California Statewide Measures

Statewide Measure Characterization

HVAC Retro-Commissioning (RCx)

VERSION 0.9

Last Updated October 16, 2023

Revision Log

Version	Publish Date	Description of Revisions	Owner
0.1	n/a	Initial draft for Custom Subcommittee	Cal TF Custom RCx Working Group
0.9	n/a	Draft for Cal TF	Cal TF Custom RCx Working Group

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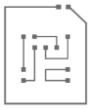

Section 1: Standard Measure Template

Measure Information

Measure Name	Retrocommissioning (RCx)
SW Measure ID	TBD
Use Category	HC-HVAC

Technology Summary

Retrocommissioning (RCx) is fine-tuning existing buildings and systems to make them operate optimally and more efficiently through scheduling, sequencing, controls programming, and optimizing setpoints. While retrofitting involves replacing outdated equipment, RCx focuses on improving the efficiency of what is already in place [1]. RCx activities generally include comprehensive on-site investigations and analysis to identify and document cost-effective energy saving opportunities. These activities optimize existing equipment and controls with improved integration strategies, low-cost modifications, repairs, and upgrades [2]. RCx projects often include multiple measures—such as controls optimization strategies, operation and maintenance (O&M) improvements, and equipment repairs—that reduce overall energy consumption and demand.

All RCx measures are categorized as BRO Measure Application Types (MATs). Equipment replacement (e.g., replacement of major components such as chillers or package units) or add-on equipment (e.g., installation of a new VFD) measures may be identified through an RCx study, but do not qualify as RCx measures and are not part of this measure package.

RCx is a broad category of system improvements. Eligible RCx measures improve the efficiency of the existing systems and equipment via correcting operational system deficiencies and non-routine maintenance or repairs [3]. Standard maintenance is to make repairs or address wear and tear that rectify performance degradation attributable to aging equipment. These standard maintenance projects are not considered BRO and are not eligible for CPUC savings claims and incentives [3].

The measures presented in this measure package were selected based on the inclusion within the PG&E HVAC Tool. This is the calculation tool used in this measure package. There are other RCx measures that are still eligible for CPUC savings claims but will require a custom calculation methodology. Aspects of this measure package may be applicable for those measures not included.

The following tables describe the general base case and measure case for RCx measures in this measure package. Specific systems or conditions may not be exactly as described.

Commented [AR1]: Source: Retrocommissioning for energy conservation and efficiency (pge.com)

Commented [A[2]: Source: SCE BRO Program Guidelines Version 6 (6/1/2019)

Air Side Measures

MEASURE	BASE CASE	MEASURE CASE
Scheduling Optimization	Equipment is unscheduled or schedules not optimized with building use and/or loads	Equipment schedules programmed and optimized for energy efficiency
Economizer Optimization [1]	Economizer disabled, dampers not operable, or operation not optimized	Economizer enabled and optimized for energy efficiency
Static Pressure Reset	Constant duct static pressure setpoint or inefficient duct static pressure reset strategy in a Variable Air Volume (VAV) air handling system	Duct static pressure reset strategy with reset based on VAV box damper position, outside air temperature (OAT), or space temperature offset. A Direct Digital Control (DDC) system is often required to implement this measure. The system continuously monitors the VAV box damper positions. If all the VAV boxes are partially closed, the system will reduce the fan speed until at least one of the VAV boxes is 100% open.
Supply Air Temperature Reset	Constant supply air temperature setpoint	Supply air temperature reset involves monitoring multiple variables because OAT alone cannot characterize the conditions in the building. For Air Handling Units (AHUs) with more than ten zones, the reset schedule should be based on the calculation of the warmest zone temperature, coolest zone temperature, and average zone temperature.
Fan Airflow Optimization through VAV Minimum Settings	VAV flow (cfm) minimums are higher than necessary	Decrease VAV minimum flow (cfm) setpoint
Fan Airflow Optimization through Unoccupied Setback	Unoccupied airflows are higher than necessary	Decrease unoccupied VAV cfm setpoint and/or close VAV box dampers
Fan Airflow Optimization through Air Change Rate Settings	Air change rates are higher than necessary	Reduce air change rates to allowable minimums
Space Temperature Optimization through Deadband	Deadband between heating and cooling is too tight	Decrease heating setpoint and/or increase cooling setpoint
Space Temperature Optimization through Unoccupied Space Temperature setpoints.	Unoccupied space temperature setpoints are the same as occupied and can be loosened	Implement unoccupied space temperature setbacks

[1] An adjustment of the changeover setpoint on a HVAC unitary direct expansion or split system is an eligible deemed measure and cannot be included in this custom measure. See Related Deemed Measure section.

