Energy Efficiency's Impact on California's Renewable Energy Development

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ABSTRACT

California is entering uncharted territory in terms of scaling-up energy efficiency (EE) savings goals. In 2006, California's Assembly Bill 2021 tasked the California Energy Commission (CEC) with setting statewide savings targets, aiming to reduce total forecasted electrical consumption by 10% over the ten-year period of 2007 – 2016, or approximately 1% per year.

The state is also speeding up the development of renewable energy via legislated renewable portfolio standards (RPS). Specifically, California's Senate Bill 107 mandates that the investor-owned utilities obtain generation equivalent to 20% of their retail sales from renewable energy by 2010, while municipally-owned utilities must set their own corresponding RPS targets. The Governor has set an even more aggressive, non-binding goal for renewable energy to total 33% of retail sales by 2020.

This paper quantifies the effect of EE savings on the state's RPS compliance cost. The effect arises because reduced retail sales result in less renewable energy being required to meet the RPS. If California reduces electricity demand by an additional 1% per year between 2007 and 2010, the state will reduce its cumulative RPS compliance costs by approximately $98 million. If this 1% per year rate of energy efficiency savings is extended through 2020, and the state achieves the 33% RPS goal by 2020, the cumulative RPS compliance cost reduction due to energy efficiency will be as much as $770 million.

This analysis is based on renewable energy cost and potential data derived from a publicly available 'Greenhouse Gas Calculator,' developed for the California Public Utilities Commission (CPUC) to model the state's electricity sector greenhouse gas emissions reduction potential by 2020.

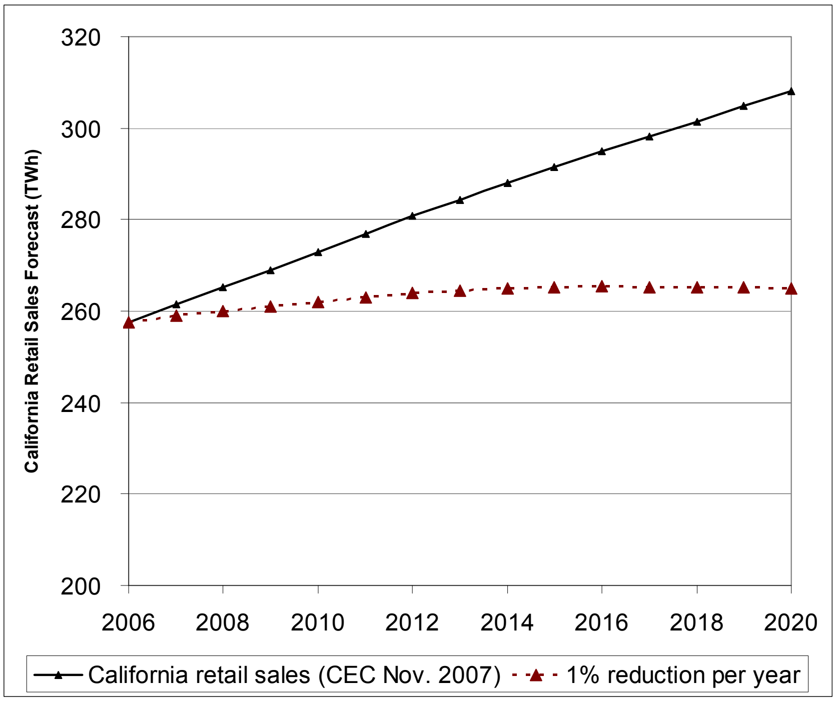
Introduction

California's Energy Efficiency Targets

California has aggressively pursued energy efficiency (EE) since the 1970s, contributing to the state's relatively constant per capita electricity consumption (Chang, Rosenfeld & McAuliffe, 2007). Despite these efforts, the state's economic and population growth continue to increase total electricity consumption. In September 2006, with the passage of Assembly Bill 2021, the state raised the bar for energy efficiency by directing the California Energy Commission (CEC) to establish statewide annual targets for energy efficiency, "so that the state can meet the goal of reducing total forecasted electrical consumption by 10 percent over the next ten years" (California Assembly Bill 2021, 2006). In compliance with AB 2021, the CEC has since adopted the "statewide savings goal to achieve 100 percent of the estimated economic potential savings for electricity, peak demand and natural gas usage" (CEC, 2007a).

