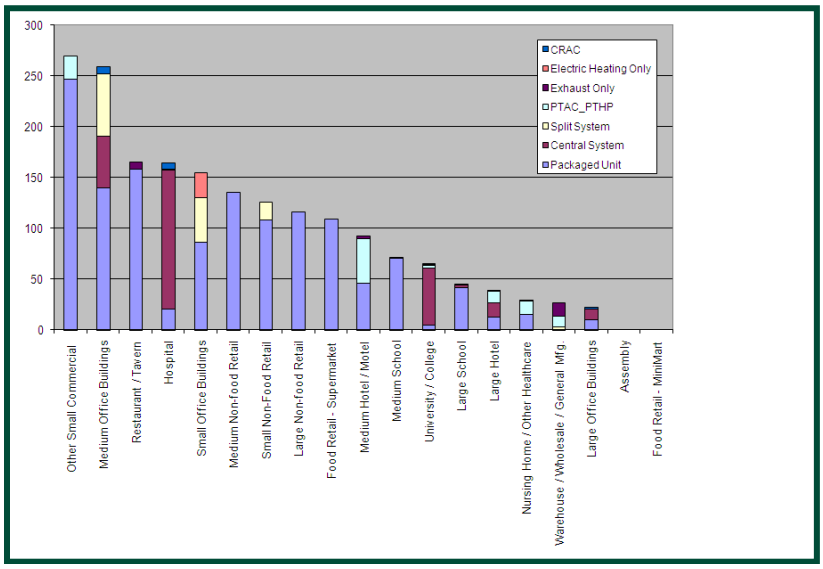
HVAC Application Matrix for Identifying Promising Energy Efficiency Measures

ET11SCE4040/HT11SCE009 Report



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Disclaimer

EXECUTIVE SUMMARY

The Heating, Ventilating, and Air Conditioning (HVAC) Application Matrix seeks to develop a simple and powerful method to target high impact HVAC measures for commercial buildings. The secondary goal was to demonstrate that the methods used to develop the earlier Lighting Application Matrix could be adapted to identify opportunities for other technologies and markets.

Standard practice for developing an energy efficiency (EE) program portfolio calls for gathering information from multi-year comprehensive market potential studies. However, because these studies are often costly and time-consuming, they may be delayed until later stages of program development, or deferred completely. In 2010, BC Hydro developed a novel solution to this conundrum: the Lighting Application Matrix. The Lighting Matrix uses the capabilities of a spreadsheet to combine two different types of information. The two are lighting technology energy savings, and BC Hydro data on lighting energy use by market segment and building space type. The two help to yield data-driven estimates of the combinations of lighting measures and specific market areas that can generate the greatest energy savings over the next few years.

Based on the success of the Lighting Application Matrix, Southern California Edison (SCE) joined with BC Hydro and Bonneville Power Administration to create a similar tool for the commercial retrofit heating, ventilation, and air conditioning (HVAC) market.

The project team used Microsoft Excel workbook software to develop the HVAC Application Matrix by combining HVAC market data by subsector with estimates of energy use by space type, as well as expected savings for progressively more efficient bundles of measures for the applicable HVAC systems.

The HVAC Application Matrix is an Excel workbook made up of tabbed worksheets addressing the following successive steps: data collection, assumption development, analysis and graphical display of results. The Matrix uses Excel pivot tables and pivot chart functions for data mining, synthesis, graphical representation, and prioritization of findings based on the data compiled and generated in the worksheets.

Results indicate that SCE stands to benefit from programs to address packaged units in multiple sub-sectors, notably restaurants, retail outlets, and other small commercial facilities.

This and other data-driven results from the HVAC Application Matrix can provide SCE energy efficiency program managers the information they need to identify and prioritize program options, as well as justify program timing and design decisions. In addition, the pivot capabilities provide a systematic, easy-to-use, and rapid process for exploring the matrix data sets and developing *what if* scenarios for program planning and targeting.