Chilled Water Side Measures

MEASURE	BASE CASE	MEASURE CASE
Chilled Water (CHW) Plant Lockout Control	Lockout temperatures prevent the CHW plant from operating below a specified temperature. If this temperature is set too low the chiller plant will provide cooling when it is not needed.	Modified lockout temperature set to the highest OAT that the building can maintain the discharge air without cooling.
Chiller Staging Sequence Optimization (for multi-chiller systems)	Existing chiller operation includes more chillers operating than required and/or chillers operating at inefficient points on the chiller curves.	Chiller sequence to minimize energy consumption at given cooling loads through maintaining operation at efficient points of the chiller curves and/or staging chillers to minimize pump operation.
CHW Supply Temperature Reset	Constant CHW supply temperature setpoint or inefficient CHW supply temperature reset strategy. The CHW system must be controlled by a Direct Digital Control (DDC) system or equivalent level of control service.	Reset strategy to dynamically adjust the CHW supply temperature setpoint based on return temperature or cooling load.
Condensing Water (CW) Supply Temperature Reset	Constant CW supply temperature setpoint or inefficient CW reset strategy.	Reset strategy to adjust the entering CW temperature setpoint based on the approach temperature of the cooling tower. Many recently manufactured chillers can operate with entering condenser water temperature (ECWT) as low as 58 °F with consideration of chiller lift requirements.
Water Side Economizer Optimization	Mechanical cooling is performed when outside air and cooling load conditions would allow economizer operation for the entire cooling load.	Economizer operation is optimized based on outside air and cooling load conditions.
Cooling Tower (CT) Staging Sequence Optimization (for multi-CT systems)	Existing cooling tower operation includes an inefficient use of the cooling tower cells resulting in more CT fan and CW pump energy than required.	Cooling tower sequence to minimize energy consumption at given heat rejection demands through sequencing cell operation to minimize energy consumption of the CT fans and CW pumps.
CHW Differential Pressure (DP) Reset	Fixed/constant DP setpoint.	Optimized DP reset strategy based on cooling loads.

Hot Water (HW) Side Measures

MEASURE	BASE CASE	MEASURE CASE
HW Lockout Control	Lockout temperatures prevent the hot water plant from operating above a specified temperature. If this temperature is set too high the boiler plant will provide heating when it is not needed.	Modified lockout temperature set to the lowest outdoor air temperature that the building can maintain the discharge air without heating.
HW Temperature Reset	Constant HW supply temperature setpoint or inefficient HW supply temperature reset strategy. The hot water system must be controlled by a DDC system or equivalent level of control service.	HW supply temperature reset strategy that dynamically changes the HW supply temperature setpoint based on return temperature or heating load.
HW Differential Pressure Reset	Fixed DP setpoint or inefficient DP reset strategy in hot water plant.	Optimized DP reset strategy based on heating loads.

Related Deemed Measures

The list below shows related, active deemed measure packages. Products that qualify as deemed measure packages must use the deemed measure package savings. SOURCE

- SWHC008-01 Variable Speed Drive for Central Plant System
  - This measure is for the installation of a VSD on an existing chilled water or condenser water pump. The related measures in this measure package involve an already installed VFD that is not operating efficiently.
- SWSV010-02 0 Economizer Controls, Commercial
  - This measure is defined as the replacement of an existing economizer control sensor or the optimization of the existing economizer control by adjusting the changeover setpoint on a non-process unitary direct expansion (DX) and split system.

Measure Case Description

The typical measure case for each RCx measure is described in the tables above.

The measures presented in this measure package were selected based on the based on the inclusion within the PG&E HVAC Tool. There are other RCx measures that are still eligible for CPUC savings claims but will require a custom calculation methodology.

Where feasible and applicable, for activities that add control sequences, retrofit control sequences should utilize Sequence of Operations consistent with ASHRAE Guideline 36.

Offering ID

Air Side Measures

MEASURE	STATEWIDE MEASURE OFFERING ID	MEASURE OFFERING DESCRIPTION
Scheduling Optimization	A	Equipment schedules programmed and optimized for energy efficiency.
Economizer Optimization	B	Economizer enabled and optimized for energy efficiency.
Static Pressure Reset	C	Duct static pressure reset strategy with reset based on VAV box damper position, outside air temperature, or space temperature offset. A DDC system is often required to implement this measure. The system continuously monitors the VAV box damper positions. If all the VAV boxes are partially closed, the system will reduce the fan speed until at least one of the VAV boxes is 100% open.
Supply Air Temperature Reset	D	Supply air temperature reset involves monitoring multiple variables because outside air temperature alone cannot characterize the conditions in the building. For Air Handling Units (AHUs) with more than ten zones, the reset schedule should be based on the calculation of the warmest zone temperature, coolest zone temperature, and average zone temperature.
Fan Airflow Optimization through VAV Minimum Settings	E	Decrease VAV minimum flow (cfm) setpoint.
Fan Airflow Optimization through Unoccupied Setback	F	Decrease unoccupied VAV cfm setpoint and/or close VAV box dampers.

Commented [AR3]: PG&E Resource Rulebook points to EE Policy Manual page 36 and D.12-05-015p. 331. Current CPUC Staff has pointed to E-5152 page 18.

Commented [SL4]: https://www.techstreet.com/ashrae/standards/guideline-36-2021-high-performance-sequences-of-operation-for-hvac-systems?product_id=222969

MEASURE	STATEWIDE MEASURE OFFERING ID	MEASURE OFFERING DESCRIPTION
Fan Aiflow Optimization through Air Change Rate Settings	G	Reduce air change rates to allowable minimums.
Space Temperature Optimization through Deadband	H	Decrease heating setpoint and/or increase cooling setpoint.
Space Temperature Optimization through Unoccupied Space Temperature Setpoints	I	Implement unoccupied space temperature setbacks.

