Public Hearing (9/16/09)
Once Through Cooling
Deadline: 9/30/09 by 12 noon

PACIFIC ▪ ENVIRONMENT

Protecting the living environment of the Pacific Rim

30 September 2009

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Jeanine Townsend, Clerk to the Board
State Water Resources Control Board
1001 "I" Street, 24th Floor
Sacramento, CA 95814
commentletters@waterboards.ca.gov

Re: Pacific Environment Comments to Once Through Cooling Policy

Dear Chair and Members of the Board,

These comments are written on behalf of Pacific Environment, an organization dedicated to protecting the living environment of the Pacific Rim. We are in strong support of the Board's on-going commitment to examining options for the phase out of once-through cooling technology, and appreciate the opportunity to offer our perspective on the matter.

We have signed on to extensive comments spearheaded by California Coastkeeper Alliance regarding specific sections of the draft policy, and potential loopholes in the policy's language. The comments below are meant to be supplemental, and address the role the OTC power plants play in grid reliability. These comments are specific to California's fleet of 17 natural gas power plants that use once through cooling. We expect much of this data will be useful in the implementation of the policy. Any questions or comments should be directed to me at the contact information below.

Yours,

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Comments prepared for Pacific Environment by Robert Freehling, Rory Cox and Suzanne Doering.

I. Introduction: The Conflict Between Fossils and Clean Energy

1. An important precedent on power plant replacement has been set: The adoption and implementation of the OTC policy provides California with an opportunity not only to help restore the state's marine ecosystems, but also to help meet the state's renewable and greenhouse gas reduction goals. This became most apparent in July of 2009, when the California Energy Commission rejected a proposed 100-megawatt natural gas-fired gas turbine power plant in part because, they concluded, that solar photovoltaics (PV) could potentially achieve the same objectives for comparable cost.

The CEC decision said the following:

"Photovoltaic arrays mounted on existing flat warehouse roofs or on top of vehicle shelters in parking lots do not consume any acreage. The warehouses and parking lots continue to perform those functions with the PV in place. (Ex. 616, p. 11.) . . . Mr. Powers (expert for intervenor) provided detailed analysis of the costs of such PV, concluding that there was little or no difference between the cost of energy provided by a project such as the CVEUP (gas turbine peaking plant) compared with the cost of energy provided by PV. (Ex. 616, pp. 13–14.) . . . PV does provide power at a time when demand is likely to be high—on hot, sunny days. Mr. Powers acknowledged on cross-examination that the solar peak does not match the demand peak, but testified that storage technologies exist which could be used to manage this. The essential points in Mr. Powers' testimony about the costs and practicality of PV were uncontroverted." (CEC Decision, pp. 29–30)

The CEC thus concluded that PV solar arrays on rooftops and over parking lots may be a viable alternative to the gas turbine project, and that if the gas turbine project proponent opted to file a new application, a much more detailed analysis of the PV alternative would be required. The use of the urban PV alternative as the litmus test that must be passed before a new or re-powered gas turbine plant can be approved should move the rooftop solar PV option onto center stage of how to replace lost generation from OTC power plants. The proposed Chula Vista power plant was intended to serve "peak load," which is the function served by many of the currently operating OTC natural gas power plants.

2. For many of the OTC natural gas power plants, solar PV is a viable and preferable alternative to fossil replacement of any type. Most of the aging natural gas power plants are primarily used during peak demand times, usually hot summer afternoons when air conditioning is being used. They are responsible for supplying about 25 percent of California's highest peak power demand of 60,000 megawatts. However, because these plants are only used in the summer, they only generate about 4 percent of the year-round electricity supply.

California stands at a crossroads. Over the course of decades a large natural gas power plant infrastructure has been built —totaling 40,000 megawatts— that now supplies nearly half of the state's electricity. Natural gas plants could easily provide a far greater share of electricity, but most are operated only a fraction of the time to meet daily and seasonal peak demand. Some of the plants are old, and at or near the end of their useful service life. In addition to a high cost of operation and a relatively inefficient use of natural gas, the OTC natural gas plants cause significant environmental damage. They use billions of gallons sea water for cooling, a practice that kills sea life over a wide area. And even though many of the plants have been retrofit to meet modern air pollution standards, there is still a local impact to health. The most important damage, however, is the contribution to climate change caused by burning of fossil fuel.

Retirement of the aging plants would raise the question of how to replace over 15,000 megawatts of lost power supply—roughly ¼ of the state's peak electricity demand on the hottest summer day. On the one hand they could be replaced by building new natural gas plants. This would commit billions of dollars to new plants that would continue to operate 50 years into the future. Such a path would eliminate the use of sea water cooling, but would also entail the continued depletion of our natural gas resources, more air pollution (often in disadvantaged communities), millions of tons of carbon emissions per year, and a need pay whatever the unpredictable price of natural gas will be in the coming decades to produce the power.

On the other side of the coin are the state's greenhouse gas reduction and air quality commitments. These include a dramatic increase in the use of renewable energy, improving some of the nation's most polluted air, to reducing future energy demand through efficiency increases, protecting consumers from rising energy prices, and reducing carbon emissions. The state's own analysis—and common sense— demonstrate that if California is to achieve the existing mandates, the state must move now to renewable energy sources and improved energy efficiency, and not to more fossil fuel-fired power plants.

3. California has excess supply of natural gas generation at the expense of renewables. There has been a rapid build-up of nearly 20,000 megawatts in new natural gas power plants around the state, dramatically increasing California's capacity for natural gas generated electricity to a record high of over 40,000 megawatts. The failure to meet the state's renewable portfolio standard is directly connected to the relentless march of new natural gas plants. This is mainly because natural gas is the next prioritized energy supply resource after renewables. In other words, renewables have to lose in order for natural gas to win. Even though renewables are nominally a higher priority, a competitive struggle for existence between natural gas and renewables is embedded directly into state policy - by design.

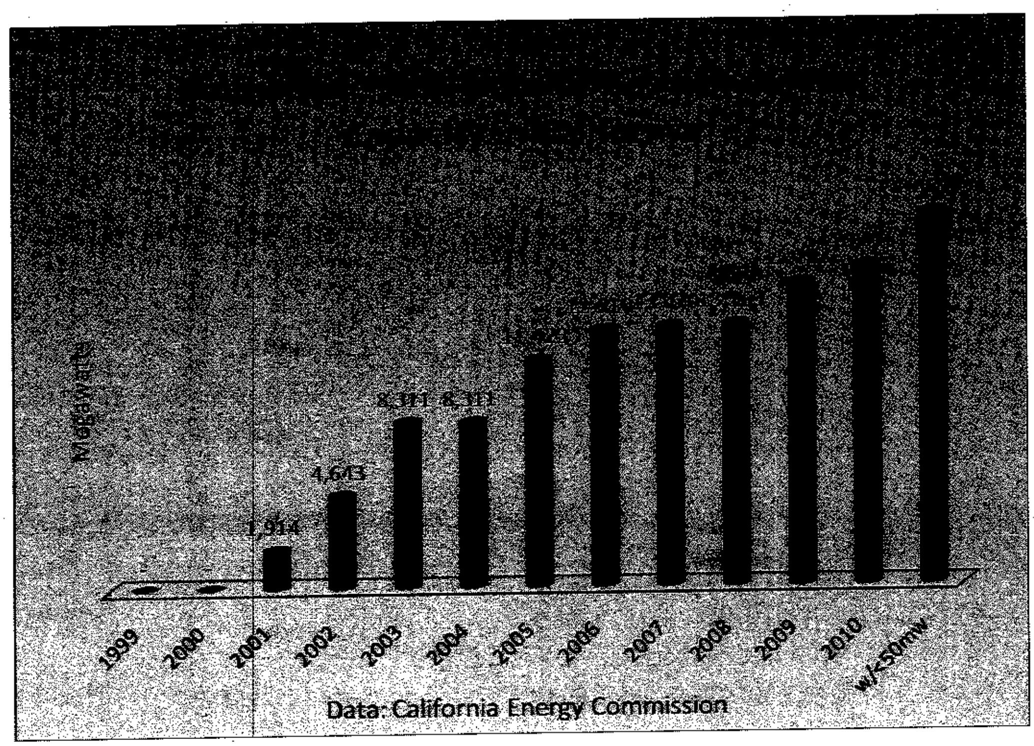
The regulatory process makes every renewable contract compete with natural gas power. The "competition" has an interesting twist. Regulators make a forecast for natural gas fuel prices extending decades into the future. Of course, no one really knows what natural gas will cost that far out. Even the most sophisticated models are just a guess. Renewables have to compete against a fictitious price called the Market Price Referent, which is a guess at how much it will cost to generate electricity from natural gas power plants for the next 10 to 25 years— given the assumptions about future natural gas prices. However, natural gas plants get an unfair advantage. No matter how high the price of natural gas goes up in the future, the higher cost just gets passed on to consumers. They are not bound by the natural gas price forecasts or the Market Price Referent. On the other hand, the renewable developers *are bound* by the result of this invented competition. Not surprisingly, natural gas seems to win this game almost every time.

As a direct result of this failure to increase renewable energy, policymakers have come to assume that we "need" to build more natural gas power plants. Utility companies are only too happy to oblige and foster this impression, which is not surprising given that the other major product these utilities provide, in addition to electricity, is natural gas.

