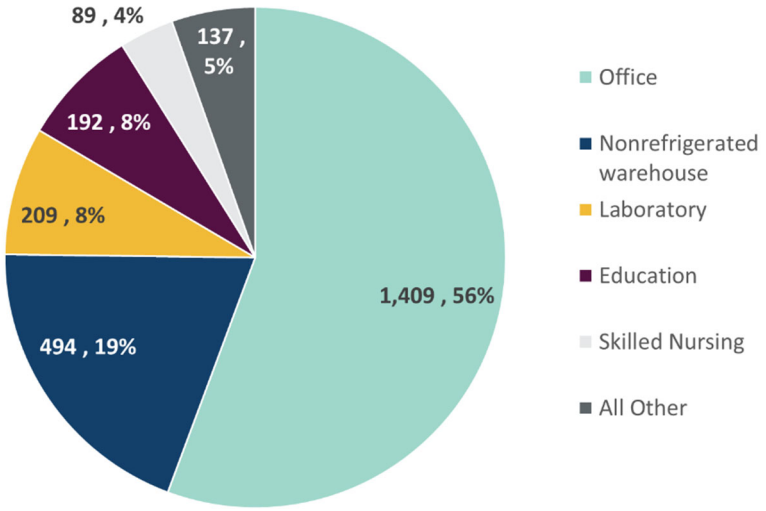


Figure 2 shows the share of buildings within a given building type that have SEDCs. Many building types have no SEDCs and other building types have only a small fraction of facilities with SEDCs. SEDCs are prevalent in a few building types, with almost all laboratories (94 percent) and over half of inpatient health care facilities (51 percent) having SEDCs. While SEDC penetration in these building types is significant, there are fewer total facilities in those categories, reducing the overall number of SEDCs they represent.

Figure 2: By building type, proportion of commercial buildings that have SEDCs

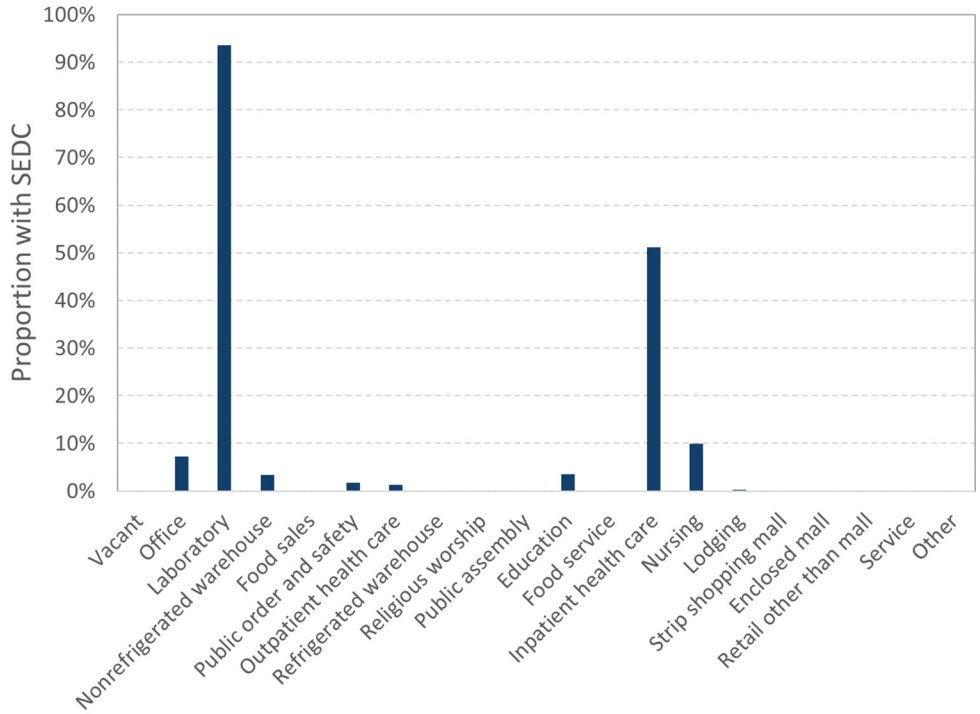
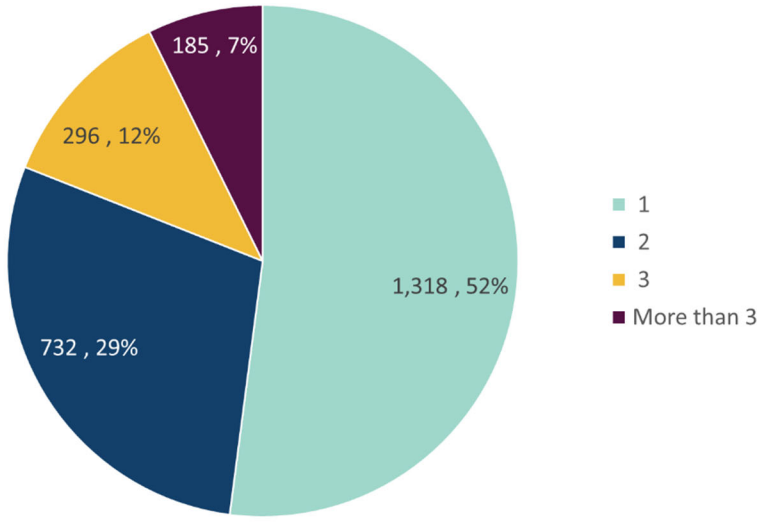


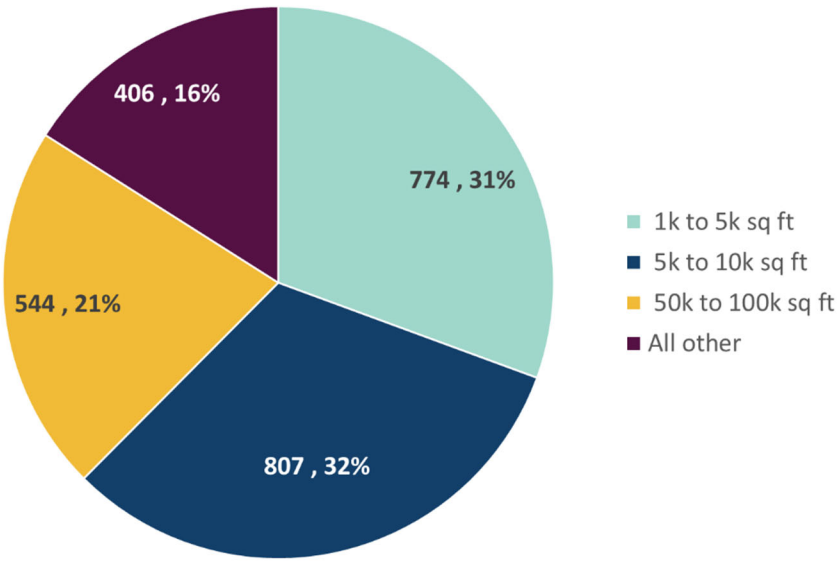
Figure 3 illustrates that over half (52 percent) of SEDCs are in single-story buildings. In single-story buildings there is likely easier access to an exterior surface that could be used for exhaust and economizer savings.

Figure 3: Buildings with SEDCs in ComEd territory by number of floors



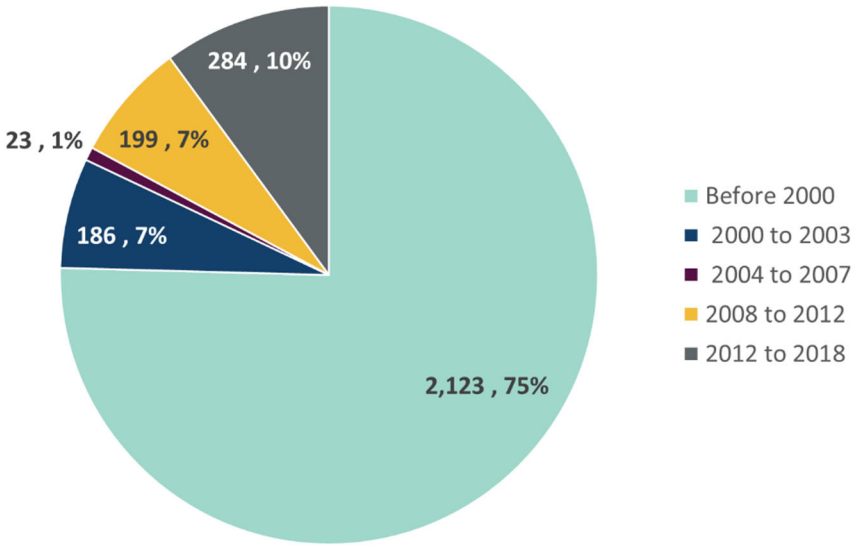
Unsurprisingly, the majority of SEDCs are found in small buildings, with nearly two thirds (63 percent) located in buildings less than 10,000 sf (Figure 4). Twenty one percent of SEDCs are located in medium-sized buildings (50-100k sf).

Figure 4: Buildings with SEDCs in ComEd territory by building size category



The majority of SEDCs are in buildings built before 2000 (Figure 5). This means that they are likely in rooms that were not specifically designed for the type of server equipment in use today and may not be in rooms that were originally intended to house servers.

Figure 5: Buildings with SEDCs in ComEd territory by construction year



There are approximately 22,600 servers in ComEd service territory SEDCs. This equipment consumes approximately 155 GWh annually at a cost to ComEd service territory businesses of $13.8 million.[7,8] Figure 6 shows the share of SEDC servers in ComEd service territory broken out by the building type in which they reside: over half (52 percent) of SEDC servers are in offices, while more than a quarter are in laboratories (14 percent) and educational facilities (14 percent). Non-refrigerated warehouses and nursing facilities have a small, but non-negligible share of total SEDC servers.

