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2014 Nonresidential Downstream Deemed Plug Load PC Power Management Software ESPI Impact Evaluation Report

Prepared for
California Public Utilities Commission

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Executive Summary

This report documents the activities undertaken by the Nonresidential Downstream Deemed Plug Load PC Power Management Software Impact Evaluation of the 2014 investor-owned utilities' (IOU) energy efficiency programs.[1] The overall goal of this study is to perform an impact evaluation on the Plug Load PC Power Management Software (PCPMS) measure and/or measure-parameters as identified in the Efficiency Savings and Performance Incentive (ESPI) decision.[2]

In order to implement this approach to meet the overall study goal, a number of research objectives have been targeted. The following tasks have been performed, either by leveraging existing data from past evaluation efforts or collecting new primary data from participant in-depth interviews. A more thorough discussion of how these research objectives are applied to PCPMS are discussed in Section 4.2, but to summarize:

- Confirm installations (verification). Inherent in all in-depth interviews with customers was a verification that the PCPMS software was initially installed as per measure tracking system reports and that it had not been uninstalled or deactivated in the interim period.
- Gather information regarding pre-installation baseline PC power management conditions and post-installation PCPMS savings profiles and operating hours to support the estimate of unit energy savings values and impact load shapes. In the case of PCPMS, the measure could be installed, but not operating, or, operating in a manner that has minimal to no effect on energy use profiles of attached PCs. The PCPMS software has built-in algorithmic savings calculations (that are utilized by its reporting capabilities) that have known parameters. The IOUs claimed ex ante savings values used as a foundation several pilots and evaluations performed prior to the previous several program cycles that compared metered, logged and laboratory-tested equipment. Existing data on these impact parameters were leveraged, but combined with feedback regarding real-world usage patterns garnered from the 2013-14 IOU participants.

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1 This report focuses on the ESPI measures that were identified for the 2014 program cycle.

2 D.13.09.023, Decision Adopting Efficiency Savings and Performance Incentive Mechanism. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M076/K775/76775903.PDF

- Estimate participant free-ridership to support the development of net-to-gross ratios (NTGRs) and net savings values. Ex ante NTGR estimates were premised on defaults for alternate technologies not directly associated with the specific characteristics of the PCPMS technology. Both unstructured and structured survey responses to NTG questions were pursued.
- Estimate and update effective useful life estimates, based on independent research and participant feedback.
- Based on the above, estimate first year and lifetime gross and net ex post impacts (kWh, kW). These impacts represent the unit energy savings (UES) values for 2013-14. Illustrate the dynamic change over time of UES values, for the purposes of predicting 2015 and onward UES values.
- Apply eligibility criteria to arrive at the final net savings estimation for 2014.

A number of data sources were utilized to support the development of each impact parameter in order to update UES values, NTGRs and the effective useful life (EUL) for the PCPMS measure in this study. These data sources were leveraged from past impact evaluation activities and research reports as well as from new primary data collection in the form of in-depth interviews with customers representing 77% of the 2013-14 kWh savings for this measure.

1.1 Key Findings

The final evaluated 2014 PCPMS average weighted UES value (gross) with all adjustments taken into account is 37.3 kWh. Both a service rate factor and an eligibility factor caused significant decreases from the ex ante UES values in use by the IOUs.

The Service Rate Factor (SRF) of 0.777 accounts for participants that chose to curtail the power use of only the monitor portion of the PC-monitor combination.

An Eligibility Factor (EF) is defined as the proportion of participants that adhered to an eligibility requirement defined in the program to prevent like-for-like replacements or regressive baselines. The EF was applied differentially for large customers (those with 5,000 or more units rebated) versus others. The large-participant EF is 16% (meaning that 84% were ineligible according to the program eligibility requirements). Other-participants had an EF of 54% applied to their savings, to account for the 46% ineligibility finding for them.

Aside from the reductions due to these mentioned factors, the UES is on a steady and mostly predictable decline due primarily to technology advancements. SCE factored this trend into their work paper updates; PG&E and SDG&E did not. Even lifecycle savings calculations should not assume a flat rate of savings into the future.

The NTGR was 0.70, in-line with ex ante assumptions that ranged from 0.6 to 0.8.

Table 1-1 and Table 1-2 present the kWh and kW first year and lifecycle gross savings and gross realization rates (GRR) along with the corresponding ex ante and ex post gross kW and kWh savings for the overall PCPMS population, by PA and statewide. [3] All evaluated kW savings were zeroed (explanation why is in Section 4.4; as a result, there are effectively no GRRs for kW savings). They are shown as 0% in the tables.

Table 1-1: 2014 PCPMS Gross First Year Savings and Realization Rates

PA	Ex Ante First Year Gross kWh	Ex Post First Year Gross kWh	GRR kWh	Ex Ante First Year Gross kW	Ex Post First Year Gross kW	GRR kW
PG&E	1,095,400	280,988	26%	110	-	0%
SCE	1,626,628	245,104	15%	16	-	0%
SDG&E	1,222,200	313,514	26%	122	-	0%
SW	3,944,228	839,607	21%	248	-	0%

Table 1-2: 2014 PCPMS Lifecycle Gross Savings and Realization Rates

PA	Ex Ante Lifecycle Gross kWh	Ex Post Lifecycle Gross kWh	GRR kWh	Ex Ante Lifecycle Gross kW	Ex Post Lifecycle Gross kW	GRR kW
PG&E	5,477,000	1,404,940	26%	548	-	0%
SCE	6,506,513	1,225,521	19%	63	-	0%
SDG&E	6,111,000	1,567,572	26%	611	-	0%
SW	18,094,513	4,198,034	23%	1,222	-	0%

Overall, the GRR for first year gross kWh savings is 21%. For SCE, the 15% GRR is primarily driven by the effects of the eligibility factor, as 80% of the ex ante savings is associated with large projects. Therefore, the average eligibility factor for SCE is 0.23, resulting in a proportional reduction in savings (77%). The SRF also results in a 22% reduction in savings. The Delta Energy Use Assumption results in an additional reduction of 17%. Finally, the IR has a minor effect of only a 1% reduction.

PG&E and SDG&E have a GRR of 26%. None of their participants were classified as large, so the eligibility factor that was applied resulted in a 46% reduction in savings. Again, the SRF resulted in a 22% reduction in savings. The Delta Energy Use Assumption was more significant for PG&E and SDG&E (a 38% reduction) since they assumed a higher ex ante UES (200 kWh). Finally, the IR has a minor effect of only a 1% reduction.

[3] All IOU ex ante data are derived directly from the 2013-2014 quarterly tracking data posted to Energy Division's Central Server with the vintage of 11/02/2015. These ex ante data originate directly from the IOUs.

The only difference between first year and lifecycle GRRs is with the EUL values. This only affects SCE which claimed a 4-year EUL versus the 5-year ex post EUL (PG&E and SDG&E use a 5-year EUL).

Table 1-3 and Table 1-4 present the kWh and kW first year and lifecycle net savings and net realization rates (NRRs) along with the corresponding ex ante and ex post gross kW and kWh savings for the overall PCPMS population, by PA and statewide.

Table 1-3: 2014 PCPMS Net First Year Savings and Realization Rates

PA	Ex Ante First Year Net kWh	Ex Post First Year Net kWh	NRR kWh	Ex Ante First Year Net kW	Ex Post First Year Net kW	NRR kW
PG&E	657,240	202,311	31%	66	-	0%
SCE	975,977	176,475	18%	9	-	0%
SDG&E	733,320	225,730	31%	73	-	0%
SW	2,366,537	604,517	26%	149	-	0%

Table 1-4: 2014 PCPMS Lifecycle Net Savings and Realization Rates

PA	Ex Ante Lifecycle Net kWh	Ex Post Lifecycle Net kWh	NRR kWh	Ex Ante Lifecycle Net kW	Ex Post Lifecycle Net kW	NRR kW
PG&E	3,286,200	1,011,557	31%	329	-	0%
SCE	3,903,908	882,375	23%	38	-	0%
SDG&E	3,666,600	1,128,652	31%	367	-	0%
SW	10,856,708	3,022,584	28%	733	-	0%

First year and lifecycle NRRs differ from GRRs only by the difference in the ex ante and ex post NTGRs. Because the ex post NTGR is 20% higher (0.72 versus 0.6), the NRRs are also 20% higher than GRRs.

1.2 Key Recommendations

This section presents recommendations related to the findings developed for this evaluation. Section 6 of the report explains each of these recommendations in more detail. The recommendations are directed at parameters that comprise the energy savings calculations.

- There was no evidence that UES values would differ from one IOU service territory to the next. The IOUs should work together to ensure that basic variables and inputs needed for work paper assumptions are confirmed and collaborate to develop a statewide UES value.

- The IOUs should consider more explicit and industry-specific metrics and indicators in the development of deemed assumptions for IT-related measures.
- Because of the unique and malleable characteristics of the PCPMS measure, the IOUs should consider undertaking additional participant-specific data collection as part of the application and approvals process.
- California IOUs still need to actively manage the PCPMS measure, even if it is largely vendor-driven and those vendors are the most effective way to reach and influence potential participant IT decision-makers.
- Going forward, any PCPMS measure eligibility criteria should be modified to explicitly require that the entire PC, including both CPU and monitor(s), needs to be controlled for rebate eligibility purposes.
- IT-related measures like PCPMS need an updated UES every year, not less often at each program or funding cycle.
- Very precise and measure-specific eligibility definitions need to be developed in advance of rebate offerings for IT-related equipment or software or combinations.
- Ensure that IT-related measures can be adequately verified, including onsite, after installation.

2

Introduction and Overview of Study

This report documents the activities undertaken by the Nonresidential Downstream Deemed Plug Load PC Power Management Software Impact Evaluation of the 2014 IOUs' energy efficiency programs.[4] The overall goal of this study is to perform an impact evaluation on the Plug Load PCPMS measure and/or measure-parameters as identified in the ESPI decision.[5]

This report is informed by Attachment 2 and 3 of the ESPI decision for program year (PY) 2014 and details the goals and objectives of the impact evaluation to meet those requirements. Likewise, the report discusses the researchable issues, information on the measure evaluated as well as the data sources used, the approach for sampling, the verification analysis and the methods used to determine ex post energy and demand impacts. Finally, the report presents the results and findings from the analysis that can then be used to update the UES, NTGRs, and gross/net first year and lifecycle savings for this measure.

2.1 Evaluation Research Objectives

The objective of this study is to perform a measure and/or measure-parameter impact evaluation, utilizing existing evaluation data and new primary evaluation data, in order to update existing gross and/or net savings estimates and inform future savings values for the Plug Load PCPMS measure identified in the ESPI decision. PCPMS is a non-standard measure from at least three perspectives. First, its installation requires the cooperation and participation of corporate information technology (IT) decision-makers, rather than building/facilities management staff. Second, it is not a piece of technology with defined energy use characteristics, but rather akin to an energy management system in that there are a wide range of configuration and reporting capabilities that may or may not be used, even when it is "installed." Third, PCPMS is not a static product in that it is a piece of software subject to evolution of functionality and features. It can adapt over time to become more effective or to retain popularity and competitiveness.

In addition to the non-standard characteristics of the measure technology and end-uses, there is also a broader concern about whether the PCPMS measure incentivizes technology that has become industry-standard practice (ISP). The combination of these factors plus the relatively

4 This report focuses on the ESPI measures that were identified for the 2014 program cycle.

5 D.13.09.023, Decision Adopting Efficiency Savings and Performance Incentive Mechanism. http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M076/K775/76775903.PDF

small proportion of portfolio savings that the PCPMS measure represents led to taking a two-stage approach to the evaluation. All research objectives would be pursued initially, but once more information became available, it was recognized that it may not be feasible to pursue fully all objectives within any reasonable or available evaluation budget.

The parameters associated with deemed measure verification for PCPMS include measure installation/verification, UES, NTGRs, gross and net energy savings values, EUL, and impact load shapes. The evaluation team has determined, with guidance from the CPUC, what savings parameters are subject to ex post evaluation. This determination is based on a number of factors, which are presented in more detail throughout this report.

In order to implement this approach to meet the overall study goal, a number of research objectives have been targeted. The following tasks have been performed, either by leveraging existing data from past evaluation efforts or collecting new primary data from participant in-depth interviews. A more thorough discussion of how these research objectives are applied to PCPMS are discussed in Section 4.2, but to summarize:

- Confirm installations (verification). Inherent in all in-depth interviews with customers was a verification that the PCPMS software was initially installed as per measure tracking system reports and that it had not been uninstalled or deactivated in the interim period.
- Gather information regarding pre-installation baseline PC power management conditions and post-installation PCPMS savings profiles and operating hours to support the estimate of unit energy savings values and impact load shapes. In the case of PCPMS, the measure could be installed, but not operating, or, operating in a manner that has minimal to no effect on energy use profiles of attached PCs. The PCPMS software has built-in algorithmic savings calculations (that are utilized by its reporting capabilities) that have known parameters. The claimed ex ante savings values were themselves premised on an analysis of several evaluations, the vast majority of which were performed prior to the previous several program cycles. These early pilots and evaluations variously contained and compared metered, logged and laboratory-tested equipment. Existing data on these now-dated impact parameters will be leveraged, but combined with feedback regarding real-world usage patterns garnered from the 2013-14 IOU participants.
- Estimate participant free-ridership to support the development of NTGRs and net savings values. Ex ante NTGRs were premised on alternate technologies, none of which matches the specific characteristics of this technology. Both unstructured and structured survey responses to NTG questions were pursued.
- Estimate and update effective useful life estimates, based on independent research and participant feedback.

- Based on the above, estimate first year and lifetime gross and net ex post impacts (kWh, kW). These impacts represent the UES values for 2013-14.
- Illustrate UES values dynamic change over time for the purposes of predicting 2015 onward UES values.
- Apply eligibility criteria to arrive at the final net savings estimation for 2014.

2.2 Measure Studied

Table 2-1 and Table 2-2 present the PCPMS contribution to each PA's portfolio energy savings (as well as the statewide contribution) for the 2013 and 2014 program years, respectively. The overall contribution to ex ante gross first year energy savings that stem from the installation and activation of this measure is over 1% statewide in 2013. There is clearly a smaller contribution to savings from PCPMS in 2014 than in 2013, as can be seen by comparing the tables below. The popularity of the measure declined dramatically in the second year of this program cycle.

Table 2-1: Plug Load PC Power Management Software kWh and kW Savings – Expressed as a Percentage of the PA's 2013 Portfolio Gross Ex Ante Savings

	2013 kWh Savings				2013 kW Savings			
Measure Group	SW	PG&E	SCE	SDG&E	SW	PG&E	SCE	SDG&E
Plug Load PC Power Management	1.3%	1.4%	0.9%	2.1%	0.5%	0.8%	0.05%	1.3%

Table 2-2: Plug Load PC Power Management Software kWh and kW Savings – Expressed as a Percentage of the PA's 2014 Portfolio Gross Ex Ante Savings

	2014 kWh Savings				2014 kW Savings			
Measure Group	SW	PG&E	SCE	SDG&E	SW	PG&E	SCE	SDG&E
Plug Load PC Power Management	0.2%	0.1%	0.2%	0.7%	0.1%	0.1%	0.01%	0.4%

Given the proportionality of PCPMS savings, a modest level of rigor and effort has been applied. This level of rigor was also informed by the availability, age and reliability of existing data sources along with the need to gather new primary data. Table 2-3 illustrates this and the implications of it are discussed in more detail in following sections of the report.

Table 2-3: Percent Statewide Portfolio kWh Savings, Level of Rigor and Data Sources for 2013 Deemed ESPI Measure Groups

Measure Group	2013 Ex Ante Savings	Level of Rigor	Existing Data Source	New Data Collection		Monitor Source
				Phone Survey	Onsite	
Plug Load PC Power Management	1.3%	Medium	Yes	Yes	No	Existing

The energy and demand savings associated with each level of rigor (as a percentage of the statewide Deemed ex ante ESPI savings) is provided below along with a brief discussion of how this level of rigor has been applied:

New primary data has been collected utilizing telephone-based in-depth interviews. These wide-ranging interviews are designed to update existing NTGRs and provide customer-specific feedback on PCPMS operational details in their facility(ies). No prior formal evaluation exists. No new primary data was collected on-site.

2.3 Overview of Impact Evaluation Approach

For PCPMS, the general approach that will be used to estimate ex post gross UES values is based on refining or confirming all of the existing inputs into the "all-in" prescriptive PCPMS gross savings assumption. This prescriptive gross savings value encompasses all gross impact factors, detailed below, and once established, has the NTGR applied to result in final evaluated net savings. Ex ante PCPMS prescriptive gross savings assumptions vary by utility, but the evaluation is assumed to present a single statewide result as no evidence could be found to suggest that the measure or the implementation was different in one utility's service territory versus another.

Ex Post Gross Savings = Unit Energy Savings (UES) x Installation_Rate (IR) x Eligibility_Factor (EF)

Where,

Installation_Rate (IR) = the percentage of claimed measures reported as installed by participants. The original assumptions presume a 100% installation rate.

Eligibility_Factor (EF) = the proportion of participants that adhered to the program eligibility requirements that were designed to prevent like-for-like replacements or regressive baselines (explained in more detail in Section 4.7).

The per-unit, prescriptive savings (UES) calculation algorithm looks like this:

UES (Gross kWh Savings) = Delta_Energy_Use_Assumption (ΔkWh) x Service_Rate_Factor (SRF)

Where,

Delta_Energy_Use_Assumption (ΔkWh) = a kWh/year, or more accurately, an annual delta Watt-hour, value that attempts to account for the average energy savings per attached/controlled PC on a network where PCPMS has been deployed. The value incorporates a range of field-tested and laboratory results that themselves represent a variety of specific PC hardware, operating systems and pre- and post- operating practices. This evaluation cannot replicate the types of studies referenced by the IOU work papers and used to generate the ex ante ΔkWh savings estimates, so it remains in place to be modified by two factors (IR and SRF) described immediately following. The ΔkWh assumption, by definition, attempts to account for ex post versus baseline conditions.

