January 14, 2016

REPORT #E16-295

Embedded Data Centers

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Acknowledgements

The CLEAResult team would like to thank the Northwest Energy Efficiency Alliance (NEEA) for sponsoring this work and for its ongoing support of the Data Center Research Partnership.

The team would like to thank the following Data Center Research Partnership member organizations and extended partners for their continued insights and contributions:

- Priscilla Johnson, Pacific Gas and Electric (PG&E)
- Dale Sartor, Lawrence Berkeley National Laboratory (LBNL)
- Bill Tschudi, Lawrence Berkeley National Laboratory (LBNL)
- Mary Madeiros McEnroe, Silicon Valley Power
- Josh Wallace, City of Palo Alto
- Mark Bramfitt – Bramfitt Consulting
- Mike Barr, QDI Strategies
- Chris Harty, QDI Strategies

The team also thanks the many property managers and owners, facility engineers, data center managers, information technology (IT) managers, contractors, and data center product vendors and distributors who agreed to be interviewed for this effort and who participated in the data center workshops.

Table of Contents

Executive Summary

This report summarizes 2014-2015 research activities conducted by the Northwest Energy Efficiency Alliance (NEEA) related to embedded data centers, and by extension includes an overview of findings by other Data Center Research Partnership members.

The data center market continues to evolve at a rapid rate. Embedded data spaces are consolidating as rack density increases and information technology (IT) performance increases. Physical data center footprints are shrinking and growing business demands are putting more pressure on data center managers to deliver more, with fewer resources. At the same time, decision-making related to energy efficiency is complex; decisions occur at the speed of business requirements, the level of sophistication in the market varies dramatically, and the subject matter is highly technical. The findings from this research suggest that the following three market interventions have the highest success potential related to energy efficiency in embedded data centers:

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

Other avenues for market interventions include aligning with existing initiatives, such as NEEA's commercial sector efforts.

This report describes the market research conducted, the findings, and their implications for market interventions; outlines the potential market interventions for consideration; and recommends next steps.

1. Introduction

This report provides an overview of the Northwest Energy Efficiency Alliance's (NEEA's) market research activities related to embedded data centers: server closets, server rooms, and localized data centers colocated in commercial, institutional, and industrial facilities.

1.1. Background

This market segment lags in its adoption of energy efficiency measures due to several identified market barriers, including the presence of split incentives between facility and data center decision-makers and an extreme focus on data center uptime and performance. Recent research conducted by the Northwest Power and Conservation Council (NPCC) estimates that data center measures will yield over 260 aMW of savings potential in the Pacific Northwest by 2035 (NPCC 2015).

In 2013, NEEA initiated development of a Data Center Research Partnership intended to better characterize the market and to identify intervention options for increasing the adoption of energy efficiency measures in this hard-to-reach market. As an organization focused on market transformation, NEEA was interested in taking an innovative approach to confirm market barriers and to identify key market leverage points with specific market actors that could lead to a market transformation initiative.

The Data Center Research Partnership includes members and partners from NEEA, Pacific Gas and Electric (PG&E), Silicon Valley Power, the City of Palo Alto, and Lawrence Berkeley National Laboratory (LBNL). The Partnership has sought to tap industry experts, leverage existing market studies, and conduct new research to further explore market transformation opportunities for embedded data centers.

1.2. Objectives

NEEA developed several guiding principles for the Partnership:

- Better characterize "embedded" data centers
- Identify energy efficiency market intervention strategies
- Take a holistic view of these data centers as part of the building, not simply as a standalone use

With regard to the third principle above, the Partnership efforts sought to develop the following:

1) A series of market interventions or utility program solutions that had potential to transform or promote energy efficiency within this market segment
2) A standardized data collection method that supports local, regional, and national field demonstrations for embedded data centers, in order to better understand the physical infrastructure and energy savings potential of these facilities – their heating, ventilation, and air-conditioning (HVAC), information technology (IT) equipment, and power systems

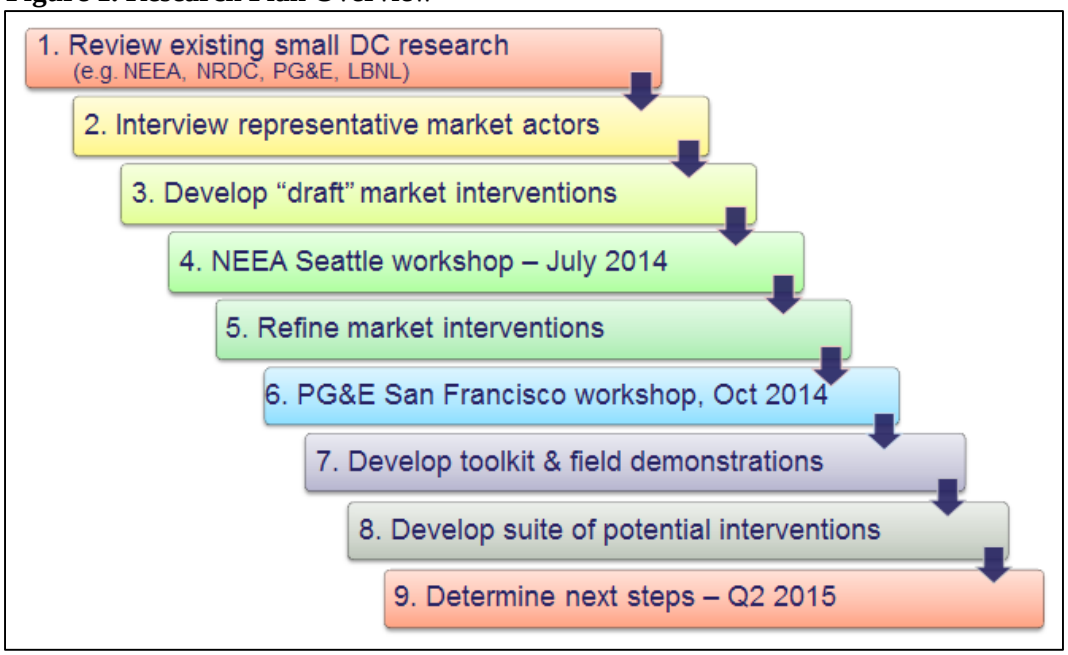
The following list summarizes the Data Center Research Partnership contributions:

- NEEA funded initial planning efforts and led a research plan that enabled the Partnership team to quickly execute research and build off research findings in succession. NEEA funded the Pacific Northwest workshop and the preceding interviews with market actors in preparation for the workshop.
- PG&E funded the Silicon Valley workshop and development of an embedded data center "field demonstration toolkit" that consisted of a targeted audit form and a service providers' checklist.
- Silicon Valley Power funded the execution of a small-scale pilot designed to leverage the field demonstration toolkit.
- LBNL provided subject matter expertise, as well as review of the field demonstration toolkit.
- The City of Palo Alto contributed subject matter expertise.

