

Advanced Controls Retrofits For Packaged HVAC Systems in Small and Medium Commercial Buildings

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Heschong Mahone Group, Inc. conducted this technology evaluation for Pacific Gas and Electric Company with overall guidance and management from Keith Forsman and Mananya Chansanchai.

For more information on this project, contact KEF1@pge.com.

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EXECUTIVE SUMMARY

PROJECT GOAL

The goal of this study is to provide recommendations for integrating emerging technologies into energy efficiency incentive programs for existing Small and Medium Business (SMB) Packaged HVAC applications in Pacific Gas and Electric Company ("PG&E") territory. These recommendations are to be guided by the results of a field monitoring and evaluation study currently being conducted concurrently.

PROJECT DESCRIPTION

To achieve the project goals, a market and technology feasibility assessment was conducted through a literature review of manufacturer and technology market data. This is to be followed by field evaluation of each technology selected.

The study is organized into six tasks:

1. Market Assessment of SMB HVAC Retrofit Technologies
2. Selection of Technologies for Field Study
3. Field Monitoring
4. Review Monitored Data
5. Emerging Technologies Report
6. Administration and Reporting

This report covers findings from the first two tasks.

This study is a collaborative effort between HMG and the UC Davis Western Cooling Efficiency Center (WCEC), under two separate contracts with PG&E. HMG conducted the market and technology feasibility assessment to develop a recommended list of products to be tested. The field testing, analysis, and reporting of selected controls and retrofit strategies is currently being conducted by WCEC, with advisory input by HMG.

Final composition of a draft and final emerging technologies (ET) is being conducted by HMG with inputs from PG&E and WCEC.

PROJECT FINDINGS/RESULTS

1. Task 1: Market Assessment of SMB HVAC Retrofit Technologies

Based on the literature review we identified six categories of products eligible for further study:

- **Advanced Retrofit Solutions:** Products in this category are characterized by performing a deep retrofit of an RTU by replacing parts and adding controls to optimize performance.
- **Analytics:** This type of product is geared towards monitoring runtime behavior to assist building operators on the performance of their HVAC system.
- **Auto-DR:** This category consists of automated demand management and demand response control technologies.
- **BMIS "Middleware":** These are products not directly connected to the HVAC system, but link other third party controllers to one central portal enabling control of several end-use devices. They also provide one user interface for each of the controllers plugged into the "middleware" device.
- **Controller add-in:** Controller add-ins is a device directly added to the HVAC system enabling RTU controls. They also offer retrofits to fans/compressors and provide additional capabilities to the RTU (i.e. add-in economizer).
- **Advanced Thermostat:** These technologies typically involve a one-for-one replacement of a thermostat and can be installed and operated by in-house staff or HVAC contractor. Many products in this category can be considered mini-EMS's and have the capability to offer scheduling, system optimization, multi-site management, and can be paired with a variety of sensors and controllers.

2. Task 2: Selection of Technologies for Field Study

Following review of each technologies capabilities and suitability to the study, the following technologies were selected for field studies:

- a. Enerfit (www.enerfitllc.com)
- b. Excel 10- Light Commercial Business Solution by Honeywell (www.honeywell.com)
- c. Jade™ W7220 Controller by Honeywell (www.honeywell.com)
- d. Ecoview by Siemens (www.siemens.com/buildingtechnologies)
- e. Smart Thermostat by Ecobee (www.ecobee.com)

PROJECT RECOMMENDATIONS

This report provides a summary of the technologies recommended for field evaluation for application in small and medium businesses (SMB) in PG&E's service territory.

These technologies cover a wide range of technology types and control retrofit options. Enerfit is considered an "Advanced Retrofit Solution" providing the most comprehensive retrofit option in the final technologies selected, and great potential for high energy savings.

The two "Controller Add-in" technologies offer one technology to be evaluated as an emerging technology, Light Commercial Business Solution by Honeywell, and the second an add-in economizer for RTUs that do not have an economizer. Both technologies offering different retrofit solutions within this category with the potential for energy savings by adding physical controls.

Lastly, the two advanced thermostats offer energy savings through an "out of the box" thermostat replacement solution. These are retrofit solutions are the easiest for building owners to install and maintain in-house, while still seeing energy savings. All five of the technologies selected for field evaluation show great energy savings potential along with matching PG&E's programmatic goals for the Small and Medium Business sector.

Results of the field evaluation conducted by WCEC will be reported in Fall 2013.

INTRODUCTION

This study originated from a PG&E Contract Work Authorization for Heschong Mahone Group, Inc. (hereinafter "HMG"). This study identifies targeted retrofit devices, controls, and interfaces that optimize existing constant volume packaged air conditioning and heat pump systems in the SMB segment. The objective was to select technologies for field evaluation to better understand the relative strengths, weaknesses and opportunities of the technologies in relation to the existing SMB segment.

BACKGROUND

As part of its efforts towards incorporating Emerging Technologies into energy efficiency incentive programs, Pacific Gas & Electric (PG&E) initiated this study to conduct a market assessment, technical evaluation and field evaluation of advanced system controls, sensors and displays for Small and Medium Commercial Packaged HVAC Applications. Small and Medium Commercial Business represent a large portion of PG&E's service territory. This study seeks to offer customers advanced retrofit options not addressed through the existing PG&E HVAC tune-up programs.