Figure 6: Servers by building type in ComEd territory SEDCs

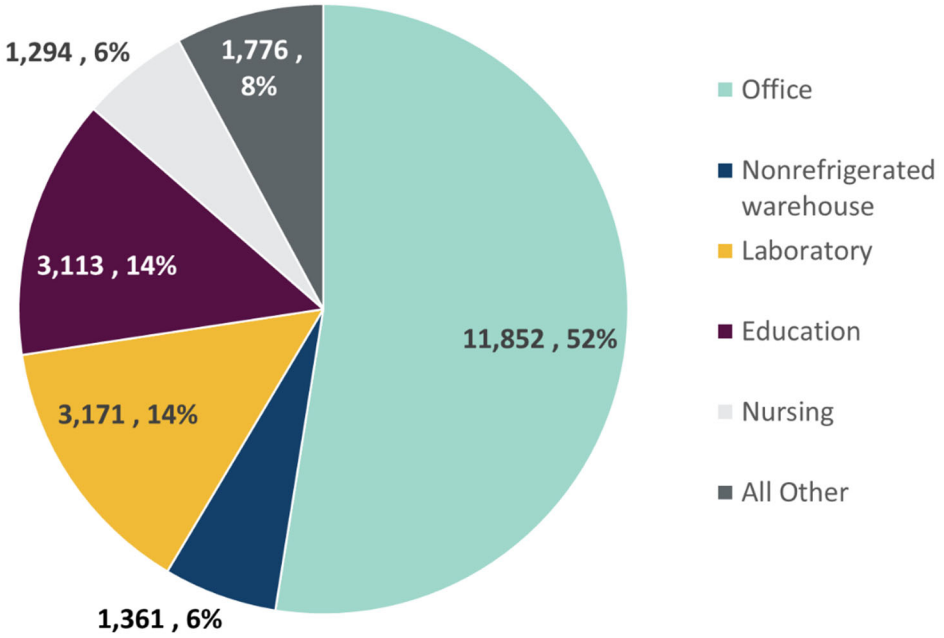


Figure 7 shows that nearly half (46 percent) of ComEd service territory servers are in SEDCs that have between 20 and 49 servers, nearly one third (31 percent) of servers are in SEDCs with between 5 and 9 servers and nearly one sixth of the servers (16 percent) are in SEDCs that have between 10 and 19 servers. This is significant since the opportunity for a program to cost-effectively serve the SEDC market increases as the number of servers in a given data center increases.

[7] Shen et al. (June 2017). *Small Embedded Data Center Program Pilot*, COMM-CARD01-20140512-86772. Assuming an average demand of 411 W per server and a Mechanical Load Component of 1.9 with 8760 hours per year.

[8] U.S. Energy Information Administration (August 2018). *Electric Power Monthly*. "Table 5.6.A: Average Price of Electricity to Ultimate Consumers by End-Use Sector." Assuming $0.0896/kWh. Available at: https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

Figure 7: Servers by number of servers per facility in ComEd territory SEDCs

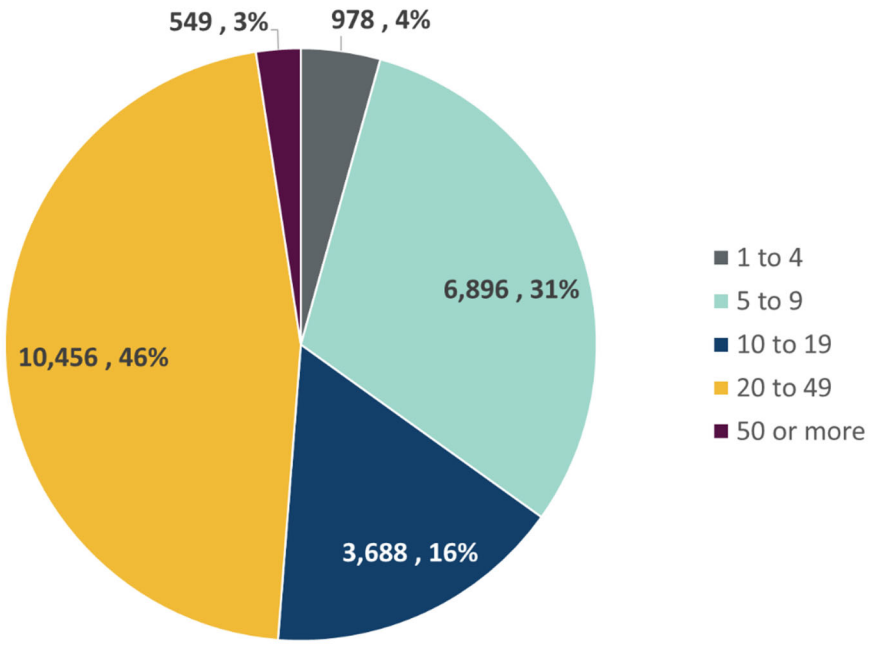


Table 1 summarizes the relationship between computers (desktops and laptops) and servers by building type.[9] This information is useful for program design as it is often easier to count computers than to get access to and count servers. It is important to note that the number of computers per server does vary significantly by building type.

Table 1: Number of computers per building area, worker and server

Building type	Computers per 1000 sf	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

[9] U.S. Energy Information Administration (2012). *U.S. Commercial Buildings Energy Consumption Survey*. Available at: http://www.eia.gov/consumption/commercial/

Literature review

In the last decade, several energy efficiency program administrators have funded research to assess energy savings opportunities in the SEDC market. Some of the earliest market characterization studies were done in California and the Pacific Northwest with funding from PG&E[10] and the Northwest Energy Efficiency Alliance (NEEA),[11] respectively. In the Midwest, more recent research has been funded by Minnesota Department of Commerce through the CARD Grant program[12] and Wisconsin's Focus on Energy Environmental & Economic Research and Development (EERD) program.[13] These studies were included in our literature review, as were SEDC reports by Natural Resources Defense Council (NRDC)[14] and Lawrence Berkeley National Lab (LBNL).[15]

There are a number of consistent themes across the SEDC studies we reviewed:

- Unlike large enterprise data centers, SEDCs are not typically operated to maximize energy efficiency. Given the large number of SEDCs across a variety of building types, there remains a significant opportunity for energy savings across SEDCs in aggregate.[16]
- At the same time, there is relatively small energy savings potential per SEDC, necessitating program strategies that cost-effectively aggregate savings across a large number of sites.[17]
- IT trends such as virtualization of servers and migration of applications and storage to the cloud are major drivers of increasing energy efficiency in the SEDC market.[18] Virtualization is not eligible for ComEd incentives due to the high potential for free ridership.
- There is very low awareness of energy efficiency incentives among IT staff, with recent survey of Minnesota IT managers measuring awareness at two percent.[19] Developing effective outreach and awareness-building strategies will be critical to program success. Customer outreach and recruitment has been a major barrier to the success of programs targeting SEDCs.
- IT service providers are a trusted source of information for SEDC managers, with the same Minnesota survey finding that over 50 percent of IT staff report their vendors are a trusted source of information.[20] Leveraging these relationships and trust will be critical to effectively tapping into the SEDC market.
- Programs should seek to develop prescriptive incentive offerings to reduce program cost and administrative complexity.[21]
- Midstream program approaches that leverage IT and HVAC service providers may help to overcome customer acquisition challenges.[22]

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[10] Bard & Huang (2013). *Small Data Center Market Study*. Prepared for Pacific Gas & Electric Company by Cadmus Group, Inc. Available at: https://datacenters.lbl.gov/sites/all/files/PGE_SmallDCs2013.pdf

[11] Wickes & Lichtenfeld (2016). *Embedded Data Centers*. Report #E16-295. Prepared for Northwest Energy Efficiency Alliance (NEEA). Available at: https://neea.org/resources/embedded-data-centers

[12] Shen et al. (2017). *Small Embedded Data Center Program Pilot*, COMM-CARD01-20140512-86772. Available at: https://www.mncee.org/resources/projects/small-embedded-data-center-pilot-program/

[13] Schuetter et al. (2018). *Small Embedded Data Centers in Wisconsin*. Prepared for Focus on Energy Environmental & Economic Research and Development program. Available at: https://www.focusonenergy.com/sites/default/files/2018-05/WI_SEDC_Final_Report%285-7-18%29.pdf

[14] Bramfitt & Delforge (2012) *Utility Energy Efficiency Program Design: Server Room Assessments and Retrofits*. Prepared for the Natural Resources Defense Council.

[15] Greenberg & Herrlin (2017). *Small Data Centers, Big Energy Savings: An Introduction for Owners and Operators*. Prepared by Lawrence Berkeley National Lab, U.S. Department of Energy.

[16] Bramfitt & Delforge (2012).

[17] Wickes & Lichtenfeld (2016).

[18] Bard & Huang (2013).

[19] Shen et al. (2017).

[20] Shen et al. (2017).

[21] Wickes & Lichtenfeld (2016).

[22] Shen et al. (2017).

- There is free ridership risk associated with some IT measures, with virtualization a commonly-cited example.[23]

We searched the literature for energy efficiency programs targeting SEDCs in other markets, with a particular interest in identifying programs that have successfully deployed midstream or upstream incentive strategies. PG&E launched the DC Plus program in mid-2014, initially targeting data centers smaller than 5,000 sf. This was not a midstream or service provider-driven approach, instead using a third party implementer to provide pre-screening, in depth assessments, and action plans to implement improvements.[24] According to PG&E's report to the Public Utilities Commission, the program had difficulty recruiting participants from the outset, largely due to challenges identifying buildings with embedded data centers.[25] In 2016 the eligibility threshold was raised to 30,000 sf in an effort to drive greater participation, but the program was discontinued in 2017 citing difficulties in converting pipeline projects to completed savings.

