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Abstract

Trying to compare energy types is a challenge. The purpose of this project is to convert various energy sources used in California into common units so that they can be compared readily by the public. Additionally, the amount of space occupied by each facility or unit is provided so that their land use can also be compared. These numbers for windmills, solar panels, oil wells, etc. will be published on a bookmark for public distribution.

Introduction

A variety of energy sources are used to produce electricity. These energy sources include natural gas, nuclear power, wind, solar, geothermal, hydropower, and biomass. The primary electricity sources from California in 2003 are as follows: 43% gas, 16.78% hydroelectric, 16.57% nuclear, 12.67% coal, 10.98% renewables (see figure 1).[1]

Example calculation: $\frac{\text{(Natural Gas 92,356 Gigawatt-hours)}}{\text{(Total in-state power 214,801 Gigawatt-hours)}} \times 100 = 43\%$

*These percentages are not including the import sources. Both large and small hydro was combined into one percentage.

Natural gas is used for producing electricity, but is also used for heating. In 2000, 6,600 million cubic feet of natural gas was consumed a day in California for heating purposes[I]. Petroleum, a different type of energy source, is used primarily for transportation (gasoline) and manufacturing a variety of products including plastics and medicines. Californians consumed 289,416 thousand barrels of oil in 2003[II].

Based on usage in California, the following sources will be evaluated in this project: natural gas, both offshore and onshore; nuclear; hydropower; oil, both offshore and onshore; wind; solar; and wave power.

The basis for the simplified numbers identified in the bookmark is provided in the following discussion. In each case, the goal was to determine the parameters for a "typical" facility. This is not an easy task and there are a wide range of potential types of facilities, and several different ways that one might determine what the average energy production might be from a particular facility. In this report, the median values were often preferred to a straight average, so that the final number represents a true facility. Note that most of the technologies have been around for some time; as technology improves and older facilities are replaced with more efficient or more advanced technologies, the amount of power which can be obtained from a given facility will also increase. This report did not use the most advanced values for each type of energy; instead these calculations look at what exists today and provides an average of both older and newer facilities. Note that in most cases, current technology would provide numbers higher than that represented on the bookmark.

The following report provides the assumptions and constraints used to arrive at the "typical" facilities and the values identified on the bookmark. This report was developed by an MMS intern, Laura Martinez as a summer project. Laura is a chemical engineering student at Texas A&M-Kingsville.

[I] http://www.energy.ca.gov/naturalgas/consumption.html

[II] http://www.energy.ca.gov/oil/statistics/crude_oil_receipts.html

Assumptions and Constraints

Wind Turbines (onshore)

California has five major wind farms consisting of Altamont, San Gorgonio, Tehachapi, Pachecho, and Solano. Small 100 kW turbines are the most common turbine in California wind parks. [2] In order to calculate the electrical output from one wind turbine this average number was used and a capacity factor of 35%.[III]

Electrical Output from a 100 kW turbine:

100 kW *24 hours/day *0.35= 840 kWh/day
Converting from kWh to BTU's:

840 kWh | 3412 BTU[IV] = 2,866,080 BTU/day
day | 1 kWh

Land Area Per Turbine:

One 100 kW turbine has a rotor diameter of 21 feet and requires a concrete pad that is 20 feet by 20 feet.

Area of foot print = 20 * 20 = 37.2 m²
37.2 m² * 0.0002471 acres = 0.009183 or 0.0092 acres/turbine
turbine m²

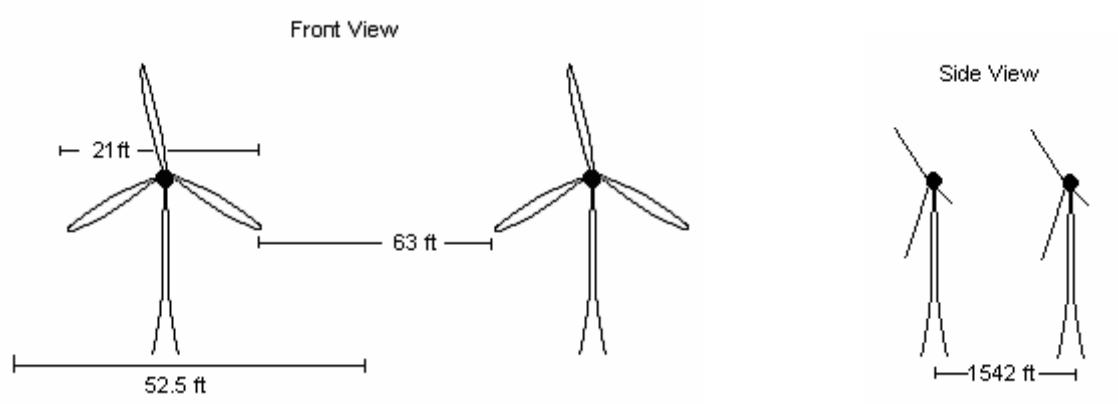
The standard rule is that there must be at least three rotor diameters between each turbine which in this case means that there must be at least 63 feet between each turbine. When this area is taken into consideration, the diameter becomes 31.5 feet, half of 63 feet or the distance between two turbines.[V] The distance to separate rows of turbines so the wind is not too turbulent by the time it gets to the next row of turbines is 1,542 feet.

Calculations:

Finding the space one wind turbines occupies with wind into consideration:

(63 ft) between turbines * (1542 ft) between rows = 2.23 acres

[III] California State Department of Energy. Renewable Resources Report.
[IV] 1 Kilowatt hour of electricity = 3412 BTU
[V] Lawrence Mott Northern Power Systems (802)496-2955



Hydropower

Hydroelectricity is the second highest energy producer in California. The Trinity power plant, located in Trinity County near Weaverville, CA, had a median capacity of 140,000 kW out of the thirteen power plants located in California (see figure 3).[5] The median value was used since there is a wide range in capacities from the hydropower plants.

Maximum Capacity Potentials are all in kilowatts (kW):
Folsom: 198,720; Judge Francis Carr: 154,400; Keswick: 117,000; Lewiston: 350; New Melones: 300,000; Nimbus: 13,500; O'Neill: 25,200; Parker: 120,000; San Luis: 202,000; Shasta: 646,000; Spring Creek: 180,000; Stampede: 3,650; Trinity: 140,000

Finding the median capacity:
{350; 3,650; 13,500; 25,200; 117,000; 120,000; **140,000**; 154,400; 180,000; 198,720; 202,000; 300,000; 646,000}

The power plant has an installed capacity of 140,000 kW and a capacity factor of 0.4209.[VI]

Calculations:

Finding the amount of energy per day:
(140,000 kW) * (24 hours/day) * (0.4209) = 1,414,224 kWh/day

Converting to from kWh to BTU's:

$$\frac{1{,}414{,}224\ \text{kWh}}{\text{day}} \left| \frac{3412\ \text{BTU}}{1\ \text{kWh}} \right. = 4{,}825{,}332{,}288\ \text{BTU/day}$$

[IV]

The Trinity dam sits 538 ft high and 2600 ft long. At the top, the crest width is 40 ft and expands at the bottom to 2680 ft (see figure 5).[7] The power plant located at the bottom of the dam, occupies 10 acres (pers.com Greg Morris, June 24, 2004). Both the dam and the power plant occupy an estimated total space of 170 acres (does not include the area of water behind the dam).[8]

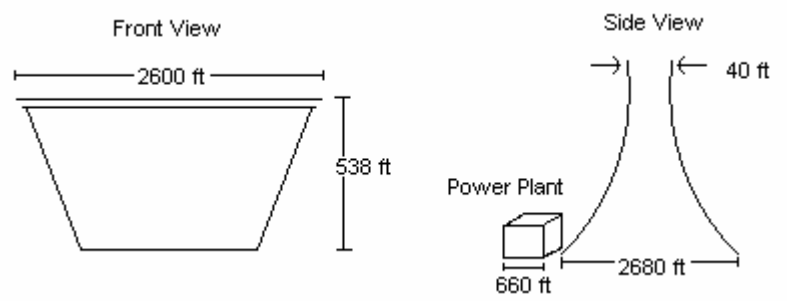
[VI] Department of the Interior Bureau of Reclamation. Trinity Powerplant.

Calculations:

Area for both power plant and dam:

(2600 ft) * (2680 ft) = 160 acres

(160 acres) + (10 acres, Powerplant) = 170 acres



Solar Thermal Plant

At the Luz plant in California there are nine Solar Electric Generating Systems (SEGS) with capacities of 13.8 MW, six at 30 MW, and two at 80 MW with a median of 30 MW.

Average Efficiency of a 30 MW plant:

(29.4 + 30.6 + 30.6 + 30.6 + 37.5 + 37.5) / 6 plants = 32.7%

Daily Output of the Average SEGS Plant:

30 MW *24 hours/day*0.327 = 235.44 or 235 MWh or 235,440 kWh

Converting to from kWh to BTU's:

$$\frac{235{,}440\ \text{kWh}}{\text{day}} \left| \frac{3412\ \text{BTU}}{1\ \text{kWh}} \right.^{IV} = 803{,}321.3\ \text{BTU/day}$$

Land Area of a 30 MW Plant:

$$\frac{(190{,}338 + 230{,}300 + 230{,}300 + 230{,}000 + 250{,}500 + 188{,}000 + 194{,}280)\ \text{m}^2}{6\ \text{plants}} = 257{,}219.8\ \text{m}^2$$

$$257{,}219.8\ \text{m}^2 \left| \frac{0.0002471\ \text{acre}}{\text{m}^2} \right. = 63.559\ \text{acres}$$

Photovoltaic (PV) Systems

A Photovoltaic Solar Electric System is put on top of houses and buildings to reduce electricity bills. A complete PV system usually consists of one or more modules connected to an inverter that changes the PV's DC electricity to alternating current (AC) electricity to power your electrical devices. Batteries are sometimes included in a system to provide back-up power in

case of utility power outages. Typically, the southern part of the state of California will produce more PV electricity than in the north and the inland regions have more sunny days and can potentially produce more electricity than coastal areas (see figure 7).[12]

A typical California home system is 3.5 kW for an average household of three people, and it will also depend on the efficiency of the PV module to determine the output power of the system (see figure 8).[13] This system will produce 1.68 kWh per day for 6 hours of sunlight and at 12% efficiency or 8,598.24 BTU per day.[12] A typical system operates 6 hours a day for sunlight in the southwest with a 12% efficiency. (pers.com, Michael Quintana, August 2, 2004)[11]

