Renewable Electricity Production in Upstate California

Present and Future Resource Use and Its Economic Impact

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Center for Economic Development
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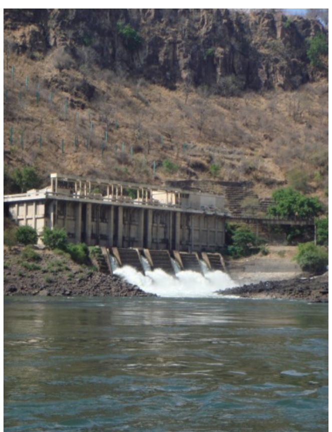



Table of Contents

List of Tables

List of Figures

Executive Summary

Summary and Conclusions

The 20-county Northern California area (Upstate California) is a significant producer of electricity from renewable resources. If it were a separate utility service area, subject to the state Renewables Portfolio Standard (RPS), it would have already exceeded the requirements imposed by the 20 percent 2010 standard and the stricter, 33 percent 2020 standard imposed on November 17, 2008 by Executive Order S-14-08. As of 2006 the area generated an amount of electricity from renewable resources equivalent to 43 percent of area consumption.

With 43 percent of area electricity demand offset with generation from renewables, Upstate California far exceeds the 11.4 percent achieved for PG&E's service area as a whole. However, current area generation from renewables is less than 25 percent of undeveloped potential. Development of 100 percent of Upstate California's resources over the next 20 years would, even accounting for demand growth, lead to renewable electricity generation equal to 92 percent of area electricity demand. An aggressive program of renewable resource utilization would not only assist in meeting the statewide Renewables Portfolio Standard, but would also be a major driver of economic development in the north state.

Study Goals

The goals of the study are accomplished through completion of each of the following tasks:

- Determine current RPS-eligible electricity generation in the region
- Determine current regional electricity consumption in Upstate California, comparing it to regional RPS-eligible electricity generation
- Estimate the additional renewable resource potential of the region
- Analyze the economic impacts on Upstate California of a strategy that results in full utilization of the electric generating capacity of the area's renewable resources

Study Area

The study area is the twenty counties defined as the Upstate California. The southern boundary includes Mendocino, Lake, Colusa, Sutter, Placer and El Dorado Counties, with the Upstate region defined as all counties to the north of that line.

Existing Renewable Electricity Generation Resources

Presently renewable electricity generation resources consist primarily of small hydroelectric, biomass, and geothermal facilities. Solar photovoltaic and wind make minor contributions to the area's renewable energy mix. Plant capacity of renewable electricity generation facilities in Upstate California is currently 1,189 megawatts, producing an estimated 5,793,540 megawatt hours of electricity annually. There are 11 counties in the study area that produce more than 100,000 MWh's of electricity annually from renewable resources.

Current Electricity Demand in Upstate California

For 2006 regional electricity demand totaled 13,482,000 megawatt hours (MWh's). Of this amount, 6,345,000 MWh's were used by residential customers, while non-residential consumption was 7,127,000 MWh's. Residential customers were responsible for 47 percent of area electricity consumption, with the remaining 53 percent used in the sectors comprising non-residential customer classes.

Current Ratio of Renewable Electricity Production to Electricity Use

Currently renewable electricity production in the 20-county Upstate region is 43 percent of area electricity consumption. This ratio far exceeds the current state Renewables Portfolio Standard (RPS) of 20 percent, as well as the proposed 2020 statewide RPS of 33 percent. Seven counties in the study area have ratios of renewable electricity production to local use exceeding the 43 percent average. Four of those counties—Sierra, Lake, Lassen, and Plumas—produce more electricity from renewable resources than the total amount consumed by their residents and businesses.

Potential Renewable Electricity Production

Potential renewable electricity production greatly exceeds current consumption. Dominated by solar photovoltaic resources, the area could potentially add 4,689 MW's of capacity over the next 20 years; producing 13,755,000 MWh's of electricity. Allowing for electricity demand growth in Upstate California at the average statewide annual rate of 1.2 percent, realization of the area's full potential would result in electricity generation from renewable resources equal to 92 percent of area demand.

Economic Impacts of Renewable Electricity Resource Development

Based on a 20-year development period, construction of renewable electricity generation facilities produces an annual impact on local business sales of over $2.7 billion. Those additional sales are responsible for $1.6 billion in area income and 23,109 full- and part-time jobs. With the exception of additional solar PV on new buildings (and probably new wind capacity), at the end of twenty years the construction income and jobs are eliminated, leaving the area economy with the impacts of biomass fuel production and operation and maintenance of completed plant capacity.

The area impact of the plant operation phase increases over the 20-year scenario as additional capacity is brought on line at the rate of five percent of potential. In the first year local spending is increased by $46.5 million, adding $25.0 million to local income and 364 jobs. Area spending, income, and employment continue to grow, reaching levels of $930.8 million, $519.7 million, and 7,287 jobs, respectively at the end of the 20th year. Those levels are then sustained for the entire useful project lives.

Introduction

Purpose of the Study

The primary purpose of this study is to determine the impact on the 20-county Northern California region of the state's energy policy emphasis on renewable resources and energy efficiency. Many of the region's abundant energy resources are eligible under the Renewables Portfolio Standard and therefore qualify for special tariff treatment by the investor owned utilities. Over 40 percent of the housing units in the region were constructed prior to the state's implementation of Title 24 Standards. This presents additional employment opportunities in the form of energy efficiency upgrades to structures and space and water heating systems. This study identifies the extent of the future business and employment opportunities presented by area renewable energy development.

Institutional Background

The Renewables Portfolio Standard (RPS) was established in 2002 under Senate Bill 1078, with the compliance date moved up under Senate Bill 107 in 2006. It requires that the state's electric utilities increase annual procurement from renewable energy resources by 1 percent, reaching a goal of 20 percent no later than 2010. The California Public Utilities Commission (CPUC) and the California Energy Commission (CEC) have jointly proposed that renewable energy become a larger share of electricity production, with 33 percent of the state's electricity coming from these resources by 2020. Assembly Bill 1585 specifically directs the CEC to evaluate the feasibility of a 33 percent RPS. While not codified in California law, the California Air Resources Board sees this further progress as necessary for meeting the state's goals for curbing greenhouse gas emissions.

The state's aggressive push towards renewable energy has two components. First, it opens up opportunities for regions with renewable energy resources. Development of those resources can make a significant contribution to area economic growth and job creation. The ability to anticipate that trend provides greater local benefits as appropriate local job training, and business assistance can ensure that a major portion of the benefits accrue to local residents.

Second, since the RPS measures renewable energy production as a percentage of retail electricity sales, progress towards achieving that standard can also take the form of conservation and energy efficiency improvements. This opens up further economic opportunities for firms and workers in construction and related industries. With limited natural gas service, Upstate California presents greater than average investment opportunities for conservation of electricity. As in the case of expanding electricity production from renewable resources, capturing the economic benefits at the local level requires local investment in the businesses and labor training necessary to perform the needed services.

Structure of the Study

The goals of the study are accomplished through completion of each of the following tasks:

- Determine current RPS-eligible electricity generation in the region
- Determine current regional electricity consumption in the 20-county region, comparing that to regional RPS-eligible electricity generation
- Estimate the additional renewable resource potential of the region
- Analyze the economic impacts on Upstate California of a strategy that results the full development of the electric generating capacity of the area's renewable resources

Geographical Area

Upstate California is composed of the 20 counties included in Figure 1. The area is primarily rural with only Placer, Butte, and Shasta counties having cities with populations nearing 100,000. Because of the rural nature of the area, a large portion does not have natural gas service. This includes six counties and significant portions of the remaining fourteen (CEC 2008b). For that reason there is heavier reliance on electricity for water and space heating than would be the case in a more densely populated region.

Figure 1: Upstate California

Existing Renewable Electricity Generation Resources

Presently the 20-county northern California region produces a significant amount of electricity from renewable resources, primarily from small hydroelectric, biomass, and geothermal plants. Some additional renewable generation comes from solar photovoltaic and wind facilities. Large (greater than 30 MW's) hydroelectric facilities in the region contribute further to the renewable resource mix, although they are not counted in the Renewables Portfolio Standard (RPS).

Small Hydroelectric

> In 2007 renewable resources in Upstate California generated 5,793,540 megawatt hours of electricity.