SCE's EE and EE marketing teams could benefit from using the HVAC Application Matrix to explore different possibilities and develop relevant *what if* scenarios. As appropriate, these explorations could lead to action plans to design and implement specific measures and programs.

In addition, SCE could continue its partnership with BC Hydro and BPA (and possibly with additional collaborators) to augment the value of the Matrix for the benefit of a wide range of decision makers within a utility. Specific next steps could include:

- Review and refine assumptions
- Work with codes and standards experts to provide more specifics around the timing and levels of future codes and standards requirements
- Develop Matrix capabilities for automatic pivot table and chart generation to allow for more flexible queries and better display of results
- Add a data entry form to facilitate inclusion of emerging technologies
- Add macros to automate the Matrix
- Expand the Matrix to include residential HVAC energy efficiency options and additional project scenarios such as new construction.

ABBREVIATIONS AND ACRONYMS

BPA	Bonneville Power Administration
CEUS	California Commercial End-Use Survey
CFM	cubic feet per minute
CRAC	computer room air conditioner
C&S	Codes and Standards
DES	Design & Engineering Services
DX	direct expansion
EE	energy efficiency
ETP	Emerging Technologies Program
GWh	Gigawatt-hour
HVAC	heating, ventilating, and air-conditioning
RTU	rooftop unit
SCE	Southern California Edison

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INTRODUCTION

To create high-impact portfolios of energy-saving measures, energy efficiency (EE) program managers and Emerging Technologies Program (ETP) staff continually search for combinations of technologies and market segments that can generate the greatest energy savings, cost-effectively, and efficiently. Historically, EE planners have commissioned market potential studies that serve as sources for program and portfolio development. However, because the studies are often costly and time-consuming, they may be delayed until later stages of program development, or deferred completely. A simple assessment approach that isolates a subset of technology and market criteria would help EE program managers identify and prioritize opportunities prior to program design.

The primary project goal was to develop the Heating, Ventilating, and Air Conditioning (HVAC) Application Matrix, a simple and powerful method to target high impact HVAC measures for commercial buildings. The secondary goal was to demonstrate that the methods used to develop the Lighting Application Matrix could be adapted to identify opportunities for other technologies and markets.

The project drew on California Commercial End-Use Study (CEUS), the standard, large-scale energy end-use study for California, as sources for annual HVAC electricity use by market sub-sector. To develop and gain consensus on key assumptions, the project team obtained input from HVAC engineers at SCE and partner utilities as well as HVAC industry practitioners, EE program managers, and codes and standards experts.

SCE and its partners then developed estimates of electricity use by space type based on expert judgment applied to the current building stock, the factors that determine appropriate HVAC system types for a specific application, and the expected energy performance of these systems. This effort also yielded estimates, for each type of HVAC system, of the potential electricity savings for groups of synergistic HVAC energy efficiency measure referred to as “bundles”.

The project team used Microsoft Excel workbook software to develop the HVAC Application Matrix by combining HVAC market data by subsector with estimates of energy use by space type, as well as expected savings for progressively more efficient bundles of measures for the applicable HVAC systems.

BACKGROUND

In 2010, BC Hydro developed a novel solution to the challenge of identifying promising lighting energy efficiency markets: the Lighting Application Matrix. The Lighting Matrix uses the capabilities of a spreadsheet to combine two different types of information—lighting technology energy savings and data on lighting energy use by market segment and building space type—to yield data-driven estimates of the combinations of lighting measures and specific markets that will generate substantial energy savings over the next few years. Although less rigorous than a full-fledged market potential study, the Lighting Application Matrix offers the advantages of being easy-to-use, low-cost, up-to-date, and market-specific. BC Hydro is currently applying Lighting Matrix findings to design its upcoming lighting programs and marketing efforts.

Based on the success of the Lighting Application Matrix, SCE joined with BC Hydro and Bonneville Power Administration (BPA) to create a similar tool for the commercial retrofit HVAC market.