Calculations:

Finding the amount of energy per day:

(3.5 kW) * (6 hours of sunlight/day) = 21 kWh/day

Finding energy with 12% efficiency:

(21 kWh/day) * (.12) = 2.52 kWh/day @ 12% efficiency

Converting to from kWh to BTU's:

$$\frac{2.52 \text{ kWh}}{\text{day}} \left| \frac{3412 \text{ BTU}^{IV}}{1 \text{ kWh}} \right. = 8{,}598.24 \text{ BTU/day}$$

A rule of thumb is that a square foot of single- or poly-crystalline PV module area produces 10 watts of power in bright sunlight. Therefore, a 1000-watt system requires about 100 to 200 square feet of roof area, depending on the type of PV module. With a 3.5 kW system and with 12% efficiency, it will occupy an approximate space of 525 ft² or .0120523 acre (see figure 9).[12]

Calculations:

Interpolating to get 3.5 kW from data (figure 8) with 12% efficiency

$$\frac{(4 \text{ kW} - 2 \text{ kW})}{(400 \text{ ft}^2 - 200 \text{ ft}^2)} = \frac{(4 \text{ kW} - 3.5 \text{ kW})}{(400 \text{ ft}^2 - X)}; \quad X = 350 \text{ ft}^2$$

Converting area from ft² to acres:

$$\frac{350 \text{ ft}^2}{1} \left| \frac{1 \text{ acre}}{43560 \text{ ft}^2} \right. = .008 \text{ acres}$$

Nuclear

The State of California has two nuclear plants, Diablo Canyon and San Onofre. They produce a very similar amount of electricity.[15] A nuclear plant uses a process of fissioning or splitting of uranium atoms that produces the heat in a nuclear plant. That heat boils water to make the steam that turns the turbine-generator, which generates electricity.[14]

Diablo Canyon's unit one's median production was 796,269 MWh (megawatts-hours) a month for 2003 which was very close to the average rate, and unit two was 791,217 MWh a month, which is a total of 1,606,163 MWh per month (see figure 10).[17] To find the daily production,

27 days in a month was used because the plant runs about 90% annually.[16] There are 59,255,037 kWh per day and is equivalent to 202,178,186,370 BTU/day.

Calculations:

Finding the median monthly energy generation for:
(Jan. - Dec. numbers in Megawatt hours rearranged in order from smallest to largest):

Unit 1: {738,617; 744,367; 781,249; 794,860; 794,907; **796,269**; 821,069; 821,465; 821,615; 821,735; 823,181; 826,097} = 796,269 MWh, median value

Unit 2: {784,934; 788,949; 790,678; 791,756; **809,894**; 816,927; 817,586; 818,688; 819,883} = 809,894 MWh*, median value
*Note: not including the three lowest values because they were below the range of other values.

Finding the average monthly energy generation for:

Unit 1: (738,617 + 744,367 + 781,249 + 794,860 + 794,907 + 796,269 + 821,069 + 821,465 + 821,615 + 821,735 + 823,181 + 826,097) / (12 months) = **798,786** MWh, average value
Note that the median value of 796,269 MWh and the average value of 798,786 MWh are similar. The median value is used for further calculations.

Unit 2: (784,934 + 788,949 + 790,678 + 791,756 + 809,894 + 816,927 + 817,586 + 818,688 + 819,883) / (12 months) = **804,366** MWh*, average value
*Note: not including the three lowest values because they were below the range of other values.
Note that the median value of 809,894 MWh and the average value of 804,366 MWh are similar. The median value is used for further calculations.

Finding the amount of energy per day:

(796,269 MWh) + (809,894 MWh) = 1,606,163 MWh for total plant

$$\frac{(365 \text{ days} * .90)}{(12 \text{ months})} = 27 \text{ days/month}$$

$$\frac{1{,}606{,}163{,}000 \text{ kWh} \mid 1 \text{ month}^{VII}}{\text{month} \mid 27 \text{ days}} = 59{,}487{,}518.5 \text{ kWh/day}$$

Converting to from kWh to BTU's:

$$\frac{59{,}487{,}518.5 \text{ kWh} \mid 3412 \text{ BTU}^{IV}}{\text{day} \mid 1 \text{ kWh}} = 202{,}971{,}413{,}122 \text{ BTU/day}$$

The Diablo Canyon plant is on a 750-acre site in San Luis Obispo County.[14] The plant actually occupies 50% of the 750 acres which is 375 acres.(pers.comm, Jeff Lewis, July 2, 2004) [15,16]

[VII] 1 month = 27 days, Plant runs 24 hours 90% annually

Wave

Since California has so much shoreline an obvious source of energy might be wave energy. There are three ways of capturing wave energy: floats or pitching devices, wave surge or focusing devices, and oscillating water columns. The most commercially feasible is the oscillating water columns (OWC), which generates energy from the wave-driven rise and fall of water in a cylindrical shaft.[18] The world's first wave power station, the LIMPET, was opened on Islay, an island in Scotland. The plant has operated for nearly two years connected to the local grid with minimal maintenance.[21] Based on its success, the LIMPET was used for evaluation.

The generating capacity for the two generators is 500 kW and the overall turbine efficiency is 40%.[21]

Calculations:

500kW * 24hours/day * 0.40 = 4800 kWh

Converting to from kWh to BTU's:

$$\frac{4800\ \text{kWh}}{\text{day}} \left| \frac{3412\ \text{BTU}^{IV}}{1\ \text{kWh}} \right. = 16{,}377{,}600\ \text{BTU/day}$$

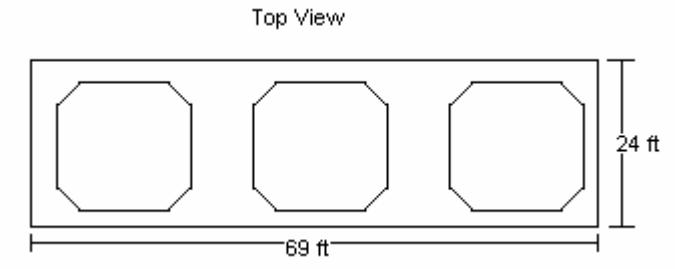
The wave column is approximately 92 ft long and 69 ft wide with a total space of about .15 of an acre.[21]

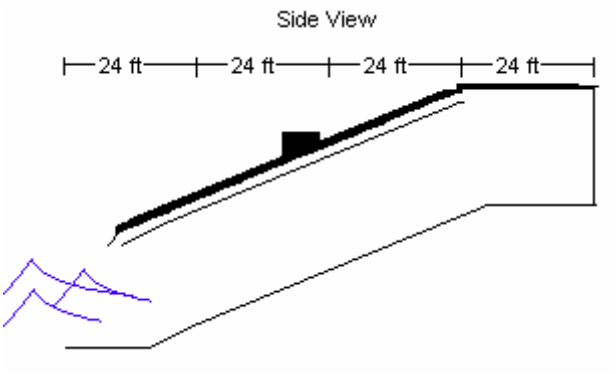
Calculations:

Area of wave power station:

(69 ft, width) * (92 ft, length) = 6348 ft²

$$\frac{6348\ \text{ft}^2}{} \left| \frac{1\ \text{acre}}{43560\ \text{ft}^2} \right. = .152\ \text{acres}$$





Onshore Oil and Gas Wells

California has many onshore oil wells with production rates ranging from trace amounts to 800 barrels (bbl) of oil equivalent[VIII] in 2002 (see figure 12).[22] Production rates of gas wells also vary widely in California from well to well. For the year 2002, there were a total of 47,217 producing onshore wells.[23]

Gas

Since there are so many wells that are producing a wide range of gas, and yearly figures only account for a snap shot of the actual production, a typical well has been estimated by calculating the average daily production over the life of the recoverable gas reserve field. A recoverable reserve is an estimate of the cubic feet of gas in a particular field. First all the total recoverable reserves in California were looked at from the Division of Oil, Gas, and Geothermal Resources' 2002 Production by Field data.[23] Next, all the total reserves were added and the median value was determined (see figure 13). In this case Kirk Gas Field came within the range of the median production for total reserves and production per well for all the fields. Taking a look at the Kirk Gas field from 1961, when the field started production, to 2002, the amount of gas, in ft^3/well/day was calculated for each year (see figure 14).

Calculations:

Finding the production/day/well for the 2002 production year:

(939,788,000 ft^3, produced) / (14 wells * 365 days) = 183,912 ft^3/day/well

Over the past 41 years, the average number of wells for this field is 5 and the median production rate is 98,575 ft^3 (1006.5 therms[IX]) per day or 100,645,075 BTU per day per well.[23]

Calculations:

Converting to from kWh to BTU's:

$$\frac{98{,}575\ ft^3}{day} \mid \frac{1021\ BTU}{1\ ft^3} = 100{,}645{,}075\ \text{BTU/day/well}$$

Oil

[VIII] The BTU content of one barrel of oil is the equivalent of about 6,040 ft^3 of natural gas.

