Appendix F3

DRECP Acreage Calculator

APPENDIX F3

California Energy Commission

DRECP Renewable Energy Modeling: The Acreage Calculator (Overview)

What is the Acreage Calculator?

The Renewable Energy Acreage Calculator (henceforth, "Acreage Calculator")[1] is a spreadsheet tool designed to estimate the **total number of MW of renewable capacity** a*nd* **subsequent acreage of the DRECP area required for that capacity** to be developed, **given a host of assumptions** regarding electricity demand growth, GHG emission reduction targets for the electricity sector, and the portfolio of generation resources that would meet them.

It's important to understand what the Acreage Calculator is, but also what it is not. One of the best ways to think about the Acreage Calculator is as a **data-driven way of providing an answer to a series of complex "What if?" questions**, rather than a crystal ball trying to predict the future. It's also important to understand that the ultimate goal of the calculator is to provide broad, data-driven insight about what general scale of renewable development it makes sense to plan for, *not* precise estimates.

The Acreage Calculator is **not** a prediction of the future; it is a reflection of what many different possible futures could be given the different series of assumptions described above. Most of all, the Acreage Calculator is *not* a policy lever, only a simple planning aid. It provides estimates of how many MW of renewables and subsequent acreage *might* be needed given different assumptions about the future of electricity demand growth, GHG emission reduction goals, and low-carbon/renewable technologies. These assumptions are the "What if?" questions fed into the calculator.

How was it used in the development of the plan?

The Acreage Calculator was first introduced to DRECP stakeholders in February 2011 as a tool to help stakeholders understand how different assumptions about electricity demand growth, GHG emission reduction goals, and the set of low-carbon and renewable generation technologies would lead to changes in how much renewable energy, and therefore how many acres of renewable development in the DRECP ***might*** be necessary over the next several decades. (The initial slide deck used to introduce the tool in 2011 can be found here: http://www.drecp.org/meetings/2011-02-16_meeting/presentations/DRECP_Acreage_Scenario_Calculator.pdf)

[1] In earlier documents, the Acreage Calculator is also occasionally referred to as the DRECP Calculator, as well as the Energy Calculator, or Renewable Energy Calculator. All of these terms refer to the same tool.

Over the next year and a half, three simulations based on best available data and Energy Commission staff assessments, the latter two refined with stakeholder and public comment and input, were run through the Acreage Calculator to provide *estimates* of both (1) California's renewable energy development needs, and (2) the acreage of renewable development that *might* need to take place in California and in the DRECP area in order to satisfy those needs. Three Acreage Calculator scenarios were developed for the DRECP: The **May 2011**, **October 2011**, and **July 2012 scenarios**. Details on the specific inputs, predictions, and refinements based on stakeholder and public comments and input are described below in the next section, "Inside the Acreage Calculator: Modeling History and Revisions."

The general trend can be characterized as follows: Energy Commission staff have attempted to estimate needed renewable development inputs as closely as possible to best available data, and reasonable assumptions. Many stakeholder and public comments have voiced concerns about the quantity of energy and therefore acreage that might be needed to meet California's greenhouse gas emission reduction goals and to ensure the long-term stability and reliability of a next-generation renewable-driven grid. Additional concerns have included that Energy Commission staff have placed too much reliance on central utility-scale renewable power plants, and insufficient emphasis on distributed generation, such as rooftop solar, as well as yet-to-be developed zero and low-carbon generation technologies such as fossil fuel combustion with carbon sequestration, offshore wind, and those based on advanced biofuels. Staff have addressed these concerns and worked to ensure that accurate data and reasonable if not conservative assumptions were fed into the Acreage Calculator and the renewable development scenarios for the DRECP area generated by the tool.

Understanding the Role of the Acreage Calculator:
How does it pertain to policy and development?

The Acreage Calculator is a planning aid, not a policy lever. The Acreage Calculator is a tool that can be used to estimate the total amount of megawatts of renewable energy and DRECP area acreage that will need to be developed by 2040 given a number of inputs and assumptions, including electricity demand and renewable energy demand growth, growth in distributed generation, increasing use of electric and hybrid electric vehicles, and the central-station renewable and zero- and low-carbon generation technologies that will be economic and preferred at that time. The Acreage Calculator is an analytical tool that helps digest energy demand and supply data; the scenarios developed using it *reflect* and *respond* to existing policy set by the state and federal governments by generating helpful predictions.

The Acreage Calculator and the scenarios developed do not drive development, but rather reflect data-driven, reasonable (if not conservative) assumptions about future energy needs, as well as renewable and low/zero carbon development in the state based on those assumptions (enumerated above).

How does the Acreage Calculator impact development?

The Acreage Calculator does not determine the future, nor even provide recommendations, whether based on cost, environmental impact or any combination thereof, of the resource development that should be undertaken.

Instead, the Acreage Calculator merely assesses the implications of electricity demand growth, GHG reduction targets, self-generation, and a host of other input assumptions. Then, based on those assumptions, the calculator attempts to predict central-station renewable and other zero- and low carbon generation needs *could* be, *given those assumptions*, and then translates those possible needs into *potential* implications of that need for development in the DRECP area, given the current state of technology.

In other words, the Calculator **does not predict** what the future **will** be, but helps inform and prepare for a number of **different futures** that **might** be.

The Acreage Calculator allows for an assessment of many possible futures so that California has the best chance at planning and being prepared for the renewable development and low-carbon future that will come. By providing the best possible data-driven estimates of possible renewable energy needs, the Acreage Calculator helps to chart a course on renewable development that safeguards the environment while reliably continuing to meet the state's changing energy needs.

State and federal energy policy, population growth, and technological changes drive demand for new renewable development, not the Acreage Calculator. The DRECP is a program that helps determine *where* whatever installations *will* be developed should and should not be built—as well as helping determine where they may and may not be built—especially on public lands. (To use a sports analogy, the DRECP is like a catcher's mitt: it doesn't throw the ball, and it doesn't swing the bat: it just catches whatever ball is thrown at it by assumptions about electricity demand growth, GHG reduction targets, self-generation, and a host of other input assumptions.)

For additional information about the specific details and history of these three scenarios, stakeholder and public comments and input, and changes that have been made over the course of the three models, see the next section "Inside the Acreage Calculator: Scenario History and Revisions," below.

How does the Acreage Calculator work?