EMERGING TECHNOLOGY/PRODUCT

The types of technologies and solutions reviewed ranged from a simple retrofit consisting of "Do-it-Your Self" or "Plug & Play" solutions that can be easily installed by the owner/tenant or HVAC contractor or electrician, to complex solutions requiring outside expertise to install and maintain the technology. Covering a wide range of solutions was intentional in order to conduct a broad review of all applicable and relevant technologies and retrofit solutions. Many technologies on the market are stand-alone devices designed to have one function, while others can be paired with other technologies to create a comprehensive retrofit solution for various end uses. The study covers both of these types of solutions.

To aid the technology selection process for field study, each product was categorized based its functionality and how it retrofits or controls the RTU. These product categories include:

- **Advanced Retrofit Solutions:** Products in this category are characterized by performing a deep retrofit of an RTU by replacing parts and adding controls to optimize performance.
- **Analytics:** This type of product is geared towards monitoring runtime behavior to assist building operators on the performance of their HVAC system.
- **Auto-DR:** This category consists of automated demand management and demand response control technologies.
- **BMIS "Middleware":** These are products not directly connected to the HVAC system, but link other third party controllers to one central portal enabling control of several end-use devices. They also provide one user interface for each of the controllers plugged into the "middleware" device.

- Controller add-in: Controller add-ins is a device directly added to the HVAC system enabling RTU controls. They also offer retrofits to fans/compressors and provide additional capabilities to the RTU (i.e. add-in economizer).
- Advanced Thermostat: These technologies typically involve a one-for-one replacement of a thermostat and can be installed and operated by in-house staff or HVAC contractor. Many products in this category can be considered mini-EMS's and have the capability to offer scheduling, system optimization, multi-site management, and can be paired with a variety of sensors and controllers.

ASSESSMENT OBJECTIVES

1. Market Assessment of SMB HVAC Retrofit Technologies:

The objective is to identify a list of technologies eligible for the study based on:

- a. Promise of energy savings
- b. Potential to reach a broad swath of existing SMB HVAC systems
- c. Reasonable chance of market adoption; and
- d. Maturity of technology development

2. Task 2: Selection of Technologies for Field Study

The objective is to select up to five technologies for scaled field placement based on:

- a. Technology Readiness
- b. Design and Application
- c. Energy Savings
- d. Measurement & Verification
- e. Measure Specification
- f. Cost Effectiveness

3. Task 3: Field Monitoring

The objective is to monitor performance of each technology to better understand the energy savings potential on SMB HVAC systems in the PG&E territory.

4. Task 4: Review Monitored Data

The objective is to quantify the performance of each technology and any concerns with installation, commissioning, operations, and any equipment failures as well as performance issues.

TECHNOLOGY/PRODUCT EVALUATION

EVALUATION APPROACH

TASK 1: MARKET ASSESSMENT OF SMB HVAC RETROFIT TECHNOLOGIES

DATA SOURCES REVIEWED

HMG developed an initial list of technologies, followed by a literature review of the technology capabilities identifying market opportunities and appropriate applications for roof top unit (RTU) retrofit devices. The main sources reviewed to develop the list of technologies include:

- 2011 BPA E3T Energy Management TAG Report¹ - This report was created by the Bonneville Power Administration (BPA) and the Washington State University's Energy Program as a result of the Energy Efficiency Emerging Technology (E3T) Program technical Advisory Group (TAG) evaluation of new efficiency measures. This served as the starting point to identify potential technologies.
- E3Tnw.org²- Is an online repository of emerging technologies created as a result of the 2011 BPA TAG Report.
- Emerging Technologies Coordinating Council (ETCC)³ – The ETCC is a collaboration of the California Public Utilities to promote energy saving technologies. This website houses previous emerging technologies reports completed by each utility as well as some of the current ongoing studies.
- ACEEE⁴ - The American Council for an Energy-Efficient Economy is a non-profit industry organization promoting energy efficiency through publications, conferences and events.
- Recommendations from peers such as the Western Cooling Efficiency Center (WCEC) and kW engineering, both of whom are currently engaged in HVAC retrofit efforts.
- Recommendations from PG&E program managers
- HMG's previous work on EMIS systems and retrofit solutions for HVAC systems

TECHNOLOGY SELECTION CRITERIA

HMG, PG&E staff, WCEC, and kW Engineering identified additional criteria for RTU system type and size to narrow the types of technologies most appropriate for this study.

These criteria include:

¹ Mountjoy-Venning. Et al. (2012)

² Bonneville Power Administration (2012)

³ Emerging Technologies Coordinating Council (2012)

⁴ American Council for an Energy-Efficiency Economy (2012)

- Solutions targeting single-zone packaged rooftop units and multi-zoned systems with 2-3 zones and ≤ 30 ton units
- No VAV systems
- No built up systems
- Systems that require limited on-site experience to manage

With the above criteria in place, research was focused only on technologies targeting buildings with these system types as listed in Figure 1.

The "Summary of Technologies" section provides summary descriptions of each product.

