1. BACKGROUND

1.1. Description

California's energy policy is based on the provision of clean, cost-effective energy services. The California Energy Action Plan (EAP)[1] , which defines the state's energy policies, says that the state's goal is to "Ensure that adequate, reliable, and reasonably-priced electrical power and natural gas supplies, including prudent reserves, are achieved and provided through policies, strategies, and actions that are cost-effective and environmentally sound for California's consumers and taxpayers."

The EAP also establishes a "loading order," which requires that the state first "optimize all strategies for increasing conservation and energy efficiency to minimize increases in electricity and natural gas demand," and only then should we consider building new energy supply. The loading order also requires that any new supply be added "first by renewable energy resources and distributed generation" and next by "clean, fossil fuel, central-station generation." The EAP also requires that "all cost-effective energy efficiency is integrated into utilities' resource plans on an equal basis with supply-side resource options."

Because of this directive, the CPUC has spent many years developing a cost-effectiveness framework which is used to assist decision-makers in determining which programs should be approved. This framework is defined by the California Standard Practice Manual[2] (SPM), which defines several cost-effectiveness tests, with different cost and benefit inputs depending on the test's perspective. Many of these cost and benefits inputs are *estimated*, rather than calculated – by necessity, as they will occur in the future. For example, to determine if a proposed EE program will be cost-effective, we must estimate quantities such as the future annual energy savings for each year of the lifetime of equipment, the number of utility customers who will participate in the program (which determines the amount of the incentive payments), the savings (which is known as the "avoided cost") to a utility of *not* building and operating power plants, etc. Because these quantities are estimated, there is an ongoing need for refining the models and techniques used, so that the accuracy of the estimates can be improved as new research and data is available.

In addition to improving accuracy of estimated values, we also need to refine our cost-effectiveness framework as new technologies, strategies and policy directives emerge. For example, the recent introduction of a Permanent Load Shifting (PLS) program to the utilities' Demand Response portfolios will require ongoing modification of the Demand Response Cost-effectiveness Protocols to take into account the differences between dispatchable Demand Response and load shifting. Another example is the need to better estimate the cost of greenhouse gas (GHG) emissions, so as to determine cost-effective strategies to achieve the state's GHG abatement goals.

1.2. Research Scope

[1] Final 2003 California Energy Action Plan, http://www.energy.ca.gov/energy_action_plan/
[2] http://www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF

Cost-effectiveness related research is needed in five broad areas:

1. Demand-Side: Updates and modifications to those aspects of the cost-effectiveness framework which are used for all demand-side resources (Energy Efficiency, Demand Response and Distributed Generation), as well as programs which integrate these resources. This includes changes to avoided costs calculations.
2. Energy Efficiency: Updates and modifications to those aspects of the cost-effectiveness framework which are specific to EE resources, such as determining the additional value provided by comprehensive, whole-building retrofit programs.
3. Demand Response: Updates and modifications to those aspects of the cost-effectiveness framework which are specific to DR resources, such as determining the value of dispatchability, reliability and flexibility.
4. Water/Energy: Modifications of the cost-effectiveness framework which are needed to measure the value of programs which reduce both energy and water usage.
5. Low Income: Updates and modifications to the cost-effectiveness framework used for the Energy Saving Assistance Program (ESAP).

1.3. Uncertainties and Challenges to Successful Implementation

The state of California has ambitious environmental and energy goals – by 2020, 33% of our electricity will come from renewable sources and our GHG emissions will be at 1990 levels. One of the greatest challenges we face in implementing these goals is to reduce fossil fuel use without burdening ratepayers with overwhelming cost increases. To do this, we must better understand all the benefits and costs associated with our demand-side programs. The challenges we face are due to several factors, as discussed above.

First, new technologies often require us to modify or better define certain cost and benefit inputs. This includes not only new programs (such as PLS, discussed above) but also larger technological changes such as the development of the smart grid and the emergence of more cost-effective customer generation and storage technologies. These changes allow ratepayers to better manage their own energy use through self-generation, more efficient devices, and automatic controls. However, these changes lead to many challenges for determining cost-effectiveness of new programs. What is the value to the participant, to the utility, and to the state of improved load management? To what extent do all utility ratepayers, even those who don't adopt them, benefit from these new technologies? How can we use the vast amount of customer usage data now available from smart meters to better understand the value, to utilities, and to both participating and non-participating ratepayers, of demand-side programs?