Chilled Water Side Measures

MEASURE	STATEWIDE MEASURE OFFERING ID	MEASURE OFFERING DESCRIPTION
CHW Plant Lockout Control	G	Modified lockout temperature set to the highest outdoor air temperature that the building can maintain the discharge air without cooling.
Chiller Staging Sequence Optimization (for multi-chiller systems)	H	Chiller sequence to minimize energy consumption at given cooling loads through maintaining operation at efficient points of the chiller curves and/or staging chillers to minimize pump operation.
CHW Supply Temperature Reset	I	Reset strategy to dynamically adjust the CHW supply temperature setpoint based on return temperature or cooling load.
CW Supply Temperature Reset	J	Reset strategy to adjust the entering CW temperature setpoint based on the approach temperature of the cooling tower. Many recently manufactured chillers can operate with ECWT as low as 58 °F with consideration of chiller lift requirements.
Water Side Economizer Optimization	K	Economizer operation is optimized based on outside air and cooling load conditions.
CT Staging Sequence Optimization (for multi-CT systems)	L	Cooling tower sequence to minimize energy consumption at given heat rejection demands through sequencing cell operation to minimize energy consumption of the CT fans and CW pumps.
CHW Differential Pressure Reset	M	Optimized DP reset strategy based on cooling loads.

Hot Water Side Measures

MEASURE	STATEWIDE MEASURE OFFERING ID	MEASURE OFFERING DESCRIPTION
HW Lockout Control	N	Modified lockout temperature set to the lowest outdoor air temperature that the building can maintain the discharge air without heating.
HW Temperature Reset	O	HW supply temperature reset strategy that dynamically changes the HW supply temperature setpoint based on return temperature or heating load.
HW Differential Pressure Reset	P	Optimized DP reset strategy based on heating loads.

Base Case Description

The base case for all RCx measures is the existing equipment and operation. E-4818, OP11 Table 1.1. The tables below describe typical existing conditions for common RCX measures.

Base Case Descriptions

Air Side Measures

MEASURE	EXISTING DESCRIPTION	STANDARD DESCRIPTION
Scheduling Optimization	Equipment is unscheduled or schedules not optimized with building use and/or loads	n/a
Economizer Optimization	Economizer disabled, dampers not operable, or operation not optimized	n/a
Static Pressure Reset	Constant duct static pressure setpoint or inefficient duct static pressure reset strategy in a VAV air handling system	n/a
Supply Air Temperature Reset	Constant supply air temperature setpoint	n/a
Fan Airflow Optimization through VAV Minimum Settings	VAV flow (cfm) minimums are higher than necessary	n/a
Fan Airflow Optimization through Unoccupied Setback	Unoccupied airflows are higher than necessary	n/a
Fan Airflow Optimization through Air Change Rate Settings	Air change rates are higher than necessary	n/a
Space Temperature Optimization through Deadband	Deadband between heating and cooling is too tight	n/a
Space Temperature Optimization through Unoccupied Space Temperature Setpoints	Unoccupied space temperature setpoints are the same as occupied and can be loosened	n/a

Chilled Water Side Measures

MEASURE	EXISTING DESCRIPTION	STANDARD DESCRIPTION
CHW Plant Lockout Control	Lockout temperatures prevent the CHW plant from operating below a specified temperature. If this temperature is set too low the chiller plant will provide cooling when it is not needed.	n/a
Chiller Staging Sequence Optimization (for multi-chiller systems)	Existing chiller operation includes more chillers operating than required and/or chillers operating at inefficient points on the chiller curves.	n/a
CHW Supply Temperature Reset	Constant CHW supply temperature setpoint or inefficient CHW supply temperature reset strategy. The CHW system must be controlled by a DDC system or equivalent level of control service.	n/a
CW Supply Temperature Reset	Constant CW supply temperature setpoint or inefficient CW reset strategy.	n/a
Water Side Economizer Optimization	Mechanical cooling is performed when outside air and cooling load conditions would allow economizer operation for the entire cooling load.	n/a
CT Staging Sequence Optimization (for multi-CT systems)	Existing cooling tower operation includes an inefficient use of the cooling tower cells resulting in more CT fan and CW pump energy than required.	n/a
CHW Differential Pressure Reset	Fixed/constant DP setpoint.	n/a

Commented [AR5]: "OP11: The default measure-level baseline that is applicable to downstream program delivery for deemed or calculated savings determinations shall be existing conditions for the following measure installation types: behavioral, retrocommissioning, and operational; non-mechanical building efficiency improvements (e.g. windows, insulation, air sealing, duct sealing, weatherization); and add-on equipment measures."

Hot Water Side Measures

MEASURE	EXISTING DESCRIPTION	STANDARD DESCRIPTION
HW Lockout Control	Lockout temperatures prevent the hot water plant from operating above a specified temperature. If this temperature is set too high the boiler plant will provide heating when it is not needed.	n/a
HW Temperature Reset	Constant HW supply temperature setpoint or inefficient HW supply temperature reset strategy. The hot water system must be controlled by a DDC system or equivalent level of control service.	n/a
HW Differential Pressure Reset	Fixed DP setpoint or inefficient DP reset strategy in hot water plant.	n/a

Code Requirements

RCx measures involve adjustments to an existing system and are not governed by state or federal codes and standards, as long as the RCx project does not include other code-triggering activities (e.g., replacement of the HVAC system components).

Implementation of the RCx measures must not violate building code requirements (e.g., minimum ventilation rates). The 2022 California Building Energy Efficiency Standards (Title 24) provides minimum requirements for equipment and system operation.