As a spreadsheet tool, the Acreage Calculator allows the user to create possible futures (answers to "What if?" questions) based on sets of assumptions. The result is one set of outputs, called scenarios. Based on best available data, reasonable (if not conservative) assumptions, known policy, forecasts, and agreement among Energy Commission staff (factoring in stakeholder input) on the best possible reasonable assumptions about uncertain variables, each scenario strives to provide an accurate and useful set of predictions.

The Acreage Calculator works in two parts: **demand side** and **supply side**. Key assumptions drive the demand side calculations; these are then combined with key assumptions about technologies and policies that shape the supply side calculations, which return **outputs** that describe the total DRECP acreage that *would* be needed, *given those assumptions*.

Each of these scenarios include assumptions about electricity demand growth, the development customer-side distributed generation, the availability of zero- and low-carbon energy from existing and future non-renewable sources, the GHG emissions cap for the electricity sector, and limits on the share of RPS-eligible renewable energy that can be located out-of-state. These are used to develop an estimate of the amount of in-state central-station and utility-side distributed renewable energy that will be needed (the **demand side**).

In order to satisfy electricity demand, there must be an equal amount of supply.

Thus, the demand estimate is then used as an input to develop *another* input: the **supply side**, a portfolio of in-state generation resources that provides the requisite amount of energy. The user chooses the amount (in MW) of each renewable technology in the portfolio subject to the constraint that the portfolio meet the estimated need for in-state renewable energy; the **output** is the **amount of acreage in the DRECP area (and elsewhere) that the portfolio occupies** (the supply side).

What *exactly* are the inputs fed into each scenario?

The **demand side** of the Acreage Calculator estimates the 2040 demand for energy from new central-station and utility-side distributed renewable generation, relying on the following assumptions (inputs):

- **Electricity demand growth** (driven by population growth, expected energy efficiency savings, and the anticipate electrification of sectors and processes that switch from fossil fuels to electricity in order to reduce GHG emissions). The transportation sector is explicitly represented, requiring assumptions regarding vehicle electrification (number of vehicles, vehicle miles traveled, share of miles traveled on electricity, electricity consumption per mile), port electrification, high-speed rail, and the electrification of goods transport.
- **Storage losses** are input as a percentage of utility-provided energy. High levels of variable energy (wind, solar) will require the multi-hour storage of electricity to meet morning and evening ramping needs without overly relying on natural-gas fired generation
- **GHG emission cuts required by policy** as a percentage of 1990 baseline.

- **Ability to meet GHG reduction requirements using offsets** rather than real sectorial reductions in emissions.
- **Existing sources of zero- and low-carbon energy expected to be operating in 2040**, and new sources of such energy other than renewables (economy, policy). The former include a user-specified share of existing renewables serving California customers that would still be in operation, and, at the user's discretion, the nuclear facilities at Diablo Canyon and Palo Verde and existing rights to energy from the Colorado River. The latter may include new nuclear facilities, as well as new coal- and natural gas-fired generation that sequesters user-specified shares of its carbon emissions.
- **Assumptions regarding the deployment of customer-side distributed generation** (combined heat and power, or CHP, and rooftop solar). Both affect the amount of energy, and thus renewable energy that must be provided by utilities; CHP also produces GHG emissions, reducing the amount of energy that can be produced under the emissions cap by natural gas fired generation. These assumptions include total MW installed, capacity factor, and share of output consumed on site vs. exported to the grid

The **supply-side** of the Acreage Calculator provides an estimate of the MW of capacity and acreage in the DRECP area needed to meet the renewable energy requirement, relying on the demand side results and the following series of assumptions (inputs):

- **MW assumed of each renewable technology**, as determined by the state of the technology, the economy, and relevant underlying policies.
- The **capacity factor**, or annual output per MW for each renewable technology.
- **Acreage requirements per MW** of each technology.
- The share of that specific technology's in-state MW that is **located in the DRECP area**.
- The **share** of needed renewable energy that can be **met with out-of-state resources**, as determined by policy and market forces.

What renewable technologies are covered in the scenarios?

The renewable technologies specified in the scenarios developed by staff include the following:

- Central station solar thermal (troughs, power towers)
- Central station solar photovoltaic (PV)
- Utility-side distributed generation (i.e. very large rooftop solar to 20MW ground-mounted solar)
- Wind

- Biomass (both with and without acreage requirements; the latter would include, for example, natural gas pipeline-quality bio-methane combusted by conventional generators.)
- Geothermal
- Customer-side distributed generation (i.e. up to 1.5MW rooftop solar)

Additional inputs:

- *The characteristics of each technology are also an assumption fed into the calculator.*
- *Other assumptions as necessary to ensure best possible estimates and reasonable accuracy.*

Inside the Acreage Calculator: Scenario History and Revisions

This section attempts to provide an accessible yet still technically descriptive and accurate walkthrough of the three sets of scenarios that have been created by Energy Commission staff using the DRECP Acreage Calculator.

What are the three scenarios? Why discuss all three?

The three major sets of scenarios produced were:

- The **initial scenarios from May 2011** that described three *possible* futures (high, reference, and low acreage scenarios)
- A revised **October 2011 model** that used two different supply scenarios called “60/40” and “40/60” to describe both a high solar (60% solar, 40% wind) and a high wind (40% solar, 60% wind) development pathway; and
- Finally, a **July 2012 scenario** based on the incorporation of stakeholder input in synergy with the best available data and reasonable assumptions.

While it is not necessarily important for all stakeholders to thoroughly understand the technical modeling history, the DRECP program emphasizes (1) solid, credible data and reasonable assumptions, (2) adaptive management techniques such reiterative refinement, and (3) open, clear, transparent communication and dialogue with stakeholders. This walkthrough is provided to help maintain and improve transparent dialogue with DRECP stakeholders, help make input data/assumptions transparent, and refine program accuracy.

What are the key drivers in these scenarios? What variables have the biggest impact?

Many assumptions are fed into the Acreage Calculator. While the following is not intended to be a comprehensive technical listing of all variables and assumptions, this section provides a brief summary of those inputs and assumptions common to most of the Acreage Calculator scenarios. (Links to technical staff overviews and presentations are cited at the beginning of each scenario.)

(1) Increases in demand due to **population and economic growth**, as well as the longer-run electrification of residential and commercial space and water heating and industrial processes, expected to occur as part of the effort to reduce GHG emissions. This was initially modeled (for the May 2011 and October 2011 scenarios) as an average yearly growth rate based on historical (1990 – 2010) trends. The July 2012 scenario modified this approach in response to stakeholder comments regarding slower population growth in the longer run (2025 – 2040)

(2) The impact of **energy efficiency** measures and programs on electricity demand. This was modeled as an annual percentage reduction based on 1990 – 2010 trends.