Service_Rate_Factor (SRF) = Unlike traditional energy conservation measures, the installation alone of PCPMS does not bring about savings. The features of PCPMS have to be activated and utilized. There are a myriad of combinations and permutations for PCPMS operation, but the two fundamental options that affect the rate of savings are:

1) Power management control of CPU and monitor
2) Power management of monitor only

The remainder of this report will discuss how the Ex Post Gross Savings values and factors were generated for the PCPMS measure. Specifically:

- Section 3 discusses the data sources that were utilized to estimate each of the individual measure-parameters, the sample design and resulting data used in the evaluation.
- Section 4 presents the details related to savings variance factors used to arrive at directional changes to the UES, which includes the Delta Energy Use (ΔkWh) Assumption itself and the service rate factor. Then, findings related to the installation rate and an eligibility rate are detailed, followed by load shape information that informs the kW savings estimates. A comparison of ex ante and ex post delta energy uses is then followed by effective EUL analysis that is the last step required to develop and present the final UES values. Lastly, the NTGR results are presented in preparation for the results presentation in the next section.
- Section 5 presents the final study results, including a discussion of how the Final UES values were applied to the population to develop gross and net realization rates and total population level ex post energy savings values.
- Section 6 presents findings and recommendations related to PCPMS as delivered in 2014, and for subsequent years.

- Appendix A provides the four in-depth interview guides used to gather primary data about the installation of PCPMS during the 2013-2014 program cycle.
- Appendix AA presents the standardized high level savings for both gross and net first year and lifecycle.
- Appendix AB presents the standardized per unit savings for both gross and net first year and lifecycle.
- Appendix AC presents the summary of recommendations for the Response to Recommendations (RTR).

3

Data Sources, Sample Design, and Data Collection

3.1 Data Sources

A number of data sources were utilized to support the development of each impact parameter in order to update UES values, NTGRs and the EUL for the PCPMS measure in this study. These data sources were leveraged from past impact evaluation activities and research reports as well as from new primary data collection in the form of in-depth interviews with customers representing 77% of the 2013-14 kWh savings for this measure. The various sources of data are discussed in more detail below.

3.1.1 IOU Work Papers and Associated References

The combined work papers from the IOUs contain a wealth of background information and references that provide a basis for understanding the premise of PCPMS energy savings. Many pilots and tests were conducted in the early days of this technology. Ultimately, SDG&E was the first California IOU to offer an incentive measure for a "software plug load sensor" in 2004-2005. Studies with significant vendor participation were also developed during these early years—to be expected given the embryonic nature of the product.

As a prescriptive measure, the PCPMS savings assumption is an amalgam of many factors and assumptions. In fact, each IOU attempted to reconcile these factors in their own manner, with SDG&E ultimately deciding to adopt the PG&E work paper assumptions on August 17, 2012. SCE maintained its own work paper for the measure and in fact released an updated version of it March 4, 2014. Table 3-1 illustrates the similarities and differences between the two utilized work papers in place for the 2013-14 program cycle.

Table 3-1: PCPMS IOU Ex Ante Assumptions 2013-14 Work Paper Comparison

Parameter	PG&E/SDG&E[6] (PGECOCOM105 Rev #3)	SCE (SCE13OE001 Rev 1.0)
Electric Savings (kWh/unit)	200	129.52
Peak Electric Demand Reduction (kW/unit)	0.02	0.00113
Gas Savings (therms/unit)	0 / (N/A)	Negative savings due to interactive effects
Measure Cost ($/unit)	20.00	20.00
Installation Labor Cost ($/unit)	6.79	9.00
Incremental Measure Cost ($/unit)	26.79 (comment only)	29.00
Rebate/Unit Measure	15.00	
Effective Useful Life (years)	5	4
NTGR	0.6/0.8	0.6
Climate Zone	All / (N/A)	Savings and costs specific to Climate Zone

Aside from various particular differences, there is one critically important "philosophical" difference that is relevant to the findings of this evaluation. SCE in its succession of work papers recognized that the evolving state of computer technology needed to be factored in to the basic savings assumption value, since it is premised on older studies, mostly from the mid-2000s time period. SCE addressed this issue by reducing claimable ex ante savings by approximately five percent per year—an assumption that was validated in ex post evaluation.

A study of the work papers and their sources led to the development of several key research questions focused on factors or trends that could affect both gross and net savings levels. Attempts to address these questions were woven into the in-depth interviews that were undertaken for this evaluation (described in the more detail below). Given the limited scale of this evaluation effort, the goal of pursuing these issues was to determine whether the conclusions drawn by the authors of the IOU work papers needed to be adjusted. Had the product itself, the technology it was being applied to, or market conditions changed significantly? Would this change, if found, lead to a different conclusion about PCPMS savings assumptions? The issues pursued with both further secondary research and in-depth interview subjects were as follows:

1) Are desktop PCs still prevalent in the workplace, or have they been significantly supplanted by laptop and handheld devices?

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6 SDG&E Work Paper WPSDGENROE0001 Revision 0 (August 17, 2012) adopts the key assumptions and values from PG&E's Work Paper PGECOCOM105 Rev #3.

   a. This question could affect popularity of the measure, since it is aimed at computers that are plugged-in, not battery powered.
   b. This question could also affect lifetime savings if participants signed-up for and received rebates, but then migrated a significant number of their users away from plug-in PCs.

2) Has technology evolution resulted in more, less, or about the same amount of power consumption per PC in the 2013-2014 time-frame versus the mid-2000s when most of the studies and pilots were performed?
   a. Computer technology evolves rapidly compared to most other technologies.
   b. Did the source studies capture the transition from CRT to LCD monitors, since by 2013, LCDs were industry-standard practice?
   c. Have typical office PC specifications changed significantly in the ensuing years?
3) Has power management technology in PCs and servers evolved significantly such that PCPMS savings could be eroded (made redundant by built-in functionality or features)?
   a. Hardware
   b. Software (operating system)
4) Is energy efficiency now a higher priority in organizations, resulting in PCPMS or PCPMS-equivalent functionality as industry-standard practice?
5) Where PCPMS has been deployed:
   a. Are both CPUs and monitors being controlled, or only one of those (likely the monitor)?
   b. How aggressive are the power management profiles utilized (versus minimizing user inconvenience or complaints)?
   c. What proportion of attached PCs had power management disabled or minimized (to avoid user inconvenience or complaints or to avoid other operational difficulties)?
   d. What operating hours are designated for PCPMS management (all, or is it disabled or curtailed during normal working hours)?
   e. Do any new PCs automatically get added to the controlled population (i.e., is it now/remains corporate standard practice to centrally manage the PC energy use)?
   f. Is there any corporate interest in the ongoing reporting and tracking of energy savings (that is a standard feature of the PCPMS packages)?

3.1.2 In-Depth Interviews

A wide-ranging number of in-depth interviews were conducted to support this impact evaluation. The interviews were carried out to gain a better understanding of customers' use of PCPMS, learn about how customers became aware of the rebates available for PCPMS, and gather the information required to develop a NTGR to apply to ex post gross energy savings of PCPMS. Interviews were carried out with California electric IOU staff that possessed specialized knowledge about PCPMS, IOU account representatives who were responsible for customers who received rebates for PCPMS, vendors who worked to promote the sale and installation of rebated PCPMS, and purchasers of rebated PCPMS (i.e., program participants). A total of 25 in-depth interviews were conducted in support of this evaluation across these categories of individuals. Additional details about these interviews are discussed in Section 3.3 below.

3.2 Data Collection

3.2.1 Participant In-Depth Interview Sample Design

The sample design for the PCPMS measure was generated using 2013 and 2014 program participants and was based primarily on the percentage of ex ante savings associated with the measure. However, several secondary considerations were analyzed given the imbalanced characteristics of the PCPMS participant population. A total of 46 customers (some of them with multiple sites) purchased PCPMS and received rebates through the California electric IOUs during the 2013-2014 program years. From this set of customers, a total of 10 were interviewed and their savings constitute 77% of the total savings from PCPMS in the 2013-2014 energy efficiency portfolio for California IOUs.[7]

The measure participant population was dominated by one large multi-site customer. This single customer accounts for 53% of the total 2013-14 ex ante kWh savings. A further complication arises because this dominant customer received rebates from two of the three IOUs. Then, upon further investigation, it was realized that sites in the third IOU had participated at the very end of 2012 and that most other utilities in the state also deployed the PCPMS measure with this same customer. They represent a case of true statewide implementation. The combination of the scale and the multi-utility scope of the PCPMS deployment at this organization meant that it was a critical and absolutely necessary respondent for evaluation purposes.

Another population characteristic too dramatic to ignore was the overwhelming dominance of two customer segments: health and education. There is some variety within those two categories, but together they represent virtually all of the ex ante kWh savings.

[7] The largest customer represents 53% of the total and the remaining 9 customers constitute 24% of the savings represented by the sample of customers interviewed.

When the relatively small total number of customers is factored in, four strata emerge. The largest customer; health sector organizations; education organizations, and all others. The largest customer is in the health sector. The non-health and non-education "other" participants represent less than 1% of the total kWh savings and can therefore be ignored for sampling purposes.

Table 3-2 below presents the sample design for PCPMS, along with existing data points and the percentage of 2013-2014 first year ex ante savings associated with each participant type.

Table 3-2: PCPMS IDI Sample Design by Participant Sector

Participant Type	Population	Ex Ante kWh Savings	Population % Ex Ante Savings	PCPMS Sample	Sample % Ex Ante kWh Savings
Largest Customer	1	13,467,272	53.0%	1	68%
Health	3	1,657,200	6.5%	2	8%
Education	34	10,311,027	40.0%	7	24%
Other	7	120,242	0.5%	0	0%
Total	**45**	**25,555,741**	**100%**	**10**	**100%**

3.3 Interviews Completed

As mentioned earlier, a total of 25 in-depth interviews were conducted in support of this impact evaluation. Table 3-3 presents the number of interviews conducted by interview type and the number of customers/IOUs represented by the interviews. The evaluation team found that, in some cases, interviews with more than one individual from a single entity (IOU or company) were required in order to gather sufficient information for the evaluation. For example, a total of 2 electric IOU staff were interviewed from PG&E and 1 staff member from SCE. The first PG&E staff member was relatively new to responsibilities related to PCPMS. Therefore, after this PG&E staff member provided us with the information about the current state of the technology and availability of rebates, we were referred to another PG&E staff member who had additional explanations about the uptake of the software, adjustments in ex ante energy savings claims, and the types of customers who showed the most interest in the measure in their service territory.

Table 3-3: In-Depth Interviews Conducted for PCPMS Impact Evaluation

Interview Type	Number of Interviews Conducted
Electric IOU Staff	3
Electric IOU Account Representatives	8
PCPMS Vendors	2
Program Participants	12
Total	**25**

In addition to the 3 electric IOU staff, a total of 8 IOU account representatives were interviewed. These 8 account representatives served as liaisons between the three electric IOUs and 9 PCPMS customers. Four of the account representatives were from PG&E, 3 were from SCE, and 1 was from SDG&E. Though only a single SDG&E account representative was interviewed, he was responsible for 3 different customers who purchased PCPMS and received utility rebates.

Attempts were made to contact a total of 6 PCPMS vendors who marketed and sold the rebated software to participating customers, however only 2 interviews could be completed. The vendors provided information about how they learned about the availability of PCPMS utility rebates and how they used the rebates to help market and sell the software to customers.

Customers from the health care and "other" (the large majority of which is education) sectors were the predominant purchasers and installers of rebated PCPMS during the 2013-2014 program years. A total of 12 in-depth interviews were conducted with individuals representing 10 different customers (see Table 3-4). A total of 7 customers were from the education/other sector and 3 were from the health care sector. Note that though only 3 customers represented the health care sector, two were extremely large customers with multiple hospitals, offices, and health care facilities throughout the electric IOU service territories. Two interviews were conducted with each of the two major health care providers in order to capture the feedback of the decision-makers as well as the IT/technical administrators of PCPMS. So, a total of 5 interviews were conducted with individuals from the health care sector and 7 interviews were conducted with program participants from the education/other sector.

Table 3-4: Program Participant Interviews by Sector

Participant Interviews by Sector	Number of Interviews Conducted	Number of Customers/IOUs Represented
Education/Other	7	7
Health Care	5	3
Total	**12**	**10**

4

Evaluation Methodology

This section provides an overview of the methods used to estimate the key impact parameters, the ex post UES values and the NTGRs for the PCPMS measure.

4.1 Overview of Approach

The primary objective of this evaluation is to perform a measure and/or measure-parameter impact evaluation, utilizing existing evaluation data and new primary evaluation data, in order to update existing gross and/or net savings estimates and inform future savings values for the PCPMS measure identified in the ESPI decision. These parameters, that include baseline versus post-installation wattages, service levels and operating hours, plus installation rates, EULs and estimates of free-ridership, can be used to measure ex post performance for PY 2013 and 2014.

More specifically, these parameter level results will be aggregated in order to develop kW and kWh UES values, impact load shapes, and NTGRs for the PCPMS measure identified in Appendix 3 of the ESPI decision.

Based on the peculiar nature of the measure participant population, it could be argued that some significant differences existed between the implementation of the PCPMS technology in the health sector versus the education sector. For example, operating hours in these two sectors could be different enough to warrant specific savings algorithm assumptions. This is the only dimension examined that could suggest other than a program/measure-wide consistent result. The small size of the overall population of participants, let alone the sub-segments, suggests a single ex post UES value is most appropriate.

This section discusses, in detail, the inputs that were used to develop these parameter estimates. They also inform the general approach that was used to develop the UES values. The per-unit, prescriptive savings (UES) calculation algorithm is as follows:

UES (Gross Savings) = Delta_Energy_Use_Assumption (ΔkWh) x Service_Rate_Factor (SRF)

Where,

Delta_Energy_Use_Assumption (ΔkWh) = a kWh/year, or more accurately, an annual delta Watt-hour, value that attempts to account for the average energy savings per attached/controlled PC on a network where PCPMS has been deployed. The value incorporates a range of field-tested and laboratory results that themselves represent a variety of specific PC hardware, operating systems and pre- and post- operating practices. This evaluation cannot replicate the types of studies done to generate the ex ante ΔW savings estimates, so it remains in place to be modified by two factors (ISR and SRF) described immediately following. The ΔkWh, by definition, attempts to account for ex post versus baseline conditions.

Service_Rate_Factor (SRF) = Unlike traditional energy conservation measures, the installation alone of PCPMS does not bring about savings. The features of PCPMS have to be activated and utilized. There are a myriad of combinations and permutations for PCPMS operation, but the scale of this evaluation limits the choices to the two most fundamental options that affect the rate of savings:

1) Power management control of CPU and monitor

2) Power management of monitor only

The remainder of this section will discuss the following analyses and factors:

- The methods used for estimating each individual impact parameter included in the delta Energy Use (ΔkWh) Assumption itself;
- The Service Rate Factor (SRF);
- Load Shapes and demand (kW) savings;
- Final UES Values;
- The Installation Rate (IR);
- An Eligibility Factor (EF);
- EUL; and
- The approach for estimating the NTGRs.

4.2 Delta Energy Use Assumption (ΔkWh) Analysis

The Delta Energy Use Assumption (ΔkWh) is the core element in the ex ante savings formula. As a prescriptive measure, it should represent a global average value that approximates the per-unit savings expected from a representative sample of actual use cases. It is expressed as a kWh/year value that attempts to account for the average energy savings per attached/controlled PC on a network where PCPMS has been deployed. The value should incorporate a range of field-tested and laboratory results that themselves represent a variety of specific PC hardware, operating systems and pre- and post- operating practices.

This evaluation cannot replicate the types of detailed studies referenced in the generation of the ex ante ΔkWh savings estimates, so instead, the component elements that affect estimates or that might have changed in the ensuing period are examined. A series of issues is investigated with the purpose of weighing a preponderance of evidence as to whether factors suggest greater, lesser, or approximately the same level of savings as already assumed for ex ante purposes.

4.2.1 Core ΔkWh Assumption

The studies and evaluations referenced to formulate IOU ex ante ΔkWh assumptions reported site-by-site PCPMS savings ranging from zero (0) to 323 kWh per-unit, per-year. Selecting some form of weighted average of these values was defensible, especially given the inconsistency in many of the details and conditions inherent in those studies. Had a range of newer studies been available that reflected current technologies and use-patterns, this evaluation could have relied upon a literature review for part of its analysis.

All PCPMS deemed savings values, from the California IOU work papers and from other jurisdictions, contain the core premise that PCPMS takes into account the difference between the same PC equipment operating in an "uncontrolled" environment versus being controlled by a centralized PCPMS system on the network. PCs have multiple power-using, or duty-cycle, states that are usually described something like the following:

Table 4-1: PCPMS Duty-Cycle Categories

Power State
Unplugged
Off
Sleep
Idle
Active

The PCPMS software deployment affects the amount of time the PC unit spends in each of these states (with the exception of physically unplugged) and is designed to push the operation "up the stack" because each category uses successively less power than the one below it. When a computer CPU or monitor is actively being used/operated, PCPMS can have no effect. That is also the time when the equipment draws the most power because the constituent components are all operating. A slight reduction in power is experienced when the devices are in an idle state, where they would remain when unused unless a manual intervention occurs or a local power management default engages. PCPMS is designed primarily to monitor this idle state and actively, to some degree of aggression controlled by the network administrator, push the equipment into sleep mode sooner than it otherwise would or instead of it remaining idle indefinitely. It is possible for PCPMS to turn off the PC, but the savings differential between "Sleep" and "Off" is minimal, so typically the "Sleep" function is utilized.