Product Category	Manufacturer	Product
Advanced Retrofit Solution	Enerfit	Enerfit
	Transformative Wave Technologies	Catalyst
	DTL Controls	Digi-RTU
Analytics (EIS)	Virtjoule	Virtjoule
Auto-DR	REGEN Energy	REGEN
BMIS “Middleware”	Tridium	Jace
	Kite and Lightning	Unity
	Trane	Tracer SC
	Siemens	Site Controls
	Ubiquity	TCS Basys Controls
	Delta	Delta Controls (customized)
	Can2Go	UN2 Universal Controller
	Distech Controls	ECB-203
Controller add-in	Honeywell	Excel 10 Unitary Controller
	NexRev	Drive Pak
Economizer add-in	Honeywell	Jade™ W7220 Economizer Controller
	KMC	FlexStat
	Siemens	Ecoview
	Ecobee	Smart Thermostat
	LightStat	E-stat
Advanced Thermostat	Illumra	Illumra Wireless Thermostat
	Distech Controls	Allure ECB-Stat

FIGURE 1. LIST OF TECHNOLOGIES REVIEWED

TECHNOLOGY REVIEW PROCESS

After the initial list of technologies was developed, HMG gathered technical product information, equipment, installation and O&M cost data from various device manufacturers, installers, service providers and operators. The full list of technologies reviewed can be found in the appendix "Initial list of Technologies." HMG coordinated with WCEC to develop categories of information needed in order to thoroughly evaluate each technology. These categories include:

- General Information – Information on the targeted system type and size the technology is geared towards, presence of vendors or providers in CA, who does the installation, and has the technology been field or lab tested.
- Product Capabilities – Does the technology provide controls for temperature, CO₂, humidity, economizer mode, ventilation, and characteristics of HVAC component control. In addition, what other features does the technology have: Fault Detection and Diagnostics (FDD), lighting, refrigeration, monitoring, plug loads, and enterprise-level management.
- Technical Details – Information on the how associated hardware and software required for the retrofit, how the technology communicates (i.e. wirelessly, remote access, protocols, etc.), and what the functioning interface of the technology consists of.
- Purchasing and Installation – This category addressed the retrofit logistics of installing, maintaining, and ongoing support of the technology.

The data collection process was driven by formal interviews and surveys with manufacturers supported by reviewing manufacturer websites and third party reports. The intent of the latter was to gain knowledge of the product and its functionality through prior efforts.

Interviews with manufacturers consisted of sending the manufacturers a questionnaire regarding their product which can be found in the Appendix "Manufacturer Questionnaire." Once the questionnaire was sent, HMG staff followed up with a phone conversation to discuss product details further. Through this process HMG was able to identify the relative market opportunities and most appropriate applications for each RTU retrofit device. (e.g.: business type; system types targeted; climate zones appropriate, etc.).

TASK 2: SELECTION OF TECHNOLOGIES FOR FIELD STUDY

PROCESS

To select technologies most suitable for field monitoring HMG used a similar process as found in the 2011 BPA E3T Energy Management TAG Report⁵. This consisted of forming an advisory group consisting of staff from various groups including: PG&E, WCEC, and kW Engineering. Each group member was then asked to score each

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http://www.bpa.gov/energy/n/emerging_technology/pdf/E3T_2011_EM_TAG_Final_Report.pdf

technology based on the information HMG obtained through a market assessment. The full process of how the technologies were selected includes:

1. HMG prepared the technology review spreadsheet with each product categorized
2. HMG hosted a conference call with all parties to explain the spreadsheet and identify each product's strengths and weaknesses. Each entity was asked to score each product according to the criteria listed in the following section.
3. HMG compiled each entity's score for each technology.
4. HMG applied engineering and professional judgment based on the scores and technology specifics to identify five technologies recommended for field evaluation.
5. HMG conducted a follow-up call to discuss recommendations.
6. As a result of the follow-up discussion, HMG made one modification – to replace Enerfit for Digi-RTU.

CRITERIA

The below questions are the criteria the group was asked to evaluate each product on. In the first round of scoring, only Technology Readiness, Design & Application, Customer Adoption, and Energy Savings were scored. The remaining questions were evaluated in the second round.

1. **Technology Readiness** – Are products and providers available, reliable, and ready to scale up?
2. **Design & Application** - Are design practices, standards and ratings developed and widely available? Are applications understood and guidelines developed for selection and installation?
3. **Customer Adoption** – Is the customer value identified, communicated, understood, and positive?
4. **Energy Savings** – Are energy savings predictable, consistent, persistent and significant? (Note: Data on this is most likely not available for the truly emerging products so will require judgment calls on behalf of the team.)
5. **Measurement & Verification** – Are the energy savings measurable and are EM&V approaches selected, developed, and available? (Note: This will be need to be coordinated with the EM&V protocol efforts currently being led by Leo Carrillo)
6. **Measure Specification** – Are applications, baseline, incremental savings, incremental costs, and measure specification defined and reliable?
7. **Cost Effectiveness** – Is this likely to be a TRC cost-effective conservation resource?
8. **Program Implementation** – Can PG&E implement a cost-effective program to specify and deliver this measure?

Each technology was given a score for each of the eight criteria from 1-5 with the following definitions:

- 0 Not Relevant/Not Likely To Meet Program Intent

- 1 Marginally Relevant/Perhaps Meets Program Intent
- 2 Somewhat Relevant/May Meet Program Intent
- 3 Relevant/Likely to Meet Program Intent
- 4 Recommended/Meets Program Intent
- 5 Highly Recommended/Exceeds My Expectations

The scores were compiled and ranked from highest to lowest. Once the scores were compiled, the technologies were narrowed from twenty two down to nine for further discussion. This was considered the second round and additionally included review of the remaining four criteria: Measurement & Verification, Measure Specification, Cost Effectiveness, and Program Implementation.

