Embedded Data Centers Workshop
Final Report

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Executive Summary

This report documents QDI Strategies' (QDI) findings from the Silicon Valley *Designing the Next Generation Embedded Data Center: A Workshop* session conducted on October 6, 2014. PG&E is collaborating with Silicon Valley Power, City of Palo Alto Utilities, NEEA, and Lawrence Berkeley National Laboratories to explore how to drive energy efficiency in embedded data centers. Embedded data centers are server rooms, closets, and localized data centers embedded in other commercial and institutional buildings — often (but not always) less than 5000 ft^2 in size or less than 50 kW in load.

The Silicon Valley work session builds on conversations from a previous work session in Seattle on July 23, 2014, which was hosted by NEEA on behalf of its 141 participating utilities. The outcomes from the July session suggested that a broad effort would be needed to overcome known barriers to achieving energy efficiency in data centers. This transformative program would need to cover multiple utility territories, engage other members of the data center's ecosystem, and address the rapidly changing nature of data center products.

To design programs to drive this change and characterize the market, PG&E engaged PECI and its subcontractor, QDI. QDI orchestrated a collaborative work session for leading members of the data center supply chain to help develop operational plans for four market intervention programs. These programs included exploring the potential for deemed measures programs.

According to participating data center managers, embedded data centers are evaluated on performance and reliability, often resulting in little attention to energy efficiency. The data centers receive support from an "ecosystem" of decision-makers and influencers, including IT equipment, power and HVAC vendors, IT distributors and resellers, and building owners and facilities managers. However, a shortage of time and resources, lack of a common language, and differing goals result in little focus on energy efficiency and, typically, an ad-hoc approach to data center energy efficiency projects.

In the Seattle work session, the team identified four market intervention concepts: (1) the Website Clearinghouse, (2) the Shared Savings Implementation Company (SSIC), (3) the Tenant Support Service, and (4) the Strategic Energy Champion program. In addition, the Seattle work session highlighted that all four concepts include a data center audit and that Deemed Incentives can help motivate firms to participate in an audit. Given the inherent connection points between these programs, it may be that market transformation and deemed programs form a self-reinforcing loop.

While there was strong evidence to support the intervention concepts brainstormed in the Seattle work session, there were barriers associated with them as well. For example, the Strategic Energy Champion concept can be onerous to implement with the time required to adequately fund a training program and institute metrics to gauge the success of an intervention program.

Deemed measures are preferred to custom measures from both the utility and customer perspective. However, rapid technological advances from one server generation to the next makes it difficult for deemed programs to keep up with technology advances. For example, HP's

Gen9 servers introduced in 2014 are four times more efficient than Gen7, introduced in 2010. Moreover, larger companies typically replace servers after three years. This replacement period determines when newer technologies can be implemented. In the Embedded Data Center (EDC), the focus of this report, the replacement period can be much longer — five to seven years — before servers are replaced.

PG&E leveraged the Seattle work session to push concepts further and deepen the program operational designs for three of these concepts noted above: the Website Clearinghouse, the Strategic Energy Champion Program, and the Shared Savings Program (which PG&E broadened to an audit to identify energy efficiency potential). PG&E further expressed interest in exploring the potential for deemed measures.

At the Silicon Valley workshop, five teams worked on defining operational plans for the market interventions and related deemed measures, with two teams focusing exclusively on deemed measures.

The key statements by the respective teams are outlined below:

1) **Deemed Measures** could exist in several product areas: efficient servers, efficient UPS, storage optimization, server virtualization (re-open for smaller data centers), and VFDs on CRACs and CRAHs. The team outlined how new communication channels (VARs) and efficiencies (as part of a utility collaborative) could make these programs more effective than in the past — deliverables that would not be possible without the overall program.

2) **Website Clearinghouse or Resource** could be very effective with support and governance that enables the following conditions: collaboration between different market actors and members of the ecosystem, vendor neutral information, and easy access to upstream, midstream and/or deemed incentive information. As a single site, it could be widely marketed and has the potential to achieve long-term administration and funding efficiencies.

3) **Shared Savings** as a pure ESCO business may have limited applicability since the potential energy savings in individual embedded data centers is small. However, the team saw three potential efficiencies that could make it possible for ESCOs, building owners, and third-party implementers to offer this service.
   a. Create a structured **Shared Savings Audit**, possibly as a regional program, to minimize the upfront cost of the audit.
   b. Design a utility-approved audit methodology to support and simplify savings calculations.
   c. Associate with a recognized brand to achieve data center acceptance of the program.
   The team recommended further exploration of the opportunities with these efficiencies.

4) **Strategic Energy Champion** as a concept was problematic. The concept works in large organizations, but still has a limited impact on the companies' embedded data centers.

Scaling the concept to smaller organizations requires resources (coaching, recognition, tools) greater than the potential return it could generate. The team recommended that if the tools from the other programs are used, synergies could make the return worthwhile.

This report includes four sections. Section 1 introduces the teams and the brainstorming process. Section 2 describes four operational plans in the work session. Section 3 outlines key findings from the cloud panel discussion. Section 4 describes QDI's recommendations and suggested next steps.

Author's Note: The language throughout much of this document is a transcript of the various workshop breakout groups, so it may contain colloquial expressions.

1. Background and Approach

1.1 Background

The problem of motivating embedded data center owners to implement energy-efficient solutions is well-documented, even when projects have a high ROI. Small data centers are evaluated on uptime and performance, resulting in little attention to energy efficiency. Data centers are supported by an "ecosystem" of decision-makers and influencers; including the IT equipment supply chain, the power and HVAC supply chain, and building owners and facilities managers. However, the shortage of time and resources, lack of a common language, differing goals, and often-short decision cycles result in little focus on energy efficiency at the level of the data center.

Success implementing energy efficiency in embedded data centers tends to occur when one or more of the following is true:

- Solutions are simple (e.g. selecting ENERGY STAR® servers)
- Energy efficiency is a byproduct of other objectives (e.g. virtualization to increase utilization and reliability)
- The business case is well-defined by a vendor (e.g. equipment and product resellers or utility representatives)
- A dedicated individual champions the cause well beyond their job description

These occasional successes suggest that it is possible to increase the adoption of energy-efficient solutions in the data center — with a new approach.

In 2013, PG&E began working with NEEA on a Data Center Research Collaborative that sought to better characterize and take action to address energy efficiency in the hard-to-reach market of embedded data centers (EDCs). EDCs are defined as server rooms, server closets, and localized data centers embedded within other commercial and institutional buildings. Established in 2014, the "Collaborative" includes members from NEEA, PG&E, SCE, SDG&E, Silicon Valley Power, the City of Palo Alto, and Lawrence Berkeley National Laboratory. The Collaborative seeks to tap industry experts, leveraging existing market studies and conducting new research to further explore market opportunities.

Key findings of the Collaborative include:

1) A validated series of potential market interventions or utility program solutions that would transform or promote energy efficiency within this market
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 HVAC, IT equipment, and power systems

The Collaborative intends to share results of this research, in efforts to help drive effective energy efficiency programs in this market segment.

By design, the Collaborative strives to complement rather than duplicate existing research related to small and medium data centers embedded in commercial buildings. This body of work includes the following:

- Lawrence Berkeley National Lab (LBNL), April 2013, Final Project Report: Energy Efficiency in Small Server Rooms, available at https://datacenters.lbl.gov/sites/all/files/SmallServerRooms_Final%20Report%20Task%202.13_2013.pdf
- 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, available at http://www.nrdc.org/energy/files/Saving-Energy-Server-Rooms-IssuePaper.pdf
- 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), available at http://energy.lbl.gov/ea/mills/HT/documents/data_centers/fact-sheet-ee-server-rooms.pdf
- Cadmus report to PG&E (with contributions from Mark Bramfitt and PECI), December 2013, PG&E Small Data Center Market Study, available at http://www.calmac.org/publications/FINAL_REPORT_PGE_Small_Data_Center_Study.pdf
- PECI report to NEEA, 2013, Integrated Data Centers Opportunity Assessment – Final Report (unpublished)

1.2 Initial Market Intervention Development

Prior to the Silicon Valley Focus Group *Designing the Next Generation Embedded Data Center: A Workshop* conducted on October 6, 2014, PECI led information-gathering sessions with NEEA to:

1) Develop a series of initial market intervention strategies for data centers and commercial real estate that address key market barriers.

2) Complete 12 formal interviews of market players to obtain market insights and help inform market intervention development. These interviews included building owner/property management, data center managers (end users), and tenants.

PECI's initial set of market intervention strategies were used as a starting point for a Seattle work session, hosted by NEEA. Participants identified four market interventions with the potential to drive a market transformation:

1) Website Clearinghouse
2) Shared Savings Implementation Company (SSIC)
3) Tenant Support Services
4) Strategic Energy Champion Program

1.3 Market Intervention Dynamics and Deemed Programs

The Seattle work session highlighted that all four concepts should include a data center audit, and that deemed incentives can help motivate and/or facilitate making the audit happen. Thus market transformation and deemed programs might form a self-reinforcing loop.
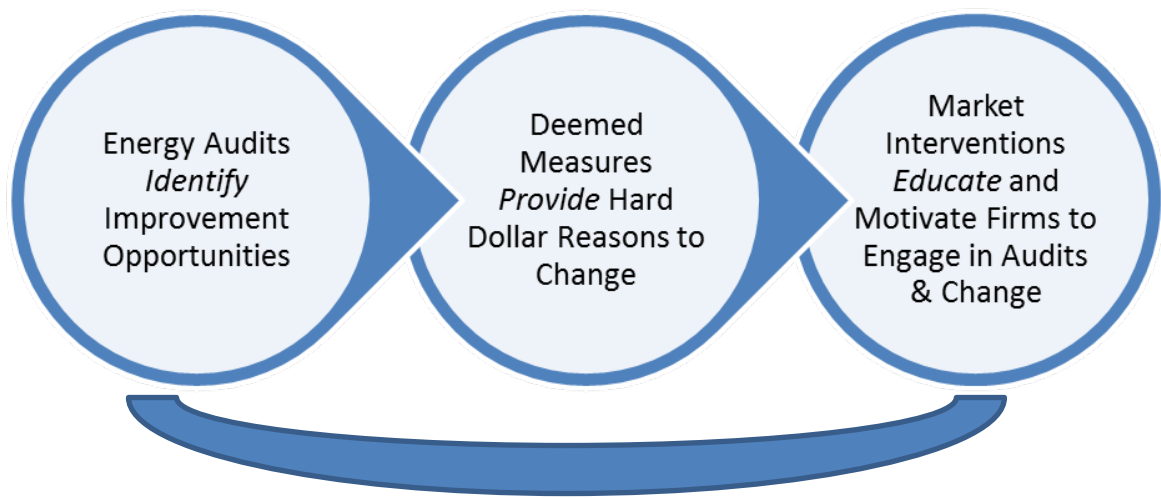
Figure 1. Market Interventions and Deemed Measures

To take these concepts further, PG&E developed a "Solutions Setting" workshop or focus group composed of the relevant players in the supply chain to brainstorm how to operationalize the program concepts identified as having potential in the Seattle workshop:

1) Deemed Programs
2) Website Clearinghouse or Resource
3) Shared Savings
4) Strategic Energy Champion Program

Five teams worked to define operational plans for the market interventions and related deemed measures. Two teams worked on deemed measures.

Due to the complexity of the issues identified for "Tenant Support Services" in Seattle, this intervention was not selected for further review at the PG&E work session.

1.4 Workshop Objectives

The objectives of the *Silicon Valley Designing the Next Generation Embedded Data Center: A Workshop* session conducted on October 6, 2014 were two-fold:

1) Outline operational plans for selected energy-efficient concepts that were uncovered during the Seattle Work Session.

2) Hear from a panel of cloud vendors/service providers about the trend and impact of moving to the cloud. Discussion specifics included who is using the cloud, what applications are hosted in the cloud, and what happens to the data center hardware/applications that move to the cloud.

The desired outcomes of the work session were:

1) **Operationalize build-out** of the concepts:
   - Are there existing firms that could deliver parts of what is needed?
   - What skills and expertise are needed?
   - What organization structure is required for success?
   - What funding model would make this a self-sustaining program?

2) **Gather feedback** on the individual plans for presenting the plans to the larger group

1.5 Workshop Participants

This was an invitation-only work session. Recruitment of workshop participants was conducted by QDI, PG&E, Silicon Valley Power, and the City of Palo Alto Utilities. Recruitment focused on individuals that had the relevant backgrounds and experience that related to brainstorming activities.

The workshop brought together data center managers, IT distributors and resellers, building/facilities managers, and equipment OEMs. Representatives from each member of the Collaborative were also present.

In all, 46 individuals attended the focus group.

Figure 2: Silicon Valley Focus Group Participants
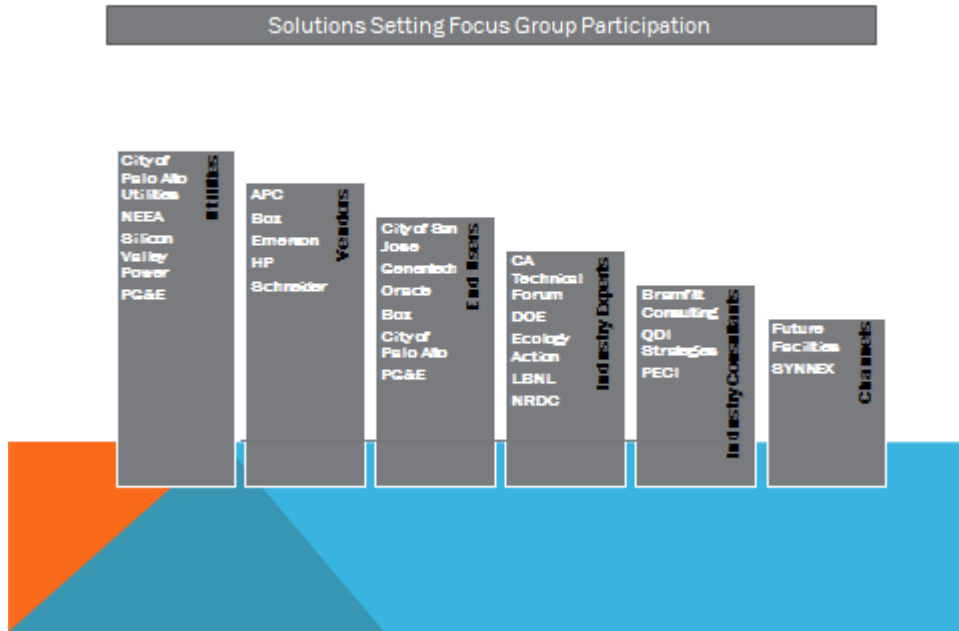
1.6 Brainstorm Structure

QDI contacted each participant a week before the work session to determine which team would best leverage the participants' expertise. Many of the participants have held positions in different roles, giving them broad experience with data center issues.