Note that PCs in an "Off" state still draw power, now typically and consistently 1W due to successful standards requiring minimal off-state plug load power consumption. "Unplugged" rarely means literally unplugged, but rather disconnected from "Off" state plug load power draw by a power bar or similar device with a manual on/off switch.

The core ΔkWh savings element can therefore be represented by the following formula:

$$\Delta \text{kWh} = \left(\sum_{STATE} Power_{STATE} \times Hours_{BASE,STATE}\right) - \left(\sum_{STATE} Power_{STATE} \times Hours_{PCPMS,STATE}\right)$$

If the ΔkWh is effectively the difference between the sum of the annual PC consumption distributed across the various operating states, one with and without PCPMS, then the apportioning of the operating states, or duty-cycle, and the corresponding power consumption assumptions are key. Examples of each are provided immediately below for illustrative purposes—the values are plausible but do not represent California or PCPMS participant data (Table 4-2). The Power Draws in various states are, as expected, not affected by PCPMS since it can only shift controlled PCs from one Power State to another (more aggressively than otherwise would be the case) (Table 4-3).

Table 4-2: PCPMS Illustrative Example of Duty-Cycle Distribution

Power State	Duty-Cycle, as %	
	Base	Measure
Unplugged	2%	2%
Off	23%	66%
Sleep	4%	6%
Idle	54%	9%
Active	17%	17%
Total	**100%**	**100%**

Table 4-3: PCPMS Illustrative Example of Corresponding Power Draws

Power State	Power Draw, W	
	Base	Measure
Unplugged	0.00	0.00
Off	1.05	1.05
Sleep	2.53	2.53
Idle	52.57	52.57
Active	76.13	76.13

The original evaluation studies and pilots of PCPMS that comprised the basis for IOU work paper ex ante estimations unfortunately did not all conveniently adhere to this strict engineering breakdown when measuring the power savings effectiveness of PCPMS. A wide variety of metering and monitoring methodologies were used to arrive at some ultimate average per-unit savings values. As a result, neither individual duty-cycle distribution values nor power draw values can be compared across the studies comprehensively, nor could the results from those older studies be correlated directly to any on-site measurement and verification (M&V) results gathered today. The recognition of this limitation contributed significantly to the decision to not pursue M&V at PCPMS participant sites for this evaluation.

The PCPMS measure as delivered in 2013-14 in California did not have a large and diverse population, nor a population that particularly matched any of the source studies, which are outdated regardless. As a result, the primary purpose of this evaluation was to investigate the need for directional changes to the existing ΔkWh Assumptions, not attempt to reverse-engineer with precision a particular array of duty-cycle distribution or power draw values. However, these constructs are the most logical manner to organize any preponderance of new evidence.

In advance of the discussions about the various savings variance factors, it should be noted again that the ex ante UES values/ΔkWh Assumptions are an amalgam (in most cases an average of some sort) of end results that already include traditional adjusted gross savings factors like part-use, the efficacy of the power state shifting illustrated above, real-world variations in duty-cycle distribution and so forth. Variance factors therefore focus on recognizable and acknowledged changes over the ensuing time span between the seminal studies and 2013-14, not on the veracity of the engineering specifics of the factors themselves.

4.2.2 Savings Variance Factors

The ΔkWh Assumption, by definition, attempts to account for ex post versus baseline conditions. All of the component potential savings variance issues described and discussed below are baked into the global ex ante assumptions, either implicitly or explicitly. In addition to the relatively straightforward engineering calculation described in the prior section, there are other factors that affect the overall savings potential of PCPMS. For the purposes of exploring underlying changes in the ensuing years, the savings variance factors are grouped into three categories.

The three categories are:

1. **Duty-Cycle Distribution.** Those items that relate to the proportion of time a PC remains in one power state versus another.
2. **Power Draw.** Those items that affect the raw connected demand or power consumption of the PC technology itself, as used in typical office scenarios.
3. **Other.** This category includes any factors that do not fit either of the primary two categories.

The factors that might suggest an increase or decrease in the ΔkWh Assumption are embedded in the research questions outlined in Section 3.1.1 above. For clarity and organization, these questions are captured in Table 4-4, below, sorted by the three categories just outlined.

In addition to a savings influence rating, the table also shows the follow-up method(s) used to investigate the particular issue. The rating describes the likely influence of changes in technology or the market, each compared to 2012 or earlier when the ex ante assumptions were developed, or, how 2013-14 surveyed participants particularly deployed PCPMS. Following the table is a brief discussion of each factor and then a section describing the conclusion regarding update of the Delta Energy Use Assumption (ΔkWh). A legend of the savings influence ratings precedes the Table here:

Table 4-4: Delta Energy Use Assumption (ΔkWh) Savings Variance Factors

Savings Influence Rating Legend

— = strong downward influence on savings assumptions

— = moderate downward influence on savings assumptions

0 = neutral influence on savings assumptions

\+ = moderate upward influence on savings assumptions

+ = strong upward influence on savings assumptions

PC = a monitor/display screen and CPU

CPU = central processing unit, but for PCPMS purposes refers to the computer "box" and all parts and systems that are not the monitor/display screen

Item	Issue Description	Rating	Nature of Investigation
DCD-1	Basic patterns of use without PCPMS have remained the same	0	Confirm with interviews whether this appears to be the case with measure population
DCD-2	Has power management technology in PCs and servers evolved significantly?	0	Investigate whether both hardware and operating system (drivers and direct power management functions) are commonly being utilized outside the adoption of PCPMS.
DCD-3	Is PCPMS now or becoming industry-standard practice?	0	Confirm with interviews whether this appears to be the case with measure population.
DCD-4	How aggressively are the power management profiles utilized?	0	Confirm with interviews whether this appears to be the case with measure population.
DCD-5	What proportion of attached PCs had power management disabled or minimized? (to avoid user inconvenience or complaints or to avoid other operational difficulties)?	0	Confirm with interviews whether this appears to be the case with measure population.
DCD-6	What operating hours are designated for PCPMS management?	0	Confirm with interviews whether this appears to be the case with measure population.
PD-1	Many source studies included cathode ray tube (CRT) monitor technology	–	Investigate power consumption of LCD monitor technologies at various sizes
PD-2	Have use-case changes occurred?	+	Investigate trends related to size and number of monitors; speed and capabilities of CPU; and relationship to energy consumption
PD-3	PC power consumption continues to evolve	–	Investigate whether overall per-PC power consumption is more, less, or about the same in the 2013-2014, time frame versus the mid-to late-2000's when most of the studies and pilots were performed?
O-1	PCs still prevalent, or numbers/savings eroding due to more laptops and handhelds?	0	Confirm with interviews whether this appears to be the case with the measure population.
O-2 ◆	Both CPUs and monitors being controlled, or only one of those (likely the monitor)? See Section 4.3 below for a detailed examination of this topic.	◆	Confirm with interviews whether this appears to be the case with measure population.
O-3	Do any/all new PCs automatically get added to the controlled population?	0	Confirm with interviews whether this appears to be the case with measure population.
O-4	Is there any corporate interest in the ongoing reporting and tracking of energy savings?	0	Confirm with interviews whether this appears to be the case with measure population.

◆ This item was determined to be a critical savings-related element and a factor was developed to address it. Details in the noted section below.

DCD-1. Basic patterns of use without PCPMS have remained the same.

PCPMS savings variation is driven proportionately first by variation in baseline conditions, and secondarily by the way the PCPMS software is deployed. In other words, there is less variation in the range of specific characteristics of typical/useful PCPMS deployments than in the range of pre-installation conditions. This was true even for the pilots and early studies designed mostly by vendors and program administrators that had an interest in testing the full capabilities of the PCPMS technology and therefore emphasized "full" deployments of the technology. Detailed logging of pre-installation conditions was a prerequisite to formulating the initial savings estimates, and a wide range of operating practices and operating schedules were encountered.

Interviews with 2013-14 PCPMS participants confirmed that a wide range of pre-installation operating practices, including variation among the users within a single participating organization, is still typical. This makes sense given that a PC is a multi-purpose tool that can perform many different functions for different professional purposes according to the schedule and needs of the user. It has no required or prerequisite operating parameters that affect its value to the user the way most other energy conservation measures would.

Although a prescriptive rebate, the PCPMS delivery anticipated this variation and attempted to ensure that some form of baseline was collected before PCPMS was triggered into its active state. This was relatively convenient since one of the core functions of PCPMS packages is to audit "pre-installation" conditions so that an algorithmic savings estimate and report can be produced. The PCPMS package is installed and activated, but left in an inert mode so no actual power management is occurring. The system collects baseline information and then can demonstrate the extent of savings once a savings profile(s) is selected by the network administrator for active deployment.

Participants were interested in these audits as much for inventory and asset management purposes as they were for precise savings estimates. Several participants had cleverly deduced that the in-built reporting was algorithm-based, not an actual measurement of metered electricity or other unique characteristics of the equipment. Despite this, they were interested in the assessments of what the baseline settings were for their equipment—many did not know as it was never a priority to manually inventory those settings. The most typical frustration is that without a sophisticated network administration package, PCs need to be left "on" at all times so that patches and maintenance can occur out of working hours during evenings, over-nights or weekends. Which time slot is chosen usually depends on the risk elements involved in the IT tasks, with higher risk items reserved for times with a buffer available to correct any missteps before employees need regular work-hour access to the machines.

There was no evidence that any form of organized power management was occurring within the participant organizations that were interviewed. However, these were all participants who ultimately found value in a PCPMS product, so perhaps a non-participant population would have different characteristics.

A second aspect of baseline conditions that could not be captured even by a thorough pre-deployment audit assisted by the PCPMS software is whether overall use of PCs and computers in commercial settings is increasing over time. The audit is a snapshot in time that cannot reveal past usage trends. It is unlikely that any PCPMS users have thought to perform a study to track the Active versus Idle state statistics over time that could prove or disprove, even on an anecdotal basis for their organization, notions that computer use is increasing in terms of the numbers of hours per day workers spend doing tasks that require a computing device (e.g., larger volume of electronic mail, Internet-based research, Internet-based personal tasks, etc.). Some business management-related articles in the popular press suggest computing activity is increasing over time, but the amount of that tied to a PC versus other computing devices like smart phones or tablets is not precisely known.

There was not enough evidence to suggest a directional change to the core Delta Energy Use Assumption.

Rating: 0 (neutral influence on savings assumptions)

DCD-2. Has power management technology in PCs and servers evolved significantly? The power management capabilities of PCPMS software has already existed in standard server operating systems for networked PCs for many years. Despite this, PCPMS packages nevertheless found a market due to several factors:

- Combining other useful network administrative functionality, which in most cases provides the actual incentive to purchase
  - Asset management
  - Wake-up computers for automated maintenance (patching)
  - Monitoring PC usage
- Simplified the administrative burden involved in managing power settings
- Simplified the process of managing exemptions, special cases, or other one-off and small group anomalies
- Despite the ability to control power management, it was relatively uncommon for IT administrators to do so for the following reasons:
  - Automated PC shut-downs or sleep sequences generate user complaints
  - PC operating systems not always able to gracefully awake from sleep—this also generates user complaints and may also negatively affect productivity
  - Burdensome to deal with exceptions and special cases that need non-standard power management settings
  - IT departments dealing with PCs (i.e., not data centers) rarely have any responsibility or even awareness of electricity bills for their organizations

- Even if perceived or promised savings were assessed as credible, the IT department would rarely if ever benefit directly from energy bill savings, but would bear responsibility for all complaints or issues generated by power management practices—an unfavorable reward/risk equation

Interviews with PCPMS participants (that reflected health and education sectors predominance) confirmed that the ultimate rationale for adopting PCPMS was often not energy-related, but the energy savings were still valued. When energy savings was a motivating factor at the corporate level, the other appealing features of the PCPMS packages piqued interest, decreased resistance and opened the door to testing and serious consideration of what on the surface initially appeared to be a non-starter due to the instinctive negative risk/reward assessment by IT professionals.

Interviews also revealed widespread satisfaction with the PCPMS packages, with IT administrators often commenting that they were surprised it worked so well and caused so few or no problems. Despite this, there was no evidence from interviews that power management in and of itself was growing in interest or becoming industry-standard practice. Each case involved a particular sequence of events and/or surreptitious introduction of the concept of PCPMS, after which the rebate and combination of appealing features prompted administrators to try it. Once the promise of useful features was confirmed and the power management features could be deployed with little effort and no "blowback," there was no reason not to do so. Several respondents referred to pleasure at being able to assist their organizations and the state with energy conservation—painlessly.

There did not appear to be any general motivation to deploy power management practices outside the context of the PCPMS "sales opportunity" that involved the full range of benefits of the software. In almost every case there was (the expected) initial resistance from IT staff. Even associating power management directly with PCPMS installation may be a case of *post hoc ergo propter hoc.* It is wrong to assume active power management automatically or must consistently follow the purchase and installation of a PCPMS package. As mentioned in this report, it is quite possible to set PCPMS in a manner that little to no savings occur. It is also possible, as was the case with one respondent, to already own the software and be using it for various non-energy benefits purposes, but conscientiously choose not to have the PCPMS functions activated (easily possible since the software is usually modular in design). The test of the PCPMS program intervention appeared to be whether it instigated the active pursuit and practice of energy management, not simply the purchase and installation of the product itself (especially if in an inert mode).

Probing of these various scenarios in participant organizations did not reveal evidence that active power management was occurring, planned or even thought about seriously prior to the program offering. This extends to a scenario where the software was already purchased and installed, but unused due to the perceived negative reward/risk assessment.

Despite this evidence relating to the 2013-14 period, there are indications that power management of PCs will soon increase by default. Although largely bypassed in corporate environments, the most popular PC operating system shipped during 2013-14 (and recently updated in mid-2015) has incrementally advanced power management features enabled by default. The latest iteration of the desktop operating system has crossed a threshold that now includes a well-functioning maximum savings “Sleep” mode. Once/if this newest system makes its way into corporate workplaces and accompanying updates occur on the server-side, a much more efficient baseline for PCs will become the norm.

Rating: 0 (neutral influence on savings assumptions, but likely to change to a major negative influence on savings once the latest generation operating system propagates to corporate environments.)

DCD-3. Is PCPMS now or becoming industry-standard practice? The discussion in the prior point supports the notion that active power management of PCs on networks has not increased substantially up to the time span of 2013-14. The lack of PCPMS measure participant representation from sectors other than health and education organizations also suggests that there is still significant resistance in many typical IT departments to investing (time, effort, budget) in active power management of PCs. Limited and narrow overall uptake of a measure that was generally reported as a favorable deal once understood and tested by the respondents suggests broadly that power management is not yet a relative priority for IT departments, which confirms the premise for developing it (in the mid-2000s) and including it as an incentivized measure (in 2013-14).

Respondents represent current PCPMS active users, so are not representative of a general population of computer networks or IT administrators. However, the health and education sectors may be somewhat atypical in terms of higher levels of PC (versus mobile device) usage, but the participating organizations encountered may also be larger than average. Larger organizations typically contain more sophisticated IT staff capable of pilot testing and comparison analyzing competing PCPMS products. Many respondents reported performing formal comparisons of products and even testing more than one PCPMS product before making a final decision to deploy PCPMS.

The organizations encountered also more often than not had strong corporate responsibility policies that included environmental stewardship. Saving energy was rewarded, at least morally if not financially, to the extent that IT staff were well aware of these goals and policies. Some reported pride in being able to contribute to those purposes.

One very large organization did track and account for IT energy costs in its data center operations in a manner that allowed the IT staff to gain directly (in terms of budget allocation) from lowering those costs. Typically, the electricity bill is paid by another department (usually facilities/property management) and is never seen by line operations managers, nor are any increases or decreases in consumption or cost tied to operations performance.

Respondents were also asked if their deployment of PCPMS was in response to knowledge that competitor or peer organizations had already deployed PCPMS or if they were aware of other organizations or trends that would suggest peer pressure or need to go with PCPMS. The overwhelming response was that internal assessment alone drove their decision-making. Respondents were mostly unaware of whether peers were actively managing power on networked PCs and suggested that even if they were aware, it would not be interpreted as pressure to follow suit.

Unfortunately, there are very few current and useful sources of information regarding how commonplace is the power management of PCs (manual or via PCPMS) in typical commercial office settings. One of these is a case study from 2012, undertaken by PECI (the former Portland Energy Conservation, Inc., and now part of the CLEAResult company) of their own headquarters occupying three floors of a LEED® Platinum office building in Portland, Oregon, shows about half of desktop PCs still "on" outside normal 8:30 – 5 pm work hours.[8]

The 2014 Survey of Computer Power Modes Usage in a University Population prepared for the CEC[9] also shows primary office desktops on about 50% (Figure 17), but this study is of only one organization. Although still potentially relevant to the higher-education participant population for the PCPMS measure, the study findings may be less than fully useful for evaluation purposes due to the methodological choice of asking end users certain questions about power management that likely only IT staff would know the answers to.

A detailed market penetration study could confirm who is deploying what extent of PCPMS in various types of organizations.

The interviews conducted for this evaluation revealed no evidence that PCPMS is becoming or is already industry-standard practice. Central control and monitoring of networked PCs is industry-standard practice in larger organizations, due to very obvious labor cost and convenience benefits, but active power management is not an automatic corollary with that, even when it is literally already included in the management software and could be relatively easily activated.

8 Case Study: Analyzing Plug Loads, Applying a New Methodology for Reporting Plug Load Energy Use. PECI in association with the New Buildings Institute. Eliot Crowe, PECI, primary author.

9 California Plug Load Research Center, University of California, Irvine (October 2014). Survey of Computer Power Modes Usage in a University Population, prepared for the California Energy Commission (CEC-500-2014-093).

Rating: 0 (neutral influence on savings assumptions)

DCD-4. How aggressively are the power management profiles utilized? There is one basic element to determine how "aggressively" active power management is deployed: idle time required before triggering intervention to "push" an idle PC to Sleep or Off. The shorter the idle time, the greater the savings due to the obvious minimization of energy-wasting unproductive idle time.