In September, 2009, Governor Schwarzenegger signed an executive order for utilities to procure 33 percent of their electricity from renewable sources by 2020. Complying with this will require reversing course. As the state slipped year-after-year on meeting renewable energy targets, a spree of construction since 1999 has resulted in major investment in new natural gas electric generation in California, at least $15 billion so far.

Many of these plants replaced older, less efficient power plants, and for a time actually reduced consumption of natural gas fuel. However, this improved efficiency is undermined by the fact that while 7,500 megawatts of old plant capacity retired by 2008, over 18,000 megawatts have been built, or will be built, by the end of 2010.[1] The cumulative new natural gas generation added in California over the last decade is shown in Figure 1. Figure 1 shows only new natural gas plant construction. This is far less than the total natural gas plant capacity in the state, which exceeds 40,000 megawatts.

Figure 1.



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[1] Source data for the chart is in Appendix 1, from the California Energy Commission's Energy Facility Status database. The column on the far right-adds in plants that are outside the jurisdiction of the commission's approval process,. These are primarily plants under 50 megawatts built between 2000 and 2007.

The build-up of natural gas plants occurred just as the state was supposed to be implementing its renewables policy. But the usage rate of natural gas plants will *need to decrease* if the clean energy policies are to achieve their goals. A study from 2003 by Lawrence Berkeley National Laboratory (LBNL) looked at the effects of increasing renewables and reducing growth in energy demand on the future need for natural gas plants in California.[2] LBNL found that by 2030 the state would need 8,000 megawatts less of natural gas plants if it were to adopt the proposed requirement to get 33 percent of electricity from renewable energy. Similarly, if aggressive energy efficiency policies slows the rate of growth in electricity demand, this could reduce the need for natural gas power plants by about 4,000 megawatts. The study did not consider the possibility of combining energy efficiency with renewables, but the state is actually in the process of adopting both of these requirements.

Figure 2.

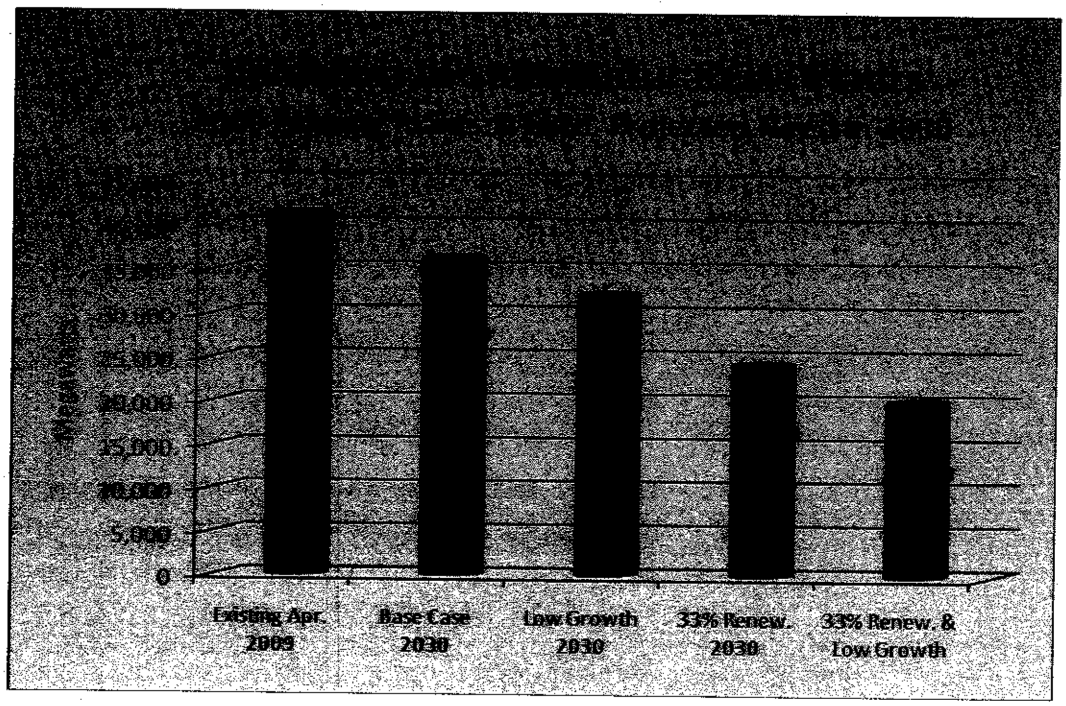

Figure 2 above shows California's existing natural gas plant capacity in April 2009 at 41,499 megawatts.[3] The LBNL study projected that if the state implements both the 33 percent

[2] California's Electricity Generation and Transmission Interconnection Needs Under Alternative Scenarios, CERTS, LBNL, 2003. CEC, 500-03-106. The original study, however, shows only 32,100 megawatts of existing natural gas plants due to the fact that the report dates to 2003. Since that time thousands of megawatts of new plants have been built, as the previous chart illustrates.

[3] California Power Plant Database (Excel File), http://energyalmanac.ca.gov/powerplants/POWER_PLANTS.XLS

renewables requirement and aggressive efficiency programs, then over 20,000 megawatts could be retired, more than the capacity of the 15,400 megawatts of aging once-through cooled coastal natural gas plants. The policy to move to green energy directly conflicts with any new natural gas capacity beyond those already built or under construction. Even repowering existing plants would amount to pushing aside the state's green energy targets.

It is important to realize how much "padding" is placed into the LBNL projections. The report looks at the need for natural gas power plant capacity in 2030, a full decade beyond the 2020 renewable program policy target. This allows up to a full decade of delay in meeting these targets, and also accomodates an extra decade of growth in demand. The report made the following growth assumptions:

"To address California transmission interconnections for the future, this study focused on the year 2030. By that time, California is forecast to experience:

- Population growth to over 50 million, an increase of 18 million over 30 years;
- Electricity peak demand of 80 G W, an increase of 28 GW from current [2003] levels, or an average annual peak demand growth of 1.5 percent."

In its 2008 report produced for the California Ocean Protection Council, ICF Jones & Stokes conclude that given their low usage, the shuttering of the once through cooling natural gas plants by 2015 could occur with no additional generation to replace it. The report states that "...the retirements could be compensated for with as little as $135 million in in-state transmission upgrades."[4]

4. Natural gas power plants cause other damages and costs that go uncounted besides those to marine ecosystems. These include public health impacts due to emissions of nitrogen oxide and particulate matter, and the cost of climate change from carbon dioxide and other emissions. Even as renewable energy policies are adopted, the rules and decisions continue to push relentlessly for more natural gas plants. Unfortunately, the playing field is as unlevel on the environmental side as it is in the natural gas versus renewable energy arena.

Most damage to human health, water resources, air quality and the global climate are not folded into the price that utility companies pay for electricity. However, the costs to human health and the environment are real, and consumers pay for them. Air pollution causes lost days of work, increases the cost of health care, adds to wear and tear on buildings, and causes billions of dollars in damage to crops every year. Destruction of ocean life may reduce commercial opportunities and increase the cost of seafood. Much of the damage is unquantified, or defies measurement. For example, it is difficult to estimate the burdens future generations will bear for climate change, or for the lack resources that have been wasted.

Some of the damages caused by fossil fuel plants can loop back to increased utility bills as well. For example, climate change can lower snowpack, and this in turn reduces hydropower.

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[4] ICF Jones & Stokes. Electric Grid Reliability Impacts from Regulation of Once-Through Cooling in California. California Ocean Protection Council and State Water Resources Control Board. April 2008. Page 3.

To counter this risk, utility companies pay many millions of dollars for natural gas generators to be on call to provide backup power in years when hydro resources fall short.

Rising temperatures also increase use of air conditioning on ever hotter summer days, which calls for increased use of natural gas to meet peak energy demand. Air conditioning in California consumes up to 14,400 megawatts of power during the summer, as much as one-third of peak demand, and is the major reason why electricity demand soars during the summer season. Air conditioners that use less electricity, combined with more and better insulation, and strategically placed shade trees, can substantially reduce electricity demand in summer months.

Although new natural gas plants are preferable to the current aging plants from an environmental standpoint, pollution from the new plants would cause hundreds of millions of dollars in damages per year. The majority of this cost comes from carbon dioxide emissions, which California must curb if it is to reach the climate protection goals of AB32.

II. Cost Benefit Analysis Comparisons – Fossil & Clean Energy Replacement

1. Replacing old power plants with new power plants, either on the same site or elsewhere (fossil replacement scenario) would result in a cost of energy for the new plants of approximately 31 to 39 cents per kilowatt-hour—when external costs are included.

The seventeen OTC natural gas power plants produce significant and quantifiable damages to the environment. To determine whether such impacts can be reduced in a cost-effective manner, this letter establishes a base-case scenario, in which aging units are repowered at existing sites with newer, more efficient units, and closed-cycle cooling replaces once-through cooling systems. We calculate some, but not all, of the external costs associated with natural gas power plants.

For such a replacement option to occur, it would have to be physically, politically and economically possible at each site, which may not be the case.[5] Additionally, we assume that when plants are repowered, they are left operating at the same capacity as previously. Such a plan may not be as profitable for power generator companies as repowering with bigger units, which decreases marginal capital and operating costs and increases overall generation. However, it is possible that companies would repower at the same capacity, particularly given the incentives of AB1576, which allows utility companies to pass on the costs of repowering to consumers.[6] Beyond that, there are serious risks as to whether additional power capacity will be able to be sold into the market, particularly as renewables come on line and displace natural gas generation.