(3) Demand increases due to **transportation electrification**. The July 2012 scenario assumes more than 63,000 GWh will need to be generated to accommodate transportation sector demand in 2040, most of which will fuel a fleet of more than 17 million vehicles.

(4) Decreases in the **demand for utility-provided electricity** due to **combined heat and power** (**CHP**) development, assumed to be fueled by natural gas. The model assumes that the share of GHG emissions attributable to electricity generated and consumed on site by CHP (50 percent of CHP generation) is attributed to the industrial sector. As a result, futures (i.e., possible scenarios) with greater amounts of CHP have electricity sectors that can accommodate more conventional natural gas-fired generation (thus requiring less renewable or zero-carbon energy) and still stay below a given carbon emissions cap, despite the fact that total GHG emissions may only be slightly if at all lower. This arbitrary assignment of the emissions of 4,500 MW of CHP to the industrial sector allows for an additional 17,145 GWh of conventional natural-gas fired generation in the July 2012 scenario, energy that would otherwise have to produced by renewable or other zero-carbon resources. This increases requirements for the latter by 14.6% in the July 2012 scenario.

(5) Incremental **energy needs due to storage requirements**. Staff has assumed that 15% of all energy generated would have to be stored in 2040, with an assumed efficiency of 80%. In the July 2012 scenario, this increases the demand for renewable or other zero-carbon energy by 11,004 GWh. Each 5 percentage-point change in the share of energy stored changes the need for renewable or other zero carbon energy by 3,668 GWh.

(6) Whether the **use of offsets can lead to an increase in sectorial emissions above the assumed cap**. Each of the scenarios developed by staff assumes that offsets can be used to avoid a share (8%) of the GHG emission reductions required under the cap. Current policy, however, merely allows those with compliance obligations to substitute CARB-approved offsets for allowances for this share of their GHG emission reductions, but requires the emission reductions themselves. Thus **the July 2012 scenario may overstate the amount of sectorial carbon emissions that are**

allowed by more than 5 million metric tons, and thus u**nderestimate the required amount of renewable (or other zero-carbon) energy needed in 2040 by 13,000 GWh (8%)**

(7) Whether **existing nuclear power facilities are operating or not**. Existing nuclear facilities at Diablo Canyon and Palo Verde provide 18,000 GWh and 6,000 GWh, respectively of zero-carbon base load energy in service of California end-users. Their assumed status has a substantial impact on the need for zero-carbon energy to meet 2040 GHG emission reduction goals: the July 2012 scenario yields an incremental need for new renewable energy in 2040 of 167,292 GWh in their absence, this would fall by 24,000 GWh (14.3%) if the facilities are still operating.

(8) **Policy shifts** targeting GHG reductions in the electric sector; staff has assumed a 58 percent reduction from 1990 levels, roughly consistent with a 20-percentage-point reduction each decade from 2010 – 2050 on the path towards an 80 percent reduction in GHG emissions from 1990 levels by 2050.[2] A five-percentage point change in the required reduction changes the renewable energy need by roughly 13,500 GWh (8%).

(9) **Limits on out-of-state renewables**. Staff has imposed a 25 percent cap on the share of central station and utility-side distributed generation that can be out-of-state reflecting a desire that renewable resource development by California provide in-state employment. A five percentage-point change in this cap would change needed in-state renewable energy by roughly 10,100 GWh (8.6%).

What's the most current scenario?

The July 2012 scenario is the most recent scenario that Energy Commission staff have created with the help of the Acreage Calculator. This scenario is fully consistent with the latest Energy Commission's most recent ten-year energy demand forecast (*California Energy Demand 2014 – 2024*[3]) , projections for longer-run (2025 – 2040) demand growth including those for transportation electrification developed for the California Air Resources Board. In addition, the July 2012 scenario is consistent with current state policy, and expected trends in the comparative costs of utility-scale (i.e. large desert solar) and distributed (i.e., small rooftop solar) renewable deployment.

For additional details on the July 2012 scenario scroll down to that section, which includes a short summary and key results, a brief technical walkthrough meant to be accessible to non-scientists, and links to Energy Commission staff's technical overview.

[2] The GHG emission reduction target of 80 percent from 1990 levels is an economy-wide target, not a sectorial one. The electricity sector may be ultimately called upon to reduce emissions by a greater or lesser percentage.
[3] Available at http://www.energy.ca.gov/2013_energypolicy/documents/#adoptedforecast

May 2011 Initial Scenarios

The May 17, 2011 DRECP stakeholder presentation of this model, at the Ontario, California meeting, can be found here: http://drecp.org/meetings/2011-05-17_meeting/documents/May%2017%202011%20RPS%20Calculator%20presentation.pdf

A technical overview of the model can also be found here: http://drecp.org/meetings/2011-05-17_meeting/documents/2050%20RPS%20and%20acreage%20calculator%20background.pdf

Summary:

This was the first application of the Acreage Calculator. The original goal was to allow users to explore, hypothetically, future reductions in GHG emissions from the electricity sector that might be necessary to meet California's obligations under AB 32, and then model different future paths renewable development in California could take to achieve these reductions, looking out to as far as 2050. For each of these possible pathways, users could then turn to the Acreage Calculator to estimate the acreage of renewable development necessary to reach this goal. The purpose of the Acreage Calculator was emphatically NOT to forecast or prescribe the future, but rather to understand the acreage requirements of a *range* of *possible* futures.

Initial Modeling:

The Acreage Calculator was applied in two stages: estimating

(1) 2050 need for renewable energy, *and*

(2) acreage needed for the portfolios of renewable resources that would provide that energy.

To describe the possible range of future pathways California could take, Energy Commission staff employed one reference case and two "bookend" scenarios. The purpose of these bookends was to set the outer limits of what might reasonably occur, providing "worst case" and/or "best case" scenarios, assuming that mature central-station and distributed renewable technologies continue to be a major tool for decarbonization of the electricity sector, and that this decarbonization would lead to increased electrification of processes and sectors that currently rely on fossil fuels.