OBJECTIVES

SCE joined the HVAC Application Matrix project team to address several key objectives. Foremost, SCE sought to develop a simple and powerful method to map the HVAC energy efficiency opportunity for commercial buildings and to target high impact HVAC measures. A second objective was to demonstrate that the methods used to develop BC Hydro's Lighting Application Matrix could be adapted to identify opportunities for other technologies and markets. SCE expected that combining its knowledge, experience, and ideas with those of its project partners and outside experts and reviewers would lead to a robust and valuable tool and allow EE program managers and ETP staff to focus their resources on developing new measures and programs.

REPORT CONTENTS

This report presents an overview of the development of the HVAC Application Matrix project, the methodology and data used to create the Matrix, and the resulting structure. It also presents example results for SCE, and concludes with recommendations for future development and use of the HVAC Application Matrix and its concept in general.

METHODOLOGY

To create the HVAC Application Matrix, SCE and its partners worked in a collaborative fashion, holding several daylong workshops and web-enabled virtual meetings to develop and refine the tool. **Error! Reference source not found.** and the sections below summarize the Matrix development process.

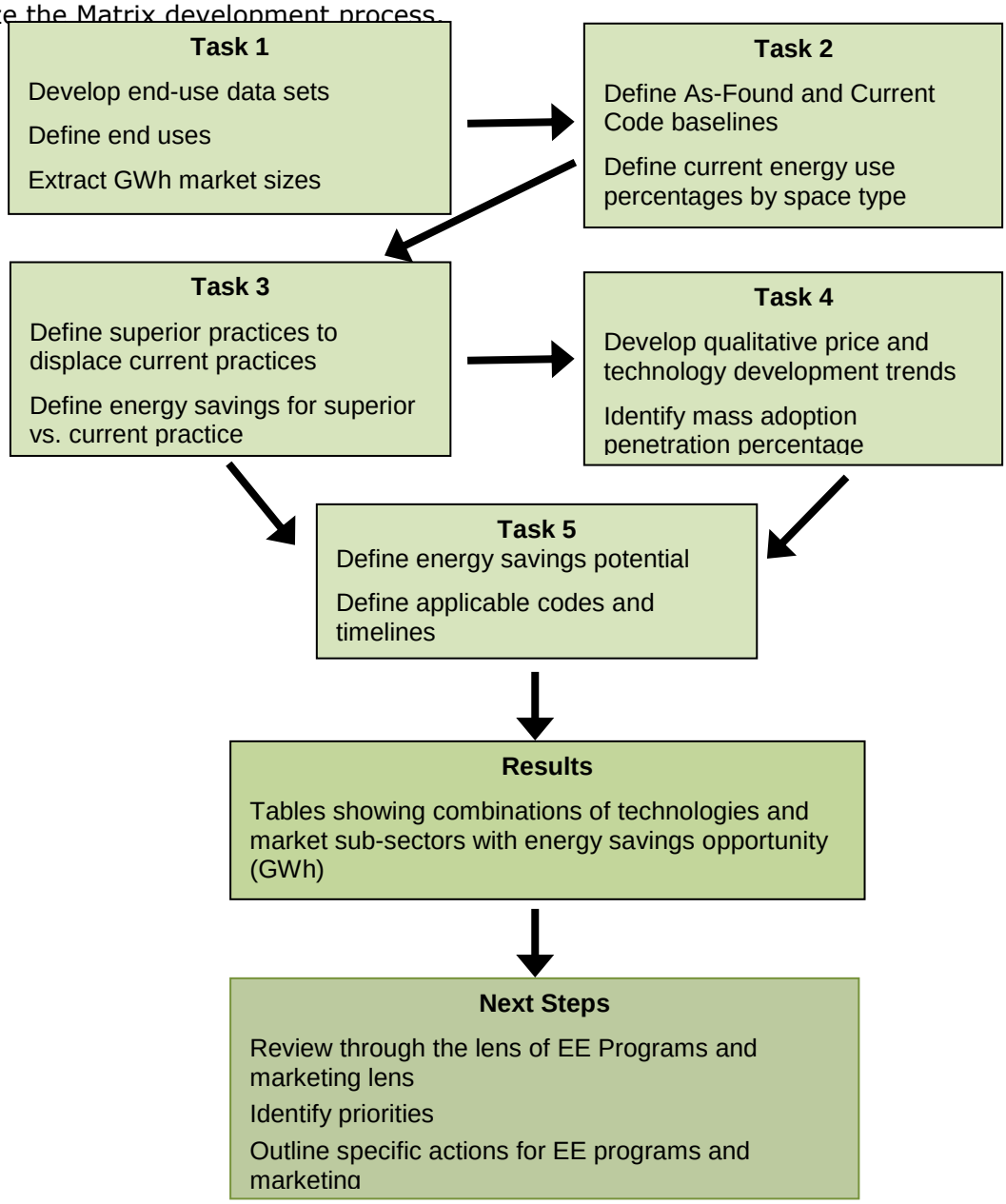

FIGURE 1. HVAC APPLICATION MATRIX DEVELOPMENT

DATA COLLECTION

The HVAC Matrix development team used standard, large-scale energy end-use studies for each utility as sources for annual HVAC electricity use by market sub-sector:

- The CEUS served as the principal data source for SCE's service area.
- The base year consumption data in the BC Hydro 2007 Conservation Potential Review served as the principal source for the BC Hydro service area.
- Sixth Northwest Conservation and Electric Power Plan and the 2009 Northwest Commercial Building Stock Assessment served as principal data sources for the BPA service area.

DEVELOPMENT OF ASSUMPTIONS

To develop and agree on key assumptions, the HVAC Application Matrix project team convened a group of utility HVAC engineers, EE program managers, and C&S experts. Outside experts from the Northwest Power and Conservation Council, Western Cooling Efficiency Center, and PECI were also consulted. This group developed criteria and determined characteristics of HVAC systems, applications and measures based on review and discussion of their expert opinions and perspectives on trends in technology and market activity.

