California Public Utilities Commission

February 6, 2014

Ex Ante Review Fact Sheet #3

HVAC Equipment Savings Estimates Assumptions

This fact sheet describes the high-level assumptions for HVAC savings estimates currently in the Database for Energy Efficient Resources (DEER) or non-DEER workpapers. In addition to providing an overview of HVAC assumptions, this Fact Sheet identifies under- and over-estimated assumptions.

Residential Quality Installation Workpapers:

Residential Quality Installation (RQI) savings are covered in workpapers submitted by SCE and SDG&E at the beginning of the 2013-2014 program cycle. Commission staff did not review these workpapers due to historically low participation in these programs. As specified in D.12-05-015, un-reviewed workpapers receive interim approval and may be used as the basis of claims. If Commission staff chooses to review the workpaper, any revisions are effective prospectively and accomplishments prior to a review receive the interim approved values. The purpose of Residential Quality Installation is to achieve efficiency improvements during the installation of new or replacement residential HVAC systems by using industry best practices to install efficient HVAC equipment. The RQI workpapers assume the following improvements for calculating savings:

- Systems will be downsized by 20%,
- Duct leakage will be reduced by 50%,
- Airflow will be increased by 12.5%,
- And Fan power will be reduced by 25%.

Commercial Quality Maintenance Workpapers:

Commercial Quality Maintenance (CQM) savings are claimed as single values based on an expected occurrence of the following commonly indicated remedies to package rooftop HVAC units:

- Refrigerant charge adjustment
- Refrigerant system improvements due to non-refrigerant charge related remedies
- Condenser coil cleaning

- Evaporator coil cleaning
- Supply air flow adjustment
- Programmable thermostat installation
- Programmable thermostat reprogramming
- Economizer reprogramming
- Economizer repair

CQM workpapers were reviewed by Commission staff at the beginning of the 2013-2014 program cycle. Below is a summary of the assumptions applied to develop the final approved ex ante values:

Refrigerant Charge Adjustment: DEER values are used.

Refrigerant System Improvements Due to Non-Refrigerant Charge Related Remedies: Staff assumed the benefit of non-charge related services to be equal to 25% of refrigerant charge adjustment savings, with the breakdown by remedy listed below:

- Condenser Coil Cleaning: 12.5%
- Evaporator Coil Cleaning: 6.25%
- Supply Air Flow Adjustment: 6.25%

Programmable Thermostat Installation: Savings are determined through a series of energy models of different control scenarios compared to an uncontrolled baseline. Staff has determined that uncontrolled HVAC systems are rare and adjusted the baseline and reduced savings accordingly.

Thermostat Reprogramming: Savings are determined similar to programmable thermostat installation with additional control scenarios in the baseline. Staff accepted the calculation methods in the workpaper, but determined that reprogramming thermostats may result in changing fan control from intermittent to continuous operation and, therefore, reduced savings accordingly.

Economizer Reprogramming: Savings were developed through modeling changes to control point settings that would expand the use of outside air for cooling. Staff accepted the calculation methods in the workpaper.

Economizer Repair: Savings were developed in a manner similar to economizer reprogramming. Staff accepted the calculation methods included in the workpaper, but was concerned about the possibility of repairing economizers in a way that would increase outside air supply throughout the year and therefore increase in energy use. Staff reduced the savings for economizer repair measures to consider this possibility.

Expected Occurrence of Treatments: The workpapers proposed single savings values for each quality maintenance "visit" or "occurrence" by using the savings of each individual treatment described above weighted together by the expected occurrence of each treatment during a visit. Staff reviewed historical program and evaluation data and concluded that some of the proposed values for expected occurrence were too high and therefore reduced some of these values.

HVAC Related Savings in the Energy Upgrade California (EUC) Workpapers

Energy Upgrade California, Home Upgrade Program: Savings for individual HVAC measures in the Energy Upgrade CA Basic Path Program use DEER methods. The approved workpaper includes a methodology to reduce these savings when multiple measures are combined in a single retrofit. For example, if an HVAC system replacement is combined with a ceiling insulation measure, the combined actual savings of those two measures would be less than the sum of the savings for the individual measures listed in the DEER. The reduction occurs because the upgraded insulation measure reduces overall heat loss of the home and reduces the savings from the HVAC equipment. This methodology assumes that each project will achieve about a ten percent reduction in pre retrofit energy use using DEER. Basic Path projects included attic insulation, whole house air sealing, duct sealing or replacement, low flow shower heads and domestic hot water pipe wrap.

Energy Upgrade California, Advance Path: The Advanced Path uses EnergyPro energy modeling software to determine the reduction in energy use by a whole house retrofit. Staff analysis showed that this software greatly over-predicted program eligible end uses (space heating/cooling and water heating). The over-prediction is not due to any fundamental problems with the modeling software. Rather, the assumptions built into the EnergyPro models about pre retrofit energy consumption of key end uses were not consistent with DEER assumptions and generally predicted far more energy use than indicated by the latest Residential Appliance Saturation Survey (RASS). The RASS yields energy consumption estimates for residential end-uses and application saturations based on household surveys. EnergyPro can generally be expected to provide reasonable results if the input assumptions are revised (such as thermostat set-points, occupancy hours and HVAC faults). Staff analysis showed that electricity consumption was overestimated by a factor of four for air conditioned homes. Gas use was over-predicted by more than 50%. Final staff direction required electricity consumption savings to be reduced by 60% (instead of the 75% indicated by the staff analysis) and gas savings to be reduced by 20% (instead of the 37% indicated by the staff analysis).