Note: The deployment of zero- and low carbon technologies in service of California's energy needs over the next 25 years will depend upon long-run technological advance, changes in relative costs, desired tradeoffs between environmental and economic costs, policy preferences for or against nuclear energy and the extraction, shipment and combustion of fossil fuels, etc. **The DRECP process planning process is not a forum** in which desired futures should be assumed and planned for but one in which the **possible** need for acreage for renewable project development is **estimated under a reasonable**, if not **conservative set of assumptions**. As noted above, the use of these scenarios to estimate potential development in the DRECP area in the long-run will have no bearing on actual development, which will depend upon the factors enumerated above.

May 2011 Key Assumptions and Outputs:

The **reference scenario** assumed an annual growth rate for electricity demand due to economic and demographic factors of 1.5 percent and annual energy efficiency savings of 0.81 percent, values based on 1990 – 2010 data. This yielded a net energy for load of 382,000 GWh in 2050. Some 5.2 million full and hybrid electric vehicles, along with additional electrification of the transportation sector increased demand by 37,000 GWh; this was offset by increased “self-generation” from 6,000 MW of customer side distributed generation (e.g., rooftop solar) and 6,500 MW of CHP, resulting in utility-provided energy totaling 385,000 GWh. The assumed 58 percent reduction of sectorial GHG emissions from 1990 levels and continued operation of all of the nuclear facilities serving California customers (including San Onofre) led to an incremental need for 200,000 GWh of renewable (or other zero-carbon) energy (equivalent to a 67 percent RPS). The portfolio assumed this energy included 34,000 MW of central-station renewables, 15,000 MW of distributed generation and required 571,000 acres in the DRECP area for renewable development.

The **low acreage scenario** assumes reduced demand growth due to economic and demographic factors (1.35 percent/year) and lower amounts of vehicle electrification in 2040 (2.6 million vehicles). . It resulted in 138,000 GWh of new renewable energy needed (equivalent to a 57 percent RPS). The portfolio assumed to provide this energy included 17,000 MW of central-station renewables and 18,000 MW of distributed generation and required 256,000 acres in the DRECP area,

By contrast, the **high acreage scenario** assumed reduced energy efficiency savings (0.65 percent/year), an 87% RPS by 2050, very high levels of vehicle electrification (over 26 million vehicles and high speed rail), and the closure of all currently operating nuclear plants. This would entail 358,000 GWh of new renewable energy required (provided by 62,000 MW of central-station renewables, 27,000 MW of distributed generation), and 1,166,000 acres developed in the DRECP.

Some contention attached to the high acreage scenario during stakeholder meetings. Of particular concern was the way that customer-side distributed generation and vehicle electrification were tallied. Overall, the scenario presents an exceptionally high-end view of electrification, factoring in the closure of all three of California’s nuclear stations and widespread vehicle electrification.

What changes did stakeholders and the public suggest following the May 2011 release?

Aside from the above concerns, the major suggested revision was scaling back the time horizon from 2050 to 2040. The October 2011 model reflects stakeholders’ desire to see a 2040 model, and incorporated a variety of additional updates.

The October 2011 Scenarios

A technical overview of the scenarios can also be found here: http://drecp.org/meetings/2011-10-12_meeting/20402050_Scenario_Description.pdf

Summary:

In this update, Energy Commission staff produced four scenarios, two for 2040, and an identical pair for 2050. For each target year the model was used to develop two different scenarios referred to as "60/40" and "40/60," to describe both a high solar (60% solar, 40% wind) and a high wind scenario (40% solar, 60% wind). All four scenarios used the same demand assumptions. As a result, the October 2011 model provides the following four scenarios: 2040 high solar, 2040 high wind, 2050 high solar, 2050 high wind. These are intended to be outer boundaries examining the mixture of wind and solar renewable capacity to be installed in the state.

All of these scenarios assumed that California's electricity will attempt to reach a GHG emissions reduction target of 80% below 1990 levels by 2050. In order to accomplish this reduction, given demand growth, electrification, and other variables described above, it is very likely that over 400,000 GWh of new renewables will need to come online in California by 2050. This model assumes that one fourth of this demand will be satisfied by out-of-state renewables. Even assuming strong (and probably overly optimistic) contributions from geothermal, biomass, and distributed generation (i.e. rooftop solar), over 22,000-33,000 MW of new central solar and 19,000-28,000 MW of new wind installations will be necessary to meet California's 2050 goals. The majority of this is presumed to be built in the DRECP area.

Key Inputs and Assumptions:

Energy Commission staff assumed that of this new renewable capacity, for purposes of the DRECP:

- All in-state central station solar thermal (trough or power tower) is located in DRECP.
- 70% of in-state central station solar PV capacity is located in the DRECP.
- 50% of wind capacity is located in the DRECP.
- 3,000 MW of geothermal is in the DRECP.
- 250 MW of biomass is in the DRECP.
- 27.5% of utility-side DG (i.e. large rooftop and ground-mounted solar up to 20 MW) is located in the DRECP.
- Energy storage was presumed to exist by 2050, amounting to roughly 10% of output, with 70% efficiency.
- Diablo Canyon and San Onofre stations were presumed to have shut down by 2040. (San Onofre closed in 2013).

- 20,000-30,000 GWh of increased electricity delivery due to demand growth (economy and population) must come entirely from renewables.
- A large portion of emissions reductions (from 58% of 1990 levels in 2040 to 80% of 1990 levels in 2050) come during this decade, reflecting trends in technology shifts, markets, and policy.
- Vehicle electrification increases rapidly, moving from a rough projection of 18 million electric vehicles in 2040 to over 41 million by 2050. In order to meet the state's GHG reduction obligations, this must be met with zero-carbon renewables.
- The Palo Verde nuclear plant is retired, leaving 6,000 GWh that must be provided via renewables.
- An additional 1,000 MW of geothermal is built in the DRECP area.

Key Results:

By 2040:

- **high solar** (284,000 acres for 194,000 GWh new renewable energy)
- **high wind** (351,000 acres for 194,000 GWh new renewable energy)

(Both equate to roughly 22,000 MW of new renewable capacity installed by 2040.)

By 2050:

- **high solar** (686,000 acres for 385,000 GWh new renewable energy)
- **high wind** (789,000 acres for 385,000 GWh new renewable energy)

What changes did stakeholders and the public suggest following the October 2011 release?

Energy Commission staff received a wide variety of comments from DRECP stakeholders following the October 2011 model. The following page briefly summarizes major comments and staff response.