Commented [SL6]: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency

Applicable State and Federal Codes and Standards

CODE	APPLICABLE CODE REFERENCE	EFFECTIVE DATE
CA Appliance Efficiency Regulations – Title 20	None	n/a
CA Building Energy Efficiency Standards – Title 24	Varies by building type and measure	n/a
Federal Standards	None	n/a

Program Requirements

MEASURE IMPLEMENTATION ELIGIBILITY

All measure application type, delivery type, and sector combinations established for this measure are specified below. Measure application type is a categorization based on the circumstances and timing of the measure installation; each measure application type is distinguished by its baseline determination, cost basis, eligibility, and documentation requirements. Delivery type is the broad categorization of the delivery channel through which the market intervention strategy (financial incentives or other services) is targeted. This table also designates the broad market sector(s) that are applicable for this measure.

Note that some of the implementation combinations below may not be allowed for some measure offerings by all program administrators.

Implementation Eligibility

MEASURE APPLICATION TYPE	DELIVERY TYPE	SECTOR
BRO-RCx	DnCust	Com
BRO-RCx	DnCustDI	Com
BRO-RCx	DnCust	Ind
BRO-RCx	DnCustDI	Ind
BRO-RCx	DnCust	Ag
BRO-RCx	DnCustDI	Ag

PREPONDERANCE OF EVIDENCE (POE) REQUIREMENTS

POE must be documented for all Accelerated Replacement (AR) MATs. While there are no AR measures included in this measure package, CPUC Resolution E-5115 (E-5115) guidance applies to all MATs.

Per E-5115 and subsequent CPUC E-5115 pilot documents, the type and amount of required documentation depends on the project size as determined by the incentive levels.

Program influence can be in the form of financial and/or technical influence and should be documented in the Project Feasibility Study (PFS). The following represent some common influential aspects of a RCx projects. As each customer and project may have different circumstances, there may be other aspects for consideration, and the documentation described below may or may not satisfy the “more likely than not” POE criteria.

- Technical Influence:
    - Systems with deficiencies corrected through an RCx investigation are often unknown by facility staff because the system is still meeting the space conditioning needs.
        - Documentation should be collected to understand if the space conditioning requirements are being met prior to the investigation of RCx measures.
        - Documentation should be collected to understand the customer’s current and historical practice of performing RCx activities such as reviewing HVAC programming, setpoints, and other operational deficiencies.
    - Large customers/organizations or astute facility personnel may perform ongoing, routine RCx activities.

Commented [SL7]: Reference https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M366/K381/366381636.PDF page 22

Commented [SL8]: Reference https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M366/K381/366381636.PDF

        - Document the customer's typical activities to ensure the program's activity is incremental to their typical procedure.
    - Program-related engineering and/or technical expertise can provide support in the customer's decision-making process.
- Financial Influence:
    - RCx measures tend to have short paybacks. Financial incentives may not drive the decision to implement measures with some projects. Programs should ensure technical influence aspects are well documented.

ELIGIBLE PRODUCTS

The existing building and/or system must be at least three years old. RCx measures are not eligible for a new building or new system within the first three years of installation and operation.

The existing equipment must meet the service needs and/or have completed routine maintenance before implementing the RCx measures.

A central DDC system may be required for some measures. Additionally, DDC systems will assist with the necessary data collection and trending required to verify the existing and retrofit conditions. Therefore, it is recommended to target DDC-controlled existing systems. However, it is not a requirement. The installation of a DDC system as a replacement or a new system does not qualify under this BRO measure. Those installations may qualify under an AR, NR, or AOE MAT depending on the project specifics.

See Data Collection Requirements section for data requirements to verify eligibility.

The following information includes module requirements for applicability with the PG&E HVAC Tool.

Air-side systems must:

- Be a single duct constant or VAV system,
- Not include fan-powered terminal boxes for VAV systems,
- Have cooling coils in the AHU and not at the zone level,
- Operate with all fans always running simultaneously at the same speed when multiple fans or AHUs are serving the same load,
- Have return fans and not relief/exhaust fans for AHU equipment (possible exception for labs where the exhaust fans track with the supply fans), and
- Have zone reheat in systems with DX or chilled water coils.

Chilled water systems must:

- Have three or fewer chillers of the same type and rated efficiency serving the load.
- Serve space-conditioning or other weather-dependent cooling load; a constant cooling load (e.g., data center cooling) is allowed.
- Consist of water-cooled chillers only (air-cooled option may be added in the future)
- Eligible chiller types include positive displacement (e.g., screw, centrifugal, and centrifugal with VFD chillers only) and magnetic bearing chillers (modeled as centrifugal with VFD).
- Use an eligible pumping configuration:
    - Primary-Only

        - All CHW pumps must be of equal size with the same design parameters (head and flow rate).
    - Primary-secondary system
        - Dedicated primary CHW pumping (i.e., one primary CHW pump operates per chiller).
        - Primary CHW pumps operate at constant flow.
        - All secondary CHW pumps must be of equal size with the same design parameters (head and flow rate).
- Have dedicated CW pumps (i.e., one CW pump per chiller) that operate at constant flow and head.
- Operate a non-integrated water side economizer (i.e., all cooling provided with either mechanical or economizer).