In this scenario, each unit is repowered with a simple-cycle (SC) gas turbine. Combined-cycle turbines are more efficient than steam turbines or simple-cycle gas turbines, because

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[5] Local Power investigated replacement options for one aging plant with OTC in its report to the Environmental Health Coalition, Green Energy Options to Replace the South Bay Power Plant, by P. Fenn and R. Freehling, Feb. 15, 2007.

[6] http://www.leginfo.ca.gov/pub/05-06/bill/asm/ab_1551-1600/ab_1576_bill_20050929_chaptered.html

the waste heat from the gas turbine is used to power one or more steam turbines. They are also cheaper per unit of electricity generated than simple-cycle turbines. However, the efficiency of combined cycle units decreases, and wear and tear increases, if they are run as peaking or load-following rather than baseload units. Consequently, for a load-following unit, the more cost-effective choice is usually a modern simple-cycle gas turbine.

Private Costs

In estimating the costs to repower each plant, we use the California Energy Commission's (CEC's) 2007 "levelized costs" of Simple Cycle technology.[7] This is a standard method for calculating the cost of operating power plants. The levelized cost takes an inventory of all the expenses involved in building and operating a power plant over its full expected lifecycle, then divides this total expense by the amount of electricity generated over that time. The net result is a cost of energy expressed as a rate per kilowatt-hour or per megawatt-hour. The CEC's model is similar to our scenario, with a few exceptions. We propose to repower existing units instead of building on new sites, and these will have lower land and permitting costs. The model assumes a closed-cycle cooling system with access to recycled water, which will marginally increase capital and operating costs. The model also considers a range of capacity factors, rather than the 5 percent value used by the Energy Commission report.

A cost per megawatt-hour is assigned to each repowering project based on the plant's size, with larger plants generally benefitting from some economy of scale. Plant capacity is measured in two ways: nameplate and "capacity factor." The "nameplate capacity" is the full amount of power the plant is capable of producing, and is measured in megawatts. The "capacity factor" is the fraction of the full capacity that the plant actually operates at, averaged over time. The proposed replacement plant is assumed to operate at the same as capacity factor as the existing plant. The CEC estimates a 60 percent capacity factor for new combined cycle turbines, whereas the plants in the study group ranged between 2 and 23 percent capacity factor in 2005 with an average of 9 percent.[8] This shows that the operational features of the aging plants are a better fit for simple cycle combustion turbines. Even with the efficiency loses imposed by closed-cycle cooling, the new units will be more efficient.

Figure 3 below shows that the major contributor to the high cost of electricity from a power plant is the low operational capacity of the simple-cycle turbines. The CEC estimates simple cycle plants to be more than three times as expensive per unit of electricity, measured in kilowatt-hours or megawatt-hours, as combined cycle plants, even though the capital costs are comparatively close.[9] The 2003 CEC model showed levelized cost of $160 per megawatt-hour for simple cycle plants, which was revised to $600 per megawatt-hour in the 2007 report. This newer cost, while quite surprising, is based on an inventory or natural gas power plants in California. However, it is worth noting that the aging plants actually operated at 9 percent capacity factor, which is the same as the figure used in the 2003 CEC cost model.

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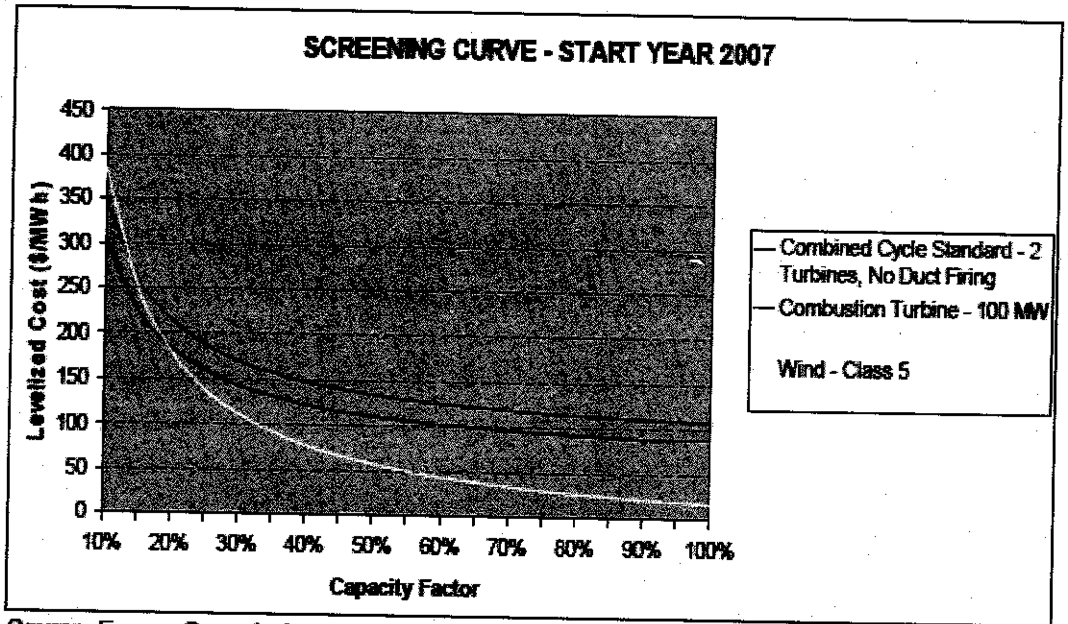
[7] CEC "Comparative Costs of California Central Station Electricity Generation Technologies." 2007.

[8] Ibid, pg 40

[9] CEC 2007 pg. 41



Source: Energy Commission

Figure 3: Screening Curve in Terms of Dollars per Megawatt Hour

Nevertheless, replacement plants operating at this capacity factor would generate electricity costing over $350 per MWh (i.e., over 35 cents per KWh). In order for power plants to have electricity costs under 20 cents per kilowatt-hour, they either require lower cost fuel than is assumed, or they would need to operate at a higher capacity factor than has been typical for the aging power plants . This fact will be significant later when other technology options are evaluated for comparison.

Fuel Savings

Although the total cost to plant owners of repowering is probably higher, fuel costs will usually decrease due to lower heat rates of newer turbines. The model in this report projects the amount of fuel saved by repowering the plants with newer turbines, and assumes that natural gas costs $10 per million btu over the next 20 to 30 years. For comparison, recent prices of natural gas for power plants over the last few years (2005 to 2008) have generally fluctuated between $6 and $10 per million btu, although price significantly higher and lower have occurred.

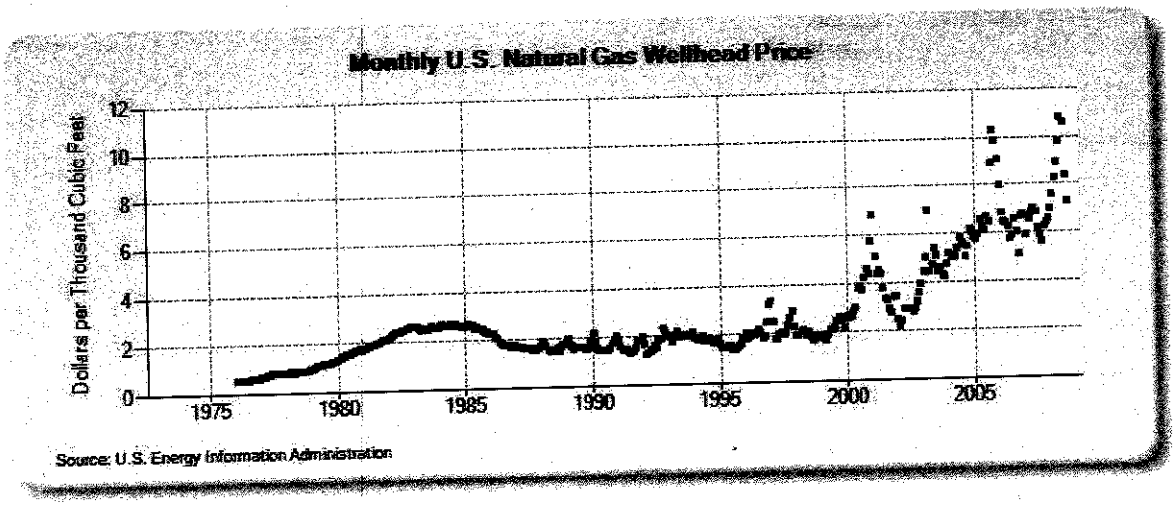


Figure 4

As figure 4 above shows, the general trend over the last decade has been increasing prices for natural gas fuel for electric generators. This trend, however, is not new. While there was stability between 1982 and 1998, natural gas prices have escalated on average significantly more than the inflation rate since the 1950s. One important change since 1998 is increasing volatility of natural gas prices, which may double or fall by half over a period of months. At the time of this writing, the cost of natural gas is very low. This creates a risk for generators that rely on natural gas fuel, and an even greater risk to customers who must foot the bill.

Table 1 shows that the 17 plants used 134 trillion btu (about 130 billion cubic feet) of natural gas fuel in 2005 to generate 12 million megawatt-hours. At $6 per million btu, the total fuel cost would be $780 million. The plants generated far more electricity in 2002, putting out over 35 million megawatt-hours and consuming 350 billion cubic feet of natural gas. Thus, there has been considerable variation in electric generation and fuel use from year to year.