[IX] 1 therm of natural gas = 100,000 BTU

Using the same process as with the gas wells, the field within the range of both a median oil reserve and well production of the overall fields was Los Angeles City (see figure 15). This field has a median of 88 wells producing during the 112 year period. Since the median and average values for the bbl/day/well were similar, the 2.35 bbl/day/well was used for a typical well. With a rate of 2.35 bbl/day/well and using 5,800,000 BTU for one bbl of oil, a typical well was determined to produce 13,630,000 BTU/day/well.[23]

Calculations:

Converting to from kWh to BTU's:

$$\frac{2.35 \text{ bbl}}{\text{day}} \mid \frac{5{,}800{,}000 \text{ BTU}}{1 \text{ bbl}}{}^{X} = 13{,}630{,}000 \text{ BTU/day/well}$$

A typical oil and gas well pad is ¼ to ½ of an acre (pers.comm, Jeffery Prude, June 22, 2004).[24]

Offshore Oil and Gas

Federal Platforms

Using the oil and gas reserves fields data for 2002, the Dos Cuadras field was determined to be the median field (see figure 16).[23] Production of both oil and gas from all platforms that are producing from the Dos Cuadras field were analyzed, from 1969 to present. Platform A and B were installed in 1968, Platform C in 1977, and Platform Hillhouse was installed in 1969. The average and median rates of all these platforms was compared to determine the most reasonable value (see figure 17).[25] The average number of wells for a typical platform is 60 well.[26]

Calculations:

Finding average number of wells per platform:

	# of wells
Platform A:	57
Platform B:	63
Platform C:	60
Platform Hillhouse:	60
Average:	**60**

Gas

The average gas production for a typical platform is approximately 70,000,000 ft³ per month and comes to 2,333,333 ft³ per day, by using 30 days in a month, with a total of 2,382,333,333 BTU per day for a platform (see figure 18).[25]

Calculations:

Finding the production/day/platform:

$$\frac{70{,}000{,}000 \text{ ft}^3}{\text{month}} \mid \frac{\text{month}}{(30 \text{ days})} = 2{,}333{,}333 \text{ ft}^3\text{/day/platform}$$

Converting to from kWh to BTU's:

[X] One barrel of oil = 5,800,000 BTU

2,333,333 ft³ | 1021 BTU = 2,382,333,333 BTU/day/platform
day | 1 ft³

Oil

The average oil production for the same field is approximately 120,000 bbl per month which is equivalent to 4,000 bbl/day/platform (see figure 18). This is the same as 23,200,000,000 BTU per day per platform.[25]

Calculations:

Finding the production/day/platform:

120,000 bbl | month = 4,000 bbl/day/platform
month | (30 days)

Converting to from kWh to BTU's:

4,000 bbl | 5,800,000 BTU^{X} = 23,200,000,000 BTU/day/platform
day | 1 bbl

A typical shallow water offshore platform for the Dos Cuadras field is approximately ½ an acre at the seafloor base (pers.comm, Glenn Shackell, July 29, 2004). The deck is about .30 of an acre.

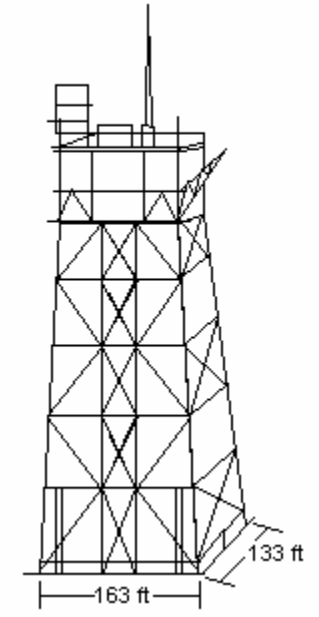
Calculations:

Area of platform at seafloor base:

(163 ft * 133 ft) = 21679 ft²

Converting from ft² to acres:

21,679 ft² | 1 acre = .4976 acre
| 43,560 ft²



*** Note:** The Dos Cuadras field was evaluated for this exercise since it was the median sized field. There are three platforms producing that field. Note, however, that technology offshore has significantly improved since the late 1960's when Dos Cuadras platforms were first put in. It would now only take one platform to produce the oil and gas from the same size or larger field.

Coal

In the United States an average coal fired power plant has a capacity of 300 MW with a capacity of 61%. [XI]

300 MW * .61 * 24 = 4392 MWh

$$4392 \text{ MWh} * \frac{3{,}412{,}141.479 \text{ BTU}}{\text{MWh}} = 14{,}986{,}125{,}379.7 \text{ BTU/day}$$

Bookmark Calculations:
The following calculations are based on consumption of electricity in California only in 2001.

Finding the amount of BTU/year for one person:

$$\frac{253{,}614{,}000{,}000 \text{ kWh of electricity/year (2001)}}{(34{,}385{,}000 \text{ people in Cali.(2001)})} = 7{,}375.00 \text{ kWh/person/year [27]}$$

$$\frac{7375.00 \text{ kWh of electricity}}{\text{year}} \left| \frac{3412 \text{ BTU}}{1 \text{ kWh}} \right.^{[IV]} = 25{,}163{,}500 \text{ BTU/year}$$

Finding the amount of BTU/year for 100,000 people:

(25,163,500 BTU/year/person) * (100,000 people for a city) = 2,516,350,000,000 BTU/year for a city of 100,000 people =
2,516,000,000,000 BTU/Year for City of 100,000 people

Finding the BTU/year for a facility:

Nuclear:

$$\frac{2.02178 \text{ E+11 BTU}}{\text{day}} \left| \frac{365 \text{ days}}{\text{year}} \right. = 7.3795 \text{ E+13 BTU/year}$$

Finding the number of facilities:

[XI] US Department of Energy. Trends in Power Plant Operating Costs. Report#:EIA/DOE-0607(99) J. Alan Beamon and Thomas J. Leckey

Nuclear:

$$\frac{\text{2,516,000,000,000 BTU/Year for City of 100,000 people}}{\text{7.3795 E+13 BTU/year}} = \text{1/30 of a nuclear plant}$$

Finding the land for the number of facilities:

Nuclear:

(375 acres) * (1/30 of a nuclear plant) = 12.5 acres for 1/30 of a nuclear plant

The following calculations are based on gasoline or diesel powered vehicles.

Finding the number of cars for 100,000 people:

$$\frac{\text{100,000 people} \mid \text{1.9 vehicles}^{XII}}{\mid \text{2.87 persons}^{XIII}} = \text{66,202 vehicles* / 100,000 people}$$

Finding the total amount of BTU/year for all vehicles:

$$\frac{\text{66,202 vehicles} \mid \text{323,000,000 BTU*}}{\mid \text{1 vehicle}} = \text{21,383,246,000,000 BTU/year}$$

*Note: Vehicle averages 12 miles/gallon and uses 30,000 miles annually.[28]

[XII] Average number of vehicles per household in California for 2000-2001 [29]

[XIII] Average number of persons per household in California for 2000 [30]

	Calculations for Generating Bookmark					
Source	BTU/day	Acres	BTU/year	City of 100,000 people (BTU/Year) *	# of Facilities	Land for # of Facilities
Nuclear	202,178,186,370	375	73,795,038,025,185	0.034094451	1/30	12.4999875
Hydro	4,825,332,288	170	1,761,246,285,120	0.429809281	3/7	73
Offshore Gas	2,382,333,333	1/2	869,551,666,545	0.870563566	7/8	2/5
Onshore Gas	102,579,870	3/8	37,441,652,550	20.21812469	20	8
Wind	2,866,080	2 2/9	1,046,119,200	723.626906	724	1615
Wave	16,377,600	3/20	5,977,824,000	126.6347085	127	19
Solar Thermal	803,321	64	293,212,275	2581.747307	2582	165248
Solar PV	8,598.24	1/83	3,138,358	241208.9687	241209	2907
Coal	14,986,125,379		5,469,935,763,335	0.13839285		
				* It is assumed that 100,000 people would use this number of BTUs per year:		
				757,000,000,000		
				Vehicles for City of 100,000 people (BTU/Year):		
				21,383,246,000,000		
Offshore Oil	23,200,000,000	1/2	8,468,000,000,000	2.53	2.50	1.3
Onshore Oil	13,630,000	3/8	4,974,950,000	4,298.18	4,298	1,612

Reference:

[1] "California's Major Sources of Energy." California Energy Commission. 25 May 2004. State of California. 16 July 2004 <http://www.energy.ca.gov/html/energysources.html>.

[2] "Wind Performance Report Summary 2000-2001." California Energy Commission. Dec. 2002. State of California. 29 July 2004 <http://www.energy.ca.gov/reports/2003-01-17_500-02-034F.pdf>.

[4] "Renewable Resources Development Report." California Energy Commission. November 19, 2003. State of California.

[5] "Definition of Efficiency." Webster's Online Dictionary. 2003. 11 Aug. 2004 <http://www.webster-dictionary.org/definition/efficiency>.

[6] "Bird Risk Behavior and Fatalities at the Altamont Wind Resource Area." National Renewable Energy Laboratory. December 2003. http://www.nrel.gov/docs/fy04osti/33829.pdf

[5] "Hydroelectric Powerplants Listed by State." Bureau of Reclamation-Managing Water in the West. 23 Apr. 2004. Bureau of Reclamation. 30 July 2004 <http://www.usbr.gov/power/data/faclstat.htm>.

[6] "Trinity Dam." Dams, Projects & Powerplants. Bureau of Reclamation. 21 June 2004 <http://www.usbr.gov/dataweb/dams/ca10196.htm>.

[7] "Trinity Powerplant- Central Valley Project." Bureau of Reclamation-Managing Water in the West. Bureau of Reclamation. 23 June 2004 <http://www.usbr.gov/power/data/sites/trinity/trinity.pdf>.

[8] Morris, Greg. "Energy Conversion." E-mail to Laura Martinez. 24 June 2004.

[9] http://www.solarpaces.org/US_boeing_ses_25kWdish.pdf

[10] http://www.nrel.gov/clean_energy/concentratingsolar.html

[11] Quintana, Michael. "PV Systems?" E-mail to Laura Martinez. 2 Aug. 2004.

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Figures:

FIGURE 1
California Gross System Power for 2003 in Gigawatt-Hours (GWh)
Percentages Used for Electricity

Fuel Type	In-State	NW Imports	SW Imports	GSP	GSP Percentage
Coal	27,222	7,488	24,306	**59,016**	**21.3%**
Large Hydro	30,889	12,126	1,911	**44,926**	**16.2%**
Natural Gas	92,356	1,911	7,738	**102,005**	**36.9%**
Nuclear	35,594	778	5,553	**41,925**	**15.2%**
Renewables	28,740	-0-	-0-	**28,740**	**10.4%**
Biomass	5,574			**5,574**	**2.0%**
Geothermal	13,771			**13,771**	**5.0%**
Small Hydro	5,146			**5,146**	**1.9%**
Solar	758			**758**	**0.3%**
Wind	3,491			**3,491**	**1.3%**
Other	-0-			**-0-**	**0.0%**
TOTAL	214,801	22,303	39,508	**276,612**	**100.0%**

Source:
2003 Net System Power Calculation Report, Energy Commission Publication # 300-04-001R.
Download copy of report in Acrobat PDF (8 pages, 309 kilobytes, date on line May 10, 2004)

Note: To convert from gigawatt hours into megawatts, divide the number of gigawatts by 8,760 then multiply by 1,000 to get megawatts.

2002 Gross System Power (April 22, 2003)

*Note: This table shows hydro separated into large and small hydro. This is because small hydro is an eligible renewable which are considered for tax or credit purposes.

