Analysis of the CEC–DRECP Spreadsheet Model and Scenarios

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I. INTRODUCTION AND PURPOSE

Sierra Club has carefully reviewed the current California Energy Commission (CEC) staff assumptions and model scenarios developed for the Desert Renewable Energy Conservation Plan (DRECP) to estimate the amount of renewable energy infrastructure that may need to be developed in the DRECP region by 2050. As everyone involved in the DRECP process knows, these are complex issues and much good work has gone into developing the assumptions and calculator by CEC staff and consultants, which we appreciate.

These comments contain our consultant's analysis of the assumptions in the CEC-DRECP scenarios, and recommendations for improvements. Sierra Club's goal in providing this analysis is to help generate further discussion and modification of the model and its assumptions based upon current state policies, historical data, state agency forecasts, and other information that we provide with this report.

Applying modified assumptions explained in this analysis, we have constructed what we believe are realistic reference scenarios for renewable energy development in 2040 and 2050 in the DRECP region. Sierra Club would be happy to provide a presentation to the CEC and DRECP at a future meeting to explain these findings, and hope that this analysis is useful in further fine-tuning our collective understanding of how much large-scale energy will be needed in the DRECP region to help achieve the state's environmental policy goals.

II. OVERVIEW AND SUMMARY OF RECOMMENDED ADJUSTMENTS

The Energy Commission staff has developed scenarios and a spreadsheet model for DRECP to estimate infrastructure and land use that California will need to achieve 80% CO2 reductions by 2050 in the electric power sector, a goal that the Sierra Club supports. Sierra Club's concerns with some of the assumptions in the Commission staff scenarios, as well as several proposed adjustments to quantitative inputs to the model, are summarized below.

In addition to the model inputs that Sierra Club would like to see adjusted or corrected, the Energy Commission staff scenarios also raise strategic concerns about how California should meet its climate protection goals. Sierra Club finds that several of the current model assumptions are actually at odds with existing forecasts, plans and policies that have already been created by the state.

The large amount of land claims for renewable energy in the Commission staff scenarios—1.2 to 1.5 million acres in 2050, about half of which would be in the desert— reflect what could result if the state does not fully implement its own energy conservation policies and falls far short of its

energy efficiency goals. Sierra Club believes that improved energy efficiency and conservation are the foundation on which a clean energy system and carbon reductions must be built.

Moreover, reaching 80% renewable electric generation only makes sense in the context of a world where there is a serious commitment to reducing carbon emissions and implementing green energy policies. The CEC-DRECP scenarios, as they now stand, rely excessively on renewable electric generation to pull the overwhelming majority of the weight for reducing carbon emissions, both for the electric generation sector as well as the transportation sector. Over-reliance on a single strategy is not sound policy, from the perspective of planning, cost-effectiveness, or risk management. A commitment to transformational carbon reduction should include a diverse and balanced mix of strategies and resources.

Certainly there will be a lot of renewable electric generation, but there must also be a similar commitment to efficiency in the electric sector, major advances in building design and construction, as well as diverse clean fuels, reduced vehicle miles of travel, and increased efficiency in the transportation sector. Sierra Club's recommendations reflect this approach to achieving what all agree is a challenging goal.

The performance values we recommend for energy efficiency and electric vehicles are all taken from existing policy and forecast documents—such as the Energy Commission demand forecasts, the state Alternative Fuels Plan, EPRI's study of electric vehicles in 2050, and the AB 32 Climate Scoping Plan. The Sierra Club accepts most of the input assumptions in the Commission staff scenarios and model as reasonable, and the proposed modifications are narrowly focused on a few key values:

- Electricity consumption needs for plug-in hybrids
- The rate of energy efficiency deployment
- Land use per megawatt of solar power plants
- The amount of distributed generation in 2050
- The amount of energy storage needed in 2050

Where the Energy Commission staff found a need for 1.2 to 1.5 million acres of land for renewable energy power generation in 2050, Sierra Club finds that California could achieve the same 80% reduction of carbon dioxide emissions in the electric sector with land use of about 350,000 acres inside the state; 165,000 acres of this land would be in the desert if the amount of desert and non-desert renewables are allocated according to the percentages assumed by the Energy Commission staff. These values are derived by using Sierra Club's proposed model assumptions in the Energy Commission staff's DRECP spreadsheet acreage calculator. The following are our key findings regarding these assumptions, which are enumerated in more detail in the next section of this report.

1. The projected amount of electricity needed by electric vehicles to 2050 should be revised downward.

- The CEC-DRECP model assumes that 90% of miles traveled by plug-in hybrid vehicles will use electricity. This is at odds with Electric Power Research Institute (EPRI) modeling of vehicle recharging patterns that shows plug-in hybrids traveling between

12% and 66% of miles on electricity by 2050. *Sierra Club recommends adopting the highest EPRI figure, which is 66% of miles on electricity.*

- The CEC-DRECP model's assumed efficiency for electric vehicles (EVs) in 2050 is 0.33 kilowatt-hours (kWh) per mile, yet Tesla Roadsters today already achieve 0.210 kWh per mile. EPRI conservatively forecasts a reduction of EV energy use from an average of 0.312 kWh per mile in 2010, to 0.255 kWh per mile in 2050.
- The CEC-DRECP model assumes that each electric vehicle will travel 13,000 miles per year in 2040 and 2050. Yet current state transportation and climate protection policies promote reduced vehicle miles traveled (VMT).
- *Sierra Club recommends reducing the assumed energy load from plug-in hybrids to conform with California's Alternative Fuels Plan, such that a) VMT per vehicle is reduced from the CEC staff value of 13,000 miles/year to 12,500 miles/year in 2040 and 11,500 miles/year in 2050, b) Plug-in Hybrid utility factor (miles driven all-electric) is reduced from 90% to 66% of miles traveled, and c) efficiency of electric vehicles improves from the current average of (.312 per kilowatt-hour to .285 miles per kilowatt-hour by 2040 and .25 miles per kilowatt-hour by 2050.*

2. The CEC staff model underestimates future energy efficiency and it should be increased to conform to existing forecasts and state policy goals.

- The CEC-DRECP reference-case energy efficiency savings rate of 0.83% per year is very close to historical average efficiency savings from 1990 to 2010, the sample period used to justify this savings rate. During the 1990s efficiency programs showed their worst performance due to neglect. Reliance on this unfortunate low historic baseline for performance has incorrectly limited the range of potential future efficiency savings.
- California Energy Commission forecasts show efficiency savings of approximately 1.15%/year over the next decade in a mid-case scenario—when both "committed" and "uncommitted" efficiency savings are accounted for; this is significantly higher than the CEC-DRECP model mid-assumption of 0.83%/year.
- The staff report implies—through reference to an unspecified report— that efficiency savings may become increasingly difficult and costly over time. However, the rate of efficiency savings in both the US and California is increasing over time, and some technologies—such as LED lighting — decrease in cost and improve performance over time. Furthermore, spending on utility programs is often displaced either by market adoption of the efficient technologies, or by enforced codes and standards.
- The assumed growth rate of baseline electricity use of 1.5%/year—prior to efficiency savings—in the CEC-DRECP model is higher than the Energy Commission's 2009 Integrated Energy Policy Report (IEPR) demand forecast of 1.2%/year for the next decade. The 1.5%/year assumption is reasonable only as an "unmanaged growth rate," implying that *additional* efficiency savings of 0.3%/year are embedded into the IEPR forecast of 1.2%/yr.
- *Sierra Club recommends that a) the model account for both uncommitted and committed efficiency savings if the 1.5%/year demand growth rate is used.*

- *Sierra Club recommends assuming 1.15% efficiency savings per year which is the average for 2000-2020, a period where efficiency programs are being implemented in the context of concern for climate change.*

3. The model assumes too much acreage per megawatt of solar PV and solar thermal plants.

- The CEC-DRECP model acreage requirement of 9.1 acres per megawatt (MW) for central station solar PV is inconsistent with the assumption used by the Renewable Energy Transmission Initiative (RETI) and the acreages reported for various utility scale PV projects under construction, which is 7 acres per MW.
- The acreage requirement for central station solar thermal generation in the CEC-DRECP model of 9.1 acres per MW is inconsistent with the explanatory text in the CEC staff document on the DRECP scenarios, and with RETI's estimate of 7 acres per MW. This is also borne out by experience of project developers.
- *Sierra Club recommends correcting the assumptions for central station solar PV and thermal to 7 acres per MW, equivalent to 0.14 MW per acre.*

4. The CEC staff estimate of distributed solar PV generation in 2050 is too modest compared to existing state policies.

- Sierra Club estimates that the state's current Zero Net Energy goals will require over 15,000 MW of residential rooftop solar PV, and additional rooftop PV for commercial buildings.
- Decreasing solar PV prices, and increasing utility rates, over time will drive greater penetration of distributed and rooftop solar PV statewide.
- *Sierra Club recommends increasing the assumed total rooftop PV (or the equivalent in other onsite renewable generation) in 2050 from 10,000 MW to 15,000 MW, as more in line with the state's zero net energy policy for residential construction after 2030.*

5. Sierra Club agrees with most CEC staff assumptions about energy storage, except there may be a need for additional storage in 2050.

- Sierra Club agrees with CEC staff's increased value for the efficiency of energy storage from 70% to 80%, especially for distributed battery technologies.
- The energy demand value for 2010, and forward forecasts from that date, should already incorporate the existing 4000 megawatts of pump storage in California; the existing storage ought to help to integrate renewable energy in the future.
- Sierra Club believes the assumption that 10% of additional energy would be stored in 2040 is reasonable; however, the much higher level of intermittent renewable energy in 2050 is likely to require more energy storage.
- *Sierra Club recommends increasing new storage in 2050 to support 20% of the state's electricity supply.*

II. OTHER FACTORS NOTED, BUT NOT ADJUSTED IN SIERRA CLUB SCENARIOS

1. The CEC-DRECP model assumes a fixed energy growth rate of 1.5% per year to 2050, yet state forecasts show decreasing population growth over time.
Demographic data from the state show decreasing population growth rate over time, from an average of 1.4%/year in the 1990s and 2000s, to only 0.9%/year by the 2040s. This implies that a baseline electricity demand growth of 1.5% per year should also decrease over time, a factor that is not reflected in the CEC-DRECP scenarios for 2040 and 2050, and that Sierra Club has not adjusted in the proposed scenario input values.

2. The CEC-DRECP model may be double counting energy demand of millions of electric vehicles. The CEC-DRECP model assumes that all electric vehicles are additional to the fundamental CEC forecast. Yet the CEC forecast energy demand growth of 1.2% per year to 2020 already embeds within that rate the addition of 1.5 million electric vehicles per decade. This would result in over 8 million electric vehicles if the same compound growth rate were extended to 2050, and might result in double counting of electricity needs for millions of electric vehicles in the DRECP forecast model.

3. The current state efficiency forecasts undercount public utilities' efficiency program savings.
The Energy Commission's forecast of uncommitted efficiency savings only included the Investor-Owned Utilities; the potential savings from new utility efficiency funding and other new measures in the service territories of the publicly-owned utilities was assumed to be zero in all the state forecasts—only known committed efficiency savings and existing funding cycles were incorporated. Publicly-owned utilities serve about one quarter of the state's electricity, making this an important omission. Thus, potential for efficiency savings is likely even higher than the 1.15%/year rate that Sierra Club is proposing.

4. The model has inputs for adding offshore energy, but assumes none is developed before 2050.
The new IEPR emphasizes that most of California's wind resource is offshore, while an assessment from Stanford University shows an offshore wind potential of 140 gigawatts that could generate over 400,000 gigawatt-hours—enough to power the entire state. There is also large potential for offshore wave power. Technologies to tap these offshore resources are currently being developed, and might become commercial well before 2050.

5. The CEC-DRECP model assumes virtually no improvements in renewable energy technology over the next four decades.
The model has assumed no breakthroughs in fuel cell technology, or other potential forms of distributed generation in a state that is staking its future on renewable energy and innovation. The acreages assumed necessary for utility scale solar generation are assumed to remain static over decades, even though technologies such as tracking and/or concentrating PV achieve 30% capacity factors or greater with far less acreage consumption than assumed.

6. The CEC-DRECP scenarios for 2050 rely excessively on transmission, costing $60 - $100 billion, adding security vulnerabilities, and imposing large environmental costs

While transmission requirements are not a direct input into the spreadsheet model, The CEC-DRECP scenarios would need about 60,000 megawatts of transmission capacity to access renewable zones, costing $60 to $100 billion, creating security vulnerabilities for the electric grid, and greatly increasing environmental impacts of the renewable energy program. These problems can be greatly reduced by placing more of the generation resources closer to energy load centers, and by more aggressive energy efficiency programs than the CEC staff model assumes.

III. ANALYSIS AND RECOMMENDATIONS

Assumptions in the DRECP Demand Forecast Should Be Examined More Closely

The CEC-DRECP load growth rate is significantly higher than what is forecast in the IEPR .
The DRECP model's 1.5% annual growth assumption for electricity demand is significantly higher than the CEC IEPR ten-year demand forecast for 2010 to 2020. The California Energy Commission's base case is about 1.2%/year, while even the "optimistic" economic growth scenario shows only 1.3% annual growth in electricity demand out to 2020 (CEC 2009 Demand Forecast, p.6).

Use of the higher growth rate of 1.5%/year might be valid, but implies the need to use higher rates of efficiency savings that are embedded into the 1.2% demand growth rate for 2010 to 2020, but would not be embedded in the 1.5% growth rate. The amount of efficiency savings that is embedded into the forecast is called the "committed" efficiency, while the portion of savings that is beyond what is included in the demand forecast is called "uncommitted efficiency."

By using the 1.5% growth rate it is necessary to assume a larger value for efficiency savings that is otherwise embedded within the 1.2%/year growth rate of CEC's IEPR forecast—the so-called "committed efficiency." The section below on efficiency will examine more closely the relative amounts of committed and uncommitted efficiency that need to be included to derive a correct value for efficiency savings over the next decade. Specifically, if an energy efficiency savings rate of 0.83%/yr is assumed in conjunction with a 1.5% annual demand growth rate, it is likely that a portion of efficiency savings may have been mistakenly removed.