Two factors potentially affect the user experience negatively and therefore could generate complaints to IT administration. The first is time to recover (or wake-up from a Sleep or Off state). If a simple touch of a mouse or keyboard key could illuminate a monitor screen and reactivate a PC to active/working state in less than a second, few users would complain. Waking-up a PC CPU from sleep mode can take a considerable time (relatively, but enough to be considered an unacceptable inconvenience to many users). The time also varies dramatically depending on hardware and operating system combination. If a PCPMS idle timer is set to 30 minutes, this activity might be required once or twice a day; at 5 minutes it could be 10 or twenty times a day depending on the work habits and mobility of the user.

The second factor is network security. Requiring a log-on after an idle period is ubiquitous policy in organizations large enough to have networked computers. In fact, the security setting that locks a computer after a period of inactivity uses the same controls that could also shut off the monitor and/or PC CPU itself. The security lock has been industry-standard practice for many years, but the requirement to log back on to your PC is generally considered an inconvenience if the idle timer is set too short.

Network security is a primary driver for network administrators. It is therefore common for PCPMS monitor settings (to Sleep) to be configured to match corporate security requirements. If set to a typical 30 minutes, these are adequate to capture savings when people leave their work station to attend meetings or go to lunch, etc. Some organizations, like health care, banking or insurance that regularly deal with confidential patient and client records may use a much more aggressive default timer setting for security purposes. Depending on preferences, people may not want to "wake" a blank screen each time they need to log-on for security purposes.

Of course the security lock works whether the monitor is put to sleep or not. Use of PCPMS assures that it will sleep. The CPU may also be put to sleep, or not, in conjunction with the security lock procedure. It has generally not been the case to do so because of the combination of user inconvenience, especially if more aggressive security settings are needed, and due to unreliability of the CPU sleep procedure. If unsaved files or other "open" work could be disrupted or lost during the CPU sleep procedure, then the risk is generally considered too high by users and IT staff. It is also the case that if organizations do not deploy sophisticated networked-PC remote control software, then the traditional stance is to not deploy CPU sleep mode ever. Staff are instructed to leave PCs on after-hours so they will be readily available for patching and other IT systems maintenance.

Interviews with PCPMS respondents revealed a variety of preferred settings, but none that pursued a maximum energy savings mode if it might generate ongoing user complaints. There were several reports of success because no one (users) noticed the implementation, which could suggest mild settings or even settings that mirrored existing settings. However, the real benefit of PCPMS is in reliably shutting off PCs after-hours when users wouldn't normally notice the difference. They could be activated at some obscure hour instead of running 16 hours needlessly just so they would be available for the time needed for maintenance. These operations are invisible to the typical user.

Attempting to deploy overly-aggressive settings during normal work hours is likely to incite push-back from users. "Average" settings are still able to capture the primary savings opportunities that occur when someone is away from their work station for an entire or significant parts of a work day. All after-hours and weekend hours are captured regardless. Given this inherent efficacy of the PCPMS design, it is somewhat predictable that interview respondents did not deploy purposefully weak settings. As expected, they were more likely to be aligned with corporate security policies and to take advantage of non-work-hour efficiencies.

Rating: 0 (neutral influence on savings assumptions)

DCD-5. What proportion of attached PCs had power management disabled or minimized? Another possible erosion of PCPMS savings could occur if organizations deployed PCPMS on certain numbers of units, but then deactivated PCPMS on some portion of them afterward due to user complaints or technical issues.

Respondents seemed keen to avoid this scenario and pointed to piloting and testing performed in advance. In general, IT best practices are always not to install something in the first place if there are anticipated problems so as to avoid unintended secondary and interactive effects. However, there were reports of specialized users and equipment that needed to be exempted from standard PCPMS profiles to prevent disruption to critical functions. These were typically limited, but IT administrators were pleased with the ease of the PCPMS functionality that permitted individual or small groups to be configured differently from the norm.

Most respondents confirmed that they would not have deployed the software, even if it was free, had there been any operational problems detected during testing. Conversely, by the time it was deployed successfully, there was no reason to disable or minimize settings other than for a few specialized cases.

Rating: 0 (neutral influence on savings assumptions)

DCD-6. What operating hours are designated for PCPMS management (all, or is it disabled or curtailed during normal working hours)? As mentioned above as part of item DCD-4, the idle timer setting determines the level of inconvenience for the user. Respondents, and presumably PCPMS customers in general, were unwilling to adopt settings that would incite push-back from users or risk user productivity. For this reason, that the PCPMS operation was mostly non-intrusive, where settings could be left alone and remain universal.

There is ultimately no rationale to curtail idle timer settings during active work hours if the PCPMS product is actually working as it should and settings are not an inconvenience or disruption to users. Respondents were unwilling to deploy the product unless it worked without generating user complaints or compatibility issues for network administrators, so once deployed had no reason to curtail the operation from its standard 24/7/365 universal settings.

Rating: 0 (neutral influence on savings assumptions)

PD-1. Many source studies included cathode ray tube (CRT) monitor technology. The age of the pilots and initial evaluation studies (early to mid-2000s, when PCPMS emerged as a candidate for utility program sponsorship) meant that CRT monitors were still commonplace. The now ubiquitous liquid crystal display (LCD) flat panels were still emerging onto the market and relatively expensive. Did this inclusion of now-outmoded technology impact the IOU ex ante savings calculations because savings from those monitors were embedded in the original reference studies?

The mid-2000s saw continuing gains in PC efficiency. One major development was the introduction of LCD panel technology to replace CRTs. LCD panels are physically much smaller (use less desk space per sq. in. of screen), lighter (easier to maneuver, move, ship) and ultimately more reliable than CRTs, but cost was ultimately the motivating factor for the transformation of the market. CRTs were effectively a very high quality television, but TVs did not use the same size or high quality and resolution of tubes. Conversely, LCD panels gained popularity due to the proliferation of their use in many technologies, including televisions. The cost per sq. in. of LCD panel is a small fraction today of what it was in the mid-2000s, and an even smaller fraction of what a high quality CRT cost prior to that. As an important corollary benefit, a similar-sized LCD panel uses about one-third the energy of a CRT. This basic relationship is illustrated in the first two data rows of Table 4-5.

Table 4-5: CRT versus LCD Monitor Power Consumption

Monitor Type	Power Consumption Range
19" CRT	102W – 111W
19" LCD	31W – 33W
20" LCD	34W
24" LCD	68W
22" LCD w/LED Backlight	18W

Source: Patrick Schmid and Achim Roos, Display Power Consumption: CRTs Versus TFT-LCDs, Tom's Hardware, Aug 19, 2010[10]

Although one seminal study (referenced for work paper ex ante savings estimates purposes) did involve the exclusive use of LCD monitors,[11] and LCD panels were available by the time many of the studies used as references for ex ante savings estimates were undertaken, they were not prevalent. The common technology was CRT and that is also the monitor technology that dominated the tests and measurements of that era. Between then and now, LCD panels have effectively assumed 100% penetration of the market.

Around 2010, a new and even more efficient LCD monitor (and television) technology adaptation was introduced: LED backlighting to replace the former fluorescent backlight technology. Table 4-5 illustrates that a 22" LED backlit monitor uses approximately half of the energy of the prior fluorescent models of similar sizes. LED backlighting technology is now (in 2015) approaching 100% of standard configuration new monitor sales and is therefore in the process of propagating its way to ubiquity in the installed equipment base over the coming years.

Basic LCD panels use approximately one-third of the energy of equivalent-sized CRTs. LED backlighting cuts that consumption in half again, for a one-sixth ratio. However, the impact on the ex ante savings estimates is not as straightforward as simply reducing the monitor portion of the savings by five-sixths. The precise proportion of LED-based LCD monitors in service in PCPMS participants in 2013-14 is unknown. The savings assumption already includes some bias downward to include some (but also unknown precisely) proportion of LCD panels versus CRTs. Therefore, a strong downward influence is indicated, but this should not be assumed to mean an 80% or more cut to the monitor portion of the savings. A more modest, but still significant, cut in the 50% to 60% range would account for both the CRT to LCD and LED technology shifts.

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10 Tom's Hardware is a valued IT industry resource for technical specifications and testing on a wide range of computer technologies and one of the few sources that pays some attention to power consumption. The article can be found online here: http://www.tomshardware.com/reviews/lcd-backlight-led-cfl,2683.html.

11 A 2004, test of Verdiem Corporation's Surveyor Network Energy Manager product in the offices of Puget Sound Energy (as reported in the Summary of EM&V Studies reviewed for WPSCNROE0003 – Power Management Software for Networked PCs (embedded in SCE's PCPMS most recent work paper of May 30, 2012.

Also, there is a rebound effect related to typical use cases (to be discussed in the next section PD-2) that mitigates some of this savings loss.

Rating: **—** (strong downward influence on savings assumptions)

PD-2. Have use-case changes occurred? As mentioned in the previous section, the decreasing cost of LCD panel technology combined with its convenient physical properties encouraged the use of ever-larger screens (especially evident in the consumer television market), since each time a device came-up for a corporate-defined scheduled replacement, a larger size could be purchased for the same cost as the smaller unit previously. Larger screens are a benefit to productivity in many cases and well-liked by users, so at no "additional" cost from a budgetary perspective, the common screen size grew from 14" to 15", then 17", then 19." Specialized uses that would benefit from even larger screens could now have that need addressed for a small fraction of the cost compared to years prior.

The proliferation of low-cost LCD panel monitors has also led to increasing proportions of users with two and sometimes even three screens. It is now commonplace for many laptop users to also have a dock and full-sized monitor screen at their workstation that is used either instead of or in addition to the screen built-in to the portable device. The Northwest Power and Conservation Council (NWPCC) noted and quantified this overall effect for their Sixth Plan[12] (in place during the 2013-14 period) at 1.18 monitors per desktop.

The trend towards larger and multiple monitors has eroded the expected energy savings of LCD monitors versus CRTs to some extent. As illustrated in Table 4-5 above, a 24" traditional LCD panel uses two-thirds of the energy of the older, but smaller 19" CRT. Two equivalent-sized 19" LCD panels would also use two-thirds of the energy of the single CRT. Only the newest LED-technology panel could be twinned (in a dual monitor set-up) and still maintain the one-third energy use ratio.

Again, there are no extensive surveys to pin-point these changes, but some moderate increase in consumption is warranted that would add to the savings potential of the PCPMS technology.

Rating: + (moderate upward influence on savings assumptions)

PD-3. PC power consumption continues to evolve. PC power use varies dramatically from one configuration to the next, but over time energy efficiency developments have driven overall usage downward. There have been tremendous advancements in hardware design, with processors becoming smaller, faster and more capable all the while using less energy per

[12] http://www.nwcouncil.org/energy/powerplan/6/supply-curves

computation. A common maxim in the industry suggests that the computational capability per Watt of input energy doubles approximately every 18 months. Inherent power management capabilities have also been added to hardware, mostly in the interest of heat management, but energy use reductions are the lucky beneficiary. The 80-PLUS power supply initiative also ensured that energy efficient power supply units (PSU) became the industry norm, though trend-line changes over time to the overall output wattage of the PSUs was not directly affected.

Operating system power management evolved tremendously as battery-powered laptops and handhelds grew in popularity. Again, desktop PCs were probably a coincidental beneficiary from features built-in to computer operating systems designed to preserve battery life of portable computers. Operating system improvements include both the obvious sleep and other power savings modes (being set on by default on working better/more reliably than in older operating systems) as well as sophisticated drivers and control capabilities for the various hardware-based power management components in a PC (mainboard, CPU and CPU cooling fan, case cooling fans, communications ports, graphics card processors and its cooling fans, etc.).

PCs experience cyclical improvements in computing capabilities and service provision that parallel cyclical improvements in energy consumption. Like significant improvements in automobile fuel efficiency (fuel consumption per hp of engine output) that get offset by customer purchases of larger (SUVs and CUVs) vehicles and more powerful vehicles (the average hp of vehicles today is higher than in the pre-oil crisis, early 1970's days of relatively huge vehicles), PC power consumption has not dropped steadily. A ratchet pattern of engineering efficiency gains then snapped-back for the most part by increased processing capabilities, repeated in cycles over the years, is probably the best way to characterize the long-term trend. A general downward trend in consumption is evident for some classes of equipment.

As mentioned, consumption can vary dramatically depending on the purpose for which the PC is being used. A machine tasked with heavy processing requirements (e.g., video editing, high performance gaming, continuous scientific calculations, etc.) has components of higher capacity and reliability than a typical office machine used at a reception desk. The specialized graphics processor alone in a high-end PC could use more power than an entire standard PC, including the monitor. Since parts can be mixed and match almost at will, there are an infinite number of combinations of hardware and resulting power consumption characteristics.

For the purposes of the PCPMS measure, relatively standard office equipment is of primary interest, since highly specialized and high performance equipment is often specifically excluded from energy management control because those functions often interfere with the machine's intended use. They are in a category not to be disturbed lest the work they are performing is lost or slowed in production. Unfortunately, power consumption of typical PC CPU and monitor combinations, in typical operation, is not information of great interest to be published by the IT industry or the energy efficiency industry. One of the only longitudinal and reasonably current sources of this information comes from the University of Pennsylvania Information Systems and Computing department.[13] Analysis of their database reveals several interesting and relevant-to-PCPMS facts and trends:

- Up until about the mid- to late-2000s, some PCs used between 2W and 6W of power when plugged-in, even when turned OFF. All modern equipment in their database now successfully complies with the maximum 1W standby power regulations in place in most developed countries by 2010 (adopted earlier in 2007, by California)
- Sleep mode on modern equipment now also consumes only 1W
- Significant power reductions can be experienced after as little as 5 minutes of inactivity if aggressive power management settings are utilized
- General power consumption levels of PC/monitor combinations fell over time, particularly starting around 2010
- Older (pre-2010) PC/monitor combination power draw range was approximately 100W to 200W
- Newer (2010-2012) PC/monitor combination power draw range was approximately 50W to 100W
- Larger LCD monitors power draw range from 26W to 57W (this corroborates the reference above in item PD-1, Table 4-5)

Monitor consumption change is already discussed in item PD-1 above. But the simplest conclusion that can be drawn about the CPU portion (everything except the monitor) of the PC is that efficiency has approximately doubled in the relevant ensuing years. It traditionally accounts for about half of the total consumption of the combination package and has fallen by half in the more recent period compared to pre-2010 machinery. This proportion is likely to remain true even if the monitor is larger or multiple monitors are present, because that usage is most often accompanied by a more powerful CPU to drive whatever advanced functions require the enhanced "screen real estate."

Where detailed data related to monitor versus PC power draw is available, such as in the supporting documentation for the NWPCC's Sixth Plan, it is largely based on the older research from the mid-2000s period, sometimes updated to the late-2000s. If combined with other sources, including the University of Pennsylvania report described above, a general rule of thumb that holds over time is that the monitor accounts for approximately one-quarter to one-third of the total power draw of a PC. This means that the CPU (all other components portion)

[13] University of Pennsylvania Information Systems and Computing, "Computer Power Usage," June 21, 2013. Available for online viewing here: https://secure.www.upenn.edu/computing/resources/category/hardware/article/computer-power-usage

represents two-thirds to three-quarters of the power draw. This thumbnail relationship is also corroborated in a report for the CEC (Table 11).[14]

Despite the latest PCs often containing more processing power and capabilities than the typical user will ever need, production cost efficiencies mean they are still most commonly produced and sold at high-capability specifications and consume power accordingly. Nevertheless, advancements suggest that CPU power consumption for non-specialized equipment has approximately halved between the time the ex ante assumptions were developed and the 2013-14 period. Some specialized equipment uses more power than ever, so without details available of the mix of units in operation in participant facilities,[15] a one-third gain in efficiency is considered reasonable. This translates to a one-third loss of PCPMS savings potential for the CPU portion of the savings.

Rating: **—** (strong downward influence on savings assumptions)

O-1. PCs still prevalent, or numbers/savings eroding due to more laptops and handhelds? It is a generally known trend that use of mobile computing devices (laptops, tablets and even smartphones) has and continues to increase relative to traditional desktop computers. This trend diminishes the long-term usefulness of the PCPMS measure because battery-powered devices already have advanced power management features designed to extend the range of use between charges and to extend battery life through intelligent charge/discharge cycling. Although it is possible that PCPMS control could still generate some savings from a laptop computer, many studies and utility program ex ante estimates point to zero savings for those devices.[16]

Increasing proliferation of battery-based computing devices could explain some of the decline in popularity of the PCPMS measure (e.g., between 2013 and 2014 here as illustrated in Section 2.2). Interviews with PCPMS participants, vendors, and IOU staff revealed that it was not coincidence that the health and education sectors dominated. Rather than a result of any specific marketing or deliberate targeting, these two sectors deploy desktop computers in their facilities, often used by a rotation of staff or students, differently than in other professional environments where a computing device is attached to its owner exclusively. These characteristics, combined with some physical needs (theft deterrent, laboratory settings (student and medical), patient care privacy, the specific design of rooms that accommodate medical procedures, etc.) means that the education and health sectors continue to deploy a higher proportion of desktop PCs and deploy

[14] California Public Interest Energy Research Program (April 2011). Office Plug Load Field Monitoring Report, prepared for the California Energy Commission (CEC-500-2011-010).

[15] Most often due to combinations of security, privacy, and proprietary concerns.

[16] Networked laptop computers are still typically included in a PCPMS control scheme portfolio, especially when the PCPMS software suite is being used for other network administration functions like asset management and maintenance (patching).

them differently. In addition to helping to explain PCPMS participation patterns, it also neutralized the concern that PCPMS was deployed in declining units-connected environments. In other words, concern that desktop PCs initially connected and rebated at the time of initial PCPMS deployment (that were actually providing savings) would be quickly replaced by battery-powered devices that, even if still connected, would not generate the expected savings (or possibly none).