2. Methodology

Figure 1 shows the high-level research activities covered in the research plan for the Partnership.

Figure 1. Research Plan Overview



The following subsections describe Steps 1 through 7 in the figure above (Section 4 details Step 8; Section 5 addresses Step 9).

2.1. Review Existing Small Data Center Research

By design, the 2014-2015 Partnership effort sought to complement rather than to duplicate existing research related to embedded data centers. The initial research consisted of reviewing the following key documents for common market barriers and lessons learned:

- Lawrence Berkeley National Lab (LBNL), April 2013, Final Project Report: Energy Efficiency in Small Server Rooms (LBNL 2013)
- Natural Resources Defense Council (NRDC), February 2012, Small Server Rooms, Big Energy Savings Opportunities and Barriers to Energy Efficiency on the Small Server Room Market (NRDC 2012)
- LBNL and NRDC, October 2012, Improving Energy Efficiency for Server Rooms and Closets – Top 14 Measures to Save Energy in Your Server Room or Closet (Fact Sheet) (LBNL 2012)
- Cadmus Group, Inc. report to PG&E (with contributions from Mark Bramfitt and PECI), December 2013, PG&E Small Data Center Market Study (Cadmus 2013)
- Portland Energy Conservation, Inc. (PECI) report to NEEA, 2013, Integrated Data Centers Opportunity Assessment – Final Report (PECI 2013)

2.2. Interview Market Actors

Following a review of existing research related to embedded data centers, CLEAResult conducted a targeted set of interviews to quickly inform and verify the Partnership's assumptions regarding key challenges, decision-making, and key business drivers related to energy efficiency in data centers. CLEAResult then completed twelve formal interviews of market actors between April and June 2014 to obtain market insights and help inform market intervention development. These interviews included building owners/property managers, data center managers (end users), and tenants in the Pacific Northwest.

2.3. Develop Draft Market Interventions

Using results from the market actor interviews as the basis, NEEA developed a suite of nine draft market intervention strategies for use during the stakeholder workshop that focused on the following:

- Establishment of market connectivity
- Fostering long-term establishment of industry best practices and continuous energy improvement
- Facilitation of information-sharing
- Driving ongoing innovation

The intervention strategies included an outline of a set of delivery channels that provide definition around successfully launching, marketing, and delivering market interventions to end users and other key market actors.

NEEA intended this initial set of market intervention strategies to cast the net broadly while focusing on the intersection of commercial real estate and embedded data center environments. In addition to market transformation concepts, the market intervention set reflected traditional utility market intervention strategies such as measures and incentives; these types of programs may serve as enhancements to implementation strategies and tactics, and help to increase and/or accelerate market uptake of energy efficiency.

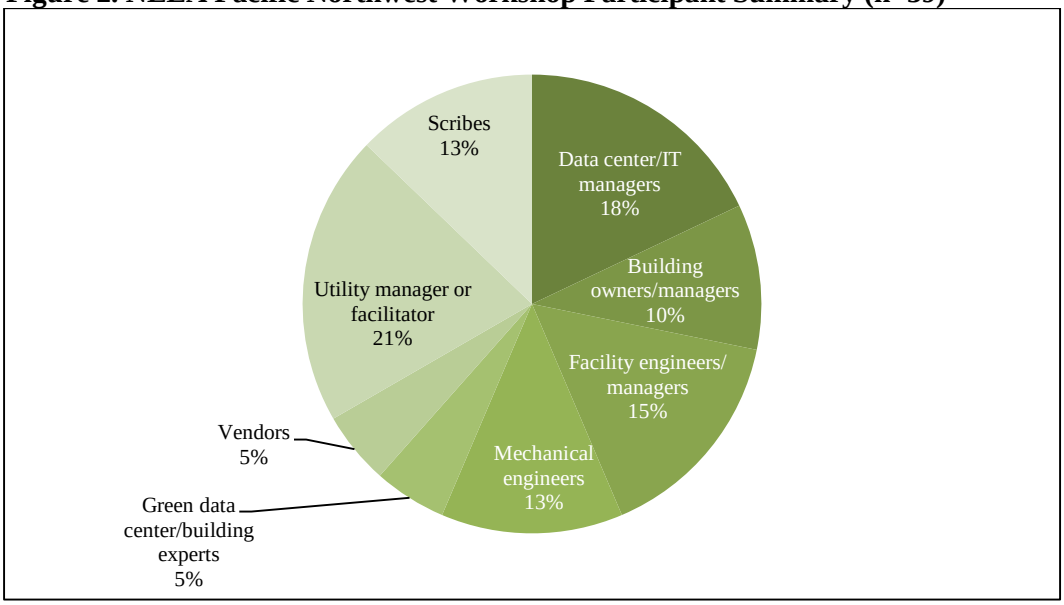
2.4. NEEA Pacific Northwest Market Actor Collaborative Workshop

The Pacific Northwest Market Actor Collaborative Workshop (workshop) took place in July 2014 in Seattle, WA, and had two objectives:

- Build on the previously-documented barriers to energy efficiency decisions in order to gain a deeper understanding of the interactions among the "ecosystems" of market actors: data center managers, information technology (IT) managers, chief financial officers (CFOs), the owners and managers of commercial real estate, and IT and HVAC vendors, distributors, and resellers.
- Use the initial intervention list to build, customize, and prioritize at least two to four market intervention concepts that participants felt had the highest potential to increase energy efficiency in embedded data centers.