Table 1: Fuel Used by California's Aging Power Plants in 2005

Plant	Capacity Factor 2005	Capacity	Annual Generation	Aging Plant Heat Rate	Annual Fuel
	%	mw	mwh	btu/kwh	mmbtu
Alamitos	7.68	1,950	1,311,898	11,715	15,368,880
Broadway	12.26	66	70,882	11,981	849,242
Contra Costa	5.56	680	331,198	10,775	3,568,659
Coolwater	2.28	146	29,160	9,740	284,021
El Centro	15.99	118	165,285	9,994	1,651,863
El Segundo	11.32	670	664,393	11,054	7,344,205
Encina	22.91	929	1,864,425	11,688	21,791,399
Etiwanda	12.92	640	724,347	11,957	8,661,016
Haynes	13.9	1,126	1,371,063	10,008	13,721,595
Huntington Beach	19.98	888	1,554,220	10,896	16,934,784
Mandalay	9.26	430	348,806	10,466	3,650,600
Morro Bay	3.64	1,002	319,502	9,952	3,179,681
Moss Landing	3.61	1,478	467,397	9,916	4,634,707
Olive	3.62	101	32,028	14,745	472,257
Ormond Beach	3.92	1,500	515,088	11,190	5,763,835
Pittsburg	5.44	1,370	652,865	11,192	7,306,868
Potrero	21.27	207	385,693	10,787	4,160,472
Redondo Beach	3.74	1,310	429,187	11,692	5,018,060
Scattergood	13.32	803	936,966	11,158	10,454,668
Total	**9.0%**	**15,414**	**12,174,404**		**134,816,812**

At a projected $10 per million per Btu average price for natural gas over the 20 year economic life of a new power plant, annual cost for natural gas would be $1.348 billion per year for the aging plants. A new plant would probably have a lower heat rate, with the best being about 9,200 BTU per kilowatt-hour. The savings in fuel would be 18.5 percent, or nearly $250 million per year at 2005 generation rates compared to the older plants, assuming the new plants operate at the same level of electric generation as the aging plants.

However, the common assumption the new plants would use less natural gas is probably unrealistic. The lower heat rate (higher efficiency) would make the new plants more competitive for more hours of the year; thus the electric generation would very likely be significantly higher than in the aging plants. This would tend to erase the fuel efficiency and carbon benefits of the new plants. A formal metric of competitiveness is called the "market heat rate," and was illustrated by the California Energy Commission's report on the aging plants. Table 2 shows the changing limit of competitive heat rates for power plants over the course of the years.

Table 2: Monthly Market Efficiency of Natural Gas Power Plants

Average Market Heat Rates, SP15

2004			
Month	**Gas**	**Elect**	**MHR/1,000**
Jan	5.23	56.99	10.72
Feb	5.36	54.06	9.80
Mar	5.10	52.16	9.94
Apr	4.68	50.18	10.35
May	4.62	50.93	10.43
Jun	4.69	56.64	11.45
Jul	4.80	64.90	12.78
Aug	4.85	69.83	13.56
Sep	4.84	61.83	12.05
Oct	4.84	54.75	10.43
Nov	5.01	56.26	10.34
Dec	5.18	58.82	10.47

Source: Forward market data from November 2002 – June 2004

The "Gas" column shows the average daily price for natural gas over the course of each month, while the electricity column reflects the cost of electricity on the wholesale market during peak hours of the day. The MHR, or Market Heat Rate, shows the maximum number of British Thermal Units of heat energy from natural gas fuel that a generator can use to produce one kilowatt-hour of electricity and still not lose money, given how much the fuel costs and how much they can sell electricity for on the market.[10]

The market heat rate does not recover the fixed costs, but only the variable ones. These include fuel plus operation and maintenance during the hours of peak demand. From October through May the market heat rate reaches a peak of 10,720 in January, but most of the rest of the time it is well below this. That means that any power plant with a higher heat rate will not recover the cost of fuel plus operations. Only six of the 17 plants, representing only 4,300 out of the 15,400 megawatts of total capacity, have heat rates low enough even to meet this minimum level of cost recovery in January.

In fact, even the plants with lowest heat rate will not generally be able to operate between October and May as they have significant additional costs beyond the variable ones. The rest of the plants with the higher heat rates will only be competitive during the four summer months of June to September, when market heat rates usually soar above 12,000 BTU per kilowatt-hour. This is only during the peak demand hours. During summer nights the plants once again become uneconomic. However, they must be kept idling at minimum power all night long in order to be ready to generate power in the morning, and cannot be shut completely off. This consumes a considerable amount of additional fuel that produces no salable electricity. The extra fuel cost must be recovered, and this requires a significantly higher market heat rate than the specified heat rate of the plant would suggest.

[10] In the table one must multiply the given value by 1000 to get the market heat rate.

The California Energy Commission report projected an effective heat rate of about 10,000 BTU per kilowatt-hour for a new natural gas combustion turbine, and this would allow a new plant to sell power nearly year round in a competitive manner, at least during the daytime. In some cases developers have even proposed building base load plants to replace aging plants, even when there is no market need for such a service. This would mean replacing aging plants that only produce at nine percent of annual capacity with base load plants that might operate at 60 percent capacity or more. Even though such plants would be much more efficient, there would be absolutely no fuel, cost or emission savings due to the much increased operation of the plant.

Pollution Reduction

New turbines have lower emission rates than older steam units, even those with SCR pollution reduction technology. Table 3 summarizes emissions rates of the pollutants, with damages quantified for five types of replacement plants.

Table 3: Emission Rates of New Natural Gas Plants

Turbine Type	NOx emissions rate (lbs/MWh)	CO2 (lbs/MWh)
Conventional CC	0.056	817.62
Advanced CC	0.046	761.47
Simple & Conventional SC	0.093	1083.84
Advanced SC	0.076	886.63
Average, Old Plants	0.128	1370.47

Replacing aging plants with new simple cycle plants would reduce the nitrogen oxide emission rate by 27 percent, from 0.128 to 0.093 pounds per megawatt-hour.[11] Multiplying the emissions rate for each repowered plant by its expected annual generation gives approximate yearly emissions for each plant. The largest environmental benefit is from CO_2 reduction, with relatively little economic value assigned for NOx reduction. While NOx is left out of account here, savings could be up to $1.33 million per year for all the plants combined. However, as stated above, the reduction in emission rates does not necessarily mean that absolute levels of pollutants would be lowered. That is due to the effect of the market heat rate, which will tend to increase the number of hours per year that new plant would operate. For this reason it is entirely possible that new plants would consume more fuel and emit more pollutants than the aging plants. [12]

[11] This leaves out of consideration NOx from Humboldt, which is not in the study group, and Coolwater, which has a significant NOx problem.

[12] An example was the proposal to replace the South Bay Power Plant in Chula Vista. In that case LS Power tried to push for construction of a base-load plant which would likely have operated at least twice as much as the current plant. It turned out, however, that SDG&E—the local utility—did not need any additional base load capacity at the time LS Power intended to bring the plant on-line around 2010.

Table 4: Carbon Dioxide Cost of all OTC Plants

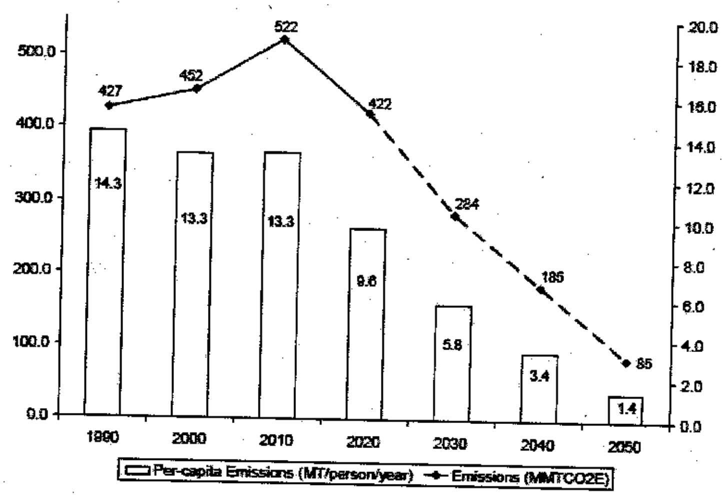
Plant	Annual CO2 Old Tons	CO2 New Tons	Savings Tons	CO2 Savings Value
Alamitos	899,080	706,063	193,016	$4,825,405
Broadway	49,681	38,149	11,532	$288,294
Contra Costa	208,767	178,251	30,516	$762,894
Coolwater	16,615	15,694	921	$23,029
El Centro	96,634	88,957	7,677	$191,934
El Segundo	429,636	357,577	72,059	$1,801,486
Encina	1,274,797	1,003,434	271,363	$6,784,083
Etiwanda	506,669	389,843	116,826	$2,920,648
Haynes	703,016	737,906	(34,890)	($872,253)
Huntington Beach	990,685	836,481	154,204	$3,855,088
Mandalay	213,560	187,727	25,833	$645,822
Morro Bay	186,011	171,956	14,056	$351,388
Moss Landing	271,130	251,553	19,577	$489,435
Olive	27,627	17,238	10,389	$259,736
Ormond Beach	337,184	277,220	59,964	$1,499,099
Pittsburg	427,452	351,372	76,080	$1,901,992
Potrero	243,388	207,580	35,808	$895,189
Redondo Beach	293,556	230,989	62,568	$1,564,195
Scattergood	611,598	504,275	107,323	$2,683,073
Total	7,787,086	6,552,264	1,234,822	$30,870,538

CO2 energy rate	117	lbs per mmbtu
CO2 value	$25	per ton

Annual CO_2 savings, assuming a cost of carbon dioxide at $25 per ton, would be over $30 million per year, or approximately $600 million over the economic lifecycle of the plants. On the other hand, total carbon costs would still accrue at $163.8 million per year, which means between $4.9 and $8.2 billion in carbon costs over the 30 to 50 year lifecycle of the replacement plants. The actual climate damage depends on the carbon damage rate, which for this report is assumed to range from $12 to $80 per ton. Thus carbon savings achieved through a replacement of aging power plants with newer, more efficient plants would amount to 18 percent. This would meet the 15% reduction target for 2020 required under AB 32, the Global Warming Solutions Act of 2006[13]. However, the plants would continue to operate for another 20 to 40 years, during which time the state—under the Governor's Executive Order S-3-05— plans to reduce carbon emissions by 80 percent below 1990 levels. The replacement plants would fall far short of carrying their weight over this longer timeframe.