In 2007 small hydroelectric plants throughout the state produced 3,675,000 Megawatt hours (MWh's) of electricity, meeting 2.8 percent of California's demand. Small hydro capacity in the 20-county northern California region is currently listed as 536 Megawatts (MW's) with annual generation of 1,643,376 MWh's.[1] The region's resources produce 45 percent of all electricity produced in small hydroelectric plants statewide. In addition, these facilities are particularly valuable as 91 percent of the electricity production coincides with peak demand. (CEC 2005a, 2008a)

Large hydroelectric plants in Upstate California produced (based on the 2006-07 statewide average of hydroelectric capacity factors) an additional 16,667,000 MWh's from 5436 MW's of capacity.[2] Although technically a renewable resource, generation from large hydroelectric facilities is not counted in the RPS.

Biomass

In 2007 biomass plants produced 5,398,000 MWh's statewide, supplying 2.1 percent of the state's electricity. Upstate California contains 56 percent of all biomass power plant capacity. Assuming the statewide average capacity factor applies to plants in the region, annual electricity production from biomass is 2,757,000 MWh's

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[1] A megawatt (MW) is a unit of capacity. One MW of capacity produces one Megawatt hour of electricity for each hour it operates. A Megawatt hour (MWh) is equivalent to 1000 Kilowatt hours and is the amount of energy produced per hour by one MW of capacity.

[2] Capacity factor is a measure of plant utilization. A capacity factor of .35 means that the plant is operating for 35 percent of the year at full generation capacity (or for a larger percentage of the year at less than 100 percent capacity). At a 100 percent capacity factor, one MW of capacity produces 8760 MWh's annually (the number of hours in a year). At a 35 percent capacity factor, one MW of capacity produces .35x8760=3066 MWh's per year. The use of the statewide average is necessitated by the lack of data on individual plant output. The use of the state average probably results in underestimation of regional hydroelectric generation in that relatively favorable water conditions in the north state are likely to lead to higher plant capacity factors than elsewhere in the state. The 2006-07 statewide capacity factor for hydroelectric was nearly identical to the average for the 1996-2006 period.

Geothermal

Statewide there are 1,772 MW's of geothermal generating capacity producing 13,000,000 MWh's of electricity in 2007. These plants supply 4.5 percent of the state's electricity. Within Upstate California geothermal resources were responsible for generating 1,360,000 MWh's of electricity from 297 MW's of capacity (CEC 2005c, 2008a).

Solar Photovoltaic

Solar capacity and energy generation are not available specifically for the counties contained in the study area. The total capacity for PG&E's service area is published and includes projects defined as completed or active and those for which incentive claims have been received (PG&E 2008). Allocating total capacity to the study area on the basis of population implies that Upstate California currently has 16 MW's of solar PV. With a capacity factor of 23 percent, solar PV in the area generates 31,725 MWh's of electricity annually.

Wind

Relatively little wind capacity has been installed within the study area. Large-scale wind generation is uneconomic in the area as there are few sites with sufficient wind resources and available transmission capacity. However, a few smaller turbines have been installed in some class 3 areas of Northern California. Most of these are in the 10 to 20 kilowatt range, and it is assumed that the total installed capacity is one megawatt, with annual generation of 2,015 MWh's.

Table 1- Current Capacity and Annual Electricity Generation from Renewable Resources in Upstate California

Energy Resource	Capacity (MW's)*	Annual Generation (MWh's)**
Small Hydro	536	1,643,000
Biomass	356	2,757,000
Geothermal	297	1,360,000
Solar	16	31,725
Wind	1	2,015
Total	1206	5,793,540

*** All capacity figures, except for solar and wind, are from the database of California power plants over 0.10 MW. Solar is estimated from the capacity of total project applications for PG&E's service area times the proportion of the population located in the study area. Wind capacity is listed at 1 MW, based on estimates from installers in the area.**
**** Estimated from regional capacity and statewide capacity factors.**

Total Renewable Generation in Upstate California

The majority of renewable energy generation in Upstate California is from biomass, small hydro, and geothermal resources. Currently wind and solar resources constitute a very small percentage of local electricity production. However, in terms of future potential, these resources are likely to yield the most significant capacity and energy increases. Estimates of regional solar and wind potential, as well as that of additional small hydro, geothermal, and biomass in the study area, are presented in later sections of this report.

Top Producing Counties in Upstate California

Table 2 lists electricity production from renewable resources for all counties producing more than 100,000 MWh's annually. The resources include small hydroelectric, biomass, and geothermal. Annual electricity production is estimated based on the average capacity factors for the specific generation resources contained within the county. The eleven counties included in the table are responsible for over 98 percent of all electricity production from RPS-eligible resources in Upstate California.

Table 2- Current County RPS-Eligible Capacity and Annual Electricity Generation

County	Capacity (MW's)	Estimated Annual Generation (MWh's)	Primary Resources
Lake	302	1,371,506	Geothermal
Shasta	211	1,187,324	Biomass/Small Hydro
Placer	141	625,094	Small Hydro/Biomass
Lassen	67	510,909	Biomass/Geothermal
Humboldt	56	421,945	Biomass/Small Hydro
Plumas	68	401,223	Biomass/Small Hydro
Butte	92	369,046	Small Hydro/Biomass
El Dorado	76	232,556	Small Hydro
Colusa	29	226,033	Biomass
Nevada	72	220,691	Small Hydro
Siskiyou	45	139,196	Small Hydro

Regional Energy Demand

Electricity

For 2006 regional electricity demand totaled 13,482,000 megawatt hours (MWh's) (thousands of kilowatt hours). Of this amount, 6,345,000 MWh's were used by residential customers, while non-residential (commercial, industrial, agricultural, and institutional) consumption was 7,127,000 MWh's. Residential consumption was 47 percent of electricity demand, with the remaining 53 percent used in the sectors comprising non-residential customer classes.

With a 2006 regional population of 1,714,195, per capita electricity consumption was 7.86 MWh's. Per capita use for the state as a whole was 7.53 MWh's. Per capita residential use for Upstate California was 3.71 MWh's; while it was 2.42 MWh's for the state as a whole (CEC 2008b). Generally, the differences in residential use can be explained by differences in climate (per capita use is lower, particularly in the coastal areas of southern California) and the unavailability of natural gas for space and water heating in much of the study area.

Natural Gas

The effect of limited availability of natural gas in the 20-county area is apparent in the comparative 2006 per capita consumption figures for this energy resource. For Upstate California, total use per capita was 194 therms, while it was 355 therms for the state as a whole. Per capita residential use for the area was 114 therms, with per capita statewide residential use higher at 133 therms (CEC 2008b).

Total Residential and Non-Residential Energy Use

Table 3 summarizes per capita residential and non-residential use of electricity and natural gas for the study area and the state of California. The figures do not include wood or propane fuel and, of course, exclude transportation fuels.

Table 3- Per Capita Electricity and Natural Gas Use

Energy Source	Per Capita Use: 20-County Study Area	Per Capita Use: State of California	Difference in Per Capita Use: Regional Minus State	Percent Difference from State Per Capita Use
Electricity (MWh's)				
Residential	3.71	2.42	1.29	53.15%
Non-Residential	4.16	5.11	-0.95	-18.66%
Total	7.86	7.53	0.33	4.42%
Natural Gas (Therms)				
Residential	114.34	133.42	-19.08	-14.30%
Non-Residential	79.34	221.39	-142.05	-64.16%
Total	193.68	354.81	-161.13	-45.41%

Ratio of Renewable Electricity Production to Electricity Use: Upstate California

Currently renewable electricity production in Upstate California is 43 percent of area electricity consumption. This ratio far exceeds the current state Renewables Portfolio Standard (RPS) of 20 percent, as well as the proposed 2020 statewide RPS of 33 percent. Penetration of electricity from renewable resources in the area is currently 3.75 times the 11.4 percent level achieved for PG&E's service area as a whole. The difference in relative dependence on renewable resources is indicative of the area's relative abundance of these resources and a supportive attitude towards their development. As is demonstrated in the final sections of this report, even with more contemporary environmental protections in place, further development of the area's renewable resources can lead to area renewable electricity generation nearly equal to its electricity use.

In 2006 the renewable resources of Upstate California produced enough electricity to meet 43 percent of area demand, far in excess of the current 2010 20 percent Renewables Portfolio Standard.