The workshop was an invitation-only working session, and brought together Partnership members, utility representatives, data center managers, IT managers, IT distributors and resellers, building/facilities managers, building owners, original equipment manufacturers (OEMs), and HVAC vendors. Thirty-nine individuals participated in the workshop. Representatives from the Partnership, specifically NEEA and PG&E, both facilitated and helped document findings from the workshop.

Figure 2. NEEA Pacific Northwest Workshop Participant Summary (n=39)



Key findings from the workshop included the following:

- Information and tools are necessary to move the market
- Market actors need a trustworthy source of information
- Standard assessments support planning, predictability, and new business opportunities

Secondary findings included the following:

- Metrics and tools are of high value to business executives
- Opportunities exist to help data center managers better deliver on their missions and plans for expansion
- For sustained change, the business case for efficiency must be made from inside the organization

2.5. Refine Market Interventions

Following the Pacific Northwest workshop, PG&E led the Partnership to focus on how it could operationalize the new set of market interventions to function as part of a utility-oriented program mechanism. PG&E refined the market interventions and CLEAResult created a full framework for potentially delivering and operationalizing each market intervention, including specifications around funding, maintenance, technical requirements, and other factors necessary

for success. PG&E circulated summaries of these documents to workshop participants prior to the workshop in order to set the stage for the workshop's brainstorming session.

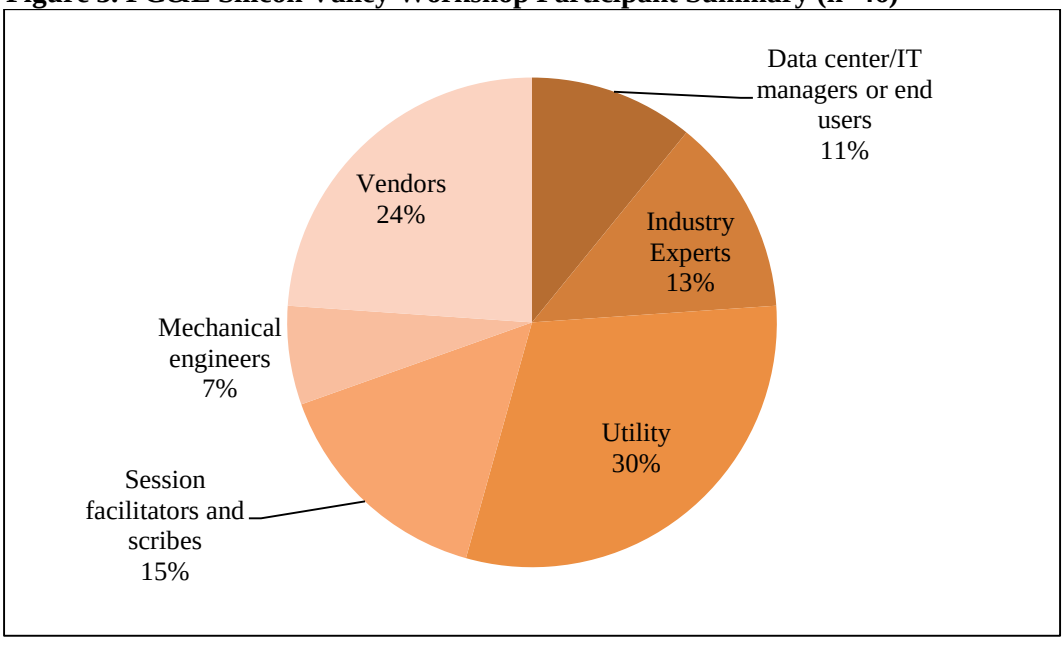
2.6. PG&E Silicon Valley Market Actor Collaborative Workshop

The PG&E-funded Silicon Valley Workshop took place in October 2014 with the following two primary objectives:

- Outline operational plans for four energy efficiency market interventions, including how interventions would be delivered, the organization structure required for success, and the funding model
- Identify the trends and impacts of data center applications moving to the cloud, including who is using the cloud, applications that are hosted in the cloud, and the fate of legacy data center hardware and applications post-migration to the cloud

Like the Seattle workshop, this workshop was an invitation-only working session. In contrast to the Seattle workshop, the Silicon Valley workshop focused more extensively on data center managers, IT distributors and resellers, equipment manufacturers, and utility representatives. Forty-six individuals participated in the workshop. Representatives from the Partnership, specifically NEEA, PG&E, LBNL, Silicon Valley Power, and City of Palo Alto, facilitated and helped document findings from the workshop.

Figure 3. PG&E Silicon Valley Workshop Participant Summary (n=46)



Key findings from the workshop included the following:

- The website clearinghouse intervention requires a vendor-neutral framework and must leverage existing industry organizations
- Prescriptive measures are attractive and would enable trade ally and vendor channel delivery of programs
- Embedded data center application movement to the cloud depends on workload being done and core business applications

Secondary findings included the following:

- An energy service company (ESCO) model for data centers is premised on a utility-approved audit methodology and program design
- Strategic energy champion services are not scalable with smaller data centers

2.7. Audit Tools and Field Demonstrations

Following the workshops, PG&E, with support from LBNL, pivoted to a set of two programmatic directions:

- A targeted Excel-based audit form that could be used during audits of embedded data centers, and that could be used to vet savings potential for a range of data center measures
- Pursuit of data center "field demonstrations" focused on understanding the utilization of servers and on uncovering the potential for server consolidation, server removal, and installation of server virtualization software

As part of this work, CLEAResult, with review and input from LBNL, developed an Excel-based audit form for modular use as part of on-site data center assessments, that asked specific questions related to a range of custom and potential deemed measures. These measures include efficient servers, virtualization, efficient uninterruptible power supplies (UPS), efficient networks, and storage consolidation. CLEAResult also gathered feedback from existing utility programs in the field currently focused on embedded data centers, and incorporated those lessons learned into the form. It completed these audit tools in early 2015. Field demonstrations are underway with Silicon Valley Power and should yield additional results by the end of 2015.

