INTEGRATION OF CONSERVATION PROGRAM SAVINGS IN LONG RUN ENERGY DEMAND FORECASTS

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ABSTRACT

This paper shares the authors' perspectives on several issues arising from the development and use of end use forecasting models to quantify conservation program savings. Experiences from ten years effort at forecasting are offered. What lessons have been learned? What difficulties encountered in using forecasting models to quantify conservation programs have been resolved? What ones still exist? This paper examines some of these questions for the residential and commercial building sector energy models and the peak load model used to produce long run forecasts. How should conservation and load management program savings be included within a long run resource planning process? Criteria for treating savings of individual programs, integrating program quantification and forecasting models, and attributing savings among programs are discussed from the CEC perspective. The effect of revisions to program savings estimates on credibility is also considered.

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INTRODUCTION

This paper shares the experience of ten years practice in the development and use of end-use load forecasting models. This experience has been gained in a regulatory environment which stresses extensive, highly public critique of competing load forecasts at the level of utility planning areas.* We make observations from this base of experience regarding the art of forecasting, the role of conservation programs in resource planning, and the need for further evolution of end-use models to answer important resource planning questions.

This paper is divided into three sections: (1) background on the California Energy Commission (CEC) and its forecasting process, (2) experiences at the CEC over the six Common Forecasting Methodology (CFM) cycles from the CEC's inception to the present, and (3) issues occuring through use of load forecasting models to quantify conservation program savings.

BACKGROUND

This section's purpose is to convey some background of the CEC role in resource planning in California and to sketch out how end-use demand forecasting is done at the CEC. Such information may be important to readers in judging how to value the experiences and observations made later.

Role of the CEC

The CEC is a regulatory agency of state government that has no equal in scope of powers and responsibilities in the United States. It was created in 1975 by the state legislature as a compromise among interests seeking "one stop" certification of power plant sites, and a state role promoting energy conservation. On a biennial cycle, the Commission adopts long run demand forecasts and determines the need for new resource additions. An Electricity Report documents the Commission's electricity findings and controls the ensuing two year period for power plant siting purposes.

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* A planning area is a collection of utility service areas. It is usually grouped around a major investor-owned utility which supplies power and/or transmission service to smaller municipal utilities in its geographic vicinity.

Energy demand forecasting plays a key role in integrating conservation policy decisions with the power plant siting approval function. More specifically, all conservation savings "reasonably expected to occur" must, by statute, be included in adopted demand forecasts. These forecasts, at the individual utility planning area, form the basis for needed power resource additions which balance demand and existing supply. No generating facilities beyond those found needed can be sited if they are subject to the Commission's jurisdiction, which is limited to thermal facilities in California with electricity capacity greater than or equal to 50 MWe.

The Commission staff prepares an independent demand forecast which "competes" with submittals from each utility. A major portion of each Electricity Report proceeding is devoted to examining differences among competing forecasts--methodological, input assumptions, and conservation policy presumptions. This portion is completed once the Commission adopts a long run demand forecast for each planning area in the state. The remainder of the proceeding seeks to determine the need for resource additions to match this level of demand, expresses preference for some types of resource additions over others, and articulates the siting policy to be followed for power plant applicants subject to the Commission's jurisdiction.

In the 1985 Electricity Report, the Comission enhanced its recognition of the role of conservation "reasonably expected to occur" (RETO) by creating two classifications--unconditional and conditional. Unconditional RETO savings (market response and program induced savings from committed policies) are incorporated into adopted demand forecasts. Conditional RETO (program induced savings from policies reasonably expected but not yet adopted) is considered as a supply resource that must "compete" with traditional resource types. Choices of specific conservation and load management programs reflect preference for such programs versus traditional resource types on a variety of criteria--cost of delivered power, environmental impact, reliability, etc. Efforts are underway in the 1986 Electricity Report proceeding to improve this decision process within the framework established in the previous report.

These regulatory functions have combined to create a unique process for energy resource planning. The CEC directly initiates energy conservation through mandatory building and appliance standards, encourages utilities to implement conservation and load management programs, and requires generating resource planning that recognizes the contributions of such programs to the reduction of load requirements. Few utilities outside of California have such regulatory controls over their decision-making.