TASK 3: FIELD MONITORING

Currently under development.

TASK 4: REVIEW MONITORED DATA

Currently under development.

TECHNICAL APPROACH/TEST METHODOLOGY

FIELD TESTING OF TECHNOLOGY

Currently under development.

TEST PLAN

Currently under development.

INSTRUMENTATION PLAN

Currently under development.

RESULTS

TASK 1: MARKET ASSESSMENT OF SMB HVAC RETROFIT TECHNOLOGIES

SUMMARY OF TECHNOLOGIES

ADVANCED RETROFIT SOLUTIONS

Enerfit

Manufacturer: Enerfit

Description: Unit level controller that optimizes the operation of a packaged unit based on occupancy, humidity and CO2. Along with providing demand controlled ventilation and economizer controls.

Targeted System Size and Type: Currently manufacturer targets rooftop packaged units that are 8-10 tons and above

Estimated Energy Savings: Manufacturer claims savings between 40-70%

Field Tested: Current field test underway in SDG&E territory

Strengths: Perhaps the most comprehensive of all the retrofit solutions studied. Customizable and has hardware components consisting of the Enerfit controller and compatible with most third party sensors. Enerfit also has a unique passive dehumidification approach, modulation of fan speed, controls compressor operation and staging, and has Fault Detection and Diagnosis (FDD) capabilities.

Weaknesses: Limited presence in California. No local representative in California could make it difficult for installation and commissioning process which is supposed to be done by Enerfit representatives. Claims large energy savings, but limited field application with verified savings.

Cost: Approximately \$4,000 (15 ton unit) – Obtained from Esource report

Sources:

- www.enerfitllc.com/
- Interview with Ron Patch, President, Enerfit
- Esource report⁶

⁶ Criscione (2011)

Catalyst

Manufacturer: Yaskawa / Transformative Wave

Description: Packaged variable frequency drive and unit level controller; demand control ventilation and economizer controls.

Targeted System Type and Size: Rooftop units that are 7.5 tons / 2 Horsepower and larger

Estimated Energy Savings: Manufacturer claims savings between 30-40%

Field Tested: Snohmish Country PUD has verified kWh savings of 48%

Strengths: Comprehensive "soup to nuts" retrofit with customized hardware, software and service solution that includes a two-week M&V and commissioning period.

Weaknesses: Limited presence in California. No local representative in California makes it difficult for installation and commissioning process which is supposed to be done by Catalyst representatives. Claims large energy savings, but limited field application with verified savings.

Cost: Approximately \$4,700 (15 ton unit) – Obtained from Esource report

Sources:

- <http://www.catalystec.com/>
- Interview and questionnaire with Evan Atwater, Senior Technical Manager, Transformative Wave Technologies

Digi-RTU

Manufacturer: Efficiency Tree DLT Controls

Description: Terminal unit controller; VFD to condenser fan

Targeted System Size and Type: Rooftop units ranging in size from 5-30 tons or 20-150 tons

Estimated Energy Savings: Manufacturer claims $\leq 50\%$ savings

Field Tested: Omaha Public Power District verified average kWh savings of 49%

Strengths: Claims to generate large electricity and demand savings. It can also communicate with a variety of HVAC systems either natively or through a gateway made by DTL Controls.

Weaknesses: Limited presence in California. No local representative in California makes it difficult for installation and commissioning process which is supposed to be done by Digi-RTU representatives. Claims large energy savings, but limited field application with verified savings.

Cost: \$3,000-\$10,000 (<20 tons), \$5,000-\$20,000 (>20 tons) – obtained from Esource report

Sources:

- <http://www.dtlcontrols.com/poptimizer.html>
- [Omaha Public Power District Case Study](#)

- Questionnaire filled in by Justin Bitz, Director of Business Development, Bes-Tech

ANALYTICS

Virtjoule

Manufacturer: Virtjoule

Description: Sensors and software monitoring of HVAC system; economizer, compressor, and evaporator control.

Targeted system size and type: Target market is casual restaurants with 3-10 ton units

Estimated Energy Savings:

- No direct energy savings from monitoring device. Savings are a result of the diagnostics this device monitors and is addressed by building operator.
- Manufacturer field studies have claimed 15-20% reduction in building electricity consumption due to monitoring and actions to address faults.

Strengths: Performance and run-time monitoring for any size commercial building. Targets buildings with large energy consumption including restaurants, server rooms, and refrigerated rooms.

Weaknesses: Only measures HVAC and lighting performance and run-times. Limited capabilities beyond those functions.

Cost: \$25/unit/month – Obtained from Manufacturer

Sources:

- <http://www.virtjoule.com>
- Interview and questionnaire with Virtjoule representative

AUTO-DR

Swarm Energy Management

Manufacturer: REGEN Energy Inc.

Description: Wireless automated demand management and demand response controllers work together intelligently communicating and managing the duty cycles of the loads being controlled.