Based on these discussions, the project team decided to focus exclusively on the commercial retrofit market, given its size relative to the commercial new construction market and the residential market in general. However, the Matrix design can allow future addition of commercial new construction and residential options.

Estimates of electricity use by space type were developed in consultation with HVAC engineers familiar with the current building stock, the factors that determine appropriate HVAC system types for a specific application, and their expected energy performance of these systems. Consultations with the same engineers and EE program experts familiar with the energy-savings impacts of equipment retrofits yielded estimates of the potential electricity savings of measure bundles. These savings are relative to the *As Found* and *Current Code* baselines, concepts that will be discussed below.

MATRIX ARCHITECTURE

The HVAC Application Matrix is an Excel workbook made up of tabbed worksheets addressing the following successive steps in the mash-up[1] process: data collection, assumption development, analysis, and graphical display of results. The sections below describe these worksheets and their contents. To aid in comprehension, Table 1provides definitions of terms and Table 2 shows the different levels of energy efficiency considered in this study.

TABLE 1. DEFINITION OF TERMS

TERM	DEFINITION	EXAMPLE
Terms describing buildings and building spaces		
Base Sub-Sector	A building type categorized by occupancy or purpose	• Large Office Building • Hospital
Combined Sub-Sector	A higher level set of building types, merging two or more Base Sub-Sectors where necessary for consistency among utilities	
Space Type	An occupancy or function within a particular building or building type	• Cubicles, Private Offices, and Meeting Rooms • Retail Sale Area
Space Type Ratio Assumption	The estimated percent of total Combined Sub-Sector square footage for each Space Type within that Sub-Sector. Space Type Ratio Assumptions usually sum to 100 percent for each Combined Sub-Sector.	
Terms describing HVAC equipment		
HVAC System	HVAC equipment categories with shared design elements.	Central System: centralized equipment that uses water or steam to deliver heated or cooled air throughout a building.
HVAC Sub-system	The components of an HVAC system	• Pumps • Compressors • Fans • Controls • etc.
Terms describing energy-efficient technologies and practices		
Measure	A replacement technology, improved practice, or combination of both that is expected to increase energy efficiency in one or more HVAC sub-systems.	• Evaporative cooling • Targeted cooling
Measure Bundle	Groups of measures that apply to one or more sub-system components and that work together to optimize system efficiency performance	For a packaged unit: • VFD • multi-speed or digital scroll compressor • electronically commutated motor