Forecasting at the CEC

The CEC has had a forecasting process for ten years. The staff acts independently of the Commission and competes with each major utility in developing long-run energy demand forecasts for each planning area. The staff was not originally conceived as an independent party with its own forecasting capability; rather, the staff was to critique utility submittals. This was soon seen as impractical as critiques were not sufficient. The independent forecasting role of the staff was formalized in changes to the statute made in 1984.

CEC staff has played a significant role in demonstrating that end use forecasting models can be successfully used in long run demand forecasts at the utility level. Staff has adapted models originally developed by others and created its own for some sectors. The CEC conducts extensive public hearings on the merits of any competing load forecasts and ultimately "adopts" one that is used as the basis for constraints on capacity expansion. The CEC is required to incorporate the savings from conservation "reasonably expected to occur" in such adopted forecasts. This statutory requirement motivates indepth examination of the impact of conservation programs on the need for additional generating facilities or other resource additions. Operating within this framework means that the forecasting models have been purposefully developed to accommodate conservation programs. Because the programs important in California are mandatory standards, the particular orientation for developing the forecasting models is their ability to quantify standards.

EVOLUTION OF FORECASTING MODELS

This section is intended to present a brief summary of the evolution of forecasting models at the CEC. It will set the stage for a discussion of particular conservation program savings quantification issues in the final section.

Over the past ten years, the staff methods for preparing forecasts have continuously evolved as new issues and/or data have surfaced. Initial staff efforts were aggregate in nature, but these proved unsatisfactory. The ability to incorporate the influence of changes in the mix of energy use and conservation programs were the primary motivations for disaggregate end-use forecasting models. Staff forecasts are prepared using eight distinct customer class models; four end-use models cover the residential, commercial and industrial sectors.[2] An end use peak demand model parallels the level of disaggregation of all energy models except the industrial model. The industrial end uses are aggregated to 2-digit SIC industry load. Tables I to III summarize the major changes that have taken place in the residential and commercial building sector energy forecasts, and the peak demand forecast respectively. Review of these tables will indicate that extension and refinement of conservation program analyses have been among the most important of these changes. Many important issues addressing the need for further evolution of models and supporting data remain unresolved at this time.[3]

Table I summarizes the key stages in the evolution of the CEC residential sector demand forecasting model. The CFM 2 version continues in use, though considerably modified, to the present. The majority of the changes made enable staff to quantify new conservation programs, or to improve the quantification of programs incorporated earlier. In this sector, the majority of conservation program savings are due to the numerous versions of new building standards and to appliance standards. Utility retrofit

Table I. CEC Residential Sector Forecast Evolution.

Version	Principal New Feature	Key Data
CFM 1 (1976)	initial application of an end-use model to long run utility demand	base year end-use saturations from 1970 U.S. Census
CFM 2 (1979)	a. improved vintaging of equipment stocks	a. end-use saturations from 1970 U.S. Census
	b. explicit quantification of CEC Appliance Standards and Building Standards	b. engineering simulations of per unit impacts
CFM 3 (1980)	retrofit improvement of thermal integrity in older vintages	retrofit penetration of ceiling insulation via CPUC program participant data
CFM 4 (1982)	attribution of retrofit measure savings to groups of programs	retrofit penetration of measures from utility surveys
CFM 5 (1984)	a. integrated thermal shell analysis	a. comprehensive retrofit measure savings data base
	b. segregation of conservation activities not "committed" over to resource plan	b. identification of criteria by which programs could be characterized in terms of relative certainty
	c. incorporation of savings from small utility programs via external analysis	c. expenditure and savings data by program
CFM 6 (1986)	climate zone specific measure penetrations and expanded list of retrofit measures	utility surveys

Table II. CEC Commercial Building Sector Forecast Evolution.