WIND

FIGURE 2
Wind Performance Report Summary 2000-2001 for California

Data Category	Net Capacity (MW)	New Capacity (MW)	Output (kWh)	Actual Capacity Factor (%)	kWh/Square Meter	Number of Turbines
STATEWIDE						
1st Quarter	1,481	0	518,549,369.50	16%	144.39	11446
2nd Quarter	1,482	1	1,132,881,649.88	35%	315.13	11461
3th Quarter	1,527	45	1,090,708,034.10	33%	294.20	11535
4th Quarter	1,549	22	492,951,014.20	15%	130.98	11572
2001 Totals	1,549	68	3,235,090,067.68	24%	884.70	11572
RESOURCE AREA						
Altamont						
1st Quarter	476.02	0	93,387,896.40	9%	77.78	4773
2nd Quarter	476.92	0.9	288,445,145.20	28%	239.62	4788
3th Quarter	476.92	0	484,626,508.30	46%	402.6	4788
4th Quarter	476.92	0	90,210,683.40	9%	74.94	4788
2001 Totals	476.92	0.9	956,670,233.30	23%	794.94	4788
San Gorgonio						
1st Quarter	317.77	0	133,468,713.50	19%	161.2	2445
2nd Quarter	318.03	0.26	286,240,548.70	41%	345.47	2445
3th Quarter	362.43	44.4	229,571,629.50	29%	243.96	2519
4th Quarter	384.63	22.2	132,552,379.30	16%	132.91	2556
2001 Totals	384.63	66.86	781,833,271.00	23%	883.6	2556
Tehachapi						
1st Quarter	605.83	0	278,353,985.90	21%	206.68	3444
2nd Quarter	605.83	0	522,665,552.08	39%	388.09	3444
3th Quarter	605.83	0	361,273,043.50	27%	268.25	3444
4th Quarter	605.83	0	256,313,430.50	19%	190.32	3444
2001 Totals	605.83	0	1,418,606,011.98	27%	1053.34	3444
Pachecho						
1st Quarter	16.4	0	2,963,613.00	8%	55.76	167
2nd Quarter	16.4	0	8,500,640.00	24%	159.93	167
3th Quarter	16.4	0	10,472,662.00	29%	197.03	167
4th Quarter	16.4	0	2,714,251.00	8%	51.07	167
2001 Totals	16.4	0	24,651,166.00	17%	463.79	167
Solano						
1st Quarter	65.1	0	10,375,160.70	7%	63.75	617
2nd Quarter	65.1	0	27,029,763.90	19%	166.1	617
3th Quarter	65.1	0	4,764,190.80	3%	29.28	617
4th Quarter	65.1	0	11,160,270.00	8%	68.58	617
2001 Totals	65.1	0	53,329,385.40	9%	327.71	617

HYDROPOWER

FIGURE 3
Hydroelectric Powerplants Listed in California

Plant	Location	Region	In Service Date	Capacity (kW)
Folsom Powerplant	Folsom, CA	Mid-Pacific	5-55	198,720
Judge Francis Carr Powerplant	French Gulch, CA	Mid-Pacific	5-63	154,400
Keswick Powerplant	Redding, CA	Mid-Pacific	10-49	117,000
Lewiston Powerplant	Lewiston, CA	Mid-Pacific	2-64	350
New Melones Powerplant	Jamestown, CA	Mid-Pacific	6-79	300,000
Nimbus Powerplant	Folsom, CA	Mid-Pacific	5-55	13,500
O'Neill Pumping-Generating Plant	Los Banos, CA	Mid-Pacific	11-67	25,200
Parker Powerplant	Parker Dam, AZ**	Lower Colorado	12-42	120,000
San Luis Pumping-Generating Plant	Los Banos, CA	Mid-Pacific	3-68	202,000
Shasta Powerplant	Redding, CA	Mid-Pacific	6-44	646,000
Spring Creek Powerplant	Redding, CA	Mid-Pacific	1-64	180,000
Stampede Powerplant	Truckee, CA	Mid-Pacific	1-88	3,650
Trinity Powerplant	Redding, CA	Mid-Pacific	2-64	140,000
Total Capacity				2,100,820

FIGURE 4
Trinity Powerplant-Central Valley Project

River:	Trinity River	**Plant Type:**	Conventional
Powerhouse Type:	Above Ground	**Turbine Type:**	Francis
Original Nameplate Capacity:	100,000 kW	**Installed Capacity:**	140,000 kW
Year of Initial Operation:	1964	**Age:**	40 years
Net Generation (FY-2003):	514.3 GWh	**Rated Head:**	426 feet
Average Plant Factor (FY-2003):	42.1 percent	**Remotely Operated:**	Yes
Production Mode:	Peaking		

FIGURE 5
Trinity Dam- Statistics

General

- Region (Map): ..... Mid-Pacific
- State (Map)..... California
- County..... Trinity
- Project: ..... CVP-Shasta/Trinity
- Dam type: ..... Earthfill
- Location: ..... 9 mi from Lewiston
- Watercourse: ..... Trinity River
- Reservoir: ..... Clair Engle Lake
- Construction Date: 1957-1962
- National ID Number..... CA10196
- Hydrologic Unit Code.....

Dimensions

- Crest Elevation of Dam: ..... 2395.0 ft
- Structural Height of Dam: ..... 538.0 ft
- Crest Length: ..... 2450.0 ft
- Top of Joint Use: ..... NA
- Top of Active Conservation: ..... 2370.0 ft
- Top of Inactive Conservation: .....NA
- Spillway Crest: .....2370.0 ft
- Top of Dead Storage: ..... 1995.5 ft
- Streambed at Dam Axis : ..... 1930.0 ft

SOLAR

FIGURE 6
Specifications and Performance of the SES Solar Dish-Stirling System

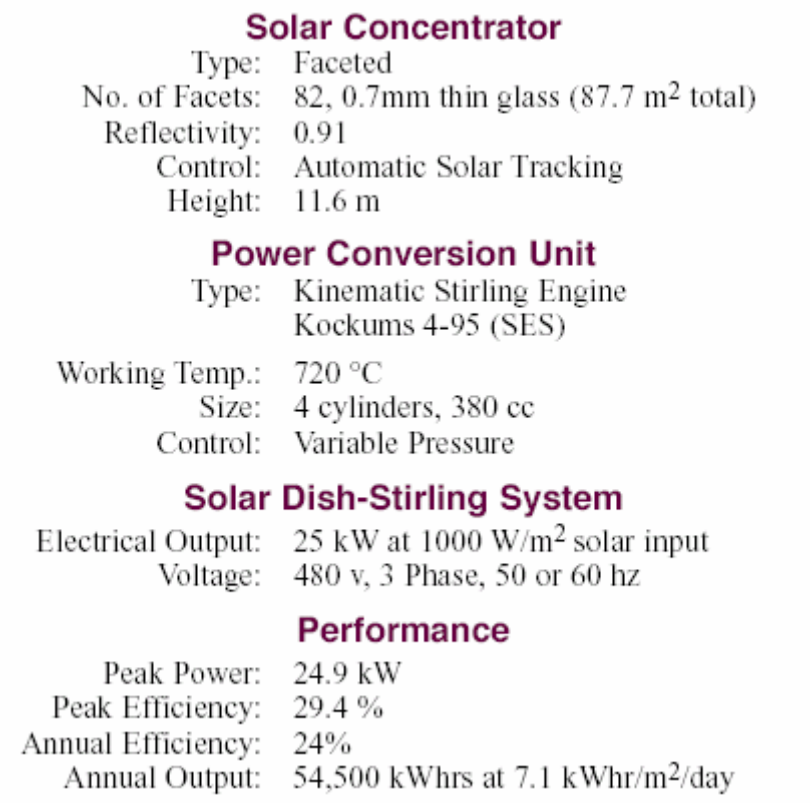
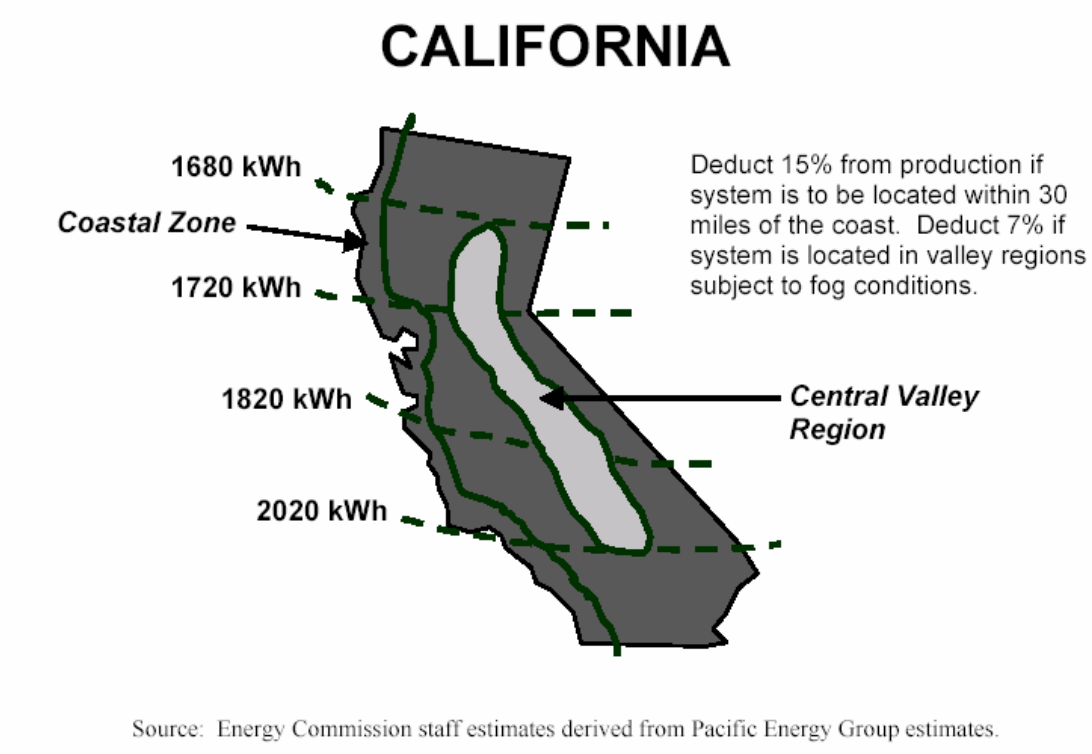


FIGURE 7
Maximum PV System Production in kWh (1 kW system)



Source: Energy Commission staff estimates derived from Pacific Energy Group estimates.