If successfully met, the EE savings target of reducing consumption by 10% would flatten the state's forecasted total consumption trend, nearly eliminating load growth. See Figure 1 below. The annual average growth rate between 2006 and 2020 would fall from 1.3% in the CEC's load forecast, referred to here as the "business-as-usual" case, to 0.2% per year under the 10% reduction by 2016 EE target (CEC, 2007b).[1]

Figure 1. California's Business-as-Usual Retail Sales Forecast and 1% per Year Reduction below Business-as-Usual Forecast, TWh (2006 – 2020)



California's Renewable Energy Future

Energy efficiency is not the only domain in which California is seeking to redirect its future energy path. In 2006, the legislature passed Renewable Portfolio Standard (RPS) legislation (S.B. 107), mandating that California's three large investor-owned utilities (IOUs)[2] procure generation equivalent to 20 percent of their retail electricity sales from qualifying renewable energy sources by 2010, and that the publicly-owned utilities (POUs) set their own RPS targets that are in-line with the goals of IOUs (California Senate Bill 107, 2006).[3] In

[1] The forecast used in this paper is extrapolated from 2018 to 2020 based on the annual average growth rate from the last three years of the forecast.
[2] California's three large IOUs are Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E).
[3] Most municipally-owned utilities have set RPS targets that are at least as strict, if not stricter, than the 20% by 2010 goal required of the investor-owned utilities. Although SB 107 does not legally require the entire state to meet the 20% by 2010 RPS target, this paper assumes that the state will achieve 20% renewable energy, as a percent of retail sales, by 2010.

addition, the Governor, the CEC and CPUC have all endorsed an enhanced statewide RPS target of 33 percent by 2020 (CEC/PUC, 2005).[4]

The energy efficiency and RPS compliance nexus. There is an important interdependence between the state's RPS goals and its EE targets. While the AB 2021 goal of load reduction equal to 10 percent of the forecasted level in 2016 is a fixed goal, the RPS is a moving target, dependent on the levels of retail sales in 2010 and 2020. The CEC's goal of achieving "100% of economic potential savings" for electricity is also a moving target, since economic potential can change as efficient technologies become less expensive or other measures of cost-effectiveness change. This additional complexity of the shifting definition of "economic potential" is not dealt with in this paper; instead we focus on the fixed EE savings goal of AB 2021.

Achieving additional EE, beyond what is already in the CEC's load forecast, can have a significant effect on the amount of renewable energy that must be procured under the RPS, and therefore on the RPS compliance cost. To see this point, consider the following accounting identity for the total cost (TC) of meeting the state's energy demand:

$$TC = (Q - E)\,\theta P_R + (Q - E)\,(1 - \theta)\,P_C + E\,P_E \qquad (1)$$

In equation (1), Q is the electricity demand before additional energy efficiency savings and E is the incremental energy efficiency savings (above any EE already embedded in Q). Hence, $(Q - E)$ is the retail sales. Suppose θ is the RPS target as a percent of retail sales, and P_R is the per MWh cost of renewable energy. The first right-hand-side term $(Q - E)\,\theta P_R$ is thus the RPS compliance cost. At a per MWh conventional energy cost of P_C, the second term $(Q - E)\,(1 - \theta)\,P_C$ represents the conventional energy cost. Finally, the third term represents the EE program cost at a per MWh cost of P_E.

To illustrate how EE may affect TC, consider an example of a small EE change $\Delta E > 0$ under the simplifying assumption of constant per MWh costs.[5] The resulting total cost effect is:

$$\Delta TC = \Delta E\,[P_E - (\theta P_R + (1 - \theta)\,P_C)] \qquad (2)$$

Equation (2) states that an EE increase of ΔE MWh would lead to a total cost saving of ΔTC dollars if EE is cost-effective with a per MWh cost P_E below the weighted average of supply costs, $(\theta P_R + (1 - \theta)\,P_C)$.