Version	Principal New Feature	Key Data
CFM 1 (1976)	commercial building sector not specifically identified as a distinct element within the nonresidential sector	
CFM 2 (1979)	a. initial application of a variant of the ORNL commercial model	a. utility surveys of customers to ascertain floor space stock and end-use saturations
	b. CEC nonresidential building standard savings	b. engineering simulations of square footage impacts
CFM 3 (1980)	revised floor space additions model	reanalysis of F. W. Dodge floor space additions data
CFM 4 (1982)	a. integrated analysis of utility commercial audit program savings	a. individual customer audit program data
	b. retrofit equipment standard savings impact	b. equipment efficiency and size distributions
CFM 5 (1984)	a. consistent EUI and audit program savings analysis	a. individual customer audit program data
	b. segregation of conservation activities not "committed" for inclusion in resource plans	b. identification of criteria by which programs could be characterized in terms of relative certainty
CFM 6 (1986)	a. retrofit air conditioning saturation	a. increasing evidence of greater sensitivity to weather
	b. increased miscellaneous end use consumption	b. recorded consumption data increasing faster than predicted in earlier CFM cycles

Table III. CEC Peak Demand Forecast Evolution.

Version	Principal New Feature	Key Data
CFM 1 (1976)	peak demand forecasts were prepared using traditional aggregate econometric techniques	
CFM 2 (1979)	a. initial application of a new end use model paralleling residential and commercial building sector detail	a. end use load shapes
	b. CEC building and appliance standard savings	b. heat load model simulations of load shape impacts
CFM 3 (1980)	None	None
CFM 4 (1982)	calibration of backcast over a multi-year period	weather data for each climate zone for each year's peak forecast
CFM 5 (1984)	a. shift to "typical" peak weather rather than most extreme	a. analysis of multi-year weather data
	b. incorporation of savings from small utility programs via external analysis	b. expenditure and savings data by program
CFM 6 (1986)	a. adjustment of planning basis from utility to total electricity usage	a. estimates of self generation capacity and capacity factors by customer type
	b. quantifying A/C appliance standards using EER measure rather than SEER measure	b. preliminary analysis of SEER versus EER divergence for CEC's certified air conditioners

programs and government programs other than standards are numerous, but individually small in scope compared to standards savings.

Table II summarizes the key stages in the evolution of the CEC commercial building sector demand forecasting model. As in the residential sector, this sector's model was initially developed for CFM 2 and continues in use to the present. A substantial effort has been made to develop a means of characterizing key utility programs within the structure of the model.[4] In this sector, mandatory standards are of greater significance than are utility programs, but less overwhelmingly so than in the residential sector.

Table III summarizes the stages in the evolution of the CEC peak demand forecasting model. This model was developed by staff[5] and parallels the end use, building type, and climate zone disaggregation of the residential and commercial building sector models. Few significant changes have been made to either the original model or the end use load shape data used within it. Computation of individual program savings estimates on peak has been especially difficult because of the complex nature of this model and the interaction among customer sectors induced by calibrating raw results to total system peak.

The motivation underlying the evolution of these forecasting models stems from the pursuit of two broad goals. The first goal is to better simulate underlying energy use phenomena as knowledge of various market segments improves. This is usually the highest priority for a demand forecasting unit within a planning organization. End use models are increasingly recognized as appropriate, even essential, to this purpose.[6] The second goal is to improve the ability to quantify the incremental impact of existing or prospective conservation and load management programs. The policy decision to embark upon a particular program is becoming more dependent upon quantification of program savings from a forecasting model, rather than from other less formal techniques. These dual functions of forecasting models can be a problem if resources available to collect and analyze data, programming support to modify computer codes, and skilled personnel to operate and interpret results are scarce.

CONSERVATION PROGRAM QUANTIFICATION ISSUES

This section will discuss four significant issues facing forecasters who need to quantify program savings for inclusion in demand forecasts.

Inclusion of Programs in the Planning Process

The statute that created the CEC requires that all conservation reasonably expected to occur (RETO) be included within adopted demand forecasts. The adopted demand forecasts are used in conjunction with the Commission's integrated assessment of the need for new resource additions to determine whether proposed generating facilities, subject to the Commission's jurisdiction, conform to the adopted forecasts. Thus, the basic enabling statute, written more than ten years ago, required that conservation and load management program savings be incorporated in the resource planning process.