- *Sierra Club (2012)*: The growth rate in electricity demand due to economic and demographic factors over 2011 – 2040 should be lower than forecasted by the Energy Commission for 2011 – 2020, as:
  - (a) the forecasted population growth rate over 2011 – 2020 was revised downward by the California Department of Finance (CDOF) subsequent to development of the Energy Commission forecast, and
  - (b) the CDOF population growth rate projection for 2021- 2040 was lower still. Furthermore, the energy efficiency savings rate assumed in the model/scenario should be increased as the value used was based on historical data from 1990 – 2010, a period during which expenditures on energy efficiency were far lower than that which can reasonably be expected for 2011 – 2040.

- ***RESPONSE***: Staff understands Sierra Club to be proposing that demand growth (not including from electrification) remain constant or decreases by 2040. The Energy Commission's latest ten-year demand forecast however projects positive growth rates.

- *Sierra Club (2012)*: Central station solar takes 7.0 acres/MW, not 9.1 acres/MW.
  - ***RESPONSE***: Staff agreed to this reduction, although it would appear to be a lower bound. A report issued by NREL in June 2013[4] – well after staff agreed to reduce the acreage requirement - found that 1 -20 MW solar PV projects in the U.S. require 8.3 acres/MW on average, with larger PV facilities requiring 7.9 acres/MW, and concentrating solar power technologies requiring 10 acres/MW.

- *Private letter (2011)*: It's wrong to assume other renewable technologies will not improve by 2040.
  - ***RESPONSE***: Model is limited in that it cannot predict dynamic technology shifts, such as deep offshore wind or tidal renewable. Staff does not have sufficient evidence to show that these technologies will be deployed by 2040, or data on their efficiency. However, it is possible.

- *California Wind Energy Association (2011, 2012)*: Acreage Calculator's prediction of 14,000 MW wind is too low. A few reasonable Acreage Calculator assumption changes can yield 25,000 MW wind or more, e.g., 75 percent of CA wind being developed now is in the desert (vs. 50 percent Acreage Calculator assumption).
  - ***RESPONSE***: Staff agrees that there is no reason that much more wind than the 14,000 MW assumed couldn't be developed. 14,000 MW was one reasonable assumption among many.

- *PG&E (2012)*: Concerns about the ability of the electrical grid to function given large amount of renewables.
  - ***RESPONSE***: Staff agrees this will be a challenge that will require technological advancement and additional distribution and storage infrastructure, including storage. This, however, is the case for almost all very-low-carbon scenarios for 2040, whether they rely on central station and/or distributed renewables, or fossil-fuel generation with CCUS. The scenario that minimizes the need for technological advance – one that relies on nuclear generation – was deemed by staff to be implausible given its potential cost and widespread opposition to nuclear power.

- *PG&E (2012)*: Concerned that Diablo Canyon is assumed not to be relicensed.
  - ***RESPONSE***: Staff suggested removal of Diablo Canyon from several 2040 scenarios due to numerous factors that might result in it being shut down including

[4] Ong, Sean, and others, *Land-Use requirements for Solar Power Plants in the United States*, National Renewable Energy Laboratory, (NREL/TP-6A20-56290, June 2013), available at http://www.nrel.gov/docs/fy13osti/56290.pdf.

        - (1) failure to be relicensed for any of several reasons in 2024 and 2025 (widespread public opposition to nuclear power, failure or inability to comply with the State Water Resource Control Board's policy on the use of once-through cooling), and
        - (2) pre- and post-relicensing safety-related events that might engender public opposition to continued operation or maintenance needs that are deemed to be prohibitively costly.

- *PG&E (2012)*: The Acreage Calculator includes large amount of new CHP. It's not clear where this capacity can be created, or even if existing CHP will reduce GHG emissions by the amounts claimed.
    - ***RESPONSE***: Staff acknowledges that planning exercises frequently exclude additional CHP from the portfolio of resources in a low-carbon future, whether it be in the CPUC's LTPP proceeding or studies of 2050. .
- *Defenders of Wildlife (2012)*: Are existing renewable facilities credited in the Acreage Calculator?
    - ***RESPONSE***: The scenarios developed by staff assume that in-state renewable resources in existence as of December 31, 2010 will still be operating in 2040 or have be replaced on site. In addition, any renewable resources developed from January 1, 2011 to date contribute to the incremental need for renewable energy projected in any scenario.
- *Sierra Club (2012)*: A blip in population growth rates skewed estimates before. Corrected?
    - ***RESPONSE***: July 2012 scenario updated to use revised growth estimates taken from Department of Finance and US Census Bureau.
- *Sierra Club (2012)*: Percentage of vehicle miles traveled with grid-supplied electricity: should be 72.6%, not 90%.
    - ***RESPONSE***: Staff agreed and changed to 72.6%.

The July 2012 Scenario

A technical overview and explanation of the model (from which this section has been generated) can be found at: http://www.drecp.org/documents/docs/DRECP_Acreage_Calculator_Documentation.pdf

Summary:

In response to stakeholder comments and concerns regarding the October 2011 model, Energy Commission staff updated the model in December 2011 (not displayed). Following this effort, additional comments were received and updates were made, leading to the July 2012 model (referred to as the "Revised Model" in some documents). Major changes included downward revisions to estimates of both

(1) energy demand in 2040 and (2) the acreage requirements for central-station solar capacity developed to meet that demand.

The July 2012 scenario yields a **reduction in development in the DRECP area** from over 20,000 MW in the October 2011 scenario to **roughly 17,000 MW** and a concomitant **decline in needed acreage**.

Key Revisions

- In response to stakeholder comments regarding slower population growth projections over 2011 – 2040 than those utilized in developing the *CED 2010 – 2020* demand forecast, staff reduced estimates of the impact of economic and demographic factors on electricity demand growth over 2011 – 2040. The result was a reduction in the estimated net energy for load in 2040 (prior to consideration of transportation electrification and self-generation[5] from 354,449 GWh (in the October 2011 scenario) to 336,597 GWh.

Since July 2012, the Energy Commission has adopted a new ten-year demand forecast.

How does the demand forecast compare to the assumptions in the scenario?