The participants interviewed consistently reported that they had specific requirements for desktop PCs and that their portfolios were stable or even growing, including when battery-powered devices were also increasing in parallel. Therefore, rational self-selection appears to be the explanation for the dominance of the health and education sectors in the PCPMS measure participant population. There is no feedback that suggests erosion of units or reconfiguration of units that would affect the fundamental savings equation.

Rating: 0 (neutral influence on savings assumptions)

O-2. Are both CPUs and monitors being controlled, or only one of those? This item was determined to be a critical savings-related element, so a special savings factor was developed to address it. Details can be found below in its dedicated Section 4.3

O-3. Do any/all new PCs automatically get added to the controlled population? This is another research question whose answer falls out of the general satisfaction with the PCPMS product expressed by respondents. If PCPMS works “as-advertised” and does not generate user complaints, then there is no reason not to adopt it as a consistent corporate practice.

It appears the non-energy benefits functionality of the PCPMS suite often drives the decision to install a software suite that in turn opens the door to deploying active power management simply and efficiently. It is virtually guaranteed that network administrators would want to include the maximum number of PCs in their controlled environment for security, maintenance and asset management purposes. There is then no reason not to include those same units in the PCPMS functionality since standardization is always preferred.

There was no evidence of respondent disengaging of the active power management component of the PCPMS suite of network management tools. Several reports confirmed that all new units are deployed consistent with the existing inventory of PCPMS-controlled PCs.

Rating: 0 (neutral influence on savings assumptions)

O-4. Is there any corporate interest in the ongoing reporting and tracking of energy savings? A standard feature of the PCPMS packages is simplified (algorithm-based) energy savings tracking and reporting. Some organizations formally examined estimates of and/or the actual reported kWh savings as part of the decision-making process whether the utility incentive plus expected bill savings warranted the investment in PCPMS. The non-energy, primarily network administrative benefits were also factored and in most cases would outweigh the energy benefits. Despite this, respondents were probed regarding whether there was any corporate interest in the ongoing reporting and tracking of energy savings, post-installation. This is considered a proxy question to help determine whether there might be interest in pursuing more aggressive PCPMS settings after initial deployment.

None of the organizations probed reported following through with any kind of regular reporting or examination of savings. This should not be interpreted as the equivalent of a lack of interest in the savings, though. Some of the lack of follow-up was due to confidence that initial savings reports and estimates were persisting due to the continued operation of PCPMS. Others were sophisticated enough to realize the limitations of the algorithm-based reporting (it is similar to a prescriptive savings assumption, not an actual measurement of the unique equipment) and suggested it would be a waste of time to put too much stock in those generalized numbers. Again, savings were assumed as long as the PCPMS was in operation. Lastly, some suggested that they were driven by and pleased with the non-energy benefits of the software, and knew that *some* savings must be inherent in its use, so *any* savings were a positive corollary benefit.

There was no evidence from respondents to justify an upward savings adjustment based on keen interest in energy savings monitoring.

Rating: 0 (neutral influence on savings assumptions)

4.2.3 Conclusion Regarding Update of Delta Energy Use Assumption (ΔkWh)

Overall Rating: — (strong downward influence on savings assumptions)

There were two strong negative influences, both related to the continuing evolution of PC CPU and monitor energy efficiency in the broader marketplace. The propagation of LCD monitors with LED technology gained significant popularity even between the time of the crafting of the ex ante assumptions (2012) and the 2013-2014 delivery period under examination for this evaluation. Energy use for LED-backlit monitors is approximately half that of the earlier fluorescent-based equivalent-sized models. The inclusion of CRT-based monitors in original savings calculations is also a contributor to this strong negative assessment.

Likewise, the second strong negative influence related to the general trend of lower PC CPU (all components except the monitor) power consumption. Advancements in recent years in all aspects of the design and operation of these have effectively halved energy consumption. There is a wide range of variability in PC power consumption—more than in monitors—but general trends suggest that commonly used basic office PCs are approximately twice as efficient in 2013-14 as in 2008-09.

There was only one factor that would lead to a moderate increase in savings: the trend to larger monitors and use of multiple monitors. Although not likely related to energy efficiency, but rather purchase price, typical monitor sizes and the incidence of multiple monitors per workstation in work places have grown steadily over the years and this trend claws back some of the savings resulting from the relative efficiency of the LCD technology versus CRT.

All of the other nine factors revealed no significant biases upward or downward.

The overall rating of strong negative savings influence needs to be put in the context of the significant uncertainty built into the assessment of the twelve factors. Each factor is not of "equal" weight or importance. The factor ratings are not additive, but only directional. The research and surveys were not exhaustive—in fact, no non-participant surveys were conducted so feedback is limited to PCPMS participants and their assessments of any broader market trends. There is also uncertainty associated with the "baseline" cases used to develop the original ex ante assumptions because many of these factors were not specifically isolated or identified in the original studies.

In the most general sense, the IOU work papers utilized the variety of studies and pilots that occurred in the early- to mid-2000s when PCPMS was being contemplated as a viable energy conservation measure. Given the wide variety of results and baseline conditions reported in those studies, the global average 200 kWh per-year value was not an unreasonable amalgam of the available evidence. However, only the SCE 2012 work paper series anticipated the consistent and continuing improvement in overall energy efficiency of PC-related technology and applied a commensurate discount to the original mid-2000s-based savings estimates. These discounts were applied over time in each successive work paper release. SCE's 2012 work paper arrived at a concluding value of 129.52 kWh per-unit per-year. The most recent SCE work paper of March, 2014, continues the trend of applying an approximately 5% per-year discount to savings, arriving at a value of 117.73 kWh per-unit, per-year.

There is no specific evidence to support a precise number like 129.52 kWh, but neither is there sufficient evidence for any alternative very precise number. The SCE espousal of a 5% annual discount to savings is aligned with the same ultimate conclusion that results from the 12-point analysis undertaken for this evaluation. The 12-point analysis was performed primarily due to the lack of availability of more recent evaluation or study results that could provide direct comparisons to the earlier results. The most important take-away from the analysis is that from the mid-2000s period to now, a consistent albeit potentially stair-step configured series of technology improvements in monitor and PC energy efficiency have dramatically reduced potential savings from PCPMS deployments.

This downward trend in savings potential will continue and evidence regarding LED backlight technology in LCD monitors suggests that for 2015 and beyond, an even higher annual discount than 5% may be warranted. For this reason, cementing in place a savings value for a multi-year period is not advisable for PCPMS technology.

Given how important is the trajectory of expected savings to the PCPMS measure—it could be argued that the downward trajectory is more certain than any actual precise savings estimate—the recommended value for 2013-14 is an interpolation of the SCE 2012 and 2014 work paper estimates.

As revealed in Table 4-6 below, the interpolated value of 123.63 kWh (a simple average of the SCE 2012 and SCE 2014 work paper values) is a defensible and appropriately discounted savings value to utilize for 2013-14 ex post savings calculations.

Table 4-6: 2013-14 Ex Ante and Ex Post ΔkWh Assumptions

IOU (and Work Paper)	**ΔkWh Assumption**
PG&E/SDG&E (2012)	200
SCE (2012)	129.52
SCE (2013) Interpolated	123.63
SCE (2014)	117.73
Evaluation Findings	**ΔkWh Assumption**
2013-14 Statewide Ex post Value	123.63

Next Steps

Values for 2015 and onward should likely be subject to an accelerating downward trajectory of 10% per-year, which would also account for an unknown uninstallation rate. Although all participants contacted for this evaluation were still actively deploying PCPMS in 2015, participants from prior years were not contacted to see if continued deployment persists into the third and subsequent years. It is feasible that some combination of circumstances could lead to PCPMS being displaced or removed after an extended number of years.

For future work paper developments, it should be noted that IT-related measures are likely to share most or all of the following characteristics:

i. Rapid and not necessarily linear technological advancement that, for typically non-energy-related reasons, is accompanied by energy efficiency improvements
ii. Devices and software that perform multiple functions (or applications)
iii. Software that is packaged (as part of a device operating system or as a "suite" of related items)

iv. Packages that can change quickly in terms of what is bundled or how it is licensed, activated or deployed in relation to other items or prior patterns

v. Rapid and not necessarily linear price declines, or, changes to pricing models (per-seat, per-organization, per-device, etc.)

These characteristics are critical to understanding customer decision-making, incremental cost to the customer, risk factors (operational and financial), and for tracking the trajectory of changes over time that could affect future offerings, even short-term and within a current program cycle. PCPMS was affected by all of these, but so will most IT-related measures. Measure-specific savings assumptions should explicitly identify which of these could affect future savings and assign uncertainty bands or risk factors to each.

In the case of PCPMS, better tracking of some very simple and easy to collect metrics could have made a significant difference in savings assessment precision and possibly in the operation of the program itself. Most participants were significant-sized organizations with hundreds, thousands, or even tens of thousands of PCs. Despite appearing on the surface like a deemed measure with a modest per-unit rebate, participants typically displayed initial resistance and then undertook significant deliberation occurred in advance of serious consideration, testing or deployment of PCPMS. The operational consequences of a sub-standard product or botched roll-out are severe.

Recall that all eligible PCPMS packages have an inherent audit and reporting function. These functions could have been better leveraged for overall program management purposes due to the ease by which participants would be able to provide additional information useful for more accurate savings calculation purposes.

4.3 Service Rate Factor (SRF) Analysis

The PCPMS measure, as mentioned earlier, is akin to an energy management software and system in that it can be installed and functioning in the technical sense, but with that status alone having very little connection to energy savings performance. A Service Rate Factor (SRF) is developed to account for this important operational performance issue. Savings only occur when the ex post deployment of the PCPMS results in a materially different practice-level of power management than was occurring before the installation of the PCPMS.

Background

To put the SRF into some context, PCs have had power management capabilities built into their operating systems for many years preceding the offer of the PCPMS measure in California during 2013-14. These features each have energy savings implications and each can remain a user-controlled setting or a network administrator-controlled setting in a network environment.

(Power management settings on stand-alone persona computers are, of course, only controlled by the user.)

A screen saver is mostly a relic of the past—having been designed primarily to prevent burn-in of images on cathode ray tube (CRT) monitors rather than to save energy. Screen savers were often "forced on" in corporate computing environments for security reasons. After a dormant, or idle, period a log-on is required upon return to a PC. This security log-on provision and the screen saver were associated with each other in control settings. The advent of LCD-based monitors rendered the energy savings aspects of the traditional screen saver moot (energy use is not so materially affected by what is displayed on the screen), though the use of them has prevailed due to the linked security aspect, which has continued to rise in prominence over time. The forced log-off after an idle period is almost universally adopted by network administrators.

Although commonplace server operating systems and PC operating systems have had the technical capability to force-deploy both monitor and CPU power management functions in a networked environment,[17] there has been little upside, but significant potential downside in the form of labor cost and potential complication to do so from the perspective of a network administrator or IT executive. Probably as a result, those server-side features were not a focus of server operating system development and they remained available, but mostly ignored (or limited to forced-activation of the log-off/screen saver in order to meet security policies). In many networked computing environments, the lack of reliable remote capability to restart a computer that was off or asleep resulted in users being asked to purposefully leave their CPUs on (but logged-off) at the end of the workday so that maintenance patches could be applied from a central server. This resulted in PCs running 24/7 in corporate environments as a common default.

PCPMS packages attempt to overcome these barriers by providing a dedicated user interface for administrators with sophisticated, but easy to implement and granular energy management control schemes; sophisticated inventory tracking capabilities; easily managed reporting functions, and; what may be the "killer app"—the ability to reliably wake-up a sleeping PC remotely for maintenance purposes (e.g., and most commonly, installing software patches during the overnight period). This wake-and-patch functionality is of significant benefit to any medium or larger-sized IT organization that does not already have that capability. Participant interviews confirmed that this functionality was of primary interest, especially if cost-discounted. The energy savings functionality was more likely of secondary interest, though of interest if the power management functionality was mostly "set and forget" and worked smoothly in a manner that did not generate user complaints or cause any form of operational issues or burden.

[17] A Microsoft example from 2009: https://technet.microsoft.com/en-us/magazine/cc462804.aspx

Core SRF Issue

The desired energy savings from PCPMS are often packaged intentionally as “savings by stealth,” or savings that are made conveniently available while the participant is investing in some other non-energy benefit functionality of more immediate interest. As a result, the degree to which the energy management functionality was deployed becomes a critical concern as there may be a tendency to minimize the effectiveness of the deployment if energy savings were not a primary concern. Hence the Service Rate Factor (SRF) is needed to account for the operational options chosen when PCPMS software is deployed often for non-energy benefits reasons.

In the Delta Energy Use Assumption Analysis (Section 4.2) it was revealed that the hours of use and numbers of PCs deployed among 2013-14 participants did not represent concerns for savings rates. The one area substantive to savings that did reveal itself was the basic option of what components of a PC to control for power management purposes.

There are several key options that can be configured in the software for energy management purposes:

- Control of CPU components such as the hard disk drive (HDD),
- Control of monitor(s), and
- Control of the PC Operating System that determines what the PC can do if instructed to change power management modes or sleep or shut down.

Table 4-7: Configuration Options that Typical PCPMS Product Can Control for an Attached PC

Power State	CPU Components (e.g. HDD)	Monitor(s)	CPU Operating System
Unplugged			
Off			X
Sleep	X	X	X
Idle	X	X	X
Active	X	X	X

When this array of options is cross-referenced against the ability to define multiple groups of computers (defined by work groups, hierarchy in an organization, or physical location, etc.) to set policies for, and even individually set or override control policies based on either an individual machine or user, dozens, if not hundreds of permutations are possible. These settings, along with user and machine-based inventory details are generally considered proprietary and are not typically shared with any agency outside of a formal corporate audit. Respondent participants confirmed reluctance to share this information.

Nevertheless, given the feedback in Section 4.2.2 that no rationale was revealed to promote the use of milder than reasonable settings, since energy savings come from after-hours control when users are rarely around to notice the difference, there are really just two fundamental options that can be readily identified that have a direct and significant impact on energy savings:

1) Power management control of CPU and monitor, and
2) Power management of monitor only.

The ex ante Delta Energy Use (ΔkWh) Assumptions assume the first option. Therefore, if both are controlled, no adjustment factor to the prescriptive savings value is needed. If only the monitor is controlled, then a significant reduction in energy savings is the result. There was no evidence of CPU's being controlled, but not monitors.

For the proportion of participants that chose option 2, and to control only monitors and not CPUs, a discount factor is needed. As described in Section 4.2.2 (PD-3), the proportional power draw of monitors compared to the whole PC has tracked over time at approximately one-quarter to one-third of the total. In the same section (PD-2), it was noted that the presence of multiple monitors in workstations is of increasing prevalence—enough that for example the NWPCC established a factor of 1.18 for them in their system plan.

Based on the analysis presented in Section 4.2.2, a one-third of total PC power draw ratio is utilized for the calculation of the SRF. This is simply the higher-end of the range generally reported and accepted, but would account for the incidence of multiple monitors.

Due to the extremely skewed participant savings-weighted distribution, a proxy value for the SRF is recommended. Based on the in-depth interviews with participants, it was clear that some IT administrations had purposefully chosen to limit control to monitors-only in an attempt to minimize potential disruptions to their own operations and to minimize potential complaints from their user populations. However, although implicitly assumed in ex ante savings calculations, program guidelines did not explicitly specify that controlling only the monitor portion of the PC was an eligibility criterion.

For 2013-14, a Savings Rate Factor (SRF) that assumes one-third of participants controlled monitors-only should be applied on a proxy basis to account for the loss of realized savings that results from this sub-optimal practice.

If one-third of the total population savings is subject to a unit-based two-thirds loss of savings (because monitors comprise one-third of the power draw), then the overall impact of the SRF is to cut savings by approximately a quarter.

SRF Calculation = (1/3 ΔkWh Assumption x 1/3) + (2/3 ΔkWh Assumption x 1.0)

SRF Calculation = ΔkWh Assumption x 0.777

SRF = 123.63 kWh x 0.777

SRF = 96.16 kWh

A SRF of 0.777 should be applied to the 2013-14 population gross savings, incorporated into the ultimate UES value. This factor could be removed at such time as controlling monitors-only is clearly ineligible and verification has demonstrated it to be the case in real-world practice.

4.4 Load Shape Analysis

It is not transparent how either IOU work paper in use for 2013-14 arrived at the kW ex ante savings values proposed. SCE chose an occupancy sensor load shape, which on the surface seems reasonably analogous to the PCPMS function. However, for the purposes of determining shifts from Active or Idle to Sleep or Off, occupancy sensor does not in fact represent these changes very well. It is obviously possible to be in an office/work station doing other activities that do not entail using the PC. The occupant could be actively engaged in meetings, telephone conversations, reading, and so forth, that an occupancy sensor would read as "occupied," while the PC could or should be asleep as it is not being used (or "occupied").

The PG&E/SDG&E work paper references the measure load shape being determined by the E3 calculator based on the applicable non-residential market sector and the computer plug load end-use. Unfortunately, the PC itself is not a useful load shape as it would be expected to be in use, or at least on, in a commercial setting during peak hours in the afternoon. The PCPMS load shape needs to highlight the difference between regular PCs and those controlled for power management by PCPMS to calculate the appropriate kW savings values. The selection of this load shape may explain why the PG&E/SDG&E value is so high relative to the SCE value.

The vast majority of the PCPMS savings are expected to occur outside of peak hours and outside normal commercial office or educational institution regular hours. The PCPMS prevents PCs from remaining idle in the large proportion of after-hours (evenings, nights and weekends) that no one is present or able to actually use the machine. Although PCPMS can also affect power draw during normal working hours, the only impact is when a user is not actively using their PC for some extended period of time. The longer the idle time-out setting, the less chance that a machine will be left alone long enough to trigger a sleep state. If put to sleep, for how long? Some machines will be used by people who spend much of their day out of their offices, but conversely, many machines encountered at 2013-14 participant sites are diagnostic or teaching laboratory units that see a succession of users throughout the day. These are less likely to be idle for extended periods, but more likely to be left on after-hours because they have no "individual owner" paying attention to when is the actual end of day or end of week for that machine.