Hot water systems must:

- Have three or fewer HW boilers,
- Use an eligible pumping configuration:
    - Primary-Only
        - All HW pumps must be of equal size with the same design parameters (head and flow rate).
        - HW pumps operate based on load.
    - Primary-Secondary
        - Constant Speed Primary Pumps where:
            - Pumps are configured in parallel,
            - One dedicated pump operates per boiler (i.e., PHWP1 operates with B1, PHWP2 operates with B2, etc.)
        - Constant or Variable Speed secondary HW Pumps where secondary HW pumps operate in parallel and stage up with load.

ELIGIBLE BUILDING TYPES AND VINTAGES

This measure is applicable for any HVAC system in all nonresidential building types of any vintage for which the PG&E HVAC Tool applies, not including New Construction. See Eligible Products section.

ELIGIBLE CLIMATE ZONES

This measure is applicable in all California climate zones.

Program Exclusions

Products that qualify as deemed measures must use the deemed measure savings.

RCx measures are not eligible for buildings or systems less than three years old (based on the assumed 3-year EUL for BRO measures).

RCx measures do not include major equipment replacement or new equipment installation. Examples of major equipment include chillers, fans, pumps, and DDC system. Replacements of

minor equipment are permissible to correct the system deficiency. Examples of minor equipment include sensors, damper linkages, and controllers.

Those systems that do not meet the system requirements in the Eligible Products section.

System and equipment operation must be able to be reasonably modeled by the PG&E HVAC Tool (See Electric Savings section).

Data Collection Requirements

Relevant project installation and product data shall be collected to ensure that measures conform to requirements described in the Eligible Products section.

The following represents data collection parameters to complete the initial set-up of the calculation tool. Specific measure information is provided in the M&V Section

PRE-INSTALLATION DATA COLLECTION

Building Information

The following information is used in the Customer Information tab of the **PG&E HVAC Tool**. Thus, it should be provided to utilize the calculation tool.

DATA COLLECTION PARAMETERS
Customer name and contact information (name, phone, email)
Site Address
Site City
Site Zip Code *
Building Type
Conditioned/Heated Area
Building Vintage
Customer/Building Monthly peak demand (kW), electric (kWh), and gas (therms) usage data (whole-building meter data)
Monthly electric and gas bundled cost

* Required information for the **PG&E HVAC Tool** to calculate savings

PRE- AND POST-INSTALLATION M&V REQUIREMENTS

M&V requirements for each measure have different requirements based on the estimated size of the incentive and energy savings. For small measures, the data parameter can generally be collected using a spot measurement, EMS screenshot, or photo as noted in the tables below. For large measures, a minimum of two weeks trend data is required. Additionally, when individual measures trigger the lower M&V tier and the cumulative savings for the project would trigger the higher M&V tier, project developers should perform higher level M&V on measures that are at least 30% of the total estimated pre-installation energy savings estimate. For all measures, calculation inputs should be consistent with verification documentation or trend data as applicable by the savings for the measure.

The tables below list the general data inputs required for each system and specific M&V data collection requirements for each measure type.

This measure package considers projects that may contain multiple RCx measures and often the same RCx strategy on different equipment (e.g., reset measures on AHU equipment). This measure package aims to balance the M&V cost with benefits in energy savings accuracy (e.g., using the same data to verify savings on multiple measures). The following bullets show some examples to illustrate these M&V procedures.

- A project may consist of an economizer measure on seven AHUs. Each AHU saves 40,000 kWh for a total of 280,000 kWh. At the project level, the M&V would fall into the more rigorous category. Thirty percent of the total project savings equals 84,000 kWh. Thus, the higher rigor data collection requirements would be performed on three AHUs, which is 120,000 kWh. The remaining four AHUs would require the lower rigor data collection.
- The following measures with estimated savings are included in a project:
    - ECWT reset (60,000 kWh)
    - CHW pump DP reset (30,000 kWh)
    - AHU 1 economizer (20,000 kWh)
    - AHU 2 supply air temperature reset (30,000 kWh)
    - AHU 3 scheduling (40,000 kWh)
    - AHU 4 economizer (30,000 kWh)
    - AHU 5 scheduling (30,000 kWh)
    - Hot water pump DP reset (15,000 kWh)

  The total estimated savings are 255,000 kWh with higher tier data collection on measures totaling 76,500 kWh. Several combinations of measures would achieve this. Since data availability is key in the cost of M&V, the measure package does not dictate which measure combinations (e.g., the highest savings measures) should receive the more rigorous M&V.
- A project may consist of chiller sequencing (160,000 kWh), chilled water reset (50,000 kWh), and entering condenser water reset (50,000 kWh). Each individual measure is below the higher M&V rigor threshold. However, the combined savings is 260,000 kWh which is in the higher M&V rigor level, the measure relates to the same equipment, and the parameters required to verify savings for the three measures have considerable overlap. In all measures, cooling load and outdoor air temperature is required. Thus, each measure should be treated at the higher M&V rigor tier.

Air Side Measures

If any measures on the air-side module are enabled, all information in the PG&E HVAC Tool Equipment Specifications & Replacement section should be included. Additionally, all baseline data for each measure should be input and accurate even if that measure is not enabled. The calculation engine references this information to properly calculate the energy consumptions. See PG&E HVAC Tool Methodology for detailed descriptions of the inputs.