Net County Electricity Production from RPS-Eligible Renewable Resources

Table 4 presents another way of assessing a county's contribution to electricity production from renewable resources. In this case the counties are ranked according to estimated annual generation relative to county electricity use. The table includes the seven counties where the ratio of renewable electricity production to consumption is near to or exceeds the average of 43 percent for the 20-county area. Four counties—Sierra, Lake, Lassen, and Plumas—actually generate more electricity from renewable resources than the total amount their residents and businesses consume.

Table 4- Ratio of County Electricity Production from Renewable Resources to County Electricity Use

County	Estimated Generation (MWh's)	Electricity Use (MWh's)	Generation/Use
Sierra	124,887	24,000	520.36%
Lake	1,371,506	650,000	211.00%
Lassen	510,909	280,000	182.47%
Plumas	401,223	224,000	179.12%
Colusa	226,033	242,000	93.40%
Shasta	1,187,324	1,618,000	73.38%
Humboldt	421,945	1,016,000	41.53%

Conservation Investments

Calculating the energy savings potential of a comprehensive conservation program is beyond the scope of this report; however, a qualitative discussion of a number of potential efficiency upgrades is included in this section. The discussion focuses on single-family homes, although much of it applies to multi-family and non-residential units as well. Improved insulation; window replacement; lighting efficiency improvements; and appliance upgrades, including heat pumps, have the potential to significantly reduce energy use in general and electricity use, in particular. In addition, an aggressive conservation program can create jobs and income for businesses and employees in the local economy as energy efficiency investment replaces the retail leakage associated with energy purchases from outside utilities.

Within Upstate California just over 20 percent of all single-family homes are heated with electricity, with a similar percentage using electricity for water heating (U.S. Census 2000). For those homes dependent on electricity as a primary energy source, the use of conventional space and water heating technologies implies significantly higher energy costs than for those households located in areas with natural gas service. In addition, 77 percent of new homes built in the area have central air conditioning—a major source of electricity use, particularly in the Sacramento Valley and lower foothill area.

Insulation Upgrades

Most homes built prior to implementation of Title 24 standards had insulation levels of R-11 in the attic area. The first California residential building standards led to the installation of R-19 attic insulation in most climate zones until the late 1980's when Title 24 was again revised. With nearly 44 percent of the single-family housing units in the study area built prior to 1980, there is a significant energy savings potential in insulation upgrades, much of it unrealized. Current practice is to insulate attics to at least R-38. The cost per square foot of $0.59 is quickly returned in energy savings, while jobs and income are generated for installers (CEC 2008c).

Window Replacement

Prior to implementation of the first Title 24 standards, single-pane windows were the norm in area homes. As in the case of insulation upgrades, installation of dual-pane windows significantly reduces home energy use with positive life cycle benefits. Single-pane windows can be replaced with dual-pane units for an installed cost of $27.25 per square foot (CEC 2008c).

Air Conditioner Efficiency Upgrades

Upgrading air conditioner units from SEER 13 to SEER 14 saves roughly 22 percent of the unit's energy use, or 526 kWh's annually in the Sacramento Valley climate. The installed cost of the higher efficiency unit is $105.36 in excess of that for the SEER 13 unit. Additional electricity savings are possible by installing an even more efficient unit, but the installed cost of a SEER 15 unit is $586.04 higher than that of a SEER 14 unit (CEC 2008c).

Solar Water Heating

The estimated cost of a solar water heating system in new single-family construction ranges from $3,000 to $3,500. For existing housing units the cost is higher, between $5,000 and $6,000. More than 20 percent of all homes in Upstate California use electricity for space heating, most because of the unavailability of natural gas service (U.S. Census 2000). It is likely that the saturation rate for electric water heating is at least as high. Electricity use for water heating averages 2,585 kWh's annually in PG&E's service area (CEC 2004). A solar water heating system providing 75 percent of a home's hot water would save 1,939 kWh's annually.

Heat Pumps Including Ground-Source Units

Air-Source Units

Newer heat pumps typically have Coefficients of Performance (COP) of upwards of 3.5, implying that for each kWh used; they deliver the energy equivalent of 3.5 kWh's to the space being heated. By comparison electrical resistance space heating cannot provide more than the heat equivalent of one kWh for each kWh used. The limitation on heat pump efficiency is that the actual COP depends on the outside temperature. The lower the outside temperature (in heating mode), the lower the COP. A COP of 3.5 may be achieved with an ambient temperature in the range of 50-60 degrees Fahrenheit, while it offers little efficiency advantage over conventional systems when the outside temperature falls to 30 degrees.

Economics impose further limitations on heat pump use. Heat pumps provide both heating and cooling, but in a cold climate air conditioning use may be minimal. Also in a cold climate the low ambient temperature reduces the COP, eliminating much of the efficiency advantage of a heat pump. Within PG&E's service area only 2 percent of housing units use heat pumps. Those homes in PG&E's service area that do use heat pumps use 28.2 percent less electricity for heating than do customers with electrical resistance space heating. However, that difference is difficult to interpret in efficiency terms as those electricity consumption estimates are not adjusted of house size, climate zone, or the age of the structure (CEC 2004).

Ground-Source Units

The effect of ambient temperature on heat pump COP is mitigated with ground-source units. Installation of an in-ground heat exchanger allows the system to take advantage of the relatively constant temperature of the soil at an appropriate depth. Typically the equipment for these systems costs an additional $4,000 (with drilling and other costs, the total installed system cost may exceed that of air-source units by $10,000 or more), but particularly in cold climates, may lead to a 50 percent increase in efficiency. With a ground temperature of 55 degrees Fahrenheit, system COP is maintained at a constant 3.5.

Potential Renewable Electricity Generation Resources

Small Hydroelectric

Renewable Portfolio Standards (RPS) Eligibility

RPS-eligible hydroelectric development applies only to those facilities with less than 30 MW's of installed capacity. In addition, to qualify for Supplemental Energy Payments (SEP's), the plants must have been placed in service after September 12, 2002 and require no new diversions or appropriations of water (CEC 2008d).

RPS-eligible small hydroelectric development includes projects at existing dams that currently do not have generating facilities; additional capacity at dams with generation, as long as the total capacity after development does not exceed 30 MW's; and the addition of generation capability in man-made conduits.[3]

Potential Capacity and Energy

A 2005 study published by the California Energy Commission identified 749 small hydroelectric projects statewide with a potential capacity of 1,927 MW and capable of producing, in an average water year, 5,880,000 MWh's of electricity. The location of the projects is indicated on the hydropower resource map included as Figure 2. Excluding sites that use existing man-made conduits, small hydroelectric potential in Upstate California is 981.5 MW's. At a typical 35 percent capacity factor, full development of this potential would result in the generation of over 3 million MWh's of renewable energy.

The development of much of this capacity is constrained by environmental considerations. However, man-made conduits offer additional possibilities for small hydro development and the utilization of this renewable resource is specifically encouraged by state policy. While these projects total only 24.9 MW's, they have the economic advantage of being eligible for above-market cost payments (from the New Renewable Resources Account) and the technical advantage of higher capacity factors: 57.5 percent rather than the 35 percent typical of small hydroelectric facilities. An additional advantage of these projects is that over 90 percent of their expected 125,800 MWh's of annual generation is coincident with peak demand, making the power they produce significantly more valuable (CEC 2005a).