Longer term demographic forecasts assume population growth rate decreases.
Another concern regarding the 1.5% demand growth rate is the fact that state demographic trends show decreasing population growth, a fact reflected in the Energy Commission's electricity demand forecast:

> "Population is projected to grow at about 1.2 percent annually during the forecast period [i.e., 2010 to 2020]. For comparison, statewide population grew an average of 1.4 percent annually from 1990 to 2008. The declining growth rates over the forecast horizon reflect lower rates of fertility and immigration as the population of California and other regions age. Older age cohorts have a lower tendency to migrate." (CEC 2009 Demand Forecast, p. 24.)

For the longer term, the state Department of Finance demographic forecast shows continuing decreases in the population growth rate in future decades, such that the average population growth by the 2040s is expected to be only about 0.93 percent per year. So the farther out the DRECP forecast goes, the lower the demand growth assumption should be, a factor that is not reflected in the spreadsheet model, which assumes 1.5% base growth rate of energy irrespective of whether the target date is 2030, 2040 or 2050.[1]

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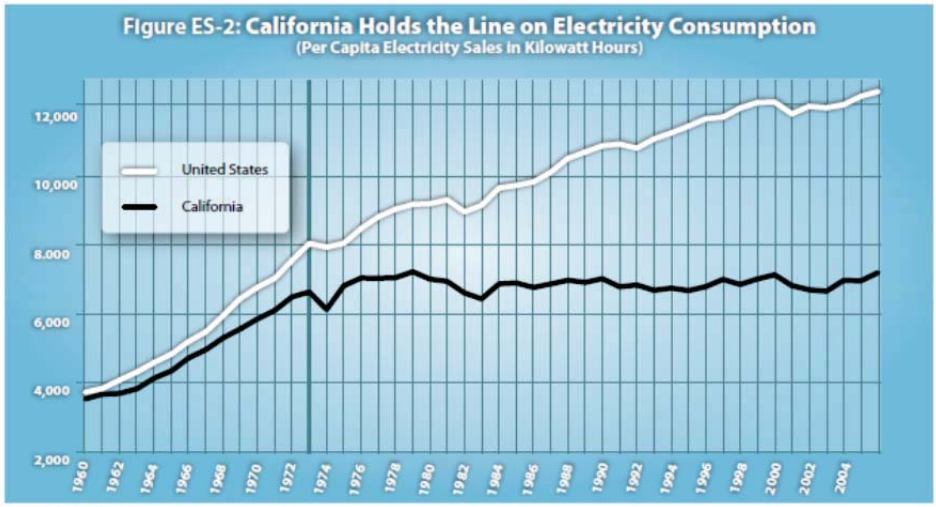
[1] Finance Department Forecast found at: http://www.dof.ca.gov/research/demographic/reports/projections/p-1/

Figure 1: California Population Forecast 2000 to 2050

State Department of Finance Forecast for California Population						
Year	2000	2010	2020	2030	2040	2050
California Poplulation	34,105,437	39,135,676	44,135,923	49,240,891	54,226,115	59,507,876
Period	2000 to 2010	2010 to 2020	2020 to 2030	2030 to 2040	2040 to 2050	
Decadal Growth	5,030,239	5,000,247	5,104,968	4,985,224	5,281,761	
Decadal Percentage Growth	14.7%	12.8%	11.6%	10.1%	9.7%	
Annual Compound Growth Rate	1.39%	1.21%	1.10%	0.97%	0.93%	

California's electricity demand has tracked population growth closely, and—correspondingly—per capita consumption remained fairly level between the mid-1970s and the 2000s. [2]

Figure 2: California per Capita Electricity Consumption, 1960 to 2006

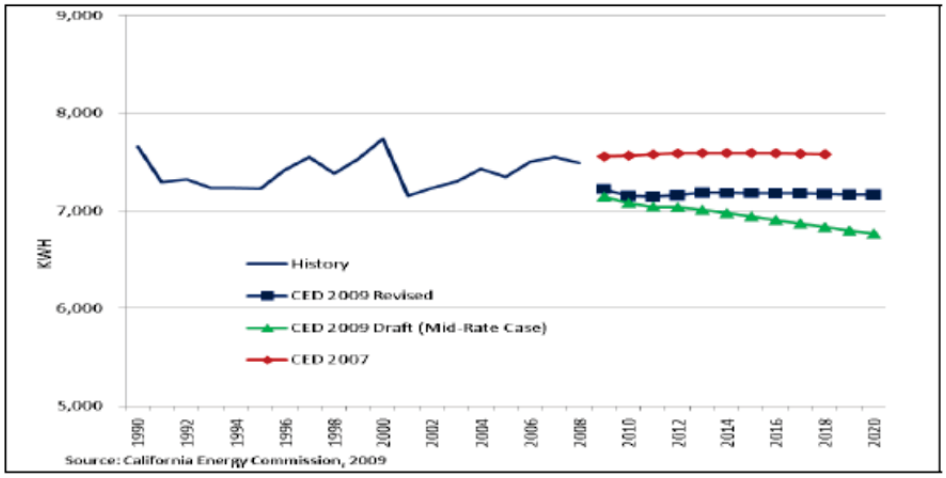


Future per capita electricity consumption cannot remain level and achieve the state's policy goals. The 2009 CEC demand forecast showed electricity consumption continuing at similar levels to the roughly 7000 kilowatt-hours per capita average since the mid-1970s, and in fact revised per capita consumption to a significantly lower level than the 2007 forecast, and also lower than the average per capita consumption since 1990. [3]

[2] The graph is from the *2007 Integrated Energy Policy Report*, California Energy Commission, p.3

[3] *CALIFORNIA ENERGY DEMAND 2010-2020 ADOPTED FORECAST*, December 2009, CEC-200-2009-102-CMF, p. 15.

Figure 3: Statewide per Capita Electricity Consumption from 1990 to 2020



Source: California Energy Commission, 2009

Three recent demand forecasts project per capita electricity consumption to 2020. The 2007 forecast showed future use of over 7500 kWh per person. The 2009 draft forecast showed per capita usage on a downward slope, but this was revised to a relatively flat rate of about 7100 kWh though the next decade—significantly lower than 1990 to 2008.

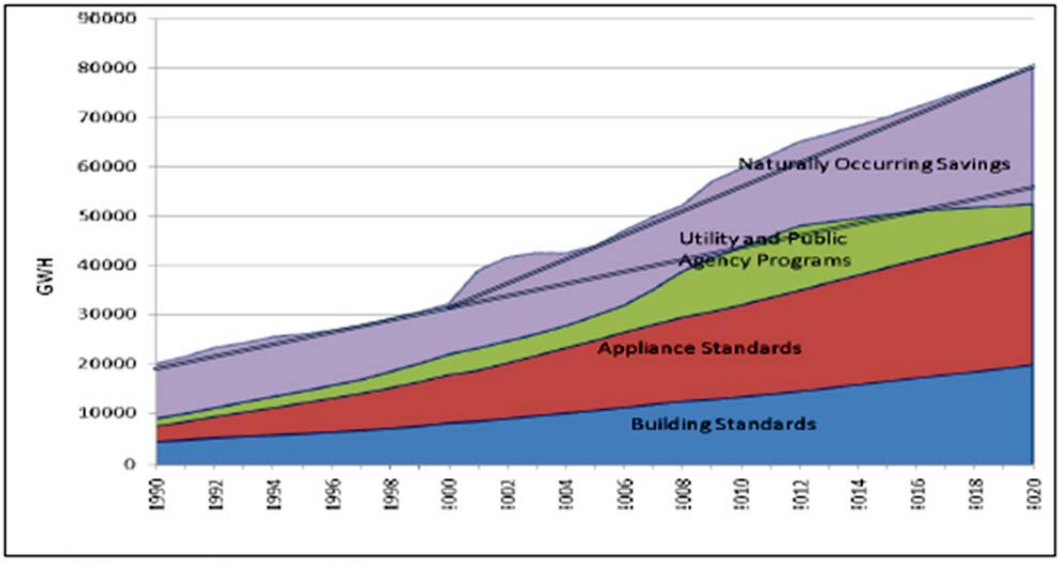
This forecast of per capita electricity use is what results after accounting for *committed efficiency program savings*, but it excludes a large portion of efficiency program savings after 2012 that are referred to as "uncommitted."If the uncommitted efficiency savings are incorporated into the graph, then per capita consumption would be significantly lower than what is shown between 2012 and 2020.

Energy Efficiency Significantly Underestimated or Omitted

Historical trends skewed by low efficiency gains in 1990s. In our view, one of the more serious problems with the CEC-DRECP scenarios is the low range of values used for energy efficiency savings. The staff report on these scenarios states that average efficiency savings from 1990 to 2010 was -0.81% per year, implying that this historical data was the basis for the slightly higher figure of -0.83% per year used in the reference-case scenario. However, the period of 1990 to 1998 had anomalously low rate of savings primarily due to anticipated energy deregulation, while the rate of energy savings in California since 2000 has greatly increased.

The movement toward deregulation in the 1990s held that a "free market" in natural gas power was going to result in electricity rates so low that it would be uneconomic to spend money on alternative sources. During that same period there was also no progress on increasing renewable energy. Efficiency savings rates increased dramatically after 1998 as the state set higher targets and increased funding for utility-administered efficiency programs, a trend that continued into the 2000s and beyond. Between 2004 and 2008 the CPUC doubled utility spending on efficiency, and now it is reaching a level of about $1 billion per year for California's Investor-Owned Utilities.

Figure 4: Distribution of California Efficiency/Conservation Savings by Source



Source: California Energy Commission, 2009

The trend-lines have been added to the chart above to illustrate the low rate of savings throughout the 1990s.[4] If that rate of efficiency deployment had continued, it would have resulted in a shortfall of approximately 25,000 gigawatt-hours per year of annual savings by 2020 compared to the current forecast.

Reasonable estimates of "uncommitted" efficiency should be included in any reference case. The chart above only reports *committed* efficiency program savings—savings for which programs and funding already exist or savings that have already been achieved in the past. New efficiency programs and funding after 2012 are omitted. Thus, the actual rate of efficiency savings after 2012 will be significantly higher than what is shown for that period in the chart above.

The Energy Commission has produced a committee report that developed scenarios for uncommitted efficiency savings between 2010 and 2020 that are not included in the main IEPR demand forecast.[5] The committee developed high, low and mid case scenarios to estimate uncommitted efficiency over the next decade. The committee report's mid case scenario for uncommitted efficiency results in an additional savings of 12,000 gigawatt-hours per year in 2020 beyond what is embedded in the Energy Commission 2009 demand forecast. *This represents 0.5% additional efficiency savings per year between 2012 and 2020.* Once the uncommitted efficiency is accounted for, it becomes clear that efficiency savings in the 1990s

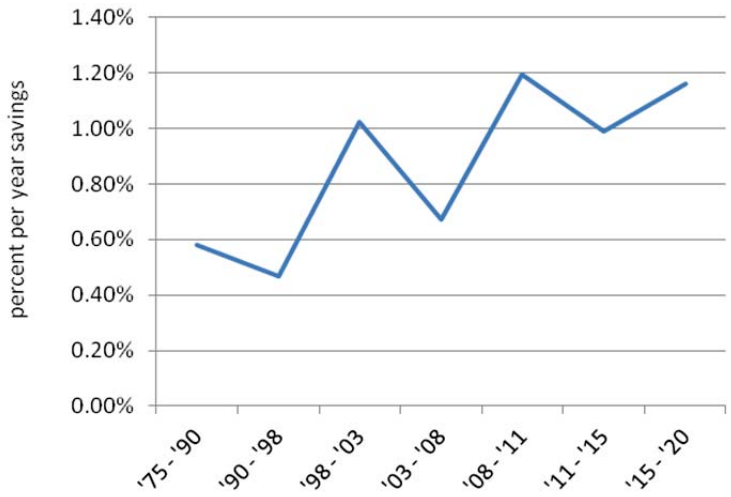
[4] CEC 2009 Demand Forecast, Figure 159, p. 242.

[5] *Incremental Impacts of Energy Efficiency Policy Initiatives Relative to the 2009 Integrated Energy Policy Report Adopted Demand Forecast*, Committee Report, California Energy Commission, May 2012, CEC-200-2010-001-CTF. Table 8, the Mid Savings Scenario, is on page 44 of the committee report. (Shown in Appendix E of this Sierra Club Comment Letter) These values for committed and uncommitted efficiency are added and compared to the reported annual electricity demand for the period in the 2009 CEC demand forecast in Table 34 to derive average percentage efficiency savings for 2012 to 2020.

were the low point for California's efficiency programs since they were first created in the 1970s.

The following table shows efficiency savings rates, presented as annual averages over the successive block periods starting in 1975. The table adds up savings from all forecast programs, including both committed efficiency included in the IEPR demand forecast and uncommitted efficiency from the committee report. [6]

Figure 5: California's Rate of Energy Efficiency Savings from 1975 to 2020



The historical record does not support the assumption that future efficiency will be more difficult and expensive over time. The CEC-DRECP staff report defends the low efficiency growth rate by suggesting that efficiency savings may become more difficult and expensive to achieve as time goes on, citing an unspecified analysis:

> "A recent analysis indicates that annual funding for energy efficiency may have to increase dramatically over the coming decades to maintain the level of benefits projected from current expenditures."