[13] Climate Change Proposed Scoping Plan, a framework for change, October 2008, p. ES1.

Figure 5: California Greenhouse Gas Emissions Trajectory Toward 2050



Source: California Air Resources Board [14]

Avoided Marine Damages

Equipped with closed-cycle or dry cooling, new simple-cycle turbines are assumed to eliminate their use of seawater completely. Even if some plants must continue to use seawater, the volume required for closed-cycle cooling is less than 5 percent of OTC cooling needs. Closed-cycle cooling has some minor disadvantages compared to OTC: the increased energy required to operate it, the extra cost to install it, cooling towers emit plumes of vapor that might be considered unsightly (which can be abated at a cost of $6/kW), and any pollutants in the source water will be discharged in higher concentrations.[15] Because the damages of these concentrated contaminants have not been extensively studied, they are not accounted for here. For all practical purposes, and especially when compared to the aging plants, the new gas turbines, will inflict no significant marine damage.

Aside from the nuclear power plants, the aging natural gas power plants are the only source of marine damage. Both the repowering and clean energy replacement options would eliminate this problem. Of the 12,174,404 MWh total generated by the aging power plants in 2005, 86 percent of the electricity, or 10,469,987 megawatt-hours, was produced by OTC plants.

The environmental cost of OTC for marine damages ranges between $177 million and $540 million per year for existing power plants that would be avoided in the replacement scenarios.

[14] Ibid., p.118.

[15] "Issues and Environmental Impacts Associated with Once-Through Cooling at California's Coastal Power Plants." CEC, Page 43.

Summary of Cost for Fossil Replacement Scenario

Replacing aging plants with new natural gas power plants will avoid marine damages from the existing plants. It may also reduce fuel consumption and greenhouse gas emissions by about 18 percent; however this assumes that the new plant operates at a similar capacity as the aging plants—which is unlikely. These are the primary benefits of a replacement option. Air pollution is likely to be relatively unchanged, since the aging power plants have generally been retrofitted to comply with modern air quality requirements. The new power plants may also have lower operation and maintenance expense due to reduced repair needs. This last point, however, is not certain, as many newer turbines have been found to have more problems than originally expected. [16]

On the other side of the coin, new power plants would require a large infusion of new capital spending. These new plants would be much more expensive than the older ones they would replace, at a projected total of $15.4 billion for all the plants combined. This borrowed and invested money must return a rate of interest and profit. Assuming an 11 percent average weighted cost of capital over a 20 year period would mean that the $15.4 billion investment (equivalent to $770 million per year) would need to return over $49 billion in combined interest and profit. Fuel would add another $1.3 billion per year, or $26 billion over 20 years. Combined lifecycle costs would approach $100 billion, not including environmental damages. Natural gas fuel prices are also expected to be higher in the future than they have in the past. The CEC natural gas price prediction for a plant starting operation in 2010 averages about $10 per MMbtu, with prices gradually rising over a 20 year period up to 2029.

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[16] *Calpine to Spend More to Improve Plant Performance, Fusco Says,* By Jim Polson, Bloomberg.com, Sept. 5, 2008. Article states that Calpine's operating expensed for its mostly natural gas power plants increased $59 million in the first half of 2008, up 15% from a year earlier. The fleet of plants is on average less than 10 years old, and the new high efficiency technology is having more problems than expected.

Table 5: Summary of Annual Costs, Baseline Scenario

	Low	High		Low cost per kwh	High cost per kwh
Fuel Price/mmbtu	$6.00	$10.00			
Cost of Carbon/ton	$12	$80			
<u>Costs to Owner</u>					
Capital Cost	$770,700,000	$770,000,000		$0.063	$0.063
Interest & Profit	$1,695,540,000	$1,695,540,000		$0.140	$0.140
O&M	$411,707,000	$411,707,000		$0.034	$0.034
Fuel	$808,900,872	$1,348,168,120		$0.067	$0.111
Total Costs to Owner	$3,686,847,872	$4,225,415,120		$0.303	$0.348
<u>External Costs</u>					
NOx	$1,301,094	$4,945,248		$0.0001	$0.0004
CO2	$71,000,000	$524,000,000		$0.006	$0.043
Total External Costs	$72,301,094	$528,945,248		$0.006	$0.044
Total All Costs	$3,759,148,966	$4,754,360,368		$0.309	$0.391
Electric Generation	12,152,397,600	kwh			

The annual combined cost to the owners of all the plants is estimated to range between $3.68 and $4.22 billion to generate 12.1 billion kilowatt-hours. This translates into a wholesale energy rate of 30.3 to 34.8 cents per kilowatt-hour (Table 5). The figure predicted by the Energy Commission chart shown previously is slightly higher, at just over 35 cents per kilowatt-hour.[17] This is partly because the CEC model adds in the cost of taxes. In addition, their model also takes into account the fact that power plants operating at less than full capacity will operate at less than their rated efficiency.

The environmental damages range between 0.6 cents per kilowatt-hour to as high as 4.4 cents per kilowatt-hour. While this is significantly lower than the existing plants' environmental cost at 2.3 to 10.1 cents per kilowatt-hour, achieving this reduced environmental damage results in much higher cost of electricity. Thus, building newer plants could be interpreted as internalizing the environmental costs of the aging plants, especially since the environmental damage is a major factor for considering replacement in the first place. However, the new plants would also incur continuing external costs, particularly for carbon.

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[17] Comparative Cost of California Central Station Electricity Generation Technologies, Dec. 2007, reported a cost of 59.96 cents per kilowatt-hour for electricity from new simple cycle natural gas plants.

All these figures assume that the replacement plant operates in a similar manner to the current plant. However, this may not be true since power plants have a strong motive to try to sell more electricity. If this is the case, then O&M and fuel costs will increase and environmental damage may be much greater. These could rise to where the replacement plants would have more carbon and other air emissions than the current plants that they would replace. This is an important risk if new natural gas plants are built.

2. At 17 to 29 cents per megawatt hour, efficiency and renewables are a cost effective OTC replacement strategy.

Our modeling proposes a replacement for the aging power plants by applying California's clean energy policies. These include accomplishing greater energy efficiency improvements, increasing renewable energy, and implementing programs for reducing peak demand. The resources chosen for this model all address peak demand to replace the electric generation profile of the aging plants.

Certain functions of the aging plants — such as voltage regulation and the ability to modify generation over the course of the day — might have to be met with other technologies. However, such resources are not entirely lacking in California. There are currently 41,499 megawatts of natural gas power plants in California. If all of the 15,400 megawatts of aging plants retired by 2012, as the Energy Commission would like, the state will still continue to operate 26,000 megawatts of existing natural gas plants.

In addition, nearly 2,000 more megawatts of natural gas plants are currently under construction and due to come on-line by the end of 2010. Another 18,000 megawatts of power can be imported over existing transmission wires, and more transmission capacity is likely to be built in the future. There is also some capacity to vary the electric generation from hydroelectric plants, especially the 4,100 megawatts of pumped storage that is specifically designed to meet peak demand. [18]

One important function of the aging plants is to meet local reliability needs. Retiring these plants will require replacing this capacity as well. Local resources, such as solar built on rooftops or at substations, and energy efficiency measures, can help. And there are thousands of megawatts of natural gas peaking capacity that is already in place that can also meet local needs.

Another issue is the increasing demand for electricity. The Energy Commission's first study on aging plants reviewed the ability to meet demand growth with demand side programs in place at the time the report was written in 2004. The projected increase in peak demand from 2004 to 2008 was 3,194 megawatts. During that time new energy efficiency improvements were supposed to meet 1,100 megawatts of that growth, while peak demand reduction programs were to meet another 1,549 megawatts. The two combined left 545 megawatts of

[18] The amount of pumped storage in California is likely to increase in the next decade to at least 4500 megawatts if SMUD brings its Iowa Hill unit on-line as planned.

demand growth that would have to be met with new plants over a four year period, a rate of only 136 megawatts per year.[19]

Since 2004 spending for energy efficiency has more than doubled to nearly $1 billion per year,[20] and the bar for performance in these programs has been raised significantly. In addition, the California Solar Initiative has committed $3 billion in funding to put photovoltaic systems on rooftops throughout the state. The target is to install an average of 300 megawatts per year over the 10 year life of the program. At this point the state does not even have to meet all of its targets to erase demand growth.

The California Ocean Protection Council and the State Water Resources Control Board (SWRCB) commissioned a study by ICF Jones & Stokes to examine the effects on electric system reliability of various scenarios relating to regulation of power plants using once-through cooling.[21] This included computer modeling of the operation of these power plants on the electric grid. While acknowledging the limitations of their efforts, they were able to draw certain general conclusions. The report had an alternate scenario which examined the option of retiring the natural gas plants, and concluded that the cost and resources necessary to assure grid reliability depended heavily on the timing of retirement.