As with so many other important details pertaining to PCPMS, there is a dearth of current information regarding the impact PCPMS could have on Power State shifting vis-à-vis modern equipment in current practice settings. The PCPMS purpose and functionality has not changed substantively over time, but the baseline use-case may have. The Delta Energy Use Assumption Analysis (Section 4.2) outlines a number of aspects of technology change and equipment selection that are changing over time and that likely affect PCPMS savings assumptions. Peak kW assessment also requires a look at basic assumptions, available research and any plausible trends that could suggest a higher or lower savings value.

The first consideration involved in determining whether either of the IOU-selected PCPMS load shapes versus a modified/alternative load shape should be selected for ex ante purposes is operating hours.

4.4.1 Operating Hours

A prerequisite to any concern about Power State baselines versus those with PCPMS influence involves the basic total operating hours estimate. The SCE ex ante kW estimate is dramatically lower, so that calculation can form the starting point for basic checks.

Respondent participants were queried, in general terms, about pre- and post-installation operating hours. Two common baseline scenarios produce the following reference hours (of a total 8,760 hours per year):

- PC on "almost all the time" (8,500 h)
  - Instructed to leave machines on at all times to facilitate IT maintenance
  - Special periods like holiday season may see shut-downs
- PC gets turned off at end of normal (8-hour) service day (1,960 hours)
  - 5 days a week for 49 weeks of the year allows for typical vacations and holidays

Within either of these common baselines exists idle time during each service day, potentially significant. The "always on" scenario has significant idle time outside of the service day hours.

The SCE assumption for its ex ante kW value for building type "Offices" lists 2,640 hours for "Annual Operating Hours." This is one typical work week of hours (40) more than 10 hours per day, 5 days per week, 52 weeks per year. That is significantly more hours than one might expect for a typical employee's PC to be operating in the scenario where machines are turned off at the end of each work day, but vastly less than if they are not turned off. It is not clear if this value is supposed to refer to the office itself, the affected PC, or the PCPMS run-time.

The SCE work paper calculation references a problematic study[18] and concludes that based on the usages profiles found in the study, 2.3% of energy savings from power management software occur during weekdays between 2-5 PM. The weekday hours of 2-5 PM comprise just under 9% of total annual hours, so an assumption of just under one-third of these may seem reasonable. Not every PC is in full use, all the time. However, the calculation undertaken is not consistent with the definition of peak in California nor does it recognize the inherent nature of the PCPMS measure.

The SCE ex ante calculation is as follows:

Peak Demand Reduction = (2.3% x Annual Unit Energy Averaged Savings) / Operating Hour by Building Type

The Annual Unit Energy Averaged Savings is equivalent to what is referred to as the Delta Energy Use (ΔkWh) Assumption in this report. That Savings value already has a variety of operating hour and savings profile characteristics that were inherent in the original studies that were "averaged" to develop the value in the first place. Some of those studies may have had hourly (or better) metered data available, although likely unpublished.

Dividing 2.3% of this Savings value by the overall operating hours for a building type (e.g., 2,640 for Offices as mentioned above) does not produce a value that relates to the connected demand (kW) savings for any particular hour. Instead, it produces an hour-based kW savings value that ignores that PCPMS is running 8,760 hours of the year and that its effectiveness is maximum (and different) outside of normal working hours, which include the 2-5 PM weekday period.

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18 The Northwest Energy Efficiency Alliance (NEEA) report (80 PLUS Market Progress Evaluation Report #5, November 26, 2013, REPORT #13-271, prepared by Research Into Action) says of the SCE referenced report: QDI Strategies Thin Client Investigation: In 2010, QDI Strategies, Inc. conducted a large study on behalf of Pacific Gas & Electric (PG&E) to evaluate computer duty-cycles and demonstrate savings with enterprise power management (Barr et al. 2010). QDI performed analyses in a number of different commercial markets (financial, healthcare, education, transactional business) in the United States. A sample of 91,000 desktop computers were electronically monitored for a two-week period to obtain the amount of time each unit spent in various modes (on, sleep, off). Logging of machine power states was conducted over local networks using system logging software; power meters were not used to verify power states. Researchers reported that the baseline desktop computer active/idle time on an average business day was 95%, and standby/off time only 5%. As a result, QDI concluded that dramatic savings are possible by using enterprise power management software such as Verdiem. These findings contrast sharply with other published studies. We question the validity of these results due to the large deviation from other contemporary studies, but also because operational modes were monitored remotely and not verified with power data.

4.4.2 Power State Shift

Documented research[19] that generates UES values with heritage that can be traced to the same source studies used to generate the California IOU ex ante kWh values, updated with more recent Energy Star and evaluation data, suggests a method to determine kW savings. The sources used for Power State derivations are not reliable enough to use for definitive UES kWh calculations, but do provide useful guidance for creating kW savings coincidence factors.

A. Some proportion of PC CPU units already have/had the equivalent of PCPMS-level power management enabled. Assume 20%.

B. Some PC monitors already have/had the equivalent of PCPMS-level power management enabled. Assume 85%.

C. Some proportion of combined PC units are successfully controlled by PCPMS after its installation. Assume 85%. Rate after 2 years is still 85%. Longer-term rate unknown.

D. PCPMS successfully shifts usage from Idle to Sleep or Off state. Assume 23% of annual hours for CPUs and 8% for monitors.

E. Weekday hours 9 to 18 represent the lowest savings potential for PCPMS for offices; weekday hours 9 to 17 represent the lowest savings potential for schools (because schools close earlier, there may be some savings in the 4 pm to 5pm period).

F. Only hours 15 to 17 are relevant for peak kW purposes.

To put all of this into perspective, the RTF assumptions suggest that PCPMS is affecting 65% of PC CPUs (85% fully controlled when PCPMS is installed subtract 20% baseline already equivalent-to-PCPMS power management). Since even the most liberal definition of the normal workday (8 hours/day x 5 days/week x 52 weeks of the year) comprises just 2,080 hours out of the total 8,760 (23.7%), the 23% successful shifting assumed by RTF is curious in that it must assumes the PC will be asleep/off for virtually the entire normal work-hour window (minus just one and half weeks of the year). The shift from Idle to Sleep or Off must therefore be occurring primarily outside the normal work-hour window or else the PCs must be superfluous to their users.

There is a lower expectation for monitors, with the assumption that 85% of them are already under equivalent-to-PCPMS level of power management and that only 700 hours (8%) will be affected.

An examination of the RTF PCPMS savings load shape reveals exactly what is expected. Other than the weekdays single hour 17 (4 to 5 pm) for K-12 schools, when school operations are likely

[19] The Northwest Power and Conservation Council (NWPCC) Regional Technical Forum (RTF) Deemed Measures – Commercial: Non-Res Network Computer Power Management.

to have ceased, no significant PCPMS savings are occurring during other peak hours for those schools or for any peak hours for machines in the generic "Office" category. The PCPMS measure produces energy savings for the majority of hours of the year that are not normal workplace hours. Peak demand hours are when it has little to no effect—by design. It should not interfere with normal PC use when a user is present and using the machine during work or study time.

The RTF concludes that there may be some very small distribution system peak load reduction (in the neighborhood of the SCE work paper level). However, they also conclude that the power system coincident peak reduction is so small that it rounds to 0 kW. Some technical reference manuals calculate kW savings to the customer.

Given that all of the evidence collected in this evaluation corroborated the concept that participant IT departments were highly interested in ensuring that their users were not inconvenienced by PCPMS, it is highly unlikely that PCs were aggressively being put to Sleep or turned Off during normal work hours in any significant numbers. The PCPMS benefit was to prevent machines running needlessly during the 77% of not regular work hours.

Seemingly, the only exception to effectively zero peak impact due to the purposeful design of PCPMS to lurk in the background unnoticed when people are actually using their PCs relates to schools' participants (a very small proportion of the overall 2013-14 savings by weight). Other than the small effect of a single hour (4 to 5 pm) for those schools that do not use their PCs after school lets out in the afternoon and that are in climate zones where the DEER Peak periods coincide with the operating school year, there appear to be zero or approximately zero peak kW savings from PCPMS.

For reference, the CPUC-Defined DEER Peak Periods by Climate Zone (Beginning July 1, 2014) are listed below:

Table 4-8: CPUC-Defined DEER Peak Periods by Climate Zone

Climate Zone	Start Date	End Date
1	16-Sep	18-Sep
2	8-Jul	10-Jul
3	8-Jul	10-Jul
4	1-Sep	3-Sep
5	8-Sep	3-Sep
6	1-Sep	3-Sep
7	1-Sep	3-Sep
8	1-Sep	3-Sep
9	1-Sep	3-Sep
10	1-Sep	3-Sep
11	8-Jul	10-Jul
12	8-Jul	10-Jul
13	8-Jul	10-Jul
14	26-Aug	28-Aug
15	25-Aug	27-Aug
16	8-Jul	10-Jul

4.4.3 Load Shape Effect on kW Savings

The measure savings assumptions and load shape analysis undertaken by the RTF has the most extensive documentation and calculation methodologies available for PCPMS. This is undoubtedly a legacy of the work done by Northwest Energy Efficiency Alliance (NEEA) to foster this measure in its embryonic period. If the California peak period definition is applied to that research, combined with corroborating feedback from 2013-14 participants, the most reasonable conclusion is that peak kW savings for PCPMS in California are zero or approximately zero.[20] **For that reason, this evaluation recommends no system-level kW savings be ascribed to PCPMS participation.**

[20] Peak demand has been defined by the CPUC as the DEER Peak definition. DEER defines peak demand as the average grid level impact for a measure between 2:00 p.m. and 5:00 p.m. during the three consecutive weekday periods containing the weekday temperature with the hottest temperature of the year.

4.5 Development of Final Unit Energy Savings (UES) Values

UES (Gross Savings) = Delta_Energy_Use_Assumption (ΔkWh) x Service_Rate_Factor (SRF)

Where,

Delta_Energy_Use_Assumption (ΔkWh) = a kWh/year, or more accurately, an annual delta Watt-hour, value that attempts to account for the average energy savings per attached/controlled PC on a network where PCPMS has been deployed. The value incorporates a range of field-tested and laboratory results that themselves represent a variety of specific PC hardware, operating systems and pre- and post- operating practices. This evaluation cannot replicate the types of studies done to generate the ex ante ΔW savings estimates, so it remains in place to be modified by two factors (IR and SRF) described immediately following. The ΔkWh assumption, by definition, attempts to account for ex post versus baseline conditions.

Service_Rate_Factor (SRF) = Unlike traditional energy conservation measures, the installation alone of PCPMS does not bring about savings. The features of PCPMS have to be activated and utilized. There are a myriad of combinations and permutations for PCPMS operation, but the two fundamental options that affect the rate of savings are:

1) Power management control of CPU and monitor, and

2) Power management of monitor only.

UES (Gross Savings) = (ΔkWh of 123.63) x (SRF of 0.777)

UES (Gross Savings) = 96.16 kWh

Table 4-9: Ex Post UES Values for PCPMS

ESPI Measure Configuration	UES kWh	UES kW
PCPMS		
Health Sector	96.16	0.0
Education/Other Sectors	96.16	0.0

4.6 Installation Rate (IR)

There are two variations of an "installation rate" discussed below. A PCPMS-specific definition that attempts to deal with the unique characteristics of this measure is followed by a more traditional definition consistent with how a broad range of energy conservation measures are generally handled.

4.6.1 PCPMS-Specific Installation Rate (IR_1)

This definition of installation rate focuses on the savings pathway as might be delineated in a logic model or program plan. It attempts to quantify/verify the percentage of PCs under active, network-based centralized power management, as installed by participants. Rebates are based on the number of PC units that are to be controlled, though the control software itself resides on a central network server. The number of PC units under PCPMS-directed management in a participant's ex post inventory could vary dramatically even if the rebate-related PCPMS package is still installed.

The PCPMS measure presents a conundrum in that many large organizations have IT security policies and provisions that prevent physical verification during on-site visits or even the sharing of an electronic or paper-based inventory of PC and server equipment. The choice to pursue in-depth interviews with participants rather than attempt on-site visits was based in large part on this reality.

Verification of traditional energy conservation measures involves identifying the number of measures that are currently installed and in working condition (operable), since some may not have ever been installed or some may have failed (prematurely) since the time of initial installation. A traditional installation rate is calculated directly from this measurement:

$$\text{Installation Rate} = \frac{\text{Quantity of measures installed and operable}}{\text{Quantity of measures reported installed in tracking system}}$$

In addition to identifying the amount of equipment that is installed and operable, evaluation also identifies the amount of equipment that was:

- Failed and in place – The number of measures that are currently installed, but were not in working condition (failed).
- Failed and replaced – The number of measures that had been installed, but then had failed and were replaced with a different technology.
- Removed and not replaced - The number of measures that had been installed, but had been removed (either due to failure or other reasons), but were not replaced, such that the lamp socket is empty.

- In storage – The number of measures that were found in storage and have not yet been installed.

PCPMS is an atypical measure that is not analogous to pieces of equipment that can be installed or retrofitted in place of older, existing equipment. Because PCPMS involves a server-side installation that controls some number of individual, but networked PCs, there are two elements important for understanding a PCPMS-specific installation rate. Is the server-side application installed and licensed—and configured by the network administrator to be in some active state? And secondly, how many individual PCs are controlled by the server-side software? In addition, the traditional concept of storage or stock-piling is not particularly relevant here.

Server-Side Installation

Network administration is a complex endeavor in larger organizations with thousands of employees. It can be safely assumed that even the least competent network administrator follows the golden rule of minimizing applications and server-side functions only to those critical for business or computing operations purposes. There is effectively no fear that server-side software would be casually installed. Only a product deemed necessary would be added to the stack for fear of negative interactive effects that could result in user/customer service interruptions, which in turn would spawn complaints or outright service outages. This maxim was confirmed by multiple respondents in the in-depth interviews of PCPMS participants.

One premise of incentivizing PCPMS was the explicit assumption that IT managers and administrators would resist introducing another layer of application(s) that are not essential for business or computing purposes. In-depth interviews with PCPMS participants confirmed that IT decision-makers in the majority of larger organizations had an initially tepid response to suggestions that PCPMS be installed on their networks. When coaxed to contemplate the prospect, most deployed fairly sophisticated pilots to ensure that the PCPMS product would interoperate successfully within the rest of their system.

The hurdle to overcome to get PCPMS installed in a larger organization is daunting. It is unlikely to get installed until fully tested and internal deliberations have determined it to be a worthwhile trade-off of benefits versus effort, cost and (lack of) operational risk. This decision-making process often occurred before the product was purchased on a mass scale and subsequently rebated—during smaller-scale pilots or testing, often with the support of the vendor. The supposition is that once tested and deemed satisfactory, paid for and installed, it would not be uninstalled within a relatively short time frame (a couple of years) under normal circumstances.

In the sample of 2013-14 participants interviewed throughout 2015, there were no instances of the server-side software having been uninstalled. This implies a confirmation of the implied 100% installation rate, but there is a second component needed to assess the true installation rate.

Client-Side Installation

Due to the server-client structure of the PCPMS measure, the installation rate for PCPMS requires both components of the installation to be considered. A participant could purchase a PCPMS suite with licenses for a certain number of PCs, but then encounter problems or issues that would cause them to delay installing the software on certain machines. Another scenario could involve uninstalling the software on some portion of the attached PCs after initial experience with them revealed problems or led to user complaints. These would be similar but not precisely equivalent to the traditional "in storage" and "failed and replaced" in-service rate factors. The server-side PCPMS software could still be installed and functioning under either of these scenarios.

As discussed in above in sections DCD-5 and DCD-6, interviews with the 2013-14 participant sample revealed no indications that client-side functionality was systematically reduced or eliminated post-installation. The only suggestions were that as normal business growth occurred, all new PCs were added to the system. This could represent participant spillover if that was to be accounted for. Interviews occurred well after respondents would be able to assess workability and long-term satisfaction with the product. In effect, there is no evidence to suggest an in-service rate of other than 1.0 or full.

Even a missing server-side installation would not automatically zero savings from an IT operational perspective. If no PCPMS or manually-implemented power management strategy was in place prior to participation and then the participant tried and subsequently uninstalled their rebated PCPMS after some reasonable period, but then deployed an equivalent alternate PCPM strategy, then the participation may have engendered PCPM awareness and action where none existed prior. An alternative to this scenario is that a second, more suitable PCPMS was purchased to replace a less than satisfactory rebated PCPMS[21]. From the perspective of whether behavior and actions took place that are a prerequisite for PC power management savings, meaning active power management was occurring ex post that was not occurring ex ante, then the in-service rate is fulfilled by this "practices" definition. These scenarios and issues were probed both during the interactive in-depth interview and in the NTG-specific standardized survey questions in an attempt to better understand the behavioral, practice, technological and decision-making elements that blend to make PCPMS work as an incentivized measure.

[21] Suitable or Acceptable versus not suitable or not acceptable related to IT ecosystem compatibility or interoperability issues, not the basic functionality of the software. All eligible PCPMS packages could perform the requisite functions and power management.

The server-side in-service rate, even allowing for the alternate strategy opportunity, is still a 1/0 (or 100%/0%) toggle. The client-side in-service rate is then applied to produce the PCPMS measure-specific Installation Rate, which would be zero in all instances where the PCPMS software was not installed and not replaced with an equivalent strategy. To illustrate the algorithm, albeit redundant in this situation:

PCPMS-Specific Installation Rate (IR_1) = $\text{Server-side Installation Rate} \times \text{Client-side Installation Rate}$

$$IR_1 = \mathit{Server\text{-}side\ Installation\ Rate}\ (1 \text{ or } 0) \times \frac{\text{Quantity of client-side measures reported installed and operable}}{\text{Quantity of client-side measures reported installed in tracking system}}$$

Conclusion

The PCPMS Installation Rate (IR_1) was 1.0, based on a 100% server-side in-service rate and an approximately equal to 100%, with any uncertainty leaning towards a higher than 100%, client-side in-service rate. These details are shown in Table 4-10.