National Grid invested significant effort on program development to determine a cost-effective data center program strategy, targeting opportunities across large and small data centers.[26] For the retrofit market, they pursued a "hands-on" approach which included a site visit, comprehensive assessment of energy efficiency opportunities, and implementation of upgrades which are incentivized through the Custom program. At the outset they offered large incentives to attract projects---50 percent of the total project cost---but still had low participation. During program development, National Grid worked to develop partnerships with major players in the data center market, including American Power Conversion (APC) and Schneider Electric (APC was bought by Schneider in 2006). One of the major challenges was personnel-related, where the success of the initiative depended largely on the utility's ability to develop a strong relationship with a key person within the service provider organization. But the initiative faltered when the key contact either moved to another position or was unable to successfully motivate others within their organization to promote the program. With a commission-based compensation structure, sales personnel were reluctant to make changes to their typical process, and some were not receptive to making changes recommended by someone outside their division. National Grid also tried engaging with smaller, local providers but found they also required significant investments in relationship-building which was impacted by staff turnover.[27] They found the move toward colocation had an even larger impact on staffing at these smaller providers, with some contacts getting out of the data center business entirely. Another challenge was related to the energy efficiency measures themselves. The program manager cited five great projects that had come through the program, all of which generated significant savings from non-standard measures that required an experienced technical expert to identify. They would have missed these opportunities if they had been focusing on a more standardized, cookie-cutter program approach, and the program still would not have been cost-effective.

We also contacted authors of earlier SEDC studies to determine if midstream or upstream program strategies had been pursued following conclusion of that research. Mark Bramfitt, a California-based independent consultant who co-authored the SEDC studies for PG&E and NRDC, was not aware of any midstream/upstream program approaches that had been tested.[28] Similarly, the primary author

[23] Bard & Huang (2013). *Small Data Center Market Study*. Prepared for Pacific Gas & Electric Company by Cadmus Group, Inc.

[24] Pacific Gas & Electric Company (May 1, 2018). *2017 Energy Efficiency Annual Report*. Available at: http://eestats.cpuc.ca.gov/EEGA2010Files/PGE/AnnualReport/PGE.AnnualNarrative.2017.1.pdf

[25] Pacific Gas & Electric Company (July 3, 2017). *Fourth Supplemental: PG&E's 2017 Energy Efficiency Annual Budget Advice Letter in Compliance with Decision 15-10-028, Ordering Paragraph 4*. Submitted to the Public Utilities Commission of the State of California. Advice 3753-G-D/47901-E-D.

[26] Fran Boucher (April 9, 2019). Energy Efficiency Program Manager, National Grid. Phone interview with Claire Cowan.

[27] Fran Boucher (April 9, 2019). Energy Efficiency Program Manager, National Grid. Phone interview with Claire Cowan.

[28] Mark Bramfitt (March 19, 2019). Email communication to Claire Cowan.

of the NEEA study, Geoff Wickes, said that none of the utilities in the Northwest have pursued midstream or upstream incentive strategies for data centers.[29]

Service provider interviews

Our original interview recruitment strategy was to identify a few service providers who have been highly engaged in ComEd's data center program in the past. However, we revisited this approach after learning that the program's historical focus was on large data center new construction, mostly involving a different set of service providers than those actively working in the SEDC retrofit market. In addition, turnover on the program outreach team made it difficult to leverage existing relationships for recruiting purposes. In the end, most of the service providers we interviewed were familiar with ComEd programs either because they were involved in a past data center project incentivized by ComEd or were a ComEd trade ally—either for data centers or other ComEd offerings like RCx. Table 2 lists the service providers that participated in this project.

Table 2: Service provider interviews

Service Provider	Round 1	Round 2
IT firm 1	Scoping interview	
Engineering firm 1		Interviewed - HVAC
IT firm 2		Interviewed- IT
Engineering firm 2	Scoping interview	Interviewed - HVAC
Engineering firm 3	Scoping interview	Interviewed – HVAC and IT

ComEd's program implementer identified two major players in the Illinois data center market—Schneider Electric and American Power Conversion (APC)—that did not agree to participate in an interview despite multiple recruitment attempts. (APC is a fully owned subsidiary of Schneider). It may be useful to obtain input from these firms if ComEd decides to move forward with a targeted initiative for SEDCs. As part of the recruitment research, we also identified eight firms that provide IT and network services to companies in the Chicago market and made multiple attempts to recruit one or more of them for an interview. We were ultimately unsuccessful, and these recruitment challenges helped to illuminate the outreach hurdles that ComEd is likely to face in building relationships with IT firms that do not have a track record of working with energy efficiency programs. We were able to interview an IT services firm that works in the Madison market, and their perspective is likely similar to firms serving the Chicago market. We also interviewed an IT service provider that leverages utility programs in other parts of the country and is interested in expanding to the Chicago market.

Key findings from service provider interviews are summarized below:

- There are a diverse set of service providers involved in implementing efficiency upgrades for SEDCs, from equipment resellers to IT service providers to engineering firms and HVAC contractors.
- Some service providers concentrate in specific market segments (i.e., healthcare, higher education) while others work across most market segments. Firms that focus on serving small- to medium-sized businesses would likely be good targets for an SEDC initiative.
- There is a lot of market churn among smaller IT service providers, with firms opening and closing on a regular basis. Engaging well-established firms that have been serving customers for at least a decade would be advisable for SEDC programs.
- The sales process for efficiency measures in SEDCs is relationship-based, with most discussions conducted in person. Service providers are a trusted source of expertise and

[29] Geoff Wickes (April 12, 2019). Senior Product Manager, Emerging Technologies, Northwest Energy Efficiency Alliance. Email communication to Claire Cowan.

many customers rely on service providers to determine the optimal strategy for SEDC improvements.

- Customers' top priorities are reliability and avoiding downtime. The easiest time to make efficiency improvements is when an unreliable system is being replaced, whether as part of an equipment refresh cycle or due to failure/end of life.
- Service providers told us that energy efficiency and operational cost savings are important messages in their sales process. Those that agreed to an interview were familiar with ComEd programs and most of them differentiate themselves on green/sustainability messaging.
- All of the interviewees expressed interest in participating in a future offering for SEDCs except for an IT services firm whose business is entirely Wisconsin-based.
    - Service providers thought a midstream incentive strategy would be a viable approach, particularly if the participation process could be kept simple and efficient.
    - One company suggested the use of free facility assessments (funded by ComEd) where service providers receive payment on the basis of kWh savings delivered.
    - Several of the companies expressed willingness to consult with ComEd during the program design process.
- Technology trends are driving SEDCs to use less energy because there is less equipment required and the major components of data center infrastructure are becoming more energy efficient. Server virtualization has been a major factor driving this change over the last decade. Trends that will continue to drive data center efficiency into the near future include:
    - Migration of software, storage and applications to the cloud.
    - Converged and hyperconverged infrastructure (HCI) in which the data center's storage, computing, and networking functions are merged in an integrated hardware stack that allows for cohesive management to optimize workflow and scalability.[30]
- Service providers cited the following measures as largest opportunities for saving energy in SEDCs:
    - Increasing UPS utilization
    - Increasing data center temperature set points
    - Replacing older servers with current generation models
    - Removing dormant servers
    - Cooling efficiency upgrades at end of equipment life
- IT measures present good opportunities for bundling, particularly integrating efficient new servers, removal of dormant servers and upgrading the UPS.
- Bundling IT and HVAC measures into a single project is more of a challenge because many service providers focus on one or the other and the timing factors are often different (e.g., server replacement cycle versus cooling system failure).
- Bundling is more feasible with new construction or major renovation/facility move. There may also be some opportunities around engaging HVAC or RCx providers to address IT measures when straightforward, prescriptive incentives are available.
- Service provider recommendations for utility program support include:
    - Keep participation process simple, minimize paperwork requirements.
    - Provide certainty on what incentives will be from the outset—before the customer has made the decision to move ahead. Prescriptive incentives or standardized calculations are preferred.
    - Provide co-marketing support, allowing service providers to leverage the ComEd brand.
    - Provide a dedicated point of contact for program questions.
    - Provide education about optimal thermostat set points in data centers.

[30] Fulton (April 3, 2018). *What is Hyperconvergence? Here's How It Works and Why It Matters.* ZDNet Technology News. Available at: https://www.zdnet.com/article/what-hyperconvergence-is-how-it-works-and-why-it-matters/

A synthesis of interview responses is provided in Appendix A.

Program design

Energy efficiency measures

Based on prior SEDC research in Wisconsin and Minnesota as well as input from service providers, we focused on the energy efficiency measures shown in Table 3. Savings assumptions for each measure are listed in Appendix B.

Table 3: SEDC energy efficiency measures

#	Measure	Category	Type	Description
1	UPS utilization	Service	IT	Increase UPS utilization to 75-80 percent through UPS consolidation
2	Server consolidation	Service	IT	Remove dormant servers and reduce number of servers by moving IT services to the cloud or consolidating services on other servers
3	ENERGY STAR server	Product	IT	Purchase ENERGY STAR-certified IT equipment when refreshing
4	ENERGY STAR UPS	Product	IT	Purchase ENERGY STAR-certified IT equipment when refreshing
5	ENERGY STAR data storage	Product	IT	Purchase ENERGY STAR-certified IT equipment when refreshing
6a	HDD storage reduction: remove dormant	Service	IT	Archive unused hard disk drive (HDD) storage onto tape drives and power down unneeded disk drives
6b	HDD storage reduction: move to cloud	Service	IT	Move HDD storage to cloud services
7a	SSD storage reduction: remove dormant	Service	IT	Archive unused solid state drive (SSD) storage onto tape drives and power down unneeded disk drives
7b	SSD storage reduction: move to cloud	Service	IT	Move SSD storage to cloud services
8	Air flow management	Service	HVAC	Achieve reduction in cooling energy use by improving air flow management through: - Cold aisle/hot aisle containment by delivering the conditioned air to the front (cold aisle) and exhaust the heated air from the back (hot aisle) of the server racks - Installing blanking panels - Performing cable management best practices
9	Raise temperature set point	Service	HVAC	Achieve reduction in cooling energy use by increasing data center set point to deliver 75 F inlet temperatures at server racks
10	High efficiency cooling equipment	Product	HVAC	Install CEE-designated premium-efficiency cooling equipment in SEDCs

Virtualization was omitted from the measure list due to concerns about free ridership. ComEd does not currently incentivize this measure based on guidance from the evaluation team. Other

researchers have noted the potential for free ridership, with PG&E's study noting that SEDCs were pursuing virtualization independently without support from utility programs or encouragement from vendors.[31] At the same time, two of the service providers we interviewed did not think virtualization should be off the table for utility incentives. One provider said virtualization is not applicable to every customer site and they recommend it selectively when they find the right fit. Another provider said that they frequently must encourage customers to implement virtualization and getting customer agreement is not a foregone conclusion.