QDI organized the participants into five teams. Each team had representatives from end-user data centers, vendors and/or channels, building owners, utilities and other experts as appropriate. This provided each team with balanced perspectives from around the ecosystem. Participants used their backgrounds to discuss multiple perspectives on barriers, concepts, and operational ideas.

There was overlap in participation from the Seattle workshop, where there were the same representatives from HP, APC, and Schneider. Staff from PECI, Priscilla Johnson of PG&E, and Geoff Wickes and Rob Curry of NEEA attended both work sessions.

Team Composition

Each team included a participant from:
- Data Center / IT
- Vendors
- Channels
- Facilities / Owners
- Utilities

1.7 Brainstorming and Creative Process

Prior to the workshop, each team member received a one-page description of the concept for his or her team to address. Participants were asked to come prepared to discuss how to make their concept operational.

The sequence for the team brainstorming session was:

- Quick team building exercise
- QDI review of the market transformation concept
- Teamwork to answer the operational questions for their concept
- Lunch and keynote presentation by Gary Cook, Greenpeace Data Center/ IT Expert
- Team presentations on their operational plans
- Wrap-up

Facilitators led the conversations in each team using a structured outline with the questions the team needed to address. These questions are included in the Appendix.

1.8 Market Barriers

The market barriers identified during team discussions were consistent with prior PG&E and industry work referenced in Section 1.1, particularly:

- Embedded data centers vary widely in sophistication, attitudes, and needs
- Embedded data centers are slow to take risks or adopt new energy efficient IT solutions
- The data center equipment operations are characterized by rapid and continuous change
- Barriers hinder adoption of virtualization, right-sizing of server room infrastructure, including transformers, uninterruptible power supplies (UPS), cooling, lighting, and PC Power Management

The following figure of barriers was presented to the teams on a wall chart and referenced during the initial brainstorming session.

Figure 3: Market Barriers List

Barrier	Description
Split investment	The data center budget generally does not include the HVAC or power costs, so they do not receive a direct return for investment in energy efficiency.
No corporate metrics	The data center is measured on reliability, performance, capacity, and equipment costs. Taking time to explore software, hardware, or HVAC options to reduce energy use is an expense with minimal direct benefit to IT.
No time	The purchase cycle is often too fast to facilitate pre and post measurement or documenting original and revised plans. Therefore, it is difficult for the IT group to participate in utility programs that require pre measurement.

No vendor incentive	Vendors (VARs, contractors, Distributors, OEMs) play a key role in recommending solutions; however, including a more energy efficient option can slow down or stall a sales process, so they do not voluntarily include this option.
No feedback	Data center equipment and cooling needs are not segregated and monitored, such that the data center manager does not receive feedback.
No visibility	Changes, upgrades, and retiring of equipment create change in building electrical and HVAC load isn't easy to estimate or track, building management and HVAC doesn't have visibility to the changes.

Workshop results are reflective of and confirm what is known from existing literature about how the data centers are managed and what are the key priorities of data center managers. These include:

1) Data center managers are focused primarily on uptime and performance.
2) Data center managers have resource constraints and short-term priorities they must meet.
3) "Energy efficiency" as a message is not compelling by itself.
4) There is a lack of standards and best practices to indicate what opportunities for improvement exist, and what kind of benefits they yield to data centers.
5) Within the IT organization and associated facilities management, decision-making is generally a multi-layered and complex process with split incentives.

1.9 Market Players and Activities

The figure below provides a schematic overview of the key market players and their relative levels of influence on end-users.

Figure 4: Market Map
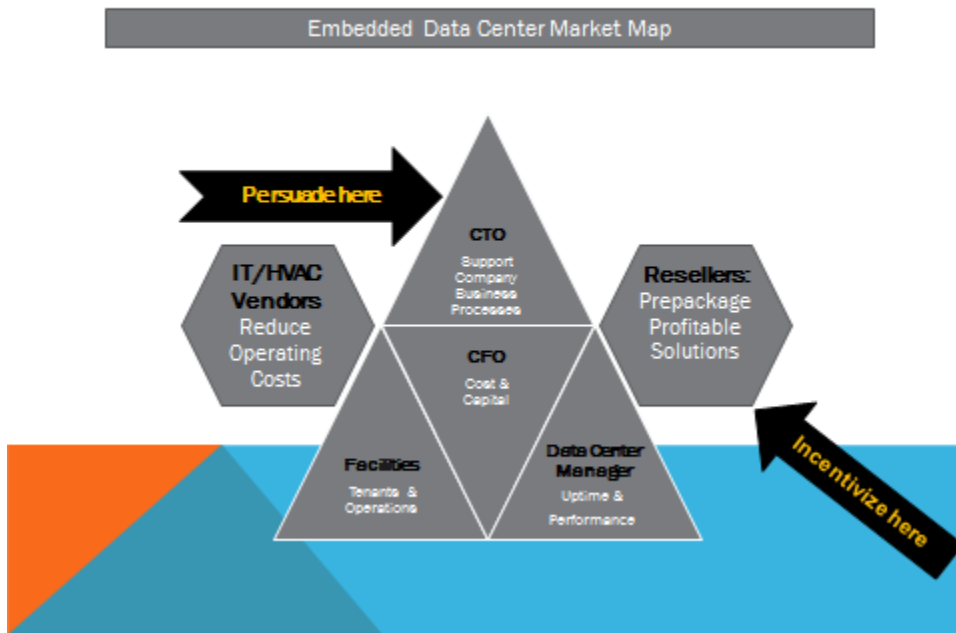
The operational plans in each team dealt with some of the complexities in the data center supply chain:

- Market players do not have a common vocabulary, nor do they have a common way of looking at data center energy consumption and efficiency
- There are many layers of decision makers and influencers, ranging from the CIO to the IT, or the HVAC vendor to the building owner/manager
- The ecosystem members rarely act collaboratively
  - Often they don't know each other's objectives or may have conflicting objectives
  - They receive direction or information that is "translated" more than once before reaching them, which makes clear communication difficult

- While resources exist to help the data center, there isn't one source that addresses the complete picture
- Few of the participants can package an "ROI Story" for the C-Level decision maker, which impacts their ability to "sell" energy efficiency

1.10   Impact of the Cloud

The final hours of the afternoon contained a panel discussion on the impact of the cloud on embedded data centers. The panel was composed of Box — who uses the cloud for internal IT and to deliver their service — and Cisco and HP, who are leaders in providing infrastructure and services for firms using the cloud.

The panel presentations and discussion are covered in Section 3.

2   Market Interventions and Deemed Programs

Five teams worked to define operational plans for the market interventions and related deemed measures. Because there were five teams and four concepts, two teams were assigned to work on deemed measures):

1) Deemed Programs (two teams)
2) Website Clearinghouse
3) Shared Savings (Audit)
4) Strategic Energy Champion Program

The operational plans from the two deemed programs teams have been combined for simplicity and presented in the following section.

2.1 Deemed Measures

Deemed measures were addressed by two work groups with strong participation from Data Center Hardware and Cooling equipment manufacturers, the distributor/VAR channel, data center evaluation services (power and cooling efficiency modeling), and others. The particular mix of participants enabled the groups to specifically address the requirements and challenges of developing deemed measures for both the Data Center IT and Power/HVAC areas.

2.1.1   Definition

Deemed measures would provide a simplified way to offer incentives to customers to improve energy efficiency in their embedded data centers. These measures would have a simplified calculation approach, with pre-determined estimates of energy and peak demand savings. In order to reach customers within the SMB segment that present an opportunity, the measures would need to target embedded data centers meeting the following criteria:

- Size $< 5,000$ ft^2 and/or
- Consumption < 50 kW

- 20 kW/rack

Anything larger would likely be purpose-built and therefore not a suitable candidate for deemed measures, or would have most likely implemented the latest policies to maximize efficiency.

The work groups proposed potential measures in the following areas:

- **Efficient servers:** Servers that have more [the highest] processing power/watt of consumption. In addition, servers that can automatically ramp up/down CPUs based on needs. The unit of measurement could be challenging without measurement tools.

- **Efficient Uninterrupted Power Supply (UPS):** A UPS that minimizes power loss.

- **Storage optimization:** Storage solutions that maximize storage quantity at minimum energy consumption.

- **Server virtualization:** There is still an opportunity in the EDC space, even though programs for larger datacenters have been discontinued because server virtualization is not industry standard practice for embedded data centers. The resources are currently not available to perform this across multiple buildings in campuses, e.g.

- **PUE or kWh/Rack:** Meeting targets for a specified metric of energy consumption per unit of performance in an embedded data center.

- **Improved cooling systems:** Build efficiencies by implementing fully integrated cooling systems and utilizing the latest generation of cooling equipment in the EDC.

- **Financial support for Assessments:** Provide cash to customers for undertaking data center IT and cooling-type assessments to identify efficiency opportunities. This is not a deemed measure, per se, but a "market intervention identified" by this group, and others.

2.1.2   Operational Details

Value-Added Resellers (VARs)

In the SMB marketplace across the United States, tens of thousands of value-added resellers (VARs) work with data center operators. VARs have technical staffs that focus on specific technology areas: IT, network, servers, and storage.

Cooling is generally not addressed through VARs, but some do provide cooling solutions. Cooling solutions are primarily delivered through HVAC/Mechanical contractors. VARs could acquire this expertise just as they have for IT. Some VARs also sell integrated products like cooling cabinets for servers. They "rack it and stack it" and deliver it to you. The team agrees that VAR is a good partner since they have been discussing virtualization and other solutions for the data center.

VARs can be reached through five major distributors: Arrow, Avnet, Ingram Micro, SYNNEX and Tech Data. For the three largest distributors alone (Ingram, SYNNEX, Tech Data), revenue exceeded $65 billion in 2015.

Deemed Measures

Deemed measures will need to address several key factors:

- Deemed savings approaches may require on-site inspections to verify installation or removal

- The market appears to be shifting from EDCs to co-location facilities, because of cost-pressures in building a dedicated data center as compared to outsourcing (Source: Group 1; Data Center Knowledge, Sep. 11, 2014)

- Deemed measures have to be approved based on the expected savings from the technology and specified application, and utilities need to be able to prove to CPUC that savings occur

- Small applications have less variability

- The tier classification (I-IV) of data centers defines the redundancy and therefore efficiency of the DC; this will vary by industry, but most EDCs likely fall under Tier II. A data center with Tier II classification has servers with redundant capacity components that guarantee 99.741% availability.

> *"A combination of applications assessment along with a DCEP-type facility assessment that is supported by utility funds to defray cost could…lead to more efficiency improvement projects."*

Time is an important factor for deemed measures and places constraints on the operational period for deemed measures. Larger companies typically replace servers after three years. In the EDC, it can be much longer — five to seven years — before servers are replaced. This replacement period determines when newer technologies can be implemented. In addition, within a relatively short period, data center equipment can achieve large efficiencies. HP's Gen9 servers introduced in 2014 are four times more efficient than Gen7, introduced in 2010. This trends makes it difficult for deemed programs to keep up with technology advances.

Requiring a standard assessment methodology is important for deemed measures to work. Industry experts, including LBNL, should vet the assessment methodology. Utilities and/or their regulatory bodies should approve standard assessment templates. Small companies need a clear assessment process to know how to build a more efficient data center without reinventing the wheel. They need a guaranteed recipe, without having to approach a specific supplier. Standardized assessments can also combat the rapid advancement of technology, by focusing on outcomes that result in some improvement from a current to a future (more energy efficient) scenario. The expertise to perform these assessments lies within the ecosystem of VARs and HVAC contractors.

Financing

The significant up-front cost of an energy efficiency assessment deters end users. Efficiency will pay for itself, but it has to start with IT. Data Center IT systems are either bought through Capital

expenditures (Capex) or leased through operating expenditures (Opex – less frequent). Both types of transactions go through the VAR. While VARs can be segmented according to the varying levels of service they provide, they are still the primary acquisition channel. VARs should receive incentives as well as the customer. There is no need to provide an incentive at a higher level than to the VAR (to the manufacturers — upstream) and to the end-user. It is up to the VAR to define the solutions and products.

There are a handful of financing resources for end users. Omni-funds are HP specific buckets of money while other vendors have similar funding mechanisms for defined opportunities. "Omni funds" are funds provided by HP to the IT channel for assessments and other activities that exist to help VARs address leads. HP has a "whole ecosystem of VARs that do this on behalf of HP." Distributors usually administer these for VARs and agents. VARs know what applications are running at their customers' premises, and can best work with data center managers to address utilization and other issues.

Perhaps utilities could contribute to the Omni-funds, or provide support that is not vendor-dependent. The utility typically must be neutral regarding recommendations related to a specific product manufacturer. With the support of utility funds to defray costs, a combination of applications, network and Data Center Energy Professional (DCEP) -type facility assessments that include both IT and facilities/cooling should be used to drive energy efficiency projects. The DCEP program has several hundred people already certified and qualified to perform assessments. The broader PG&E Data Center Market Characterization seeks to do this.

Alternatively, funding for these types of projects covered under deemed measures could be a key component of the business case for securing project approval at the customer level. Internally, the approval process takes a long time due to split incentives, fragmented decision-making, and lack of priority, and this causes missed sales opportunities. It is important to understand the financial barriers and determine how financing can assist with implementing projects.

Another consideration is where to apportion the costs for an energy efficiency project. Going virtual to a cloud service could allow companies to move their costs to Operating Expenses instead of Capital expenditures for the data center. An open question is whether an incentive should be provided for this. Providing an incentive to migrate load to the cloud would be in line with the trend towards more co-locations rather than small, underutilized embedded data centers.

Reliability

Since reliability is the primary goal of data center operators, the most important motivational factor for change toward energy efficiency is cost savings without sacrificing reliability. The data center operator is not motivated to be energy efficient; s/he is motivated to keep applications running. The team identified many potential ways deemed programs could motivate data center managers. These motivational tactics are:

- Provide incentives for energy efficiency achieved through multiple products or solutions. For the purposes of deemed programs, we have to define what "energy efficiency" means in this context and how is it measured. For example, what level of efficiency is to be rewarded?

- Consider providing an incentive to companies to move to cloud, and eliminate embedded data centers through operational changes.

- Ask equipment manufacturers such as Schneider or Reynolds Electric for power solutions

- Explore a way to dispose of stranded assets through a recycling or decommissioning program. Utility programs exist that can be benchmarked and lessons from these learned.

- Enhance controls by providing tools or other support mechanisms to optimize load across the entire racks, such as, through data center information management (DCIM) tools.

- Focus on utilization as a data center metric. Support some form of utilization reporting for customers that can highlight applications and infrastructure that are under-utilized and should be reassessed. Internal change can be driven by visibility of applications running on servers.

- The cost of current operations, including the cost of doing nothing should be assessed.

"Incentives are not always downstream and could be upstream/midstream to the manufacturers or distributors, or value added resellers (VARs)."