The second challenge is in defining the costs and benefits associated with new program implementation strategies. For example, we need to better understand how prices paid for GHG in the emerging cap and trade market relates to the actual costs associated with climate change. Our efforts to provide integrated demand-side programs by enabling customers to develop an integrated strategy of energy efficiency, demand response and distributed generation activities to meet their needs requires a much better understanding of the interactive effects of EE, DR and DG resources. The goal of market transformation is a key to making energy-efficient and environmentally-sound technologies less costly and more accessible, but while market transformation programs have huge long-term benefits, they sometimes come with large short-term costs. Both determining the value of those long-term savings and managing the short-term costs are challenging. For EE programs, we have encouraged a strategy of providing comprehensive, whole-building retrofits, but the exact nature of the cost savings and additional benefits of comprehensiveness are unclear. On the DR side, we have implemented a policy "dual participation," which is allowing customers to participate in more than one DR program. Determining how to attribute the benefits of different DR programs with the same customers has proven challenging.

Lastly, an ongoing challenge is simply keeping up with new research, data, models and methods that allow us to better estimate costs and benefits and make cost-effectiveness tools more accurate and easier to use.

2. RECENT EVALUATION

2.1. A Summary of 2010-12 Cost-Effectiveness Studies and Activities

During 2010-12, studies related to cost-effectiveness were carried out separately by Energy Division analysts responsible for EE, DR, DG, IDSM and Low Income programs.

A study of cost-effectiveness for integrated demand-side programs was completed in 2011. This study looked at the feasibility of developing a method for estimating the cost-effectiveness of programs which integrate EE, DR and DG. This study was significant in that it was the first time that we've looked at cost-effectiveness across the demand-side, rather than only in the context of a particular resource.

An important accomplishment in 2012 was the adoption for EE of the avoided cost model used for DR and DG. As a result, all demand-side programs now use the same basic cost-effectiveness framework. This enabled Energy Division to hold workshops in June 2013 which, for the first time, brought together parties in EE, DR and DG proceedings to discuss issues common to all demand-side resources. Subsequent to these workshops, Energy Division embarked on two consultant studies: one to develop a social cost test, and another to develop a more sophisticated model to estimate the hourly likelihood of a capacity shortage, which is used to allocate avoided generation capacity costs to each hour of the year.

In the low income proceeding, a 2010 study on non-energy benefits (NEBs) looked at the latest research on the specific NEBs which accrue to low-income customers receiving EE improvements to their homes through the Energy Saving Assistance (ESA) program. NEBs are currently included in the cost-effectiveness analysis only of low income EE programs.

Various studies examining the cost-effectiveness of specific technologies and programs, such as Permanent Load Shifting and the California Solar Initiative were also carried out.

2.2. Key Research Questions Addressed in 2010-2012 EM&V

Table 1. Summary of Research Questions Addressed in 2010-2012 EM&V

Study Name	Key Research Questions [2010-2012]
Permanent Load Shifting*	• What aspects of PLS-specific cost-effectiveness differ from the larger DR framework, and how do we value them?
CSI cost-effectiveness study	• Is the CSI program cost-effective?
SGIP cost-effectiveness study	• Are the 25 renewable technology configurations supported by SGIP cost-effective for participants, utilities and society? • What are the appropriate incentive levels for these technologies?
Net Energy Metering 2010 study and Net Energy Metering 2012-13 study (in process)	• Is the NEM program cost-effective? • Are avoided cost updates needed?
Technical Potential of High Penetration PV*	• What are distribution-area specific distribution values for photovoltaics?
Analysis of impact new avoided costs on EE	• What would be the impacts on the cost-effectiveness of various types of EE programs if the DR/DG cost-effectiveness calculator is adopted?
DR and EE calculator updates	(updates for new data, error correction, increased precision, decisions ordering modification)
Allocation of avoided capacity costs/LOLP	• Can we develop a transparent LOLP model that is more sophisticated and accurate than what we're using now?
Social Cost Test	• What are the key components of a Social Cost Test for California IOU's demand side programs?
IDSM cost-effectiveness	• What are the key issues, obstacles and barriers with development and use of a common IDSM cost-effectiveness framework? • Is it feasible to develop a cost-effectiveness framework that is common to all demand-side resources? • Are there additional or specific benefits for IDSM that should be included?
ESAP 2010 NEBs study	• Is it feasible and advisable to update or better estimate the NEBS values current used to determine ESAP cost-effectiveness?