[1] "Mash up," a term from web application development, means using and combining data, presentation or functionality from two or more sources to create a new service. The main characteristics of a mash-up are combination, visualization, and aggregation.

TABLE 2. LEVELS OF ENERGY EFFICIENCY

TERM	DEFINITION
Terms used with HVAC systems, sub-systems, and components	
As found	Consistent with standard practice typical at the time of installation of average equipment found in service.
Current code	Consistent with current state, provincial, national, and/or international energy codes.
Terms used with energy efficiency measures	
Enhanced retrofit	Consistent with current practice for retrofit-only system EE upgrades. Implementation of this bundle of measures may produce 10–15% savings.
Best practice	Consistent with best available equipment and system installation practices for deep energy reductions. Implementation of this bundle of measures may produce 15–50% savings. This bundle addresses best practices for new construction and gut/rebuild projects, as well as retrofits.
Advanced technologies	Consistent with emerging technologies and practices that typically represent no more than 2% of the current market and are expected to become standard practice in 10+ years, with new construction and gut/rebuild as the early adoption opportunities.

MARKET DATA WORKSHEETS

The Matrix includes two types of Market Data Worksheets:

- Utility-specific worksheets: Three identically formatted worksheets present detailed estimates of annual electricity use for HVAC systems in SCE's service territory, and in those of each of the partner utilities. These worksheets combine electricity use for the three primary functions of HVAC equipment—space cooling, space heating, and fans and pumps, and display annual estimates for each sub-sector and space type (Table 3).
- Summary worksheet: A Market Data Summary Worksheet compiles data from the three utility-specific worksheets to show total annual energy use by space type for each utility (Table 4).

TABLE 3. EXCERPT FROM SCE MARKET DATA WORKSHEET: ANNUAL ENERGY USE BY SPACE TYPE

Combined Sub-Sector	Combined Total	Space Type	Space type Ratio Assumptions (Expert Opinion only)	Annual GWh Market Size
Large Office Buildings	542.0	Cubicles, Private Offices, and Meeting Rooms	90%	487.79
		Data Closet / Server Room	10%	54.20
Medium Office Buildings	1100.4	Cubicles, Private Offices, and Meeting Rooms	95%	1045.39
		Data Closet / Server Room	5%	55.02

TABLE 4. EXCERPT FROM THE MARKET DATA SUMMARY WORKSHEET: ANNUAL ENERGY USE BY SUB-SECTOR AND HVAC SYSTEM TYPE

Estimated Sub-Sector Space Type GWh/yr				
Combined Sub-Sector	**Space Type**	**BC Hydro Annual GWh Market Size**	**BPA Annual GWh Market Size**	**SCE Annual GWh Market Size**
Large Office Buildings	Cubicles, Private Offices, and Meeting Rooms	400.59	1575.00	487.79
	Data Closet / Server Room	44.51	175.00	54.20
Medium Office Buildings	Cubicles, Private Offices, and Meeting Rooms	123.31	826.50	1045.39
	Data Closet / Server Room	6.49	43.50	55.02

SYSTEM WORKSHEETS

Seven identically formatted System Worksheets detail the baseline and superior practice conditions for each of the system types used in the Matrix (Table 5). System Worksheets also display the assumptions for efficiency improvements for measures bundles relative to *As Found* and *Current Code* baselines, as well as graphical representations of projected technology development and cost trends.