Targeted System Size and Type: Single-zone commercial facilities with at least 4 RTUs

Estimated Energy Savings: Manufacturer claims demand savings of up to 30%. Ongoing pilot study with SMUD, report expected to be released soon.

Strengths: Unique approach to load monitoring and management that does not use any sensors, but rather indirectly observes the "baseline" HVAC requirements and sheds load when needed by directly communicating to HVAC equipment in terms of duty cycles.

Weaknesses: Not capable of fault detection of diagnostics of any sort and actually requires a full HVAC equipment operation verification before controls equipment can be installed

Cost: Unknown

Sources:

- <http://www.regenenergy.com/>
- Interview and questionnaire with Mark Kerbel, Co-founder & EVP Business Development, REGEN Energy Inc.

BMIS "MIDDLEWARE"

JACE

Manufacturer: Tridium

Description: Building level controller that serves as a "middleware" between utility price signals and building automation systems or building thermostats.

Targeted system size and type: >5 Tons

Estimated Energy Savings: Unknown, no field or lab tests available

Strengths: Designed for national accounts and for benchmarking, centralized management, and aggregated demand response using a network operations center. Works with major communications protocols, BACnet and LONworks, and can also be customized to work with legacy systems. Can communicate with other 3rd party controls.

Weaknesses: Not applicable to single-sites and not cost effective for total capacities of 10 tons or less.

Cost: \$5,000-\$7,000 installed – obtained from manufacturer

Sources:

- <http://www.tridium.com/>
- Interview and questionnaire with Ed Merwin, Director at Vykon Automation, Energy & Security

Unity

Manufacturer: Kite and Lightning

Description: Completely customized building management software that offers temperature modulation; optimization, economizer and lighting controls.

Targeted system size and type: Commercial buildings with constant volume systems

Estimated Energy Savings: Manufacturer claims savings up to 20%

Field Tests: Puget Sound Energy field test achieved 9.5% electricity savings and 12.8% natural gas savings

Strengths: Capable of wirelessly communicating with a wide variety of end-use loads such as lighting, HVAC, refrigeration and miscellaneous food service appliances. Manufacturer provides ample support from project inception to continuous monitoring and savings verification.

Weaknesses: Customized hardware and software solution may prove to be costly. Manufacturer has very little presence in California which may make installation logistics difficult.

Cost: <\$10,000 (hardware, install, and 3 year warranty) – obtained from manufacturer estimate

Sources:

- <http://kiteandlightning.com/>
- Interview and questionnaire with Paul Needham, Director of Marketing, Gorge Logic

Tracer SC

Manufacturer: Trane

Description: Controls software and device that enables control of various HVAC field devices

Targeted System Size and Type: Targeted towards small offices with rooftop packaged units

Estimated Energy Savings: No lab or field tests available and highly variable due to customization.

Cost: Varies

Strengths: Customized solution in which Trane technicians, engineers and consultants take the project from “soup to nuts” and also offer continuing remote management and savings verification services. Manufacturer makes several gateway solutions that would allow this product to communicate with legacy systems.

Weaknesses: Customized hardware solution and Manufacturer labor may prove to be costly. Not a wirelessly enabled product; requires physical wiring from sensors to controller to HVAC equipment.

Sources:

- <http://www.trane.com/commercial/>
- Interview and questionnaire with Justin Keough, Controls Accounts Manager, Trane

Site Controls

Manufacturer: Siemens

Description: Enterprise-level management software platform connected to IP enabled building level controllers.

Targeted System Size and Type: National accounts with network operations centers that want full, fine grain monitoring and management of their buildings' HVAC equipment.

Estimated Energy Savings: Unknown, no lab or field tests available and highly variable due to customization.

Strengths: Wireless enabled controllers and sensors allow for the full capabilities of an energy monitoring and management system, including lighting, HVAC and refrigeration. Well suited for large national accounts looking to implement energy efficiency, benchmarking and demand response in their facilities.

Weaknesses: No on-site interface, only gives temporary override controls to the building occupant. Requires a network operations center since Siemens doesn't provide management services. Annual licensing fee for the software platform.

Cost: Unknown

Sources:

- <http://w3.usa.siemens.com/>
- Interview and questionnaire with David Lopykinski, Siemens

Ubiquity

Manufacturer: TCS Basys Controls

Description: Complete energy management system with an on-site server, controllers, thermostats and sensors.

Targeted System Size and Type: National accounts of small to mid-sized facilities such as branch banks, restaurants, retail and convenience stores.

Estimated Energy Savings: Unknown, lab or field tests unavailable and highly variable due to customization.

Strengths: Fully customized solution managed, installed and commissioned by a team of TCS Basys consultants, engineers and technicians. Dedicated support, monitoring and management services available.

Weaknesses: Not cost-effective for single-site facilities

Cost: Unknown

Sources:

- <http://www.tcsbasys.com/>
- Interview with sales representative at TCS Basys Controls

Delta Controls

Manufacturer: Delta

Description: Suite of HVAC and lighting controls tailored to each building

Targeted System Size and Type: Custom solution targeted at any system

Estimated Energy Savings: Unknown

Strengths: Customizable solution of sensors and controls for any system type.

Weakness: Large variety of hardware controls and sensors with general applications.