MEASURE	REQUIREMENTS FOR SMALL MEASURES (<$25,000 INCENTIVE OR 250,000 KWH OR <25,000 THERMS) [1]	REQUIREMENTS FOR LARGE MEASUIRES (>$25,000 INCENTIVE OR >250,000 KWH OR >25,000 THERMS) [1]
Scheduling Optimization	**Pre/Post** - BAS Screenshot of Fan Schedule (Weekday, Saturday, Sunday)	**Pre/Post**: Trend data showing equipment operation (e.g., Fan On/Off Status or Fan Speed)
Economizer Optimization	**Pre/Post**: BAS screenshot(s) of AHU(s) that shows mixed air temperature (MAT), outdoor air temperature (OAT), return air temperature (RAT), supply air temperature (SAT) or outside air percentage with OAT and SAT or pictures of the economizer showing failed (pre) and repaired (post) linkages.	**Pre/Post**: Trend data of MAT, OAT, RAT, SAT for enough operation to show economizer functionality across minimum outside air and economizer modes. When utilizing trend data, the order of preference in determining the OA% is to: 1) Calculate OA% based on MAT, RAT, and OAT 2) Use the trended outside air damper position values
Static Pressure Reset	**Pre**: BAS screenshot of AHU constant pressure control or unoptimized reset strategy **Post**: BAS screenshot of AHU showing static pressure reset enabled or of the static pressure reset Logic	**Pre**/**Post**: Trend data of the setpoint and actual Static Pressure.
Supply Air Temperature Reset	**Pre**: BAS screenshot of AHU constant temperature setpoint **Post**: BAS screenshot of AHU showing SAT reset enabled or of the SAT Reset Logic	**Pre**/**Post**: Trend data of the setpoint and actual SAT.
Fan Airflow Optimization through VAV Minimum Settings	**Pre**/**Post**: BAS screenshots showing the minimum and maximum setpoints for the VAV boxes	**Pre**: Trend data showing min/max operation. **Post**: Trend data of VAV data to show efficient operation consistent with the inputs.
Fan Airflow Optimization through Unoccupied Setback	**Pre/Post**: BAS screenshots showing the unoccupied setpoints	**Pre/Post**: Trend data fan amperage, kW, or speed during both occupied and unoccupied times.
Fan Airflow Optimization through Air Change Rate Settings	**Pre/Post**: BAS screenshots showing the occupied and unoccupied airflow or VFD min speed	**Pre/Post**: Trend data of fan amperage, kW, or speed during both occupied and unoccupied times.
Space Temperature Optimization through Deadband	**Pre/Post**: BAS screenshots showing the heating and cooling setpoints.	**Pre/Post**: Trend data of fan operation of heating and cooling setpoints and fan mode (heating or cooling). Fan mode can be determined with SAT and MAT if status is not available.
Space Temperature Optimization through Unoccupied Space Temperature Setpoints	**Pre/Post**: BAS screenshots showing the occupied and unoccupied temperature setpoints.	**Pre/Post**: Trend data of temperature setpoints and space temperature.

[1] Measures that save both electric and gas use a ratio of savings to determine rigor levels. For example, a measure that saves 200,000 kWh (80% of the requirement) and 6,000 therms (24% of the requirement) adds up to 104% and would be categorized as a large measure.

Chilled Water Side Measures

If any measures on the chilled water side tab are enabled, baseline data for each measure should be input and accurate even if that measure is not enabled. The calculation engine references this information to properly calculate the energy consumptions. CHW plant cooling load is a key input. See PG&E HVAC Tool Methodology for detailed descriptions of the inputs.

MEASURE	REQUIREMENTS FOR SMALL MEASURES (<$25,000, OR <250,000 KWH OR <25,000 THERMS)	REQUIREMENTS FOR LARGE MEASUIRES (>$25,000, OR >250,000 KWH OR >25,000 THERMS) [1]
CHW Plant Lockout Control	**Pre/Post**: BAS screenshot of CHW plant graphics with lockout temperature or control logic showing cooling lockout	**Pre/Post**: Trend data of OAT dry bulb, chiller status (on/off, amps, or kW), and chiller plant cooling load [2]
Chiller Staging Sequence Optimization	**Pre/Post**: BAS screenshot of chiller staging sequence or procedure documented from the customer.	**Pre/Post**: Trend data of OAT dry bulb, chiller status (on/off, amps, or kW), and chiller plant cooling load [2]
CHW Temperature Reset	For no existing CHW reset control **Pre**: BAS screenshot showing constant CHW setpoint. **Post**: BAS screenshot of graphic of CHW reset control parameters or programming logic. For not enabled or unoptimized CHW reset control **Pre/Post**: Trend data OAT dry bulb and chilled water supply temperature (CHWST)	**Pre/Post**: Trend data OAT dry bulb and chilled water supply temperature (CHWST), CHWST setpoint, and chiller plant cooling load [2]
CW Temperature Reset	For no existing CW reset control **Pre**: BAS screenshot showing constant CW setpoint. **Post**: BAS screenshot of graphic of CW reset control parameters or programming logic. For not enabled or unoptimized CW reset control **Pre/Post**: Trend data OAT dry bulb and entering condenser water temperature (ECWT)	**Pre/Post**: Trend data OAT dry bulb and entering condenser water temperature (ECWT), ECWT setpoint, and chiller plant cooling load [2]
Water Side Economizer Optimization	**Pre/Post**: BAS screenshot, equipment specifications, or design documents for cooling tower approach temperature, OAT wet bulb enable, heat exchanger approach temperature, and average CW flow.	**Pre/Post**: Trend data for economizer enable, OAT wet bulb, CW flow, and cooling load [2]. Equipment specifications, or design documents for cooling tower approach temperature and heat exchanger approach temperature.
CT Staging Sequence Optimization	**Pre/Post**: BAS screenshot showing CT staging sequence	**Pre/Post**: Trend data on CT Fan Status or Speed to establish the staging and cooling load [2].