These studies were not primarily cost-effectiveness studies, but did contain specific content related *to cost-effectiveness.*

In addition to the above studies, several less formal research projects are currently underway:

Comprehensiveness Working Group : This Working Group was formed to discuss the additional value and the cost savings associated with Energy Efficiency programs such as Energy Upgrade California, which provide comprehensive, whole building retrofits.

Load Shapes Working Group: This Working Group was formed to determine if the load shapes for specific Energy Efficiency measures require updating, and if so, which measures should be prioritized.

ESAP Cost-Effectiveness Working Group: This Working Group was asked to recommend updates and modifications of the cost-effectiveness framework used to determine the cost-effectiveness of low income Energy Efficiency programs. This Working Group produced a white paper on Feb. 15, 2013, which was filed in A.11005-017

Discount Rate discussion group: There has been considerable discussion, over the course of at least 5 years and many Demand Response and Energy Efficiency proceedings, about what the most appropriate discount rate is for calculating the net present value of the costs and benefits of demand-side programs. Stakeholders were invited to join with E3, Energy Division's consultant, to informally discuss this issue, in hopes of achieving a consensus.

The research questions addressed in these studies are significant for different aspects of demand-side programs:

Ex-post program analysis: The Distributed Generation studies, in particular, were focused on ex post analysis of existing programs. These studies enable decision-makers, program managers and designers, and other stakeholders to better determine important questions such as whether these programs should be expanded in the future, whether the incentive levels should change, or if the program has accomplished its goals and can be disbanded.

The IDSM and other broad, demand-side studies are need to help determine the feasibility of integrating demand-side programs, as well as the costs and benefits of doing so. Studies such as PLS, and updates of the various cost-effectiveness calculators, are important in determining how much ratepayer money should be invested in new technologies and ongoing programs. These studies do not address policy issues per se, but rather provide or improve the tools used to determine program cost-effectiveness.

3. EMERGING INFORMATION NEEDS

During 2012, six workshops were held which focused (some only partially) on demand-side cost-effectiveness issues.

The issues raised by parties and Energy Division at these workshops fall into three broad categories, as discussed above:

1. New strategies: Studies to support new implementation strategies and infrastructure changes, such as integration, comprehensiveness, GHG reduction, market transformation, mitigating intermittency, etc.

2. New technologies: Studies to determine additional costs and benefits and needed modifications of the cost-effectiveness framework as new technologies are adopted.

3. Improved estimation: Studies to determine (1) when policy, technology, or knowledge base changes require us to add new cost and benefit inputs; (2) when additional research is enabling us to better estimate existing inputs; (3) how inputs which parties feel are inaccurate can be better estimated; (4) if costs and benefits of particular resources or programs have been overlooked.

3.1. Key Research Questions To Be Addressed in 2013-2014

Table 2. Summary of Research Questions to be addressed in 2013-2014

Study Name	**Research Questions [2013-2014]**
All Demand-Side Programs	
Avoided Cost studies:	
• Localized capacity and energy avoided costs	• How do avoided generation costs vary by region? How should localized costs be used in cost-effectiveness analysis?
• Avoided Transmission and Distribution costs and allocations	• Can we better estimate T&D costs? Can we develop more locally granular T&D costs? Should T&D costs differ for different resources? Can we improve allocation?
• Further refinement of LOLP modeling for allocation of capacity costs	• Can we continue to improve the way we allocate capacity costs to 8760 hours?
• Avoided ancillary services costs	• Can we determine more accurate and specific values?
• Avoided GHG forecasting	• How can we better estimate the costs of avoided GHG? How do these estimates relate to cap and trade prices?
• Avoided environmental health	• What are the avoided environmental health costs associated with demand-side programs? Are there other significant non-energy impacts?
• Avoided embedded energy in water	• How can we estimate and value the energy savings that result from a demand side program designed to save energy by saving