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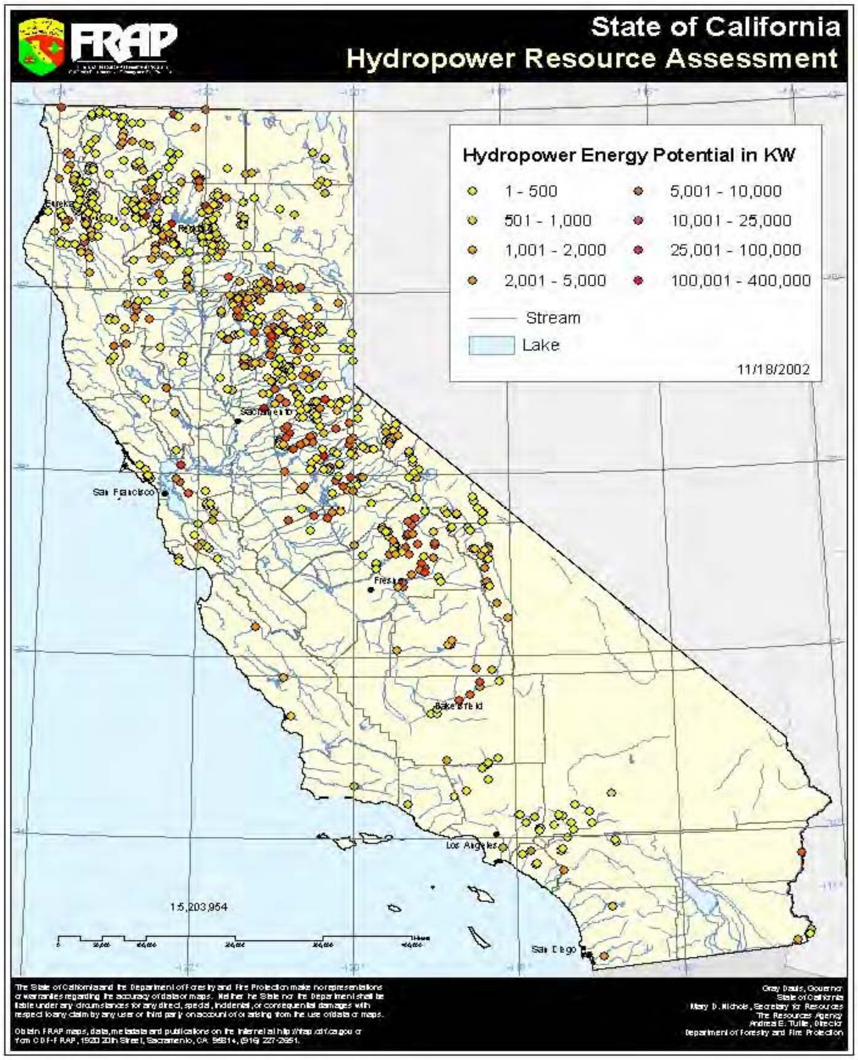
[3] Due to environmental concerns over water diversions, there is an implicit bias in the policy against hydroelectric project development except where generation is added to man-made conduits associated with water delivery systems. The bias is a graduated one based on the probable extent of environmental damage resulting from project development. Large hydroelectric facilities—presumably those inflicting the greatest amount of environmental damage—are not counted as renewable resources in the RPS. Systems of less than 30 MW's, but requiring new water diversions, are counted in the RPS, but are not eligible for incentive payments. That includes run-of-river projects that do not involve storage dams (but do require diversion structures) and additions of generating capacity at existing dams that require additional water appropriations for the generation portion of the project. The only projects that are specifically encouraged under the policy—those counted in the RPS and receiving above-market cost payments—are those in existing man-made conduits. Since these structures are already in place, and added generation facilities utilize existing water appropriations, electricity can be produced at these sites without significant adverse environmental impacts.

Figure 2- California Hydroelectric Sites



Biomass

Technology Description

There are a number of technologies available for converting organic wastes into more usable forms of energy. Generally, the selection of the specific technology depends on the types of waste material to be used as fuel. Direct combustion, anaerobic digestion, pyrolysis and gasification, and thermal depolymerization convert various biomass wastes into electricity, gaseous fuels, and liquid fuels, respectively.

Most fuel sources available in California are woody or other cellulosic materials, combustion is the logical biomass technology choice. There are three options available for combustion of biomass. Each is a method of generating electricity, but also produces waste heat in the form of residual steam. The most mature technology is a stoker boiler which burns the fuel in a thin layer on a fixed grate. While it generates electricity at slightly lower cost than the newer, fluidized bed combustion techniques, it also has the disadvantage of somewhat lower conversion efficiency, higher emissions, and less fuel flexibility (CEC 2007).

Fluidized bed combustion is a newer technology with further improvements in efficiency expected in the future. It involves the combustion of the fuel on a bed of granular material with air injected at high velocity beneath the bed. The result is a more even distribution of the fuel, lower emissions, and more complete carbon conversion (CEC 2007).

Another method of converting biomass to electricity is biomass gasification combined cycle. While it has the potential to reduce conversion costs, no commercial scale plants have been built. The potential cost advantage the technology offers is primarily due to higher efficiencies. The wood chips or other biomass material is first gasified and that fuel is used to operate a combustion turbine. The waste heat from the combustion turbine is then used to produce steam to operate a steam turbine as in a conventional stoker or fluidized bed boiler. Electricity is produced with both the combustion turbine and the secondary steam turbine, while the waste heat from the latter can boost output from the front-end gasifier. Overall, the system should achieve conversion efficiencies of 32 percent compared to 21.5 percent for stoker boilers and 22 percent for fluidized bed combustion.[4]

Resource Potential

Estimates of Biomass fuel supplies are available on the statewide level (Milbrandt 2005, Walsh 1999). The amount of the resources available in the study area is determined by allocating the statewide estimates by a number of factors explained in the Table 5 footnotes. The totals for each of the biomass waste categories are the amounts available at prices that permit economic biomass generation: below $50 per dry ton. No energy crops are included in the biomass resource base for California. The exclusion of switchgrass and other biomass crops is consistent with the sources consulted and is due to the relatively high production cost of these crops in California.[5]

[4] Overall efficiency of many biomass plants is considerably higher due to the utilization of a portion of the plant waste heat. The efficiency gains of biomass cogeneration—the simultaneous production of electricity and process heat—are not included in the calculations, as the additional energy produced ordinarily substitutes for industrial use of natural gas. Since the focus of this study is electricity production from renewable resources in Upstate California and the ratio of renewable based electricity generation to area consumption, the energy efficiency gains from the cogeneration portion of biomass plant operation are outside the scope of this report.

[5] There are some researchers who do not share this opinion, holding the position that some energy crops are economically feasible in California. Due to the high costs of both water and productive agricultural land it is likely that energy crops are limited to those requiring little or no irrigation that can be grown on less than prime agricultural soils.

Table 5- Biomass Fuel Availability and Study Area Potential Biomass Electric Generation

Source	Statewide (dry tons)	Percent in 20-County Area*	20-County Area (dry tons)	Generating Capacity (MW's)**	Annual Generation (MWh's)***
Crop Residues	1,659,000	18.25%	302,833	49.56	368,987
Forest Residues	1,303,000	91.38%	1,190,695	194.84	1,450,805
Unused Mill Waste	255,000	15.01%	38,265	6.26	46,625
Urban Wood waste	3,901,000	3.95%	153,993	25.20	187,633
Landfill methane	1,359,000	3.95%	53,647	8.78	65,366
Wastewater Methane	56,000	3.95%	2,211	0.36	2,694
Totals	8,533,000		1,741,644	285.00	2,122,110

*** Allocation of the state totals (Milbrandt 2005) is: for crop residues, by the percent of statewide harvested acreage in the study area; for forest residues, by the percent of harvested timberland in the study area; for unused mill waste, by the percentage of mill output in the study area, and for urban wood waste, landfill methane, and wastewater methane, by the percent of population in the study area.**

**** Calculated based on available fuel amounts and that 80 percent of biomass plants are built with the current lower (22 percent) thermal efficiency, while 20 percent of the units are the advanced gasification combined cycle units with a thermal efficiency of 33 percent**

***** Annual generation is based on a biomass energy content of 8,600 BTU's per pound.**

Economic Feasibility

Table 6 includes the capital costs and other pertinent operational and cost data for the three biomass combustion technologies discussed in the preceding section. All data entries are from 2007 sources including a California Energy Commission publication and a PowerPoint presentation by Navigant Consulting (CEC 2007, 2007a). Plant size ranges from 21.5MW to 25MW. While smaller plants can be built, they are less competitive in terms of generating costs. Capital costs are what is called “overnight costs” and do not include interest accrued during construction. Construction costs range from a low of just under $60 million to nearly $70 million. With capacity factors of 85 percent, a 25-year useful life for the project, and financing with private non-utility bonds, the cost per kilowatt hour ranges from 11.7 to 12.7 cents.