This report provides a final summary of the suite of potential interventions and recommendations for next steps.

3. Research Findings

The following findings summarize and synthesize the body of research findings of the Data Center Research Partnership, including the early interviews with market actors, the two market actor collaborative workshops, and the audit tool and field demonstration activities. Sections 3.1 and 3.2 provide overviews of market barriers and market potential. Sections 3.3 through 3.6 describe findings in four broad categories:

1. Consistent and trusted information about energy efficiency in embedded data centers is important
2. Engagement of data center and facility end users requires multiple outreach channels
3. Embedded data center energy efficiency projects can be complex
4. Engagement of vendors is essential

Each category provides a description of the finding and its impact on potential market intervention. Research findings of the interviews and workshops, and subsequent discussions regarding tools, programs, and field demonstrations are consistent with work previously conducted by NEEA, PG&E, and others.

3.1. Market Barriers

Figure 4 summarizes the top five overarching market barriers that hamper adoption of energy efficiency in embedded data centers. Results reflect and confirm learnings from existing literature about how smaller data centers are managed and their key priorities. Although the Partnership research provides no significant breakthroughs compared to prior research, the market barriers deserve restating.

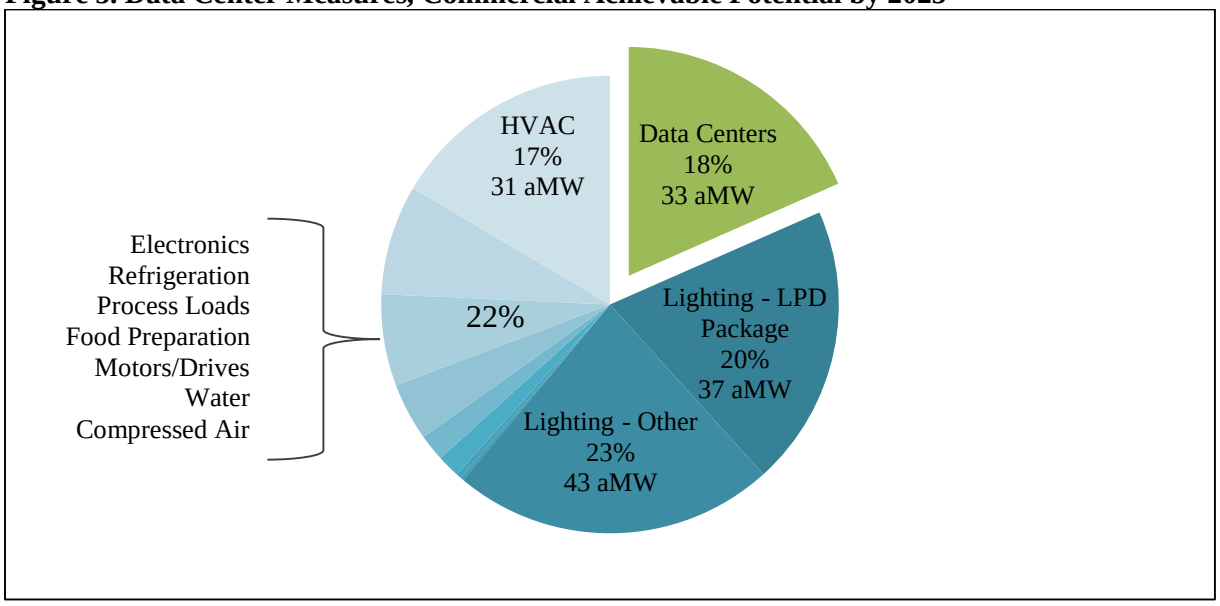
Figure 4. Market Barriers

Barrier	Description
Split incentive	The data center budget generally does not include the HVAC or power costs, so data center managers do not receive a direct return on their investments in energy efficiency. Decision-making is a multi-layered and complex process.
Focus on uptime and performance	The data center is measured on reliability, security, performance, capacity, and equipment costs. Taking time to explore software, hardware, or HVAC options to reduce energy use is an expense with no measured benefit to IT. The link between energy efficiency and non-energy benefits is not well articulated.
Timing	The utility must intervene at the right time in the purchase or design cycle. The purchase cycle is often too fast to facilitate pre- and post- measurement or to enable documentation of original and revised plans.
No vendor incentive	Vendors play a key role in recommending solutions; however, intervening with a more energy efficient option or introducing utility incentives can slow down or stall a sales process.
No standard metrics for energy efficiency	Data center equipment and cooling needs are not segregated and monitored separately from the larger facility, which complicates the tracking of energy use. The data center manager does not have a clear line of sight to holistic data center optimization opportunities, and the facility management lacks visibility into data center energy use.

3.2. Market Potential

New Pacific Northwest market potential data further supports the assumption that the savings potential in embedded data centers is relatively large. The Northwest Power and Conservation Council's (NPPC's) estimates of achievable savings potential in the region show that NPPC expects a significant amount of future savings potential to come from embedded data centers (NPPC 2015). Per this new data (summarized in Figure 5), data center measures will be a source of an estimated 185 aMW of achievable potential by 2025 and 261 aMW by 2035, second only to lighting in achievable potential.

Figure 5. Data Center Measures, Commercial Achievable Potential by 2025



Note: Source: Pacific Northwest Total Achievable Potential, Commercial Measures, NPCC, March 2015

3.3. Consistent and Trusted Information is Important

Findings suggest that the embedded data center market faces challenges from a lack of consistent and trusted information:

- Lack of information and metrics. No common vocabulary or set of tools and metrics exists to facilitate understanding of data center energy consumption, efficiency benefits on the bottom line, and non-energy benefits. The use of Power Usage Effectiveness (PUE) as a metric does not readily apply to embedded data centers, as it can be difficult and time-consuming to calculate.
- Risk aversion and trust. End users are typically reluctant to take risks or to adopt new solutions; program implementers or vendors may need to make significant time investments to help overcome these concerns and earn the trust of data center operators.