• Avoided "capacity" costs related to water	water? • How can we separate energy/non-energy avoided costs for water?
Social Cost Test	• Is a Social Cost Test a useful tool to determine measure, program or portfolio cost-effectiveness? • How should a Social Cost Test be used by the Commission? • What are the key cost and benefit inputs to include in a social cost test? • How can those inputs be quantified? • What is the appropriate discount rate for the SCT?
Discount Rate	• Which discount rate is the most appropriate to use to determine the net present value of demand-side programs? • If we continue to use each utility's weighted average cost of capital (WACC), is the before-tax WACC or the after-tax WACC correct? • Should different discount rates be used for different part of the cost-effectiveness calculations?
IDSM cost-effectiveness	• Can we build on the work that's been done on demand-side cost-effectiveness to develop an IDSM cost-effectiveness framework?
Interactive effects of integrated resources	• What are the possible interactive effects of projects that combine EE, DR and DG measures, and how do they affect the cost-effectiveness of integrated programs? • Given the resulting tradeoffs of these interactions, how should we design programs so that the preferred action is taken?
Standardized Output	• What is the best way to present cost-effectiveness results? • What data from which calculators is needed as inputs? • Is additional data needed?
Energy Efficiency	
Sensitivity Analysis	• What are the key variables that are driving the cost-effectiveness results? • Which of these variables are highly uncertain • What kind of sensitivities should be run on these variables? • How should the sensitivity analysis be used?
Comprehensiveness	• Are there additional benefits and/or costs savings associated with comprehensive, whole-building/whole facility retrofits?

	Can they be quantified? • How should EULs for water saving programs be determined? • How should these inputs be used in cost-effectiveness analysis?
Load Shapes	• Which EE measures are using inaccurate or outdated load shapes? • Is there sufficient data for updating them? If not, what are next steps?
Expected Useful Lifetime	• Are there EE measures with inaccurate or outdated EULs? • Does the 20 year cap on EUL make sense? • How should we proceed with updating EULs?
Calculator updates	(updates for new data, error correction, increased precision, inclusion of water-energy avoided costs, decisions ordering modification)
Demand Response	
Improved Adjustment Factor analysis	• Are additional modifications needed to the A factor analysis? • Can the RA group's new modeling project provide improved A factor analysis? • Does E3's new LOLP model provide sufficient data for a more granular B factor analysis? • Should the C factor analysis be based on actual program call, or can we determine another method? • Can we more precisely define D factor criteria? • Should we add an "F factor" to estimate local capacity value?
Participant Costs	• What are the methods we could use to estimate service loss and transaction costs? • Are any of these methods likely to produce reasonable estimates without requiring high cost studies? • Are there particular DR programs for which we can better estimate service loss and transaction costs?
Market Effects	• Does the use or availability of DR have an impact on energy prices or markets that is different that the impact of equivalent supply-side resources? • What are the types of market effects that may exist? • What is the status of the research on market effects of DR? (literature review) • Does a literature review indicate that some of this research should be pursued?

Permanent Load Shifting (cost-effectiveness only)	• Is additional data (e.g., measure costs, load shapes, EULs) needed to determine PLS cost-effectiveness? • Are additional changes to the DR cost-effectiveness protocols and calculators needed for PLS?
Value of flexibility	• What is the value of flexible DR products to the grid, especially to mitigate intermittency? • What is required of DR programs to provide flexible capacity? • What additional research is needed to incorporate flexibility value into the cost-effectiveness analysis?
Value of dispatchability	• Do dispatchable resources have an additional value that non-dispatchable resources do not have? Can that value be quantified?
Value of reliability	• DR is traditionally seen as an "insurance policy" for the grid, in that grid operators can use it when reliability is threatened. Can this reliability value be quantified? • Do newer forms of reliability insurance, such as resource adequacy, make DR's reliability value obsolete?
Calculator Updates	(updates for new data, error correction, increased precision, decisions ordering modification)
Low Income	
New Methods for Measuring non-energy impacts?	• Should we replace some or all of the NEBs values with an adder? • How can we best measure the health, comfort and safety benefits of ESA measures?
Calculator Updates	(updates for new data, error correction, increased precision, decisions ordering modification)