However, this conclusion is not consistent with the historical record. The rate of efficiency savings over the 45-year period shown in the chart clearly increases over time. Furthermore, the historical period over which this growth occurred is even longer than the 40-year CEC-DRECP forecast to 2050, showing that efficiency savings need not be assumed to erode simply because these savings have accrued over decades. Furthermore, there is a major error in the assumption that efficiency savings are mainly a function of spending on utility programs. Spending money on efficiency programs is very important, and Sierra Club strongly supports continued and even increased funding. But at least half of savings between 1975 and 2020 are shown in Figure 9

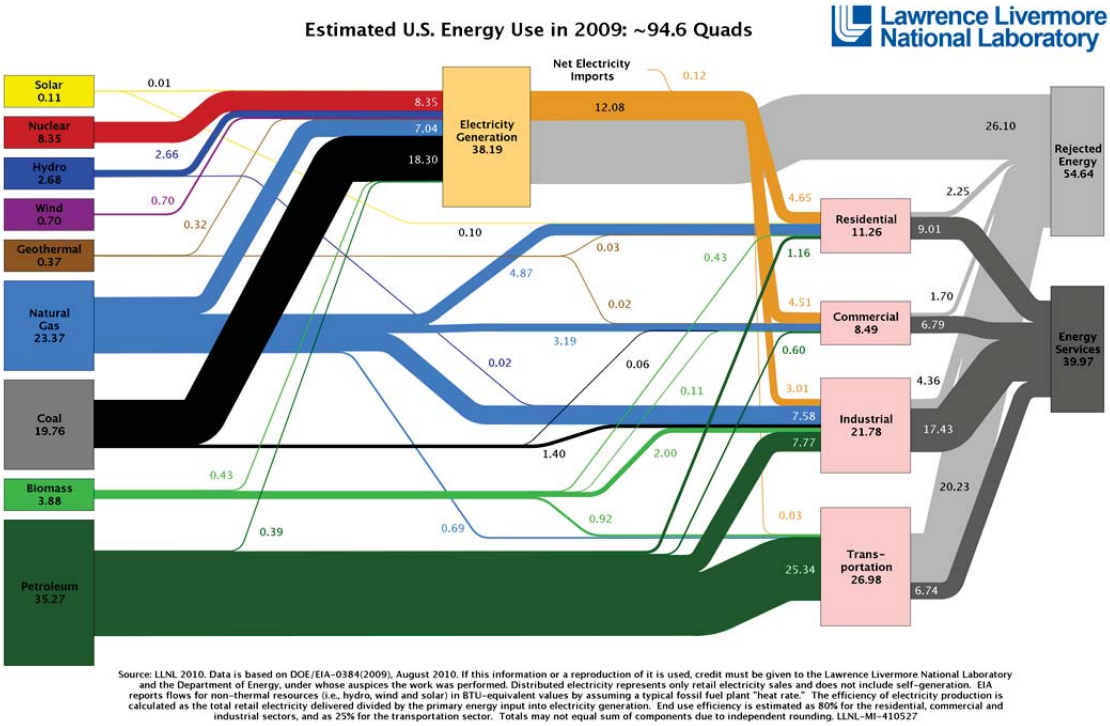
[6] Data for committed efficiency is from *2009 CEC Demand Forecast*, Table 34, p. 241 (shown in Appendix D to this Sierra Club comment letter) and analyzed with a spreadsheet to derive annual incremental savings, since the table shows cumulative savings rather than incremental, and it covers multi-year periods which have to be translated into annual rates.

above to come from improving building codes and appliance standards as well as market developments such as increased utility rates that encourage reduced consumption.

Future potential for efficiency in both electrical and transportation sectors is huge. California is very far from the limits of efficiency savings. As an illustration, compact fluorescents are increasing in market penetration, replacing far less efficient incandescent bulbs. New CFLs emit approximately 60 lumens of light per watt of electricity, compared with about 15 lumens per watt for incandescent bulbs—a fourfold improvement. However, the maximum theoretical luminous efficacy of a white light is about 250 lumens per watt—over four times the efficiency of a CFL. Furthermore, most lighting is often misdirected by fixtures and absorbed by room surfaces, and a large portion of lighting is used during the day when sunshine is ordinarily available. Assuming a 25% efficient CFL has 50% of light that is effectively directed, and that this light is used 50% of the time when people are in the room, and 50% of the light could be replaced by daylight, then the total lighting system is only 2.5% efficient. In fact, this example is probably very optimistic, and some of these measures—such as adding lighting sensors for when people are in the room, or installing venetian blinds that reflect daylight into a room—are relatively cheap and rarely applied. There is layer after layer of improvement that could be implemented, and we are very far from reaching any practical limit of lighting system efficiency.

The transportation sector state of affairs is also ripe for efficiency improvements. A typical vehicle has quite low efficiency in converting fuel into a useful energy, as illustrated by the following chart from Lawrence Livermore Laboratory:

Figure 6: United State Energy System Flow Chart

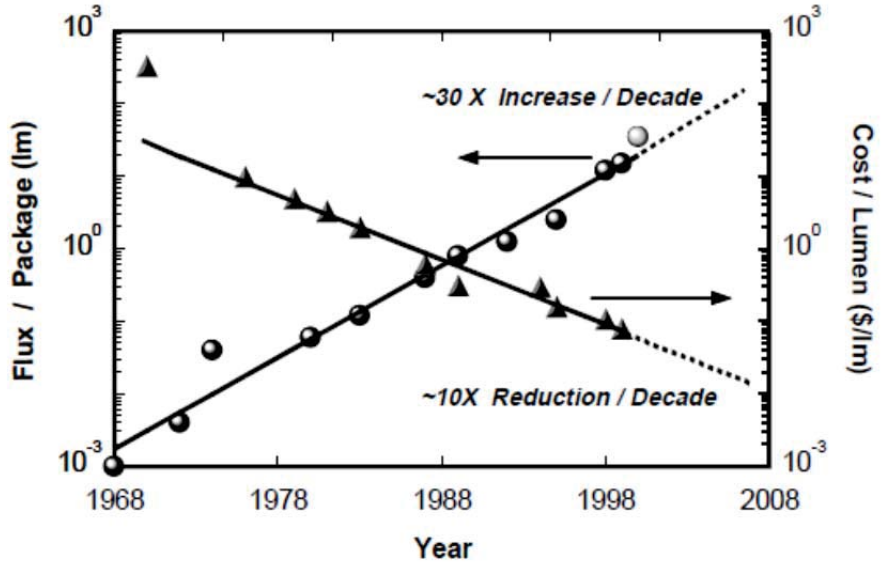


The energy input for U.S. transportation is shown as 26.98 quadrillion BTUs in 2009, of which only 6.74 quadrillion BTUs provided useful energy services—a net efficiency of 25%. This definition includes all energy that is currently used to move vehicles, but is very far from illustrating the limits of possible efficiency gains. A 25% efficiency figure provisionally implies that if we increased gas mileage from its current 25 miles per gallon to 100 miles per gallon, then all efficiency potential would have been tapped. This would be somewhat misleading, as the world record for fuel efficiency was reported by the U.S. Department of Energy back in 2005 as 12,665 miles per gallon using a fuel cell-powered vehicle on a test track in the Shell Eco-Marathon.[7] While the conditions required for reaching this record may never allow commercial applicability, the example shows that current fuel-based technology is much farther from what is technically possible than most people realize.

Thus, both the transportation and electricity sectors are far from being tapped out for efficiency improvements.

Furthermore, the assumption that new measures must "cost more" is misleading. At any given time, new and more efficient technologies will frequently cost more than existing less efficient technology. Historically, new technologies may start out being quite expensive when first introduced; but they often decrease as they are more broadly adopted by the market. CFLs that cost $20 per bulb in the 1990s today may cost as little as $2. Similarly, the price of LED bulbs—the next generation of lighting technology—has been decreasing rapidly even as performance increases.

Figure 7: Haitz's Law—Increasing Efficiency and Decreasing Cost of LEDs [8]



[7] http://www1.eere.energy.gov/vehiclesandfuels/news/news_detail.html?news_id=9166

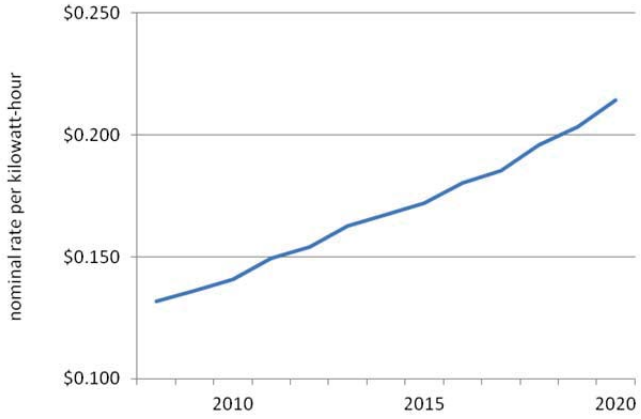
[8] *The Case for a National Research Program on Semiconductor Lighting*, R. Haitz and F. Kish, Hewlett-Packard Co., J. Tsao and J. Nelson, Sandia National Laboratories, white paper presented at the Optoelectronics Industry Development Association, Washington DC, October 6, 1999, p. 5. http://lighting.sandia.gov/lightingdocs/hpsnl_long.pdf

The cost per unit of light from LEDs historically has decreased at a rate of 10-fold per decade, while the amount of light produced by an LED package increased 30-fold per decade, a relationship known as "Haitz's Law" that was derived by examining historical records of LED cost and performance going back to the 1960s. Increasing efficiency and reduced cost of LEDs has continued since it was presented in the 1990s. LEDs are significant because their efficiency potential is far higher than other lighting technologies, because lighting uses about 20% of electricity, and because LEDs have applications beyond basic lighting.

Suggestions that efficiency is running out, or on the verge of pricing itself out of the market, should be balanced with this long record of improving economics. LEDs, flat-screen displays, control systems, and even solar cells— are all semiconductor technologies that increase efficiency and decrease in cost over time, similar to Moore's Law for microprocessors.

The decreasing cost of efficiency is also met over time by increasing utility rates. Retail electric power rates are forecast to increase by 50% between 2010 and 2020, and the general trend of increasing rates seems likely to continue into future decades. This rising cost of energy makes efficiency measures that seemed too expensive in the past, more cost effective in the future.

Figure 8: California Average Electricity Rate 2008 to 2020

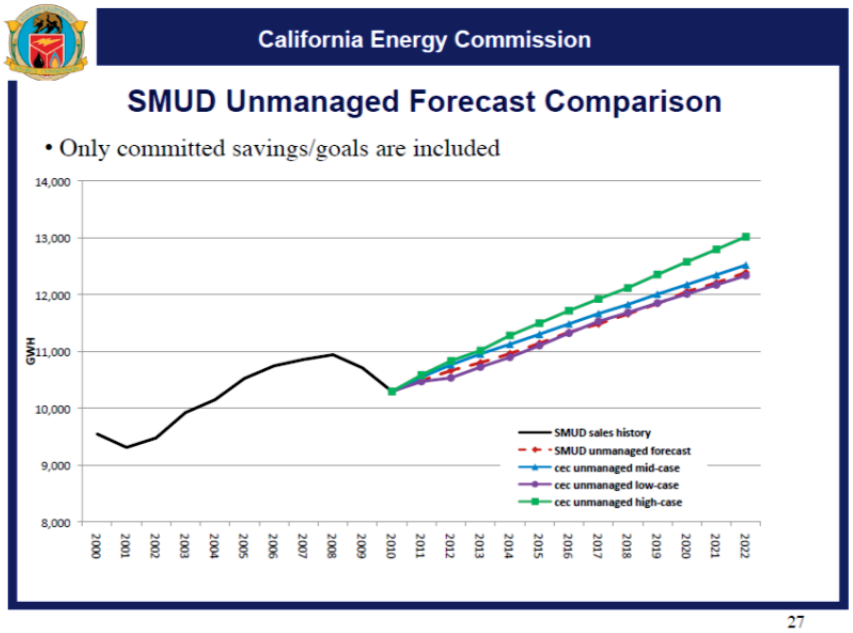


Public utilities show higher efficiency potential. The potential savings in the service territories of the publicly-owned utilities was significantly understated in previous state forecasts—only committed efficiency savings and existing funding cycles were incorporated. And when the commission looked at the potential for new savings over the next decade in the "uncommitted efficiency" report, it only examined the three big Investor-Owned Utilities (IOUs), PG&E, SDG&E, and SCE; Publicly-Owned Utilities POUs) were *not* included. Publicly-owned utilities serve about one quarter of the state's electricity, making this an important omission that tends to under-represent the true amount of efficiency savings expected over the next decade in California.

The forecast efficiency savings from Investor-Owned Utilities fall short of state policy goals, a fact which appears to have lowered expectations from state agencies. However, higher savings is possible if programs are well designed, and are administered by agencies that have better program design and implementation than the Investor-Owned Utilities have currently.

An illustration of the potential for higher efficiency savings is Sacramento Municipal Utility District (SMUD). The new 2011 IEPR forecast shows a 2010 demand of about 10,300 gigawatt-hours, which increases to about 12,400 gigawatt-hours in 2022, implying a growth rate of about 1.55%/year. Note that even the "unmanaged" growth already includes some efficiency savings.

Figure 9: Energy Commission 2011 Electricity Forecast for SMUD [9]



The current IEPR, in developing the 2011 demand forecast, attempts to remedy the omission of large portions of public utility efficiency measures—the so-called "uncommitted" savings which come from new programs and goals that have not yet been funded or adopted, but can reasonably be anticipated. For instance, any savings coming from future budgets that have not yet been approved by SMUD—including continuation of existing programs— would be considered "uncommitted" if the budget or program has not actually been approved yet.

Energy Commission staff evaluated the potential for efficiency in SMUD's territory. The demand growth prior to efficiency savings is referred to as "unmanaged," while the growth rate after efficiency savings is called "managed." The results are quite remarkable—the Commission staff's *managed mid-case* forecast shows demand growth nearly flattened by energy efficiency measures out to 2022, while the *managed low-case* actually shows decreasing demand.