The PG&E study concluded that IT measures were more frequently implemented in SEDCs than HVAC measures, with installation of energy-efficient servers or UPSs, decommissioning unused servers, and data storage reduction/consolidation being most frequently implemented.[32] The PG&E study noted that some SEDCs do not have the ability to control thermostat settings and others rely on the building's existing HVAC system.

In the Round 2 interviews, we asked service providers to give more detailed input on the SEDC measures identified in Table 3, gathering data so that we could categorize measures by the following criteria:

- **Free ridership risk**: Prevalence of non-program factors driving measure uptake.
- **Applicability**: How frequently each measure is found in SEDCs they work on and annual number of projects they implement that include the measure.
- **Implementation hurdle**:[33]
    - Low: Simple to implement, no cost or very low cost
    - Medium: A little more work and/or cost but still cost-effective
    - High: Higher-investment and/or complexity
- **Decision hurdle**: How easy/difficult it is to convince customers to implement the measure.
- **Incentive impact:** Whether specified incentive range would have low, medium or high impact on customer's decision to implement the measure.[34]

Findings from Round 2 interviews are summarized in Table 4.

[31] Bard & Huang (2013). *Small Data Center Market Study*. Prepared for Pacific Gas & Electric Company by Cadmus Group, Inc.

[32] Bard & Huang (2013).

[33] We also relied on our Wisconsin SEDC research for this category.

[34] See Appendix B for estimated kWh savings per measure. We multiplied the kWh by $0.05/kWh, $0.07/kWh and $0.12/kWh to generate the incentive ranges that were shared with the service providers prior to the interview.

Table 4: Program opportunity analysis

#	Measure	Free ridership risk	Category	Applicability	Impl. hurdle	Decision hurdle	Incentive impact	Sav. per SEDC (kWh)	Incentive range per SEDC[35]	Incremental cost threshold [36]
1	UPS utilization	Low	Service	High	Low	Medium[37]	Low	5,183	$250-625	$542
2a	Server consolidation: remove dormant	Low	Service	High	Low	Low	Low	2,891	$145-350	$302
2b	Server consolidation: move to cloud	Low	Service	High	Low	Low	Low	2,891	$145-350	$302
3	ENERGY STAR server	Medium	Product	Medium	Low	Low	Low	1,236	$60-150	$129
4	ENERGY STAR UPS	Medium	Product	Medium	Medium	Low at end of life	Low	70	$5-10	$7
5	ENERGY STAR data storage	Medium	Product	No responses	Medium	No responses	No responses	270	$15-30	$28
6a	Storage reduction (HDD): remove dormant	High	Service	High	Medium	Low	Low	315	$15-40	$33
6b	Storage reduction (HDD): move to cloud	High	Service	High	Medium	Low	Low	315	$15-40	$33
7a	Storage reduction (SSD): remove dormant	Low	Service	High	Medium	Low	Low	210	$10-25	$22
7b	Storage reduction (SSD): move to cloud	Low	Service	High	Medium	Low	Low	210	$10-25	$22
8	Air flow management	Low	Service	High	High	High	Low	2,252	$115-270	$236
9	Raise temperature set point	Low	Service	Medium	Low	Medium	Low	2,252	None[38]	$393[39]
10	High efficiency cooling equipment	Medium	Product	Medium	Medium	Low at end of life	Low	2,022	$100-240	$212

It was challenging to obtain incremental cost and project cost data from service providers during the interviews. In some cases (i.e., UPS utilization) the costs per project are highly variable and service providers were not able to provide a range. In other cases service providers were not certain about cost. The service providers we interviewed felt strongly that the incentive ranges that were shared

[35] Low end of range assumes incentive of $0.05/kWh and high end assumes incentive of $0.12/kWh (incentive values were rounded for purposes of discussion with service providers).

[36] Pursue measure if incremental cost is below this threshold. Assumes two-year simple payback, electric cost of $0.087/kWh and incentive of $0.07/kWh.

[37] Decision hurdle is lower when there is equipment failure or it is part of data center reconfiguration project.

[38] ComEd can claim savings from this measure but cannot award incentives due to persistence concern,

[39] Calculation assumes no incentive for this measure.

prior to the Round 2 interviews were mostly too low to have much influence on the customer's decision to implement the measures we discussed. Incentive levels were based on expected savings from implementing each measure in a typical SEDC, and incentive rates that ComEd has offered for IT incentives in the past ($0.05-$0.12/kWh). ComEd's current incentive range for data center measures is $0.10-0.12/kWh. For the most part, service providers felt that our estimated savings per measure were accurate (see Appendix B).[40] Table 5 summarizes the measures where we obtained some cost data[41] from service provider interviews, comparing costs with potential incentives using a range of $0.05-0.15/kWh. For all but UPS utilization, the incentive ranges represent less than 2% of the total project cost. For UPS utilization the incentive range is 7-22%.

Table 5: Comparison of cost data and incentive ranges

			Incentive range				
#	Measure	Savings per SEDC (kWh)	Low ($0.05/kWh)	Med ($0.10/kWh)	High ($0.15/kWh)	Project cost	Incr cost
1	UPS utilization	5,183	$259	$518	$777	Variable	
2	Server consolidation	2,891	$145	$289	$434	$2,000	
3	ENERGY STAR server	1,236	$62	$124	$185	No responses	
4	ENERGY STAR UPS	70	$4	$7	$11	$3,000	$250
5	ENERGY STAR data storage	270	$14	$27	$41	No responses	
6	HDD storage reduction	315	$16	$32	$47	No responses	
7	SSD storage reduction	210	$11	$21	$32	No responses	
8	Air flow management	2,252	$113	$225	$338	$3,500-30,000	
9	Raise temperature set point	2,252	$113	$225	$338	Not applicable	
10	High efficiency cooling equipment	2,022	$101	$202	$303	$24,000	$4,000

Low savings (and as a result, low incentives) per measure will be a significant challenge for a SEDC-targeted program offering to overcome. Low incentives means the program is less likely to have influence on the customer's purchasing decision and thus increased risk of free ridership. Even when multiple measures are bundled together in a single project, average savings and incentive per SEDC remains low. For example, bundling measures 2-7 in Table 5 produces a project cost that exceeds $5,000 and an incentive of $750 at $0.15/kWh.

[40] The only service provider who thought the savings estimates were too low works on 1000-2000 sf data centers, where our savings estimates are based on an assumed data center size of 500 sf.

[41] Where provided, cost information is based on one or two service provider responses. Where blank, we received no cost information from service providers.

Estimated energy savings

We estimate that typical annual electricity consumption of SEDCs in ComEd service territory is approximately 107,000 kWh per facility. This estimate was derived using the assumptions in Table 6.

Table 6: Assumptions to estimate savings per building with SEDC

Parameter	Units	Value[42]
Ave demand – server room	W	4,520
Ave demand – server closet	W	882
Ave server rooms per building	-	0.6
Ave server closets per building	-	1.7
Mechanical load component	-	1.9
Annual hours of operation	hr	8,760

A comprehensive IT-only SEDC project could include implementation of measures 2-7 from Table 4, achieving annual savings of around 8,400 kWh. Using the $0.05-0.15 incentive ranges discussed above, the expected incentive from this bundled project would be between $420 – 1,260. Increasing the thermostat set point in the SEDC would increase savings to 16,000 kWh but would not increase the customer incentive.[43] Adding all ten of the measures in Table 4 produces maximum potential savings of 20,000 kWh per SEDC, but it is worth noting that interactions between some of these measures would lower the savings estimate somewhat.

Using this range of 8,400-20,000 savings kWh per site and typical SEDC usage of 107,000 kWh/year means that a reasonable energy savings target for an SEDC program is an 8-20 percent reduction in energy use per facility. According to the CBECS market segmentation analysis discussed above, we estimate there are approximately 2500 SEDCs in ComEd territory. Applying a 20 percent reduction to annual usage per facility means that the maximum achievable savings potential in the SEDC market is 53.5 million kWh.

Table 7 shows estimated program savings at varying levels of market penetration. Given the challenges that other data center programs have encountered with project recruitment and pipeline conversion, we expect the lower end of the participation and savings range is more likely.

