**DMQC review of the IOU 2010-2012 Prescriptive Whole House Retrofit Program energy savings estimates work papers**
19 March 2010

The following review comments are based on a technical review of the simulation model input files plus detailed spreadsheet calculations provided by each of the IOU's in response to Energy Division's request for input and other files pertaining to work papers for the Prescriptive Whole House Retrofit Program (PWHRP), dated March 8, 2010.

FINDINGS AND COMMENTS
The technical review confirmed that the work papers were largely based on detailed hourly simulation modeling using eQUEST v3.63b (SCE/SCG) and EnergyPro v5.0.20 (PG&E/SDGE), with SCE/SCG supplementing their eQUEST simulations with calculations for DHW pipe loss savings using the 3E Plus v4.0 pipe insulation calculator from the North American Insulation Manufacturers Association.

A principal purpose of the PWHRP work papers is to substantiate the PWHRP Program's ability to achieve the program goals of providing a statewide average reduction of approximately 20% of total residential energy use in the participating residences. In summary, the work papers estimated that the PWHRP Program will achieve whole premise savings presented in the table below.

| IOU | Savings per Residence |
|---|---|
| PG&E | 23% |
| SDGE | 33% |
| SCE/SCG | 20%-40% |

A review of the files submitted in support of the PWHRP work papers identified several significant concerns that suggest <u>these estimated program savings are significantly over estimated, i.e., by a factor of two or more</u>. Principal concerns include the following:

1) The simulation models did not appear to have been calibrated to available RASS data to help assure their reliability in predicting percent decreases in total residence energy use attributed to the modeled package of measures. The result is that the predicted whole premise energy use for the simulated cases tended to significantly overestimate whole premise electric and gas use (e.g., by a factor of two or more). More importantly, the percentage breakdown of residential energy by end use estimated using the simulations differed significantly from the RASS breakdown of end use energy. Table 1 below compares the percentage breakdown of electric and gas use in residences between RASS results and the residential simulations used for the PWHRP work papers. In summary, the simulations overestimated the role of HVAC energy by a factor of two to four (space cooling electric was more over overestimated than space heating gas) and underestimated the role of appliances by a factor of approximately two and the role of indoor lighting by a factor of 1.5 to two. Since the simulated package of measures focused primarily on HVAC benefits (i.e., duct sealing, infiltration reduction, and attic insulation), the result is that the

percentage benefits estimated for the PWHRP program are significantly over estimated.

Table 1: Percentage Breakdown by End Use and IOU
Residential Electric and Gas Use

| End Use | PG&E RASS | PG&E Modeled | SDGE RASS | SDGE Modeled | SCE/SCG RASS | SCE/SCG Modeled |
|---|---|---|---|---|---|---|
| ***Electric Use*** | | | | | | |
| Heat | 3% | 0% | 3% | 0% | 2% | 0% |
| Cool | 8% | 42% | 9% | 43% | 14% | 35% |
| InLight | 19% | 9% | 19% | 10% | 19% | 31% |
| OutLight | 2% | 2% | 2% | 2% | 2% | 0% |
| Recep | 56% | 28% | 55% | 30% | 51% | 31% |
| Fans | 2% | 19% | 1% | 14% | 1% | 2% |
| Pumps | 4% | 0% | 5% | 0% | 5% | 0% |
| Process | 2% | 0% | 4% | 0% | 4% | 0% |
| DHW | 4% | 0% | 2% | 0% | 2% | 0% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% |
| ***Natural Gas Use*** | | | | | | |
| Heat | 46% | 80% | 36% | 65% | 38% | *n/a** |
| Process | 13% | 0% | 15% | 0% | 16% | *n/a** |
| DHW | 40% | 20% | 49% | 35% | 46% | *n/a** |
| Total | 100% | 100% | 100% | 100% | 100% | *n/a** |

* *the SCE/SCG analysis of domestic hot water pipe insulation was based on a separate calculator tool (3E Plus) and yielded only savings estimates associated with a limited length of treated pipe rather than a domestic hot water UEC.*

2) The PG&E and SDGE results for the proposed package of prescriptive measures were reported only on an aggregate basis rather than on a per measure basis. Reporting only the aggregate package of measures obscured a serious problem with the modeling procedure used in the PG&E and SDGE analysis where 100% of the total estimated savings actually resulted from only the attic insulation upgrade, i.e., although the others measures in the PWHRP package were included in the simulation models (e.g., HVAC duct sealing, infiltration reduction, and DHW pipe and tank insulation additions), the simulation results for these other measures showed no impact. Note also, that the baseline assumption for the attic insulation measure was unrealistically low (e.g., no attic insulation), as described in item 4 below.

3) While simulations were conducted for multiple climate zones to account for the diversity in climate effects, there was little or no attempt to capture diversity among other key assumptions such as residence type and vintage, thermostat setpoints, HVAC equipment scheduling, and use of natural ventilation (i.e., operable windows). Specifically, all of the simulation estimates were based on pre-1978 detached single family residences although the PWHRP PIP did not specifically limit the target market to pre-1978 residences. Thermostat and HVAC unit operations schedules assumed 24/7 operations at constant temperature setpoints and only the SCE/SCG models assumed the use of natural ventilation.