Table 6: Electricity Generation Costs for Biomass Combustion Technologies

Technology	Overnight Capital Costs	Plant Size (Megawatts)	Useful Life (Years)	Capacity Factor (%)	Generation in kWh's/Year	Levelized Cost/kWh
Stoker Boiler	$64,150,000	25	25	85	186,150,000	$0.117
Fluidized Bed	$68,750,000	25	25	85	186,150,000	$0.126
Integrated Gasification Combined Cycle	$59,500,000	21.25	25	85	158,227,500	$0.127

Solar

Technology Description

There are two methods for utilizing solar energy for generating electricity: photovoltaic cells and solar thermal systems. Solar photovoltaic systems (PV) use solar cells to directly convert sunlight to electricity. PV cells are combined into arrays and can be mounted on roofs or the ground. Systems can be stand-alone or grid-connected. They may also use concentrating lenses, reducing the capacity of the arrays needed to generate a given amount of electricity.[6] All PV systems require an inverter to convert the DC power produced by the cells to AC power used to run motors and other electrical equipment. In spite of the relatively high cost of PV systems, domestic shipments of PV cells and modules increased from 12,561 kilowatts in 1997 to 206,511 kilowatts in 2006 (EIA 2007).

Photovoltaic cells can be made from a variety of materials including silicon, gallium arsenide, cadmium telluride, and others using one or more of the nine elements with photovoltaic potential. Silicon based cells are the most commonly available and can be manufactured from silicon in monocrystalline, multicrystalline, ribbon, or amorphous form. The latter two are the least costly, but also the least efficient, with amorphous silicon cells having efficiencies of around 6 percent. Most commercially available cell arrays and modules (interconnected cells) are constructed of multicrystalline cells with efficiencies of around 15 percent.

PV cells can be configured as flat arrays, utilizing the sun's natural intensity, or the sun's energy can be concentrated with the use of lenses. The advantage of focusing solar energy on a smaller array is that more efficient cells can be utilized, their higher cost offset by much greater electrical output.

Another method for converting the sun's energy to electricity is the thermal trough. These systems use parabolic reflectors mounted on an east-west axis to collect the sun's heat energy and to transfer it to a working fluid, usually oil. The parabolic shape of the collector allows solar energy to be concentrated as much as 60 times. The heated fluid is then passed through a heat exchanger to produce steam to operate a turbine, generating electricity. Between 1984 and 1991 nine plants with an installed capacity of 343 megawatts were constructed by Luz International at sites in the Mojave Desert (EB 2005). Currently, an additional eight plants are under review for installation in the desert areas of southern California.

Solar Resources in Upstate California

As shown in Figure 3 most of the inland portions of Upstate California have moderately good solar energy resources, with annual solar potential of 5 to 6 Watt-hours per square meter per day. While study area resources are not of sufficient quality to attract development of large-scale solar trough facilities, they are adequate for economic installation of rooftop flat plate collectors on homes and commercial buildings.

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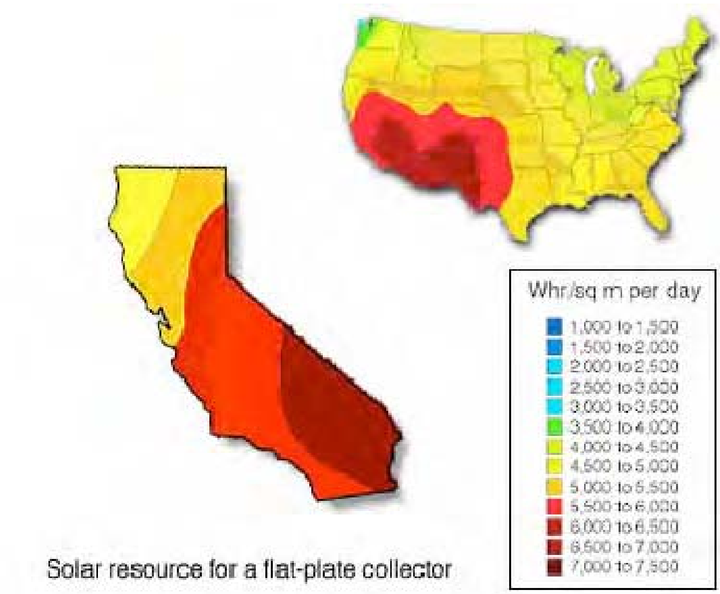
[6] Because of the need for fewer arrays, concentrating PV systems generally cost less per installed kilowatt. However, they do suffer a greater annual rate of decrease in output (due to cell degradation) than do systems without lenses.

Figure 3- California Regional Solar Energy Potential



Resource Potential

In a 2005 California Energy Commission (CEC) study, the technical potential of rooftop installations of flat plate solar photovoltaic systems was estimated for California as a whole and for individual counties within the state. The statewide potential for residential installations was estimated at 38,000 MW's, with an additional 37,000 MW's for commercial buildings. For Upstate California the residential and commercial potential was estimated at 2,190 MW's and 3,760 MW's, respectively (CEC 2005b).

The estimates presented in the cited CEC report are representative of maximum potential, but not technically feasible potential. In the case of residential applications, they require a rooftop oriented towards the south. That requirement alone may prevent 50 percent of homeowners from installing rooftop solar power. In addition, plumbing vents, roof vents, and other obstructions probably limit system sizes below the 2.5 kW's assumed in the residential potential analysis. Multifamily housing units of two or more stories further limit solar capacity per housing unit, although multifamily units (including single story units) are only 15.7 percent of all units in the study area.

A more realistic projection for Upstate California is based on an average of 1 kW per existing housing unit and 2.5 kW's for all newly constructed units. On this basis, area residential PV system potential is 765 MW's for existing units and an additional 47 MW's annually for the of the 18,776 new single-family housing units (yearly regional average for the 2000-07 period) expected to be added annually.

Estimated commercial solar potential is 3,760 MW utilizing 100 percent of retail and wholesale rooftop space in Upstate California (CEC 2005b). Again allowing for HVAC systems and other rooftop obstructions, perhaps 50 percent of the commercial rooftop area is suitable for solar PV installations, implying a potential of 1,880 MW's.

With an average capacity factor of 23 percent, potential solar electricity generation within the study area is 5,424,000 MWh's annually. And, since most of the electricity is produced during summer peak hours, the power supplied to the grid is considerably more valuable than the average wholesale rate.

Economic Feasibility

Rooftop photovoltaic systems provide positive benefits to homeowners in the form of non-taxable reductions in their utility bills. The state buy down program, available for customers of major investor owned utilities; net metering, eliminating the need to match the timing of solar PV generation and household energy use; the state property tax exemption for solar PV equipment; and the federal tax credit, recently extended with the $2,000 limit eliminated, all improve the economics of residential PV installations. While the buy down program is phased out as additional PV capacity is installed, this cost increase is likely to be offset by declining costs as industry economies of scale reduce equipment costs.

There are incentives available for commercial and institutional (including non-profits) customers as well. The tax benefits of system depreciation improve the economics of PV for private businesses. In addition, large commercial and industrial customers are eligible for time of use rates. Since the majority of the generation occurs during the summer peak demand period, under this rate structure more of the economic benefits accrue to private businesses installing PV systems.

Wind

Technology Description

Wind is utilized in the generation of both utility scale, and small scale electricity. The world-wide trend in producing utility scale wind energy is the increased utilization of large arrays of industrial sized, multi-megawatt (MW) turbines with 50 meter rotors mounted on 75 meter tall towers. Recent technological and material improvements allow for taller turbines and larger rotors. The increase in the scale of the turbines has led to a decrease in the average cost of each unit of electricity produced. Multi-MW turbines, greater than 3 MW, are primarily targeted for offshore installation where wind is more consistent and is less turbulent. For on-shore applications, multi-MW turbines will likely have size constraints of 2.5-3 MW or less because of inadequate wind sources and logistical problems in transporting turbine blades 50 meters in length (CEC 2006a). The average size of turbines installed in 2007 was 1.65 MW (DOE 2007).

One of the most important factors in determining the viability of wind energy generation is the wind resource potential. A unique characteristic of wind is that its energy varies with the cube of its speed. This means that small differences in wind speed lead to big differences in the power output of a wind turbine. For example, if wind speed is doubled, energy content increases by a factor of eight. Turbulence, obstructions, and ground effects all can decrease the performance of a wind system, while higher wind speeds associated with increased elevation lead to improvements in performance.