Table 4-10: PCPMS Installation Rate (IR_1)

ESPI Measure Program Type	Sites	Server-Side In-Service Rate	Alternate PCPM? (Y/N)	Client-Side In-Service Rate	PCPMS Installation Rate (IR_1)
PCPMS					
Health	3	100%	N/A	≈100%	1.0
Education/Other	7	100%	N/A	≈100%	1.0
Total	**10**	**≈100%**		**≈100%**	**1.0**

4.6.2 Traditional Installation Rate (IR_2)

In addition to the PCPMS-specific definition, the traditional installation rate is simply the percentage of claimed measures reported by participants as installed. Although the rebate is PC-based, the PCPMS system cannot function without the server-based package installed.

As described elsewhere in this report, it is possible to install PCPMS, but effectively not to use it. It is possible to install PCPMS, deploy it in full, but then to uninstall it (which "un-deploys" it). No participants interviewed reported these experiences. However, other variations are possible, such as installing and using a rebated PCPMS package, discovering that it is unworkable for some reason or another, and then replacing it with an alternate PCPMS package that gets deployed and used as expected. There was one instance of this scenario.

To maintain consistent treatment with, for example, how a rebated energy management system (EMS) that was replaced by a better functioning EMS, other energy efficiency measures, the rebated PCPMS in this scenario (the original one) is deemed "not installed."

However, replacing PCPMS systems with "better" PCPMS systems is not so rare as to ignore the incidences. As will be discussed in the next section, the converse scenario also occurred in that a less-than-acceptable functioning PCPMS was eventually replaced by a rebated, acceptable PCPMS system that went on to be successfully deployed.

A Traditional Installation Rate (IR_2) of 0.99 (savings-weighted; precise value is 0.988) is arrived at to account for the one smaller-scale participant that later replaced a dysfunctional, but rebated PCPMS package with a functional non-rebated one.

IR_2 = 0.99

Since IR_1 is 1.0, the conclusive Installation Rate (IR) recommendation for the PCPMS measure is to use the value of IR_2.

PCPMS IR=0.99.

4.7 Eligibility Factor (EF)

The Eligibility Factor (EF) is defined as the proportion of participants that adhered to an eligibility definition designed to prevent like-for-like replacements or regressive baselines. That definition is based on the IOU work papers and program materials and can be clarified with the following descriptions:

If the participant had no prior PCPMS, they are eligible. This includes participants that owned pre-existing network management suites without a PCPMS module embedded in them.

If the participant owned a pre-existing network management suite that contained a PCPMS module, regardless of whether it was unused or not deployed, they would be ineligible. If a new PCPMS is purchased to replace a pre-existing unused or not-deployed PCPMS, they are also ineligible. A pre-existing PCPMS may have been tested or piloted, rejected out-of-hand based on specifications or deemed unacceptable for some unknown reason. No distinction is made on the basis that a pre-existing PCPMS could have been easily deployed had the participant had an interest in doing so.

These distinctions are based on rules laid out by two of the three IOUs, which were then adopted by the third, in 2014. They state that qualifying software must result from:

- A new installation, where none previously existed, or
- An upgrade of an operating system or other network support software where the desktop computer power management function did not previously exist.

Larger-scale organizations are much more likely to be familiar with PCPMS technology than smaller organizations. Application of the EF to the sample of participants that were subject to in-depth interviews corroborated this difference. For that reason, the measure participant population was divided into two strata: large, for participants with more than 5,000 PCs rebated, and "other," for the smaller participants that encompass the full range beneath the 5,000 size threshold.

Table 4-11 presents the eligibility factors for large and small participants, identifying if each participant sampled was eligible or not, along with their first year ex ante savings values. The large-participant EF is 16% (meaning that 84% were ineligible according to the definition outlined in this section). Other-participants had an EF of 54% applied to their savings, to account for the 46% ineligibility finding for them.

Table 4-11: Eligibility Factor

Customer Size	First Year Ex Ante Savings kWh	Eligible	Cause for Ineligibility
Small Participants			
<5,000 PCs	153,999	N	Pre-existing PCPMS*
<5,000 PCs	253,400	N	Had replaced unsuitable rebated PCPMS
<5,000 PCs	851,800	N	Pre-existing PCPMS*
<5,000 PCs	43,400	Y	
<5,000 PCs	395,200	Y	
<5,000 PCs	474,199	Y	
<5,000 PCs	594,200	Y	
Eligibility Factor		**54%**	
Large Participants			
> 5,000 PCs	1,613,000	N	Pre-existing PCPMS*
> 5,000 PCs	13,467,272	N	Pre-existing PCPMS*
> 5,000 PCs	2,934,425	Y	
Eligibility Factor		**16%**	

* Pre-existing unused or not-deployed PCPMS was present, likely as a module of a broader network management server suite.

IT executives and network management staff are generally unfamiliar with energy efficiency terminology and programs. Therefore, ensuring that IT-related measure eligibility definitions are expressed in a manner that IT vendors and IT managers will comprehend is critical to ensuring that rebates are targeted at officially eligible utility customers. It is particularly important that eligibility requirements be crystal clear for PCPMS, since it can be packaged in a broader network management suite of software, or, may have to coexist with network management software. Clarity regarding what constitutes a pre-existing "installation" is necessary to avoid the significant discounts applied to savings estimates here.

Also, non-energy considerations and benefits played a huge role in the success of PCPMS installations. This can either be considered energy efficiency achievement by stealth, or, a failure to get participants to make energy efficiency their top priority, depending on eligibility definitions.

Regardless, any definitions decided upon need to be communicated very clearly and consistently to avoid the need for an EF factor in the future.

4.8 Ex Ante and Ex Post Gross Savings Values

Recall that:

Ex Post Gross Savings = Unit Energy Savings (UES) x Installation_Rate (IR) x Eligibility_Factor (EF)

Where,

UES (Gross kWh Savings) = Delta_Energy_Use_Assumption (ΔkWh) x Service_Rate_Factor (SRF)

Delta_Energy_Use_Assumption (ΔkWh) = a kWh/year, or more accurately, an annual delta Watt-hour, value that attempts to account for the average energy savings per attached/controlled PC on a network where PCPMS has been deployed. The value incorporates a range of field-tested and laboratory results that themselves represent a variety of specific PC hardware, operating systems and pre- and post- operating practices. This evaluation cannot replicate the types of studies referenced to generate the ex ante ΔkWh savings estimates, so it remains in place to be modified by two factors (IR and SRF) described immediately following. The ΔkWh assumption, by definition, attempts to account for ex post versus baseline conditions.

Service_Rate_Factor (SRF) = Unlike traditional energy conservation measures, the installation alone of PCPMS does not bring about savings. The features of PCPMS have to be activated and utilized. There are a myriad of combinations and permutations for PCPMS operation, but the two fundamental options that affect the rate of savings are:

1) Power management control of CPU and monitor
2) Power management of monitor only

Installation_Rate (IR) = the percentage of claimed measures reported as installed by participants. The original assumptions presume a 100% installation rate.

Eligibility_Factor (EF) = the proportion of participants that adhered to an eligibility definition designed to prevent like-for-like replacements or regressive baselines (explained in more detail in Section 4.7).

Table 4-12 illustrates the gaps among the two IOU-based ex ante UES values and the final ex post evaluated UES value.

Table 4-12: Ex Ante versus Ex Post UES Values

Parameter	Ex Ante PG&E/SDG&E (PGECOCOM105 Rev #3)	Ex Ante SCE (SCE13OE001 Rev 1.0)	Ex Post Evaluated Savings
Final UES kWh/unit	200	129.52	96.16
Final UES kW/unit	0.02	0.00113	0
Final UES therms/unit	0 / (N/A)	Negative savings	Negative savings for SCE

Table 4-13 shows the ex post evaluated UES as reduced by the 0.988 Installation Rate (IR).

Table 4-13: Ex Post UES Values with Installation Rate (IR) Applied

Parameter	Ex Post Evaluated Savings – Final UES	Ex Post Evaluated Savings – Final UES with IR (0.99)
UES kWh/unit	96.16	95.0
UES kW/unit	0	0

Finally, Table 4-14 illustrates the comparative effect of applying the large-customer (5,000 units or more) versus the other-customer Eligibility Factor (EF) to the evaluated ex post UES value.

Table 4-14: Ex Post UES Values with Eligibility Factor (EF) Applied

Parameter	Ex Post Evaluated Savings – Final UES	Ex Post Evaluated Savings – Final UES with Large Customer EF (0.16)	Ex Post Evaluated Savings – Final UES with Other Customer EF (0.54)
UES kWh/unit	96.06	15.38	51.92
UES kW/unit	0	0	0

The cumulative effect of the IR and EF can be seen in the next chapter (5, Evaluation Results), just following the discussion and findings related to Effective Useful Life.

4.8.1 Effective Useful Life (EUL) Analysis

Effective Useful Life (EUL) estimates of both four (4) and five (5) years were utilized for ex ante purposes by the IOUs. These values are in-line with those utilized by other program administrators, though values may have been borrowed from one another in the absence of rigorous analysis.

Variously, the lifespans of a desktop computer, a monitor, or a server are referenced by program administrators to justify the EUL for PCPMS. None of these are appropriate analogues because they represent computer hardware, most often replaced on a pre-scheduled basis in corporate environments. PCPMS is software, so a more appropriate comparison would be Microsoft Office or perhaps a corporate-level anti-virus program. Once the suite (productivity software, anti-virus, security, etc.) is installed, it is continuously updated by the vendor, and unless there is a usability or satisfaction concern, it gets transferred and propagated to new, replacement and existing equipment as a single integrated process.

PCPMS appears to fit this model. The evaluation encountered several instances of various tests, pilots, installations, deployments and changes that were required to roll-out the PCPMS to the level of satisfaction of IT management. Once successfully deployed, it becomes a part of the "IT ecosystem" more or less "permanently."

"Permanence" is perfectly feasible because not only does the product get updated over time to correct performance issues, it is also sold on the basis of ease-of-configuration. Any exceptions to the rule in an organization where the application of generic PCPMS could cause a productivity issue or generate user complaints can easily be "excluded" or managed differently than the norm with minimal effort. As discussed above, these sorts of exclusions are already built into the Delta Energy Use (ΔkWh) Assumption and into UES values from other jurisdictions (e.g., RTF assumes a liberal 15% of units will not ultimately be controlled in an environment with PCPMS operating).

Despite the evidence of "permanence" (RTF also found no evidence of removal of PCPMS once it was installed), this is for a two-years or less period. No studies could be located that looked back at older PCPMS deployments to see what had transpired. The three-year and onward period is one of increasing uncertainty as to the continuation of PCPMS operation as defined by the measure rebate specifications.

There is also the unrelated, but important, concept reinforced by this evaluation that the year-over-year savings expectations should decline—as put into practice by SCE each time a new work paper was issued. However, modification to the work paper UES value is not enough. Because PCPMS is dynamic in that exists inside an evolving IT ecosystem with continuous replacement of older equipment with newer, more energy efficient hardware and operating systems, the application of a technical degradation factor is called for.

There is no convenient manner to apply a technical degradation factor in the current CPUC savings reporting infrastructure. As a result, a shorter EUL is required as a blunt instrument method to achieve similar ends.

It is almost 100% certain that before the end of a “permanent” measure life (20 years), power management of PC equipment will have evolved to some level equivalent to the best battery-powered devices today, or even better. Each new desktop operating system release is leaps and bounds ahead of the prior ones in terms of power management default settings and capabilities. Hardware continues to evolve rapidly also, with known more energy efficient technologies already in the pipeline for release in the short-term coming years.

SCE implemented a 5% per-year equivalent degradation in its work papers. Directional findings in this evaluation confirmed that approximate historical decline as valid and warns that the downward curve is sharpening. A 10% per-year value is probably more appropriate going forward to accommodate expected technological improvements.

In addition to the 10% technology-based degradation, there is still uncertainty about the deployment levels going forward. These could fall from the current expected levels (85% being the only documented value) of numbers of PCs actively controlled (probably due to the greater proportion of battery-powered mobile devices in use), or could drop because PCPMS itself is no longer needed or practicable due to future changes in server and desktop operating systems. The number of famous quotes from icons in the IT industry that are truly laughable with 20-20 hindsight suggests extreme caution is needed for defining EULs for IT-based measures for the purposes of deemed savings assumptions.

A 10% year-over-year decline in values results in a total savings representing 550% of first year savings, or an EUL equivalent of 5.5 years.

A 15% year-over-year decline (10% technology-based plus an additional 5% to account for other PCPMS redundancy-related uncertainties) results in total savings of 385% of first year savings, or an EUL equivalent of just under 4 years.

An EUL of “5” years is a reasonable compromise value that factors in the known and critical decline in year-over-year savings, and some future uncertainty about a number of developments and advancements that could render PCPMS redundant. Although the end result is equivalent to one of the IOU ex ante EUL assumptions, the methodology to arrive at this conclusion is completely unrelated to that or the other IOU assumption.

4.9 Net-to-Gross Analysis

According to the *California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals* (April 2006), the NTGR is "a factor representing net program load impacts divided by gross program load impacts that is applied to gross program load impacts to convert them into net program load impacts." It is in essence the ratio of the energy impacts resulting from non-free riders of the program over the total gross energy savings from all program participants and it is used to capture the "true" energy savings that result from the program. Free riders are those who purchase energy efficiency equipment through a utility program, but would have done so in absence of the program. In other words, the program did not have an effect on the decision to purchase and install the equipment and therefore the energy savings that resulted from the equipment installation should not be attributed to the program.

Researchers have developed a comprehensive set of questions to ask of program participants in an effort to quantify free-ridership. These questions have been asked of thousands of California IOU EE program participants to develop NTGRs that are applied to gross energy savings in order to arrive at ex post net energy savings for programs. For PCPMS, the estimation of this ratio is even more complicated. Asking the same battery of questions will allow for the estimation of an NTGR, but the answers to these questions in all likelihood will not accurately capture information needed to properly estimate an NTGR for this measure. PCPMS is not a typical energy conservation measure. It is a software that is installed on a server, but acts on individual PCs in a network. It is often a component (or module) of a broader network administration server software package. It is more akin to an energy management system, where adjustments can alter the amount of energy savings, which may evolve over time as the software is patched and upgraded by the vendor or as the user chooses more or less aggressive settings.

Typically, free riders are those who would have purchased and installed energy efficiency equipment in the absence of a rebate program. In the case of PCPMS, this is complicated by the scenario where PCPMS may exist as part of a broader network management suite that may already be owned or installed by a potential participant. Just because PCPMS was purchased and technically installed by a customer, does not mean it has been activated (where it could generate savings). The PCPMS component software may have a variety of activation options, some of which involve physical installation of new software, physical installation of an add-on component to software already installed, or no physical installation, but rather some other form of licensing or key-based activation. A free rider would have installed and/or activated the power management software without the incentive.

Installation of PCPMS was reportedly not trivial to customers, particularly to their IT departments, because of their perception that it will either cause problems on the network, for the controlled PCs, or generate complaints from users. These barriers are significant enough that IT managers are resistant to deploy PCPMS even when it is already part of a "mother" or "sister" server software suite already owned or in use in the organization.

The NTGR was estimated using responses to a slightly adjusted set of questions that are based upon the "Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Nonresidential Customers" paper developed for the CPUC (October 2012). The questions that were asked are included in the in-depth interview guide for customers of PCPMS found in Appendix A of this report. Though the questions were modified to more accurately reflect the characteristics of PCPMS, they were asked of all program participants and were the basis of the development of the NTGRs applied to savings in this study. Because the decision-makers involved in the purchase of PCPMS are not the same as for other utility-sponsored measures and were most often from IT departments, they were rarely familiar with their company's purchases of other more typical building and facilities energy efficiency equipment and therefore they possessed limited information about the way energy efficiency programs operate. Evaluators were able to conduct relatively lengthy in-depth interviews with participants prior to the NTG battery, which is typical for large custom engineering projects, but rare for deemed measures. Since NTG-related topics were discussed in the initial part of the in-depth interview, both the interviewer and interviewee enjoyed an enhanced awareness of important contextual factors that likely affected responses.

It should also be noted that IT staff tended to have industry-specific definitions of what constitutes an installation of server-based software. Many server and other software can contain modules that may be physically installed, but not licensed or activated. Sometimes they are stored, but in a pre-installation package form. There are many variations, but IT professionals tend to focus on deployment of a software function as the indicator of "installation," as in whether the conservation measure was installed. If PCPMS was actively in use, it was considered installed. If it was not actively in use, it was considered not installed. This is regardless of whether a PCPMS module was technically residing on a server, awaiting a license key or other form of activation. The NTG questionnaire did not attempt to parse these interpretations. Respondents applied their own understanding when answering specific questions.

The approach for estimating NTGRs was based on the large non-residential free-ridership approach developed by the NTGR Working Group and documented in the *Methodological Framework for Using the Self-Report Approach to Estimating Net-to-Gross Ratios for Non-residential Customers*. The NTGR is calculated as the average of three program attribution indices (PAI) known as PAI-1, PAI-2, and PAI-3. Each of these scores represents the highest response or the average of several responses given to one or more questions about the decision to install a program measure. The in-depth participant interviews were the basis for the inputs to each score.

