POTENTIAL PIER R&D INITIATIVES IN HOME ENERGY UPGRADING
for CEC Workshop on Building R&D Opportunities

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The following retrofit program-related R&D recommendations:

A. Program Cost-Effectiveness

- **Determine home sales value effects of substantial energy improvements**. This could be a major addition to quantifiable benefits for use in home retrofit program justification as well as marketing. Potential home selling price increases could be one of the biggest and most easily understood non-energy benefits, but there is no statistical data on which to base the case for including it. Requires identifying retrofitted homes that have sold recently and doing comparisons with selling prices for similar nearby homes, also interviews with some sellers and buyers. Possible game-changer.
- **Identify, characterize, dimension and monetize (other) non-energy benefits.** The Total Resource Cost (TRC) cost-effectiveness test used to assure the value of energy efficiency programs improperly values both benefits and costs, particularly for some innovative programs that provide more benefits than just energy savings and are needed to reach AB 32 goals. This topic includes a broad range of both homeowner and community/societal benefits and costs. Such a study is urgently needed now, before the TRC test can be assessed effectively and an improved approach made ready in time for the 2015-18 energy efficiency program cycle. This effort should make use of social science measurement techniques designed specifically for dimensioning and monetizing such effects, and should demonstrate the impacts of the addition of such non-energy benefits on current California cost-effectiveness metrics as well as potential refinements of those metrics to encompass all benefits.

B. Program Design Improvements

- **Test and improve accuracy of EnergyPro simulation modeling to forecast energy savings.** Use accumulated program and billing data to compare with model forecasts. This would allow more informed judgment of the adequacy of modeling and improve or replace energy audit and forecasting procedures for contractors and program monitors. It could also identify specific deficiencies and opportunities for accuracy improvement as well as ease of use. The model appears to substantially overstate energy savings, which leads to liability risks as well as large post-program reductions in reported energy savings. Many deficiencies contributing to inaccurate results have been identified, as well as user difficulties. This software project would encompass both easier near-term corrections needed now as well as broader improvements for longer-term application.
- **Assess and develop high-value use of smartmeter data**. As an alternative to simulation modeling, use of smartmeter usage data could allow detailed bill disaggregations and simplified in-home audits to streamline home energy savings forecasts as well as make them much more accurate. Millions of smartmeters are installed, and such uses of the resulting fine-grain data could permit major cost and effort reductions as well as more accurate savings forecasts.
- **Roadmap retrofit program scope expansion.** Current home retrofit programs consider only about half of the typical home energy use (HVAC and water heating), which greatly limits potential savings needed to meet AB 32 goals. This project would develop ways to include a broader range of energy uses for higher savings in allowable program designs, e.g., more on appliances, lighting, plug loads, controls, and behavioral change. It would address the structural limitations of CPUC requirements for reliable long-term savings via use of hard-wired long-term technologies, asset ratings only, etc. to

remove present institutional barriers to the inclusion of a broader range of home energy improvements in the EUC retrofit programs.

- **Project financing options study.** Despite high utility and ARRA rebates, the high cost of whole-house energy upgrades remains a major problem in market penetration. By some estimates, the state's homes may require an expenditure of $150 billion or more by 2020 if the AB32 goals are to be met. Little of that can be provided from utility funding. New financing models and instruments must be developed to meet financial resource and availability needs of very large scale retrofit programs, emphasizing engagement of large-scale private capital in ways profitable to investors but also affordable and low-risk to consumers.
- **Behavioral modification and take-back effects study.** Pre/post utility bills versus predicted energy savings suggests the existence of adaptive behavior that increases energy use after a home retrofit. A better understanding is needed of the nature and level of post-retrofit behavioral changes, e.g., reduction of savings due to more wasteful behavior re thermostat settings, lighting use, and other regressive behavior. In addition, testing is needed of new ways to influence energy conservation behavior, e.g., in-home monitors, email refreshers, rewards for utility bill reductions. This study would take advantage of national interest and effort in this topic and fill key gaps in knowledge, most importantly on the take-back issue where little has been done.
- **Feasibility study of integrated presentation of energy-saving options.** At present, Energy Upgrade California focuses only on the most costly energy-saving option for homeowners—a broad whole-house energy retrofit. A possibly more effective delivery strategy would present a broad range of options, from no-cost behavior changes and single-measure improvements to full retrofits. This study is an investigation of the potential for development and effective use of more integrated marketing and deployment of the broad range of energy-saving options for consumers, from no-cost conservation behaviors and aids to low-cost/limited-effect measures to more comprehensive and costly retrofits, all under a single marketing umbrella including web, media, and other means of public information and contractor engagement.
- **Technical protocol standardization.** Different retrofit program implementers and sponsors in California now develop and enforce their own technical testing and installation protocols, which can differ substantially. This project involves updating and expanding on a prior (2005) PIER protocols development project to permit standardizing technical testing and installation standards statewide It would include engagement with local programs, contractors, technical researchers, and related efforts nationally that have not been recognized in California.