2.1.3 Value Proposition

The value proposition of deemed programs to the data center manager and the facilities manager is a way to help them implement changes to the data center at a reduced cost. This places the focus onto the data center or facilities manager's channel partners, VARs and HVAC contractors. Their role is to identify incentives for specific opportunities to improve energy efficiency in the data center, and thereby help build the business case for change.

The deemed approach is beneficial and effective for several reasons:

- **Simplicity:** Simplified measure offerings and predictable incentives for data center equipment will drive uptake of energy efficiency; a deemed approach will dramatically simplify program administration and M&V. Simplified participation for customers and their vendors/allies; create predictability.

- **Speed:** Increase in expediency of projects throughout the project lifecycle (application, audit, reviews and approvals) will attract more program participants and partners.

- **Specificity:** Solutions differ based on tiers [in the data center] and segments. It is important to note that sectors can be motivated differently. That said, what is the highest motivation factor and how does it differ between end users?

- **Incentives:** Incentives are not always downstream and should be upstream/midstream to the manufacturers, distributors, or the value added resellers (VARs). They have proposed virtualization and other solutions to improve energy efficiency.

Deemed measures will also have the overall support of the various constituencies involved in the process, including the utility, trade allies/partners, and customers alike.

Customers should support this initiative because it benefits the bottom line, is easy to access (simplicity) and requires less effort than custom programs. Improving ease for end-users will benefit trade-allies and partners, which in turn, increases the likelihood of project execution. The utility is likely to support this because it dramatically reduces costs for all by eliminating a parallel review and by simplifying evaluation. EM&V is a challenge with deemed products and it would help if PG&E could adopt a standardized product approval such as the Air-Conditioning, Heating and Refrigeration Institute (AHRI) process or packaged systems with M&V already performed.
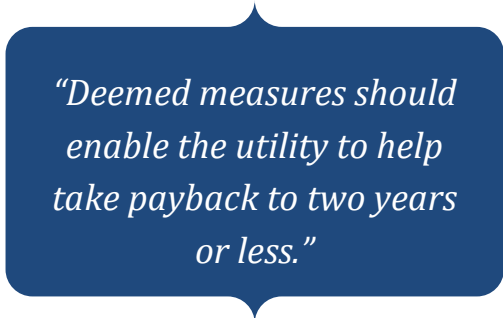
2.1.4 Finance & Administration of Solution

Overall finance and administration for deemed measures would need to respond to the nature of the different types of projects and partners involved in the process.

The primary funding source for deemed measures would likely be the utilities themselves. This would complement existing funding coming from the IT channel community, made up of vendors (manufacturers), distributors, and resellers/contractors. As noted previously, vendors, such as HP, provide some funding for developmental activities such as "Omni Funds" to defray the costs of Server/Network utilization assessments. These assessments are effective in identifying energy saving opportunities, and the funding from utilities provides an additional hard dollar reward for changes in behavior. Distributors have invested and built products, solutions, sales and support infrastructure to give VARs the tools they need to sell to end-customers. The VARs themselves invest by providing specific training and certifications for OEM products and solutions that are being sold. Deemed programs will enable the utilities to support these effort and produce a "multiplier effect".

Project Payback

Project payback is an important decision factor for customers. Generally, shorter-payback projects are paid out of operating expenditures (OPEX). Longer-term projects go through a capital expenditure process and are more difficult to complete. Deemed measures should enable the utility and utility customer to receive payback to two years or less, which would help get more projects approved. A deemed catalogue from the utility has huge value for technologies and solutions that are offered by partners, who can leverage their deemed product status into marketing campaigns and other strategic efforts.

> *"Deemed measures should enable the utility to help take payback to two years or less."*

Incentive Structure

These incentives should be paid out to the VAR/contractor and end-customer. Having a rebate on specific products/solutions would help VARs sell to the end-user. Rebates could be tailored to

specific product types, efficiencies above baseline levels, or specific benchmarks yet to be developed. For example, OEMs are making self-aware servers that can ramp CPUs to adjust for cooling and power needs. These products drive higher savings beyond reduced energy consumption on the server. Since these have a price premium relative to other high-efficiency servers (ENERGY STAR® servers, e.g.) they could have a tiered rebate.

Because the VAR/contractor is identifying the need and designing the solution, there is value in providing an incentive to them to develop energy efficiency projects. Buying cooling solutions would follow a similar process, although they would primarily be from a mechanical or HVAC contractor. In some cases, a VAR might be selling fully integrated IT/HVAC systems, such as cooling cabinets. As such, for IT solutions, the target of the incentives will be the VAR and end-user. For HVAC, requiring mechanical/electrical work and the pulling of permits, would involve the contractor and end user. Both of these cases are a midstream approach.

The ability to easily distribute incentives between the end-users and their vendors may be a key success factor to helping ensure financial incentives are allocated appropriately to drive projects. Because solutions may require investment by multiple parties — such as the end user and two vendors — creating a process to split payment of utility incentives among the parties could make it easier to facilitate the project transaction, reward the appropriate party, and result in an increase of customer uptake.

Figure 5: Alignment of deemed incentives to enablers
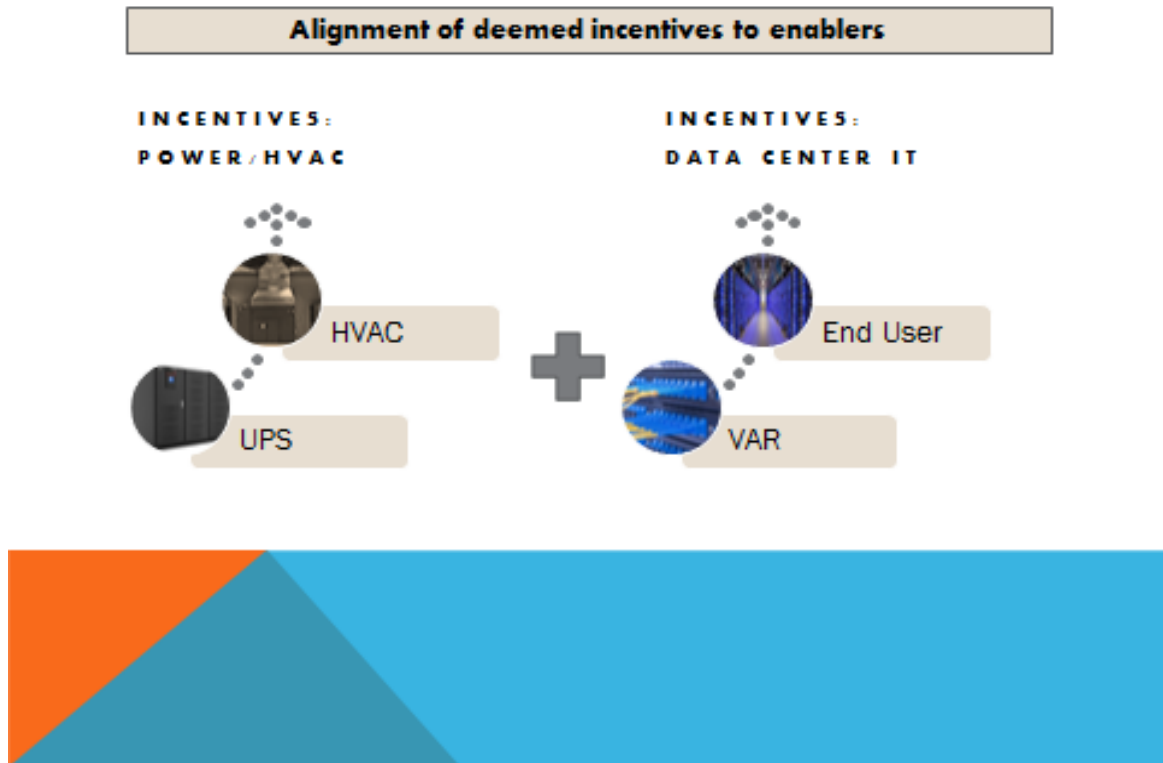
The mechanisms for splitting incentives are unclear. In a purchase scenario, the end-user is assuming the cost. In a leasing scenario, the VAR assumes the cost. Further research would be required, but a mechanism could be developed to apportion the incentive split based on the party (VAR or End-User) and "Buy" vs. "Lease" scenarios.

On the Power/Mechanical Cooling side, incentives should go to the mechanical/electrical contractor and end-user, but (generally) not the VAR or property manager, unless the VAR is actually doing the work (Integrated VAR). The work may need permitting that a typical VAR is not going to handle. The challenge is getting the property manager (for multi-tenant buildings) on-board with potential upgrades, so we may need to consider providing incentives to the property manager, as well. For multi-tenant buildings, because the property manager/owner is impacted by costs, brainstorming work may be required to identify other incentives for this constituency.

Other key elements to consider for incentives include:
- Incorporating thermal imaging into audits to identify hot spots
- Introducing automated cooling optimization as a potential deemed product
- Offering the audit at a discount or incorporating a HVAC controls assessment into the audit. The assessment would determine potential HVAC control upgrades so you could take advantage of the latest technologies and optimize your business

Cooling optimization opportunities include:

- Smart meters (sub-metering) to help directly attribute savings for HVAC controls

- Improving system design and the location of crack unit sensors to improve levels of monitoring

- Offering a deemed incentive for fully integrated "Smart Row" cooling systems that integrate Server/storage racking, UPS, Power and Cooling management all in one (Emerson-Liebert, et. al.). Sensors in the unit monitor how much cooling is needed based on air temps and the system automatically compensates — note, these are more efficient than stand-alone solutions

- Incorporate other wireless sensors to improve HVAC controls

A new program design is required, which will vary depending on which measures are candidates for a deemed approach. The EDC program could be targeted to data centers or could be integrated into the existing Commercial and Industrial portfolio – but must ensure that marketing and outreach is sufficient to achieve market penetration. The group recommends that these measures get a specific program design to ensure customer uptake.

> *"A mechanism could be developed to apportion the incentive split based on the party."*

2.1.5   Marketing & Outreach Approach

VARs (including contractors), distributors and end-users are key marketing channels for deemed programs. As HP indicated in the session, they rely on their distributor and VAR partners to implement their programs and sell their solutions to end-users. They are the focus since incentives should be towards the upstream/mid-stream. Slightly different messages need to go to each segment, especially between VARs and end-users.

VARs are best reached through the five major IT distributors, who have existing business relationships, member and outreach programs, and tools and services to support VAR sales of IT products and services to end users. Distributors have regular conferences several times a year, where VARs attend to receive training on products and services from vendors, distributors and other parties. Utilities could sponsor training sessions at these events for resellers from a particular geographic region. In addition, distributors' marketing organizations could assist with targeting the message and organizing regional conferences to address very specific groups of VARs. The same applies to HVAC/Mechanical.

> *"VARs are best reached through the five major IT distributors."*

End-users can be reached through forums, Data Center community conferences (such as Green Grid, 7x 24, Critical Facilities Round Table, Uptime Institute, Data Centers User Group, Data Center

Dynamics, etc.), and other end-user member organizations. Mechanical/electrical contractors should also attend these conferences because they might offer training opportunities. Utilities could sponsor training on technology for energy efficient designs, and on the programs to access incentives.

End-users in general will find out about these programs from the VARs, with whom they have a direct relationship; therefore, marketing efforts should be focused around them and target both the end-users and VARs.

Addressing Barriers

An obstacle is that property managers are risk adverse and not comfortable being the first to try new technology; marketing should focus on the first to market (VARs and end users). Utilities would design the messages with third-party implementers to carry the message through the channel and manage interactions. The deemed program messaging should be created after discussion with the key stakeholders. Utility product and program teams will be responsible with facilitating the discussion, which would include key stakeholders and implementers.

Marketing will require targeted campaigns by utilities, industry organization involvement, and strategic partnerships with other leading technical and business organizations. This could be bundled with other initiatives that help drive action in the marketplace.

2.1.6 Deemed Programs

IT/data center managers are the primary target audience for deemed programs. VARs and OEMs have strategic interests in helping customers obtain incentives to help buy down the cost of their products and overall solutions. VARs and mechanical contractors are the other audience to consider, especially because of their role in scoping and delivering solutions to end-users.

Today PG&E and many other utilities (including the California utilities) have no incentive for specific data center equipment. The only programs these utilities have are custom processes. Other utilities throughout the country do have deemed programs for specific equipment. For example, Duke Energy offers $150 per server removed through virtualization. However, it would appear that no utilities offer deemed programs for specific data center products such as intelligent servers, integrated cooling systems, or the like.

The utilities have a wealth of resources across academia, industry, and the public sector to assist with developing and finalizing solutions for deemed programs. The key will be finding the right resources to provide the supporting detail necessary to complete development of the deemed measures. Below are the identified resources to consider.

Figure 6: Utility Resources for Deemed Programs
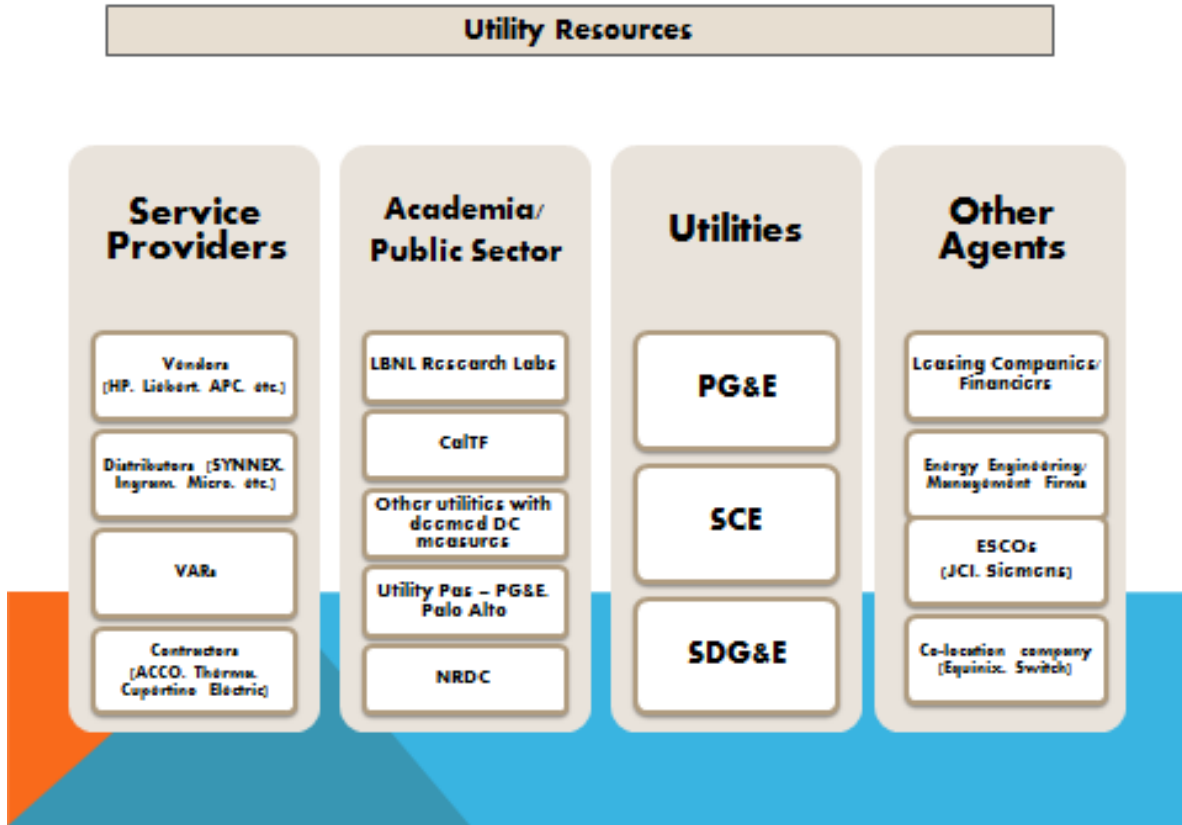
2.1.7 Success Metrics

The success of a deemed program will be determined through standardized reporting and tracking of results to ensure that savings are achieved. In addition, the results will include valuable data regarding corresponding demographics. EM&V, standards, and guidelines should be implemented to evaluate savings and energy efficiency.