- **Program attribution index 1 (PAI–1)** is a score that reflects the influence of the most important of various program-related elements in the customer's decision to select a given program measure. The PAI-1 score is calculated as the highest program influence factor divided by the sum of the highest program influence factor and the highest non-program influence factor. Some example non-program factors are: previous experience with the measure, recommendation from an engineer, standard practice, corporate policy, compliance with rules or regulations, organizational maintenance or equipment replacement policies and "other – specify." Payback is treated as a program influence factor if the rebate/incentives played a major role in meeting payback criteria, but is treated as a non-program influence factor if it did not play a major role in meeting payback criteria.
- **Program attribution index 2 (PAI–2)** is a score that captures the perceived importance of program factors (including rebate/incentives, recommendation, and training) relative to non-program factors in the decision to implement the specific measure that was eventually adopted or installed. This score is determined by asking respondents to assign importance values to the program and most important non-program influences so that the two total 10. The program influence score is adjusted (i.e., divided by 2) if respondents had made the decision to install the measure before learning about the program. The final score is divided by 10 to be put into decimal form, thus making it consistent with PAI-1.
- **Program attribution index 3 (PAI–3)** is a score that captures the likelihood of various actions the customer might have taken at the given time and in the future if the program had not been available (the counterfactual). This score is calculated as 10 minus the likelihood that the respondent would have installed the same measure in the absence of the program. The final score is divided by 10 to put into decimal form, thus making it consistent with PAI-1 and PAI-2.

The NTGR is estimated as an average of these three scores. If one of the scores is not available (generally due to respondents giving a "don't know" or "refusal" response), then the NTGR is estimated as the average of the two available scores. If two or more scores were missing, results are discarded from the calculation.

Table 4-15 presents the NTGRs that were developed for each major participant type of PCPMS, weighted by ex post kWh and kW. The average NTG score of 0.72, weighted by either kWh or kW, provides evidence to support the deemed NTG ratios listed in the work papers of both 0.6

and 0.8 for PG&E and SDG&E and 0.6 for SCE.[22] There is no variability in the NTG scores for either sector regardless of whether they are weighted by kWh or kW savings.

Table 4-15: NTGRs by PCPMS Customer Segment

ESPI Measure Sector	n	NTGR kWh	Relative Precision	NTGR kW	Relative Precision
PCPMS					
Health Sector	3	0.75	3%	0.75	3%
Education/Other Sectors	7	0.64	20%	0.64	20%
Weighted Average NTGR	**10**	**0.72**	**7%**	**0.72**	**7%**

The development of the NTGR for the PCPMS measure is a simple average of the three average program attribution index scores for interviewed purchasers of rebated PCPMS, which are as follows: PA-1 = 0.51, PA-2 = 0.83, and PA-3 = 0.81.

The individual NTGRs were reviewed to ensure that respondents were consistent in their responses and in all cases where adjustments were warranted, this review resulted in slight upward adjustments of the scores. The review took into account that participants' decisions to activate PCPMS in their business locations were not taken lightly and that in most cases, rigorous testing of the software occurred to ensure that it operated in such a way that did not disrupt their operations. This, along with the collection of evidence that suggests the tendency of program participants to activate the PCPMS software because of their interaction with the program, leads the evaluation team to recommend that a NTGR of 0.72 be applied to the ex post gross energy savings of 2014 PCPMS participants.

22 Two entries in the tracking system for SCE actually use an NTGR of 0.7, referencing an older work paper (WPSCNROE0003.4).

5

Evaluation Results

This section presents the gross and net first year savings and realization rates, followed by gross and net lifecycle savings and realization rates for the PCPMS measure for 2014. Savings are provided in kWh and kW, but due to the zeroing of kW savings, realization rates for kW savings are all 0%.

Related NTGR findings are detailed in Section 4.9 and the EUL findings are covered in Section 4.8.1.

5.1 Gross First Year Savings and Realization Rates

Once all the UES values have been created, as discussed in Section 3, these values can be applied to the population of participants. Gross realization rates (GRRs) are then estimated for kWh and kW savings by looking at the ratio of the aggregate evaluated gross savings to the aggregate ex ante gross savings. Specifically, the GRR for PA j is estimated as:

$$Gross\_Realization\_Rate_j = \frac{\sum_{i=1}^{n} Gross\_Ex\_Post\_Impact_{i,j}}{\sum_{i=1}^{n} Gross\_Ex\_Ante\_Impact_{i,j}}$$

Where,

> $Gross\_Ex\_Post\_Impact_{i,j}$ is the site-specific gross ex post impact estimate for customer i, in the population, who is in PA segment j.
>
> $Gross\_Ex\_Ante\_Impact_{i,j}$ is the site-specific gross ex ante impact estimate for customer i, in the population, who is in PA segment j.

Table 5-1 presents the total kWh and kW first year gross savings and realization rates for the PCPMS measure in 2014, by IOU, along with statewide totals. **The final 2014 PCPMS average weighted UES value with all adjustments taken into account is 37.3 kWh.**

Table 5-1: 2014 PCPMS Gross First Year Savings and Realization Rates

PA	Ex Ante First Year Gross kWh	Ex Post First Year Gross kWh	GRR kWh	Ex Ante First Year Gross kW	Ex Post First Year Gross kW	GRR kW
PG&E	1,095,400	280,988	26%	110	-	0%
SCE	1,626,628	245,104	15%	16	-	0%
SDG&E	1,222,200	313,514	26%	122	-	0%
SW	3,944,228	839,607	21%	248	-	0%

Overall, the GRR for first year gross kWh savings is 21%. For SCE, the 15% GRR is primarily driven by the effects of the eligibility factor, as 80% of the ex ante savings is associated with large projects. Therefore, the average eligibility factor for SCE is 0.23, resulting in a proportional reduction in savings (77%). The SRF also results in a 22% reduction in savings. The Delta Energy Use Assumption results in an additional reduction of 17%. Finally, the IR has a minor effect of only a 1% reduction.

PG&E and SDG&E have a GRR of 26%. None of their participants were classified as large, so the eligibility factor that was applied resulted in a 46% reduction in savings. Again, the SRF resulted in a 22% reduction in savings. The Delta Energy Use Assumption was more significant for PG&E and SDG&E (a 38% reduction) since they assumed a higher ex ante UES (200 kWh). Finally, the IR has a minor effect of only a 1% reduction.

5.2 Lifecycle Gross Savings and Realization Rates

Lifecycle Gross Savings are calculated as:

Lifecycle Gross Savings = First Year Gross Savings x Effective_Useful_Life (EUL)

Table 5-2 presents the total kWh and kW first year gross savings and realization rates for the PCPMS measure in 2014, by IOU, along with statewide totals.

Table 5-2: 2014 PCPMS Lifecycle Gross Savings and Realization Rates

PA	Ex Ante Lifecycle Gross kWh	Ex Post Lifecycle Gross kWh	GRR kWh	Ex Ante Lifecycle Gross kW	Ex Post Lifecycle Gross kW	GRR kW
PG&E	5,477,000	1,404,940	26%	548	-	0%
SCE	6,506,513	1,225,521	19%	63	-	0%
SDG&E	6,111,000	1,567,572	26%	611	-	0%
SW	18,094,513	4,198,034	23%	1,222	-	0%

The only difference between first year and lifecycle GRRs is with the EUL values. This only affects SCE which claimed a 4-year EUL versus the 5-year ex post EUL (PG&E and SDG&E use a 5-year EUL).

5.3 Net First Year Savings and Realization Rates

Net savings are estimated in a manner similar to the gross savings. Ex post gross savings values are multiplied by the corresponding NTGRs to get net savings values. Net realization rates (NRRs) are then estimated for kWh and kW savings by looking at the ratio of the aggregate evaluated gross savings to the aggregate ex ante gross savings. Specifically, the NRR for PA segment j is estimated as:

$$Net\_Realization\_Rate_j = \frac{\sum_{i=1}^{n} Net\_Ex\_Post\_Impact_{i,j}}{\sum_{i=1}^{n} Net\_Ex\_Ante\_Impact_{i,j}}$$

Where,

$Net\_Ex\_Post\_Impact_{i,j}$ is the site-specific net ex post impact estimate for customer i, in the population, who is in PA segment j.

$Net\_Ex\_Ante\_Impact_{i,j}$ is the site-specific net ex ante impact estimate for customer i, in the population, who is in PA segment j.

First Year Net Savings are calculated as:

First Year Net Savings = First Year Gross Savings x Net-to-Gross Ratio (NTGR)

Table 5-3 presents the total kWh and kW first year net savings and realization rates for the PCPMS measure in 2014, by IOU, along with statewide totals.

Table 5-3: 2014 PCPMS Net First Year Savings and Realization Rates

PA	Ex Ante First Year Net kWh	Ex Post First Year Net kWh	NRR kWh	Ex Ante First Year Net kW	Ex Post First Year Net kW	NRR kW
PG&E	657,240	202,311	31%	66	-	0%
SCE	975,977	176,475	18%	9	-	0%
SDG&E	733,320	225,730	31%	73	-	0%
SW	2,366,537	604,517	26%	149	-	0%

5.4 Lifecycle Net Savings and Realization Rates

Lifecycle NRRs are estimated in a similar way as lifecycle GRRs, by looking at the ratio of the evaluated ex post net lifecycle savings to the ex ante net lifecycle savings. The approach is identical to that for the lifecycle GRRs, but using net savings instead of gross.

Lifecycle Net Savings are calculated as:

Lifecycle Net Savings = First Year Net Savings x Effective_Useful_Life (EUL)

Table 5-4 presents the total kWh and kW first year net savings and realization rates for the PCPMS measure in 2014, by IOU, along with statewide totals.

Table 5-4: 2014 PCPMS Lifecycle Net Savings and Realization Rates

PA	Ex Ante Lifecycle Net kWh	Ex Post Lifecycle Net kWh	NRR kWh	Ex Ante Lifecycle Net kW	Ex Post Lifecycle Net kW	NRR kW
PG&E	3,286,200	1,011,557	31%	329	-	0%
SCE	3,903,908	882,375	23%	38	-	0%
SDG&E	3,666,600	1,128,652	31%	367	-	0%
SW	10,856,708	3,022,584	28%	733	-	0%

First year and lifecycle NRRs differ from GRRs only by the difference in the ex ante and ex post NTGRs. Because the ex post NTGR is 20% higher (0.72 versus 0.6), the NRRs are also 20% higher than GRRs.

6

Findings and Recommendations

The following section presents the findings and conclusions drawn from the evaluation of the PCPMS measure.

Finding 1 (Section 3.1.1): Source studies utilized in the development of PCPMS deemed savings assumptions were scant and very dated. The studies were also inconsistent in design, execution and documentation, leaving only a global "average of averages" approach for ex ante deemed savings assumptions development. The complexity inherent in the various, but dated, savings assessments is lost when they are stacked and averaged. Without the ability to "look under the hood" at the core actions and technologies that could trigger measurable savings, in this case the shifting distribution of power states, deemed assumptions become progressively more detached from current reality as time passes. This is a general concern for any measure, but a critical one for a rapidly evolving technology like computers.

Recommendation 1: There was no evidence that UES values would differ from one IOU service territory to the next. The IOUs should work together to ensure that basic variables and inputs needed for work paper assumptions are confirmed and collaborate to develop a statewide UES value. Collaboration on atypical measures with scant references is always preferred. At a minimum, the fundamental logic modelling of the source of savings and the variables that contribute to any potential savings should be documented and collectively agreed-to in advance of individual work paper development.

Finding 2 (Section 2.1; Section 4.2.3): PCPMS is a non-standard measure that does not conform to the characteristics of typical energy efficiency equipment for which the California IOUs offer rebates. This measure (1) requires the participation of corporate information technology (IT) decision-makers rather than building/facilities management staff; (2) operates more like an energy management system in that there are a wide range of configuration and reporting capabilities that may or may not be used, even when it is "installed"; and (3) as software, gets adapted over time to become more effective or to retain popularity and usefulness.

Recommendation 2A: The IOUs and the CPUC should consider more explicit and industry-specific metrics and indicators in the development of deemed assumptions for IT-related measures. For a number of reasons, but primarily rapid evolution of technology, IT-related measures need measure-specific savings assumptions that explicitly identify which of these could affect future savings. Explicit uncertainty bands and/or risk factors should be assigned to each metric or variable so they can be tracked and responded to in a transparent manner.

Recommendation 2B: Because of the unique and malleable characteristics of the PCPMS measure, the IOUs should consider undertaking additional participant-specific data collection as part of the application and approvals process. Program operations and precision of evaluated savings could be improved by adding a requirement that participants report basic pre-installation operating conditions and provide additional PCPMS-generated reports post-installation.

For each rebate of 100 units or more, the participant should provide prior to testing or installation:

i. A preliminary estimate of their pre-existing PC power management profile (or baseline) detailing basic settings and operating schedules (how many hours PCs and monitors spend, collectively, in the various duty-cycle Power States (simply, the “Base” column from Table 4-2)). The accuracy of this estimate is less important than that it occur prior to the next step.

Subsequent to initial testing, the participant should provide (in electronic format if convenient):

ii. The inventory/audit of pre-deployment equipment duty-cycle distribution (the accurate baseline estimate);
iii. A simplified description (or PCPMS-output file) of the profile choices and operating schedule selected for ongoing power management (the “aggressiveness” indicator);
iv. A post-deployment PCPMS-generated savings report showing the basic delta energy use (ΔkWh/year) results (this was already collected by the IOU in many post-installation follow-ups, but not systematically filed for tracking or evaluation purposes).

These four requirements are extremely low-effort (the latter three can be auto-generated by the PCPMS software itself), but extremely valuable for savings estimation purposes. They relate to the fundamental pre and post changes to duty-cycle distribution that is at the core of any assessment of PCPMS-generated savings.

Finding 3 (Section 2.1.2): Vendors played an important role in the promotion and sales of PCPMS and its adoption through the California IOU energy efficiency programs. Vendors provided potential adopters with information about the capabilities of the software and that a rebate was available from their local utility. They were, by design, a primary driver of the measure. A statewide and multi-year implementation by one large participant with facilities in every major utility service territory in California can be credited in large part to the tireless work of a vendor willing to coordinate among multiple utilities.

Recommendation 3: California IOUs still need to actively manage the PCPMS measure, even if it is largely vendor-driven and those vendors are the most effective way to reach and influence potential participant IT decision-makers. IT vendors have a clear self-interest in selling their product. This natural motivation should be counter-balanced by ensuring that the partner-vendors are aware of key savings differentiators like the Service Rate Factor (SRF) and eligibility requirements (discussed in Section 4.3) so they can assist program administrators to focus limited resources on higher-savings participants. Vendor input could also help clarify eligibility definitions and concerns (see subsequent Recommendation 6).

Finding 4 (Section 4.3): Significant savings reductions were applied due to the gap between the ex ante savings assumption that both PC CPUs and monitors undergo power management control, while in fact some participants chose to manage only monitors. Looking back, vendors could have played a major role in educating participants as to the benefits of controlling the PC CPUs in addition to monitors. As per Recommendation 3, vendors could have been instructed to by-pass potential participants that were not willing to apply power management to the entire PC—at least for rebate purposes. During the same 2013-14 period, general market monitor energy efficiency accelerated and out-paced the CPU energy efficiency improvement rate, exacerbating this problem.

Recommendation 4: Going forward, any PCPMS measure eligibility criteria should be modified to explicitly require that the entire PC, including both CPU and monitor(s) need to be controlled for rebate eligibility purposes.

Finding 5 (Section 3.2.3): UES values used to estimate kWh energy savings are assumed to be constant over the effective useful life (EUL) of the measure for lifecycle savings calculation purposes. However, PCPMS savings are following a predictable decline that stems back to the initiation of the measure in the mid-2000s period. Although SCE recognized this downward trend in successive updates to its work paper, this does not account for the almost certain decline in savings throughout the lifetime of the rebated PCPMS measure as controlled devices are systematically replaced with new and more efficient models that draw less power while in operation.

Recommendation 5: IT-related measures like PCPMS need an updated UES every year, not less often at each program or funding cycle. If a technical degradation factor (TDF) cannot be applied to account for continuously shrinking savings over the lifetime (EUL) of the measure, then adjustments to the EUL are required to compensate for this (as described in Section 4.8.1. At some point on the predictably declining savings curve, a measure becomes cost-ineffective to deploy. Even if an EUL work-around is utilized, an appropriately scaled TDF (10 to 15% annually, in the case of PCPMS) should be used directly for program planning purposes. Else, assessments are likely to produce falsely optimistic savings estimates that could influence the ultimate decision of when to adjust incentives or drop a measure.

Finding 6 (Sections 4.6, 4.7): An Eligibility Factor (EF) was applied to savings for 2014. As described in Finding 2, above, IT-related measures can generate confusion regarding exactly where savings are being generated, what is the ultimate technical definition of the measure itself, and what constitutes an "installation." In the case of PCPMS, the rebate is offered on a PC-unit basis, yet the measure cannot achieve savings without a server component. The server component could be installed and latent, or installed and configured to be wholly ineffective (each equivalent to not installed or inoperative for a traditional measure). The server component could be technically installed, but not activated unless a license "key" is purchased and activated. These are just some of the major permutations available—and more could be developed as the IT industry evolves to respond to competition or customer preferences.

Recommendation 6: Very precise and measure-specific eligibility definitions need to be developed in advance of rebate offerings for IT-related equipment or software or combinations. Definitions that fit normal characterizations in the IT industry are preferred to avoid generating confusion by customer/participants.

Finding 7: IT security policies and provisions either prevent or strongly complicate on-site verification. Even the sharing of an electronic or paper-based inventory of PC and server equipment may not be possible or require extensive pressure from the program administrator. This industry characteristic suggests extreme caution should prevail if contemplating support for IT-related measures that may be at risk of being industry-standard practice (ISP) or customer standard practice or some combination depending on the particular size of the organization or which economic or activity sector or sub-sector the organization inhabits.

Recommendation 7: Ensure that IT-related measures can be adequately verified, including on-site, after installation. If special agreements are required to overcome security, privacy or proprietary concerns, then the measure is unlikely to be suitable for deemed treatment.