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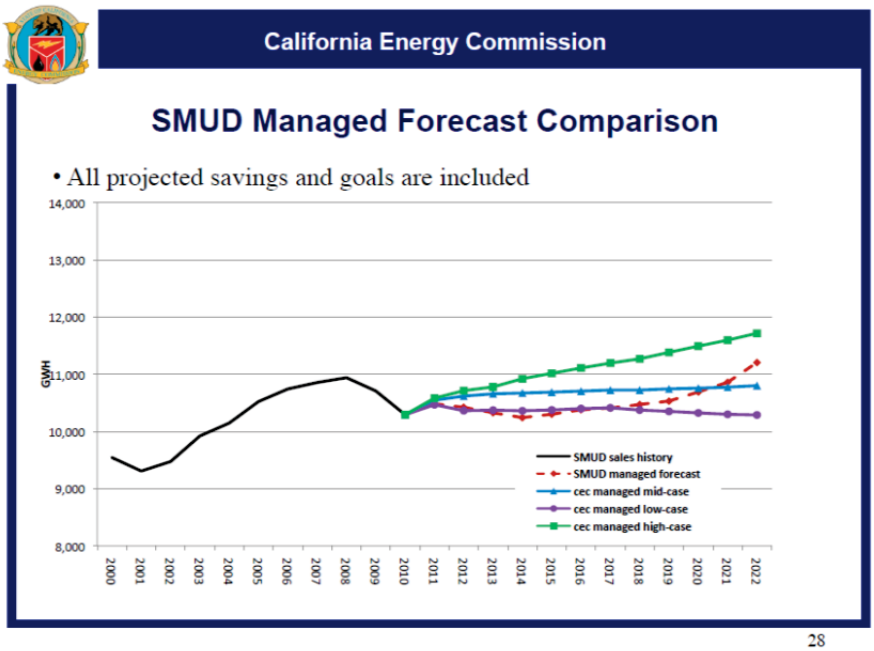
[9] IEPR Committee Workshop, CALIFORNIA ENERGY DEMAND 2011-2022 PRELIMINARY STAFF FORECAST, SMUD Service Area Forecast, Slide 27, Nick Fugate, Demand Analysis Office, Electricity Supply Analysis Division, California Energy Commission.

Figure 10: CEC 2011 Growth Forecast for SMUD after All Efficiency Savings [10]



The growth rate in the managed mid-case is about 0.4%/year, implying a savings rate of 1.15%/year from uncommitted programs alone—in other words this rate does not include the committed efficiency savings.

Consideration of publicly-owned utilities shows that:

> 1) The state's future efficiency savings rate is higher than previous estimates, due to omission of most of the savings from publicly-owned utilities,
>
> 2) The efficiency forecast for SMUD shows mid-case efficiency savings in the future that are much higher than the CEC-DRECP assumption of 0.83%/year—refuting the notion that cost-effective efficiency is currently "running out."

Current state Zero Net Energy Buildings policies could eliminate demand growth for grid power after 2030. The state has a policy for Zero Energy Buildings, reflected in the CPUC's Zero Net Energy Action Plan.[11] This plan has four features that are embodied in the Big Bold Energy Efficiency Strategy:

1. All new residential construction in California will be zero net energy by 2020,

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[10] *ibid*, Slide 28, Nick Fugate, Demand Analysis Office, Electricity Supply Analysis Division, California Energy Commission. http://www.energy.ca.gov/2011_energypolicy/documents/2011-08-30_workshop/presentations/08_Nick_Fugate_SMUD_Planning_Area_Forecast.pdf

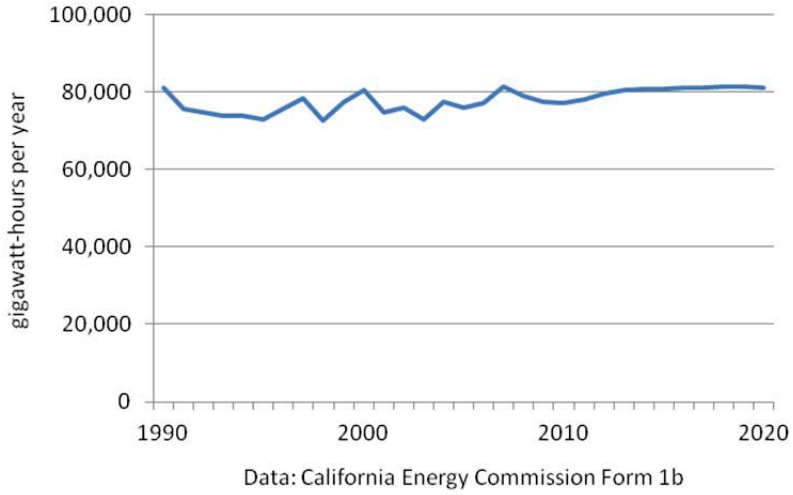
[11] http://www.cpuc.ca.gov/NR/rdonlyres/6C2310FE-AFE0-48E4-AF03-530A99D28FCE/0/ZNEActionPlanFINAL83110.pdf

2. All new commercial construction in California will be zero net energy by 2030,
3. Heating, Ventilation and Air Conditioning (HVAC) will be transformed to ensure that its energy performance is optimal for California's climate, and
4. All eligible low-income customers will be given the opportunity to participate in the low income energy efficiency program by 2020.

California's residential and commercial sectors are forecast to account for 220,000 out of 301,000 gigawatt-hours of electricity sales in 2020. [12] Thus commercial and residential buildings—which for all practical purposes are assumed here to be identical to consumption for these sectors— represent 72% of demand. Growth in electricity demand in California is driven by population which is closely tied to new construction to house additional people. After 2030, the current state policy is that electricity used by new buildings should not increase demand on the grid. Thus, 70% of electricity demand should be at or near zero growth after 2030.

The principal exception to the zero net energy policy is energy demand from industry, mining, agriculture, pumping loads, and street lighting, sectors that historically have shown very little if any growth in energy use. This chart shows the sum of electricity consumption from these sectors that are not covered by the zero net energy (ZNE) policy, but excluding vehicle use: [13]

Figure 11: Electricity Demand in Non-Zero Net Energy Sectors



Demand for electricity by industrial customers was 41,414 gigawatt-hours in 1990, and is forecast to be 37,393 gigawatt-hours in 2020, a *decrease* of 4,000 gigawatt-hours over 30 years.[14] During the same period, the Energy Commission demand forecast shows that industrial

[12] *CALIFORNIA ENERGY DEMAND 2010-2020 ADOPTED FORECAST*, December 2009, CEC-200-2009-102-CMF, Form 1.1b, p. 38, shows 107,398 gigawatt-hours of energy demand in the residential sector, and 112,754 gigawatt-hours in the commercial sector, at total of approximately 220,000 gigawatt-hours out of a total forecast retail sales of 301,385 gigawatt-hours.

[13] *ibid*, p. 38. The graph shows the sum of the non-building sector electric energy use data from CEC Form 1.1b: industrial, mining, agriculture, TCU, and lighting. It does not include electric vehicles, which is dealt with in the next section of this comment document.

[14] *ibid*, p. 38. This table is also presented as Appendix A in this document.

production increases from $138 billion in 1990 to $362 billion in 2020 (both figures in 2007 fixed dollars). The value of industrial production in 2020 is forecast to be 2.6 times what it was in 1990, yet the sector will consume 10% less electricity.

This shows that energy intensity per dollar of economic output—one important measure of efficiency— can maintain a high level of improvement over a 30 year period. It also shows that economic growth of the industrial sector does not necessarily drive growth in electricity consumption, since industry is even more driven to improve energy efficiency than the commercial and residential sectors.

Current state policy, if implemented, should prevent any significant growth of electricity *retail sales* after 2030 in almost every sector. Zero net energy policy will result in increased *total electricity use* and consumption; however, the buildings should produce enough on-site electricity to offset on-site electricity consumption. This policy implies significantly more distributed generation than the 12,000 megawatts of PV assumed in CEC-DRECP scenarios, which will be covered in the discussion of distributed generation later in this report. Taken together, these factors suggest that electric vehicles will be the only significant driver of growth in electricity demand that draws upon grid power after 2030.

Increasing the annual rate of energy efficiency savings from 0.83% to 1.15% is recommended. Sierra Club proposes replacing the 0.83% per year energy efficiency assumption with 1.15% per year, which reflects historical trends. This proposed higher number is simply a continuation of current savings and existing policy, and is lower than the 1.4% efficiency savings per year that the Western Governors' Association (WGA) adopted as a policy goal for the 15 year period of 2006 to 2020, based upon a review of existing efficiency programs and potential studies in the Western U.S.:

> "In general, the efficiency potential studies show it is possible to reduce electricity demand growth by 0.5-2% per year through more concerted energy efficiency efforts. For comparison, the energy efficiency goal in the WGA clean and diversified energy resolution is equivalent to about a 1.4% annual reduction in electricity demand growth. Studies that consider a wider set of efficiency measures and more aggressive implementation strategies tend to project savings at the higher end of this range, while those with more limited measures and/or more conservative assumptions about measure adoption are at the lower end." [15]

An assumption of 0.83%/year efficiency savings is 40% lower than the WGA goal and almost 30% lower than the CEC's forecast efficiency rates for 2000 to 2020 in California.

The recommended increase is aligned with state climate policy. Furthermore, the CEC 2009 Demand Forecast falls significantly short of the target set by the AB 32 Scoping Plan of 32,000 gigawatt-hours reduction by 2020.

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[15] Clean and Diversified Energy Initiative, *Energy Efficiency Task Force Report*, Western Governors' Association, January 2006, p. vi, http://www.westgov.org/component/joomdoc/doc_download/94-energy-efficiency

Figure 12: California Climate Plan Electricity Efficiency Targets [16]

($MMTCO_2E$ in 2020)

Measure No.	Measure Description	Reductions
E-1	Energy Efficiency (32,000 GWh of Reduced Demand) • Increased Utility Energy Efficiency Programs • More Stringent Building & Appliance Standards • Additional Efficiency and Conservation Programs	15.2
E-2	Increase Combined Heat and Power Use by 30,000 GWh	6.7
	Total	21.9

The AB 32 Scoping Plan proposed demand reduction is to be "additional to savings currently assumed to be incorporated in CEC's 2007 demand forecasts," which already included significant savings. The values for efficiency are calculated by the Commission on the base year of 1975, so it is necessary to take the difference between 2008 and 2018 to see what annual efficiency savings are new in the forecast period of 2007 to 2018, which is equal to 63,323 (for 2018) less 47,383 (for 2007) = 15,940 gigawatt-hours of new annual savings that are embedded in the 10-year demand forecast out to 2018.

Figure 13: Estimates of Efficiency Savings for California Investor-Owned Utilities

	Residential Energy Savings (GWH)				Commercial Energy Savings (GWH)				
	Building & Appliance Standards	Utility and Public Agency Programs	Market and Price Effects	Total	Building & Appliance Standards	Utility and Public Agency Programs	Market and Price Effects	Total	Total Energy Savings
1990	5,740	994	253	6,987	2,499	398	12,109	15,006	21,993
2000	11,650	1,308	413	13,371	6,736	1,358	8,259	16,353	29,724
2005	14,615	1,416	447	16,478	9,572	1,987	13,724	25,283	41,761
2008	16,336	1,355	458	18,149	11,682	2,132	15,420	29,234	47,383
2013	18,977	1,256	476	20,709	15,563	2,094	17,135	34,792	55,501
2018	21,533	1,186	497	23,216	19,608	2,052	18,447	40,108	63,323
	Residential Peak Savings (MW)				Commercial Peak Savings (MW)				
	Building & Appliance Standards	Utility and Public Agency Programs	Market and Price Effects	Total	Building & Appliance Standards	Utility and Public Agency Programs	Market and Price Effects	Total	Total Peak Savings
1990	1,717	325	56	2,099	460	62	2,303	2,825	4,924
2000	3,066	426	92	3,584	1,279	256	1,409	2,943	6,527
2005	3,772	501	100	4,373	1,807	378	2,846	5,032	9,405
2008	4,121	489	102	4,713	2,195	406	3,248	5,849	10,562
2013	4,677	451	106	5,235	2,928	399	3,610	6,937	12,171
2018	5,277	425	111	5,814	3,697	391	3,899	7,986	13,800

Source: California Energy Commission, 2007.

The Air Resources Board (ARB) additional efficiency target of 32,000 gigawatt-hours adds about 1% energy savings per year to existing programs, in relation to the average electricity generation for meeting load that is forecast to increase from about 290,000 gigawatt-hours in

[16] *Climate Change Scoping Plan*, California Air Resources Board, December 2008, p. 44.

2010 to about 327,000 gigawatt-hours in 2020. However, the total efficiency savings target by 2020 implied by ARB's AB32 Scoping Plan should be considerably larger because the efficiency savings in the ARB plan is additional to the efficiency already embedded in the demand forecast.

This assumes that the state's policies for energy efficiency are implemented, which we maintain should be built into any modeling exercise for achieving 80% reduction in greenhouse gas emissions. Of course, implementation does not guarantee that targets will necessarily be met; Sierra Club's model assumptions include a margin for shortfall relative to efficiency targets that is backfilled by renewable energy to meet carbon reduction goals.

Electric Vehicles' Energy Consumption Should be Revised Downward

The revised calculator increases the number of electric vehicles forecast for 2040 from 5.2 million in the May 2011 version to 17 million in the October version. For 2050, the model assumes a penetration of 41.6 million electric vehicles, consuming over 170,000 gigawatt-hours of electricity per year. This is equivalent to 60% of current electricity consumption in California. Sierra Club supports aggressive electrification of transportation due in part to the higher efficiency of electric vehicles compared to internal combustion technology, as well as the ability to move the transportation sector to energy sources that do not emit pollutants, including greenhouse gases.

However, several problematic assumptions in the CEC-DRECP scenarios tend to increase electricity use by these vehicles far beyond what has been found in other reports. The Energy Commission's 2009 demand forecast (CED) shows much smaller electricity consumption by plug-in hybrids, as does an EPRI/NRDC study of future electric vehicle energy consumption that was noted in the 2009 demand forecast.

Some EV growth is already embedded in CED load forecast, so the CEC-DRECP model may include double-counting and if so, this should be corrected. The fundamental load forecast growth rate in the CEC-DRECP calculator is performed *100% prior* to calculating load growth due to electric vehicles, while the Energy Commission in the IEPR demand forecast *includes* electric vehicle growth inside the load forecast.