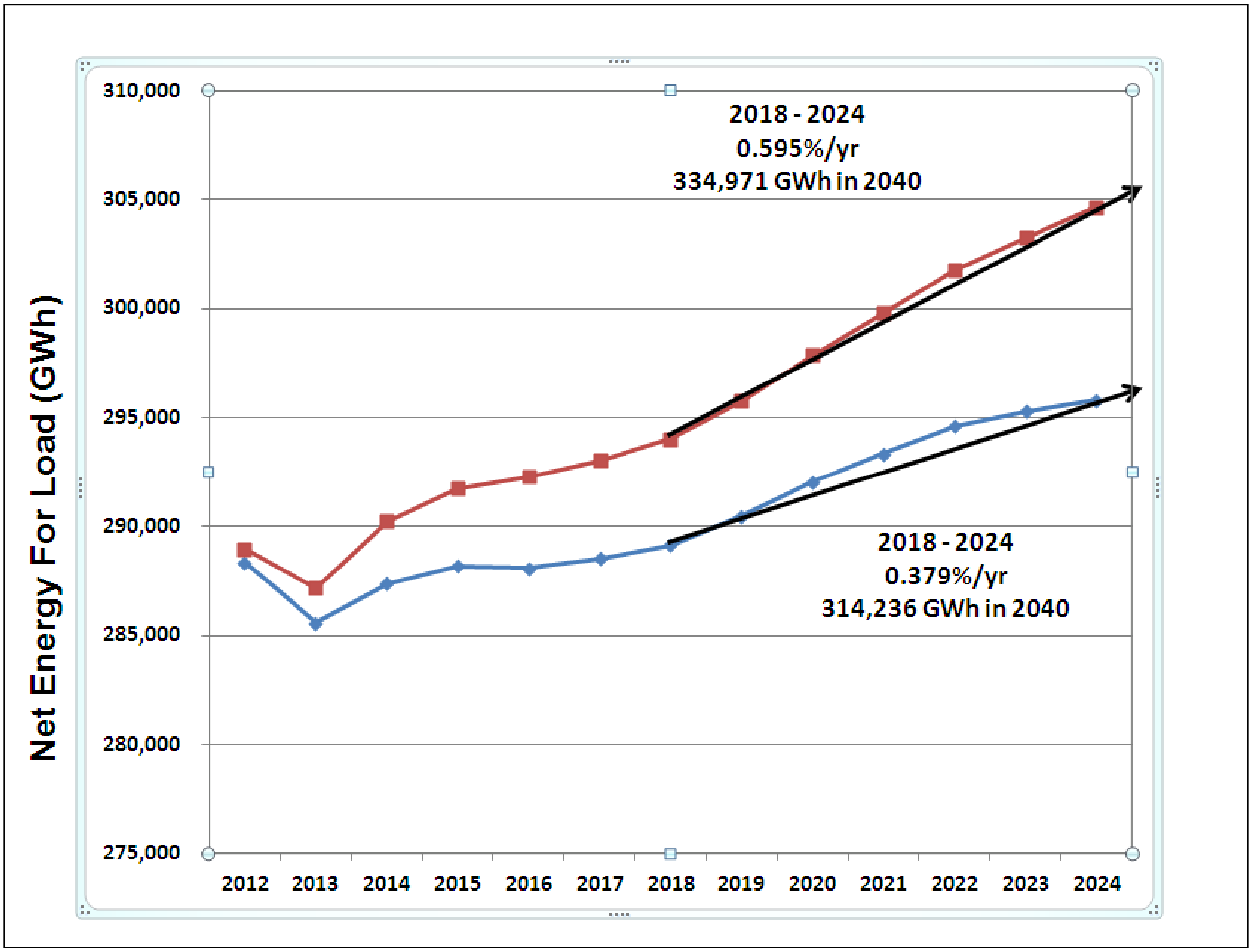
The Energy Commission adopted the staff's ten-year demand forecast in *California Energy Demand 2014 – 2024* (*CED 2014 – 2024*) in January, 2014. In order to directly compare the forecast to the assumption of 336,597 GWh of net energy for load in 2040 (the assumption in the July 2012 scenario), several adjustments to the forecast have to be made. The forecast also has to be extrapolated from its endpoint of 2024 out to 2040.

The *CED 2014 – 2024* forecast (adjusted to account for "mid-case" estimates of additional available energy efficiency (AAEE) must first be adjusted downward to remove the demand associated with electric vehicles (and transmission and losses associated with meeting this demand), which are considered separately in the Acreage Calculator. It then must be adjusted upward to include self-generation (such as rooftop solar and other customer-side distributed generation), which is also treated separately in the Acreage Calculator.

[5] This is cell D11 in the Acreage Calculator

Figure 1 illustrates the impact of these adjustments on the forecast.