A number of metrics and key performance indicators, and quantitative and qualitative data, should be tracked during the administration of deemed measures that are diagramed below. The program administrator would be accountable for the tracking and analysis of these metrics. Ultimately, the California Public Utilities Commission (CPUC) authorizes the catalogue of incentive offerings through the Investor Owned Utilities (IOUs).

Figure 7: Deemed Program Potential Success Metrics
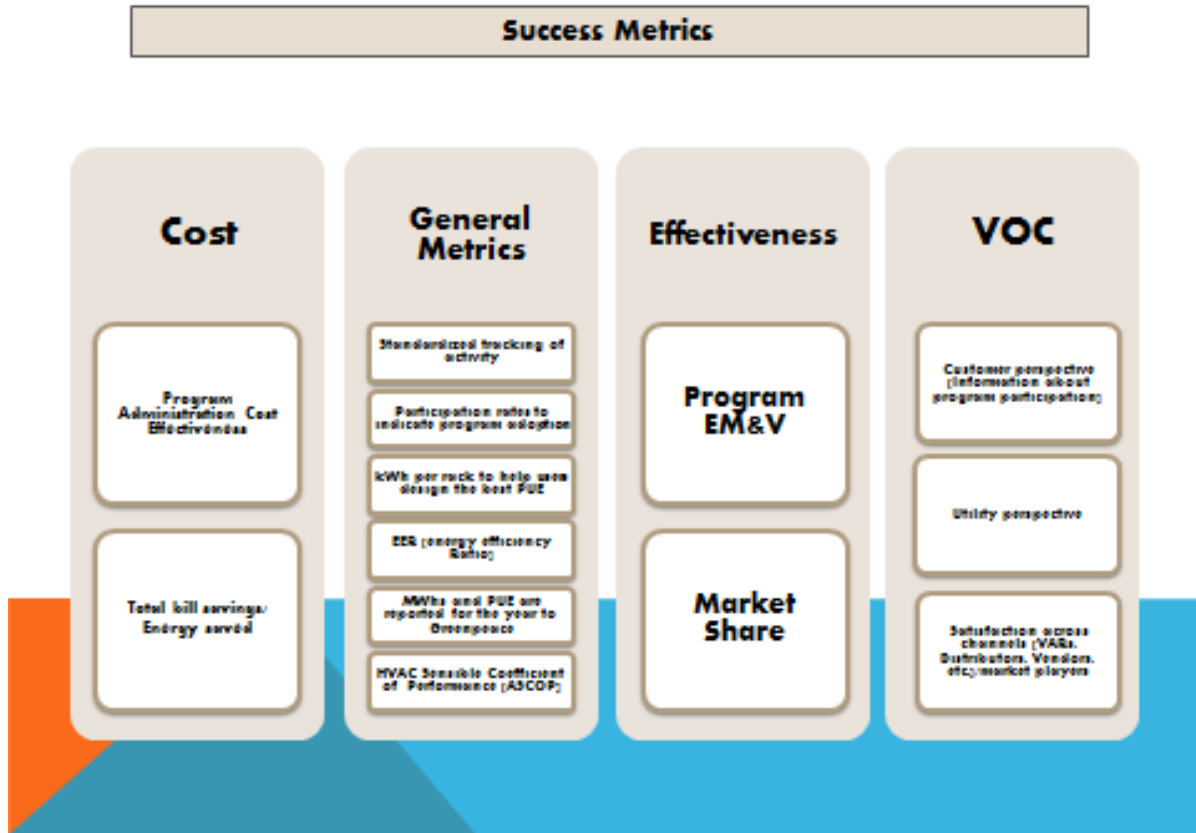
2.1.8 Risks & Unknowns

Even with clear feedback from the market that deemed programs are necessary and important to achieving energy savings, major risks and unknown factors lie in the amount of work that remains to be done to develop and implement a deemed program. Some of the risks include:

1) Developing savings values and securing approvals from regulatory bodies

2) Regularly addressing technology shifts that could rapidly impact savings values

3) Potential that data center measures may only be candidates for a simplified calculator approach versus a deemed approach

4) Providing incentives for IT measures based on current CPUC rules

5) Needing tiers for reliability in the data center — the higher the tier, the more redundancy

6) Risks for the utility — uncertainty if they will get credit, potential cost increases, risk of realizing the planned Net-To-Gross (NTG)

7) Evaluations must be standardized

8) Standardization does not exist among data centers

2.1.9 Final Recommendations

The Deemed Measures groups' final recommendations include:

- Define and vet measures further.

- Expand current HVAC measure to specifically include data center applications.

- Match utility specs to nationally accepted efficiency standards, e.g. ENERGY STAR ® and ASHRAE.

- Implement an incentive structure based on IT or facility channels, rebates for deemed products, or incentives for midstream (VARs) and downstream (end user) participants.

- Involve marketing to help target purchase decision makers (VARs, End user, property manager).

- Focus on success metrics. These metrics can include MWh, PUE, and ASCOP vs EER for HVAC performance.

The next section discusses the best forum to market the deemed measures on a vendor-neutral platform.

2.2 Website Clearinghouse

2.2.1 Definition

The website clearinghouse is a website and mobile platform that IT, facility managers and other embedded data center decision-makers can access to find unbiased, benchmark information on how to optimize their data center and get their projects off the ground.

The website would provide relevant, unbiased, trusted information about data center efficiency, best practices, case studies, resource library, tool library, social media, rankings and reviews, technology showcases, and a "bid marketplace". The website would serve anyone in the country with a ZIP code look up to find relevant utility program incentives, codes and standards, and regional vendors.

Figure 8: Website Clearinghouse Interaction with Market Players

2.2.2 Operational Detail

The website is targeted at data centers from 1,000 to 5,000 square feet, or those operating at less than about 50 kW. These data centers are small scale and have similar problems: often no dedicated personnel, once in place the data centers are often kept running, despite low utilization levels.

Key features:

- Database of voluntary declarations of data center metrics (e.g., benchmark, energy use, PUE) that allows for users to undertake comparative analyses
- Google search appliance core
- Video library: C-level summaries, technology demos, case studies, and how-to tutorials
- Resource library: Links to other resources, glossary, forums

- Tool library: Links to, built-in or downloadable audit tools, airflow tools, ROI tools, calculators for NPV, ROI and other financials, total cost of ownership, etc.
- Blogs, bulletin boards and chat rooms for participants to engage with other users
- User rankings and reviews for all posted content (e.g. 5 star, comment format); archival feature for out-of-date information
- Market place opportunities for vendors, suppliers, providers, property owners and finance providers
- Through the creation of "eBay" or "Open bid" opportunities for IT managers, facilities managers, and companies looking to improve performance of hidden data centers, the market place can compete for services
- Show case of best practices for Embedded data centers, Green leases, operations and maintenance of small data centers
- ZIP code look up to relevant utility program incentives, codes and standards, and regional vendors
  - Savings claimed by utility programs — each utility will have its own program
- Tools: server, UPS, airflow, storage, benchmarking, backup
  - Some tools exist but require substantial technical skills to effectively use them, so they are not very practical
  - The industry needs to develop practical tools
- Resources: case studies, white papers, FAQs, discussion forum, membership, e.g. linked in

> *"Allow the market place to compete for services...to improve performance of hidden data centers."*

- Marketplace: Market verticals, IT services, facility services
  - Equal opportunity
  - Vendors have to pay to be on the website
- Vendor neutrality: the website doesn't play favorites with vendors
- Vetted content
- Website administrator, through peer review and ratings, will oversee the vetting approval process
  - Similar to Green Grid, the site will define criteria and rules for submitted white papers similar to Science Journal peer-reviewed process

The website would be a moderated forum so users cannot interact or post things without a secure login. There is a concern regarding registration costs/membership fees. The team recommends a website structure that enables potential user's access to the information and free tools to try/use before registering. Since many potential users will be searching for solutions on the internet, the Search Engine Functionality is critical to get these potential users to the website. Today it is difficult to find quality information quickly, often because too much information exists, which has the result of masking the useful information.

Users could also input energy, equipment, and HVAC information about their data center in order to do one or more of the following:

- Calculate PUE or other established efficiency metric
- Compare their performance to similar data centers
- Identify types of equipment appropriate for their room size

Select information could be available to the property owner's facilities manager to assist in planning and coordination of HVAC needs.

The website would provide:

- Rankings and peer-reviewed information to drive decision making in data center
  - Best practices/case studies should include:
    - Initial design of the data center
    - Energy considerations
    - Ongoing operations
    - Optimizations and improvements
- Relevant information briefs or how-to guides, targeting specific applications, problems and solutions
- Aggregation of relevant content from other sites or sources
- Best practice guidance in a digital format with strategic distribution channels to increase presence and uptake
- Simplified data center planning tool – that can be used to compare self to industry
- Identify types of equipment that can give potential incentives
- Facilitate use of common language
- Information on sub-metering requirements or options
  - Requirements of Seattle code or State regulations as appropriate

"The website would provide rankings and peer-reviewed information to drive decision making in data centers."

To increase the functionality the site would be:

- Designed to work on a mobile device
- Organized to provide quick information
- Organized to show peer reviewed and monitored information with the archiving of older information

The website would contain information on how to reduce cost and increase efficiency.

2.2.3 Value Proposition

The website is designed to be a central point of information, from general to specific for each data center location. Therefore, the website will deliver value for each of the market actors as outlined below:

Data center manager
- Third-party validation of benchmarking standards by industry experts of tools and methods
- A source of unbiased third-party, vendor information
- Discussion platforms for IT managers and facilities managers to communicate about challenges and solutions
- Ready suggestions for crisis issues that data center managers face; such as, equipment failure

IT managers
- Learning about new opportunities, marketplace, best practices
- An "Angie's List" for vendors with a new marketplace
- Tools to help IT managers improve their primary objectives (uptime, reliability, and security) including benchmark metrics to determine where a facility ranks and how to improve use/positioning. These IT metrics and rankings will be structured on parameters defined by business industry/type and comparable data center(s).

Vendors/VARS/HVAC contractors
- Facilitating more business/commerce
- Access to interested IT managers and facilities manager's for projects and improvements
- More sales with less investment by:
  - Obtaining information about the data center through an audit conducted or paid for by someone else
  - Learning about qualified customer / specific opportunities through the website in place of expensive marketing and sales activities
  - Knowledge of the data centers PUE without investing a year of the vendors time to track

> *"IT metrics and rankings will be structured on parameters defined by business industry type and comparable data centers."*

Facilities managers
- Help with cost and personnel incentives
- Assistance with financing
- Personal/Performance incentives to entice managers to facilitate change

- Help with facility manager's concerns
  - o Reliable/functioning business
  - o Planning for critical failures
  - o Business Continuity Plans/Disaster Recovery options

Building operators

- No complaints; preventative measures/process

- Greater retention of tenants (failure aversion)

- Ease of install and operation

Leasing agents

- To avoid losing commission, the potential lessor can fit their embedded data center into the building since the data center power needs can be minimized and managed

- Stable tenants — no need to move for more data center space/power/support

Financiers

- Financing opportunities (return)

- Greater stability of lessors

Building owners

- Original value sustained
  - o Source where property owners can benchmark performance of buildings to maintain competitiveness
  - o Show case of "green leases" and best practices

- If the buildings is at maximum usage of incoming power, improving the data center means the building can fit more tenants

- Challenge: utility costs need to be monitored at the EDC level

2.2.4   Finance & Administration of Solution

The team outlined the requirements (shown below), but noted that there is still work to determine what is possible and which of the various organizations should participate in this.

- Sponsored by one key organization (e.g. The Green Grid, Open Compute, DOE, etc.)

- Moderated by a core administration team

- Hybrid revenue model from donations, key sponsors, subscriptions, link revenue

- Partnership of "neutral" sources

- Customer, vendor, or utility subscriptions (Consumer Reports model)

- Utility funding

- Multi-year engagement; assume 1 year for website development and launch

- Transaction from RFP to vendor and equipment selection and work awards

Administration:

- Organizations that could manage/administer the website
    - Edison Institute – where utilities go to talk, meet up together
    - Edison Institute; & LBNL: have credibility nationwide,
- Need a low entry point; people need to know what they are going to get prior to joining
    - LinkedIn accounts seem to work well to attract users; a modest fee could get users update and started until they get qualified and then fees could be reassessed after a year
    - Utilities could potentially help funding
- A potential issue is maintaining relations and transactions on the website between the vendor and customer; possibly, the value of the first transaction and establishment of the initial relationship outweighs this concern?

The team explored hybrid business models considering utility, vendor, and end users sources of revenue.

Figure 9: Website Potential Revenue Sources

"The marketing approach would be an organic, vetted networking approach to communicate the existence of the site."

2.2.5 Marketing & Outreach Approach

Rather than a mass media marketing campaign, the website's existence would be communicated using an organic, vetted, networking approach to capitalize on the site's position as a trusted resource. Users would then see the value of the information. Established peer organizations, such as the Green Grid and similar institutions, could fulfill this role. To ensure the comments made can apply to a real source, users would have to resist using an existing verification process such as have users identified via their LinkedIn identity.

2.2.6 Market Players

The market players for the website clearing house program are prioritized below:

- **Primary**
    - IT/data center managers

- o   CIOs, CTOs and CFOs
- o   Property owners
- o   Property managers

- **Secondary**
  - o   Vendors (HVAC and IT equipment and services),
  - o   VARS
  - o   OEMs

- **Tertiary**
  - o   Tenants seeking new space
  - o   Property Managers looking for tenants
  - o   Finance providing tenant improvements, capital improvements and upgrades

2.2.7   Success Metrics

The success metrics consist of:

- Web analytics (e.g., web views, downloads, number of benchmarks established, uptake of review and rating system)

- Vibrant collection of tools and resources to draw from

- Number of incentive referrals from website to participating utility

- Energy saved by participating utilities

- Number of transactions in the "bid marketplace"

- Number of referrals to product vendors

- Green lease performance metrics

- People start looking at this and referencing this where to go; so utilities can see how to use this

"The team saw significant risks/delays in the time it would take the website to establish a brand identity."