The total cost savings can be rewritten as:

$$\Delta TC = \theta\,\Delta E\,(P_E - P_R) + (1 - \theta)\,\Delta E\,(P_E - P_C). \qquad (3)$$

The first right-hand-side term in equation (3) is $\theta\,\Delta E\,(P_E - P_R)$, measuring the EE savings' effect on RPS compliance cost. Assuming that renewable energy continues to cost more

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[4] California is also legally bound, by Assembly Bill 32, to reduce statewide greenhouse gas (GHG) emissions to 1990 levels by 2020. However, it is still uncertain how this statewide target will impact the electricity sector's energy mix, so the implications of AB 32 are not dealt with in this paper.

[5] For a large change in EE, the computation would entail an estimation of the before-EE total cost and the after-EE cost. While the computation may differ, the example herein serves to clearly illustrate how EE may reduce the RPS compliance cost.

than most energy efficiency, one would expect $\theta \Delta E\ (P_E - P_R)$ to be relatively large. The second term is $(1 - \theta)\ \Delta E\ (P_E - P_C)$, which is the EE savings' effect on conventional supply cost.

Approach

Given the EE costs savings described by equation (3), the primary goal of this paper is to answer the substantive question: "how much can energy efficiency reduce the cost of compliance with the state's renewable portfolio standard?" This question is relevant and timely given the state's current uncertainty about whether the state should legally mandate the 33% RPS goal, and how to quantify the costs and benefits of its newly expanded energy efficiency targets.

The paper builds on work performed by Energy and Environmental Economics, Inc. (E3) for the CPUC. The CPUC hired E3 to estimate the costs and retail rate impacts of a number of scenarios for state compliance with the state's greenhouse gas (GHG) legislation (Assembly Bill 32). As part of this research, E3 developed the "GHG Calculator," which estimates the costs and GHG emissions from California's electricity and natural gas sectors in 2020, based on a set of user-defined variables.

The model includes a detailed estimate of renewable energy potential in California and the other Western states, as well as estimates of the all-in cost of developing renewable energy within a number of California regions or "renewable energy zones." Costs for conventional generation and low-carbon technologies such as nuclear power and coal with carbon capture and sequestration are estimated as well.[6] Using the renewable energy supply curves developed for the GHG Calculator, as well as four independently developed scenarios of energy efficiency achievements between 2008 and 2020, we quantify the savings that energy efficiency can provide in the process of meeting the state's RPS.

Method

Four Energy Efficiency Scenarios

We estimate the RPS compliance cost savings under three RPS targets: the 20% RPS requirement by 2010, a 20% RPS by 2020, and the 33% RPS by 2020. As these compliance cost savings depend on the EE savings, we consider the following EE scenarios:

1) **Business-as-usual scenario.** This energy efficiency scenario is taken directly from the California Energy Commission's load growth forecast.[7] According to the CEC, the "demand forecasts seek to account for all conservation that is 'reasonably expected to occur'" (CEC, 2007b). The forecast includes the impact of historic energy efficiency savings, so it implicitly accounts for energy efficiency savings in the future of roughly the same magnitude as in the past. This means that for future energy efficiency programs

[6] For a more detailed description of the E3 GHG Calculator, or to down-load the MS Excel spreadsheet-based calculator itself, see the E3 website at: http://www.ethree.com/cpuc_ghg_model.html

[7] The forecast of California's retail energy sales used in this paper excludes the load from the California water agencies (WAPA, Metropolitan Water Department and the California Department of Water Resources) whose pumping load has not traditionally been included in energy efficiency programs, and which is not subject to the RPS requirement.

to impact the CEC's load growth forecast, EE achievements must exceed those that are already expected by the CEC.