Market intervention impact: Market interventions must reach the market from a place of trust and authority. In a manner similar to how PUE has become widely accepted as a metric of data center infrastructure efficiency (and generally used for larger data centers), many opportunities are available to issue new standards, metrics, and publications that promote efficiency and relate non-energy benefits to the range of data center stakeholders.

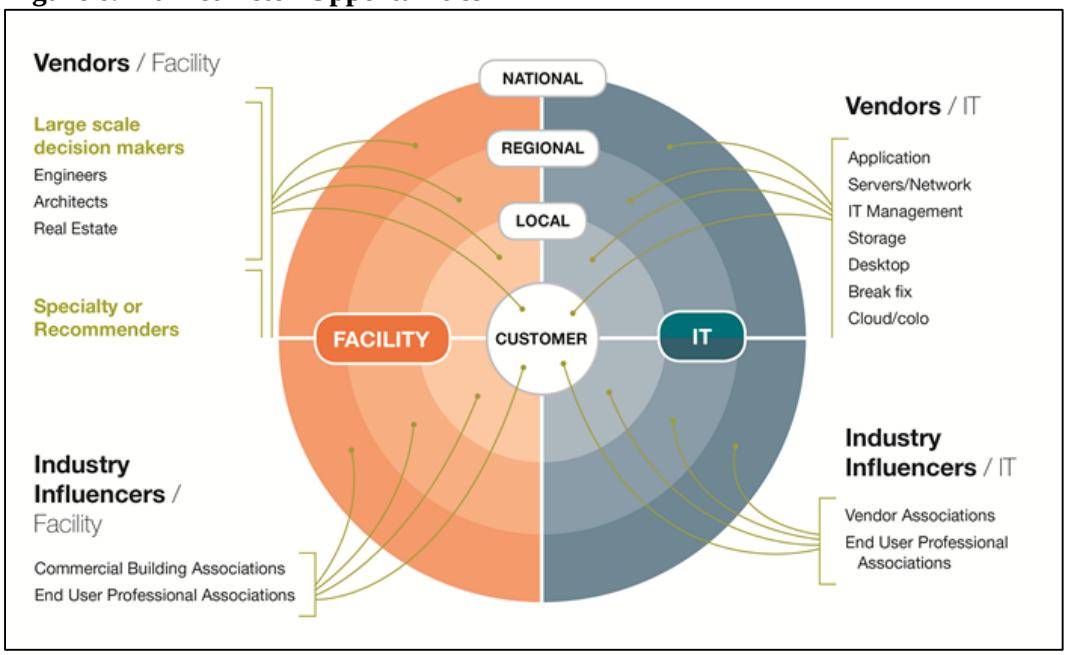
3.4. End User Engagement Requires Multiple Outreach Channels

In general, IT or data center managers or operators (end users) – as well as facility managers who operate buildings that house embedded data centers – can be difficult to reach with the message of energy efficiency, summarized in the following:

- Market actor variability. Market actors engaged with embedded centers vary widely in sophistication, attitudes, and needs. Reaching all of them with the same types of marketing and outreach strategies and tactics is difficult.
- Dispersed decision-making. Multiple layers of decision-making are necessary to affect data center efficiency, and often decision-makers do not share objectives. For effective change, the executive level of an organization must make the business case, often within both facility and IT departments.
- Program recruitment. The embedded data center market is slow to uptake utility programs. Program administrators face the challenge of identifying the embedded data center key contact and decision-maker, which is typically not the name on the customer utility bill. Often the building owner cannot control or meter tenant data center energy use.
- Timing. Reaching key decision makers at the right time is critical for success. For example, optimal intervention points include when the data center faces capacity or cooling challenges, or when the building owner is handling new construction or tenant-improvement commercial real estate transactions.

Market intervention impact: Two key market intervention implications exist for engaging end users and market actors. First, opportunity exists to fill the gap in “speaking the language” of different types of market actors; for example, executives require different information than data center operators. Furthermore, as with their physical infrastructure, no two data centers are alike; this may necessitate a customized approach to reaching them.

Figure 6. Market Actor Opportunities



In addition, market transformation programs aside, utilities have traditionally approached embedded data centers with the same treatment as a conventional custom utility program: with a focus on high-touch outreach tactics via key account managers and dedicated outreach staff, implementation of comprehensive audits, and recommendation of comprehensive project packages. Unfortunately, the savings potential of embedded data centers is relatively low at a site-specific level, and as such, can result in low overall program cost-effectiveness. Unless market mechanisms, marketing strategies, or measures are present that can reach the market at volume, these programs are unlikely to be cost-effective in the long-term. Alternatively, with appropriate and focused measures, data center measures could be properly integrated into existing commercial and industrial (C&I) program portfolios – however, data center measures are highly specialized and may require dedicated outreach and/or engineering staff to address.

3.5. Embedded Data Center Energy Efficiency Projects are Complex

Findings suggest that, to a degree greater than that predicted prior to the start of research, reaching the embedded data center market faces severe challenges due to the technical aspects of energy efficiency:

- Cloud impacts and technical change are variable. Data center equipment and operations are characterized by rapid and continuous change. Data centers are consolidating, scaling down, and moving some applications to the cloud, but they are keeping core applications on-site. A core business need drives every data center's operations, and that results in highly variable infrastructure from site to site.
- Energy efficiency measures are complex. The technical issues related to development of energy efficiency measures and associated savings calculations are highly complex, and projects currently require a heavily customized, often labor-intensive engineering approach. Even questions around server utilization get complex quickly, and require a

deeper and more time-intensive assessment of potential software solutions to validate audit results and savings.

- Comprehensive projects. Embedded data center customers are often unable to implement a comprehensive package of energy efficiency measures, whether due to budget constraints or to a lack of technical feasibility. They must often choose smaller-scale projects with constrained paybacks and lower physical complexity.

Market intervention impact: A more prescriptive, deemed, or quick-calculated approach to embedded data center efficiency is clearly necessary to move the market. Additional research will be necessary to drive measure development for a range of data center measures applicable to this market. Furthermore, given the lack of feasibility or appetite for comprehensive projects, market interventions must allow for focused and targeted approaches to energy efficiency.