2.2.8   Risks & Unknowns

The team saw significant risks/delays in the time it would take the website to establish a brand identity. This could be mitigated by associating the site with an existing trusted entity or web site. A related risk is that competing websites would crowd out the message.

While two business models were presented, there is some risk that neither is sustainable; or that to be financially sustainable, the site would need to give up vendor neutrality and its reputation as a trusted independent source.

The team saw six risks in this concept:

1) The website must be continuously updated with information from local utilities on incentives.

- Data centers have found the current incentive structure:
  - Hard to understand
  - Volatile without warning

2) The website must be continuously updated with links to other websites where best practice information resides.

3) Websites already exist for bigger data centers — confusing the messages.

4) Getting both facility managers and tenants to input information about the embedded data center given their concerns about.

- Data security (anonymity)
- Accuracy of the information
- This solution may need to partner with them to minimize the duplication of effort and content

5) This solution may require a funding model that goes beyond the voluntary participation for a fee that has driven organizations like The Green Grid.

6) The peer review process creates too large a hurdle to the submission of content for the site.

2.2.9 Final Recommendation

The team sees the website clearinghouse as the critical market intervention and key to supporting the other interventions and the success of deemed programs. The team recommends that a coalition of utilities and interested parties implement this program. We need to understand the flow of decisions in this market; the website must align with the objectives of each of the market players. Creating a logic model of the website will help drive the website structure and functionality.

The pay-to-play model does not work, since the website needs to be a place where small and large vendors can play. The team recommends exploring transaction fees, subscriptions, commissions, and a model where utility companies seed financing to get discounted membership and enough vendors in system. After that, with the content and the marketplace, there should be enough visitors to self-sustain.

> *"The shared savings approach could offer the DC manager a way to improve operations and use the resulting energy savings to pay for the improvement."*

2.3 Shared Savings

2.3.1 Definition

The Shared Savings approach could use any entity (ESCO, Utility, Building Owner or Third Party Implementer) that would offer data centers a way to improve operations, including energy efficiency, AND which is paid for by the resulting savings.

This could be the "Energy Services Company (ESCO)" model for data centers. Here, the shared savings implementation company would provide new IT, Power or HVAC equipment that would improve performance and reduce energy use. The company would then receive a portion of the energy savings as compensation.

The entity would provide services such as:, data center metering (to show energy savings); auditing and incentives for the audit; due diligence in reporting; identification of specific opportunities; project implementation support; development of a custom rate schedule for data centers; and help to secure utility incentives.

2.3.2   Operational Detail

A for-profit organization or ESCO firm could expand its services to embedded data centers. A new/ modified model should be implemented to capture savings and then find a way to share the savings. Intervention depends on size. Anything over a 2,000 sq. foot data center has professional managers. The challenge is that when ESCOs or third party implementers conduct audits, the data centers in the building are left alone because they are too complex to deal with. The cost/benefit ratio has not been analyzed yet; the assumption is that it is not cost-effective to conduct audits specifically for embedded data centers.

ESCOs and third party implementers prefer to work with buildings that do not contain embedded data centers since the embedded data centers make the measurement and validation (M&V) of the overall project more difficult. To implement this program requires a standard (easy, low cost) audit tool that would enable ESCOs and other players to accurately assess the potential savings in the embedded data center.

In a performance-contracting pilot with DOE, the highest value benefit was the labor cost savings. In this market, the value-add is security, not labor or energy. Embedded data centers are very vulnerable to cyber-attacks. One solution is rather than making these embedded data centers more efficient, we help you make them more secure.

It is expensive for small companies to migrate to the cloud. A shared savings entity could consolidate a hub of all data centers in the building and find a way to partition it for operational use for smaller companies. Those without air handling are outside the scope.

The Shared Savings program would provide:
- Data center metering (to show energy savings)
- Personal approach to DC manager
- An initial audit that covers:
    - How is the building operating with specific focus on data center
    - What are the constraints, lease or owner occupied
    - Cradle-to-grave approach
    - Providing due diligence to report in C-suite language to help obtain funding
    - Help with implementation of the project

- o Five-year savings model at which point the company continues with M&R or keeps the implementation entity on board
- Incentives to help fund the audit to ensure the firm engages an entity that meets the program requirements for energy efficiency deliverables
- Custom rate schedule for data centers for utilities
    - o Includes incentives for encouraging efficiency improvements

The entity shares in the cost savings the client receives which aligns the entities motives for the audit/implementation/M&R with the client's and energy efficiency.

2.3.3 Value Proposition

The value proposition to the data center manager and the facilities manager is they would have a partner that will help them implement changes to the data center with less (or no) upfront costs. This approach also shifts the burden of working with, and learning the language of, facilities managers, power equipment vendors, HVAC vendors, and utilities to the shared savings implementation company.

The value proposition for consolidating locally (for example multiple tenants collocating in one building) is the ability to physically see and lock up your own servers while moving to a secure, well-designed room.

These may be a new lease (renew) opportunity and it also may be possible for the landlord to write a green lease where they share the savings using a sub meter and so it is clear to know who benefits from these savings.

Another option is for building owners to convert some spaces into a data center co-located in the building, the co-location is an amenity, allowing the building to charge higher rent and attract higher quality tenants. This could be an add-on piece to existing ESCOs, not a new ESCO model.

One way to gain the efficiencies and make small projects profitable is to have a shared saving contractor that specializes in embedded data centers. The initial costs could be subsidized to help this specialist emerge and/or create a market for such specialists. During building rehabilitation, you may have the opportunity to consolidate the data centers.

2.3.4 Finance & Administration of Solution

The Shared Savings implementation entity could be an independent for-profit company or an add-on business to an existing ESCO. Existing ESCOs could offer data center programs as an expanded service to existing and new customers.

Alternatively, the third-party entity could be a property manager who identifies embedded data centers informally or contractually in the lease. Finding and possibly engaging property managers could be facilitated by changing the standard lease or the law so that data center energy consumption disclosure is required by the lessor.

The financial model could be a traditional ESCO, or the utility could contract with a service provider to provide super-efficient DC or a utility shared-savings model.

Figure 10: Shared Savings Services and Funding Flows
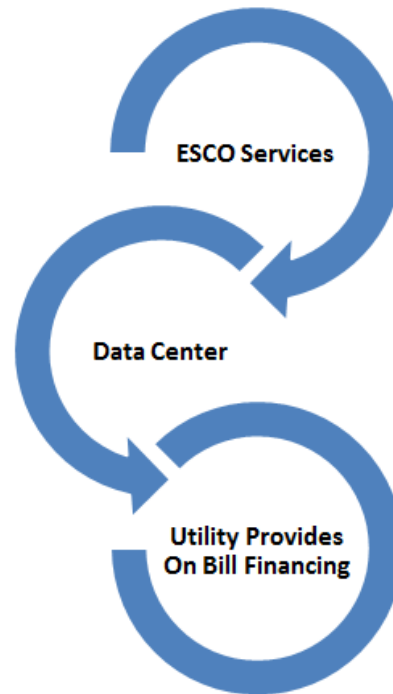
The focus on incentives should be structured in a way that it pays for the number of consolidated servers and the closing down of data closets with a reuse of closet space.

One of the benefits of using an outside resource is the implementation or facilitation of the solution, therefore the implantation entity has to have:

- Project management skills
- Technical IT and HVAC/Mechanical skills
- Marketing and outreach skills

The work group suggested that the potential savings could be 10 cents/kWh with a server life of three to five years, and to be a viable business model the entity may be able to invest a few hundred dollars per server.

2.3.5 Marketing & Outreach Approach

Since VARs (SMB-Large) or OEMs (Enterprise) work with these data centers today, they could be the primary channel to find and engage them. The program could even leverage the data center audits done by VARs — often funded by OEMS — which profile the IT hardware in the data center. Leveraging audits already being done would create a streamlined experience for customers.

2.3.6   Market Players

This program involves fewer direct players as the primary decision makers are the IT/data center managers and CFOs. The property/building owners and managers will be involved in execution and the implementation entity.

This market intervention is applicable to all market sectors.

2.3.7   Success Metrics

There are two broad measures of success, the first is the ability for entities (Shared Shavings Implementation Company, ESCO, Utility) to sustain an ongoing business, and the second are measure of the energy saved versus public goods dollars invested.

Measures of the business health are revenue, profit, the willingness of the firm to stay in the business.

Measures of energy savings are kWh saved, persistence of the savings – particularly that eliminated servers are taken off-line and that the replacement servers are not retired earlier than planned, M&V acceptance, and client's cost savings.

2.3.8   Risks & Unknowns

The team saw five risks in this concept:

1) It is against the law for non-utilities to resell energy, complicating how entities could contract for shared savings programs. Implementing this concept may require changing laws or utility regulations in some states.

2) Companies may be hesitant to share their data center information with third parties. The contracting entity may need to establish a reputation for confidentiality before the concept can become widely used.

3) Legal or lease terms may prevent the firm from treating the data center as a separate entity within the building.

4) The communication with data centers as outlined in the marketing section assumes someone can or has the system to track the existence and communications with these data centers. Today utilities do not have the systems to track this information. There is some risk finding a suitable, secure way to handle the data and communications makes the program too expensive to implement.

5) A small company may find a project requires a significant amount of engineering expertise to identify opportunity/solution and a significant amount of work in implementation. Therefore, the company will either do nothing or invest the effort in moving to the cloud.

Projects may be too small for any entity to be involved — need to understand the threshold of how small each of the potential implementation methods (ESCO, Utility, and third-party implementers) could go.

2.3.9   Final Recommendation

The team recommends piloting the concept to see if there are enough savings to justify the program. The team recommends that a project be created to:

- Determine potential
- Determine M&V to develop a new cost-effective protocol
- Address regulatory issues with cloud-based consolidation
- Verify that there isn't a persistence problem with closets being reused

2.4 Strategic Energy Champion

The team included two members with experience in strategic energy management experience. The team could not demonstrate that creating a Strategic Energy Champion program would produce significant results. While conceptually attractive, the team found the resource cost to support a Strategic Energy Champion and the barriers to effective changing would make the costs exceed the savings. However, the team did outline the operational issues. If some of the concepts can be incorporated into other programs at lower cost or effort, they are worth consideration.

"A strategic energy champion needs to understand the local utility regulations and offerings."

2.4.1   Definition

A Strategic Energy Champion program is designed to support self-selected individuals who would receive training and coaching to help them promote energy efficient considerations and solutions within their firm/data center. The program would also help the champions receive recognition and encourage corporate support for the program as part of a company's sustainability program. The program will attract future champions by encouraging recognition of the Strategic Energy Champion and the programs they create.

One alternative is to outsource the role to a Consultant, Co-location Provider, or Cloud Provider.

The program would provide consultants to help the champion:

- Develop the necessary skills and facilitate internal meetings
- Launch/manage projects that support rating systems such as LEED and other data center-specific metrics
- Design tools, including case studies that include utility incentives

2.4.2   Operational Detail

The champion would help with all venues/areas in building. The following deals with the specialized needs for their work with their embedded data centers.

The program would provide support for the champion through:

- Consultants to help build a champion:
    - Identify their company's opportunities/needs such as improved efficiency, reduction in cost of energy, etc.
    - Launch and manage projects
    - Leverage utility resource conservation managers

- Specialist in rating systems
    - LEED
    - Living buildings
    - International energy efficiency ratings

- Tools:
    - Listing of available resources
        - Codes
        - Incentives
        - Energy cost
    - Design review consultant — an inaugural charrette is held with all stakeholders who are credible and brand agnostic to understand all brands and implications of everything that is out there
    - Case studies

A large IT firm, Tibco, has a sustainability plan that works. Based on the company's green mandate, individual champions within Tibco have driven adoption of energy efficiency programs. However, scaling to a smaller company still needs to be worked out.

The strategic championship role needs to understand local utility regulations and offerings. While this may be impractical to provide via Strategic Energy Champions, the "website clearinghouse" could fulfill this function.

Sustainability champions in small organizations often do not address energy efficiency and have not gotten involved in data centers. Without prior experience, the team could determine the cost of coaching these individuals on the potential benefits of pursing energy efficiency in data centers.

The recommended next step is to pilot the concept to see if this is better served by Strategic Energy Champion Coaching or tools and education via the website clearinghouse.

One option is to see if the utilities can support a Sustainable Energy Manager can fill this role for small companies.

To motivate internal/external stakeholders to get small to medium companies to participate in energy efficiency measures the champion must:

- Get the involvement of infrastructure managers as well as IT managers
- Show IT the benefits (benefits they need, uptime, security, etc.)

- Use design tools, case studies, reference designs to help move project forward (utility)
- Obtain vendor quotes based on design selected
  - Reference designs: provide customer with multiple DC EE design choices
- Determine a payback period on project and energy savings
- Provide education and training program

Where legislation drives efficiency and holds firms accountable, the Strategic Energy Champion could be offered as a way for companies to get started. We also see C-level support driven by company values or PR/Corporate positioning.

2.4.3 Value Proposition

The value proposition to a future champion is the personal satisfaction they will receive from reducing the energy use of the firm/data center as well as public recognition for their accomplishments. The value proposition to the company and company executives is the recognition and bragging rights, which the program would elevate to be on par with LEED and ENERGY STAR - reorganization that could be included in the corporate sustainability report.

The value proposition to the data center manager or IT manager is that working with the Strategic Energy Champion will help them measure power utilization and reduce current power consumption to ensure they have power available for future growth.

> *"Where legislation drives efficiency and holds firms accountable, the Strategic Energy Champion could be offered as a way for companies to get started."*

2.4.4 Finance & Administration of Solution

Small and medium businesses do not find it profitable to employ a Strategic Energy Champion (except if needed in response to legislation). A Commission-funded program cannot afford to fund the position in small and medium businesses. The outsourced (shared) model has not been tested but may suffer the same cost versus return constraint.

The key is to integrate IT and the person responsible for paying the bills, typically the property manager. If the utility can provide sub-meters for data centers, it could provide the necessary focus.

As an example, Roche provides a top-down directive. By 2022, they must get rid of all halogen systems. Data centers have stand-alone DX systems. This would be an example of what the energy team would be spearheading.

2.4.5 Marketing & Outreach Approach

Finding new candidates to be Strategic Energy Managers and C-level executives willing to support the concept requires a mass-market communications program. It is unclear it can be done in a cost effective way except as part of another program — either in the other market

interventions or via utilities, VARs, industry/peer groups, or others with regular data center contact.

The marketing message should focus on how it addresses a primary data center concern — reliability. Because data centers are risk adverse, the marketing needs to contain case studies and demonstrated results. To launch the program may require finding the early adopters and creating a reference (Program) design plus a demonstration/case study.