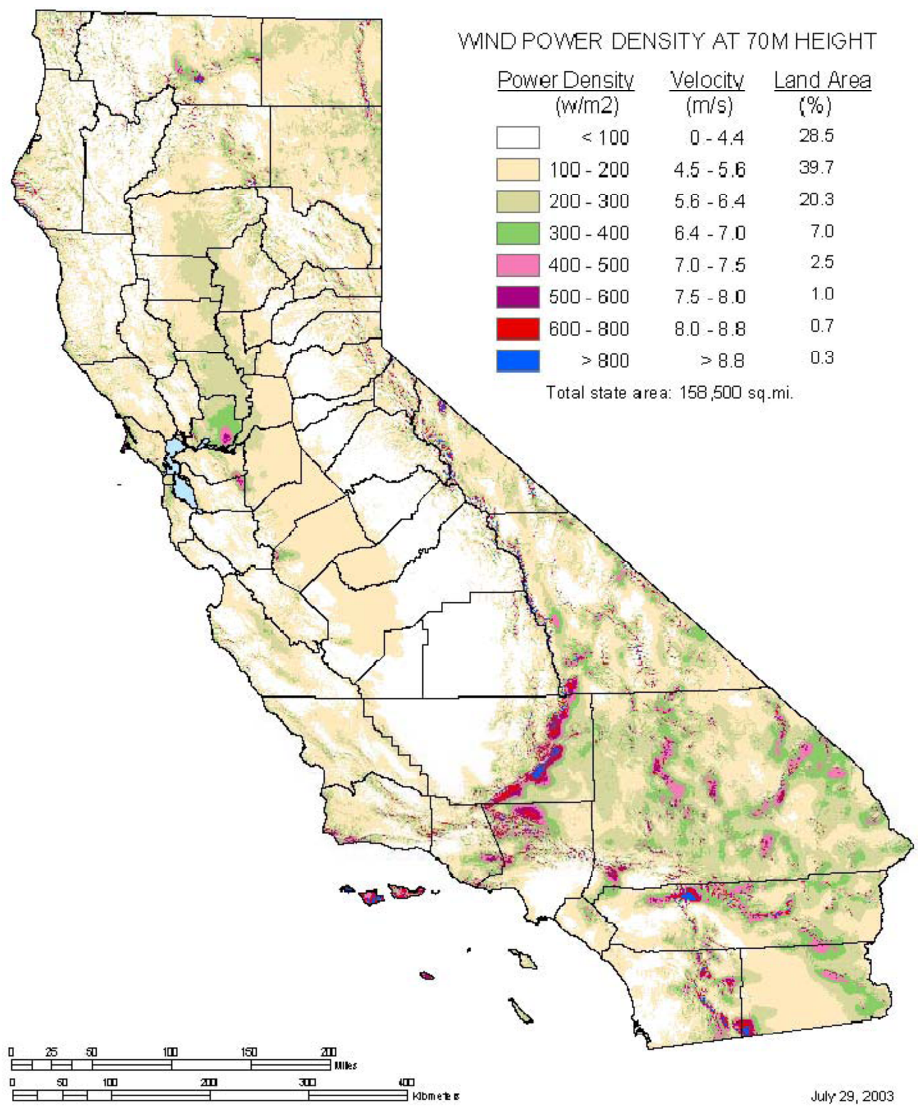
Sites suitable for large utility scale wind turbine installations have Class 5 wind speed with annual average wind speeds of at least 7m/s (15.7 mph) and power potential greater than 500 W/m2. Newer technologies being developed are expected to be capable of producing power at lower Class 3 wind speeds of 6m/s and power potential of 300 W/m2. At this time, however, it is not economically viable to develop areas of Class 3 (or less) wind speed with utility scale wind systems (CEC 2006).

Wind Resources in Upstate California

Class 4 and Greater

The California wind resource map included below indicates that there are a number of sites in northern California with Class 4 or greater wind speeds. Among the sites with Class 6-7 wind speeds (7.5-8.8 m/s) are the Warner Mountains in eastern Modoc County; several areas in southern and eastern Siskiyou County; sites near the coast in Del Norte and Humboldt Counties; and in scattered mountainous areas of the Sierras and Cascades from the southern portion of the study area through Shasta County.

Figure 4- California Wind Energy Potential



While there are significant wind resources in Northern California, most are in inaccessible locations and far from major transmission lines. Both of these factors adversely affect the cost competitiveness of large-scale wind resource development in the study area. For that reason it is unlikely that major development of wind will occur in this region in the near future

Feasible Low Speed Resources

Low speed wind resources may be developed where they produce system benefits in the form of reduced on-peak transmission loads. In a simulation study completed for the California Energy Commission 223 MW's of low speed wind capacity were studied in Lassen and Siskiyou Counties. It was determined that 41 MW's of that capacity, all located in Siskiyou County, yielded positive benefits. Development of the remaining low speed resources is likely only in association with development of nearby Class 4 and above sites, an eventuality that depends on extending transmission corridors (CEC 2005d).

Resource Potential

In the short term it is probable that wind resource development will be largely limited to areas with adequate transmission capacity already in place. With the possible exception of the Warner Mountains site and some small-scale turbines in agricultural areas on the west side of the Sacramento Valley, it is likely that the 41 MW's of low speed resources in Siskiyou County represent the upper end of near term wind resource development within the study area. With a capacity factor of 23 percent (representative of small turbines installed in Class 3 wind areas), the 41 MW's of capacity will produce 82,607 MWh's annually.

Economic Feasibility

Of all of the available renewable technologies, wind is the most cost effective with generating costs of just over $0.04 per kWh.[7] However, that cost assumes the developed site is accessible and near transmission lines of adequate capacity and appropriate voltage. Unfortunately, for Upstate California there are no wind resources, beyond the 41 MW's mentioned in the preceding section, that satisfy those criteria.

Geothermal

Technology Description

Outside of the Geysers geothermal area, geothermal energy resources available in California are of the "wet steam" variety. The nature of this resource makes it impossible to utilize the low-cost technology employed with the "dry steam" resources of the Geysers area. Instead, conversion requires the use of either dual flash or binary technologies. The flash process can be utilized only where steam reservoir temperatures exceed 400 degrees Fahrenheit. Since the binary system incorporates a secondary loop

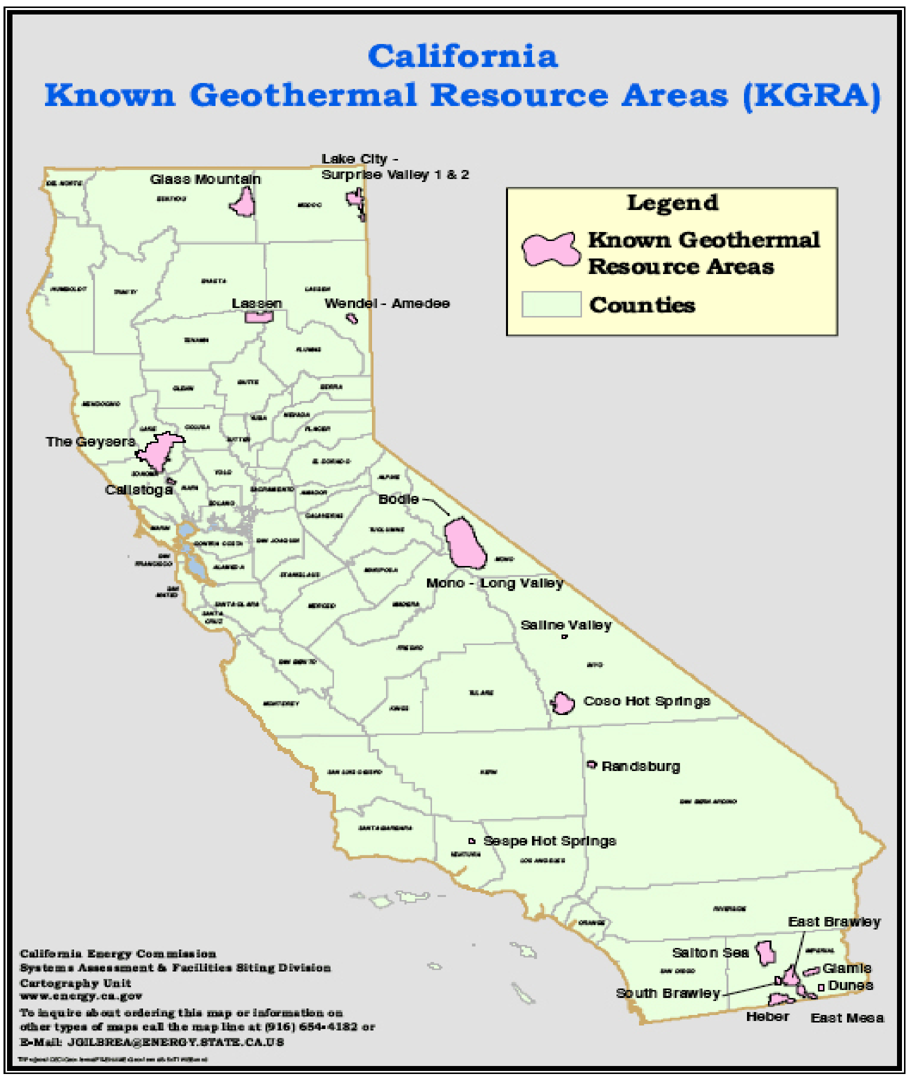
[7] These costs are not applicable to all wind generation. Costs in the $0.04 to $0.05 per kilowatt hour range are achieved with large scale systems in Class 6 or 7 wind areas. Areas with lower wind speeds or systems using smaller turbines will have costs that are significantly higher. The cost estimates presented here are representative of what can be achieved at the only site (a Class 6-7 site) included as part of the area's resource potential, but should not be generalized to other wind resources.

for vaporization and condensation of a working fluid (isobutane, for example), a plant using this technology can be built in areas where geothermal steam temperatures are below the 400 degree Fahrenheit threshold that must be met for the flash process.