TABLE 5. SYSTEM TYPES IN THE HVAC APPLICATION MATRIX

Name	Description	Capacity	Common Application
Package Terminal Air Conditioning/Package Terminal Heat Pump	Unitary ductless air-cooled units	Up to 2 tons or 24,000 Btu/hr	Hotels/motels
Split System	Air handling units with a direct expansion (DX) cooling coil served by a separate air-cooled condensing unit and ducted air distribution	1–50 ton	Small-to-medium commercial occupancies, typically single story
Packaged Unit	Air conditioning or heat pump units with an integral DX cooling system and electric or gas-fired heating units; most are air-cooled and use ducted air distribution. Includes rooftop units (RTUs).	1.5–100 ton	Low-rise commercial occupancies
Electric Heating Only	Heat source assumed to be electric baseboards, cadet heaters, unit heater, furnace, cable ceiling heat, or any radiant heat; no mechanical cooling	N/A	Small commercial occupancies with no AC load and where natural gas is not supplied for space heating

Exhaust Only	Dedicated, high cubic feet per minute (CFM) ventilation and possibly gas heating with an air handling unit	N/A	Kitchen ventilation hoods and laboratory fume hoods
Name	**Description**	**Capacity**	**Common Application**
Central System	Water-cooled units that provide cooling only and use chilled water in conjunction with steam or hot water from boilers for thermal distribution; air handling units and fan coil units provide air distribution	100 to several thousand tons	High-rise commercial occupancies, hospitals, universities and other campus-type settings
Computer Room Air Conditioner (CRAC)	Generally air- or water-cooled units designed for high reliability and minimal downtime; generally use ductless air distribution	8–30 ton	Server rooms of 1,000 ft^2 and up

RESULTS WORKSHEETS

Two identically formatted Results Worksheets present the Matrix analysis results. The *As Found* Results Worksheet calculates the technical potential for *Current Code* and *Enhanced Retrofit* measure bundles relative to the *As Found* baseline. Technical potential is displayed by sub-sector and space type for each utility's service area. Expected price and technology development trends are represented graphically, as are key dates for and potential impacts of planned future changes in building codes and regulations. The Current Code Results Worksheet provides the same information for *Enhanced Retrofit* and *Best Practice* measure bundles relative to the higher-efficiency *Current Code* baseline.

The Results Worksheets represent the culmination of the Matrix analysis, providing users with a synthesis of business type, measure options, technical potential, market trends, and expected changes in baseline conditions over time for each utility service area.

These synthesis views enable SCE and the other partner utilities to identify the most promising measure-market combinations and to guide selection of the appropriate interventions in their markets. The Results Worksheets also allow SCE to identify and better understand markets that may be transforming, a situation likely to become more common within the next few years.

RESULTS

The HVAC Application Matrix uses the pivot table and pivot chart functions of Microsoft Excel for data mining, additional synthesis, graphical representation, and prioritization of findings. As an example of the results possible, Figure 2 displays estimates for SCE's service territory of the technical potential for *Enhanced Retrofit* measure bundles relative to the *As Found* baseline. Based on these results, SCE stands to benefit from programs to replace packaged units in multiple sub-sectors, notably restaurants, retail outlets, and other small commercial facilities.

Note that this is only one example of the results from the HVAC Application Matrix, intended to highlight the type of analysis and findings that are possible using this tool.