> "*CED 2009 Adopted* incorporates a forecast for electricity consumption from light-duty electric vehicles (EVs), including both dedicated EVs and plug-in hybrids, provided by the Energy Commission's Fuels Office." [17]

The *CED 2009 Adopted* forecast includes the number of vehicles in total as well as itemized by year and by service territory in the state:

[17] *CALIFORNIA ENERGY DEMAND 2010-2020 ADOPTED FORECAST*, December 2009, CEC-200-2009-102-CMF, p. 32.

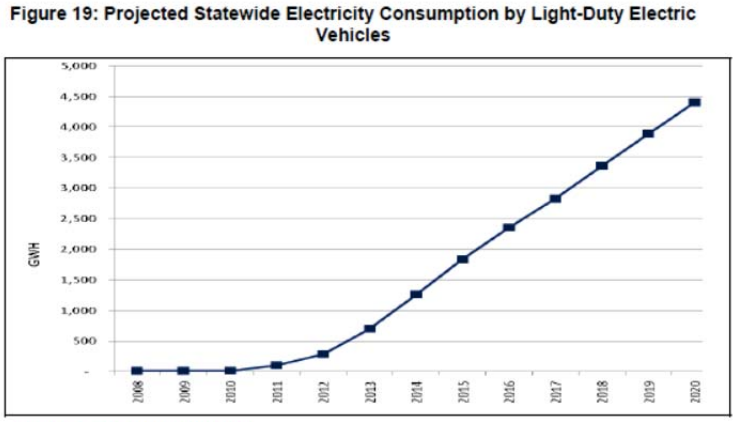
Figure 14: Forecast of Electric Vehicles by Planning Area

Year	Burbank/ Glendale	Imperial	LADWP	Pasa-dena	PG&E	SCE	SDG&E	SMUD	Total
2009	18	16	230	8	807	807	215	89	2,191
2012	812	972	10,327	381	39,511	38,954	9,941	3,993	104,892
2015	4,744	6,073	60,322	2,224	236,084	232,464	58,777	23,596	624,284
2018	8,572	11,681	108,992	4,018	435,981	428,821	107,430	43,145	1,148,641
2020	11,061	15,701	140,634	5,184	570,891	561,096	139,674	56,111	1,500,352

Source: California Energy Commission, 2009

The demand forecast includes a chart, which shows growth of electricity usage from electric vehicles: "**Figure 19** shows projected statewide electricity consumption for EVs, which reaches around 4,400 GWH by 2020. Results for the five major planning areas are provided in Chapters 2-6 of this report." [18]

Figure 15: Projected Statewide Electricity Consumption by Light-Duty Electric Vehicles



Source: California Energy Commission, 2009

Electricity consumption of 4,400 gigawatt-hours for electric vehicles is almost 1.5% of forecast state retail sales in 2020. This increasing energy demand for electric vehicles is embedded into the growth rate of 1.2% per year. This means that more than one year's worth of growth over the decade is coming from electric vehicles. If the energy growth rate for electric vehicles is extrapolated— at 0.14% per year—then 8 million EVs would be embedded in the assumed growth rate by 2050, consuming 19,000 gigawatt-hours. This represents the equivalent of 5000 megawatts of wind capacity by 2050 to provide that extra amount of renewable power.

Thus, it is important to determine whether the 1.5% annual growth rate assumption embeds the effect of increasing electric vehicles that were included in the 2009 Energy Commission demand forecast, and correct double-counting if it is occurring. We also request that the assumptions and

[18] *ibid*, p. 33

the numbers behind the CEC-DRECP demand forecast be explained to stakeholders in a public document in a manner that clarifies this question.

Energy Commission's estimate of electric-use percentage by plug-in hybrids is half that of CEC-DRECP assumption. The CEC-DRECP model assumes that plug-in hybrid electric vehicles (PHEVs), which account for nearly all of the electric vehicles in the scenarios, will travel 90% of their distance on electricity. The Energy Commission in the 2009 demand forecast, on the other hand, only assumes that 50% of the distance will be electric.[19] The Commission's assumption in the demand forecast makes sense, since this implies a fleet that would have half the battery weight and cost. This would increase the efficiency of vehicles and reduce the number of kilowatt-hours required per mile of travel, since reduced batteries means much less weight.

The smaller amount of batteries will also reduce the vehicle cost. The Chevy Volt PHEV costs about $42,000, about a quarter of which is the cost of the battery. Reducing cost will be essential if EVs are to displace future gasoline cars that will be required by law to get 35 miles per gallon on the highway. Cars with similar performance currently sell for $15,000 to $25,000, so reducing batteries in electric vehicles is an important strategy for competitiveness.

The DRECP spreadsheet has several assumptions about PHEV performance that are inconsistent with other state documents. One of the most important is the DRECP model assumption that 90% of travel miles will rely on electricity. A study by the Electric Power Research Institute (EPRI) with the Natural Resources Defense Council (NRDC) projected electric vehicle use, energy consumption and greenhouse gas emissions in the US out to 2050.[20] This report was cited in the 2009 Energy Commission demand forecast.[21] The EPRI/NRDC report uses three different vehicle designs to model what percentage of driving distance will use electric power for PHEVs; this is referred to as the "utility factor." Each PHEV design has a different maximum electric power range of 10 miles, 20 miles and 40 miles, with annual electricity usage varying according to the total annual miles driven. The following chart from the EPRI/NRDC report shows that as PHEVs drive more miles, the percentage of electric miles—the utility factor—decreases. (p. 4-8):

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[19] *CED 2009 Adopted Forecast*, p. 33.

[20] *Environmental Assessment of Plug-in Hybrid Electric Vehicles, Volume 1: Nationwide Greenhouse Gas Emissions*, Electric Power Research Institute, July 2007.

[21] *CALIFORNIA ENERGY DEMAND 2010-2020 ADOPTED FORECAST*, December 2009, CEC-200-2009-102-CMF, p. 33.

Figure 16: EPRI Model of Miles Traveled by Plug-in Hybrid Electric Vehicles

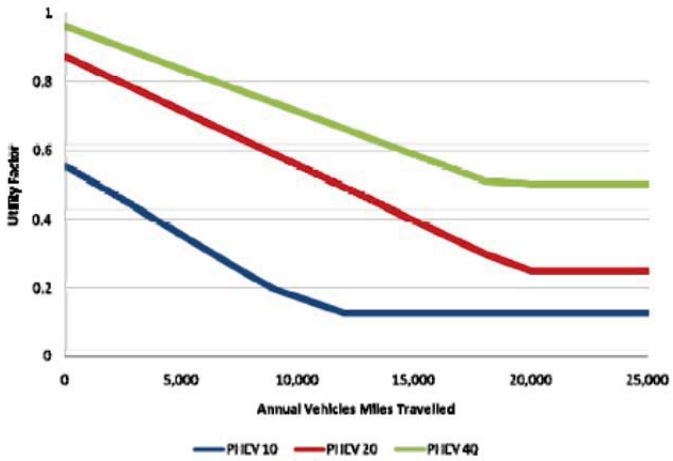


Figure 4-2
PHEV Utility Factor as a function of AER and annual VMT, assuming nightly charging.

CEC-DRECP's assumption of 90% utility factor is almost off the chart and would imply a PHEV with the highest electric range, and that travels less than 3000 miles per year. There is no contemplated PHEV technology that would travel 90% of miles on electricity with normal annual driving distances of 10,000 to 15,000 miles per year. The EPRI study assumes, reasonably, that there will be a mix of different ranges, depending on consumer choice. In this case, it is unlikely that a mixed fleet of PHEVs will exceed 50% electric utilization. However, Sierra Club's proposed scenario assumes a 66% electric utility factor, which implies consumer behavior and public policies that support PHEVs with longer all-electric range. This also helps support the overall goal of carbon reduction, and fits within the parameters of EPRI's modeling for PHEV technology. The following chart gives EPRI's specific values for the range of vehicle technologies in 2050:[22]

Figure 17: EPRI Table of Vehicle Energy Consumption in 2050

[22] *Environmental Assessment of Plug-in Hybrid Electric Vehicles*, p. 5-4.

		CV	HEV	PHEV 10	PHEV 20	PHEV 40
Annual mileage	mi	12,000	12,000	12,000	12,000	12,000
Utility Factor		n/a	n/a	0.12	0.49	0.66
Gasoline consumption	gal	400.0	259.2	226.8	131.8	87.7
Electricity consumption	kWh	-	-	382	1,504	2,024
Fuel economy	mpg	30.0	46.3	46.3	46.3	46.3
Electric efficiency	AC kWh/mi	n/a	n/a	0.255	0.255	0.255

Yearly vehicle miles traveled (VMT) conflicts with current state goals. The CEC-DRECP scenarios assume cars will travel an average of 13,000 miles per year in 2050, which is higher than the U.S. average of 12,000 miles per year assumed by EPRI. Furthermore, the state's plans for climate protection include reducing vehicle miles driven. This policy is reflected in the California Alternative Fuels Plan, which envisions going from 8600 vehicle miles per capita per year in 2005 to 8200 in 2050—a modest decrease of 5%. [23]

Figure 18: California Alternative Fuels Plan Potential Path to 2050 Vision

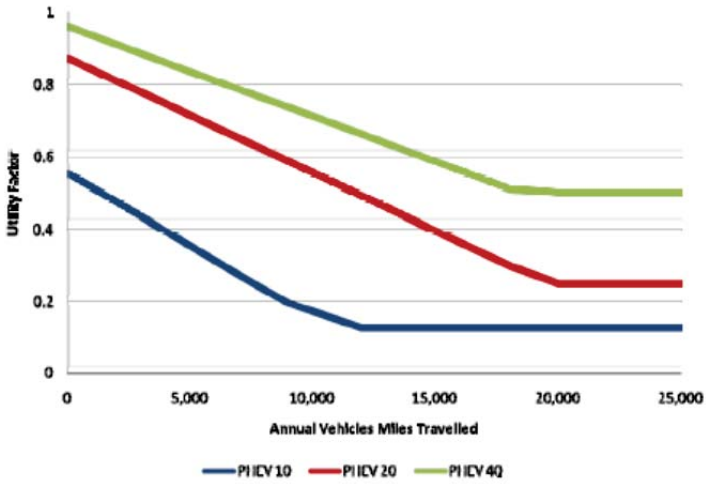


Figure 4-2
PHEV Utility Factor as a function of AER and annual VMT, assuming nightly charging.

The per capita measure is slightly different from VMT per vehicle; however, a simple approximate translation could be attempted as shown here:

Figure 19: Implied Vehicle Miles Traveled in 2050 in California Alternative Fuels Plan

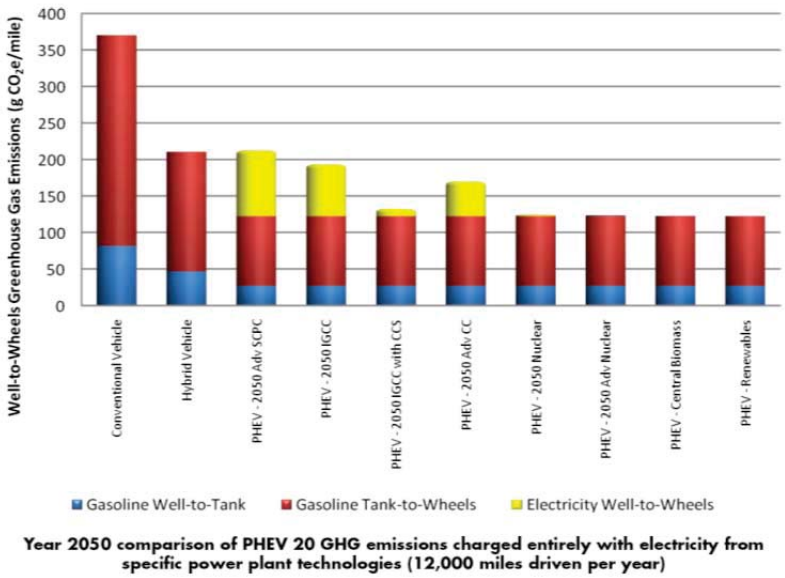
[23] *State Alternative Fuels Plan*, California Energy Commission and California Air Resources Board, December 2007, CEC-600-2007-011-CMF, p. 68.

item	number	vmt/item
number of vehicles in 2050	39,000,000	11,538
estimated population	55,000,000	8,182
annual vmt	450,000,000,000	

The state's alternative fuel plan envisions lower miles per vehicle—approximately 11,500 vehicle miles per year— than the EPRI/NRDC report, departing even further from the CEC-DRECP assumption of no improvement in meeting state goals for VMT over the next 40 years. The assumption of 13,000 miles per year is also inconsistent with the CEC-DRECP model assumption of a high value of 90% for electric "utility factor." The EPRI/NRDC report chart shown earlier, marked Figure 4-2, shows 3 different "utility factors" at a driving distance of 12,000 miles—12% for PHEV10s, 49% for PHEV20s, and 66% for PHEV 40s.

The assumption that fewer than 90% of vehicle miles would be driven on electricity is still capable of bringing transportation near to the 80% GHG reduction target for 2050, although it will need to be supplemented by other measures. EPRI shows that a 2010 conventional vehicle emits 450 grams of CO2-equivalent per mile of travel, while in 2050 PHEVs are expected to emit about 125 grams CO2-e per mile if the electric grid is powered by renewable energy. The CEC-DRECP proposal for a renewable mix of over 80%, with the balance met by efficient natural gas, would result in emission levels somewhat higher than 125 grams CO2-e, but it would be close. This implies a roughly 70% reduction in CO2 due mainly to the technology shift and high renewable mix, but not incorporating reduced VMT or a low carbon fuel that powers vehicles when they are not using electricity. [24]

Figure 20: EPRI Greenhouse Gas Emission Rates per Mile for Vehicles in 2050



[24] EPRI/NRDC, p. 8.