Cost: Unknown

UN2 Universal Controller

Manufacturer: Can2Go

Description: Enables control of various end-use devices for single site or multi-site applications

Targeted system size and type: N/A

Estimated Energy Savings: Unknown

Strengths: Works with EMS systems and can link together several controller and sensors. Web interface can be enabled and viewed on any device (i.e. computer, smartphone, etc.)

Weaknesses: This is an in between device, not a control or sensor to provide actual energy savings. Device is not a "plug and play" solution, but should be installed by a controls integrator or approved contractor. In addition, there is limited product support available to the customer.

Cost: Unknown

Sources:

- <http://www.can2go.com/>
- Interview and questionnaire with Martin Fransham, Sales Director, Can2Go

Distech Controls – ECB-203

Manufacturer: Distech Controls

Description: Programmable controller designed to control terminal units such as RTUs and communicate with other sensors; indoor temperature measurement, set point adjustment, fan speed selection, and occupancy state override.

Targeted System Size and Type: Flexible and scalable

Estimated Energy Savings: Unknown

Strengths: Communicates with other Distech controls, sensors, and custom programming HVAC control sequences; user interface to monitor and control each end use. Also controls lighting and refrigeration and can be used for monitoring multiple sites.

Weaknesses: Not a large network presence in California.

Cost: Unknown

Sources:

- <http://www.distech-controls.com/>

- Questionnaire filled out by Steve Floth, Western US Sales Manager, Distech Controls

CONTROLLER ADD-IN

Light Commercial Business Solutions Excel 10 Unitary Controller

Manufacturer: Honeywell

Description: Unit-level controller that enables basic HVAC controls strategies that account for occupancy, humidity, CO2 and open windows and doors

Targeted System Size and Type: Constant volume unitary and air handler units of any size

Estimated Energy Savings: Unknown

Strengths: Widely available and can be installed by a number of licensed HVAC contractors. Can be integrated into wider network architecture or can function as a standalone unit.

Weaknesses: Requires physical wiring from sensors to controller to HVAC equipment

Cost: Approximately \$300-\$400/hardware – obtained from web search

Sources:

- <http://customer.honeywell.com/>
- Questionnaire filled out by Daniel Jones, Honeywell

JADE Economizer

Manufacturer: Honeywell

Description: Economizer add-in controller

Targeted System Size and Type: Standalone rooftop packaged units between 4 to 25 tons on commercial buildings less than 50,000 square feet

Estimated Energy Savings: Peci and PNNL are field testing this technology in Portland

Strengths: Widely available and can be installed by a number of licensed HVAC contractors. Has an LCD display that makes diagnostics simple. Capable of demand controlled ventilation determined by occupancy, humidity and CO2 sensing. Comes with standard programming, but can be customized using a PC tool.

Weaknesses: N/A

Cost: Approximately \$150-\$300/hardware – obtained from web search

Sources:

- <http://customer.honeywell.com/>
- Questionnaire filled out by Daniel Jones, Honeywell

Drive Pak

Manufacturer: NexRev

Description: Packaged variable frequency drive and unit level controller

Targeted System Type and Size: Rooftop and split systems that with 2 Horsepower or larger

Estimated Energy Savings: Manufacturer claims energy savings of 76% in a "medium-box retail store"

Strengths: Works on a large variety of systems. Simple installation that can be done by any licensed HVAC technician

Weaknesses: Limited capabilities in terms of available HVAC controls strategies

Cost: Unknown

Sources:

- <http://www.drivepak.com/>
- Questionnaire with Ken Logsdon, National Account Executive, NexRev

ADVANCED THERMOSTAT

FlexStat

Manufacturer: KMC Controls

Description: Thermostat with a built-in BACnet controller that has standard HVAC optimization software and is also capable of controlling lighting and refrigeration with custom programming

Targeted System Size and Type: Single-zone equipment such as air handler units, rooftop packaged units, fan coils and heat pumps

Estimated Energy Savings: No field or lab tests available

Strengths: One-for-one replacement for standard thermostats that can be installed by HVAC technician. Well suited in commercial buildings with an existing residential grade thermostat.

Weaknesses: Cannot directly communicate with non-BACnet and legacy EMS systems. Not a wirelessly enabled product; requires physical wiring from sensors to controller to HVAC equipment.

Cost: \$300/thermostat controller, \$2,400/RTU (installed and package of parts cost) – quote provided by manufacturer

Sources:

- <http://kmcccontrols.com/>
- Interview and questionnaire with Rick Fellows, Vice President of Business Development, KMC Controls

EcoView

Manufacturer: Siemens

Description: Light energy management product suite with wireless thermostats, touch panel interfaces, lighting controllers, power meters and access to Siemens' cloud-based software platform

Targeted System Size and Type: Small, commercial facilities with packaged rooftop units. Specifically geared towards small retail. Typical installations have no more than 6 rooftop units between 5-15 tons each

Estimated Energy Savings: Manufacturer claims savings of up to 18% in small commercial facilities

Field test: Manufacturer field test 5-8% savings achieved in a restaurant

Strengths: Wireless enabled controllers and sensors allow for the full capabilities of an energy monitoring and management system, including lighting, HVAC and refrigeration

Weaknesses: Requires a licensed "controls integrator" who will perform a full audit and put together a customized solution. Software platform only exists in Siemens cloud. Licensing fee required for 1st year then monthly licensing fee required to access the software platform afterward.