Geothermal Resources in Upstate California

There are several sites in the study area where geothermal resources are known to exist. The California Energy Commission resource map included on the next page identifies five sites with significant geothermal resources: Surprise Valley in eastern Modoc County; Glass Mountain in eastern Siskiyou County; Lassen overlapping the borders of Lassen, Plumas, and Shasta Counties; Sulfur Bank Field near Clear Lake in Lake County; and Honey Lake (Wendel-Amedee) in southeastern Lassen County. The most promising of these sites is Glass Mountain. That resource is currently being developed by Calpine Corporation. In May 2003 the Department of the Interior issued a license that authorized the construction and operation of the 48 MW Telephone Flat power plant. However, as of 2005 development was blocked due to ongoing legal action.

Figure 5- California's Known Geothermal Resource Areas



Another facility proposed by Calpine in the Fourmile Hill area has been hampered by low steam flow rates in test wells. To date the only successful development of liquid-dominated geothermal resources in California has been by Unocal and Magma Power Company, since bought out by CalEnergy Corporation, at sites in the Salton Sea area. As of 2005 there were 288 MW of installed geothermal capacity at that location (CEC 2005c).

Resource Potential

Current geothermal resource development in Upstate California is limited to 297 MW's with all, except for 1.9 MW of capacity developed at Wendel-Amedee, in the dry steam resource area in Lake County. The projected capacity for the remaining resources is 262.3 MW's with 211 MW's at Medicine Lake (Glass Mountain); 43 MW's at Sulfur Bank Field (Clear Lake); and an additional 8.3 MW's at Honey Lake. If, as expected, they achieve the same 90 percent capacity factor as Wendel-Amedee, development of these resources will contribute an additional 2,067,973 MWh's annually to generation within the study area.

Economic Feasibility

Table 7 includes the capital costs and other pertinent operational and cost data for the dual flash and binary technologies applicable to liquid-dominated geothermal resources. All data entries are from 2007 sources including a California Energy Commission publication and a PowerPoint presentation by Navigant Consulting (CEC 2007, 2007a). Plant capacity for each of the technologies is 50 Megawatts, operating at a 95 percent capacity factor (costs are slightly higher for a 90 percent capacity factor). Capital costs are what is called "overnight costs" and do not include interest accrued during construction. Construction costs range from $137.5 million to $150 million. With capacity factors of 95 percent, a 20-year useful life for the project, and financing with tax exempt bonds, the cost per kilowatt hour for a plant incorporating either technology is 6.7 cents.

Table 7- Electricity Generation Costs for Geothermal Energy Technologies

Technology	Overnight Capital Costs	Plant Size (Megawatts)	Useful Life (Yrs.)	Capacity Factor (%)	Generation (kWh's/Year)	Levelized Cost/kWh
Dual Flash	$137,500,000	50	20	95	416,100,000	$0.0670
Binary	$150,000,000	50	20	95	416,100,000	$0.0672
Source: CEC 2007 and Navigant Consulting 2007						

These costs are considerably less than those for gas-fired combined cycle plants (the competing conventional generating technology) and therefore there are no economic constraints on development of geothermal resources within the study area. However, other impediments to resource development may exist. Calpine Corporation has experienced conflict with owners of recreational housing and Native American tribes at the Medicine Lake site.

Potential Additions of Renewable Electricity Production: 20-Year Development Scenario

Total Resource Potential

Table 8 contains total capacity and annual generation for all additional renewable resource based electricity generation in the 20-county area. Solar photovoltaic potential is based on the assumption that: one kilowatt of capacity is added to each unit of the current single-family housing stock; solar PV is added to one-half the roof area of all existing and new non-residential structures; and 2.5 kilowatts of solar PV capacity are added to each new housing unit. No capacity additions are assumed for multi-family structures or mobile homes.

Total potential capacity additions are 4,689 MW's, with solar PV providing the majority of the new capacity and 6,234,000 MWh's of annual generation. Wind makes the smallest contribution, primarily because of limitations on area wind resources and the assumption that wind development will be limited to a transmission corridor in Siskiyou County.[8]

Table 8- 20-YearPotential for Additional Area Renewable Electricity Generation: Existing Technologies

Resource Type	Capacity (MW's)	Annual Generation (MWh's)
Solar PV	3,094	6,233,791
Small Hydro: Man-Made Conduits	25	125,766
Small Hydro: Other	982	3,009,279
Geothermal	262	2,180,364
Biomass	285	2,123,438
Wind	41	82,607
20-Year Total	4,689	13,755,245

Scenario Description

In order to calculate the regional economic impact of developing additional renewable energy resources, it is necessary to make some assumptions about the rate of development. To illustrate the potential effect on income and employment in Upstate California a particular, somewhat aggressive, program is assumed. It is one that presupposes significant support at the state and federal levels and is perhaps more descriptive of a goal than of an expected outcome.

By 2029 electricity production from renewable resources could produce an amount of electricity equivalent to 92 percent of area demand.

[8] This is a particularly conservative assumption as new technology, likely to be available within the next decade, is expected to make large-scale wind generation economically feasible at Class 3 sites.

Assumptions

The following assumptions form the basis of the economic impact analysis contained in Table 9:

- Five percent of potential renewable electricity generation is developed annually
- All renewable energy resource development takes place with existing technology
- No structural changes occur in the regional economy; that is, the aggressive development of renewable energy resources does not increase the percentage of indirect industry sales that accrue to firms located in Upstate California
- Development of additional renewable generation capacity begins in 2010

Results: Future Ratios of Upstate California Renewable Electricity Production to Area Electricity Use

Table 9- Ratio of Area Renewable Generation to Electricity Demand: 20-Year Projection

Year	Area Electricity Demand (MWh's)	Generation: Existing Renewable Resources (MWh's)	Generation: New Renewable Resources (MWh's)	Total Area Renewable Electricity Generation (MWh's)	Ratio of Area Renewable Electricity Generation to Area Electricity Demand
2010	14,593,350	5,794,115	687,762	6,481,878	44.42%
2011	14,885,217	5,794,115	1,375,525	7,169,640	48.17%
2012	15,182,922	5,794,115	2,063,287	7,857,402	51.75%
2013	15,486,580	5,794,115	2,751,049	8,545,164	55.18%
2014	15,796,312	5,794,115	3,438,811	9,232,927	58.45%
2015	16,112,238	5,794,115	4,126,574	9,920,689	61.57%
2016	16,434,483	5,794,115	4,814,336	10,608,451	64.55%
2017	16,763,172	5,794,115	5,502,098	11,296,213	67.39%
2018	17,098,436	5,794,115	6,189,860	11,983,976	70.09%
2019	17,440,405	5,794,115	6,877,623	12,671,738	72.66%
2020	17,789,213	5,794,115	7,565,385	13,359,500	75.10%
2021	18,144,997	5,794,115	8,253,147	14,047,263	77.42%
2022	18,507,897	5,794,115	8,940,909	14,735,025	79.61%
2023	18,878,055	5,794,115	9,628,672	15,422,787	81.70%
2024	19,255,616	5,794,115	10,316,434	16,110,549	83.67%
2025	19,640,728	5,794,115	11,004,196	16,798,312	85.53%
2026	20,033,543	5,794,115	11,691,958	17,486,074	87.28%
2027	20,434,214	5,794,115	12,379,721	18,173,836	88.94%
2028	20,842,898	5,794,115	13,067,483	18,861,598	90.49%
2029	21,259,756	5,794,115	13,755,245	19,549,361	91.95%

The resource development scenario presented in Table 9 implies an increasing ratio of area renewable electricity generation to area electricity consumption, with the ratio rising from 44.4 percent in 2010 to 92 percent in 2029. The entries for existing generation exclude all large hydroelectric generation as it does not qualify as renewable under California's Renewables Portfolio Standard (RPS). At 43 percent the current ratio already exceeds both the current state RPS of 20 percent and the proposed 2020 RPS of 33 percent. Since the current statewide ratio falls far short of the 20 percent RPS, it can be expected that the renewable resources in Upstate California will receive considerable attention in the near future.