3.2. A Summary of 2013-14 Cost-effectiveness Studies, Budgets and Timing

Table 3

2013-2014 Study Area/Title	Study Manager	**Suggested** Budget	Priority
All Demand-Side Programs (EE EM&V budget)			
Avoided Cost studies 1. Local avoided costs 2. Avoided T&D costs		1. $300,000 2. $50,000	1. high 2. high

Capacity costs allocation 4. Avoided ancillary services costs 5. Avoided GHG forecasting 6. Avoided environmental health costs	ED	3. $25,000 4. $0 - $50,000 5. $0 6. $0	high 4. low 5. high 6. medium
Social Cost Test	ED	$0 - $100,000	high
Discount Rate	ED	$0 - $25,000	medium
IDSM cost-effectiveness	ED	$0	low
Interactive effects of integrated resources	ED	$0 - $50,000	low
Standardized Output	ED	$0	medium
TOTAL BUDGET (Demand Side)		$375,000 - $600,000	
Energy Efficiency (EE EM&V budget)			
Sensitivity Analysis	ED	$0	medium
Comprehensivenes s	ED	$200,000	high
Load Shapes	ED	$0	medium
Expected Useful Lifetime	ED	$0	medium
Calculator updates	ED	$50,000	high
TOTAL BUDGET (EE)		$250,000	
Demand Response (DR EM&V budget)			
Improved Adjustment Factors	ED	$0 - $100,000	high
Participant Costs	ED	$50,000	low
Market Effects	ED	$50,000	medium
PLS	ED	$0 - $50,000	high
Value of flexibility	ED	$150,000	high
Value of dispatchability	ED	$50,000	low
Value of reliability	ED	$50,000	low
Calculator Updates	ED	$50,000	high
TOTAL BUDGET (DR)		$400,000 - $550,000	
Water/Energy (EE EM&V budget)			
Avoided Embedded Energy in Water	ED	$150,000	high
Avoided Water Capacity Costs	ED	$100,000	high

TOTAL BUDGET (Water/Energy)		$250,000	
Low Income (ESAP Proceeding)			
New Methods for Measuring NEIs	IOU	$300,000	high
Calculator Updates	IOU	$50,000	high
TOTAL BUDGET (ESAP)		$350,000	
TOTAL BUDGET		**$1,675,000 - $2,000,000**	

Note: Studies with zero budgets will be done internally, are already in progress, or will leverage existing research (e.g., existing or planned EM&V studies, DEER contract)

4. STUDY DESCRIPTIONS

Please complete the following form for each study proposed. This is very close to the template that we will use to track project results (by adding fields for "key findings")

Study Title:	Budget:
Expected Completion Date:	Study Manager:
Description:	
Objective:	
Key Research Questions:	
Potential Study Methods:	

TABLE ABOVE TO BE COMPLETED BY PCGs FOR EACH RESEARCH STUDY

5. OTHER IMPORTANT CONSIDERATIONS

This research roadmap describes an overall research strategy to improve demand-side cost-effectiveness analysis. These research studies will be undertaken separately, in four groups:

- EE/demand side cost-effectiveness: Energy Division, with the assistance of a Project Coordination Group (PCG), will oversee a series of research studies relating to the cost-effectiveness of all demand-side programs. This PCG will also oversee any studies related to EE cost-effectiveness.

- DR research, including cost-effectiveness: Energy Division, with the assistance of a PCG, will carry out a series of research projects related to Demand Response, as ordered in D.12-04-045. As part of this research effort, several studies related to Demand Response cost-effectiveness will be undertaken.

- Water/Energy cost-effectiveness: Energy Division, with the assistance of a PCG, will carry out research related to developing a cost-effectiveness framework for programs which save both water and energy.

- ESAP cost-effectiveness: The ESAP Cost-Effectiveness Working Group will submit its final recommendation for ESAP cost-effectiveness updates on July 15, 2013. These recommendations are likely to include proposals for future research. The specific nature of this research will be determined within proceeding R.11-05-017

Several of the research studies listed in Tables 2 and 3 are already underway, or will be completed as part of EM&V or other studies or research efforts.