Future improvements in EV efficiency are underestimated. Another problem with the CEC-DRECP model is that it assumes an average electric vehicle fuel efficiency of 0.33 kilowatt-hours per mile, equivalent to traveling only 3 miles on a single kilowatt-hour. This is reasonably representative of current commercialized electric cars in 2012; but the model assumes no further improvement in electric vehicle efficiency by 2040 or 2050; in our view this assumption is improbable. Tesla Roadsters are already achieving substantially better performance today—0.21 kWh/mile at 55 mph, or nearly 5 miles per kilowatt-hour—than the 3 miles per kilowatt-hour that the CEC-DRECP model assumes for 2050. [25]

If EVs are going to dominate world transport, then they will need to greatly improve in many respects over current showroom models. Batteries will become lighter, control systems better, and costs will decrease.

The range of possible improvement for how many miles can be juiced by an electric car out of a single kilowatt-hour is highlighted by the Shell Challenge world record of 1108 kilometers (688 miles)—over 200 times farther than current commercial electric cars. [26] While this type of high performance may never reach commercialization, the example does show that there is enormous potential for improvement. Some gain from the present performance of 3 miles per kilowatt-hour by 2040 should be expected, when 688 miles per kilowatt-hour is possible today with an advanced design electric car.

A conservative assumption is given in the EPRI/NRDC report, which shows reduction from 2010 models of 0.312 AC kWh/mile to 0.255 AC kWh/mile in 2050, a value we recommend adopting in the DRECP model. [27]

Distributed Generation

Meeting Zero Net Energy goals will require over 15,000 MW of new rooftop PV. Sierra Club appreciates that the revised scenarios have greatly increased the amount of forecast distributed generation; however, we believe even higher amounts are justified. As noted earlier in these comments, the state has set goals for Zero Net Energy buildings through a combination of building design improvements, better efficiency of appliances, and onsite power generation. Most of the on-site generation will probably be solar photovoltaics (PV). The following table shows a simple method for estimating the amount of rooftop solar PV that will be needed to zero-out electricity consumption for new households constructed between 2020 and 2050. The model uses the California Department of Finance population forecast, and assumes 3 people per household, similar to levels forecast out to 2020. The model also assumes that zero-net energy households will use 30% less electricity than the current average. This results in the need for a little more than15,000 megawatts of new distributed solar PV generation (or the equivalent in other on-site renewable energy generation) after 2020.

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[25] http://www.teslamotors.com/goelectric/efficiency

[26] http://www.shell.com/home/content/ecomarathon/europe/for_media/news_and_media_releases/2011/may_28_winners.html

[27] *Environmental Assessment of Plug-In Hybrid Electric Vehicles, Volume 1: Nationwide Greenhouse Gas Emissions*, Final Report, EPRI & NRDC, July 2007. Tables 5-1 & 5-2 on pp. 5-2 & 5-4 respectively.

Figure 21: Zero Net Energy Electricity Needs for Residential Sector in 2050

Current per Household Consumption	7040	kilowatt-hours
ZNE Policy Reduction	-30%	
ZNE New Household Est. Annual Usage	4928	kilowatt-hours
PV System Capacity Factor	19%	
PV System Size to Offset ZNE Household	3.0	kilowatts
2020 Population	44,135,923	
2050 Population	59,507,876	
Population Increase	15,371,953	
Persons per Household	3	
New Households 2020 to 2050	5,123,984	
Distributed Solar PV Capacity	15,171	megawatts

After 2030, all new commercial construction will also need to be zero net energy, which implies additional on-site generation beyond what is shown in the table above. Sierra Club proposes that the CEC-DRECP model should show 15,000 megawatts of new rooftop solar PV, at a minimum, for compliance with the adopted zero net energy policy.

Decreasing solar PV prices will drive greater penetration of rooftop solar statewide and eventually out-compete remote large-scale PV. In Germany today, the cost of distributed solar PV projects smaller than 100 kilowatts is only 2.42 Euro per watt, equivalent to about $3.35 per watt in US currency. [28] While the cost of small scale solar PV in California is currently about double this amount, the prices in California are decreasing quickly and it is only a matter of time before costs in California approach Germany's in 2012. Certainly within the timeframe of the

[28] *Statistic data on the German solar power (photovoltaic) industry*, a factsheet from the German Solar Industry Association (BSW-Solar), June 2011.

DRECP model, looking out to 2040 and 2050, it is likely that distributed solar PV will cost in the range of $1.00 to $2.00 per watt installed. This is in line with U.S. government policy in the Department of Energy's Sunshot program, which seeks to reduce the cost of fully installed solar PV projects to only $1.00 per watt by 2020. The 50-year historical pricing trends in the solar PV industry also point toward this eventuality even if there were no Sunshot program. Solar panels have been decreasing about $1.00 per watt every 5 or 6 years since at least the 1980s.

The 2009 CPUC report on the cost of the 33% RPS, cited earlier, showed that building seven major new transmission lines carrying about 12,000 megawatts would cost $12.3 billion. This is equal to at least $1.00 per watt, and has major implications for the long-term economics of building remote renewables.

Figure 22: CPUC 2009 Transmission Assumptions for California RPS Programs [29]

Table 4. Locations of Renewable Resource Zones in 33% RPS Reference Case

Resource Zones Selected in Reference Cases		
Included in 20% and 33% RPS Reference Cases		
	MW	GWh
Tehachapi	3,000	8,862
Distributed CPUC Database*	525	3,118
Solano	1,000	3,197
Out-of-State Early*	2,062	6,617
Imperial North	1,500	9,634
Riverside East	1,350	3,153
Included in 33% RPS Reference Case Only		
Mountain Pass	1,650	4,041
Carrizo North	1,500	3,306
Out-of-State Late*	1,934	5,295
Needles	1,200	3,078
Kramer	1,650	4,226
Distributed Biogas*	249	1,855
Distributed Geothermal*	175	1,344
Fairmont	1,650	5,003
San Bernardino - Lucerne	1,800	5,020
Palm Springs	806	2,711
Baja	97	321
Riverside East Incremental	1,650	3,869
Total	**23,798**	**74,650**

* Aggregations of renewable resources that do not need new in-state transmission development.

By the 2030s, and possibly much sooner, the capacity cost of constructing transmission will make building remote fixed-array solar PV projects more costly than distributed solar PV. The Sunrise Powerlink is expected to cost nearly $2.00 per watt, which already today make remote solar projects more expensive than the most economical distributed rooftop solar PV when transmission costs are factored in. The superior solar resource in the desert, approximately 10% to 20% higher than other regions of the state, will not be sufficient to maintain the benefit of desert solar projects, especially if there are 5% to 10% network line losses.

The principal justification for remote solar in the desert in the future will likely be construction of high-efficiency concentrating solar thermal and concentrating solar PV with tracking. This

[29] *33% RENEWABLES PORTFOLIO STANDARD, Implementation Analysis Preliminary Results*, California Public Utilities Commission & E3, June 2009, p. 21.

provides a much higher capacity factor as well as more consistent power during the full day compared to rooftop solar applications. However, concentrating PV has much lower land intensity than low-cost thin-film or even than higher efficiency fixed flat-plate modules, a factor that is not captured in the CEC-DRECP model scenarios. Furthermore, even with the important performance benefits, the cost of tracking, concentrating solar technologies will have to come down significantly to compete with conventional fixed array PV.

A similar case could be made regarding placing large amounts of wind power in the desert, when local wind resources are available throughout California—both distributed and larger scale. If the cost of installed large wind turbines is between $1.20 and $2.00 per watt, then spending another $1.00 per watt on transmission would not balance out using more local wind sites if the local wind resources are 20% to 30% less. Since high quality wind resources are located in most counties in California, local wind power development is already likely to be a cost-effective option. Appendix C shows the wide availability of wind resources throughout California.

Energy Storage

Retain increased storage efficiency; increase storage from 2040 to 2050 to 20%. Sierra Club agrees with the recent increase of energy storage efficiency from 70% to 80% in the model. This better reflects the likely increased use of battery storage in the future. Grid connected batteries, such as Sodium Sulfur (NaS), Vanadium Flow Batteries, or Ultracapacitors, are generally 80% efficient or higher. While this adjustment has been made to the revised calculator, the CEC-DRECP acreage document still retains the old value of 30% energy loss; this document should be corrected to conform to the calculator. [30]

Sierra Club agrees with using 10% energy storage for 2040 scenarios with a 60% renewable energy mix, but we also believe that increasing grid storage may be needed for 2050, especially if much higher penetration of wind and solar is used to meet an 80% renewable target. The proposed 2050 value is 20% grid energy storage, although this storage will be supplemented by electrification of the transportation sector if there are 41 million PHEVs with battery capacity sufficient to travel 40 miles.

Desert acreage requirements per megawatt are too high

Assumed acreage per megawatt required for large-scale solar is too high. According to the text accompanying the May 2011 CEC-DRECP calculator, the acreage per megawatt for solar PV is based on the BLM's Solar PEIS assumption that utility scale PV will consume over 9 acres per megawatt (0.11 MW per acre). This acreage is far higher than the value used by the Renewable Energy Transmission Initiative (RETI), which was about 7 acres per MW for solar PV.[31] RETI's assumption is borne out by recently approved fixed-array thin film projects in the desert. For

[30] D-Vidaver 2040 and 2050 DRECP WG Final 10-21-2011.pdf

[31] *RETI Stakeholder Steering Committee Response to Phase 1A Draft Report Comments*, p. 6-9

example, First Solar's 550 MW Desert Sunlight solar farm site is 3912 acres (7.1 acres/MW),[32] and its 650 MW Antelope Valley One solar site is 4782 acres (7.36 acres/MW).[33]

Similarly, the CEC-DRECP model assumption for solar thermal is at the highest end of the range for land use, at .11 acre per MW, which is the amount of acreage required by the most land-intensive version of power tower technology. Yet the CEC-DRECP model's accompanying documentation, *2040 and 2050 Acreage Needs for Renewable Generation*, assumed 7.1 acres/MW, RETI assumed 7 acres or less/MW,[34] and the California ISO assumed only 5.5 acres/MW.[35]

Additionally, the model does not take into account commercially available Concentrated PV (CPV) and Highly Concentrated PV (HCPV). Nor does it factor in the potential for tracking PV, which will be deployed at First Solar's Antelope Valley One project.[36] Tracking concentrating solar PV has much lower land intensity than inefficient low-cost thin-film, or even than higher efficiency fixed flat-plate modules. Since it performs at up to twice the efficiency of conventional fixed flat plate PV, it uses only half the acreage assumed in the CEC-DRECP calculator. In fact, two-axis tracking CPV's capacity factor rivals the relatively low land requirements of solar thermal generation with energy storage.[37]

In light of the above considerations, Sierra Club believes the assumptions for both solar thermal and solar PV should be adjusted to 7 acres per megawatt for a conservative reference case.

Additional Considerations

The following are discussions of additional factors that should be considered in fine-tuning inputs to the calculator, although Sierra Club has not recommended specific changes in these areas in our proposed reference case scenarios for 2040 and 2050.

Cost Considerations

The CEC-DRECP scenarios would require about 60,000 megawatts of transmission capacity to access renewable zones. This staggering amount of transmission could add $60 billion or more to the cost of implementing the renewable program, a cost that can be greatly reduced by placing more of the generation resources closer to energy load centers, and by more aggressive energy efficiency programs than the DRECP-CEC model presently assumes. Furthermore, importing 60,000 megawatts (or more) of renewable energy from long distance sources greatly increases the security vulnerabilities of the electric grid and the environmental impacts of the renewable energy program.

Sequestration Errors

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[32] *BLM Desert Sunlight Solar Farm Project FEIS*, table ES-1
[33] http://www.co.kern.ca.us/planning/pdfs/eirs/av_solar/av_solar_bs_add_080211.pdf p. 2
[34] *RETI Stakeholder Steering Committee Response to Phase 1A Draft Report Comments* p. 6-9
[35] *Technical Appendices for Renewable Integration Studies, Version 1*, p.27
[36] http://www.greentechmedia.com/articles/read/First-Solar-Deploying-One-Axis-Trackers-at-AV-Solar-Ranch/
[37] See: http://www.renewableenergyworld.com/rea/news/article/2011/08/tracking-the-cpv-global-market

The revised CEC-DRECP spreadsheet has been improved by adding a section to account for power generation that sequesters CO2. The assumption of zero sequestration of fossil fuel power plant emissions—after decades of technology lead time between 2010 and 2050—suggests a world that does not take climate change seriously, which contradicts the fundamental assumption of the entire exercise. There are at least four major technology pathways for removing carbon from fossil fuel emissions—geologic sequestration, reformation of the fuel, carbon recycling, and atmospheric capture.

While Sierra Club supports phasing out coal by 2030 and other fossil fuels by 2050, the CEC-DRECP scenarios show significant use of natural gas in 2040 and 2050. The scenarios should maintain the current assumption that there will be no use of coal, but could also reasonably include a non-zero value for sequestration of emissions from natural gas power by 2040 and 2050—*if* the model is going to assume continued use of natural gas. In a world where there is a complete revolution in energy systems for electric power and transportation accompanied by dramatic greenhouse gas reduction—it would be logical to assume some investment in CO2 capture for existing fossil fuel usage.

Offshore Resources

The revised CEC-DRECP calculator now includes the potential for using offshore resources, which is an excellent addition. However, the CEC-DRECP scenarios do not take any advantage of this feature, which is unfortunate. There are currently important efforts to develop offshore wind and wave technologies, especially in Europe, that could open up large ocean energy resources. A Stanford University study of California's offshore wind potential estimates the resource at approximately 135,000 megawatts for water out to a depth of 200 meters; note that this potential excludes 1/3 of the potential resource areas. [38]

Figure 23: California Offshore Wind Potential

Table 3: Nameplate capacity of turbines (MW) in each geographical area, depth, and wind speed cutoff, assuming a 33% exclusionary factor for each area.