2.4.6   Market Players

This market intervention uses an internal or outsourced Strategic Energy Manager as the interface to all of the relevant market players: IT/data center managers, C-level managers, Utilities, Building/facilities managers, and potential IT and HVAC vendors. Insight into options could come from IT information sources such as Gartner and Forester as well as the website clearinghouse.

An emerging player is the cloud vendor as a strategic cloud champion. One option is to help the cloud vendor promote the energy efficiency benefits of moving to the cloud. Further exploration is required to understand when this would be appropriate and whether load shifting would be problematic.

2.4.7   Success Metrics

The success metrics should include:

- Energy savings (kWh saved)
- Quantification of non-energy benefits
- Program cost-effectiveness (administration cost per kWh saved)

There is a need to institute a national energy efficiency certification program that involves IT.

2.4.8   Risks & Unknowns

The team saw several risks and open questions:

1) Talent failure — finding people who have the skills and the drive to become the Strategic Energy Champions.
2) Warranty/performance guarantee that may be required if companies are asked to create a support a Strategic Energy Champion.
3) Changes happens quickly — keeping a Strategic Energy Champion current on the changing equipment and best practices in data centers that they can drive change.
4) Unclear we can create a system (business model) that includes charge back and standard rates (utility non-revenue meter) to provide them with information they need to make decisions.
5) Unclear we can engage third party implementers to capture more information at audits (i.e. facilities engineers that audit buildings also audit data centers). There is a need to expand program scope to include other areas of the building.

2.4.9   Final Recommendation

The team recommends exploring whether part or all of the Strategic Energy Champion can be part of other programs. The challenge is to find cost efficient ways to (1) coach these new Strategic Energy Champions on how to influence their organizations, and (2) provide the information they need to identify opportunities to affect embedded data center energy efficiency.

3   Impact of the Cloud

In the final hours of the day, we held a panel discussion with three key individuals from leading players in Cloud infrastructure and services. The goal of the discussion was to hear directly from market actors regarding the trend and energy efficiency impact of embedded data centers moving to the cloud. Objectives were to start to understand who is using the cloud, what types of applications are hosted in the cloud, and what happens to the data center hardware/applications that move to cloud (e.g. if they continue to operate and use energy, if infrastructure is decommissioned, etc.).

The panel included:

- **Andy Broer**, Senior Manager, Data Center Operations at Box. Andy is responsible for space and power, server management, and SaaS. Andy is also a Certified Data Center Designer

- **Omri Guelfand,** Manager, Systems Engineering at Cisco. Omri is responsible for Systems Service Provider Clouds Solutions, Platform-as-a-Service (PaaS) and open stack

- **Jerry Condon**, Jerry Condon is responsible for Technical Product Marketing for HP's Helion brand: which includes HP Helion OpenStack: HP's distribution of OpenStack, one of the leading open source cloud platforms.

The panel moderator was **Chris Harty,** business consultant with QDI Strategies. Chris has 25 years' experience in IT channel sales, marketing, operations, energy efficiency, and supply chain strategy and optimization in the United States and Latin America.

When each of the panelists was introduced, they provided an opening statement (some comments have been moved to the specific topic sections for clarity). Following that, guided and open Q&A provided the content detailed below.

The remainder of this section reflects the dialogue between the panelists and the group, not the opinion of QDI Strategies or PECI.

Andy Broer with Box

Box uses multiple collocation facilities with only one small, embedded data center in an office. Box has no dedicated facilities staff. Box has a 1.25 MW generator in a garage for backup. The UPS is also in the garage. This may sound good, but as an operator with no facilities staff, Andy has become the default facilities manager. Thanks to the APC folks, he is notified when the UPS goes off, but the building power is not great; seems like there are regular internal brownouts. At the moment, the development is going to the cloud. Andy is pushing the software development work into the cloud. Box's C-level supports cloud. Box is moving into a new corporate headquarters so Andy is looking at this as an opportunity to move his data center to the cloud. Andy's goal is to have no IT room other than a place to test hardware.

Prior to Box, Andy was with Cisco for 16 years. Andy built the first Cisco Tier 3 data center (99.982% availability). Cisco went from two to 110 data centers while Andy was at Cisco.

Omri Guelfand with Cisco

Omri is part of the Cloud and management organization. He has built and designed data centers. We want to look at how energy will be shifted and used, specifically speaking about the cloud. Some companies have been born into the cloud; however, there are legacy companies with applications that are not in the cloud. Fundamentally, it is the end users that need to adopt cloud services and most have not yet done so.

In reality, many uncontrolled/unmonitored cloud based resources are used by different groups within a company. This can create many challenges for CIOs in that services need to be delivered in a more agile way. CIOs need to gain control.

A Hybrid model is the best model for IT resources to deliver to companies, which includes co-location facilities and other platforms. The hybrid changes the way the CIO performs.

Cisco acknowledges that this is not currently happening. Therefore, Cisco will offer this as a service. Cisco will offer a global cloud product that integrates on the ground services as well. Will cater to the specific business types and needs. Cisco will help drive the adoption of cloud services.

> *"A hybrid model is the best model for IT resources to deliver to companies."*

Cisco has been building tools; Cisco partners create Data Centers to deliver cloud-based services. A lot of the shift to the cloud is led by development; faster ability to provision services, increase capacity, and scale.

Using the cloud enriches the service offering of the Data Center but also helps the CIO gaining control.

Jerry Condon with HP

The solution for many organizations will be the hybrid cloud. The cloud discussion is not about sending applications to Amazon or others, but rather it is also about "on premises" and embedded data center; there are certain workloads that you are just not going to get rid of. Applications with high privacy or seasonal needs are things firms would keep on premises.

We use a simple classification: Pandas, Pets, and Cattle.

- **Panda:** When something happens to a panda, everyone goes nuts, the whole world notes it. That is what some of these servers are like; if anything happens, they will nurse it back to health at tremendous cost; thousands of dollars to nurse back to health and everyone knows.
- **Pets:** We nurture it, but there is a line, we draw it somewhere. We really want to bring it back to life.
- **Cattle:** If something happens, we get a new cow.

That is how we use this as a metaphor. When we are thinking about moving applications to the cloud, we are thinking about the cattle. In the cloud you do not fix the server, you pitch it and put a new one in. That is what the cloud is. The fundamental architecture is designed to fail. That means there is an enormous amount of skills and culture of that kind of environment. So how can you go to the closet and say throw it out? These are pets and sometimes pandas. The local server room has 10-year and 15-year old servers, we have seen them and they are still there.

3.1 Moving to the cloud is no longer an either/or proposition

To understand the difference between a data center and a cloud, start with the concept of virtualization — applications running on a virtual machine. Virtualization is "cloud lite" — it is more about automation though, the self-provisioning of services and measuring how resources are consumed on an hourly basis. It is building a front-end. Cloud is a traditional IT workload, on any server on the planet.

You can have a cloud on a laptop or 10,000 servers in Utah, but the scale is different. Because laptops can run 10 virtual machines (VMs), but not 10M VMs based on memory and storage; it is the horsepower of the system itself. It is a traditional workload put on a server somewhere; so the cloud is an abstract layer. From a user's perspective, it is irrelevant where the machines are located.

Hybrid is the next business model for companies. In the IT world [historically], over provisioning is practiced. You look at the peak demand and provision for the peak. This is the way most data centers have developed; you overprovision because you do not have the ability to scale. You have a factor of three- and four-times the storage, capacity, and networking needed. "You would think we were building battleships here." We see it based on culture.

A private cloud would run in the embedded data centers. It is an "on premise," inside-the-firewall cloud. A private cloud can run within the business/data center. A public cloud could be used by anyone, anywhere. A company could also customize and make it "private."

You can burst work between the private and public cloud — running in your private cloud, then when you need more resources shift some work to a public cloud.

3.2 "Fork lifting" and redesigning

Fork lifting applications to the cloud means just moving it You will not get many of the benefits of the cloud other than someone else runs the hardware and provides higher server utilization. Redesigning is when you put an application into the cloud so that it

> *"Redesigning is the most daunting activity. It requires lots of skill sets and culture change, but there can be large savings."*

can scale, and continue to run when components fail. Redesigning is the most daunting activity. It requires lots of skill sets and culture, but there can be large savings.

3.3 Certain apps are born in the cloud

Box always wanted to be a cloud provider. Therefore, Box moved the business model entirely over to the cloud. Moving forward, all business decisions are evaluated with cloud migration in mind.

SharePoint was designed as a local application, so it lacks flexibility. Box was built in the cloud and provides some of the same functionality in a more adaptable and flexible model.

If you have a cloud-based service from a remote location, it will still have latency and connectivity issues.

3.4 People will migrate and stay there (Amazon, Salesforce, Box, etc.)

Moving to the cloud is like checking in to the Hotel California; once an application has moved to the cloud, it will never check out.

3.5 Migration depends on the workload being done

The question is whether there a benefit to have some data on your premise. Certain workloads dealing with privacy and seasonal issues are required to be kept onsite. Are there more scenarios like this that would increase the need for onsite-only data access?

The fundamental idea of the design of the cloud is that it assumes components will fail. Properly designed applications will continue to run in the cloud even when hardware or software component fails. The management of the cloud is what is important to control.

> *"Moving to the cloud is like checking in to the Hotel California; once an application has moved to the cloud, it will never check out."*

For example, ERP Systems that have been the standard of local virtualization would not be good candidates for cloud migration since investment costs and time commitments are too cumbersome. The idea is to utilize the cloud in the situations where it is cost effective.

When addressing the strategy about how to take on embedded data centers and what that means, we are not talking about Amazon or HP public cloud. It is about the workload that is on them. Companies must identify the proper workloads. Not all clouds are created equal and not all workloads belong in the cloud. There are ones that can be optimized for cloud computing, as well as, ones that do not belong there.

The net result of this is that embedded data centers are not going to go away.

3.6 Every application has an ROI – which ones are worth moving to the cloud

If I am in a data center, how do I figure out which servers are going to the cloud? It is the ROI of doing

> *"The net result is that embedded data centers are not going to go away."*

the work to move to the cloud versus the cost effort to package the application for movement to the cloud. For a legacy application, the question is "How easy is it to move it to the cloud?" Applications that depend on high performance computing, are complicated production-critical applications, or have regulation/compliance issues are not good candidates for moving to the cloud.

It would be migrated if the application were in the business layer, the elements of this particular application or piece of data. How much work is it to forklift the application — shove it in a moving box and move it to the cloud?

Other options are to find the software that allows you to migrate what you already have. Alternatively, you could wait for the next technology to come out. This might be the answer to your business layers. You may want to consider the migration part of moving to the cloud — how much work is the migration. You can augment capacity by slowly moving to cloud. Some organizations start with desktop applications. The thinking needs to go above the infrastructure. Need to analyze the cloud platform to see what really fits the underlying infrastructure. Look at workloads and their capacity.

Every application has an ROI and has a business decision based on the needs of the app or the developer who moves with the application. There are two basic assessment criteria: (1) How easy is it to move? and (2) What is the ROI?

It is incredibly easy to move development-centric applications to the cloud for high performance. They are in the magic quadrant. On the low end are complicated production critical applications and homegrown apps that have enormous amounts of compliance and regulation. These probably never even made it to the virtualization world (e.g. these applications have unique needs and are not able to be virtualized).

3.7 Certain business layers can move easily

You can look at moving by business layer — move it without touching anything else. Contain the application and move it to the cloud. The redesigning is the one task that is the most daunting because it requires skills and culture, but this has benefits. Go out and find the SaaS that will allow you to migrate whatever you have, and what your workload and rebirth it in the cloud. There are painful details to this; it is not as simple as "it is in the cloud now." The argument is that some apps you just cannot remove. Might even argue to wait until the next wave of technology; that might be the answer to some of these HIPAA systems, etc.

3.8 Netflix

Check what Netflix does in the cloud — they are 25% of internet traffic in prime time. Instead of using their own data centers, they went to Amazon and asked them to improve their cloud to enable them to stream.

Netflix was agile and had a culture to change. Was able to develop their offerings and develop fast to market product. They drive traffic to TV shows that they want you to watch. They are

always rolling forward, cannot do the agile development they are doing outside of the cloud. It is too fast.

Netflix wrote applications to fix Amazon's cloud — then open sourced those applications to have the world save it. Netflix has one developer to 25,000 vertical machines (VMs) versus the one to 200 typically in most development groups. Netflix built a new campus for their developers — all of them are in Los Gatos. They have incredibly fast production and time-to-market. You can only do this in the cloud. In a "Pets" environment hold on for dear life — do not ever let go. At Netflix — opposite-culture is cow — use thousands of VMs, but when the person is done then release them for someone else. Netflix use Chaos Monkey to test their software can withstand disruptions. They use auto-scalers to determine the resources they need depending on time of day, etc.

Chaos Monkey — when you are developing an application, there is an app that goes around and shoots VMs, blows them up. Therefore, while you are development, the machines go down so you can test the resiliency of the cloud. Resiliency is a tremendous part of the cloud; if a virtual machine fails, self-healing fails. For the cloud, everything is designed to fail.

3.9 Security

Security — when looking at smaller enterprises, a cloud based service provider provides very good security. It is secure and encrypted and the security is usually much higher than you could do yourself.

Security is based on the fact that there is an environment where tenants cannot see each other. Financial sectors are not in the cloud. They are very private and are looking at a hybrid-cloud services being offered on the same workload. This service pulls data from the cloud that is secured and opens data from another place (non-cloud). Clouds are built as much to keep the information within secure walls, as they are built to keep people out.

Most of these breaches are in California. Going to the cloud does not mean it is not secure; instead, it could be that the company is the issue and that they need to run tighter security. Companies need education on security and on how to effectively implement security measures.

There is a lot of security in the public cloud. Many people are in the cloud and the data and applications are running securely. As in a co-location, there are many tenants who cannot "see" each other. On the other hand, the financial sector has a lot of contractors and third parties. In addition, usually a third party is the full backend. For example, Target has failed several times, but a contractor or partner was always at fault for the breech. In the financial sector, they are not in the cloud because they deal with financial data and the idea of having exposure to any other cloud tenant is a risk.

3.10   Cloud adoption by industry and size

As a cloud-based file sharing platform, Box services every possible vertical and every business size. The slowest verticals are government and finance, while the fastest appear to be healthcare and education.

Healthcare appears to be adopting faster because they have a large R&D budget at their disposal. When you see regulation such as the Health Insurance Portability and Accountability Act (HIPAA), this helps adoption rates moves faster.

In 2013, spending was $30B on cloud adoption across all industries. The data suggests that the annual growth rate in SMB organizations regarding cloud spend is 40%. Experts predict that in a few years this spending will increase to over $40B. Data also suggests that there will be more cloud computing and that the government will see 50/50 spending between private and public cloud users. Box already sees the government moving into the cloud, but these clouds are private clouds for security reasons. Notably, however, all panelists recognized that cloud adoption is running behind expectations.