3.6. Vendor Engagement is Essential

Engagement of vendors is widely seen as a critical program component. However:

- Vendor engagement. The vendor community has been under-utilized in bringing the energy efficiency program message to customers, in part because this community to-date has focused largely on enterprise-class data centers, and in part, because the conventional utility program incentive structure can be unpredictable, time-consuming, and confusing. Data center end users perceive that vendors introduce bias into the equipment selection and service process, and such bias can overpower decisions related to energy efficiency. Such bias can lead to consumer distrust of product vendors.

Market intervention impact: Standardized and simplified program mechanisms are essential to making utility programs and market transformation work. This requires standard tools, standard audits, and the predictable incentives that typically accompany prescriptive or deemed approaches. Vendors must be engaged in a way that helps end users make more holistic decisions that go beyond a single brand or product.

4. Market Intervention Options Surfaced

Four market intervention concepts emerged from the Data Center Research Partnership findings that address key market barriers and themes as described earlier. Note that the unique market intervention options vary in their focus on market transformation, as well as on estimated impact, cost, savings potential, and utility requirements.

4.1. Status Quo

4.1.1. Definition

Recognizing the role that current utility program interventions have played in furthering embedded data energy efficiency, and the role they have to play in the future, is important. While they do not have a strong market transformation focus, these focused interventions, such as individual utility programs and measures, do accelerate uptake of energy efficient strategies to reduce data center energy use in the region.

Data-center-specific programs, pilots, and/or components are currently underway at a number of utilities in the Pacific Northwest and across the country. These programs, many still in their first few years of operations, had their genesis in response to the growing recognition of the significant amount of energy that data centers consume.

Some utilities, however, are unsure how to best move the embedded data center market. In some cases, they estimate the in-territory data center load to be relatively low and not a high priority as a standalone program effort. In other cases, utilities remain daunted by the challenge of reaching this market from a technical requirement or cost-effective standpoint. Still others project that embedded data center efficiency will follow the trend of the largest standalone data centers, and that these customers will invest in energy efficiency on their own without a utility intervention.

4.1.2. Challenges

The lessons learned from implementers of data center programs are similar and point to three key thematic challenges that can lead to risk related to utility program success and overall cost-effectiveness:

- Small, embedded data centers remain a hard-to-reach market segment. They require different and necessarily more streamlined marketing, outreach, and technical approaches than those of larger data centers.
- Long sales and implementation cycles. Similar to large data centers, the sales process from initial outreach to identification of potential measures can take upwards of four to six months, while the measure implementation cycle can range from a few months to upwards of a year. These lengthy projects can have unintended consequences on the marketing and outreach cycle: the majority of customers are contacted early in the program cycle in order to initiate projects as quickly as possible, which can be contrary to more desirable and continuous customer outreach efforts.
- Existing programs currently rely heavily on custom measures. The lack of prescriptive or quick-calculated measures impedes project cycles and the ability to engage targeted vendors to support those measures.

4.1.3. Opportunity and Requirements

In order for future program efforts to successfully reach embedded data centers, utilities need to revisit effective program designs and draw lessons learned from other successful market transformation initiatives and interventions in the field.

- Trade ally engagement. Opportunity remains for developing a regional trade ally network designed to engage data centers of all sizes and across utility service territory lines. A coordinated trade ally approach is one potential next step in the evolution of existing data center programs. For example, a trade ally network in the vein of the Northwest Lighting Network would help to break down key market barriers and bring additional strategic resources to enable market transformation. This type of effort would require collaboration and coordination across a range of funding stakeholders.
- Intersection with commercial programs. Data center measures and specific data center engineering expertise tend to serve as gaps in general commercial programs. Untapped opportunities exist to nest these elements within existing programs in order to bring comprehensive offerings to customers. However, such an approach requires the introduction of new expertise into commercial programs, as well as quick-calculated or prescriptive measures to keep the process streamlined and cost-effective.

4.2. Prescriptive Measures

4.2.1. Definition

On their own, prescriptive measures do not provide a market transformation lever, but they can increase uptake of energy efficiency in the market through their streamlined approach. The literature most frequently references the following five potential prescriptive measures as most relevant to speed uptake of energy efficiency in embedded data centers:

- Efficient servers
- Server virtualization
- Efficient UPS
- Efficient storage
- Efficient network equipment

Other technologies, such as those related to airflow and temperature management, data center infrastructure management (DCIM) software, efficient storage, and efficient network equipment, tend to be more complex measures and difficult to quantify on a site-by-site basis. Given these qualities, they tend be relatively poor candidates for a prescriptive approach.

4.2.2. Challenges

Developing values and obtaining proper approvals for prescriptive measures can require a significant time investment and effort. Given the rapid shifts in data center technologies and the flow of innovation from the largest data centers, utility programs experience risk related to such issues as free ridership and incremental cost, as well as challenges related to upkeep of those deemed values.

4.2.3. Opportunity and Requirements

The availability of prescriptive measures affords several different intervention design scenarios, ranging from effective trade ally network development focused on specific technologies, to upstream incentives for specific technologies or solutions. Prescriptive measures make it easy for customers to participate in programs, and are the stronghold for cost-effective programs and market transformation initiatives.