FIGURE 8
Typical California PV System

Size of system: 3500 Watts	
Base cost: $9 per AC Watt,* installed	
Total System Cost ($9 per Watt x 3500 Watts)	$31,500
Rebate ($3.20 per Watt x 3500 Watts)	- 11,200
	$20,300
Tax Credit (7.5% of $20,300)	- 1,523
Net System Cost	**$18,777**
Net Savings	**40%**

FIGURE 9
Roof Area Needed for Various Sizes of PV Systems

PV module efficiency* (percent)	PV capacity rating (watts)							
	100	250	500	1000	2000	4000	10000	100000
	Roof area needed in square feet							
4	30	75	150	300	600	1200	3000	30000
8	15	38	75	150	300	600	1500	15000
12	10	25	50	100	200	400	1000	10000
16	8	20	40	80	160	320	800	8000

*Although the efficiency (percent of sunlight converted to electricity) varies with different types of PV modules, higher-efficiency modules typically cost more.

NUCLEAR

FIGURE 10
Monthly Nuclear Utility Generation in California- 2003 (Megawatt-hours)

CALIFORNIA						
Reactor Name		**JAN**	**FEB**	**MARCH**	**APR**	**MAY**
Diablo Canyon 1	1,087	821,465	744,367	821,069	796,269	826,097
Diablo Canyon 2	1,087	809,894	48,854	20,470	390,989	818,688
San Onofre 2	1,070	838,931	701,416	834,978	810,276	836,140
San Onofre 3	1,080	140,365	259,624	831,891	807,839	829,402
Total	**4,324**	**2,610,655**	**1,754,261**	**2,508,408**	**2,805,373**	**3,310,327**

JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
738,617	821,615	823,181	794,860	821,735	794,907	781,249
791,756	817,586	819,883	790,678	816,927	788,949	784,934
738,999	828,821	833,948	806,668	833,805	809,521	838,979
802,035	830,375	833,845	805,515	831,181	792,379	831,817
3,071,407	**3,298,397**	**3,310,857**	**3,197,721**	**3,303,648**	**3,185,756**	**3,236,979**

Diablo Canyon 1	**9,585,431**
Diablo Canyon 2	**7,699,608**
San Onofre 2	**9,712,482**
San Onofre 3	**8,596,268**
California	**35,593,789**

WAVE

FIGURE 11
LIMPET Performance

		Initial estimate	Current Performance	Achievable Target
Incident Power	kW/m	20	12	20
Pneumatic Capture Efficiency	%	80	64	80
Pneumatic Capture	kW	336	161	336
Turbine Efficiency	%	60	40	70
Turbine Shaft Power	kW	202	65	235
Losses	kW	0	44	22
Net Output	**kW**	**202**	**21**	**214**

OIL & GAS

FIGURE 12
California 2002- Distribution of Wells by Production Rate Bracket

	Oil Wells							Gas Wells						
Prod. Rate Bracket (BOE/Day)	# of Oil Wells	% of Oil Wells	Annual Oil Prod. (Mbbl)	% of Oil Prod.	Oil Rate per Well (bbl/Day)	Annual Gas Prod. (MMcf)	Gas Rate per Well (Mcf/Day)	# of Gas Wells	% of Gas Wells	Annual Gas Prod. (MMcf)	% of Gas Prod.	Gas Rate per Well (Mcf/Day)	Annual Oil Prod. (Mbbl)	Oil Rate per Well (bbl/Day)
0 - 1	3,454	7.7	574.0	0.2	0.5	53.6	0.1	392	12.4	226.9	0.1	2.1	1.6	0.0
1 - 2	3,518	7.9	1,713.5	0.7	1.5	201.4	0.2	176	5.6	433.4	0.2	8.0	7.0	0.1
2 - 4	5,554	12.4	5,548.2	2.2	2.9	1,024.2	0.5	243	7.7	1,241.0	0.5	15.5	32.7	0.4
4 - 6	4,320	9.6	7,321.2	2.9	4.8	1,406.1	0.9	240	7.6	2,041.6	0.8	24.7	72.0	0.9
6 - 8	3,551	7.9	8,405.6	3.4	6.7	1,823.6	1.5	232	7.3	2,575.2	1.0	32.7	114.2	1.5
8 - 10	2,919	6.5	8,988.2	3.6	8.7	1,828.3	1.8	183	5.8	2,784.4	1.1	43.5	110.9	1.7
Subtotal <=10	***23,316***	***52.1***	***32,550.9***	***13.0***	***4.1***	***6,337.1***	***0.8***	***1,466***	***46.3***	***9,302.5***	***3.8***	***19.9***	***338.3***	***0.7***
10 - 12	2,547	5.7	9,546.4	3.8	10.6	2,042.3	2.3	164	5.2	3,117.5	1.3	56.4	94.4	1.7
12 - 15	3,052	6.8	14,050.0	5.6	13.0	2,966.3	2.7	174	5.5	4,149.8	1.7	69.1	116.3	1.9
Subtotal <=15	***28,915***	***64.6***	***56,147.3***	***22.5***	***5.7***	***11,345.8***	***1.1***	***1,804***	***57.0***	***16,569.7***	***6.7***	***28.4***	***549.1***	***0.9***
15 - 20	3,794	8.5	22,351.1	9.0	16.7	5,299.3	4.0	203	6.4	6,019.4	2.4	87.0	201.9	2.9
20 - 25	2,756	6.2	20,851.4	8.4	21.4	5,620.5	5.8	145	4.6	5,723.4	2.3	112.8	183.8	3.6
25 - 30	2,025	4.5	18,536.2	7.4	26.3	4,742.5	6.7	139	4.4	6,746.3	2.7	139.4	211.9	4.4
30 - 40	2,652	5.9	30,208.2	12.1	32.8	9,164.4	10.0	177	5.6	10,855.2	4.4	174.2	348.1	5.6
40 - 50	1,647	3.7	23,835.3	9.6	42.2	8,126.5	14.4	114	3.6	8,909.0	3.6	228.8	241.1	6.2
50 - 100	2,384	5.3	50,002.0	20.0	62.3	20,139.7	25.1	276	8.7	32,432.3	13.2	351.5	1,128.5	12.2
100 - 200	506	1.1	19,852.5	8.0	119.2	9,581.9	57.5	164	5.2	39,060.7	15.9	715.6	1,071.9	19.6
200 - 400	77	0.2	5,966.7	2.4	242.0	2,788.4	113.1	82	2.6	40,305.8	16.4	1488.9	836.8	30.9
400 - 800	10	0.0	1,397.5	0.6	463.7	1,243.7	412.6	50	1.6	55,515.2	22.5	3220.1	611.4	35.5
800 - 1600	1	0.0	384.2	0.2	1150.4	142.6	426.8	11	0.3	19,467.2	7.9	5511.7	219.4	62.1
1600 - 3200	0	0.0	0.0	0.0	0.0	0.0	0.0	1	0.0	4,781.0	1.9	13098.8	1.7	4.7
3200 - 6400	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
6400 - 12800	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
> 12800	0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	***44,767***	***100.0***	***249,532.5***	***100.0***	***16.2***	***78,195.2***	***5.1***	***3,166***	***100.0***	***246,385.3***	***100.0***	***235.0***	***5,605.7***	***5.3***

FIGURE 13
Production by Field for 2002 (Onshore)

Field		Total Reserves:	Total Reserves:		
	# of Wells	Oil (Mbbl)*	Gas (MMcf)*	Oil per well	Gas per well
				(Mbbl / #of wells)	(MMcf / #of wells)
Afton Gas	7	0	21464		3066.285714
Aliso Canyon	37	65778	194753	1777.783784	5263.594595
Ant Hill	17	8638		508.1176471	0
Antelope Hills	73	17281	8013	236.7260274	109.7671233
Antelope Hills North	68	7342	846	107.9705882	12.44117647
Arbuckle Gas	19		85227		4485.631579
Arroyo Grande	125	20737		165.896	0
Ash Slough Gas	1		6075		6075
Asphalto	34	37755	111274	1110.441176	3272.764706
Bandini	10	6540	15631	654	1563.1
Bardsdale	77	3187	86435	41.38961039	1122.532468
Barham Ranch	21	6077	5001	289.3809524	238.1428571
Beer Nose	1	614	204	614	204
Belgian Anticline	69	49777	160354	721.4057971	2323.971014
Bellevue	12	7885	6211	657.0833333	517.5833333
Bellevue West	8	7274	3483	909.25	435.375
Belridge North	724	163637	747243	226.0179558	1032.103591
Belridge South	5470	1900940	656472	347.5210238	120.0131627
Beverly Hills	87	158861	225618	1825.988506	2593.310345
Big Mountain	11	2666	4150	242.3636364	377.2727273
Blackwells Corner	26	1444		55.53846154	0
Bounde Creek Gas	13		44389		3414.538462
Bowerbank	7		24871		3553
Brea-Olinda	536	431291	486436	804.6473881	907.5298507
Brentwood East Gas	1		47238		47238
Buckeye Gas	9		24041		2671.222222
Buena Vista	566	671838	1197457	1186.992933	2115.64841
Bunker Gas	15	778	207743	51.86666667	13849.53333
Burrel	1	1815	2443	1815	2443
Butte Sink Gas	1		7461		7461
Butte Slough Gas	7		9644		1377.714286
Cache Creek Gas	2		2301		1150.5
Canal	11	26267	27749	2387.909091	2522.636364
Canfield Ranch	33	40952	38774	1240.969697	1174.969697
Capitola Park	1	25	74	25	74
Carneros Creek	29	1851	1209	63.82758621	41.68965517
Cascade	16	14456	2758	903.5	172.375
Casmalia	108	45192	18244	418.4444444	168.9259259
Castaic Hills	14	9020	19345	644.2857143	1381.785714
Cat Canyon	199	335158	193545	1684.211055	972.5879397
Chaffee Canyon	4	270	5349	67.5	1337.25
Cheviot Hills	11	27519	142719	2501.727273	12974.45455
Chino-Martinez	24	585		24.375	0

Cont.