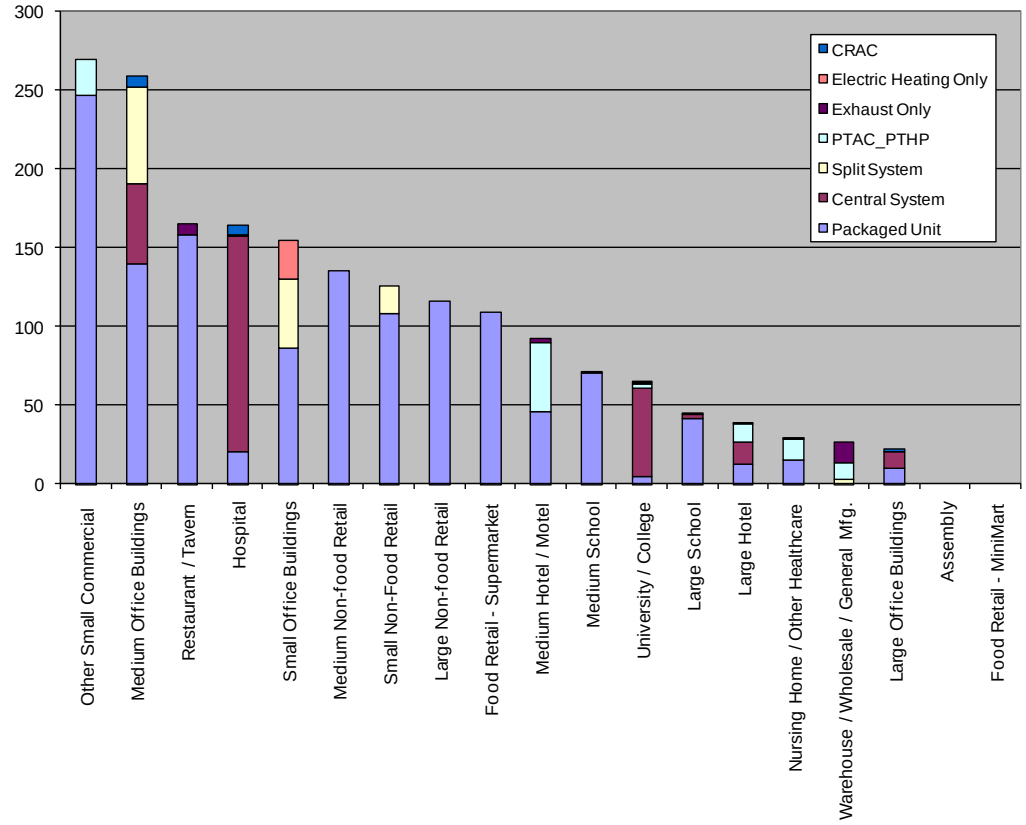

FIGURE 2. ENERGY SAVINGS TECHNICAL POTENTIAL IN SCE'S SERVICE TERRITORY BY RETROFITTING CURRENT HVAC SYSTEMS WITH MEASURES AT THE ENHANCED RETROFIT EFFICIENCY LEVEL

CONCLUSIONS

The HVAC Application Matrix is a rapid and cost-effective tool that can help SCE target opportunities with the greatest potential. As such, it provides justification for moving ahead with the most promising measures and programs quickly.

In addition, the pivot capabilities provide a systematic, easy-to-use, and rapid process for exploring the matrix data sets and developing *what if* scenarios for program planning and targeting.

RECOMMENDATIONS

SCE's EE and EE marketing teams could benefit from using the HVAC Application Matrix to explore different possibilities and develop relevant *what if* scenarios. They could then review results, bringing their experience and expertise to bear, to identify priorities and action plans for proceeding, as appropriate.

SCE could also join with the other utility partners in efforts to augment the value of the matrix approach to address the needs of a wide range of decision makers within a utility. Should this prove valuable in the design of EE HVAC programs, the matrix concept could be expanded to other EE technology and market opportunities.

In addition, several steps could be taken to enhance the accuracy, value, and application of the Matrix:

- Review, refine, and augment assumptions
- Work with C&S experts to provide more specifics around the timing and levels of future codes and standards requirements
- Develop Matrix capabilities for automatic pivot table and chart generation to allow for more flexible queries and better display of results
- Add a data entry form to facilitate inclusion of emerging technologies
- Add macros to automate the Matrix

SCE and its utility partners are also seeking additional collaborators to help validate the assumptions used and enhance the Matrix architecture and usability.

APPENDIX A – HVAC APPLICATION MATRIX

HVAC Application Matrix rev 12.7_SCE.

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