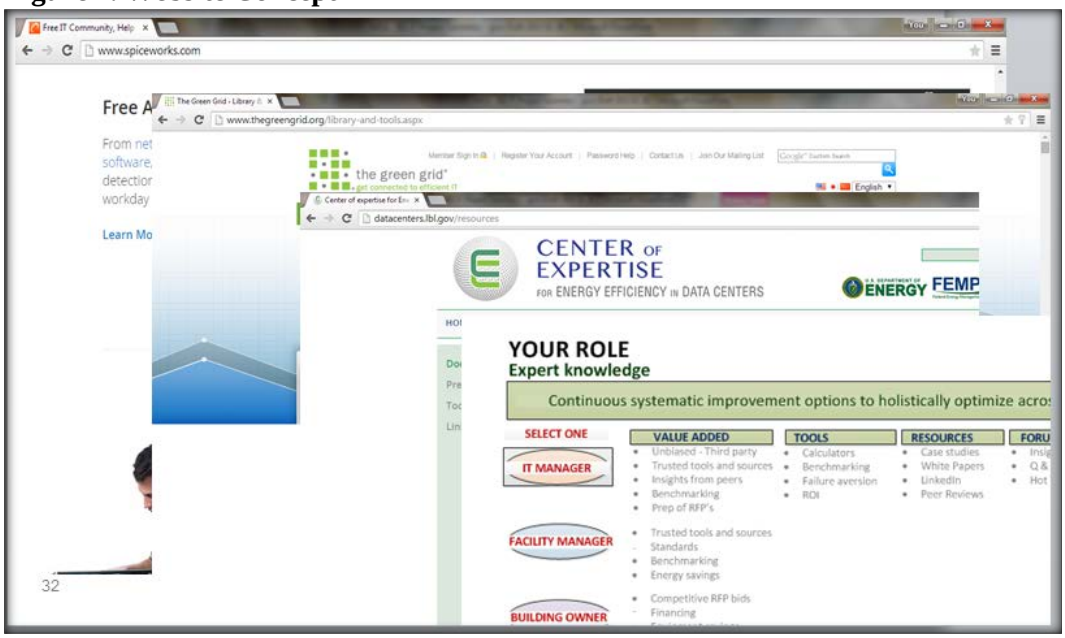
The fast-paced nature of the IT market may necessitate annual value refreshes for data center prescriptive measures. The market also needs additional deliberations to move the conversation around potential prescriptive measures forward. Additional needs include convening regional leaders, developing a multi-year roadmap, and engaging the proper technical forums and committees to move this technical topic forward effectively.

4.3. Website Clearinghouse

4.3.1. Description

Designed to help overcome several key market barriers with its focus on bringing relevant resources, metrics, and other information to market actors, a website clearinghouse is a targeted intervention that could support market transformation. A comprehensive website "clearinghouse" would serve as an impartial source of information on embedded data center technologies, equipment, best practices, vendors and service providers, trade allies, available utility financial incentives, reviews, blogs, original articles, and more. Figure 7 illustrates a rough concept for the website.

Figure 7. Website Concept



In short, the concept would be similar to a combination of Wikipedia (information) with a TaskRabbit™ or eBay (commerce) feature. User logins would constitute a core feature, in order to customize and enhance the user experience. In a more advanced version of the website, users could input specific information about their data center in order to calculate their PUE, compare their performance to similar data centers, and identify potential data center equipment or improvements.

A successful website clearinghouse would likely require collaborative governance and well-respected national and industry partners, such as The Green Grid, Lawrence Berkeley National Laboratory, Natural Resources Defense Council, or others.

4.3.2. Challenges

As described elsewhere, the data center industry is moving fast, and other websites already accomplish portions of the proposed intervention. A website such as that envisioned above would be relatively expensive and would require a high level of collaboration and coordination with a range of private and public stakeholders and partners. It may also require a national approach; thus aligning funding may be complicated. Furthermore, an effective website also has several other dependencies; for example, it is premised on utilities offering a suite of incentives for data center energy efficiency projects, or upstream or prescriptive measures. On the whole, high uncertainty and risk exist regarding the finances of the start-up and ongoing maintenance of such a website.

4.3.3. Opportunity and Requirements

An unbiased, holistic, trusted, and comprehensive website has the potential to achieve significant market impact. The value proposition to data center end users is its function as an unbiased, trusted one-stop shop for learning more about how to optimize their data center or how to solve their pressing data center operational challenges.

As a dynamic web-based presence, the website clearinghouse could serve as a platform for a series of other initiatives, such as a new data center benchmarking and reporting tool, or a venue to promote or share information related to upstream and prescriptive incentives. It could also serve as part of trade ally network establishment and ongoing engagement.

The requirements for a successful website clearinghouse are many. Most important is that a champion and keystone funding organization is required for early development, which is likely to be an intensive and time-consuming period. The governance and long-term funding mechanisms also require clear definitions upfront to establish a clear path for design and ownership. To remain relevant in the market, the website must remain dynamic, with well-structured marketing and awareness campaigns rolled out on an ongoing basis.

4.4. Colocation or Cloud Approach

4.4.1. Definition

This market intervention incentivizes an embedded data center manager to move his or her data center into a colocation and/or cloud environment. Energy savings result from the colocation or cloud facility being verifiably more efficient than the embedded data center. The utility may award the specific financial incentive to either the colocation facility, or end user, or both. On its

own, moving a server room or closet to a colocation facility does not necessarily provide a market transformation focus, but other elements of a colocation or cloud approach may. For example, additional elements may include a certification or PUE-validation program that results in deepening the pool of energy efficient colocation providers.

4.4.1. Challenges

Embedded data centers are increasingly consolidating their footprints, scaling down on-site operations, and moving ancillary applications to the cloud while keeping core applications on-site (e.g., human resources, intellectual property, and specific types of data analysis). A growing trend exists toward moving out of the embedded center, but this by no means implies business as usual, and many barriers still stand in the way of smaller businesses moving operations off-site. Highly targeted marketing and outreach are necessary to build the business case for businesses to move out of their existing data centers, and the likely amount of uptake in any given region is uncertain. Customer security and confidentiality requirements and regulations such as those associated with healthcare or financial organizations may also create barriers to adoption. Risk and uncertainty remains around the rate of movement from server rooms and closets, and around whether a certification program could gain a sufficient foothold to help promote the effort.

4.4.1. Opportunity and Requirements

Colocation and cloud facilities, also known as colos, rent retail data center space, bandwidth, and consulting services to business customers. Typically more energy efficient than embedded data centers, colos are increasingly considered a viable solution to reducing energy use in embedded data centers. In cloud facilities, data centers move their applications from servers on-site to “cloud”-based applications.

For IT managers, moving IT equipment into a colocation facility and shutting down the on-site data center can provide an attractive business case in comparison to maintaining and/or expanding an on-site data center. Colocation facilities offer flexibility and the ability to scale IT operations economically, and they offer increased redundancy and reliability. In short, IT departments can outsource the day-to-day cooling with their use of a colocation provider and receive a suite of energy and non-energy benefits in return.