4) Several key assumptions used in defining the baseline or measure conditions are unrealistic. This might be due to misunderstanding certain DEER measure assumptions, or misapplying DEER assumptions in the simulation models. Examples include the following:

    a. The baseline runs for all simulations assumed no attic insulation, an assumption that is inconsistent with RASS data for even the oldest vintages of single-family residences where 60% to 85% of single family residences older than 1978 indicated having attic insulation while only 10% to 35% indicated 'no' attic insulation (or 'I don't know'... a response option that was unfortunately omitted from the survey instrument for this question). RASS results suggest a more appropriate value for attic insulation for this vintage might be in the range of R-11 to R-19.

    b. Duct leakage was assumed to be very high, e.g., 40% supply air leakage entirely to the attic. DEER assumptions[1] specify 40% <u>total</u> duct air leakage (supply + return), 75% of which is assumed to leak into the attic. The balance is assumed to leak into conditioned spaces. Ten percent of the lost air is assumed to be made up via outside air (i.e., 10% is made up via increased infiltration) and 90% is made up via leakage from the attic into the return duct, if any, or directly into the conditioned space (e.g., via leakage through recessed down lights). See the 2004-2005 DEER Update Study for more details[1].

    c. The amount of DHW pipe being insulated in the DHW pipe insulation measure was assumed to be very high in the PG&E /SDGE analysis, i.e., 'all DHW piping' rather than a much shorter length such as the exposed DHW pipe running from the hot water tank to the nearest wall or ceiling surface (e.g., five feet). The choice to insulate 'all DHW piping' seemed due at least in part to limited model input options in EnergyPro. All DHW pipe insulation analyses appear to have also assumed a constant hot water temperature with all pipe loss assumed to result in additional water heater energy consumption. While this assumption is largely appropriate for hot water heater jacket loss (i.e., a tank wrap insulation measure), it is not appropriate for a measure that seeks to add insulation to uninsulated domestic hot water piping. Rather, the temperature of the water in the treated length of DHW pipe will vary hourly due to varying hot water draws with intervening cool down periods. While heat loss from the piping immediately adjacent to the hot water tank will contribute modestly to tank heat loss (via pipe conduction and water convection) and thus to increased water heater energy use, only a portion of the DHW pipe heat loss will result in actual increased hot water use. A significant portion of this thermal loss will result from the cool down period between intermittent hot water draws but actual increased hot water use will ocurr only for those DHW end uses that mix to a specific delivery temperature (e.g., showers and hand washing). For other end uses that do not mix hot and cold water (e.g., many automatic dish washers) or that mix hot and cold water

[1] 2004-2005 DEER Update Study – Final Report, Itron, December 2005, pg 8.18

based on a fixed ratio (e.g., the 'warm' cycle for automatic clothes washers), hot water pipe loss will not result in increased hot water use and therefore will not contribute to increased hot water energy use.

d. Infiltration control was applied only to the attic space in all IOU cases. No infiltration was modeled in the conditioned portions of the residences, either for the baseline or measure cases.

RECOMMENDATIONS

Recommendations include the following.

1) All baseline simulations should be calibrated both on a whole premise and end use basis to align at least approximately with the RASS whole premise and end use UECs. Priority should be given to calibrating to the air conditioning UEC's[2 3].

2) Despite appropriate inputs provided in the EnergyPro model by the contractor to model the various measures, EnergyPro failed to yield any impacts for three of the four measures in the PWHRP package (i.e., infiltration reduction, duct sealing and DHW piping insulation). The simulation model used by PG&E and SDGE (EnergyPro) should be thoroughly assessed to assure its ability to successfully simulate the measures included for the PWHRP package.

3) The impacts of the measures should be reported on a measure-by-measure basis rather than only as an aggregate package of measures and the measures should be run in a 'cascaded' sequence (i.e., run on top of the previous case rather than on top of the baseline case only). Reporting measure impacts on a measure-by-measure basis will help both the IOU and CPUC analysts better assess the adequacy of the simulation tools employed and assess the performance of the constituent parts of the prescriptive package of measures.

4) Critical sources of diversity among model assumptions other than climate zones should be included in the analysis, e.g., differing thermostat schedules, HVAC operating hours, residence type (one-story and two-story) and vintage. This can be accomplished either via single prototypes defined using averaged or aggregated input assumptions (e.g., averaged SEER, size, or operating conditions) or via multiple separate simulation runs weighted up to an aggregate affect (e.g., separate climate zones as was done, separate thermostat profiles[4], separate HVAC system types such as heat pumps versus gas furnaces, etc.) to help better align simulation results with RASS and DEER results.

5) The simulation model input assumptions used for the baseline and measure cases should be re-considered by careful review of RASS and DEER sources., especially

[2] California Statewide Residential Appliance Saturation Study Update to Air-Conditioning Unit energy Consumption Estimates Using 2004 Billing Data, CEC-400-2006-009, Kema-Xenergy, June 2006.

[3] 2008 DEER Update - Summary of Measure Energy Analysis Revisions, Version 2008.2.05 for 2009-2011 Planning/Reporting, JJH and Associates, December 2008, pgs 7-12.

[4] 2008 DEER Update - Summary of Measure Energy Analysis Revisions, Version 2008.2.05 for 2009-2011 Planning/Reporting, JJH and Associates, December 2008, pgs 6-7.

baseline attic insulation (see item 4a above), baseline lighting and appliance energy use, and baseline and measure duct air loss (see item 4b above) and infiltration. Analysis of domestic hot water measures should consider including the findings and the example calculation procedures included in the PIER Study, *Hot Water Distribution System, Research – Phase I*, November 2005, CEC-500-2005-161 (addresses the intermittent nature of DHW draws and the cool down period between draws).

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