C. Technology Improvements and Innovations

- **Accelerate the practical application of key technology innovations.** Confirm performance of specific energy technology innovations and accelerate their commercial availability and approval for use in utility energy efficiency/IDSM program measure listings, contractor education, and ongoing support: Examples include in-home energy monitors, intelligent home energy controllers, mini-split heat pumps, LEDs, lighting and plug load controllers, smart appliances, low-cost usage recording sensors, malfunction alerters, rigid exterior wall insulation systems, electrochromic windows, etc., for both near and longer-term.
- **Develop new technology specifically for use in deep energy savings programs.** This is a particular deficiency in home energy retrofit approaches, where much of the energy use is not adequately addressed with confidence. Examples include reducing cost and expanding variety of LED lighting, creating more convenient and effective ways to stem vampire and standby loads, magnetic refrigeration, new ways to condition spaces, distributed water heating, super-tight but safe envelope

improvement, exterior insulation, home-scale high-efficiency combined heat & power, and overall energy management controls in both new and existing homes.

- **Address plug load reduction control opportunities and technologies.** Plug loads, and especially electronic and vampire-loads, are becoming a major concern but there are no effective program responses due to lack of data on emerging solutions and their effectiveness. Field-test and verify the energy savings potential of best-available plug load reduction devices and strategies, and propose priorities for technology improvement and commercialization.
- **Home Charging Energy Effects of Electric Vehicles.** Forecast home utility bill effects, overall user cost reductions, and grid impacts of electric vehicle charging at home.
- **DC power distribution within buildings.** DC power distribution in commercial buildings and homes is a technology of great long-term potential but virtually no R&D effort. More and more buildings are going to have PV, which incurs losses through its DC-to-AC conversion for building uses...and then more energy is lost in the AC to DC (or different AC frequency) conversion that lots of devices require (computers, printers, TV, many other plug loads, fluorescent lighting, etc.). That latter conversion is done within current end-use devices but could be eliminated eventually if DC power were available. PIER should seed a public-private venture to do a proof-of concept demo and collect some real data as well as generate broader interest from potential private stakeholders and investors.

D. Institutional Process Needs

- **Identify removable implementation barriers in energy efficiency regulatory processes.** Current energy efficiency programs for introducing new technologies and practices into the market may require more flexible regulatory and implementation rules. For example, existing technologies can do most of what is needed to dramatically reduce energy use in compliance with AB32 and the state's Energy Efficiency Strategic Plan, but their effective deployment requires more flexible governing policy and administrative rules. We need more research to identify and characterize such barriers and to identify ways to minimize them through process refinements at every level…from legislation, implementing regulations, perceived legal obstacles, inflexible codes, difficult updating of conservative utility implementation rules, lack of understanding of what contractors need in program support, ineffective and misguided marketing, too short-term program horizons, lack of understanding of contractor and consumer motivational triggers and selling strategies (behavioral tendencies and potential counter-influences), and ineffective program designs and training regimes.
- **Develop and evaluate innovative energy efficiency program delivery models.** Current residential retrofit programs around the nation, and particularly in California, are overly complex, costly, and difficult for contractors and implementers to sell and deliver. We don't really know how well modeled savings track actual changes in energy consumption in a home or other building, how much consumer behavior influences such discrepancies, how that behavior might be changed sustainably, and what new models of energy efficiency program designs might do a better job with less cost. This requires completely new program designs with simpler operation and compliance as well as innovative contractor team organization and deployment approaches to permit much larger scale market adoption.
- **Collaboratively develop a state/national strategic roadmap for energy efficiency R&D.** This must include not just technology but also crucial "soft" issues such as behavioral change, cost-effectiveness metrics, societal benefits, etc. It is totally outside the ability of private industry, which focuses on individual item optimization. Likewise beyond the utility implementation programs, which always have limited budgets and too much to do in keeping the programs moving. PIER and other research groups constitute the needed providers. One possibility is to assemble several of the research organizations that are most active in EE, such as several of the national labs, FSEC, DOE-HQ,

ARPA-E, EPRI, etc., and develop a roadmap including cofunding and topic-allocation agreements to get some of these obstacles out of the way more expeditiously. Otherwise technology R&D is not going to be able to get the traction needed to overcome the challenges of climate, jobs, and trade that are going to become imperative.

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