2) **0.5% per year scenario.** This scenario assumes that the state achieves an additional 0.5% reduction in retail sales, over and above the EE that is assumed to be embedded in the CEC's load forecast. This scenario will not achieve the EE savings target set out in AB 2021.

3) **1% per year scenario.** This energy efficiency scenario, of 1% per year reduction from the retail sales forecast, meets the state's goal of reducing electricity consumption by 10% below the CEC's forecast level in 2016, established in Assembly Bill 2021. The 1% per year EE savings is incremental to any and all EE already embedded in the CEC's load forecast.

4) **1.5% per year reduction.** Finally, we test an EE scenario that is more aggressive than the AB 2021 target, equivalent to an incremental average energy efficiency savings of 1.5% of retail sales per year.

To put these energy efficiency scenarios in context, the average annual electricity savings from energy efficiency in states with strong energy efficiency programs (California, Connecticut, Massachusetts, Rhode Island and Vermont) averaged approximately 0.5% per year from roughly 2000 to 2003, out of an estimated achievable savings *potential* of about 1.2% per year (Nadel, Shipley & Elliott, 2004). Compared to this historical estimate of 0.5% per year achieved EE savings, the 1% and 1.5% EE scenarios are both aggressive savings targets, especially since the CEC's load forecast already includes the impacts of California's existing energy efficiency programs.[8]

Renewable Energy Supply Curve

To estimate the cost of procuring renewable energy required under the three RPS targets for each EE scenario, we follow the cost-based method used in the E3 GHG Calculator, which develops a renewable energy supply curve from bottom-up estimates of technology costs and incremental transmission costs for identified California renewable energy zones, and reflects estimates of resource quality within each zone. These estimates assume constant costs (in real $2008) without market transformation due to projected technology improvements. These cost-based assumptions avoid reliance on estimates of current or future market prices for power purchase agreements, which are often not publicly available, and for strategic reasons may be negotiated at prices that are either substantially above or below producer cost. Our cost estimates reflect the return of and on capital required by an independent power producer under a long-term contract with a credit-worthy utility, as well as operating costs, taxes, and applicable tax credits.[9]

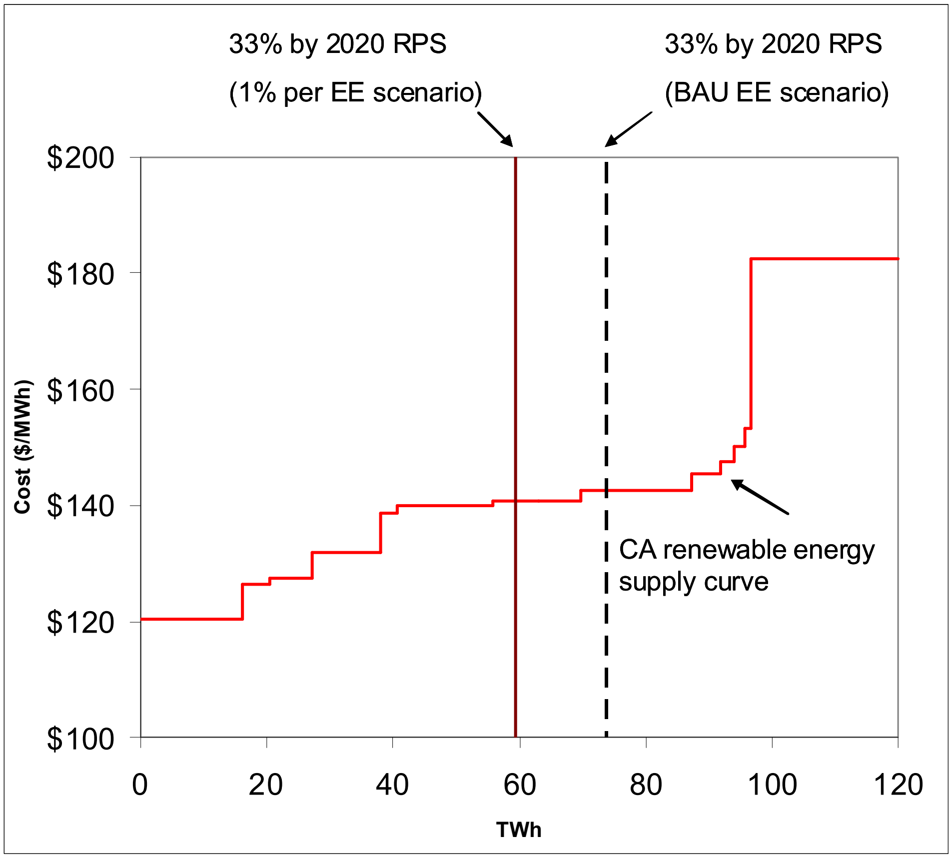
Figure 2 below portrays the state's renewable energy supply curve. It shows the total energy, in terawatt-hours (TWh), required to meet the 20% RPS in 2010 and the 33% RPS in