FIGURE 13 Production by Field for 2002 (Onshore)

Chino-Soquel	4	350	349	87.5	87.25
Chowchilla Gas	1		30684		30684
Cienaga Canyon	14	10595	427	756.7857143	30.5
Clarksburg Gas	1		14194		14194
Coalinga	1730	969890	225880	560.6300578	130.566474
Coalinga East	105	508392	553415	4841.828571	5270.619048
Coles Levee North	60	165843	248355	2764.05	4139.25
Coles Levee South	30	60450	563214	2015	18773.8
Compton Landing Gas	4		13677		3419.25
Conway Ranch Gas	14		41069		2933.5
Corning South Gas	2		3118		1559
Coyote East	58	121829	60803	2100.5	1048.327586
Cuyama South	70	225060	237217	3215.142857	3388.814286
Cymric	1769	514938	143772	291.0898813	81.27303561
Davis Southeast Gas	1		2960		2960
Deer Creek	59	3305		56.01694915	0
Del Valle	27	28348	81698	1049.925926	3025.851852
Denverton Creek Gas	12	136	43441	11.33333333	3620.083333
Devils Den	80	4399	6001	54.9875	75.0125
Dominquez	3	278997	389494	92999	129831.3333
Dunnigan Hills Gas	1		10876		10876
Durham Gas	3		38453		12817.66667
Dutch Slough Gas	16	234	148343	14.625	9271.4375
Edison	812	153098	72834	188.544335	89.69704433
El Segundo	3	14974	11939	4991.333333	3979.666667
Elk Hills	1666	1345358	2730250	807.5378151	1638.805522
Elkhorn Slough Gas	3		17300		5766.666667
Esperanza	10	1331	691	133.1	69.1
Everglade Gas	5		12900		2580
Fillmore	1	13212	20137	13212	20137
French Camp Gas	9		34543		3838.111111
Fruitvale	233	125848	41059	540.1201717	176.2188841
Gill Ranch Gas	2		90799		45399.5
Greeley	21	116862	109243	5564.857143	5202.047619
Greenwood Gas	5		8430		1686
Grimes Gas	114		685982		6017.385965
Grimes West Gas	13		78418		6032.153846
Guijarral Hills	2	50106	76758	25053	38379
Hasley Canyon	19	3495	1217	183.9473684	64.05263158
Helm	18	32366	79835	1798.111111	4435.277778
Hollister	2		8348		4174
Holser	15	1654	1322	110.2666667	88.13333333
Honor Rancho	9	31681	55791	3520.111111	6199
Hopper Canyon	8	3356	4520	419.5	565
Howard Townsite	4	6487	27760	1621.75	6940
Howells Point Gas	1		2013		2013

Cont.

FIGURE 13 Production by Field for 2002 (Onshore)

Huntington Beach	326	1164408	869802	3571.803681	2668.104294
Inglewood	360	429548	292527	1193.188889	812.575
Jacalitos	29	23810	26138	821.0344828	901.3103448
Jasmin	35	4006	5	114.4571429	0.142857143
Karnak Gas	6		3047		507.8333333
Kern Bluff	35	12192	3	348.3428571	0.085714286
Kern Front	688	216943	22300	315.3241279	32.4127907
Kern River	8600	2451300	20104	285.0348837	2.337674419
Kettleman Middle Dome	2	1465	24033	732.5	12016.5
Kettleman North Dome	37	460471	2958441	12445.16216	79957.86486
King Island Gas	1		10470		10470
Kirk Gas	14		**25191**		**1799.357143**
Kirkwood Gas	5		16782		3356.4
La Honda	3	1387	156	462.3333333	52
Landslide	9	16891	6646	1876.777778	738.4444444
Las Cienegas	39	68244	59200	1749.846154	1517.948718
Lathrop Gas	19		364194		19168.10526
Lindsey Slough Gas	53	1329	329384	25.0754717	6214.792453
Llano Seco Gas	1		5991		5991
Lompoc	23	47947	46907	2084.652174	2039.434783
Lone Star Gas	3		2644		881.3333333
Long Beach	266	945641	1092593	3555.041353	4107.492481
Long Beach Airport	3	11022	35003	3674	11667.66667
Los Angeles City	39	**23910**	1	**613.0769231**	0.025641026
Los Angeles Downtown	17	15803	21818	929.5882353	1283.411765
Los Angeles East	7	7541	12455	1077.285714	1779.285714
Lost Hills	2115	425231	943036	201.0548463	445.8799054
Lost Hills Northwest	22	817	945	37.13636364	42.95454545
Mahala	17	4272	1537	251.2941176	90.41176471
Maine Prairie Gas	7	217	187392	31	26770.28571
Malton-Black Butte Gas	52		165176		3176.461538
McDonald Anticline	47	23471	19064	499.3829787	405.6170213
McDonald Island Gas	59		183552		3111.050847
McKittrick	604	317825	243868	526.2003311	403.7549669
Midway-Sunset	11072	3456874	582016	312.2176662	52.56647399
Millar Gas	10	2190002	167834	219000.2	16783.4
Mint Road Gas	1		3494		3494
Maffat Ranch Gas	2		12590		6295
Monroe Swell	13	848	177	65.23076923	13.61538462
Montalvo West	26	44205	43678	1700.192308	1679.923077
Montebello	138	208428	228257	1510.347826	1654.036232
Monument Junction	32	11827	12695	369.59375	396.71875
Moon Bend Gas	12		62079		5173.25
Morales Canyon	5	2534	1780	506.8	356
Mount Poso	548	313823	2434	572.669708	4.441605839

Cont.

FIGURE 13 Production by Field for 2002 (Onshore)

Mountain View	157	89856	88002	572.3312102	560.522293
Newhall	4	7975	5287	1993.75	1321.75
Newhall-Potrero	42	78178	115405	1861.380952	2747.738095
Newport	3	222	977	74	325.6666667
Newport West	65	63696	8209	979.9384615	126.2923077
Oak Canyon	10	16065	21927	1606.5	2192.7
Oak Park	13	1749	470	134.5384615	36.15384615
Oakley South Gas	3	83	71916	27.66666667	23972
Oakridge	15	15880	9260	1058.666667	617.3333333
Oat Mountain	8	2995	1273	374.375	159.125
Ojai	191	36796	81111	192.6492147	424.6649215
Olive	3	3020	1209	1006.666667	403
Orcutt	140	179492	288090	1282.085714	2057.785714
Ord Bend Gas	6		29810		4968.333333
Orland Gas	1		1184		1184
Oxnard	47	43933	23791	934.7446809	506.1914894
Pacoima	2	1617	9783	808.5	4891.5
Paloma	20	61613	432899	3080.65	21644.95
Perkins Lake Gas	6		38679		6446.5
Pierce Road Gas	2		12406		6203
Placerita	151	67166	6075	444.807947	40.23178808
Playa Del Rey	5	62952	62266	12590.4	12453.2
Pleito	26	13094	7329	503.6153846	281.8846154
Poso Creek	333	86540	8459	259.8798799	25.4024024
Putah Sink Gas	2		52792		26396
Pyramid Hills	145	8902	7894	61.39310345	54.44137931
Railroad Gap	14	10825	86461	773.2142857	6175.785714
Raisin City	45	43601	23836	968.9111111	529.6888889
Ramona	91	23172	43981	254.6373626	483.3076923
Rancho Capay Gas	7		10345		1477.857143
Rice Creek Gas	26		44083		1695.5
Rice Creek East Gas	15		20882		1392.133333
Richfield	123	202941	173366	1649.926829	1409.479675
Rincon	60	125046	193214	2084.1	3220.233333
Rio Bravo	14	116974	132164	8355.285714	9440.285714
Rio Viejo	7	9000	2471	1285.714286	353
Rio Vista Gas	142	1656	3980005	11.66197183	28028.20423
River Break Gas	2	25	17302	12.5	8651
River Island Gas	19	6	172242	0.315789474	9065.368421
Riverdale	11	22120	30463	2010.909091	2769.363636
Roberts Island Gas	5		34768		6953.6
Rose	19	1117	424	58.78947368	22.31578947
Rosecrans	45	86729	170310	1927.311111	3784.666667
Rosecrans East	2	269	345	134.5	172.5
Rosecrans South	8	9665	20880	1208.125	2610
Rosedale	14	8290	8060	592.1428571	575.7142857

Cont.

FIGURE 13 Production by Field for 2002 (Onshore)

Rosedale Ranch	35	16902	11423	482.9142857	326.3714286
Round Mountain	207	112755	1765	544.7101449	8.526570048
Russell Ranch	12	68939	49780	5744.916667	4148.333333
Ryer Island Gas	3	140	141984	46.66666667	47328
Sacramento Airport Gas	2		15168		7584
Salt Lake	4	54433	213173	13608.25	53293.25
Salt Lake South	13	11526	6613	886.6153846	508.6923077
San Ardo	338	531592	77516	1572.757396	229.3372781
San Emidio Nose	4	20577	5861	5144.25	1465.25
San Joaquin	2	1243	247	621.5	123.5
San Miguelito	41	137967	210244	3365.04878	5127.902439
San Vicente	36	28743	35883	798.4166667	996.75
Sansinena	109	59640	78276	547.1559633	718.1284404
Santa Clara Avenue	19	6994	4570	368.1052632	240.5263158
Santa Fe Springs	98	633754	837872	6466.877551	8549.714286
Santa Maria Valley	80	209002	269474	2612.525	3368.425
Santa Susana	10	8505	14511	850.5	1451.1
Sargent	7	1185	528	169.2857143	75.42857143
Saticoy	24	23062	43530	960.9166667	1813.75
Sawtelle	11	18274	13101	1661.272727	1191
Saxon Gas	3		49802		16600.66667
Seal Beach	130	217865	227261	1675.884615	1748.161538
Semitropic	63	3170	1433	50.31746032	22.74603175
Sespe	233	50398	66627	216.3004292	285.9527897
Shafter North	38	10464	2352	275.3684211	61.89473684
Sherman Island Gas	1	322	33215	322	33215
Shiells Canyon	39	28357	72971	727.1025641	1871.051282
Simi	3	4245	1793	1415	597.6666667
South Mountain	348	159444	317794	458.1724138	913.2011494
Stegeman Gas	3		8888		2962.666667
Stockdale	14	4686	2036	334.7142857	145.4285714
Strand	11	22145	18154	2013.181818	1650.363636
Sugarfield Gas	3		6545		2181.666667
Suisun Bay Gas	1	29	90597	29	90597
Sutter Buttes Gas	56		205054		3661.678571
Sutter City Gas	20		120764		6038.2
Sycamore Gas	17		59448		3496.941176
Tapia	18	1678	6	93.22222222	0.333333333
Tapo Canyon South	14	5456	3330	389.7142857	237.8571429
Tapo Ridge	2	159	61	79.5	30.5
Tapo North	14	1257	159	89.78571429	11.35714286
Tejon	86	34656	20063	402.9767442	233.2906977
Tejon Hills	83	13799	2625	166.253012	31.62650602
Tejon North	32	24430	240296	763.4375	7509.25
Temblor Hills	1	10	539	10	539
Temblor Ranch	8	1366		170.75	0

Cont.