If retirement is staggered to 2015, and the nuclear plants are assumed to still be on-line, then no new electric generation would be needed, and only some relatively minor transmission upgrades. This represented the low range of cost, as the SWRCB states, "as little as $135 million in modest, low-impact transmission upgrades in the still unlikely event that all but the nuclear plants are retired in 2015."[22] As retirement of the 4,472 megawatts of in-state nuclear is not likely until the mid-2020s due to long term contracts, this is a viable scenario.

With this in mind, and with the goal of reducing other natural gas generation in the state, the following resources should be able to allow retirement of all the aging natural gas power plants, allow for population growth, and dramatically reduce other fossil fuel energy.

Photovoltaics. The energy of the sun is absorbed by flat panels containing semiconductor cells that directly convert light into electricity. These systems can be located on-site wherever power is needed. Fixed solar panels provide energy during the peak hours of demand, and its electricity production rises and falls during the day, closely following the bell-shaped summer demand curve. Photovoltaics can reduce the need for transmission upgrades, and the delays inherent in building large power facilities. 3,000 megawatts of new photovoltaic capacity is planned in California by 2017 under the California Solar Initiative, with $3 billion dollars in rebates committed toward this goal. RETI has projected that 4,200 megawatts may

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[19] see appendix 8 for table from CEC report on aging plants.

[20] $800 million per year is spent by the CPUC for the Investor Owned Utilities, with additional funds set aside for this purpose by the Publicly Owned Utilities.

[21] Electric Grid Reliability Impacts from Regulation of Once-Through Cooling in California, *Prepared for:* California Ocean Protection Council *and* State Water Resources Control Board, *Prepared by:* ICF Jones & Stokes, Global Energy Decisions *and* Matt Trask, April 2008.

[22] Ibid, p.

be installed by 2020, the date when the 33 percent renewable target is intended to be met.[23] Rooftop solar has a wide range of possible cost, depending especially on the orientation of the roof, and clear access to sunshine. Also important is the rate of return expected on the investment.

In July, 2009, the California Energy Commission denied an application for a 100-megawatt natural gas power plant to be located in Chula Vista in part because rooftop solar PV could potentially provide the same power for similar costs. In particular, the CEC ruled that locally installed solar PV arrays on rooftops and over parking lots can provide the same peak time electricity that the power plant was intended to provide—on hot, sunny days. This landmark decision is one of the few where a permitting agency ruled that solar power is a viable and cost effective alternative to fossil fuels. This decision is indicative of the fast-sinking cost of solar PV.[24]

In Gainesville, Florida the local utility has offered to pay residential customers 33 cents per kilowatt-hour for all electricity generated from their photovoltaic systems using a mechanism called a "Feed In Tariff." This is calculated to return a 5 percent annual profit over a 20 year contract period, and assumes the customer takes advantage of a 30 percent federal tax credit against the full purchase price of the system. Commercial customers can attain lower cost solar electricity through better deals on system prices as well as generally better performance when these are located on unshaded commercial rooftops.

Figure 6: One-axis tracking photovoltaic panels at the SunEdison photovoltaic power plant near Alamosa, Colorado. Source: NREL.

[23] California's Renewable Energy Goals— Assessing the Need for Additional Transmission Facilities, March 2009. RETI consultant report.

[24] Powers, Bill. "CEC Cancels Gas-Fed Peaker, Suggesting Rooftop Photovoltaic Equally Cost Effective." Natural Gas & Electricity, August 2009.

According to utility planning documents, photovoltaics on customer rooftops count as equivalent to about 40 to 50 percent of the capacity value of a natural gas power plant. However, this ignores the fact that simple cycle natural gas plants that provide peak power lose efficiency during the heat of summer, which reduces output by 25 percent or more. The real load carrying capacity of 4,200 megawatts of photovoltaics would be near 2,100 megawatts, but a similar amount of natural gas plants would also be reduced—to 3,000 megawatts or less. In addition, an onsite solar system avoids the energy losses inherent in the transmission and distribution system, which can be 10 percent or higher on hot summer days. The difference between the performance of a natural gas plant and a photovoltaic system is thus likely to be less than is normally assumed.

Projections of the cost of solar PV are constantly changing, and most recently have been declining rapidly. In 2007, the California Energy Commission calculated the cost of electricity from photovoltaics to be 72 cents per kilowatt-hour.[25] In 2009, RETI projected a range of 22 to 30 cents per kilowatt-hour, which is in line with our model projection for utility scale projects. These would be the same type of projects that RETI proposes: systems up to 20 megawatts that might be installed at or near existing substations in urban or suburban areas with suitable solar resource and a sufficient quantity of available flat ground. The major benefit of such sites is that they would require little to no upgrade in existing transmission systems, and could potentially add to local as well as to statewide reliability. Other projections demonstrate that the cost of thin-film solar promises to dramatically change the equation. According to some industry projections, thin film solar may soon cost as low as 11.4 cents per kilowatt hour, well below even out most optimistic forecast.[26]

In RETI's model, photovoltaic panels would be mounted on tracking systems, which increase power generation significantly. Rather than 15 to 20 percent capacity factor typical of rooftop systems, these tracking panels produce at 19 to 27 percent capacity factor. However, we find that similar cost of energy could be obtained with fixed (non-tracking) systems that would produce significantly less electricity. This lower production would be offset by lower installed cost largely because it would not require tracking equipment.

Larger photovoltaic systems can help to offset the cost of smaller rooftop systems and control the overall program costs. For example, one 20 megawatt system is equivalent to 6,000 to 10,000 typical household rooftop systems and therefore can easily balance the higher unit cost of many smaller systems.

b. Solar Thermal Power. Solar thermal generators use mirrors to focus the heat of the sun on to long tubes that carry a heat transfer fluid. The fluid boils water to steam which powers a turbine and generates electricity. Nearly 360 megawatts of solar thermal plants have operated for 20 years or more in the California desert, providing reliable power to the grid.

Steam turbines powered by solar thermal technology provide energy during the day.[27] If this system is supplemented with storage or backup fuel supply, then reliability can virtually match that of a natural gas power plant. Because peak electricity demand generally occurs

[25] Comparative Cost of California Central Station Electricity Generation Technologies, Dec. 2007. p. 7.
[26] Renewable Energy Transmission Initiative Phase 2 report. March 4, 2009, Page 189. http://www.energy.ca.gov/2008publications/RETI-1000-2008-003/RETI-1000-2008-003-F.PDF
[27] Local Power, "Green Energy Options to Replace the South Bay Power Plant." Feb 2007.

when solar thermal output is also available, and because much of California has abundant and reliable sunshine, solar could provide a significant portion of peak power needs. Approximately 3,000 megawatts of California's load curve could be appropriately met by solar thermal plants with no or minimal power storage. These plants begin production in the early morning shortly after sunrise and maintain a relatively flat level of electric generation through the rest of the day.

Solar thermal plants are best sited in regions with excellent sun, which is why desert regions have typically been preferred. However, when the value of being close to load demand—and the possibility of avoiding transmission congestion in the summer—is taken into account, areas with less sun can also be valuable for solar thermal development. According the California Energy Commission, the cost of electricity from solar thermal power plants is about 28 cents per kilowatt-hour for a merchant power plant, and below 20 cents per kilowatt-hour for a publicly owned and financed facility.[28] A report written for California's Renewable Energy Transmission Initiative (RETI), however, finds significantly lower costs for this technology, mostly in the range of 15 to 16 cents per kilowatt-hour. [29] The results of our cost modeling sit in the middle of these two reports. We find a range of 17 to 23 cents per kilowatt-hour under the RETI assumptions of capital cost between $4,800 and $5,200 per kilowatt, and performance between 24 and 31 percent capacity factors.

This last figure compares favorably with the electricity from new simple cycle natural gas power plants that provide for peak energy needs in nearly any feasible range which such a plant might normally operate, as the screening curve in the earlier section showed. Only if such a new natural gas plant were to operate at annual capacity factors well over 35 percent would the cost of electricity be lower than the solar thermal cost RETI reports. At capacity factors from 10 to 22 percent, the screening curve showed cost of energy for a new plant of 20 to 35 cents per kilowatt-hour or higher.

Solar thermal plants generally are not considered to carry 100 percent reliability, and their Effective Load Carrying Capacity (ELCC) is adjusted to account for this. As mentioned earlier, a solar thermal plant might be rated at about 60 percent of its capacity. However, adding storage or providing natural gas or renewable biogas as a backup fuel for the solar facility can increase the ELCC to as high as 100 percent. This will increase the cost of the power plant somewhat. However, the added benefits of providing reliable power for a wider range of hours will also add the ability to sell more power and make the plant more useful for a variety of purposes. For example, the plant will be able to sell capacity contracts for the full capacity of the plant. This will also save money for the grid as a whole, and thus for customers, by avoiding the need to build additional backup capacity.

[28] Comparative Cost of California Central Station Electricity Generation Technologies, Dec. 2007. See Appendix 8 for full table of cost of electricity from different power sources in the Energy Commission report.
[29] RETI Phase 1B Report, January 2009, Appendix D. Samples from the RETI table of projects can be seen in Appendix 9 of this report.