Table 7: Program participation estimates

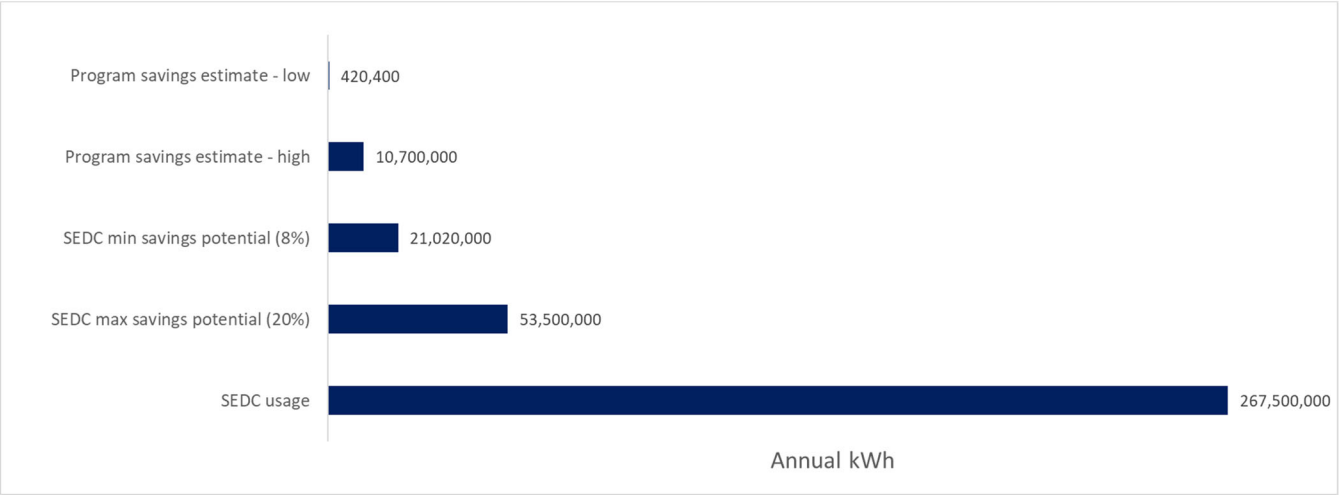
Program participation	Participation %	# participating SEDCs	Program savings at 8% savings per SEDC (kWh)	Program savings at 20% savings per SEDC (kWh)
Low	2%	50	420,400	1,070,000
Medium	10%	250	2,102,000	5,350,000
High	20%	500	4,204,000	10,700,000

Figure 8 compares estimated SEDC electric usage in ComEd territory (267,500,000 kWh per year) with the 8-20% savings potential discussed above. Potential savings from a program intervention is based on the 2-20% participation range shown in Table 7, and 8-20% savings per SEDC.

[42] Schuetter et al. (2018). *Small Embedded Data Centers in Wisconsin*. Prepared for Focus on Energy Environmental & Economic Research and Development program. Available at: https://www.focusonenergy.com/sites/default/files/2018-05/WI_SEDC_Final_Report%285-7-18%29.pdf
Shen et al. (2017). *Small Embedded Data Center Program Pilot*, COMM-CARD01-20140512-86772. Assuming an average demand of 411 W per server and a Mechanical Load Component of 1.9 with 8760 hours per year.

[43] ComEd program staff noted they are not currently able to award incentives for thermostat setback due to concerns about savings persistence.

Figure 8: Program savings potential



Program recommendations

One of our primary research objectives was assessing the viability of program strategies that operate through supply chain actors instead of targeting SEDCs directly. Downstream programs offer incentives directly to the consumer, typically via prescriptive rebate. Vendors may assist customers in completing program-required paperwork, but typically with a downstream program more of the participation burden is born by the end user. Programs that provide incentives to manufacturers for increasing supply of an energy efficient product are typically referred to as "upstream" programs whereas programs that target, distributors, contractors and installers are typically referred to as "midstream."[44]

Figure 9 compares how each program approach performs against criteria that determine the efficacy of an SEDC initiative. A downstream approach would have higher customer acquisition cost than either a midstream or upstream approach which is harnessing vendor sales efforts to acquire customers. To analyze savings potential, we determined the point in the supply chain where the SEDC measures in Table 3 could most effectively be promoted by categorizing each measure as a product or a service. Measures in the product category are high efficiency cooling equipment, ENERGY STAR qualified UPS, server, and data storage equipment (8 percent of savings potential). All of the other measures are service-related including UPS utilization, server and storage consolidation, migration of data to the cloud, and airflow management (92 percent of savings potential). Thus, the midstream approach performs best against the savings potential criteria. Service providers are an important part of ComEd's existing energy efficiency portfolio and would receive greater value from additional midstream incentive offerings they could leverage in their business. From a customer value standpoint, more of the participation burden is borne by the customer with a downstream approach so it delivers less value than a midstream or upstream approach which should deliver a seamless process to the customer. Overall, the midstream approach performs the best against all of the criteria and thus is likely the most viable strategy for capturing SEDC savings.

[44] Backen, Burmester and Sheehan (April 2016). "Moving to the Middle: How to Navigate the Ins and Outs of C&I Midstream Programs." *AESP Strategies*. Available at: https://www.aesp.org/page/MidstreamPrograms/How-to-Navigate-the-Ins-and-Outs-of-CI-Midstream-Programs.htm

Figure 9: Comparison of program approaches

	Downstream	Midstream	Upstream
Customer acquisition cost			
Savings potential			
Service provider value			
Customer value			

	Low
	Medium
	High

In general the service providers we interviewed were enthusiastic about the potential for partnering with ComEd on an initiative targeting SEDCs. Companies that agreed to participate in interviews were familiar with ComEd programs and most had a track record of past participation either in the Data Center program or RCx. However, all of them expressed concerns about the low incentive ranges for SEDC measures (Table 4) and felt that these incentive levels would not have much impact on the customer's decision-making process. With low savings and incentives per measure, ComEd would need to aggressively pursue other strategies to make a midstream program approach attractive to service providers. Possibilities include radical simplification of the participation process and allowing service providers to leverage the power of the ComEd brand in their marketing efforts.

Service providers emphasized the importance of a straightforward participation process and minimizing paperwork requirements. They want to be able to easily communicate to customers what the expected incentive will be during initial discussions, rather than having to wait weeks or longer for a program to validate estimated savings and incentives. The calculations documented in Appendix B could be readily programmed into an online form or Excel spreadsheet to provide fast feedback on expected savings and incentives per project. Some measures have the potential for interactivity (e.g., increase in cooling efficiency and reduction in thermostat set point). Simplified approaches to account for measure interaction could be developed but would also increase the imprecision of savings calculations.

Several of the service providers we interviewed were enthusiastic about the potential for leveraging the ComEd brand in marketing their services to customers. Opportunities to develop cobranded marketing materials and receiving a "preferred service provider" designation were of particular interest to the service providers we interviewed.

Overall, this research presents several important factors that should be taken into account in determining whether to develop a SEDC initiative.

- **Savings potential**: Focusing on the small end of the data center market (~500 sf) means that savings per site is relatively low. This may ultimately be the reason that other utilities that have studied the SEDC market have not proceeded to launch program offerings.
- **Service provider engagement**: Building relationships with IT service providers will be important to capturing savings from the majority of SEDC measures. The recruitment challenges we encountered in this research indicate that ComEd does not currently have a robust service provider network for this market. A significant investment in relationship-building will be needed, and one utility we interviewed has made such investments but has still had challenges securing meaningful savings from this market.
- **Free ridership:** The SEDC market is undergoing a transformation that is driven by the transition to cloud computing and computing technology that becomes more efficient with

each new generation of product. Companies like Microsoft, Amazon and Google are aggressively promoting their cloud solutions in the SEDC market. Service providers also expressed that high efficiency cooling and ENERGY STAR qualified IT products are already prevalent in the SEDC market.

Our research suggests that a midstream SEDC initiative requires significant investment to establish and there is risk that it will not be cost-effective. At the same time, it is possible to take some incremental steps short of a full-scale program offering to capture more savings from the SEDC market. A first step would be developing work papers for SEDC measures to get them included in the Illinois TRM. This would allow ComEd to confidently increase the number of prescriptive incentive offerings. TRM measures could be readily developed for all SEDC measures listed in Table 3 with the exception of #8 (airflow management) and #9 (raising thermostat set point) using the calculation methodologies show in Appendix B. Other TRMs we reviewed do not include an extensive list of SEDC measures, but rather include one or two relevant measures. For example, the Minnesota TRM includes computer room air conditioning (CRAC) units[45] and the Wisconsin Focus on Energy TRM includes data center airside economizers.[46] The California Municipal Utilities Association's TRM includes a measure for ENERGY STAR qualified UPS.[47] Once a small portfolio of prescriptive measures is available to serve SEDCs, it could be packaged in such a way that it can be promoted to midstream service providers in a targeted fashion—starting with firms that are already engaged in supporting ComEd programs like the ones interviewed for this study. This approach would fall short of a full-scale pilot with inherent costs for outreach, program infrastructure, and contractor support. ComEd could explore opportunities for bundling more SEDC measures into projects that are participating in other ComEd programs, like Standard or RCx. We found some overlap between service providers working in the SEDC market and participating in RCx and they expressed interest in doing more to address SEDC opportunities if there was a straightforward pathway to do so.

Program cost estimate

The table below summarizes the potential cost of integrating SEDC incentive offerings into an existing ComEd program. This approach would be more cost-effective than a stand-alone program by leveraging existing administrative infrastructure and trade ally relationships that already exist. This cost estimate includes the following assumptions:

- Developing TRM workpapers for four SEDC measures (likely targeting measures with the largest savings as shown in Table 4 (UPS utilization, server consolidation, efficient servers and high efficiency cooling/CRAC unit).
- Soliciting additional input from service providers to inform program strategy
- Developing a one-page fact sheet summarizing the offering prior to program launch
- Updating program application materials with SEDC measure information
- Implementation staffing of 0.75 FTE to support outreach and technical assistance, largely working with service providers to increase awareness
- Developing two case studies on successful projects in Year 1

[45] Minnesota Department of Commerce (January 10, 2019). *State of Minnesota Technical Reference Manual for Energy Conservation Improvement Programs.* Version 3.0. Effective January 1, 2020 – December 31, 2020. Available at: http://mn.gov/commerce-stat/pdfs/mn-trm-v3.0.pdf

[46] Cadmus Group on behalf of Public Service Commission of Wisconsin. *Wisconsin Focus on Energy 2019 Technical Reference Manual*. Available at: https://www.focusonenergy.com/sites/default/files/2019_TRM_Final_Update_0.pdf

[47] ERS on behalf of CMUA. *Savings Estimation Technical Reference Manual 2017*. Third edition. Available at: https://www.cmua.org/files/CMUA-POU-TRM_2017_FINAL_12-5-2017%20-%20Copy.pdf

Table 8: SEDC program cost estimate

	Task	Rate	Hours	Cost	Assumptions
Pre-launch	Develop TRM workpapers	$150	160	$24,000	40 hours per measure; 4 measures
	Service provider outreach	$130	20	$2,600	20 hours for input on program design
	Marketing materials	$130	60	$7,800	40 hours for dev. 1-page info sheet
	Application materials	$130	20	$2,600	40 hours for updates to program forms
				$37,000	
Impl.	Case studies	$130	80	$10,400	80 hours to dev. 2 case studies
	Outreach/TA	$130	1500	$195,000	75% FTE for outreach & TA
				$205,400	

In Table 9, we use the range of program savings estimates from Table 7 to develop a possible trajectory for an SEDC offering over a four-year period. By Year 4, the offering is generating around 2 million kWh per year which is equivalent to 8% savings per SEDC in ComEd territory and a 10% SEDC participation rate. The Year 1 budget includes both the pre-launch activities and the implementation activities from Table 8. The 0.75 FTE is dedicated to program design work before launch, and transitions to service provider outreach and technical assistance after launch. Year 2 includes outreach/TA plus case study development, and we assume there is no additional case study development in Years 3 and 4.