In general, staff encourages the modeling approach used for the Advanced Path program, but recommends aligning the modeling assumptions with those used in DEER or developing an alternative strategy for aligning simulated energy use with current estimates.

High Seasonal Energy Efficiency Ratio (SEER) HVAC Equipment DEER Values:

There are numerous assumptions that are part of the DEER energy modeling process for estimating energy savings of HVAC measures. The Seasonal Energy Efficiency Ratio (SEER) rates the efficiency of air conditioners and heat pumps and is the cooling output during a typical cooling-season divided by the total electric energy input during the same period. The Energy Efficiency Ratio (EER) rates the efficiency of air conditioners and heat pumps and is the cooling output divided by the total electric energy input. Generally, these can be divided into two categories:

1. Generic Assumptions that are applicable to all energy efficiency measures including lighting, building envelope, and HVAC measures
2. HVAC Specific Assumptions that are applicable only to the certain HVAC measures

Generic Assumptions:

Residential Calibration: Prototypical residential models are calibrated to heating and cooling energy use values developed as part of the RASS. The calibration process uses different thermostat schedules and building shading configurations. The results are then weighted together to match, as closely as possible, the RASS results by building type (single family vs. multi-family), California Title 24 climate zone, and building vintage. The calibration process and results are more fully described in the DEER documentation.

Once the calibration is complete, the assumptions for thermostat schedules, shading characteristics, and individual run weights are used to model energy savings for every measure. For example, if savings for a high SEER HVAC measure are modeled, then the baseline and high SEER technology are simulated multiple times using the sets of calibration assumptions. The results are weighted together using the calibrated weights. The savings are then calculated as the difference in the weighted baseline and measure results.

Prototypical Building Properties: "Prototypical" assumptions about physical building properties and occupant behavior are maintained for every measure simulation except for a limited group of measures listed in the HVAC specific assumptions below. Properties that are considered prototypical and maintained for all measure simulations include:

- Building configuration such as floor area, zone configuration and space use
- Fenestration area and performance
- Opaque surface construction and insulation levels (except for building insulation measures)
- Occupant behavior patterns including occupancy, equipment and lighting usage profiles
- Installed lighting power (except for lighting efficiency measures)

- HVAC system operations and controls
- HVAC system performance (except for high efficiency HVAC measures)

HVAC Specific Assumptions:

Package HVAC "Performance Maps": Small package air-conditioning equipment[1] energy use is estimated using an equipment "performance map" developed to represent a typical power input to cooling output relationship for a specific SEER level. The DEER team developed these performance maps based on the best available extended performance data published by major manufacturers. The performance maps include point values at standard rating conditions and performance curves for the various conditions typically seen in residential and commercial cooling applications. Typical applications see variable indoor and outdoor temperatures, variations in internal gains, as well as variations in thermostat set. The complete set of SEER and EER performance maps are included with the DEER documentation.

The prototypical performance maps for SEER rated HVAC systems are vintage specific as described below:

	Vintage	**SEER Rating**
Residential	Prior to 2006	10
	2006 and after	13
Commercial	Prior to 1978	8.5
	1978 to 1992	9.5
	2993 to 2005	10
	2006 and after	13

Residential HVAC Measures: There are nine individual high SEER measures included in DEER. Eight of those are for air cooled units ranging from SEER 14 through SEER 21. The measures for units with SEER 15 and greater assume two speed compressors. There is also a single measure for an evaporatively cooled split system with an SEER of 17.4. The baselines for these measures depend on the building vintage as listed above.

Commercial HVAC Measures: There is one high SEER measure for commercial buildings included in DEER for SEER 14. The baseline for this measure depends on the building vintage as listed above.

IOUs are offering incentives for higher SEER levels and used workpapers to develop savings for these measures. Workpapers provide estimated savings for commercial units based on the savings for similar residential units using the following process:

[1] SEER rated equipment and EER rated equipment with capacities less than 20 tons

1. Calculate the relative savings of residential SEER measure higher than 14 compared to the residential SEER 14 measure:
    a. ResSavings(SEERn=>SEER14) = ResSavings(SEER n) / ResSavings(SEER14)

2. Use the value from step 1 to calculate commercial savings:
    a. ComSavings(SEERn) = ComSavings(SEER14) * ResSavings(SEERn=>SEER14)

Workpapers for commercial high SEER measures have received interim approval from Commission staff. The current method for determining commercial high SEER equipment is highly simplified and based on the DEER results for residential HVAC equipment subject to residential load profiles and calibration. Additional analysis in modeling commercial equipment is needed to create savings specific to this sector.