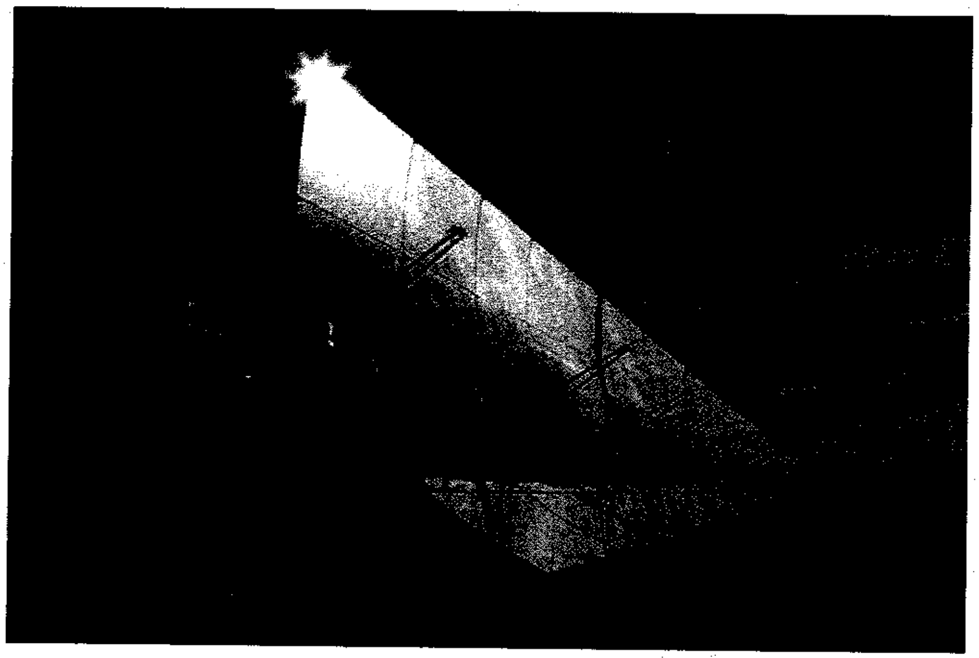

Figure 7: Solar thermal facility

Several utility companies have committed to buying power from Concentrating Solar Power (CSP) installations with large megawatt capacities by 2014. The CSP industry estimates it could produce up to 600 megawatts of parabolic trough capacity in 2010 and 1,200 megawatts in 2014 if there are favorable market conditions. The total capacity is projected to be 5,000 megawatts, which could be achieved between 2015 and 2020.

c. Peak Demand Reduction. Reducing peak demand with voluntary curtailments under conditions of stress in the electric system is a valuable and local resource. Like photovoltaics, it does not require transmission, and the infrastructure blends into existing buildings with minimal footprint. There are different types of demand reduction programs. In one type of program, called "demand response," utility companies sign contracts with large power users such as industrial manufacturing plants to reduce or cut out their power consumption during power emergencies. In exchange for this concession, the manufacturer will be paid an agreed upon price for avoided energy purchases. An added benefit to the customer is avoiding rolling blackouts.

Investor-owned utility companies are required by state regulators to get 5 percent of their power capacity needs, equivalent to at least 2,000 megawatts, from demand response programs.[30] In 2002, the California Energy Commission projected cost curves for market based demand response resources and found them to be equivalent to operation of combustion peakers: [31]

[30] See table of generation costs in Appendix 7; this assumes that the new natural gas plant operates at 5% capacity factor, equivalent to 435 hours per year, while the demand response resource will certainly be called upon to a much lower degree.

[31] 2002 - 2012 Electricity Outlook Report, California Energy Commission, February 2002. P-700-01-004F. p. 86. The chart value labels on the left show costs in the thousands of dollars, which would appear to be a

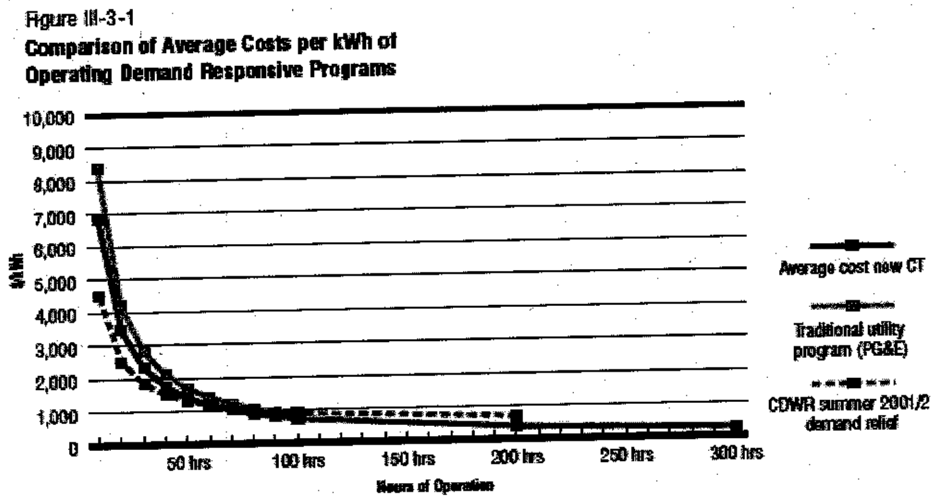

Figure 8

The actual cost, which the chart shows can range between $1.00 and $8.50 per kilowatt-hour, is very high due to the very few hours per year that the resource is called upon. Nevertheless, building and operating a peak natural gas plant to provide a similar service is shown to have a similar cost per kilowatt-hour for each assumed number of hours per year that the resource needs to be called upon. It should be noted that the cost of building new peaker plants has doubled since the Energy Commission created the above model, and that natural gas prices have also doubled. At this point, demand response programs should be decisively cheaper than building a new natural gas plant to serve the same purpose.

The Energy Commission has also indicated that demand reduction programs may actually meet the needs of grid reliability in a better manner than building new natural gas power plants from a technical as well as a policy standpoint:

"...sole reliance upon generation to provide peaking resource needs violates our flexibility criteria. Committing too much of resource additions to peakers is imprudent, given the potential that load curtailment programs and RTP rates appear to offer." [32]

d. Energy Efficiency. While California has aggressive energy efficiency programs, there has been only limited targeting of the primary driver of peak demand: air conditioning. Ground-source heat pumps, better home insulation and shade trees could go far toward reducing summer demand. A study from the US Forest Service, for example, showed that planting shade trees has the potential to avoid the need for over 700 megawatts of power plants in this

typographical error. The correct values would range from $0 to $10 per kilowatt-hour, with the comma indicating where the decimal point should be.

[32] 2002 - 2012 Electricity Outlook Report, California Energy Commission, February 2002. p. 92.

state.[33] Geothermal heat pumps use the natural and relatively constant ground temperature of about 55 degrees F. to cool a fluid in pipes that in turn cools your house.

These resources—shade trees and ground heat as well as many other efficiency measures—can be cost effective if programs are well run. As mentioned above, California is investing $1 billion per year in energy efficiency improvements, and state regulators are planning for over 4,500 megawatts of capacity savings by 2020 relative to baseline growth assumptions, including the new Big Bold Energy Efficiency Strategies (BBEES).

Table 6

Estimates of 2016 Energy Savings from Big Bold Energy Efficiency Strategies[41]

	Estimate of Sector or Segment Consumption Magnitude			Estimated EE Potential		
	TWH	MW	Million Therms	TWH	MW	Million Therms
New Commercial	9	1,900	50	4.5	950	25
New Residential	6	2,900	500	1	500	100-200
HVAC	19	14,400	3,000	2	1,400	300
Industrial	40	7,400	2,900	5	650	500

Estimating the cost of energy efficiency savings is somewhat an art, as a number of variables are difficult to determine. The most important factor is how long an investment in an efficiency measure will continue to generate savings. This variable is called "Estimated Useful Life," and can range from two to over ten years, depending on the specific measure. CPUC staff has estimated that the average cost of energy efficiency under the state's programs is between four and six cents per kilowatt-hour. [34] To be conservative we assume the higher cost in the range here. In any case this is significantly less than the average cost of generating electricity in California, and a small fraction of the cost of peak electric power that is supplied by the aging plants (see Table 6).

In our model portfolio we assume a mix of substation photovoltaic power generation with 4,200 megawatts of customer-owned photovoltaics primarily on residential and commercial rooftops. The cost of electricity from the customer owned generation would typically cost more than the larger substation solar plants; however, most of this cost is currently assumed by the customers themselves on a voluntary basis. Only a few relatively minor costs affect electric rates, such as the state rebates that are supported by a very small surcharge on everyone's utility bills. The tables that show cost, however, reflect a full cost of electricity

[33] Green Plants or Power Plants, 'Center for Urban Forest Research, USDA Forest Service, Davis, CA.

[34] "Assuming a weighted-average EUL of 8-12 years, and 5% real discount rate, the forecasted program costs in the full incremental cost scenario are equivalent to a levelized cost of roughly $0.04-0.06/kWh." CPUC Energy Efficiency Staff Paper on Recommended 2012-2020 Energy Efficiency Goals, p. 8.

from all sources. It is important to note that the actual rate impact is likely to be less than this average "levelized" cost.

Two green energy scenarios are presented in these comments, one—the "high cost scenario"— that reflects a) recent historical costs of solar photovoltaics, b) relatively low performance, and c) a 20 year economic life; and the "low cost scenario" that projects d) the lower price of solar systems that might be expected over the next decade as technology performance improves and manufacturing costs fall, e) improved performance, and f) a 30 year economic life.