MEASURE	REQUIREMENTS FOR SMALL MEASURES (<$25,000, OR <250,000 KWH OR <25,000 THERMS)	REQUIREMENTS FOR LARGE MEASUIRES (>$25,000, OR >250,000 KWH OR >25,000 THERMS) [1]
CHW Differential Pressure (DP) Reset	**Pre**: BAS screenshot showing no reset. **Post**: BAS screenshot showing reset enabled and minimum and maximum parameters.	**Pre/Post**: Trend data OAT, DP, and DP Setpoint

[1] Measures that save both electric and gas use a ratio of savings to determine rigor levels. For example, a measure that saves 200,000 kWh (80% of the requirement) and 6,000 therms (24% of the requirement) adds up to 104% and would be categorized as a large measure.
[2] Cooling load preferred derivation method is trend data of chilled water supply temperature, return temperatures, and flow. If not available, trend data of chiller amps or kW and chiller curves. Chiller efficiencies are dependent on chilled water supply temperature (CHWST) and entering condenser water temperature (ECWT). Depending on the curves used and operation of the plant, CHWST and ECWT trend data may be required. The Title-24 Alternative Calculation Method includes generic biquadratic chiller curves based on chiller type. Note that constant flow applications may not require trend data. Also note that cooling load may be derived from secondary loop or individual chiller data.

Commented [SL9]: https://www.energy.ca.gov/sites/default/files/2023-07/CEC-400-2022-009-CMF-REV2-AP5.7.xlsx

Hot Water Side Measures

If any measures on the hot water side tab are enabled, all baseline information should be included. The calculation engine references this information to properly calculate the energy consumptions. See PG&E HVAC Tool Methodology for detailed descriptions of the inputs.

MEASURE	REQUIREMENTS FOR SMALL MEASURES (<25,000 KWH AND <25,000 THERMS)	REQUIREMENTS FOR LARGE MEASUIRES (>25,000 KWH AND >25,000 THERMS) [1]
HW Lockout Control	**Pre/Post**: BAS screenshot of HW plant graphics with lockout temperature or control logic showing heating lockout	**Pre/Post**: Trend data of OAT dry bulb, boiler status (on/off, amps, or kW), and hot water plant heating load
HHW Temp Reset	For no existing HW reset control **Pre**: BAS screenshot showing constant HW setpoint. **Post**: BAS screenshot of graphic of HW reset control parameters or programming logic. For not enabled or unoptimized HW reset control **Pre/Post**: Trend data OAT dry bulb and hot water supply temperature (HWST)	**Pre/Post**: Trend data OAT dry bulb and HWST, HWST setpoint, and boiler plant heating load
HW Differential Pressure Reset	**Pre**: BAS screenshot showing no reset. **Post**: BAS screenshot showing reset enabled and minimum and maximum parameters.	**Pre/Post**: Trend data OAT, DP, and DP setpoint

[1] Heating load preferred derivation method is trend data of hot water supply temperature, return temperatures, and flow. If not available, two options exist to estimate the building load. For systems without other significant gas usage, utility bill data can be used with boiler efficiency to estimate load. Trend data of a VSD driven boiler combustion fan speed, amps, or kW can provide insight into the boiler firing rate.

Electric Savings (kWh)

METHODOLOGY

Electric and gas savings from the RCx measures included in this measure package should be calculated using the PG&E HVAC Tool. The annual energy savings are calculated as the difference between the annual energy consumption of the baseline system and the annual energy consumption of the measure case system with the RCx measure(s) installed. The calculation methodology uses CZ2022 weather data in a temperature bin analysis.

Commented [SL10]: Source https://www.calmac.org/weather.asp

See the PG&E HVAC TOOL Methodology for specific information on each tab and measure. The tables below provide the location in the PG&E HVAC Tool where specific data and/or information related to the measure are input if the simple data option is used.

CALCULATION TOOLS

Electric and gas savings from the RCx measures included in this measure package should be calculated using the **PG&E HVAC Tool**.

There are three modules: Air-Side System, Chilled Water-Side System, and Hot Water System Users input baseline data in the green cells and proposed data, as applicable, in the blue cells. Users have the option to use simple or trend data inputs. Users should be consistent with the use of simple or complex data within each project. Simple data inputs may still be used even if trend data is required. If simple data is used, the calculation assumes a standard extrapolation. Charts are embedded in the workbook, and these should be compared to trend data, where required, to ensure that the workbook is reasonably characterizing the actual operation. There are situations of deficient operation where the simple data will not accurately characterize the actual conditions. For example, faulty or sensors exposed to the sun will cause economizer functionality to operate unpredictably.

If trend data are used within the PG&E HVAC Tool's complex calculation module, the data will need to be analyzed against outdoor air temperature prior to inputting into the tool.