Table 9: SEDC program cost per kWh

	Year 1	Year 2	Year 3	Year 4
Annual savings (kWh)	100,000	420,400	1,000,000	2,000,000
Non-incentive cost	$242,400	$205,400	$195,000	$195,000
Incentive cost ($0.12/kWh)	$12,000	$50,448	$120,000	$240,000
Total program cost	$254,400	$255,848	$315,000	$435,000
Total program cost per kWh	$2.54	$0.61	$0.32	$0.22
Non-incentive cost per kWh	$2.42	$0.49	$0.20	$0.10

Conclusions

The ~2,500 SEDCs in ComEd territory contain untapped opportunities for energy savings. This study identifies a suite of IT and HVAC measures that could reduce SEDC energy consumption by 8-20 percent. At the same time, energy efficiency is not a high priority for IT system administrators and there is low awareness of energy efficiency programs among IT professionals. A successful midstream program approach would require an extensive network of service providers implementing multiple incentive-eligible measures per SEDC served in ComEd territory. Significant investments would be required to build a service provider network and develop a straightforward program offering that would be compelling enough to facilitate broad participation. With the low level of savings per measure and per site, it is unclear whether these investments would generate sufficient savings to be cost-effective. Other utilities have launched program initiatives in small to medium-sized data center market but to date there is not a proven program strategy that can be replicated in ComEd territory. Our recommendation is that ComEd pursue a more incremental approach, starting with developing a wider suite of prescriptive incentive offerings that can be used to selectively explore future program opportunities.

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Appendix A: Service Provider Interviews

Small Embedded Data Center Vendor Interview Guide
Round 1 Scoping Interviews

Background (Described to Vendor)
ComEd Energy Efficiency has engaged Slipstream to conduct research with IT service providers, manufacturers and vendors who work with businesses & organizations that have small embedded data centers (SEDCs). **We are specifically targeting facilities with server rooms and network closets, usually less than 500 square feet, physically located onsite at their business location.** The goal is to develop new program strategies to drive greater energy efficiency in this segment of the data center market. When we say "small embedded data center" throughout this interview, this is the market segment we are asking you to consider.

1. **What percentage of your business involves working with SEDCs versus larger data centers?**
    - Responses ranged from 10% to 90% of the company's work is in SEDCs
2. **What services or products does your company provide to SEDCs?**
    - 3 responses for IT solutions: migration to the cloud, server virtualization, server/network wiring, hardware care & feeding, cable management
    - 1 response: IT equipment reseller
    - 1 response: service contracts for major manufacturer of data center cooling equipment
    - 1 response: MEP design for new & existing SEDCs (mostly HVAC)
    - 1 response: cold/hot aisle containment
3. **Of your customers that have SEDCs, what market segments are they in?**
    - 2 responses: Customers across multiple market segments (office, healthcare, schools, small manufacturing)
    - 1 response: Schools and universities
    - 1 response: Healthcare
    - 1 response: Small to medium businesses (fewer than 1000 employees)
4. **Does your company focus mainly on one or more of the above market segments?**
    - 3 responses: focus on specific segments or business size
    - 2 responses: range of customer types
5. **What proportion of the SEDC market does your business serve?**
    - 1 response: 50%+ for HVAC servicing
    - 1 response: not sure
6. **What other companies serve a significant portion of the SEDC market segment? What proportion?**
    - 2 responses: APC/Schneider Electric
    - 1 response: Vertiv (formerly Liebert)

- 1 response: Powerware, Mitsubishi
- 1 response: ESD, McGuire and RTM for engineering

7. **What share of your business' annual sales volume is from selling products/services to new customers versus selling new products/services to existing customers?**
    - 2 responses: 70-80% selling to existing
    - 1 response: Equipment servicing department generates more revenue than construction design, but construction is consistently growing.
8. **What communications methods are most commonly used in your sales process to SEDCs? (Email, phone, in person meeting, etc.)**
    - 3 responses: Mostly face-to-face
    - 1 response: some email/phone with existing customers
9. **Are you usually working more closely with IT staff, facilities staff, or both?**
    - 2 responses: mostly facility staff
    - 1 response: IT and financial staff/purchasing
    - 1 response: mostly financial staff
    - 1 response: Pretty evenly split between IT and facilities
10. **What can you tell us about how decisions are typically made for SEDCs? For example, who is the decision-maker, are there multiple decision-makers, and what is the process?**
    - 2 responses: Process varies by company
    - 2 responses: Teams with representatives from IT, financial, facilities
    - 1 response: Small projects tend to move faster, big projects need to go up the chain for approval
11. **What do SEDCs decision-makers view as trusted sources of information?**
    - 3 responses: Our company
    - 2 responses: Some customers are savvy and do independent research
    - 1 response: Peer businesses
12. **Energy efficiency can be a strategy for reducing IT operating costs. Do you see this as an important message in your sales process? If not, why not?**
    - 3 responses: Efficiency is at the top of our sales messages
    - 2 responses: Efficiency is medium/low importance, an added benefit not a selling point
    - Top sales messages include:
        i. Reliability: replace old, unreliable equipment. Increase uptime.
        ii. Right sizing: most existing data centers are oversized, reduce
        iii. Reduction in total operating cost
13. **Which of the following products/services does your organization deliver in the SEDC market:**

- **Increasing UPS utilization through consolidation**. 2 yes responses
- **Identifying comatose servers and turning them off**. 3 yes responses
- **Moving email/DB services to the cloud**. 3 yes responses
- **Moving data storage to cloud**. 3 yes responses
- **Selling ENERGY STAR qualified IT products**. 3 yes responses
- **New UPS**: 3 yes responses
- **Server virtualization**. 3 yes responses
- **For facilities with dedicated mechanical cooling:**
    i. **Cold aisle/hot aisle containment via blanking panels**. 3 yes responses
    ii. **Raising set point temperature to 75 in server racks.** 2 yes responses
- **Installing CRAC units**. 3 yes responses
- **Other**: Static pressure control, VFDs, economizer (air and water side): 1 response

14. **What do you see as the biggest energy efficiency opportunities in SEDCs?**

- 1 response: Modernizing IT systems
- 1 response: Raising thermostat setpoint
- 1 response: Education of IT companies about ComEd efficiency programs & incentives.

15. **Do you currently leverage the ComEd program in selling the above products/services to SEDCs? If not, why not?**

- 2 responses: Yes
- 1 response: Not yet but would like to
- 1 response: Does not work in IL

16. **What are the biggest barriers to selling these products/services to SEDCs?**

- 1 response: Cost/budget
- 1 response: Fear of downtime/disruption
- 1 response: Customers don't know where to start
- 1 response: Fears that modernization will lead to IT staffing reductions

17. **What could ComEd do to help you sell more of these products/services?**
    - **Cobranded marketing opportunities (ComEd preferred provider):** 4 responses
    - **Educating service providers serving this market:** 2 responses
    - **Outreach support/lead generation**: 2 responses
    - **New incentives or higher incentives.** 1 response
    - **Clear, consistent program requirements**: 1 response
18. **ComEd is interested in exploring "upstream" program strategies. This means program support and incentives to reward vendors & service providers for selling more of a product/service, rather than rebates targeting the customer buying the product or service.**
    - **Like this idea:** 5 responses
    - **What priorities should ComEd keep in mind in developing this kind of offering?**
        i. Keep it simple, streamlined 3 responses
        ii. Clients love free: 1 response
    - **Would you participate in this kind of offering?** 4 "yes" responses

- **Willing to provide ongoing input if ComEd develops this new offering:** 4 "yes" responses

19. **Organizations with SEDCs may not think of themselves as needing a "data center energy efficiency" program. What terminology should ComEd use in marketing the program. "IT optimization"? Other ideas?**

    - Data Center Energy Efficiency: 3 responses
    - Keep it simple and clear

Small Embedded Data Center Vendor Interview Guide
Round 2 Interviews

IT Measure #1: UPS utilization

1. **Does your company install this measure in SEDCs?**
    - Response 1: Yes
    - Response 2: No (remaining questions in this section were skipped)
2. **How applicable is this measure to the SEDCs you work with?**
    - Response 1: Common in many/most
3. **How many of these measures is your company likely to install in SEDCs per year? [If possible, provide rough estimate for No IL.]**
    - Response 1: 60 SEDC retrofit projects/year; most have cooling or UPS component
4. **How easy or difficult would it be to convince customers to install this measure?**
    - Response 1: Difficult unless there is an equipment failure or data center move/reconfiguration.
5. **We estimate that a SEDC would save around 5,000 kWh per year from installing this measure. Does this estimate seem reasonable to you? If not, do you think savings would be significantly lower or higher?**
    - Response 1: Yes
6. **How would a ComEd incentive of $250-$600 impact the number of installations per year?**
    - Response 1: Minimal impact; operating cost savings could drive the decision
7. **What is the approximate cost of installing this measure? Typical cost range ok.**
    - Response 1: Project costs are highly variable.
8. **What are the major barriers to implementing this measure?**
    - Response 1: Taking systems offline**,** getting approval of capital expenditure
9. **How long is the typical customer decision process for installing this measure?**
    - Response 1: Fast if there is equipment failure; 6 months if it is part of a design process

IT Measure 2: server consolidation

1. **Does your company install this measure in SEDCs?**
    - Response 1: Yes, companies with SEDCs typically replace hardware every 4-5 years, once it is off warranty or at end of life. By virtue of hardware life cycle you are replacing old equipment with more powerful machines. RAM increases so you can have fewer

servers. It is rare they would do a 1-1 server replacement, you always work to get the customer into a more powerful machine.