Figure 1: Growth in Net Energy for Load, 2012 - 2024

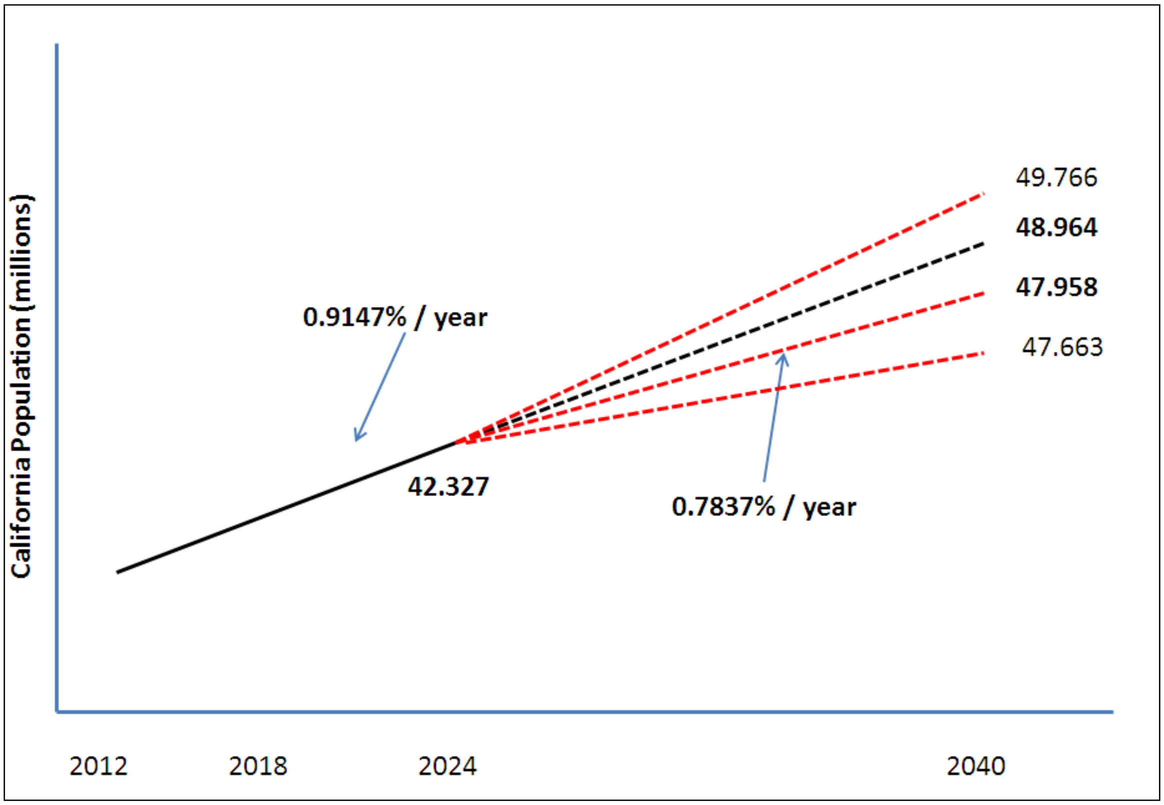


The lower, blue line represents projected growth in net energy for load over the 2014 – 2024 forecast period after electric vehicle demand is removed. If extrapolated out to 2040 at the long-run (2018 – 2024) growth rate, the resulting net energy for load in 2040 is 314, 236 GWh. When self-generation (and associated transmission and distribution losses) are considered (the upper, red line), however, the rate of load growth is higher, leading to a net energy in load in 2040 of 334,971 GWh.

It is not reasonable to linearly extrapolate the 2014 – 2024 forecast to 2040, however, as population growth is expected to slow over 2025 – 2040.

Figure 2 illustrates the population growth rate used in developing the mid-case of the C*CED 2014 – 2024* demand forecast: 0.9147 percent/year, leading to a 2024 population for California of 42.327 million.

Figure 2: Projected California Population Growth through 2040



Each of the three population forecasts used in compiling the *CED 2014 – 2024* demand forecast (once each for the low- mid- and high-demand cases) extends to 2040 and beyond. Using the "mid-case" of the three population forecasts yields 47.958 million people, or 1.06 million (2.06 percent) less than if the assumed 2014 – 2024 population growth rate is extrapolated to 2040. It is thus necessary to reduce the estimate of 2040 net energy for load by 2.06 percent to 328, 087 GWh. This is roughly 8,500 GWh lower than the July 2012 estimate of 336, 597 GWh.

The adjustments to and extrapolation of *CED 2014 -2024* demand forecast as above fails to consider factors that do not have an effect on demand over 2014 – 2024, but are expected to have an impact during 2025 – 2040. The development and deployment of new energy efficiency technologies, encouraged by continued expenditures on energy efficiency programs and higher retail electricity prices will encourage energy efficiency savings while electrification of residential and commercial space and water heating, as well as the electrification of industrial processes that currently directly combust fossil fuels, will contribute to growth in electricity demand.

Revision to July 2012 Scenario Based on Correction of Assumed 1990 GHG emission Baseline and Revised Modeled Impact of GHG Offsets, Including Customer-Side DG Solar.

In scenarios developed to date, staff has assumed that

- the 1990 GHG emissions baseline is 115.84 mmmt CO2-e, and
- the use of offsets would allow the sector to increase GHG emissions above the established (2040) cap at any point in time.

However,

- the actual 1990 GHG emissions baseline is 110.63 mmmt CO_2-e, and
- the current cap-and-trade regime allows entities with compliance obligations to acquire offsets in lieu of allowances, but does so while reducing allowances issued to a level below the aggregate emissions cap by an amount equal to offsets that may be used. In other words, the 58% reduction in GHG emissions assumed for 2040 constitutes a hard cap that cannot be exceeded by using offsets, contrary to the assumption made by staff in developing the July 2012 scenario

The implications of these changes in these inputs/assumptions for staff's July 2012 scenario are not insubstantial, as can be seen in the table below. The values in the table assume a 1990 carbon baseline of 110.626 mmmt CO_2-e.

Increase in Zero-Carbon Energy Required in 2040 Due to Change in 1990 Baseline, Revised Modeling of GHG Offset Use

	July 2012 Scenario	Revised Inputs
1990 emissions baseline (mmmt CO2e)	115.84	**110.63**
58% reduction (assumed for 2040)	48.65	46.46
Additional emissions allowed due to offsets (mmmt)	5.37	**0.00**
Total emissions allowed (mmmt)	54.03	46.46
Assumed emissions in CHP (mmmt) [1]	6.73	6.73
Emissions allowed using gas (mmmt)	47.29	39.73
Allowed gas-fired generation (GWh) [2]	120,588	101,300
Increase in needed zero-carbon energy (GWh)		**19,288**

[1]Assumes a heat rate of 7.4 mmBtu/MWh, with 50% on-site use of generation/50% exported to grid, and GHG emissions embodied in on-site use attributed to industrial sector.
[2]7,400 Btu/kWh

The corrections yield an outcome that is equivalent (in terms of its impact on required GWh of in-state renewable energy) to assuming an increase in net energy for load in 2040 from 336,597 GWh (assumed in the July 2012 scenario) to 355,885 GWh, or, roughly, assuming the retirement of Diablo Canyon. Examples of portfolios that meet this revised renewable energy need (under the constraint that only

25% of the utility-provided energy can come from out-of-state sources), as well as the portfolio in the July 2012 scenario, are presented in the following table.

Increase in Zero-Carbon Energy Required in 2040 Due to Change in 1990 Baseline, Revised Modeling of GHG Offset Use

Technology	**July 2012 Scenario**		**No Change in CSDG**		**15,000 MW CSDG Scenario**		**20,000 MW CSDG Scenario**	
	MW	**MW in DRECP**	**MW**	**MW in DRECP**	**MW**	**MW in DRECP**	**MW**	**MW in DRECP**
CS Solar PV	7,224	5,057	8,224	5,757	7,733	5,413	7,242	5,069
CS Solar Thermal	3,612	3,612	4,112	4,112	3,867	3,867	3,621	3,621
Wind	6,155	3,078	7,007	3,504	6,589	3,294	6,170	3,085
Geothermal	2,998	2,569	3,413	2,925	3,209	2,750	3,005	2,576
Biofuels	2,569	214	2,925	244	2,750	229	2,575	215
Utility-Side DG	9,421	2,591	10,726	2,950	10,085	2,773	9,445	2,597
Customer-side DG	**10,000**	N/A	**10,000**	N/A	15,000	N/A	**20,000**	N/A
Total	41,979	**17,121**	46,408	**19,491**	49,233	18,327	52,059	**17,163**

The additional 19,288 GWh of renewable energy required can be provided by central-station and/or distributed resources. The "No Change in CSDG" scenario provides the needed additional energy by increasing the energy from each central-station and utility-side DG technology *pro rata*. The remaining two scenarios do the same after increasing customer DG capacity by the indicated amount.