FIGURE 13 Production by Field for 2002 (Onshore)

Temescal	9	8533	7093	948.1111111	788.1111111
Ten Section	37	86542	181720	2338.972973	4911.351351
Thorton W.Walnut Grove Gas	1	1	125670	1	125670
Timber Canyon	32	7438	16046	232.4375	501.4375
Tisdale Gas	16		63375		3960.9375
Todhunters Lake Gas	27		255869		9476.62963
Tompkins Hill Gas	31		124180		4005.806452
Torrance	149	231693	149999	1554.986577	1006.704698
Torrey Canyon	41	22731	38395	554.4146341	936.4634146
Tracy Gas	1		17544		17544
Trico Gas	5		201415		40283
Tulare Lake	4	7127	12305	1781.75	3076.25
Union Avenue	4	1869	1033	467.25	258.25
Union Island Gas	9	7	279140	0.777777778	31015.55556
Union Station	2	2000	4996	1000	2498
Vallecitos	19	5484	3895	288.6315789	205
Van Ness Slough	3	735	875	245	291.6666667
Van Sickle Island Gas	4	48	21201	12	5300.25
Ventura	443	1012046	2058970	2284.528217	4647.78781
Vernalis Gas	10		103376		10337.6
Walnut	6	561	60	93.5	10
Wasco	1	5122	3295	5122	3295
Wayside Canyon	6	3442	255	573.6666667	42.5
West Butte Gas	2		3450		1725
West Mountain	11	4277	3683	388.8181818	334.8181818
Wheeler Ridge	47	58395	95941	1242.446809	2041.297872
White Wolf	6	1302		217	0
Whittier	25	55114	50307	2204.56	2012.28
Wild Goose Gas	1		103762		103762
Williams Gas	1		1260		1260
Willow Slough Gas	8		18503		2312.875
Willows-Beehive Bend Gas	97		497315		5126.958763
Wilmington	398	1231485	621536	3094.183417	1561.648241
Winters Gas	3		40924		13641.33333
Yorba Linda	82	95264	2079	1161.756098	25.35365854
Yowlumne	49	117232	96196	2392.489796	1963.183673
Zaca	28	32867	4100	1173.821429	146.4285714
Median Values		**15880**	**23813.5**	**617.75**	**1679.923077**

*****Note: Mbbl = 1,000 bbl
MMcf = 1,000,000 cubic feet

Figure 14
Kirk Gas Gas Production per Year (2002 -1961)

Kirk Gas			
Year	Production per year	# of wells	Production per day
	(ft^3/year)		(ft^3/day)
2002	939788000	14	183911.546
2001	1127193000	12	257350
2000	1243655000	12	283939.4977
1999	1667738000	11	415376.8369
1998	1408437000	14	275623.6791
1997	1502391000	14	294009.9804
1996	21128000	6	9647.488584
1995	190992000	5	104653.1507
1994	292507000	5	160277.8082
1993	339580000	5	186071.2329
1992	441956000	6	201806.3927
1991	991866000	6	452906.8493
1990	505697000	3	461823.7443
1989	124303000	5	68111.23288
1988	302229000	5	165604.9315
1987	55956000	3	51101.36986
1986	59138000	3	54007.30594
1985	80510000	3	73525.11416
1984	102062000	3	93207.30594
1983	121175000	4	82996.57534
1982	105864000	3	96679.45205
1981	78367000	5	42940.82192
1980	87234000	4	59749.31507
1979	87234000	4	59749.31507
1978	82744000	4	56673.9726
1977	131584000	4	90126.0274
1976	154898000	4	106094.5205
1975	139768000	4	95731.50685
1974	110162000	5	60362.73973
1973	185207000	5	101483.2877
1972	276493000	5	151503.0137
1971	263866000	5	144584.1096
1970	181964000	6	83088.58447
1969	164005000	6	74888.12785
1968	220029000	6	100469.863
1967	278954000	6	127376.2557
1966	263570000	6	120351.5982
1965	287270000	6	131173.516
1964	678216000	9	206458.4475
1963	1018835000	10	279132.8767
1962	907057000	9	276120.8524
1961	31282000	2	42852.05479
Median:		5	98574.65753
Average:		5	129814.7434

Figure 15
Los Angeles City Oil Production per Year (2002-1890)

Los Angeles City			
Year	Production per year	# of wells	Production per day
	(bbls/year)		(bbls/day)
2002	27020	39	1.90
2001	28334	43	1.81
2000	29076	43	1.85
1999	27955	53	1.45
1998	37371	59	1.74
1997	40734	58	1.92
1996	43593	59	2.02
1995	44664	59	2.07
1994	39298	58	1.86
1993	47416	47	2.76
1992	34453	48	1.97
1991	37116	48	2.12
1990	45532	59	2.11
1989	45836	61	2.06
1988	45539	57	2.19
1987	41652	55	2.07
1986	45935	58	2.17
1985	52748	61	2.37
1984	56117	62	2.48
1983	52531	52	2.77
1982	51167	52	2.70
1981	51190	54	2.60
1980	52554	51	2.82
1979	36302	50	1.99
1978	57759	49	3.23
1977	35844	44	2.23
1976	55425	49	3.10
1975	51619	46	3.07
1974	47487	46	2.83
1973	50247	48	2.87
1972	48270	50	2.64
1971	46988	49	2.63
1970	47973	50	2.63
1969	54994	58	2.60
1968	55620	59	2.58
1967	57356	68	2.31
1966	61779	69	2.45
1965	61320	70	2.40
1964	64113	76	2.31
1963	71298	80	2.44
1962	73000	80	2.50
1961	72270	90	2.20
1960	71665	93	2.11
1959	72094	88	2.24
1958	73919	89	2.28
1957	80021	90	2.44
1956	76691	89	2.36
1955	76834	87	2.42

Cont. Figure 15 Los Angeles City Oil Production per Year (2002-1890)

1954	74345	88	2.31
1953	75506	89	2.32
1952	78367	90	2.39
1951	78147	88	2.43
1950	76393	89	2.35
1949	77029	89	2.37
1948	77556	88	2.41
1947	71816	87	2.26
1946	76255	88	2.37
1945	76892	91	2.31
1944	77932	91	2.35
1943	67887	89	2.09
1942	74227	90	2.26
1941	74161	90	2.26
1940	66190	81	2.24
1939	65114	79	2.26
1938	67740	81	2.29
1937	73100	81	2.47
1936	68852	81	2.33
1935	66902	81	2.26
1934	66825	82	2.23
1933	75955	112	1.86
1932	90123	174	1.42
1931	84970	175	1.33
1930	128638	239	1.47
1929	115633	244	1.30
1928	123416	251	1.35
1927	156664	258	1.66
1926	175633	277	1.74
1925	187751	287	1.79
1924	217828	329	1.81
1923	240150	373	1.76
1922	253152	394	1.76
1921	286807	393	2.00
1920	303423	396	2.10
1919	322021	395	2.23
1918	344324	396	2.38
1917	348903	396	2.41
1916	354595	398	2.44
1915	356287	399	2.45
1914	363979	399	2.50
1913	367671	400	2.52
1912	411746	406	2.78
1911	429428	415	2.83
1910	466514	428	2.99
1909	529765	447	3.25
1908	603159	462	3.58
1907	560665	530	2.90
1906	210300	601	0.96
1905	309050	634	1.34
1904	380049	702	1.48
1903	704041	1012	1.91

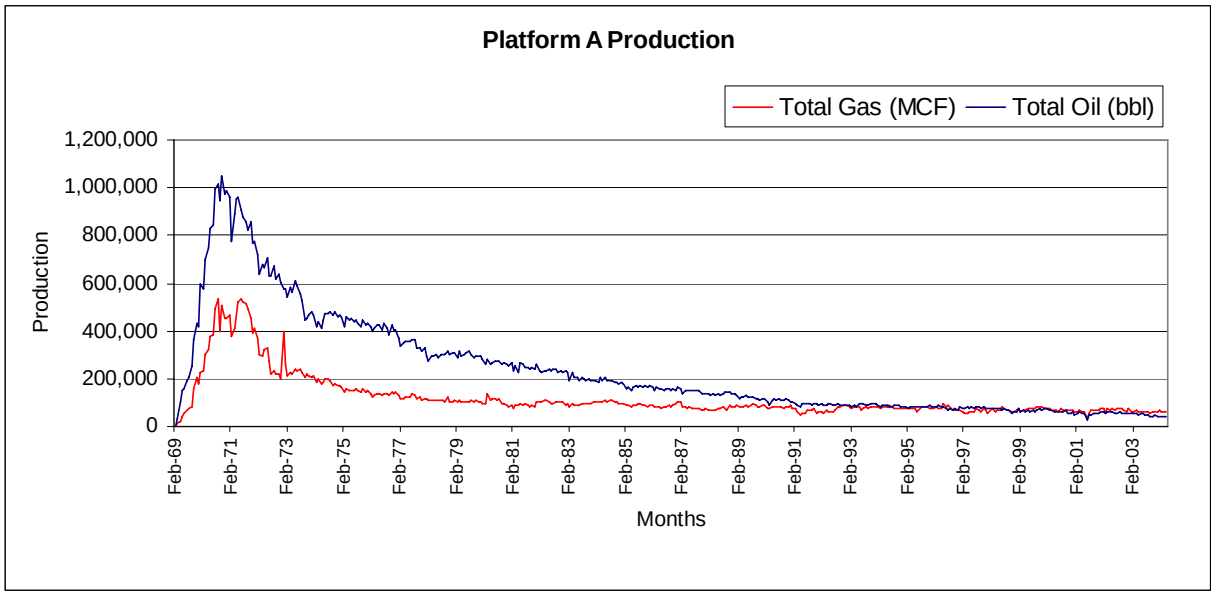
Cont. Figure 15 Los Angeles City Oil Production per Year (2002-1890)