- Response 2: Yes. Big change in the industry is companies moving to converged and hyperconverged infrastructure, especially in Fortune 1000. Virtualization was a big thing in the 1990s. Now companies are moving to native cloud-based systems. These systems use compute & storage in more efficient way by design.

2. **How applicable is this measure to the SEDCs you work with?**
    - Response 1: Highly applicable, especially when they are moving data/applications to the cloud.
    - Response 2: With smaller SEDCs you have fewer servers, so may encounter diminishing returns. But still something you take a look at, even in facility with only 5-10 servers.

3. **How many of these measures is your company likely to install in SEDCs per year? [If possible, provide rough estimate for No IL.]**
    - Response 1: 20 projects/year
    - Response 2: We work through ~24 service provider partners in Chicago market; no limit to number of projects we can do if there is an initiative to push.

4. **How easy or difficult would it be to convince customers to install this measure?**
    - Response 1: Easy, Microsoft and other cloud providers are pushing this aggressively.
    - Response 2: Easy, customers are doing equipment refreshes every 3-5 years anyway.

5. **We estimate that a SEDC would save around 3,000 kWh per year from installing this measure. Does this estimate seem reasonable to you? If not, do you think savings would be significantly lower or higher?**
    - Response 1: Seems reasonable
    - Response 2: Seems low

6. **How would a ComEd incentive of $150-$350 impact the number of installations per year?**
    - Response 1: Minimal impact. Incentives would need to be in $1000s for the kind of work they do.
    - Response 2: Consider targeting larger facilities for greater savings.

7. **What is the approximate cost of installing this measure? Typical cost range ok.**
    - Response 1: Data center upgrade typically costs at least ~$2000 for server configuration, if paying a third party rather than doing it in house.
    - Response 2: Customers that haven't touched their data center in years face much higher cost than clients who are keeping up with technology.

IT Measure 3: ENERGY STAR server

1. **Does your company install this measure in SEDCs?**
    - Response 1: They don't make the selection on the equipment (they deliver a platform), but his feeling is that ENERGY STAR is prevalent and pretty much everyone is doing it.

2. **How applicable is this measure to the SEDCs you work with?**
    - Response 1: Applicable to ~50%; roughly ½ of clients are motivated to be "green."

3. **How many of these measures is your company likely to install in SEDCs per year? [If possible, provide rough estimate for No IL.]**
    - Response 1: Not sure. They pursue hyper-converged infrastructure projects which is designed specifically to couple processors and storage to optimize performance and reduce energy –a different kind of approach than specifying more efficient hardware.

4. **How easy or difficult would it be to convince customers to install this measure?**
    - Response 1: Easy. The platforms they select for hybrid data centers include optimally efficient server as part of that platform.

5. **We estimate that a SEDC would save around 1200 kWh per year from installing this measure. Does this estimate seem reasonable to you? If not, do you think savings would be significantly lower or higher?**
    - Response 1: Seems low – the projects they see are generating more savings but typical size is 1000-2000 sf data center.

6. **How would a ComEd incentive of $60-150 impact the number of installations per year?**
    - Response 1: Minimal impact on the decision.

7. **What is the approximate cost of installing this measure? Typical cost range ok.**
    - Response 1: Not sure.

8. **How does the cost compare with standard efficiency alternative?**
    - Response 1: Not sure.

IT Measure #4: ENERGY STAR UPS

1. **Does your company install this measure in SEDCs?** Yes
2. **How applicable is this measure to the SEDCs you work with?**
    - Response 1: All – it is part of any holistic EE discussion. If you are upgrading servers you also look at UPS.
    - Response 2: Some.

3. **How many of these measures is your company likely to install in SEDCs per year?**
    - Response 1: Not sure but it's a big part of their business.
    - Response 2: 20 (1/3) out of their 60 projects a year. Typically what they do is take out the UPS that's there, right size it, or put modular/scalable units.
    - Response 3: Typically on most data center projects they are also replacing the UPS. 90% efficient old, replaced with 98% efficient new. They go after UPS prescriptive incentive or Custom incentives from ComEd. UPS replacements are always driven by other reasons, never a stand-alone item.

4. **How easy or difficult would it be to convince customers to install this measure?**

- Response 1: It's easy to get a customer to get a new UPS when they are having issues (power spikes, etc.) In that case UPS is on the top of their list. If UPS is not faulty, customer is unlikely to swap it out. Tends to only be dealt with at end of life.
- Response 2: Easy. ENERGY STAR level of efficiency is where the market is at, they don't sell lower efficiency units, but you can get them out there on the used market.
- Response 3: Most IT folks have UPS preferences not based on efficiency but based on performance, features. Most UPS manufacturers have pretty efficient equipment. Any time you change UPS it's a no brainer to go for premium efficiency, no pushback.

5. **We estimate that a SEDC would save around 70 kWh per year from installing this measure. Does this estimate seem reasonable to you? If not, do you think savings would be significantly lower or higher?**
    - Response 1 & 2: Sounds reasonable.
    - Response 3: Their bigger energy savings hits come from servers and virtualization, not UPS.
6. **How would a ComEd incentive of $5-10 impact the number of installations per year?**
    - All respondents: No impact, not even a rounding error for the customer.
7. **What is the approximate cost of installing this measure? Typical cost range ok.**
    - Response 1: $3000
    - Response 2 & 3: Not sure
8. **(For measures where this applies) How does the cost compare with standard efficiency alternative?**
    - Response 1: 10% cost premium
    - Response 2: 25-30% cost premium
    - Response 3: $200-300 increase

HVAC Measure 1: Air flow management (cold/hot aisle containment, install blanking panels, cable mgmt. best practices).

1. **Does your company install this measure in SEDCs?** Yes.
2. **When walking into a SEDC for the first time, how likely are you to find an opportunity for improved airflow management?**
    - Response 1: It's the majority, a good 80%.
    - Response 2: Most SEDCs have this opportunity – generally when they are going into small data center, it's a mess. No hot/cold aisle, no containment. Everything squished in where they have space.

    - **How often can customers be convinced to make improvements?**
        - Response 1: About 20%. Barriers include low awareness/interest from IT manager, no big incentive, not a bit priority.
        - Response 2: 15-20% of the time they are receptive to implementing this change. Major concerns are budget, logistics of moving equipment/racks. A lot of clients don't want to deal with it.

3. **How many airflow management projects is your company likely to complete in SEDCs per year? [Estimate for No. IL preferred if possible.]**
    - Response 1: Zero for small data centers. They've done a few projects as part of larger data center projects. Volume is 1-2 a year. These projects are not always driven by energy. May be part of a data center expansion, cooling system upgrade.
    - Response 2: Typical range is 6-8 projects a year, 12 max.
4. **How easy or difficult is it to convince customers to install this measure?**
    - Response 1: Difficult unless it is part of a major renovation or expansion.
    - Response 2: Difficult – see 15-20% adoption above. There are logistics & cost barriers.
5. **We estimate that a SEDC would save around 2250 kWh per year from installing this measure (3% reduction in SEDC cooling energy use). Does this estimate seem reasonable to you? If not, do you think savings would be significantly lower or higher**?
    - Response 1: 3-5% savings seems like a good rule of thumb, but for any individual project the savings value is all over the place.
    - Response 2: Pretty reasonable, agrees with 3-5% reduction.
6. **How would a ComEd incentive of $115-270 impact the number of installations per year?**
    - Response 1: No, doubtful
    - Response 2: Their engineering hourly rates are $155-160/hour. An hour of the customer's time is worth at least that much. So this incentive is really just worth an hour of the customer's time, which is negligible.
7. **What is the approximate cost of installing this measure? Typical cost range ok.**
    - Response 1: No one would hire them to do an energy study on 500 sf data center, but they might be hired to do an upgrade, fix failing equipment, etc. An engineering study alone is $4,500-5,500. To do follow up design work is another $10,000. Their firm does not do the installation, that's additional $$.
    - Response 2: Depends on # of cabinets, how bad is it. Requires relocating power whips, IT cabling, moving racks. Costs are really driven by IT cabling. If you have a dozen-rack data center, significant moving around of hot/cold aisle, cost can be as much as $30k.
    - Response 3: At least $3k-4k; $150/hour for their engineering staff.
8. **What are the major barriers to implementing this measure?**
    - Response 1: High cost, low incentive, customer reluctance to make any change.
    - Response 2: Logistical barriers and cost.
    - Response 3: Work is disruptive to customer operations, cost is much higher than proposed incentive
9. **How long is the typical customer decision process for installing this measure?**
    - Response 1: Nothing typical; could be anywhere from a week to 2 years. If client was moderately receptive at the outset, presents a proposal to upper management, could take a few months.

HVAC Measure 2: High efficiency cooling equipment (better than code requires)

1. **Does your company install this measure in SEDCs?** Yes.

2. **When walking into a SEDC for the first time, how likely are you to find an opportunity for improved airflow management?**

   - Response 1: Only happens when the customer asks b/c equipment is failing. No one would replace equipment early, it is all end of life replacement. Energy code means whatever cooling equipment gets put in will be more efficient than what they had.
   - Response 2: 50% of the time they find this opportunity in SEDCs. A lot are pretty up to date on cooling equipment, others are 30 years old. They are doing a public sector project right now where cooling equipment is from 1983.