Cost: Unknown

Sources:

- <http://w3.usa.siemens.com/>
- Interview and questionnaire with David Lopykinski, Siemens

EcoBee - Smart Thermostat

Manufacturer: EcoBee

Description: Wirelessly communicating thermostat that allows for monitoring and adaptive control of HVAC equipment

Targeted System Size and Type: Single-zone buildings up to 50,000 to 100,000 square feet and can take up to 4 stages of heat and 2 stages of cooling

Estimated Energy Savings: Manufacturer claims savings of up to 50%

Field Tests: Manufacturer claims 18% electric and 27% gas savings achieved in a restaurant

Strengths: Simple one-for-one replacement of the existing thermostat that allows for fine grain, adaptive control of set points and schedules. Is demand response enabled and is easily adapted for enterprise-level use

Weaknesses: Does not directly optimize HVAC equipment operation, rather, can only turn equipment on and off when appropriate. No lighting controls.

Cost: \$800-\$1,000/zone – Obtained from E3T.org

Sources:

- <http://www.wems.co.uk/>
- Interview with Mark Lance, Regional Sales Representative for West Central USA, EcoBee

E-Stat

Manufacturer: LightStat

Description: Wirelessly controlled programmable thermostat allowing for temperature and occupancy set points and scheduling.

Target system size and type: Standard RTU units, and multi-stage heating and cooling (up to 2 stages) targeted to national retail chains.

Estimated Energy Savings: Manufacturer claims 10-15% savings, showed 3% in retail store case study

Strengths: Simple one-for-one replacement of the existing thermostat which can also be paired with lighting controls by LightStat to offer an integrated retrofit solution for multiple end uses.

Weaknesses: Limited HVAC control capabilities beyond temperature and occupancy sensing.

Cost: Unknown

Sources:

- <http://www.lightstat.com/>
- Questionnaire filled out by Craig Bernier, LightStat

Illumra Wireless Thermostat

Manufacturer: Illumra

Description: Wireless thermostat that communicates with occupancy sensors, hotel key cards, door/window sensors, and room temperature sensors to adjust HVAC set points to a preset range.

Targeted system size and type: Fan coil or heat pump furnaces and AC units, electrical load less than 8 Amps or ½ HP.

Estimated Energy Savings: unknown

Field tested: N/A

Strengths: Indoor and outdoor lighting controls are the primary strength of this product with HVAC controls a secondary function geared towards hotels and dormitories. Short installation time (approximately 30 minutes), ample technical support, and a 3 year warranty.

Weaknesses: Targeted to small PTAC units in hotels and should be installed by a HVAC contractor.

Cost: Unknown

Sources:

- <http://www.illumra.com>
- Interview with representative

Allure ECB-Stat

Manufacturer: Distech Controls

Description: Thermostat replacement able to control single stage and multi stage temperature control with humidity control. Automatically adjusts temperature according to occupancy mode.

Targeted system size and type: Flexible and scalable

Estimated energy savings: Unknown

Field test: N/A

Strengths: Offers various models with option humidity control, economizer control, and occupancy sensing and adjustment.

Weaknesses: Limited communication with other protocols.

Cost: unknown

Sources:

- www.distech-controls.com
- Questionnaire filled out by Steve Floth, Western US Sales Manager, Distech Controls

TASK 2: SELECTION OF TECHNOLOGIES FOR FIELD EVALUATION

The advisory group made their final decisions to evaluate the following five technologies through a field study:

- **Enerfit:** Technology is still in development, application scenario is well developed, but likelihood of SMB customers doing this on a massive scale is small. Energy savings seem high, but the persistence of energy savings is undetermined. Out of the three products in the "Advanced Retrofit Solution" category this technology has a more advanced strategy to modulate fan speed, which is where the large savings potential lies. In addition, it is not currently being studied by other organizations at this time as are others in this category are.

A draw back to this technology is the limited existing presence in CA.

- **Excel 10 - Light Commercial Business Solution by Honeywell:** Solution seems to be targeted to the SMB segment, savings potential is unknown; however, is a good candidate for evaluation in the Emerging Technologies context. Due to the customizability of this product and its capabilities there is a large energy savings potential. In addition, this product is not only an HVAC control, but also has the capability to control lighting as well (through additional hardware).
- **Jade™ W7220 Controller by Honeywell:** This provides a good solution for existing RTUs that do not have an economizer.
- **Ecoview by Siemens:** Technology is highly capable and offers the most capabilities out of its peer group. A drawback is that it requires maintenance contract.
- **Smart Thermostat by Ecobee:** This product is the easiest retrofit solution for a thermostat replacement. The savings may be low, but this device is low-cost and easy to install. This may be considered a good "bang for the buck" solution, but low savings comparatively to other strategies.

These technologies range from comprehensive retrofit options to simple "do-it-yourself" control options for building owners.

TASK 3: FIELD EVALUATIONS

Field evaluations will be conducted in Fall 2012 through Spring/Summer 2013 for the selected technologies.

RECOMMENDATIONS

This report provides a summary of the technologies recommended for field evaluation for application in small and medium businesses (SMB) in PG&E's service territory.

These technologies cover a wide range of technology types and control retrofit options. Enerfit is considered an "Advanced Retrofit Solution" providing the most comprehensive retrofit option in the final technologies selected, and great potential for high energy savings.