Turbine Nameplate Capacity (MW)					
Ocean Depth	80 m Avg. Wind Speed	Northern Calif.	SF Bay Area	Southern Calif.	Total
0-20 m	≥7.0 m/s	3,052	8	309	3,369
	≥7.5 m/s	746	0	0	746
20 – 50 m	≥7.0 m/s	8,139	362	580	9,081
	≥7.5 m/s	2,713	0	0	2,713
50 – 200 m	≥7.0 m/s	66,325	31,802	4,846	102,973
	≥7.5 m/s	14,771	6,210	0	20,980

Wave resources are also quite large in California, with the waves north of Point Conception carrying an average power potential generally exceeding 25 kilowatts per linear meter of wave-

[38] Dvorak, M.J., Jacobson, M.Z., Archer, C.L. (2007): *California offshore wind energy potential.* Proceedings from Windpower 2007 Conference & Exhibition, June 26, 2007, Los Angeles, CA: AWEA.

front all the way up to the Oregon border. [39] The raw energy potential is estimated to be over 37,000 megawatts. While these technologies are expensive today, it is likely that competition and expanding production over the next decades will reduce costs of offshore energy even as conventional fossil and nuclear generation technologies continue to increase in cost. The fact that offshore resources are in close proximity to important load centers makes it likely that some fraction of these abundant resources will be developed in a carbon-constrained world.

Figure 24: California Raw Wave Power Potential near On-shore Load Centers

		Energy Flux	Primary Sites		Secondary Sites	
Zone	Zone Landmark	Density kW/m	Available km	Available MW	Available km	Available MW
1	San Diego	32.18	-	-	162	5213
2	Los Angeles	32.18	35	1126	104	3347
3	Santa Barbara	26.43	127	3357	-	-
4	Monterey	29.65	-	-	127	3766
5	Santa Cruz	28.03	-	-	127	2838
6	San Francisco	30.26	104	3147	18	545
7	Sonoma	32.18	127	4087	-	-
8	Mendocino	28.53	130	3709	-	-
9	Humboldt	33.71	116	3910	-	-
10	Del Norte	27.81	81	2253	-	-
		Total	720	21589	538	15709

Source: *California Ocean Wave Energy Assessment* (Draft Report), Beyene et al.

V. PROPOSED CORRECTIONS TO SCENARIO ASSUMPTIONS

Sierra Club proposes corrections to the CEC-DRECP scenario model inputs as follows:

1. Reduce energy load from plug-in hybrids to conform with California's Alternative Fuels Plan, and ERPI findings—

a) Reduce Vehicle Miles Traveled (VMT) from 13,000 miles/yr to 11,500 miles/year in 2050;

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[39] *California Small Hydropower and Ocean Wave Energy Resources*, California Energy Commission, April 2005 CEC-500-2005-074.

b) Reduce Plug-in Hybrid "utility factor" from 90% to 66% of miles traveled on electricity;

c) Increase efficiency of electric vehicles from the current 3 miles per kilowatt-hour to 3.5 miles per kilowatt-hour by 2040 and 4 miles per kilowatt-hour by 2050.

2. Validate whether there is double counting of PHEVs in the CEC-DRECP scenarios, and correct if necessary; however, Sierra Club has not yet made any adjustment to this value.

3. Increase the Reference-Case annual efficiency savings from 0.83%/yr to 1.15%/yr, which is the average for 2000-2020.

4. Reduce the amount of acreage per megawatt for solar technologies to conform to the value given in Table 2 of CEC's text explanation of the acreage calculator, RETI, and other sources.

5. Increase distributed on-site generation in 2050 to account for zero net energy building policies; Sierra Club has conservatively assumed 15,000 MW of distributed solar PV in 2050, but additional on-site distributed generation would be needed to meet the state policy targets.

6. Retain 10% storage for 2040, but increase this to 20% in 2050 to balance high penetration of intermittent renewable generation.

These adjustments would align the scenarios much more closely with existing policies and forecast documents.

VI. RESULTS FROM CHANGED INPUTS TO CALCULATOR FOR 2040 AND 2050

The current CEC-DRECP scenarios assume continued deployment of energy efficiency at very close to historical rates over the past 20 years—a period that included an exceptional 9-year period of anomalously low efficiency savings; and continued heavy reliance on renewable generation that is similar technologically and in site characteristics to current practice. In the transportation sector, the CEC-DRECP scenarios assume little significant diversification of transportation modes compared to today beyond the addition of high-speed rail in the 2040s; the scenarios assume people will continue to drive 13,000 miles per year per vehicle for the next 40 years; the scenarios assume no further major development of low carbon vehicle fuels; and they assume no improvement of technology performance over electric vehicles that are currently on the market—all approaches that are contrary to the State Alternative Fuels Plan and state climate policies. Additionally, there may be errors in counting of electric vehicles and in the assumed acres per megawatt for solar technologies.

The result is an inflation of electricity demand in 2050 of about 135,000 gigawatt-hours per year above values that would be more in line with state policies, planning documents, and current forecasts. Since 80% of electricity in 2050 is expected to come from renewables, the land-use requirements and potential cost of meeting the inflated demand figures are very large.

The CEC-DRECP scenarios should be modified to show the significant effects of current state policies to increase the efficiency of electricity consumption, reduce vehicle miles traveled, support more diverse transportation modes, and develop multiple low carbon fuels to help achieve carbon reduction in the transportation sector. While it can be argued that achieving the different elements of such a plan may be difficult or uncertain, putting too many eggs in one policy basket is a poor way to address this uncertainty. Furthermore, it should not be assumed that placing excessive responsibility for reducing carbon emissions in all energy sectors on the desert is devoid of risk, difficulty, or harm.

If the state's existing environmental policies for the electricity and transportation sectors are incorporated more fully into the CEC-DRECP reference case, it will greatly reduce the projected cost of renewable energy and would save hundreds of thousands of acres of land from development.

In 2009, the CPUC staff report estimated that it would cost $115 billion to build enough renewable generation and transmission infrastructure to meet a renewable net short of 75,000 gigawatt-hours.[40]

Figure 25: CPUC 2009 Estimate of Capital Cost of California RPS Programs

Table 13. Cumulative Statewide Capital Investment Required Through 2020 Under the 20% and 33% RPS Reference Cases (billions of 2008 dollars)

	20% RPS Reference Case	33% RPS Reference Case
New Renewable Generation	$32.8	$95.3
New Transmission	$4.0	$12.3
New Conventional Generation	$15.0	$6.9
Total Capital Investment Required	***$51.8***	***$114.5***

The efficiency improvements recommended in the Sierra Club scenarios for both electricity consumption and transportation could potentially save between $100 billion and $200 billion in renewable energy infrastructure costs, and even more if the full lifecycle costs are included.

Sierra Club has input its revised values in the CEC-DRECP calculator and developed scenarios for the amount of needed central station generation as well as the amount of acreage required to meet the 60% and 80% carbon reduction targets in the electricity sector in 2040 and 2050 respectively.

The amount of central station renewables in the CEC-DRECP scenarios for 2040, to achieve a 58% CO2 reduction and put 17 million plug-in cars on the road, is about 30,000 megawatts, as shown in this table:

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[40] *33% RENEWABLES PORTFOLIO STANDARD, Implementation Analysis Preliminary Results*, California Public Utilities Commission & E3, June 2009, Table 13 showing capital cost is on p. 53; Exhibit B on p. 7 shows a need for $12 billion in transmission alone to meet the 75 terawatt-hour net short. The CPUC report significantly overestimated the net short—the amount of new electric generation needed to meet the 33% RPS, resulting in a major inflation of cost. RETI and the CPUC in the 2010 Long-Term Procurement Plan later revised the net short estimate to about 54 terawatt-hours, implying that the capital cost would be much lower than the CPUC's original forecast. The CPUC's inflated $115 billion cost figure was widely circulated in the press and by critics.

2040 Reference Cases Central Station Resource Development, Statewide, MW		
	Solar/Wind 60/40	Solar/Wind 40/60
CS Solar Thermal	4,900	3,250
CS Solar PV	9,800	6,500
Wind	8,350	12,500
Subtotal Intermittent	23,050	22,250
Geothermal	4,000	4,000
Biomass (Brownfield)	1,000	1,000
Biogas (Existing Sites)	2,000	2,000
Subtotal Baseload	7,000	7,000
Total Central Station	30,050	29,250

This infrastructure in these two reference cases would occupy 570,000 acres and 690,000 acres.

By adjusting the inputs for energy efficiency and plug-in hybrids as recommended by Sierra Club, the amount of new renewables required to reduce CO2 by 58% in 2040 decreases to 180,000 acres in the Sierra Club proposed reference case below:

2040 Sierra Club Proposed Reference Case Central Station Renewable Resource Development, Statewide, MW		
CS Solar Thermal		1,000
CS Solar PV		1,000
Wind		2,000
Subtotal Intermittent		4,000
Geothermal		3,500
Biomass (Brownfield)		1,000
Biogas (Existing Sites)		2,000
Subtotal Baseload		4,500
Total Central Station		8,500

There are multiple advantages for this adjusted scenario, including reduced cost for the renewable energy program, reductions in customer bills dues to higher efficiency savings, much less requirement for transmission, reduced project development risk, reduced reliance on intermittent resources, and much less effect on the environment both within the desert region and elsewhere in the state.

For 2050, the CEC staff scenario shows demand increasing for another decade, deploying 42 million plug-in electric vehicles, and reaching a CO2 reduction target of 80%. This greatly increases the amount of renewables asserted to be needed to about 60,000 megawatts:

2050 Reference Cases Central Station Resource		
	Solar/Wind 60/40	Solar/Wind 40/60
CS Solar Thermal	11,000	7,400
CS Solar PV	22,000	14,800
Wind	18,900	28,400
Subtotal Intermittent	51,900	50,600
Geothermal	7,000	7,000
Biomass (Brownfield)	2,000	2,000
Biogas (Existing Sites)	4,000	4,000
Subtotal Baseload	9,000	9,000
Total Central Station	60,900	59,600

However, Sierra Club adjustments in assumptions about efficiency programs and performance of plug-in hybrid electric vehicles greatly reduce the need for central station renewable energy in 2050 to about 1/3 of the 2050 CEC staff scenario.

2050 Sierra Club Proposed Reference Case Central Station Renewable Resource Development, Statewide, MW		
CS Solar Thermal		4,000
CS Solar PV		3,500
Wind		3,000
Subtotal Intermittent		10,500
Geothermal		7,000
Biomass (Brownfield)		2,000
Biogas (Existing Sites)		4,000
Subtotal Baseload		9,000
Total Central Station		19,500

The Sierra Club scenario for 2050 also increases rooftop PV to 15,000 megawatts in order to come closer to the zero net energy building goals, maintains the rate of new efficiency savings at 1.15% per year, and reduces the amount of energy required to power plug-in electric vehicles. Sierra Club increases grid storage to 20% of electrical energy compared to 10% in the CEC-DRECP scenarios.

The CEC staff scenarios for the year 2050 require 1.2 million to 1.5 million acres for renewable energy projects, with 686,000 to 798,000 acres in the desert. Using Sierra Club's proposed inputs reduces the needed land to 346,000 acres for all renewables in the state, with 165,000 acres in the desert in 2050.

Sierra Club recommends that the CEC-DRECP scenarios, and the DRECP planning process, should incorporate these updated values for modeling the amount of land that will be needed for renewable energy. The large reduction in the cost of renewable energy and in impacts to wildlife and habitats shows how vitally important continued energy efficiency and conservation are for meeting California's climate protection goals.

Appendix A

California Energy Commission 2009 Revised Electricity Demand Forecast [41]

Form 1.1b - Statewide
California Energy Demand 2010-2020 Staff Revised Forecast
Electricity Sales by Sector (GWh)

Year	Residential	Commercial	Industrial	Mining	Agricultural	TCU	Street Lighting	Total Sales
1990	67,013	71,243	41,414	5,840	20,562	11,810	1,576	219,456
1991	66,457	70,968	40,126	5,751	16,100	12,010	1,610	213,022
1992	68,540	74,410	40,099	5,449	15,288	12,368	1,647	217,801
1993	67,704	74,928	38,708	5,224	15,754	12,373	1,645	216,335
1994	69,041	74,760	38,310	4,820	16,814	12,178	1,646	217,570
1995	69,031	76,425	39,681	5,037	14,147	12,540	1,620	218,482
1996	71,330	78,809	39,473	5,140	16,708	12,723	1,658	225,841
1997	72,775	82,475	41,035	5,014	17,358	13,329	1,701	233,687
1998	74,620	84,302	39,689	4,658	13,359	13,076	1,757	231,461
1999	75,674	87,451	40,993	4,369	16,951	13,397	1,658	240,494
2000	79,840	93,110	42,570	4,835	17,389	13,983	1,729	253,456
2001	75,134	88,927	37,943	3,685	18,746	12,576	1,724	238,734
2002	76,921	90,931	37,322	3,382	20,821	12,738	1,710	243,826
2003	81,385	95,411	34,850	3,490	20,091	12,702	1,748	249,677
2004	83,961	97,692	36,654	4,203	21,821	12,911	1,772	259,013
2005	85,229	98,223	37,125	4,402	19,102	13,663	1,781	259,525
2006	89,497	101,275	36,748	4,446	20,322	13,941	1,780	268,009
2007	88,901	103,130	37,140	4,901	23,219	14,303	1,837	273,431
2008	91,238	104,457	36,832	5,144	20,679	14,568	1,828	274,746
2009	89,816	100,334	35,354	4,863	20,811	14,460	1,848	267,486
2010	90,258	100,570	35,266	4,697	20,769	14,516	1,856	267,932
2011	90,989	101,762	35,854	4,927	20,720	14,674	1,865	270,791
2012	91,816	103,111	37,099	5,180	20,672	14,864	1,873	274,616
2013	93,673	104,608	37,629	5,349	20,693	15,017	1,882	278,850
2014	95,407	105,774	37,672	5,375	20,714	15,124	1,891	281,957
2015	97,128	107,031	37,699	5,359	20,736	15,236	1,899	285,089
2016	98,911	108,252	37,745	5,343	20,747	15,350	1,908	288,255
2017	100,857	109,507	37,730	5,320	20,769	15,471	1,916	291,571
2018	102,948	110,549	37,675	5,290	20,790	15,591	1,925	294,768
2019	105,110	111,620	37,561	5,264	20,811	15,710	1,934	298,010
2020	107,398	112,754	37,393	5,235	20,833	15,829	1,942	301,385

Last historical Year = 2008; sales excludes self-generation.