3. **How many of these measures is your company likely to install in SEDCs per year? [Estimate for No. IL preferred if possible.]**

   - Response 1: 3-4 per year.
   - Response 2: Higher volume than airflow management, it's easier to get customers to sign on. They have proposal volume of 2/week. With 100 proposals a year and typical acceptance rate, this works out to 30-40 projects a year.

4. **How easy or difficult would it be to convince customers to install this measure**?
   - Response 1: Easy. Customer is doing it b/c they have to (old unit failed), and it's relatively easy to sell premium efficiency equipment that is better than what code requires. Especially b/c much of their work is in healthcare and they have overarching policies to reduce energy use.
   - Response 2: Depends on client. Sometimes cooling equipment is failing – then it's very easy. Early replacement is harder.

5. **We estimate that a SEDC would save around 2000 kWh per year from installing this measure. Does this estimate seem reasonable to you? If not, do you think savings would be significantly lower or higher?**
   - Response 1: He'd have to do the math, should be around a 5% efficiency improvement.
   - Response 2: There is no typical in SEDCs. Sometimes they replace ½ the cooling units, sometimes only 1. Hard to put an average on it, really varies greatly. But if you have to use an average 2000 kWh sounds good.

6. **How would a ComEd incentive of $100-220 impact the number of installations per year?**
   - Response 1: Not much difference.
   - Response 2: No change. They just had this happen last week, one of their mechanical guys was replacing a unit, ComEd incentive was $100-200, he walked away and said forget it because the incentive application process is lengthy and complicated for that small of an incentive.

7. **What is the approximate cost of installing this measure? Typical cost range ok.**

- Response 1: A Liebert condensing unit (standard efficiency) is $20,000, premium efficiency is $3000-5000.
- Response 2: Not sure, his role is engineering not installation.

8. **How does the cost compare with standard efficiency alternative?**
   - Response 1: $10-15% cost increase
   - Response 2: Not sure.
9. **What are the major barriers to implementing this measure?**
   - Response 1: Nope, premium efficiency unit is an easy sell when they are replacing their cooling equipment anyway.
   - Response 2: No barriers, if someone is looking to swap out equipment they always recommend the highest efficiency unit they can. Easy sell.
10. **How long is the typical customer decision process for installing this measure?**
    - Response 1: Depends on why are they replacing. If it's failing the process could be a couple of hours. Usually timeline is a lot shorter than for airflow management projects.

HVAC Measure 3: thermostat set point change (3% reduction in cooling energy use)

1. **Does your company implement this measure in SEDCs?** Yes, getting more common for people to accept this change.
2. **When walking into a SEDC for the first time, how likely are you to find an opportunity for set point change?**
   - Response 1: 50%
   - Response 2: 70-75% of SEDCs have opportunity for setpoint increase. SEDCs are on two ends of spectrum – either it's freezing cold in there or its way too hot. For the most part data center operators are keeping it too cold.
3. **How many of these setpoint changes is your company likely to implement in SEDCs per year? [Estimate for No. IL preferred if possible.]**
   - Response 1: Of the 50% of SEDCs that have this opportunity, they can convince about half to make the change.
   - Response 2: About half of the customers say yes for the opportunities they identify.
4. **How easy or difficult would it be to convince customers to make this change?**
   - Response 1: They still get quite a bit of pushback on this.
   - Response 2: Neutral – ½ say yes.
5. **We estimate that a SEDC would save around 2250 kWh per year from implementing this measure (3% reduction in SEDC cooling energy use). Does this estimate seem reasonable to you? If not, do you think savings would be significantly lower or higher?**
   - Response 1: Sounds reasonable
   - Response 2: Sounds reasonable
6. **What are the major barriers to implementing this measure?**

- Response 1: Customers are used to setpoints that are too low, worried about equipment failure rates.
- Response 2: A lot of it is perception, people have been trained that data centers are supposed to be cool. More of an age thing. Younger guys are used to warmer rooms, old guys are used to it being cold and can be very resistant to change.

7. **How long is the typical customer decision process for implementing this measure?**
   - Response 1: Relatively quick – either they say no way right away or ok let's try it. They recommend this measure a lot as part of other cooling system upgrade projects. Raising the temperature set point starts chain reaction of a lot of savings. For example, they have a current project where they are getting spectacular savings from reduction in fan use energy from raising the setpoint. They never do raising the setpoint on its own – it's always in combination with other improvements.
   - Response 2: Depends on the client, some require a lot of back and forth.

8. **Given ComEd cannot offer a financial incentive for implementing thermostat setpoint change, how likely would you be to recommend this measure for SEDCs**?
   - Response 1: Doesn't affect their recommendation, it's a normal part of their procedure at a client site.

General questions (asked after measure-specific question sequences)

1. **How likely is it that you could bundle multiple measures together in a single customer site?**
   - Response 1: You would definitely aim to bundle multiple IT measures in the same project: server, storage, networking. You can isolate the measures and people do upgrade different things over time. But when you're going to the cloud it is really a holistic solution.
   - Response 2: For retrofit projects typically HVAC and IT are separate. HVAC wears out more often than UPS. For new construction they are often combined. But this kind of work is evaporating due to colo, hard for them to get those jobs any more.
   - Response 3: It's 50/50 that the HVAC and UPS measures would all be combined on the same project. (1) Redoing the entire data center – will usually include both a UPS, airflow management, and cooling system upgrade. (2) They have a couple of projects that are UPS replacement only.
   - Response 4: Varies, can have HVAC and IT on the same project. They try to combine IT measures with HVAC as these are served by different divisions in their company.
   - **Which of the above measures present the greatest opportunity for bundling?** The majority of their work is swapping out the AC equipment. Airflow is tough sell. Set points is all over the board.
   - **What barriers do you see to implementing multiple measures in the same SEDC project?** Some things are easier to get acceptance on than others, plus cost.

2. **In order to validate incentive payments, ComEd will require that service providers deliver detailed information about the customer's project before the incentive check is issued. Do you foresee difficulties with collecting any of the following data to share with ComEd? (Customer location, business name, other info required by the utility).**
    - Response 1: No major issues with data sharing. Two-way NDA with the utility is usually needed.
    - Response 2: No challenges w/ data access, typically the clients are interested in the incentive so there is no issue getting the required info.
    - Response 3: Providing this kind of info is pretty easy. If client wants to go after incentives they are willing to provide the information requested. Cost info is easy when it's their own invoice (engineering + install). When another company is doing the install then the client has to provide this documentation, which they will do if they are going after the incentives.

3. **Do you have anyone on staff whose job responsibilities include coordinating with energy efficiency programs?**
    - Response 1: Their company regularly works with utilities as part of trade ally networks and is actively working to expand their utility relationships.
    - Response 2: Their engineers do the program paperwork, and electrical/mechanical teams fill out ComEd paperwork regularly.
    - Response 3: They have 3-4 ComEd liaisons, gets all the latest & greatest info and bring it back to the rest of the team. They also have a bunch of other engineers who have done the ComEd forms for their projects.
    - Response 4: One person serves as the utility program paperwork clearinghouse. They have a couple of other PMs on new construction that do the paperwork for their own projects. In general the PMs take care of their own applications, but he plays a central role in tying it all together.

4. **How important is it for an energy efficiency program to provide support to companies like yours on processing program paperwork, performing energy savings calculations, and other requirements?**
    - Response 1: Most important thing is for the utility to support comarketing efforts.
    - Response 2: Very important to cut through bureaucracy, get fast responses. Need to know what incentives are up front before the customer decision.
    - Response 3: A service provider-driven program has to be exponentially simpler. He understands the need for program rules and requirements, but the current ComEd program approach is not workable. Too complex.
    - Response 4: Very important, they get questions from clients, they count on ComEd team to guide them through the process.

Appendix B: Energy Savings Assumptions

#	Measure	Savings assumptions	kWh/unit	Unit	Units/SEDC	kWh/SEDC
1	UPS utilization	kWh/yr = UPSload *((η1 – η 0)/ η 1 η 0) * 8760 hr/yr where UPSload 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	5,183	UPS	1	5,183
2	Server consolidation	2,891 kWh/yr per 330 W server	2,891	Server	1	2,891
3	ENERGY STAR server	Savings/server from DOE guidance on Purchasing Energy-Efficient Enterprise Servers (FEMP): https://www.energy.gov/eere/femp/purchasing-energy-efficient-enterprise-servers	412	Server	3	1,236
4	ENERGY STAR UPS	Savings/UPS from DOE guidance on Purchasing Energy-Efficient Uninterruptible Power Supplies (FEMP): https://www.energy.gov/eere/femp/covered-product-category-uninterruptible-power-supplies	70	UPS	1	70
5	ENERGY STAR data storage	Savings/storage from DOE guidance on Purchasing Energy-Efficient Data Center Storage (FEMP): https://www.energy.gov/eere/femp/purchasing-energy-efficient-data-center-storage	270	Data storage unit	1	270
6	HDD storage reduction/removal	kWh/yr = ((# of HDDs * 9)/1000 * 8760 hr/yr where # of HDDs are the number of hard disk drives taken off line	79	HDD	4	315
7	SDD storage reduction/removal	kWh/yr = (# of SSDs * 6))/1000 * 8760 hr/yr where # of SSDs are the number of solid state drives taken off line	53	SSD	4	210
8	Air flow management	An estimated 3% cooling energy savings accompanies airflow adjustments	2,252	Server room	1	2,252
9	Raise temperature set point	An estimated 3% cooling energy savings accompanies each 1°F increase in the set point.	2,252	Server room	1	2,252
10	High efficiency cooling equipment	kWh/yr = (FLH * cap * (1/Effbase - 1/Effee))/1000 where FLH is the full load hours of data center air conditioning Cap is capacity of of cooling in Btu/hr Effbase is baseline EER Effee is energy efficiency EER	2,022	Server room	1	2,022