When you look at most segments the core applications will lag in adoption. Most companies are already at capacity for existing services; so they will likely keep the core applications on their own servers, and outsource the non-core to cloud services.

We are seeing increased growth in data center spending on data, as well as growing demand for cloud services, which suggests that the embedded data center is not going away as people move to the cloud.

3.11   Keep the core, outsource the rest

The key for businesses is to identify those business applications and operations that are core to the business. These will generally remain on-premise in embedded data centers. Those applications that are non-core, can, should, and eventually will be moved to the cloud.

"We are a long way from when embedded data centers will go away."

3.12   Decommissioning of servers after the application migrates to the cloud

Storage growth stops, but we cannot answer if the servers are turned off. It appears to depend on the company's culture. Some companies have a culture of wanting to adopt new services like the cloud. Some of these want to figure out a way to reduce power usage and want to listen to what cloud people have to offer. Other organizations are moving applications to the cloud but may not be looking at what to decommission.

Cisco is not a network service. We are looking at SaaS offers and solutions. We will partner with other companies to bring solutions to market, such as software and hardware as a service. HP is normally in the hardware service and sales service business, but runs a cloud that is agnostic. We are a provider. The SaaS offering is not something we look at. We are developers developing cloud services.

We are a long way from when embedded Data centers will go away.

4   Findings and Conclusions

4.1 Summary of Market Interventions and Deemed Programs

As the data center workshop teams tackled what product categories were appropriate for deemed programs and how to make the market interventions operational, several common requirements and themes emerged:

- Data center managers are generally not held responsible for energy efficiency and lack the time and resources to improve it.

- Information and tools are needed to help data center managers and their internal stakeholders/ other decision-makers make good decisions about energy efficiency and effectively communicate the value to the C-level.

- Data center managers would prefer one trustworthy source for their information.

- Additional data center or tenant support services might be needed to move the market, such as helping data centers quantify energy and non-energy benefits, or managing projects.

> *"Data center managers would prefer one trustworthy source for their information"*

- Agreement and/or standardization on data center efficiency/performance metrics is required to support new sets of deemed measures.

- The rapid advancement of technology in the data center space makes it difficult to support specific products through deemed measures.

In addition, the teams provided new insights into indirect ways to improve energy efficiency. Some types of energy efficiency improvements could be driven by:

- Educating data centers about improvements that can help them better deliver their primary objectives — performance and reliability — and improve energy efficiency
    - For example, showing data centers that free cooling cuts down on risk (improves reliability) because it removes the mechanical cooling chance of failure and would result in a secondary benefit of improving the data center's energy efficiency.

- Helping managers of embedded data centers break out of the cycle that prevents them from planning for energy efficiency or pursuing it once a data center is up and running. Changes in the data center, such as additional servers, storage or networking capabilities, are generally made on an ad-hoc basis in response to critical business needs. Once they are running, operations are too critical to shut down or fix, and growth becomes unplanned.
    - For example, providing a combined assessment of data center operations (IT, Power & Cooling) to identify opportunities to improve energy efficiency before the next cycle of unplanned growth or change would be very valuable to customers and drive the adoption of deemed savings programs. These assessments

are done by IT resellers and HVAC contractors today. The key is to do *more* of them.

4.2 Assessments

One theme emerged across program designs: standard assessments. Assessments are tools that could exist in the Website Clearing house, Shared Savings and Strategic Energy Champion programs. Assessments conducted by VARs and OEMs are critical to the implementation of deemed programs outlined by the teams in this research.

Participants in both the Seattle and Silicon Valley workshops indicated that assessments are a key tool in improving data center efficiency. Assessments, when conducted by IT Resellers and HVAC/Mechanical contractors familiar with a customer's infrastructure and needs, can provide a clear roadmap for improving energy efficiency, and demonstrate the potential payback of energy efficiency to the customer. The Website Clearing House, Shared Savings, and Strategic Energy Champion market interventions all incorporated assessments into their structures. Deemed measures also relied heavily on the assessment process to identify opportunities for improvement and to "get the ball rolling."

IT VARs and HVAC contractors are already accustomed to providing assessments of data center IT and HVAC equipment. These existing types of assessment could be the platform for the data center assessments described in the concept build-outs. The build-outs specifically outlined the need for a "combined" assessment, incorporating IT, Power and Cooling into one. The equipment vendors and channel partners are willing work to with someone to create a **standard assessment** that would meet the requirements described in the work session:

- IT resellers and HVAC contractors Vendors need a standard assessment, not one that varies by utility
- They need a standard selection, execution, and funding process, not one that varies by utility

As assessments can be expensive in cost and time, feedback from all groups indicates that providing **financial support** to vendors (resellers and contractors), in the form of a cash incentive to defray the cost of each assessment, would result in MORE of these assessments.

"Financial support to vendors (resellers and contractors), in the form of a cash incentive to defray the cost of each assessment, would result in more of these assessments."

- Utilities can financially support assessments as an inducement for resellers and HVAC/mechanical contractors to perform more of these. Customers, having the results and a roadmap, would be more likely to pursue these projects to improve efficiency.
  - o Total number of assessments before and after incentives could be tracked, in order to demonstrate results
  - o Total projects completed as a result of assessments could also be tracked, in addition to resulting (estimated) energy efficiency

- Borrowing a mechanism from the IT channel, utilities could use some form of "deal registration" to track these projects.
  - o The result is a significant level of demographic and other information on embedded data centers in the territory

Key details regarding assessments were identified as:

1) Data center assessments
    a) The assessments can/should cover IT equipment, power equipment, and HVAC
    b) Equipment resellers have performed versions of this when funded by manufacturers
    c) Embedded data centers also need implementation project management's assistance

2) Website clearing house can provide needed information to support assessments
    a) There is a huge need for information about how to improve data center efficiency
    b) Green Grid and TC9.9 have created similar web sites but there are perceived or actual barriers that preclude their ability to act, including:
        i) Member-only access
        ii) Funding sources and missions do not align
        iii) Funding may not allow them the resources to keep them updated
        iv) They do not have the necessary relationships or partnerships with utilities to bring utility incentives and other critical types of information to their core audiences

> *"Green Grid and TC9.9 have created similar web sites but there are perceived or actual barriers that preclude their ability to act."*

3) Set incentives standards to support deemed approaches
    a) Open Compute standards
    b) Defining a class of products or solutions that qualify

4.3 Conclusions

PG&E is collaborating with Silicon Valley Power, City of Palo Alto, Lawrence Berkeley National Laboratories, and NEEA to explore how to drive energy efficiency in embedded data centers.

The *Silicon Valley Next Generation Data Center: A Workshop* built on the findings of the Seattle Workshop and focused on creating operational plans for three market intervention concepts and identifying potential deemed programs. Key outcomes include:

- A specific operational plan was developed for the website clearinghouse concept, which was the key market intervention identified in the Seattle Workshop. While some

questions exist, the work team and QDI see the website clearinghouse as an operationally viable market intervention to drive energy efficiency in embedded data centers.

- An operational plan was developed for the shared savings program. While the team was unable to address all of the operational questions, the team and QDI believe the concept is worth exploring further to design and pilot a shared savings market intervention.

- The strategic energy champion program does not appear to be a viable operational, stand-alone market intervention. The cost of the program would exceed the energy savings.

- The teams that focused on deemed measures identified a number of product categories for embedded data centers in healthcare, finance, government, and education where deemed programs could be effective. These discussions also highlighted that the deemed program would be more effective if they could leverage the current communication channels and potential market intervention activities discussed above.

As a common theme among market interventions, establishment of standard assessments as a program design element was identified as having the greatest potential to leverage deemed programs in the embedded data center market. The assessment program when conducted with an existing vendor, such as a VAR, contractor, or OEM, prepares customers to make the rapid decisions they will have to make in the months to come as the demands change on their data centers. Tying these assessments to deemed incentive programs can provide a method of financing these assessments, tracking the number of assessments undertaken and tracking the performance of the assessments in terms of increased energy efficiency

The Data Center Workshop highlighted the disparity between tools and solutions provided today by utilities and other organizations, and the perceived needs of the market. As such, it seems clear that significant progress to address embedded data center efficiency will not be achieved until there is a holistic approach to address key market barriers.

The self-reinforcing cycle provided by Assessments, Market Interventions, and Deemed Measures was a clear result of the work by the teams.

Assessments

For harried data center managers, assessments result in a "roadmap" they can follow to improve energy efficiency without sacrificing operational integrity or reliability, the two most important criteria for data center managers. Assessments currently exist today and are performed individually by utility programs, IT resellers, and HVAC contractors. However, the need exists to consolidate these into a single assessment with a common set of rules, metrics, language, and procedures. In addition, while the cost of these assessments can be a barrier, in the future, financial

> *"Establishment of standard assessments as a program design element was identified as having the greatest potential to leverage deemed programs in the embedded data center"*
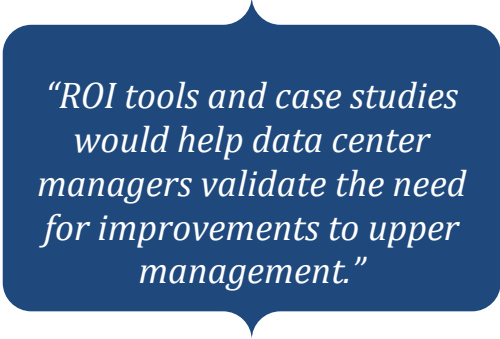
support to defray the costs could result in more of them being performed. This would provide more data center managers with the roadmap and business rationale to justify energy efficiency improvement projects.

Market Interventions

All workshop participants noted one key market intervention — an integrated and information-rich website. Such a website would address both the scarcity of information targeted to embedded data centers, as well as, the need to have information that is vendor-neutral and vetted by trusted third parties or peers. The website is a technological solution that would enable key market players to access a library of energy-efficient solutions when they need it, effectively helping data centers within the narrow window of time that they have to bring in energy efficiency solutions. The website could also resolve the issue of a common language for embedded data centers and their ecosystem of market players. In addition, ROI tools and case studies would help data center managers validate the need for improvements to upper management.

The other interventions of Shared Savings and Strategic Energy Champion served to develop the following concepts:

- Dedicated expertise and resources to identify, develop and manage energy efficiency projects

- Specialized tools (such as assessments, metrics, ROI calculators) to support project justification

- Importance of sharing financial rewards with market players (IT VARs and HVAC contractors) who are in positions to promote these solutions

> *"ROI tools and case studies would help data center managers validate the need for improvements to upper management."*

Deemed Measures

Lastly, deemed measures were identified as ways to motivate the embedded data center segment to pursue specific behaviors to improve energy efficiency. A variety of technologies/products was identified as potential recipients for deemed measures — from servers and storage, to power and cooling. In addition, behaviors leading to server removal/decommissioning, such as virtualization, were identified as necessary to drive improvement in the market. While in the IT space deemed measures might have the power to drive desired changes by providing hard dollar incentives to market players and customers, the rapid advance of technology poses a challenge. The risk is that utility deemed measures based on specific products ultimately might not be able to keep pace with the advancement of technology.

Data Center Energy Usage Levels Off

Lawrence Berkeley National Laboratories published a study indicating the trend of Energy Usage in Data Centers for the last five years. Remarkably, the LBNL study (2016) found that the energy usage of enterprise-level data centers is leveling off. The LBNL results are not entirely

unexpected. Enterprise level data centers have been at the forefront of energy efficiency as a cost and GHG-reduction measure.
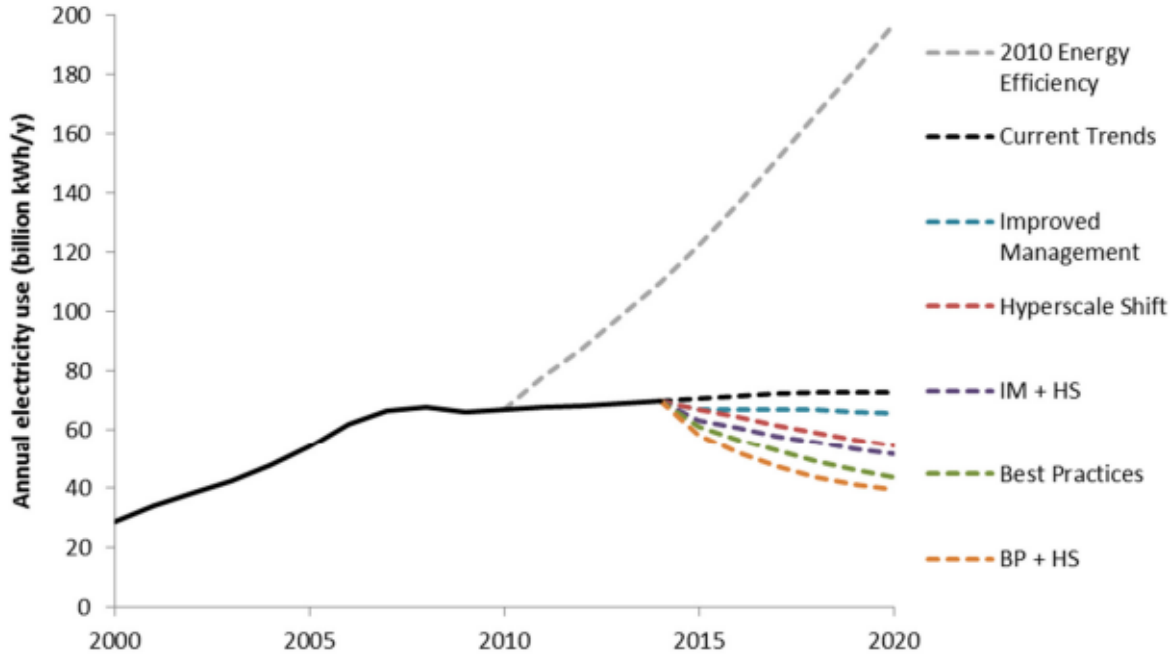

Figure ES-1 Projected Data Center Total Electricity Use

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

Source: Lawrence Berkeley National Laboratory United States Data Center Energy Usage Report (2016)
https://datacenters.lbl.gov/sites/all/files/DataCenterEnergyReport2016.pdf

With enterprise-level data centers in the U.S. consuming an estimated 70 billion kWh in 2014, representing about 1.8% of total U.S. electricity consumption (LBNL, 2016), the potential for additional savings still exists in embedded data centers. The challenge is the ability to aggregate the data centers across geographic spaces and companies to transform their operations and facilitate a move to a more energy efficient cloud solution.

Colocations and Renewable Energy

One initiative that has recently launched in July of 2016 is the Business Sustainability Roundtable's Corporate Colocation and Cloud Buyers' Principles. With the goal of powering the internet with 100% renewable energy, companies that rely heavily on colocation facilities will show preference to facilities that can adhere to six principles.

1. **Options** – Provide options for cost competitive services powered by renewable resources that reduce emissions beyond business as usual.