Defining what RETO means has been left to the Commission and is readjudicated in each cycle of the Electricity Report process. We have advocated that clearly defined criteria be used to test whether a specific program qualifies,[7] but others prefer a more ambitious approach. The recognition of demand side management and planning concepts[8] formulated at the Electric Power Research Institute (EPRI) and a desire to more fully integrate the choice of programs into the resource planning process caused the Commission in 1985 to distinguish beteween unconditional RETO, to be included in adopted demand forecasts, and conditional RETO, to be included as a committed supply resource. A program that passes all required approvals moves from conditional to unconditional status. A primary motivation for CEC involvement in end use forecasting models stems from the need to incorporate expected savings from conservation programs into the long range resource planning process.

Irrespective of the decision about where to count savings from individual programs, the Commission should quantify savings from each as realistically as possible. This can most easily be achieved by having the basic energy demand forecasting models quantify as many conservation programs as feasible. Table IV summarizes the projected savings from the large number of individual conservation and load management programs quantified by Commission staff in the current ER proceeding.[9] The large majority meet the test of unconditional RETO and have been included within adopted demand forecasts, but some are less certain and are considered conditional RETO (a specified supply addition in resource preference). This list provides an indication of the substantial commitment California has made to conservation and load management programs, and the magnitude of the problems facing us in quantifying all of these programs.

Preference for Integrated Savings Analysis

The programs listed in Table IV meet various evidentiary criteria that we advocate for determining where to account for savings from any proposed program. Many other program designs with consequential savings could be hypothesized, but these meet criteria that require they be quantified. A clear preference exists for this quantification to be performed using the basic forecasting model, but this cannot always be done. This usually results from inadequate understanding of the program to prepare a characterization of it appropriate to the sectoral model. Sometimes the model is not configured in a way to quantify the program. For example, a low income weatherization program requires that program eligibility be determined by the household's income level, yet the residential demand forecasting model does not segregate households by income level.

Our solution to this problem has been to utilize an external quantification methodology that results in a program savings estimate which is subtracted from the "bottom line" of the forecasting model's result to

Table IV. Treatment of Programs in the Current ER 6 Proceedings.

PROGRAM	Statewide 2005 Savings Energy (GWh)	Statewide 2005 Savings Peak (MW)	Status[1]	Quantification Method[2]
Residential				
1975 HCD Building Standards	3,296	1,942	U	I
1977 T24 Building Standards	387	92	U	I
1983 T24 Building Standards	1,932	528	C[3]	I
1976-82 T20 Appliance Stnds.	5,832	2,786	U	I
1984 T20 Appliance Stnds.	5,817	1,602	U	I
Misc. Weatherization Retrofit	1,093	298	U	E[4]
Solar Retrofit	69	7	U	I
Other Utility Programs				
Appliance Efficiency	265	61	U[5]	E
Builder Conservation	207	96	U[5]	E
Master Meter	55	16	U[5]	E
Subtotal	18,953	7,428	--	--
Commercial Buildings				
1976-82 T20 Equip. Stnds.	1,596	736	U	I
1977 T24 Bldg. Stnds.	4,102	1,611	U	I
1984 T20 Equip. Stnds.	569	204	U	I
1984 T24 Bldg. Stnds. (Offices)	2,426	978	U	I
Anticipated (85-86) T24 Bldg. Stnds. (2nd Tier)	1,275	407	U[6]	I
Facilities Loans and Grants Program (Schools & Hospitals)	226	62	U	E
Commercial Audits	1,016	316	U[5]	I
Commercial Retrofit Incentives Program	482	136	U[5]	I
Subtotal	11,692	4,450	--	--
TOTAL	30,645	11,878	--	--

1. U is unconditional while C is conditional.
2. I is integrated within the forecasting model while E is external side calculation.
3. The majority of the savings originally anticipated for this program are now considered conditional due to the passage of California Assembly Bill 163 which "softened" the standard.
4. Most programs quantified externally.
5. Programs contain both unconditional and conditional elements.
6. 3rd Tier now considered conditional.

produce the net forecast. A large number of consistency problems are thus introduced--market response versus program response, overall physical stock consistency for retrofit measures, potential double counting among programs, etc.[10] Although this method is unsatisfactory, it meets the essential requirement that programs which meet the criteria for RETO are actually incorporated into the planning process. We have decided that some estimate is better than no estimate. Over time, programs quantified in this way will be shifted to the main models if further disaggregation of them proves feasible.