Economic Impacts of Renewable Electricity Resource Development

IMPLAN Model

All sales, income, and employment impacts are estimated using the IMPLAN model. IMPLAN is an input-output model (I-O) that separates the economy into industrial sectors, classifying each according to the primary product or service it provides. The transaction matrix is the model that estimates impacts. The transaction matrix contains the purchases and sales that occur among the various sectors. The column entries are the purchases made by a particular sector from all other sectors included in the model. The row elements are the industry destinations of the sector's sales. The I-O model permits assessment of the total impact of an initial change in income or expenditures.[9]

The total impact is the sum of the direct, indirect, and induced impacts. The indirect impacts are the result of purchases (by the sectors directly affected) from local industries supplying inputs. The induced effects are due to the spending of additional income earned through the enhanced business activity generated by the direct impacts. The model output includes estimated impacts on business revenues, income, and employment.

Results: 20 -Year Development Scenario

Table 10 contains the estimated impacts on annual business revenues, income, and employment in Upstate California. Impacts are separated into those accruing during plant construction and the annual impact of operation and maintenance including biomass fuel costs. Impacts are expressed in terms of total area spending (business revenues), income, and employment (both full- and part-time). The entries are the total effects on the local economy and include the direct, indirect, and induced impacts.

Annual construction impacts are assumed to be uniform over the 20-year development period with five percent of potential capacity developed each year. The annual impact on business revenue (sales or

[9] The IMPLAN estimates presented in this section must be interpreted with some caution. Construction and operational expenditures are entered into the sector most closely matched to a particular renewable energy activity. For example, solar PV on new housing units is entered into the sector, "new single-family housing", while solar PV on existing homes uses the sector for "residential additions and alterations". This implies that installation of solar PV is similar, in terms of income and employment impacts, to other activities in the sector. This is not necessarily the case. A kitchen remodel or reroofing a home (typical activities included in residential alterations and additions) may have impacts that differ from those of solar PV installation. A precise estimate of income and employment impacts would require a study that precisely identifies the input requirements (and the place of purchase—local or otherwise) for each of the renewable energy technologies included in the study. Thus, as with any IMPLAN-based impact study, the income and employment impacts presented here must be seen as approximations.

spending) including indirect and induced effects is over $2.7 billion. Those additional sales are responsible for $1.6 billion in area income and 23,109 full- and part-time jobs. Since the annual spending is assumed constant, construction spending continues to support these area income and employment levels throughout the 20-year construction period. With the exception of additional solar PV on new buildings (and probably new wind capacity), at the end of 20 years the construction income and jobs are eliminated, leaving the area economy with the impacts of biomass fuel production and operation and maintenance of completed plant capacity.

The area impact of the plant operation phase increases over the 20-year scenario as additional capacity is brought on line at the rate of five percent of potential. In the first year local spending is increased by $46.5 million, adding $26.0 million to local income and 364 jobs. Area spending, income, and employment continue to grow reaching levels of $930.8 million, $519.7 million, and 7,287 jobs, respectively at the end of the 20th year. Those levels are then sustained for the entire useful project lives. Beyond the 20-year period some plant will need to be replaced, again generating construction income and employment.

Table 10- Annual Area Spending, Income, and Employment from Additional Renewable Electricity Generation Resources: 20-Year Development Scenario

	Area Spending		**Area Income**		**Area Employment**	
Year	Construction	Operation	Construction	Operation	Construction	Operation
2010	$2,736,515,803	$46,540,273	$1,556,121,235	$25,986,022	23,109	364
2011	$2,736,515,803	$93,080,547	$1,556,121,235	$51,972,044	23,109	729
2012	$2,736,515,803	$139,620,820	$1,556,121,235	$77,958,066	23,109	1,093
2013	$2,736,515,803	$186,161,094	$1,556,121,235	$103,944,088	23,109	1,457
2014	$2,736,515,803	$232,701,367	$1,556,121,235	$129,930,111	23,109	1,822
2015	$2,736,515,803	$279,241,641	$1,556,121,235	$155,916,133	23,109	2,186
2016	$2,736,515,803	$325,781,914	$1,556,121,235	$181,902,155	23,109	2,550
2017	$2,736,515,803	$372,322,188	$1,556,121,235	$207,888,177	23,109	2,915
2018	$2,736,515,803	$418,862,461	$1,556,121,235	$233,874,199	23,109	3,279
2019	$2,736,515,803	$465,402,734	$1,556,121,235	$259,860,221	23,109	3,643
2020	$2,736,515,803	$511,943,008	$1,556,121,235	$285,846,243	23,109	4,008
2021	$2,736,515,803	$558,483,281	$1,556,121,235	$311,832,265	23,109	4,372
2022	$2,736,515,803	$605,023,555	$1,556,121,235	$337,818,287	23,109	4,736
2023	$2,736,515,803	$651,563,828	$1,556,121,235	$363,804,309	23,109	5,101
2024	$2,736,515,803	$698,104,102	$1,556,121,235	$389,790,332	23,109	5,465
2025	$2,736,515,803	$744,644,375	$1,556,121,235	$415,776,354	23,109	5,829
2026	$2,736,515,803	$791,184,649	$1,556,121,235	$441,762,376	23,109	6,194
2027	$2,736,515,803	$837,724,922	$1,556,121,235	$467,748,398	23,109	6,558
2028	$2,736,515,803	$884,265,195	$1,556,121,235	$493,734,420	23,109	6,922
2029	$2,736,515,803	$930,805,469	$1,556,121,235	$519,720,442	23,109	7,287

Conclusions

Resource Potential

The 20-county northern California area is a significant producer of electricity from renewable resources. If it were a separate utility service area subject to the state Renewables Portfolio Standard, it would have already exceeded the requirements imposed by the 20 percent 2010 standard and the stricter, proposed 2020 standard of 33 percent. As of 2006 the ratio of area renewable electricity production to area demand was 0.427.

With 43 percent of area electricity demand offset with generation from renewables, Upstate California far exceeds the 11.4 percent achieved for PG&E's service area as a whole. However, current area generation from renewables is less than 25 percent of the area's additional potential. Development of 100 percent of the area's resources over a 20-year period would, even accounting for demand growth, lead to area renewable electricity generation equal to 92 percent of area electricity demand. If that same level of commitment were applied to investment in conservation and energy efficiency, demand growth would be lower or even zero, raising the percentage from 92 percent to over 100 percent.

An aggressive program of renewable resource utilization would not only assist in meeting the statewide Renewables Portfolio Standard, but would also be a major driver of economic development in the north state. Assuming full resource development over 20 years, construction employment would average over 23,100 jobs, while annual income would be increased by nearly $1.6 billion. Following completion of all plant construction, operation and maintenance expenditures would continue to add $931 million in annual income and support 7,287 permanent jobs in the area economy.

Constraints

There are a number of factors likely to limit renewable energy resource development. Environmental issues—air quality in the case of biomass and other environmental concerns associated with small hydroelectric facilities—can limit the development of these resources. Funding limitations may constrain solar PV development, particularly for residential applications. A lack of adequate transmission capacity will make it difficult to achieve the full resource potential for a number of resources located in remote areas. Distribution issues may prevent development of wind potential in southern Siskiyou County, as well as some of the listed small hydroelectric, geothermal, and biomass resources in Upstate California. Identifying the constraints and developing approaches for overcoming the limitations they impose, must be at the center of any strategy designed to pursue renewable energy development in the area.

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