[8] The CEC is currently investigating ways to improve its reporting of what energy efficiency is included in its load forecast. Most utilities argue that the forecast includes 100% of future, planned EE programs, while the CPUC ruled in its last Long-term procurement planning hearing that the forecast included 80% of the EE goals for PG&E and SCE, and 100% of the EE goals for SDG&E.

[9] The weighted average cost of capital includes an appropriate rate of return on equity for independent project developers. These costs may be lower if municipally-owned utilities finance new renewable energy development, but these financing arrangements are not modeled in the GHG calculator.

2020. The procured amount of renewable energy varies by EE scenario. This figure demonstrates that the average cost of renewable energy (in $/MWh) increases with more aggressive RPS scenarios, and decreases with more aggressive EE scenarios, as the amount procured moves either up or down the supply curve.

Figure 2. California Renewable Energy Supply Curve and 33% RPS in 2020 Target under the Business-As-Usual Scenario and the "1% Per Year" EE Scenario



Based on the supply curve shown in Figure 2 above, we estimate the volume-weighted average costs ($/MWh) of renewable energy procurement by RPS target and EE scenario. These costs are shown in Table 1 below.

Table 1. Average Cost of Renewable Energy Procurement by EE and RPS Scenario ($/MWh, $2008)

	Renewable Energy Procurement		
EE Scenario	**20% RPS in 2010**	**20% RPS in 2020**	**33% RPS in 2020**
0.5% per year	$ 123	$ 124	$ 132
1% per year	$ 123	$ 123	$ 132
1.5% per year	$ 122	$ 122	$ 133

To complete the RPS compliance cost saving estimation, Table 2 reports the EE total resource cost (TRC) and conventional generation all-in cost assumptions. To readers familiar with California's current energy efficiency costs, the EE costs reported in Table 2 may be surprisingly high. These costs are significantly higher than current EE costs, and simply represent a conservative assumption of the costs required to significantly increase energy efficiency savings in the state. To the extent that these EE costs are over-estimated, the RPS compliance cost savings from EE will be understated, and should be considered conservative estimates of cost savings.