2. **Data** – Deliver monthly data on the cool client's direct and indirect energy consumption, water consumption, greenhouse gas emissions,

3. **Incentives** – Provide opportunities to align financial incentives for efficiency.

4. **Collaboration** – Provide opportunities for cool client collaboration on efficiency and renewable energy enhancement.

5. **Disclosure** – Disclose individual sites and total global corporate footprint, as well as site-specific energy sources.

6. **Advocacy** – Engage in policy advocacy efforts that support the use of renewable energy.

Companies engaged supporting the Cloud Buyers' Principles include Salesforce, Adobe, Akamai Technologies, Autodesk, CA Technologies, eBay, Etsy, Facebook, Hewlett Packard Enterprise, LinkedIn, NetSuite, Salesforce, Symantec and Workday.

Final Considerations/Recommendations

A truly holistic solution would address four principle dimensions:

1) **"National"/Regional Scope.** For the website content and other programs to be broadly useful and credible, the peer reviews must be conducted by nationally recognized individuals. The section on regulations must cover all or a significant percentage of state laws for vendors and other market players. The section on utility incentives must be current and cover a significant percentage of the country's utility data center programs.

2) **Acceptance of a reliable standard assessment process for equipment vendors and HVAC providers.** A process that has a standard assessment definition and is consistently executed the same way each time.

3) **Creation of services that do not exist today.** Some firms need project management services, often those described in the shared savings implementation company section of this report. Other firms need assistance in assessing lease property's ability to support existing and future data center needs — those described in the tenant support services section of this report.

4) **Changes to the utility and/or regulatory framework.** Implementation of the above needs regulators to be supportive of the approaches, and needs utilities to commit to the pursuit of deemed measures and program designs that can impact the energy use of the data center. The extended regulatory process to approve new measures and workpapers does not currently support the high-tech industry rapid evolution. Additionally, traditional arguments of free ridership exclude critical energy-saving software installation and management as a deemed measure. As an example, server virtualization is a prospective deemed measure but it is not allowable in some utility service territories. Support for deemed programs should recognize that these programs are complementary to a broader and holistic market transformation effort. Mixing deemed

and market transformation programs poses new challenges for program measurement and assessment that may require new approaches by public utility regulators.

While it is a challenging task to meet the holistic requirements above, it is encouraging that the work session participants saw that it was possible to affect change through program activities and targeted interventions, and that their organizations would participate in such programs. The market players acknowledged that this transformation might take years and require the participation and the support of other organizations.

PG&E has a unique position to help lead market transformation and develop effective program designs that overcome barriers to achieve energy-efficient embedded data centers. QDI recommends that PG&E continue to pursue program designs that take the next steps toward achieving this market transformation. For example, a program based on deemed measures that drives a standard assessment approach has strong potential in California. Strategically, QDI recommends that PG&E continue to work as part of a collaborative effort to support transformation of the embedded data center market, which continues to change and evolve as technologies shift and business applications move to the cloud.

> *"A program based on deemed measures that drives a standard assessment approach has strong potential in California."*

Appendices

Appendix A: Participant Guides

A set of one-page Participant Guides was developed to facilitate discussion during the workshop. The appropriate guide was provided to each workshop participant one week before the event.

Designing the Next Generation Embedded Data Center
Energy Efficiency Program Concept Summary: DEEMED MEASURES

1.	Definition

- o A set of data center-focused utility measures that have a simplified calculation approach. These measures have pre-determined estimates of energy and peak demand savings. These measures are used instead of a more complex, custom-calculated approach.
- o Typically designed for energy efficiency measures that have consistent performance characteristics with low variability. Deemed savings approaches may require on-site inspections to verify installation
- o Requires a standard assessment (audit) methodology that will enable collection of key inputs
- o Potential measures: Efficient servers, efficient UPS, storage optimization, server virtualization

2.	Value Proposition

- o Simplified measure offerings and predictable incentives for data center equipment will drive uptake of energy efficiency; a deemed approach will dramatically simplify program administration and M&V

3.	Finance & Administration

- o Each state or region will have variability in administration. California IOUs will require approval from CPUC prior to offering deemed measures
- o Increase in expediency of projects throughout the project lifecycle (application, audit, reviews and approvals) will attract more program participants and partners
- o New program design required, which will vary depending on which measures are candidates for a deemed approach

4.	Marketing & Outreach

- o VARs and OEMs of qualifying equipment are a key marketing channel. Assess potential for upstream incentives.
- o Marketing may require campaigns by utilities; industry organization involvement; strategic partnerships with other leading organizations

5.	Market Players

- o Primary audience: IT/data center managers; VARs and OEMs have strategic interests in helping customers secure incentives to help buy down the cost of their products
- o Sectors reached: All

6.	Success Metrics

- o Cost-effectiveness of program administration
- o Program uptake

7.	Risks and Unknowns

- o Significant work must be done to develop savings values and secure approvals from regulatory bodies
- o Technology shifts could rapidly impact savings values and must be assessed regularly
- o Potential that data center measures may only be candidates for a simplified calculator approach versus a deemed approach; May or may not be able to offer incentives for IT measures

Designing the Next Generation Embedded Data Center
Energy Efficiency Program Concept Summary: STRATEGIC ENERGY CHAMPION

8. Definition

- A program for Strategic Energy Champions supports self-selected individuals who would receive training and coaching to help them promote energy efficient considerations and solutions within their firm/data center. The program would help the champions receive recognition, and encourage corporate support for the program as part of a company's sustainability program.
- The program would provide support for the champion by utilizing consultants to help:
  - The champion develop the necessary skills and facilitate internal meetings
  - Launch/manage projects that support rating systems such as LEED and other data center-specific metrics
  - Design tools, including case studies that utility incentives

9. Value proposition

- Data center: Personal satisfaction and public recognition for their accomplishments with regards to EE
- Company and C-Suite: Recognition on par with LEED and Energy Star; sustainability metrics that can be included in the corporate sustainability reports

10. Finance & Administration

- Local utility administration, requires program design specific to data center environment
- Most effective if utilized with other program offerings, such as deemed measures, and/or other channels to broaden the message of efficiency (e.g. targeted website)

11. Marketing & Outreach

- Led by administering organization; if using an SEM model, requires coordinated recruitment of cohorts or "classes" of data centers which is typically conducted by a specialty consulting firm

- Must assess how marketing can be done cost-effectively, given the level of savings that are possible

12. Market Players
- Primary audience: IT/data center managers; C-level managers
- Sectors reached: All(assume customized content for specific sectors)

13. Success Metrics
- Energy savings quantified; non-energy benefit quantification (which includes…)
- Program cost-effectiveness (administration cost per kWh saved)

14. Risks and Unknowns
- Talent failure – Can we find people with the skills/drive to become Strategic Energy Champions?
- Warranty/performance guarantee may be required if companies are asked to create a support a Strategic Energy Champion
- Changes happens quickly – Must keep a Strategic Energy Champion informed about changing equipment and best practices in data centers so they can drive change

Designing the Next Generation Embedded Data Center
Energy Efficiency Program Concept Summary: SHARED SAVINGS

15. Definition
o The Shared Savings Implementation Company would be a for-profit company organized under regulations and incentives created by the state or public utility commission.
o A shared savings implementation company (SSIC) would offer data centers a way to improve operations, including energy efficiency, AND which is paid for by the resulting savings. This could be likened to the "Energy Services Company, ESCO" model for data centers. Here, the shared savings implementation company would provide new IT, Power or HVAC equipment that would improve performance and reduce energy use. The company would then receive a portion of the energy savings.
o The SSIC would provide services such as: data center metering (to show energy savings); auditing and incentives for the audit; due diligence in reporting; project implementation support; development of a custom rate schedule for data centers; and help to secure utility incentives.

16. Value proposition
o The value proposition to the data center manager and the facilities manager is a partner than will help them implement changes to the data center with less (or no) upfront costs. This also shifts the burden of working with, and learning the language of, facilities managers, power equipment vendors, HVAC vendors, and utilities.

17. Finance & Administration
o The Shared Savings Implementation Company would be a for-profit company; potential to be an add-on business to an existing ESCO; the SSIC shares in the client's cost savings.

18. Marketing & Outreach
o Potential for partner model with VARs or OEMs to ensure customers are linked to efficient products in a timely and organized fashion. This creates a streamlined experience for customers.

19. Market Players
o Primary audience: IT/data center managers; CFOs; Property/building owners and managers

- o Sectors reached: All

20. Success Metrics

- o Energy savings secured; which directly correlates to client's cost savings; profitable company

21. Risks and Unknowns

- o It is against the law for non-utilities to resell energy, which complicates how the SSIC could contract for shared savings programs. Implementing this concept may require changing laws or utility regulations in some states.
- o Companies may be hesitant to share their data center information with the SSIC. The SSICs may need to establish a reputation for confidentiality before the concept can become widely used.
- o Legal or lease terms may prevent the firm from treating the data center as a separate entity within the building.
- o Projects may be too small for SSIC – need to understand threshold for sizing

Designing the Next Generation Embedded Data Center
Energy Efficiency Program Concept Summary: WEBSITE CLEARINGHOUSE

o   A website and mobile solutions platform that IT and facility managers and other embedded data center decision-makers can go to find information and relevant, unbiased information about embedded data center optimization.
o   Key features include: Third party validation of benchmarking standards by industry experts tools and methods; database of voluntary declarations of data center metrics (e.g. benchmark, energy use, PUE); Zip code look up to relevant utility program incentives, codes and standards, and regional vendors; Video library: C-level summaries, technology demos, case studies, and how-tos; Tool library: Links to, built-in, or downloadable audit tools, airflow tools, ROI tools, calculators for NPV, ROI and other financials, total cost of ownership, etc.; Blogs, bulletin boards and chat rooms for participants to engage with other users; User rankings and reviews for all posted content; showcase of best practices for embedded data centers, green leases, operations and maintenance of small data centers; creation of "Open bid" opportunities for IT managers, facilities managers and companies looking to improve performance of hidden data centers; platform or forum to launch new concepts, ideas, approaches that promote innovation, energy efficiency and acceleration of the adoption of new EE solutions

22. Value Propositions

o   One stop website that provides quick access to information that makes an IT manager's, Facilities Manager job easier; Vendors have access to interested IT managers and Facilities Managers for projects and improvements; Discussion platform for IT managers and Facilities Managers to communicate about challenges and solutions; source where property owners can benchmark performance of buildings to maintain competitiveness

23. Finance & Administration

o   Sponsored by one key organization (e.g. The Green Grid, Open Compute, DOE, etc.)
o   Expensive, requiring hybrid revenue model from utilities, donations, key sponsors, subscriptions, link revenue; multi-year effort

24. Marketing and Outreach
- o Led by administering organization; campaigns by utilities; industry organization involvement; strategic partnerships with other leading organizations

25. Market Players
- o Primary: IT/data center managers; CIO's, CTO's and CFOs; Property owners; Property managers
- o Secondary: Vendors (HVAC and IT equipment and services), VARS, OEMs, etc.
- o Tertiary : Tenants seeking new space; Property Managers looking for tenants; financiers
- o Sectors reached: All: assume customized content for specific sectors

26. Success Metrics
- o Web analytics (e.g. web views, downloads, tools for benchmarking, numerous benchmarks established, uptake of review and rating system); number of incentive referrals from website to participating utility; number of transactions in the "bid marketplace"; number of referrals to product vendors; Green lease performance metrics

27. Risks and Unknowns
- o Insufficient brand awareness; Competing websites crowds out the message; long term admin; funding; support by trusted third parties; ability to be vendor neutral

Designing the Next Generation Embedded Data Center
Energy Efficiency Program Concept Summary: WEBSITE CLEARINGHOUSE

28. Definition
o A website and mobile solutions platform that IT and facility managers and other embedded data center decision-makers can go to find information and relevant, unbiased information about embedded data center optimization.
o Key features include: Third party validation of benchmarking standards by industry experts tools and methods; database of voluntary declarations of data center metrics (e.g. benchmark, energy use, PUE); Zip code look up to relevant utility program incentives, codes and standards, and regional vendors; Video library: C-level summaries, technology demos, case studies, and how-tos; Tool library: Links to, built-in, or downloadable audit tools, airflow tools, ROI tools, calculators for NPV, ROI and other financials, total cost of ownership, etc.; Blogs, bulletin boards and chat rooms for participants to engage with other users; User rankings and reviews for all posted content; showcase of best practices for embedded data centers, green leases, operations and maintenance of small data centers; creation of "Open bid" opportunities for IT managers, facilities managers and companies looking to improve performance of hidden data centers; platform or forum to launch new concepts, ideas, approaches that promote innovation, energy efficiency and acceleration of the adoption of new EE solutions

29. Value Propositions
o One stop website that provides quick access to information that makes an IT manager's, Facilities Manager job easier; Vendors have access to interested IT managers and Facilities Managers for projects and improvements; Discussion platform for IT managers and Facilities Managers to communicate about challenges and solutions; source where property owners can benchmark performance of buildings to maintain competitiveness

30. Finance & Administration
o Sponsored by one key organization (e.g. The Green Grid, Open Compute, DOE, etc.)
o Expensive, requiring hybrid revenue model from utilities, donations, key sponsors, subscriptions, link revenue; multi-year effort

31. Marketing and Outreach

- o Led by administering organization; campaigns by utilities; industry organization involvement; strategic partnerships with other leading organizations

32. Market Players

- o Primary: IT/data center managers; CIO's, CTO's and CFOs; Property owners; Property managers
- o Secondary: Vendors (HVAC and IT equipment and services), VARS, OEMs, etc.
- o Tertiary : Tenants seeking new space; Property Managers looking for tenants; financiers
- o Sectors reached: All: assume customized content for specific sectors

33. Success Metrics

- o Web analytics (e.g. web views, downloads, tools for benchmarking, numerous benchmarks established, uptake of review and rating system); number of incentive referrals from website to participating utility; number of transactions in the "bid marketplace"; number of referrals to product vendors; Green lease performance metrics

34. Risks and Unknowns

- o Insufficient brand awareness; Competing websites crowds out the message; long term admin; funding; support by trusted third parties; ability to be vendor neutral

Appendix B: Facilitator Guide

A one-page Facilitator Guide was developed to facilitate discussions during the workshop, and enable quick scribing of notes to capture conversation and dialogue during the workshop's breakout sessions.

Silicon Valley DC
Workshop - Deemed -

Silicon Valley DC
Workshop - Energy C

Silicon Valley DC
Workshop - SSIC - Fa

Silicon Valley DC
Workshop - Website -

Appendix C: Cloud Panel Facilitator Guide

A one-page Cloud Panel Guide was developed to facilitate discussion during the cloud panel, and included initial research questions of interest.

Silicon Valley DC
Workshop - Cloud Par

Appendix D: Measure Summaries

PECI developed a set of brief measure summaries to help guide the deemed measures discussion.

Measures
Summaries_DC Works