Adding 10,000 MW of customer-side DG allows the additional energy to be provided without a need for additional central-station renewable capacity.

Where does the Acreage Calculator stand today?

Q. Should the central-station renewable capacity developed in the DRECP area during the past three years be considered part of the generation capacity to be planned for through 2040 under the scenarios developed using the Acreage Calculator?

Yes. In developing the scenarios, staff assumed that the 35,000 GWh of zero-carbon, energy provided by existing (as of January 1, 2011) central-station renewable resources in California would be provided in 2040 by new renewable resources at the same locations. Accordingly, any in-state central-station renewable resources that have come on line since January 1, 2011 are in effect contributing to the incremental renewable energy need as estimated using Acreage Calculator-based scenarios.

Rerunning the scenarios produced by staff to determine the difference in 2040 DRECP capacity and acreage given (actual) 2011 – 2014 in-state central-station renewable development would yield very small changes, as the technological composition and location of this development was by and large consistent with the long-run (2011 – 2040) assumptions staff made in creating the scenarios. Other assumptions (e.g., demand growth, the relicensing of Diablo Canyon) have a far greater impact on the projected need for renewable capacity in the DRECP area in 2040.

How accurate have Acreage Calculator input assumptions proven in recent years?

Q. How does renewable generation development over the past three and a half years in California compare to input assumptions used in Acreage Calculator scenarios to date? To assumptions being made in long-term planning forums at the California Public Utilities Commission (CPUC) and the California Independent System Operator (CA ISO)?

The Acreage Calculator scenarios include several assumptions regarding the portfolio of renewable generation resources that will meet electricity demand in 2040:

- the share of distributed versus central station resources,
- the relative share of each central station technology (solar PV, solar thermal, wind, geothermal, etc.), and
- the share of each central-station technology that will be in the DRECP area versus elsewhere in California.

Recent inputs and assumptions are consistent. Actual project development since December 2010, and expected project development (as evidenced by utility contracts with renewable generation resources approved by the CPUC and those announced by the Los Angeles Department of Water and Power, and 2024 renewable generation portfolios developed by the CPUC for use in ten-year planning proceedings) are consistent with the assumptions made in scenarios developed using the Acreage Calculator.

- As of January 2014, IOU-contracted central-station renewable generation resources that have come on line since January 2011 or awaiting construction total more than 6,500 MW, and are 71% of such resources in California.[6] More than 3,800 MW of these are solar thermal or PV, almost 2,700 MW are wind resources.
- The Los Angeles Department of Water and Power has announced the intended development of 311 MW of central-station solar PV, all of which will be in the DRECP area. This compares with the 150 MW of distributed solar PV being developed under a feed-in tariff.

[6] These values include 215 MW of utility-side distributed generation in the DRECP area and 310 MW elsewhere in California.

California Investor-Owned Utility Contracted, Central Station and Utility-Side Distributed Generation, On Line since January 2011 and Under Development, MW

Program	In DRECP	Elsewhere in CA	Out of State	Total	DRECP % of In-State Capacity
RPS/On Line					
Solar PV	395	444	335	1,173	47%
Solar Thermal	117	0	0	117	100%
Wind	2,269	788	1,697	4,755	74%
RPS/Approved/In Development					
Solar PV	1,897	1,091	690	3,677	63%
Solar Thermal	1,223	0	0	1,223	100%
Wind	408	0	400	808	100%
RAM					
Solar PV	215	310	0	525	41%
Solar Thermal	0	0	0	0	N/A
Wind	0	0	0	0	N/A
Total					
Solar PV	2,506	1,844	1,025	5,375	58%
Solar Thermal	1,340	0	0	1,340	100%
Wind	2,677	788	2,097	5,563	77%
Total	6,523	2,632	3,122	12,278	71%

Source: California Public Utilities Commission RPS Database, January 2014

- Projected additions over 2014 – 2024 in the Commercial Interest scenario being used for planning purposes in the CPUC's Long-Term Procurement Proceeding include more than 10,000 MW of central-station renewable generation, including more than 6,700 MW of solar capacity and 800 MW of wind capacity in the DRECP area.

Projected Additions, Commercial Interest Scenario, 33 Percent RPS in 2024, Mid AAEE Case, 2014 – 2024, MW

Technology	In DRECP	Elsewhere in CA	Out of State	Total	DRECP % of In-State Capacity
Large Solar PV	5,400	1,200	800	7,411	82%
Large Solar Thermal	1,350	0	0	1,350	100%
Wind	827	0	400	1,227	100%
Geothermal	94	25	116	235	79%
Biomass/Biogas	10	113	0	23	8%
Small Solar PV[1]	148	1,926	0	2,074	7%

1. Equivalent to utility-side distributed generation; customer-side distributed generation is embodied in the demand forecast

Source: California Public Utilities Commission,

How many MW does DRECP seek to permit? How many MW have already been built?

Roughly speaking:

- The July 2012 scenarios (including with revisions, above) call for slightly over 17,100 MW.
- The DRECP seeks to accommodate the development of up to roughly **20,000 MW** of renewable energy projects.
- **Over 3,000 MW** of renewables **have already been built** in the DRECP area.

The technology type and amount of generation built in the DRECP area will remain market-driven. There is **no guarantee** that the acreage associated with 20,000 MW will *all* be built: *ideally, it would not*. The DRECP's twin goals do not only include planning renewable energy facilities. It is *central* to the DRECP to minimize the environmental impacts of desert renewables to the greatest extent possible.

However, the collective agencies felt it was important, necessary, and beneficial to incorporate the additional MW of planning capacity to account for inherent uncertainties in the 2040 planning process. That way, *if* the capacity *is* needed, it will be covered by the DRECP, especially given many of the conservative inputs and assumptions that have been fed into the Acreage Calculator by CEC staff.