If any measures on the CHW side tab are enabled, baseline data for each measure should be input and accurate even if that measure is not enabled. This is because the calculation engine references this information to properly calculate the energy consumptions. Please see **PG&E HVAC Tool Methodology** for detailed descriptions of the inputs.

RCx measures not included in this measure package may still be eligible for claimed savings. Alternative approaches for these measures may be a temperature bin analysis or computer simulation. This measure package provides no guidance on the appropriateness of these approaches, required inputs, and acceptable equations and relationships.

KEY PARAMETERS AND SOURCES

See Data Collection Requirements for key parameters and source requirements for each measure.

Peak Electric Demand Reduction (kW)

See Electric Savings section.

Peak kW calculations are based on CPUC Resolution E-5152 which states that the DEER peak kW be calculated as the average kW calculated from the period of 4pm to 9pm over a three day period determined by California Climate Zone. The DEER peak dates for each climate zone are listed below:

CLIMATE ZONE	START DATE	END DATE
1	26-Aug	28-Aug
2	26-Aug	28-Aug
3	26-Aug	28-Aug
4	26-Aug	28-Aug
5	16-Sep	18-Sep
6	2-Sep	4-Sep
7	2-Sep	4-Sep
8	2-Sep	4-Sep
9	1-Sep	3-Sep
10	29-Jun	1-Jul
11	29-Jun	1-Jul
12	29-Jun	1-Jul
13	29-Jun	1-Jul
14	29-Jun	1-Jul
15	29-Jun	1-Jul
16	12-Aug	14-Aug

Gas Savings (Therms)

See Electric Savings section.

Life Cycle

Effective useful life (EUL) is an estimate of the median number of years that a measure installed through a program is still in place and operable. Remaining useful life (RUL) is an estimate of the median number of years that a technology or piece of equipment replaced or altered by an energy efficiency program would have remained in service and operational had the program intervention not caused the replacement or alteration.

Note that RUL is only applicable for add-on equipment and accelerated replacement measures and not applicable for these measures.

Effective Useful Life and Remaining Useful Life

MEASURE OFFERING	EUL ID	EUL YRS	RUL YRS	SOURCE	START DATE	EXPIRE DATE
All Measures	NonRes-RCx-Operational	3	N/A	E-4818 OP2	1/1/2017	

Commented [AR11]: OP2: "We direct the Program Administrators to ensure that all program activities and installations resulting in performance that does not exceed the nominal efficiency (i.e., rated, intended, or original efficiency) of the pre-existing condition are offered through a behavioral, retrocommissioning or operational program framework, with an effective useful life not to exceed three years."

Base Case Cost

The base cost refers to the Standard Practice Cost. This cost component is not applicable for BRO measures.

Measure Case Cost

Measure case costs for custom measures should be calculated based on project-specific information.

The measure case cost refers to the full measure cost and is relevant for BRO measures. This cost is for the purchase, where applicable, and installation of the RCx measure equipment. At the pre-installation stage, included in this cost estimate is the cost of the materials purchased, including sales tax, installation labor, and other related costs (e.g., disposal costs less salvage value).

An itemized vendor bid or quote is the preferred source of the measure case cost. Section 2.5.2 of the Statewide Custom Project Guidance Document v1.4 lists alternative methods for obtaining costs. These include, in preferred order, DEER look-up, cost estimating reference (e.g., RS Means), and DEER approximation.

Commented [SL12]: https://file.ac/OEr-2p-bk3A/

For post installation, an itemized invoice should be provided to document the separate eligible materials and labor costs. Other eligible costs such as permits, taxes, design work, M&V may be included as well, where applicable. Eligible costs are those cost elements that are part of the energy efficiency measure.

Net-to-Gross

The net-to-gross (NTG) ratio represents the portion of gross impacts that are determined to be directly attributed to a specific program intervention.

These NTG values are based upon the average of all NTG ratios for all evaluated 2006 – 2008 **commercial** sector programs, as documented in the *2011 DEER Update Study* conducted by Itron, Inc. These sector average NTGs ("default NTGs") are applicable to all energy efficiency measures that have been offered through commercial sector programs for more than two years and for which impact evaluation results are not available.

Net to Gross Ratio – Nonresidential

NET TO GROSS RATIO ID	NTGKWH	NTGTHERM	EXPIRE DATE
NonRes-sAll-mCust	0.6000	0.5000	
Com-Default-HTR-di	0.8500	0.8500	

Gross Realization Rate

The gross realization rate (GRR) is a multiplier that attempts to take into account the likelihood that not all Commission-approved projects undertaken by utilities will come to fruition. RXX

Decision 11-07-030 set default gross realization rates to apply to all custom projects which do not have an alternate value or specific gross energy savings values set because of an ex ante review process disposition.

If the CPUC ex-ante team pulls and reviews a specific project, then that project gets a 1.0 GRR.

Gross Realization Rates

GRR ID	GRR VALUE
Def-GRR	0.900

Non-Energy Impacts

Non-energy impacts (NEIs) are not quantified for this measure.

Qualitative non-energy impacts for RCx measures may include:

- Longer equipment life,
- Improved occupant comfort,
- Improved indoor air quality,
- Reduced O&M costs, and
- Increased productivity/safety. [5]

Commented [AR13]: SOURCE: Microsoft Word - 139858.DOC (ca.gov)

Commented [AR14]: Energy Star Building Upgrade Manual Retrocommissioning Chapter 5