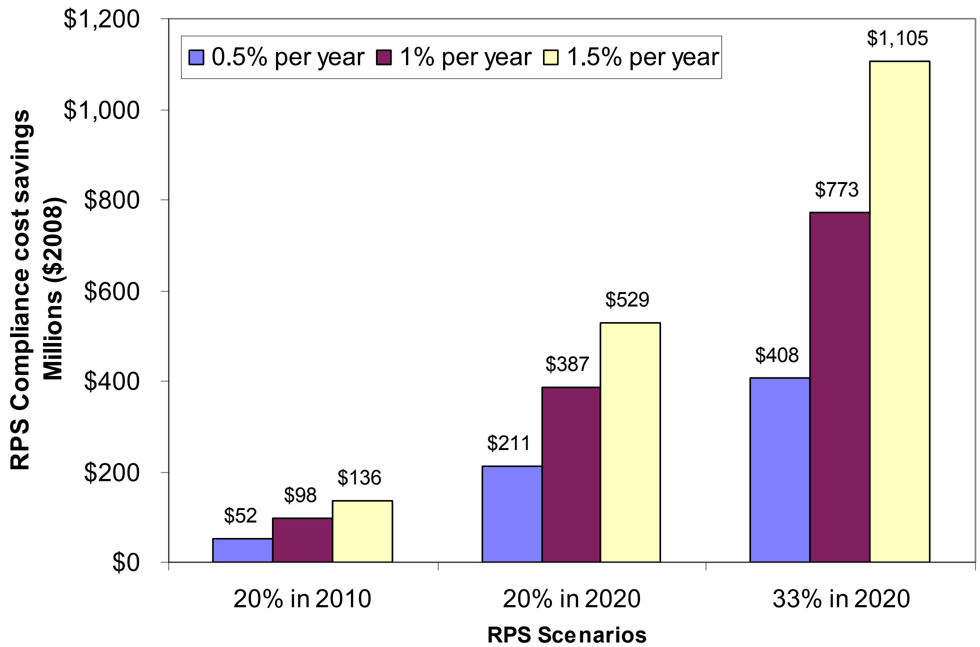
Table 2. Energy Efficiency Total Resource Cost (TRC) and All-in-Cost of Conventional Generation, Combined Cycle Natural Gas Unit (CCGT) ($/MWh, $2008)

EE Scenario	EE TRC	Conventional (CCGT)
0.5% per year	$ 75.00	$ 82.85
1% per year	$ 78.00	$ 82.85
1.5% per year	$ 81.00	$ 82.85

Total Cost Savings of RPS Compliance Under EE Scenarios

Recall from equation (3) that the EE savings' effect on RPS compliance costs is given by the term $\theta \, \Delta E \, (P_E - P_R)$. Figure 3 shows the RPS compliance cost savings, based on the renewable energy supply curve in Figure 2 and the EE cost assumptions in Table 2. The state's EE goal of 1% per year would save California approximately $98 million in cumulative RPS compliance costs under the 20% RPS target in 2010. Extending the 1% per year EE savings goal through 2020 would yield approximately $387 million in 2008 – 2020 cumulative RPS compliance cost savings under the 20% RPS target in 2020. If the RPS target in 2020 were instead increased to 33% in 2020, the same 1% per year EE goal would cumulatively save the state approximately $773 million between 2008 and 2020. All cost savings above are reported in real 2008 dollars.

Figure 3. RPS Compliance Cost Savings due to Energy Efficiency: Three RPS and Three EE Scenarios



Here we do not calculate the effect of EE-related kWh savings on the cost of conventional generation, given by the second right-hand-side term of equation (3). However, at approximately $83/MWh, the cost of conventional energy exceeds the estimated TRC cost of energy efficiency. Hence, EE is also cost-effective when compared to the cost of conventional generation. Finally, as EE reduces kWh consumption at the end-use level, its cost-effectiveness improves with the inclusion of transmission and distribution benefits, and improves still further when environmental benefits due to reduced pollutants are included (Baskette, 2006). [10]

Implications and Conclusions

This paper provides preliminary evidence of EE's potential to reduce the state's cost of compliance with RPS, an important but often ignored topic in the debate of the state's energy future. To be fair, this evidence may well be challenged by the lack of reliable estimates of the per MWh cost of EE savings, as EE programs are dramatically scaled up. The values of $75, $78 and $81/MWh for the levelized cost of energy efficiency shown in Table 2 above represent our educated guess. To the extent that these per MWh costs are understated (overstated), the RPS compliance cost savings are overstated (understated). Hence, an area of useful research

[10] The CPUC adopted avoided cost calculation of energy efficiency quantifies the benefits of reduced energy demand, which result from not building new generation. These benefits include generation energy and capacity, area- and time-specific transmission and distribution benefits, a price elasticity of demand adder and an environmental adder. For a more detailed description of the current avoided cost calculation as applied in California see Baskette, 2006.

would be to develop a more reliable EE supply curve which will help improve estimates of the "cost-effective" energy efficiency potential that the state seeks to capture.

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