Further vetting will be necessary to assess the opportunity to facilitate embedded data center movement to cloud and/or colocation providers – as well as any potential unintended consequences of doing so. For example, if a regional approach is desirable, [stakeholders] must place attention on how load shifts across utility territories. Similarly, power purchase agreements between utilities or independent service operators may necessitate review. If implemented within individual utility territories, other potential consequences, such as increasing data center new construction activities that may increase load within the territory, also merit consideration. Lastly, researchers must also conduct additional technical analysis related to how to effectively calculate baseline and proposed conditions for purposes of quantifying energy savings. Additionally, properly configured facilities and ongoing performance must be completed and certified.

4.5. Market Intervention Summary

Each market intervention offers a solution to a different number of market barriers. The "Status Quo" option encourages utilities to address the embedded data center market segment using an optimal strategy for its unique situation, but the research team recommends that this intervention undergo a redesign to more effectively engage trade allies and to leverage existing commercial programs. The team sees additional vetting of the "Prescriptive Measures" intervention as essential to pursuing other market interventions at relatively low cost, whereas the "Website Clearinghouse" intervention could yield high savings – but at a high cost. Finally, the "Colocation/Cloud" intervention provides an elegant solution to moving IT load from inefficient small data centers into larger, more efficient data centers, but it would require a highly coordinated effort and dedicated start-up funding.

Success in embedded data centers, as with many other target markets before it, is likely to occur when solutions are simple and they intersect the market:

- Solutions must be easy to understand and easy to access; interventions must include campaigns that broadly reach the market.
- Solutions must leverage a data center's trusted advisors, equipment sales representatives, and service contractors, and reflect the most current industry knowledge.
- Solutions must be available when the data center customer is ready to invest and upgrade for reasons that go beyond energy efficiency: at the time of construction of a new data center, when the data center is expanding, when budget is available, or when the data center has an uptime or performance challenge to overcome.

Table 1 below provides a summary of the market intervention recommendations and a general scoping of their focus on market transformation, impact, cost, savings potential, and risk.

Table 1. Market Intervention Recommendations for Embedded Data Centers

Intervention Opportunity	Market Transformation Focus?	Local or Regional Impact	Total Cost	Regional Potential	Utility Risk
Status Quo • Trade ally networks • Commercial program integration	No	Local and/or regional	$-$$	**	Medium
Prescriptive Measures • Efficient servers • Server virtualization • Efficient UPS	No	Regional	$	**	Medium
Website Clearinghouse • Efficient UPS	Yes	Regional	$$$$	****	High
Colocation/Cloud Approach • Incentives • Colocation certifications	Partial	Coordinated Regional	$$	***	Low

4.6. Other Market Intersections and Leverage Points

While not a focus of the Data Center Research Partnership, NEEA's existing commercial real estate initiatives such as the Existing Building Renewal Initiative may provide critical market segment intersections and leverage points that could complement promotion of energy efficiency in embedded data centers. These include commercial real estate tools, metering, and other complementary energy efficiency technologies such as facility HVAC equipment and PC power management. The commercial real estate market and data center market share some key characteristics, including the presence of split incentives, lack of metering or submetering, and a focus on timing to ensure that the intervention can take advantage of the purchase, design, or budget cycle.

5. Conclusions and Recommendations

Market research conducted by NEEA and the Data Center Research Partnership and input from its partners bring to light several market interventions that they anticipate will overcome key market barriers and meet the needs of embedded data centers. These interventions place focus on different parts of the data center market actor ecosystem and vary in their focus relative to market transformation, estimated impact, cost, savings potential, and utility requirements. Of the four market interventions uncovered in the course of market research, only two are partial or full market transformation opportunities.

Since the completion of the market actor collaborative workshops and completion of the Partnership research in early 2015, several new developments have emerged that highlight the ongoing interest in addressing energy efficiency of embedded data centers. One of these is the growing number of websites devoted to providing a platform for data center solutions; in the first quarter of 2015, one of the largest data center equipment vendors launched a new standalone website devoted to giving IT managers more resources to manage their data centers. Other organizations continue to provide relevant dynamic content and to publish regular market research to track trends and to enable IT managers to compare their operations against their peers.

5.1. Recommendations and Next Steps

Given that research findings of the Data Center Research Partnership point to a range of potential market opportunities, the study research team provides several recommendations and next steps for consideration by NEEA and members of the Partnership.

- Pacific Northwest and California region stakeholders should initiate vetting of a suite of potential data center prescriptive measures and quick calculated approaches. Potential venues include the Pacific Northwest and California Regional Technical Forums, as well as the Consortium for Energy Efficiency (CEE). Prescriptive measures have traditionally provided the greatest energy savings return for the lowest cost, and additionally form the foundation for other successful efforts – from effective trade ally engagement, to commercial program integration, to more significant market transformation platforms such as a website clearinghouse.
- NEEA and/or other members of the Partnership should consider a website focused on transforming the market for embedded data center efficiency. This could take the form of a new website or serve in a complementary role to existing websites. The team acknowledges that this effort would require significant financial investment and that it may not be feasible at this time.
- NEEA, PG&E, and other utilities should consider a colocation and cloud approach to energy efficiency and helping smaller data centers move to more efficient colocation or cloud facilities. While this effort would require additional vetting for viability and technical discussion, it is an innovative concept with potential to help close the gap in embedded data center efficiency.

Last, the team recommends that NEEA assess how its existing commercial sector initiatives align with promoting efficiency in embedded data centers. Given the relative maturity and uptake of NEEA's commercial sector efforts, the inclusion of embedded data centers is a complementary addition that it could address with minimal financial investment. Current research summarized here and lessons learned from current first-generation data center programs suggest that while challenges remain to overcoming barriers in the hard-to-reach market of embedded data centers, progress is possible along several different pathways. Continued collaboration, shared research, and a strong technical backbone will be essential as these conversations move forward within and outside the Data Center Research Partnership.

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