Annual Growth Rates (%)

1990-2000	1.77%	2.71%	0.28%	-1.87%	-1.66%	1.70%	0.93%	1.45%
2000-2008	1.68%	1.45%	-1.79%	0.78%	2.19%	0.51%	0.70%	1.01%
2008-2010	-0.54%	-1.88%	-2.15%	-4.45%	0.22%	-0.18%	0.76%	-1.25%
2010-2020	1.75%	1.15%	0.59%	1.09%	0.03%	0.87%	0.45%	1.18%

38

[41] *CALIFORNIA ENERGY DEMAND 2010-2020 ADOPTED FORECAST*, December 2009, CEC-200-2009-102-CMF, p. 38.

Appendix B

California Energy Commission 2009 Economic and Demographic Assumptions [42]

Form 2.2 - Statewide
California Energy Demand 2009-2020 Staff Revised Forecast
Economic and Demographic Assumptions

	Population	Households	Persons per Household	Real Personal Income (Millions 2007$)	Industrial Output (Millions 2007$)	Commercial Floorspace (MM Sqft.)
1990	29,828,685	10,370,753	2.79	947,562	138,684	4,879
1991	30,458,225	10,543,350	2.80	934,780	135,692	5,041
1992	30,986,940	10,666,773	2.82	955,075	131,876	5,177
1993	31,313,835	10,769,374	2.82	948,606	126,566	5,275
1994	31,523,270	10,864,237	2.81	958,716	125,542	5,350
1995	31,711,155	10,956,461	2.81	983,941	129,647	5,419
1996	31,961,985	11,045,475	2.81	1,019,330	135,273	5,487
1997	32,451,640	11,139,125	2.83	1,064,402	162,265	5,557
1998	32,861,690	11,244,536	2.83	1,147,435	186,762	5,640
1999	33,416,925	11,365,123	2.85	1,204,844	216,628	5,750
2000	34,152,028	11,463,373	2.88	1,298,741	269,942	5,879
2001	34,747,465	11,588,888	2.91	1,308,464	241,615	6,006
2002	35,358,330	11,724,250	2.93	1,304,260	226,459	6,149
2003	35,926,021	11,867,587	2.94	1,322,633	233,927	6,279
2004	36,437,344	12,025,981	2.94	1,374,146	249,012	6,384
2005	36,894,972	12,202,745	2.94	1,415,798	284,020	6,491
2006	37,337,019	12,372,264	2.93	1,483,203	308,617	6,576
2007	37,804,451	12,513,296	2.94	1,520,755	301,062	6,676
2008	38,291,487	12,617,018	2.95	1,518,642	298,902	6,788
2009	38,778,524	12,749,518	2.95	1,521,956	294,136	6,890
2010	39,265,560	12,885,706	2.96	1,548,566	300,152	6,963
2011	39,752,596	13,022,822	2.96	1,584,880	310,593	7,023
2012	40,239,633	13,162,069	2.96	1,643,022	324,728	7,090
2013	40,726,669	13,303,449	2.97	1,704,025	333,451	7,186
2014	41,213,705	13,447,033	2.97	1,750,675	337,922	7,296
2015	41,700,741	13,592,844	2.98	1,793,585	342,310	7,408
2016	42,187,778	13,740,946	2.98	1,838,368	347,015	7,512
2017	42,674,814	13,891,372	2.98	1,886,487	351,407	7,605
2018	43,161,850	14,044,170	2.99	1,934,279	355,508	7,698
2019	43,648,887	14,199,394	2.99	1,982,339	359,070	7,792
2020	44,135,923	14,357,080	3.00	2,031,266	362,014	7,886

Annual Growth Rates (%)						
1990-2000	1.36%	1.01%	0.33%	3.20%	6.89%	1.88%
2000-2008	1.44%	1.21%	0.29%	1.97%	1.28%	1.81%
2008-2010	1.26%	1.06%	0.13%	0.98%	0.21%	1.28%
2010-2020	1.18%	1.09%	0.14%	2.75%	1.89%	1.25%

[42] *CALIFORNIA ENERGY DEMAND 2010-2020 ADOPTED FORECAST*, December 2009, CEC-200-2009-102-CMF, p. 48.

Appendix C

California Energy Commission Inventory of On-Land Wind Resources [43]

Gross Wind Resource by County
Hub Height: 70 m
Wind Power Method

County	Land Area km²	HWS Land Area km²	HWS Capacity MW	HWS AEP GWh	LWS Land Area km²	LWS Capacity MW	LWS AEP GWh
Alameda	2124	28	173	562	120	750	2431
Alpine	1918	117	733	2374	238	1487	4821
Amador	1568	2	11	36	8	51	165
Butte	4342	2	11	34	84	527	1710
Calaveras	2683	0	0	0	6	40	131
Colusa	2995	2	12	39	43	270	874
Contra Costa	2084	6	40	130	129	809	2623
Del Norte	2631	28	177	572	288	1798	5827
El Dorado	4636	49	305	990	98	615	1994
Fresno	15586	54	337	1091	185	1158	3754
Glenn	3437	1	4	13	11	67	216
Humboldt	9282	158	991	3211	468	2926	9483
Imperial	11608	234	1460	4733	1911	11943	38711
Inyo	26496	825	5155	16710	3505	21908	71008
Kern	21113	1490	9311	30180	2352	14701	47649
Kings	3605	0	0	0	4	25	81
Lake	3446	1	8	27	93	579	1875
Lassen	12220	70	440	1427	583	3642	11805
Los Angeles	10584	838	5236	16970	2167	13544	43898
Madera	5577	20	124	400	53	334	1082
Marin	1534	25	154	498	202	1262	4090
Mariposa	3784	1	6	20	7	43	139
Mendocino	9100	8	50	162	292	1825	5916
Merced	5103	10	60	193	148	924	2996
Modoc	10888	117	730	2366	354	2213	7172
Mono	8114	437	2732	8855	781	4879	15814
Monterey	8581	14	88	286	149	931	3018
Napa	2047	1	7	24	29	183	595
Nevada	2522	5	33	106	46	286	926
Orange	2070	8	50	161	171	1067	3457
Placer	3885	14	89	288	76	473	1534
Plumas	6773	33	207	671	287	1797	5823
Riverside	18908	863	5397	17492	4160	26006	84292
Sacramento	2574	0	0	0	60	372	1206
San Benito	3599	0	1	3	19	120	389
San Bernardino	52072	1198	7486	24265	12308	76940	249377
San Diego	10976	520	3249	10532	1485	9283	30089
San Francisco	278	0	0	0	45	282	914
San Joaquin	3690	0	1	2	49	308	999
San Luis Obispo	8599	4	27	88	156	975	3160
San Mateo	1430	3	20	65	129	807	2616
Santa Barbara	7119	466	2911	9434	859	5367	17396
Santa Clara	3383	0	0	0	6	39	125
Santa Cruz	1156	0	0	0	3	18	58
Shasta	9963	111	693	2247	577	3607	11691
Sierra	2492	31	191	618	175	1095	3549
Siskiyou	16452	207	1297	4203	1039	6496	21054
Solano	2356	50	310	1005	1029	6431	20844
Sonoma	4150	8	48	157	128	800	2593
Stanislaus	3924	0	0	0	11	66	213
Sutter	1577	0	1	3	17	105	340
Tehama	7668	5	28	91	197	1232	3995
Trinity	8310	21	130	422	184	1148	3721
Tulare	12539	88	548	1775	232	1448	4695
Tuolumne	5899	52	323	1047	140	875	2835
Ventura	4833	193	1209	3917	794	4960	16077
Yolo	2646	0	3	10	119	744	2412
Yuba	1668	0	0	0	0	0	0
Statewide	410594	8415	52605	170504	38806	242582	786257

[43] *California Wind Resources*, Dora Yen-Nakafuji, Draft Staff Report, California Energy Commission, April 2005, CEC-500-2005-071-D.

Appendix D

Committed Efficiency in the CEC Demand Forecast for 2010 to 2020

Table 34: Statewide Electricity Savings by Category

Year	Building and Appliance Standards	Utility and Public Agency Programs	Total Savings-Programs, Standards	Naturally Occurring Savings	Total Savings	Elec. Use *CED 2009 Adopted*	Elec. Use 2009 Un-managed Forecast	Percentage Reduction in Use from Savings
Residential plus Commercial* Consumption Impacts								
1990	7,411	1,453	8,863	11,085	19,948	228,473	248,421	8.0
1998	15,117	3,267	18,384	10,675	29,059	242,564	271,623	10.7
2003	21,676	4,313	25,989	16,502	42,491	262,255	304,746	13.9
2008	29,419	9,322	38,741	13,380	52,120	286,771	338,891	15.4
2011	33,410	12,365	45,775	16,531	62,307	283,908	346,215	18.0
2015	39,537	10,702	50,239	19,789	70,028	297,649	367,677	19.0
2020	46,838	5,591	52,429	27,559	79,989	311,890	391,879	20.4
Residential plus Commercial* Peak Impacts								
1990	1,811	358	2,170	2,272	4,441	47,521	51,963	8.5
1998	3,933	806	4,739	2,267	7,005	54,525	61,530	11.4
2003	5,196	998	6,195	3,383	9,578	55,106	64,684	14.8
2008	7,182	2,259	9,441	2,570	12,011	61,682	73,692	16.3
2011	8,533	3,165	11,698	3,309	15,007	63,023	78,030	19.2
2015	10,192	2,808	13,000	4,052	17,052	66,475	83,527	20.4
2020	12,142	1,434	13,575	5,948	19,523	70,387	89,910	21.7

Source: California Energy Commission, 2009
*Commercial also includes agricultural program savings.

The CEC demand forecast for 2010 to 2020 shows annual savings in 2011 at 15,007 gigawatt-hours, and this increases to 19,523 gigawatt-hours in 2020. The savings are measured against a baseline of 1975, when California's efficiency programs began. The new savings from 2011 to 2020 is calculated by the difference of the annual savings between those years: 19,523 less 15,007 = 4516 gigawatt-hours of new annual savings by 2020.

This figure only represents the portion of efficiency savings embedded in the demand forecast, and excludes most new efficiency programs after 2012. The rest of the efficiency savings are contained in the "uncommitted efficiency" category, because these program funding cycles had not begun when the CEC forecast was made. Reasonable values for uncommitted efficiency are in a separate report, with the mid-case savings shown in Appendix E.

The mid-case sum of committed plus uncommitted efficiency is 16,741 gigawatt-hours, far short of the target set in CARB's AB32 Scoping Plan of 32,000 gigawatt-hours reduction from energy efficiency by 2020. [44]

[44] The committee report on uncommitted efficiency assumed that the necessary savings is only 22,000 gigawatt-hours due to the fact that energy demand growth was revised downward between 2007 and 2009 by the CEC. However, Sierra Club is skeptical about whether reductions in forecast demand that are due to the global recession can legitimately be counted toward the AB32 Scoping Plan efficiency target. In either case, the current efficiency forecast/scenarios fall well short of the AB32 target.

Appendix E

Uncommitted Efficiency Mid-Case Savings for California IOUs [45]

Table 8: Electricity Energy and Peak Demand Impacts Incremental to *2009 IEPR* Demand Forecast for Combined IOUs, Mid Savings Scenario

Mid Goals Case	2013	2014	2015	2016	2017	2018	2019	2020
Energy Impacts (GWh)								
IOU programs	1,050	2,055	3,017	3,847	4,716	5,521	6,325	7,126
Huffman Bill (AB 1109)	345	302	163	430	941	1,469	1,678	1,628
Title 24 & Fed Standards	55	133	254	437	624	844	1,071	1,304
Big Bold Initiatives	194	397	655	926	1,209	1,516	1,835	2,167
Total GWh	**1,644**	**2,888**	**4,089**	**5,640**	**7,490**	**9,350**	**10,909**	**12,225**
Peak Impacts (MW)								
IOU programs	284	560	830	1,081	1,336	1,583	1,830	2,075
Huffman Bill (AB 1109)	49	46	29	67	137	210	240	234
Title 24 & Fed Standards	36	76	143	294	448	623	803	987
Big Bold Initiatives	175	358	602	857	1,123	1,421	1,732	2,056
Total MW	**544**	**1,039**	**1,604**	**2,298**	**3,045**	**3,839**	**4,605**	**5,352**

Source: Itron and California Energy Commission, 2009

The CEC's Uncommitted Efficiency Mid-Savings Scenario shows 12,225 gigawatt-hours of savings incremental to the energy savings already embedded in the CEC Demand Forecast for 2010 to 2020 that is shown in Appendix D. The low scenario has 10,658 gigawatt-hours and the high scenario 14,374 gigawatt-hours of additional energy reduction for IOUs territories in 2020.

The mid-case sum of committed plus uncommitted efficiency is 16,741 gigawatt-hours, far short of the target set in CARB's AB32 Scoping Plan of 32,000 gigawatt-hours reduction from energy efficiency by 2020.

These figures only represent the portion of efficiency savings that *are not* embedded in the demand forecast, and only apply to the Investor-Owned Utilities. The rest of the efficiency savings are contained in the "committed efficiency" category. Forecast values for committed efficiency are in a separate report, shown in Appendix D.

The mid-case sum of committed plus uncommitted efficiency is 16,741 gigawatt-hours, far short of the target set in CARB's AB32 Scoping Plan of 32,000 gigawatt-hours reduction from energy efficiency by 2020. [46]

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[45] *Incremental Impacts of Energy Efficiency Policy Initiatives Relative to the 2009 Integrated Energy Policy Report Adopted Demand Forecast*, Committee Report, California Energy Commission, May 2012, CEC-200-2010-001-CTF, Table 8, showing the Mid Savings Scenario on page 44.

[46] The committee report on uncommitted efficiency assumed that the necessary savings is only 22,000 gigawatt-hours due to the fact that energy demand growth was revised downward between 2007 and 2009 by the CEC. However, Sierra Club is skeptical about whether reductions in forecast demand that are due to the global recession can legitimately be counted toward the AB32 Scoping Plan efficiency target. In either case, the current efficiency forecast/scenarios fall well short of the AB32 target.