The two "Controller Add-in" technologies offer one technology to be evaluated as an emerging technology, Light Commercial Business Solution by Honeywell, and the second an add-in economizer for RTUs that do not have an economizer. Both technologies offering different retrofit solutions within this category with the potential for energy savings by adding physical controls.

Lastly, the two advanced thermostats offer energy savings through an "out of the box" thermostat replacement solution. These are retrofit solutions are the easiest for building owners to install and maintain in-house, while still seeing energy savings. All five of the technologies selected for field evaluation show great energy savings potential along with matching PG&E's programmatic goals for the Small and Medium Business sector.

Results of the field evaluation conducted by WCEC will be reported in Fall 2013.

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APPENDICES

INITIAL LIST OF TECHNOLOGIES

Manufacturer	Product
Tridium	Jace
ite and Lightning	Unity
Trane	Tracer SC
KMC	FlexStat
Honeywell	Excel 10 Unitary Controller - Light Commercial Business Solution
Honeywell	Jade™ W7220 Economizer Controller
Siemens	Site Controls
Siemens	Ecoview
WEMS International	WEMS International
Ubiquity	TCS Basys Controls
Ecobee	Smart Thermostat
Enerfit	Enerfit
Yaskawa/Transformative Wave	Catalyst
DTL Controls	Digi-RTU
NexRev	Drive Pak
REGEN Energy	REGEN
Virtjoule	Virtjoule
Delta	Delta Controls (customized product)
LightStat	E-stat
Can2Go	UN2 Universal Controller
Illumra	Illumra Wireless Thermostat
FDSI	Field Diagnostics
NEST Labs	“self-learning” programmable thermostat
Green Life Systems	GLS-2000

Manufacturer (cont.)	Product (cont.)
Pulse Energy	Pulse
Cypress Envirosystems	Wireless Pneumatic Thermostat
Energy Controls Company	ecWizard
Millennialnet	Wireless Pneumatic DDC Thermostat
Novar	Opus Manager
Optimum Energy	Optimum software suite
BuildingIQ	BuildingIQ
E2 America	E2America
Johnson Controls	Metasys
Innotech	Innotech
Automated Logic	Automated Logic
Distech Controls	Control System

MANUFACTURER QUESTIONNAIRE

General Information	
System Overview	Product Name
	URL
	Case Studies
	Installer Type
	Locations of Qualified Providers in CA
	Targeted System Type
	Targeted System Size
Product Capabilities	
Temperature Control	Senses Temperature
	Allows program of temperature set point schedule
	Automatically adapts temperature set point schedule according to an algorithm
	Responds to sensed occupancy
	Automatic decides warm up to achieve set point schedule
	Delays warmup (optimum start) slowly shift setpoint rather than immediate change
	Allows pneumatic thermostat to communicate with DDC system
CO2 Control	Extended Fan Runtime
	Senses CO2
	Allows program of CO2 set point schedule
Humidity	Responds to Sensed Occupancy
	Senses Humidity
Economizer Mode	Allows program of humidity set point schedule
	Differential (Comparative) Economizer (T or enthalpy)
	Integrated Economizer (will allow compressors to run w/ 100% OSA)
Ventilation Controls	Other
	Varies fan speed in response to CO2 set point
	Varies OSA damper in response to CO2 Set Point
Characteristics of HVAC Component Control	Varies fan speed in response to HEAT/COOL/VENT mode or stage
	Retrofits CV Fan with Variable Speed
	Retrofits Compressor to VS
	Controls Compressor Operation
	Controls Compressor Staging
	Controls Compressor VS
	Retrofits Evaporator fan to VS
	Controls Evaporator Fan
	Controls Evaporator Fan Speed
	Retrofits Condenser fan to VS
	Controls Condenser Fan
	Condenser Fan multiple stage
	Retrofits equipment with motorized OSA Damper
OSA Damper Actuation	
FDD	Supply temperature modulation
	Communicates off Board
	Diagnosis Specific Fault
	Signals Performance Degredation

Lighting	Controls Lighting on-off remotely
	Controls Lighting dimming remotely
	Responds to sensed occupancy
	Set Lighting Schedule remotely
	Senses Daylighting
Refrigeration	Senses open doors
	Switches off Refrigeration/Lights based on Occupancy
	Detects Refrigerant Leaks
Monitoring	Monitors real-time power use
	Monitors Compressor RunTime
Enterprise-Level	Multi-site
Plug Loads	Plug Load Mng
Technical Details	
Communication	Online Access
	Remote notification (text,email)
	DR enabled
	Communication protocol(s) (Please List)
	DDC compatible
	Wireless enabled
	Physical control wiring
Interface	Physical Interface
	Software Interface
	Automatic Optimization Feature
	Dashboard Name
	Web-based
	Workstation Name
	Cloud Based Services
Hardware/S oftware	"Out of the box" hardware
	"Kit of parts" hardware
	Customized hardware solution
	Software only solution
Purchasing and Installation Information	
Retrofit Logistics	What info is needed from the facility?
	Is an audit needed?
	Who performs the audit?
	How/Who determines the retrofit solution?
	Who performs the installation
	How long does it take to do the installation
	Commissioning requirements
	Ongoing maintenance
	Who performs maintenance
	Warranty
	Technical support type
	Product support
	Maintenance Contract Required