1902	1355051	1044	3.56
1901	1830000	1150	4.36
1900	1280000	891	3.94
1899	1032036	745	3.80
1898	1126000	729	4.23
1897	1064158	551	5.29
1896	902868	404	6.12
1895	749695	310	6.63
1894	196094	218	2.46
1893	89200	121	2.02
1892	6000	22	0.75
1891	4000	21	0.52
1890	1000	9	0.30
Median:		88.00	2.31
Average:		205.78	2.39

Figure 16
Federal Offshore Oil and Gas Total Reserves

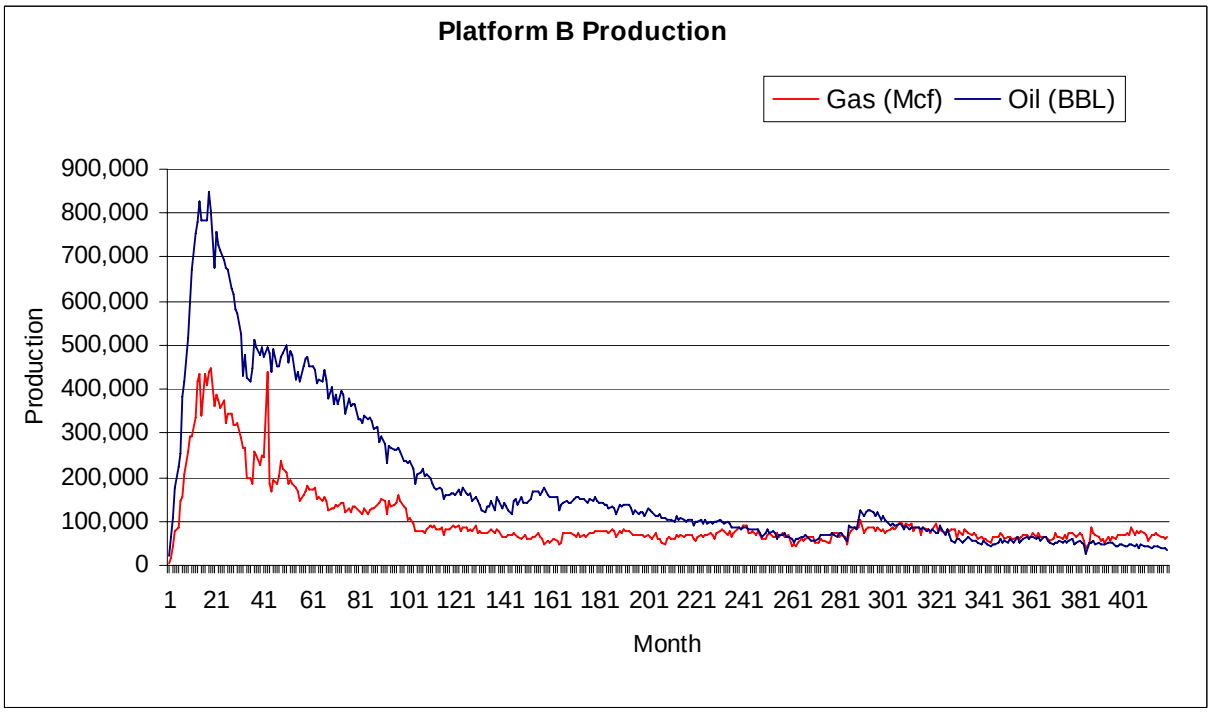
Total Reserves								
	# of Wells	**# of Platforms**	**Oil (Mbbl)**			**Gas (MMcf)**		
Federal				Mbbl/Well	Mbbl/platform		MMcf/Well	MMcf/Platform
Beta	41	4	105420	2571.22	26355.00	34788	848.49	8697.00
Carpinteria	50	3	66300	1326.00	22100.00	55078	1101.56	18359.33
Dos Cuadras	147	4	256800	1746.94	64200.00	137659	936.46	34414.75
Hondo	50	2	278900	5578.00	139450.00	834020	16680.40	417010.00
Hueneme	3	1	10500	3500.00	10500.00	4771	1590.33	4771.00
Pescado	22	1	110791	5035.95	110791.00	222321	10105.50	222321.00
Pitas Point	11	1	206	18.73	206.00	239215	21746.82	239215.00
Point Arguello	23	3	225000	9782.61	75000.00	156152	6789.22	52050.67
Point Pedernales	13	1	77300	5946.15	77300.00	25498	1961.38	25498.00
Santa Clara	25	2	49763	1990.52	24881.50	63451	2538.04	31725.50
Sockeye	21	1	70701	3366.71	70701.00	165837	7897.00	165837.00
		Median:	77300.00	3366.71	64200.00	137659.00	2538.04	34414.75

Figure 17
Platform 'A'



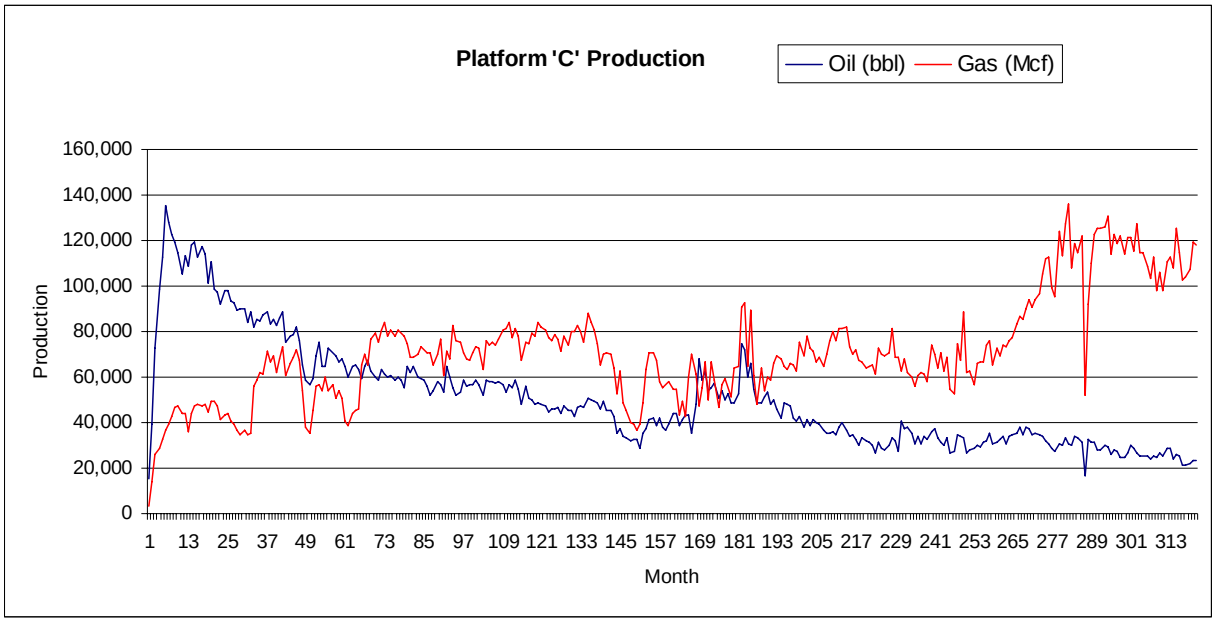
Platform A:	Oil (bbl/month)	Gas (Mcf/month)
Median:	152409	85,508
Average:	235320.6	118,902

Platform 'B'



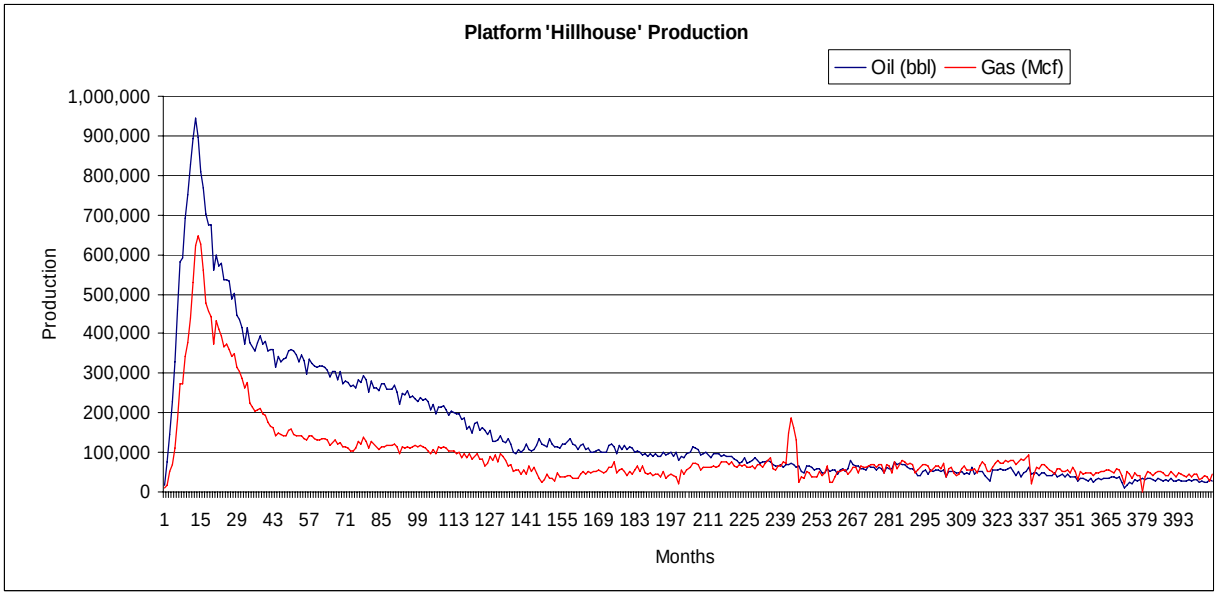
Platform B:	Oil (bbl/month)	Gas (Mcf/month)
Median:	112,143	73,973
Average:	181,177	103,063

Platform ‘C’



Platform C:	Oil (bbl/month)	Gas (Mcf/month)
Median:	45,855	69,514
Average:	50,703	71,556

Platform ‘Hillhouse’



Platform Hillhouse	Oil (bbl/month)	Gas (Mcf/month)
Median:	93,205	64,555
Average:	154,102	95,730

Figure 18
Dos Cuadras Platforms Average Values

Dos Cuadras Platforms	Median Values:	
	Gas (Mcf/month)	Oil (bbl/month)
Platform A	85508	152409
Platform B	73973	112143
Platform C	69514	45855
Platform Hillhouse	64555	93205
Average:	69347.3	119252.3
*Note: only took averages of values in red because of wide range.