Attribution of Savings Among Programs

The large number of current and prospective conservation and load management programs listed in Table IV requires substantial efforts to quantify individually. Individual quantification is felt necessary to satisfy policy requirements. Attribution of savings is guided by the principle that program savings are determined in the reverse order of introduction. This chronological sequencing[10] approach requires that a series of model runs be made.

As an example, let runs A, B, and C denote three runs of the model with alternative input data sets characterizing the influence of two programs, a single program, and no programs, respectively, with run B representing the single program introduced first. We use the difference between runs A and B to quantify the savings from the last program introduced.

In the CEC convention, run B would have the inputs characterizing the influence of the program first introduced, while run A would have the inputs characterizing both this initial program and a second one introduced later. This convention makes the estimate for the second program conditional upon the first. In our opinion, this properly allocates the savings between the two programs because it reflects what would have taken place in the real world. This example is complicated several fold in actual CEC practice due to the large number of programs.

A significant complication of implementing this convention is the attribution of savings to market forces, including direct consumer price response. Extending the previous example further, let run D denote a case with fuel prices constant at the level of some reference year. Runs A, B, and C used fuel price assumptions from the baseline forecast. Market savings are quantified as the difference between runs C and D. This is a straight-forward extension of the previous example. Unfortunately, savings quantified using runs A, B, and C are conditional upon the market savings, which depend upon the fuel price assumptions of the baseline forecast. Changes in such fuel price assumptions, all other effects held constant, change the savings quantified for each program. High fuel prices lead to lower program savings and lower fuel prices lead to higher program savings. Conditional program savings estimates are clearly a logical outcome of this method of attribution and seem correct to the forecaster, but are difficult to explain to the decision maker.

Revision of Program Savings Estimates

An issue of increasing concern to forecasters and policy analysts is the loss of credibility when program savings estimates are continually revised. For example, the program savings estimates reported in Table IV are lower than the estimates published in 1985 in the CEC staff's preliminary forecasts.[11] Energy savings estimates in the residential and commercial sectors are reduced six percent and capacity savings are reduced twenty five percent. Capacity savings in the commercial sector alone decreased over thirty percent from the preliminary revised forecasts. A substantial portion of the difference in the commercial sector is a result of the decisions to alter the status of the Third Tier Title 24 Nonresidential Building Standards from unconditional RETO to conditional RETO. Similarily, residential standard savings are reduced as the provisions of Assembly Bill 163, diluting the anticipated impact of the 1983 Title 24 Residential Building Standards, become more clear.

Revisions stem from many factors: (1) improvements in understanding of program effects on individual participants, (2) changes in projections of number of participants, (3) changes in underlying demand forecast parameters such as housing stock, mix of building types, fuel prices, or personal income rate of growth, and (4) improvements in forecasting models. Forecasters feel compelled to produce the best savings estimates possible, while decision makers and external observers feel threatened by a maze of continual shifting claims for the efficacy of programs. Mutual trust can go a long way to mitigate this problem, but this can be difficult to achieve in a regulatory environment where top management and political appointees rotate through the institution at a fast rate. We do not yet have a means of eliminating this problem.

CONCLUSION

The ten years of end use demand forecasting at the CEC have seen a steady evolution of models (originally designed for forecasting) to accommodate the need to quantify the long run savings from conservation programs. Significant staff and computer resources are devoted to quantifying the savings from a large number of current and prospective programs. Management of the forecasting function has had to resolve conflicting priorities of price forecasting and conservation policy roles expected of the staff.

Refined forecasting techniques, updated underlying forecasting assumptions, and improved data on program operation have led to revisions in program savings. Continued development of integrated supply/demand planning processes requires that program savings estimates be further improved and characterized in more detail to facilitate utility system impact analysis. This requires improved data, better staff, continued and sustained efforts that are costly and may seem difficult to justify. Nevertheless, the costs avoided by improved estimates in the planning process are many fold greater than the costs of good planning. Management of utility companies and regulatory bodies must prudently represent the interests of the ratepayers within their jurisdiction and make the decision to expand the scope of integrated demand forecasting, program policy analysis, and resource planning.

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