Table 7

Aging Powerplants: Proposed Replacement Portfolio (High Cost Scenario)								
	MW	ELCC	MW-ELCC	Cap Fact.	hour-equiv./yr	MWh	Cost/KWh	Annual Cost
Energy Efficiency (BBEES)	3500	100%	3500	50%	4,380	15,330,000	$0.060	$919,800,000
New DR	1200	100%	1200	0.1%	9	10,512	$8.500	$89,352,000
Substation PV	6000	60%	3600	23%	2,017	12,099,878	$0.297	$3,599,128,765
DG Photovoltaics	4200	50%	2100	16%	1,430	6,005,125	$0.383	$2,299,219,927
Solarthermal	5500	60%	3300	22%	1,942	10,679,394	$0.227	$2,424,673,614
Generation Only	15700		9000			28,784,397	$0.289	$8,323,022,306
Total w/Efficiency	20400		13700			44,124,909	$0.211	$9,332,174,306

In the "high cost scenario", Table 7 above, rooftop photovoltaics are projected to average about 38 cents per kilowatt-hour, with a range of 35 to 50 cents per kilowatt-hour for residential and commercial scale systems, while larger solar projects would produce electricity at about 30 cents per kilowatt hour (the high side of the RETI report range).

Table 8

Aging Powerplants: Proposed Replacement Portfolio (Low Cost Scenario)								
	MW	ELCC	MW-ELCC	Cap Fact.	hour-equiv./yr	MWh	Cost/KWh	Annual Cost
Energy Efficiency (BBEES)	3500	100%	3500	50%	4,380	15,330,000	$0.060	$919,800,000
New DR	1200	100%	1200	0.1%	9	10,512	$8.500	$89,352,000
Substation PV	6000	60%	3600	22%	1,970	11,818,911	$0.181	$2,135,626,614
DG Photovoltaics	4200	50%	2100	17%	1,506	6,325,306	$0.301	$1,901,009,432
Solarthermal	5500	60%	3300	22%	1,942	10,679,394	$0.227	$2,424,673,614
Generation Only	15700		9000			28,823,611	$0.224	$6,461,309,660
Total w/Efficiency	20400		13700			44,164,123	$0.169	$7,470,461,660

In the "low cost scenario," Table 8 above, rooftop solar electricity ranges from 29 to 34 cents per kilowatt-hour, and the larger systems cost 18 cents per kilowatt-hour.

Total Private Cost of Scenario 2

Assembling a portfolio of options for replacing the aging plants and avoiding new ones would make the most sense. Because a green energy system includes demand reduction it does not require as much power plant infrastructure. In general, the energy efficiency and peak demand reduction programs are defined to be cost effective resources. In other words, the energy they save is worth more than the cost of the measures. Thus, they do not have a net cost. At worst they are zero net cost or—more typically—a net savings. Utility programs for energy efficiency have been measured and found to have a benefit to cost ratio that is better than one overall, thus verifying the assumption of zero net cost. Also, there is significant potential to improve the performance of the state's efficiency programs. As discussed earlier, California has allocated a regular budget of about $1 billion annually to achieve its energy efficiency goals.

The combined efficiency and demand reduction program targets are 4,500 and 2,000 megawatts respectively, for a combined savings of 6,500 megawatts. We will assume a program shortfall of 25 percent, resulting in a savings of 4,875 megawatts. Because this program is on the demand side it avoids transmission and distribution system losses, which can be 10 percent or higher on hot summer days when the current aging plants are most called upon. Thus the 4,875 megawatts of savings is worth about 5,300 megawatts.

This portfolio is approximately equivalent to the load carrying capacity of the aging plants. However, if the state actually implements a requirement to build 33 percent renewables by 2020, that would create a larger reduction in need for replacement plants than what is proposed here. The efficiency component is effective in lowering the average cost per kilowatt-hour from 27.4 cents to 21.2 cents.

III. Conclusion: Green Energy Replacement is Cost Effective and Consistent with State Law

By applying its policy tools, California can retire its aging natural gas power plants while achieving significantly lower levels of greenhouse gas emissions, air pollution, and natural gas consumption. Among the most important policies are the state's mandate to increase renewable energy to 20 percent by 2010, and increasing renewables to 33 percent by 2020 as required by the Energy Action Plan, the AB 32 Scoping Plan and the Governor's executive order. A 33 percent renewable energy supply would allow a large amount of the state's natural gas power plants—about 10,000 megawatts— to be retired.[35] The state has also adopted aggressive requirements for energy efficiency and conservation that have the aim of reducing 4,500 megawatts of future demand by 2020, a goal that state regulators expect to exceed.[36] In addition, there are demand reduction programs, such as demand response and interruptible load that should reduce even further the need for the specific service the aging

[35] California's Electricity Generation and Transmission Interconnection Needs Under Alternative Scenarios, Consultant Report, California Energy Commission, November 2003, 500-03-106.

[36] DECISION ADOPTING INTERIM ENERGY EFFICIENCY SAVINGS GOALS FOR 2012 THROUGH 2020, AND DEFINING ENERGY EFFICIENCY SAVINGS GOALS FOR 2009 THROUGH 2011, California Public Utilities Commission, Decision 08-07-047 July 31, 2008.

natural gas plants provide. Replacing the aging power plants with new natural gas plants is thus at odds with achieving the state targets for a range of green energy programs.

Continuing to rely heavily on natural gas power plants may be technically and conceptually easier for grid operators than moving to renewable energy, and we will continue to need some amount of natural gas power for decades into the future. Yet, if the state is to achieve its environmental and policy goals, alternative ways of meeting our future energy needs must be given a higher priority than taking the technically easier path. The challenges of climate change and depletion of fossil fuels increasingly make it necessary to surmount the technical challenges of moving to an electric power grid that depends on renewable energy.

A confluence of events is creating an opportunity to change how we meet our energy needs. An impressive raft of policies, rules and legislation in California are aiming to address global warming, to increase environmental protection, to reduce dependency on fossil fuels, and to secure a stable and economical energy supply for the future. These could have a dramatic impact on California's need for electricity generated from natural gas:

- AB 32, California's Global Warming Solutions law that would roll back carbon dioxide emissions to 1990 levels by 2020, equivalent to a reduction of about 25 percent.
- The Renewable Portfolio Standard that requires all utilities to obtain at least 20 percent of their electric energy needs from renewable sources by 2010.
- The Energy Action Plan that sets a goal of 33 percent renewable energy by 2020. This is codified in the draft plan for AB32, and it likely will become law.
- The California Solar Initiative that commits $3 billion to subsidizing the construction of 3,000 megawatts of rooftop solar installations by 2017.
- Energy Efficiency programs that have been ramped up over the last few years to a total state budget of nearly $1 billion per year to reduce electricity consumption.
- Programs that require utilities to procure 5 percent of their peak capacity needs by reducing their customers' peak demand, *in addition to energy efficiency savings.*

As the state contemplates retirement of aging natural gas power plants, it is important to keep in mind that there are a number of opportunities for meeting California's energy needs with alternatives to conventional power generation. These include preferred resources in the "Loading Order," which is the state's priority rankings of energy resources: 1) Energy Efficiency and Demand Reduction, 2) Renewables and Distributed Generation (i.e., local or on-site), and last 3) clean fossil fuel. The need to enforce this order has become more acute under the pressure of AB 32's mandate to decrease greenhouse gas emissions.

The higher loading order resources are potentially quite large. About 30 percent of normal summer peak demand, nearly 15,000 megawatts, is driven directly by air conditioning struggling against the California heat. There is great potential to reduce this need through more efficient technologies such as geothermal heat pumps, through better home insulation, through "cool roofs" that reflect the heat rather than absorb it, through timed cycling of air conditioners, and through shade trees. Only a fraction of the resources of renewable energy and reducing demand have been tapped.

Implementation of California's goal to get 33 percent of its electricity from renewable sources and deployment of demand side resources would displace the need for over 15,000 megawatts or more of natural gas power plants, and can eliminate the need for replacing aging power plants with new fossil fuel units. Certain technologies, such as solar energy and peak demand reduction programs, can effectively match most of the benefits of natural gas power plants that are used to meet peak energy needs. Significant quantities of these green resources can be deployed into the regions where they are needed for grid reliability. Clean energy plans for San Francisco, San Diego and the LA Basin have shown that there is a path to the future other than 100 percent reliance on new fossil fuel power plants.

Resource decisions are made at the California Public Utilities Commission, and by the utility companies, according to a "least cost" criteria. For example, when energy efficiency measures are evaluated, they are compared to the cost of generating comparable amounts of electricity. If the efficiency measure is less costly, then it will be prioritized. The same is true of contracts for renewable energy. Contracts are signed and power plants are "dispatched" according to the cost ranking. If full and realistic costs are imposed on environmentally destructive practices, like once-through cooling (OTC) and carbon emissions, then priority will shift toward resources that are less destructive. Thus policy-makers do not need to wait passively for an abstract "market" to take the lead on energy decisions, particularly when that market has not internalized the proper costs into its assessments.

We recommend applying the following guiding principles:

- Project appropriate internal and environmental costs onto the power plant, rather than on future ratepayers, those who pay for loss of health, or on the natural environment.

- A single fixed projection does not give a correct picture of the future cost of natural gas; thus the market price referent should be replaced with alternatives that better characterize risk.

- Market based assessments of environmental cost should be supplemented by econometric projections of future climate damages that account for the ethical implications of our choices.

- Retirement of aging plants should be timed to deployment of new clean energy resources; this will minimize cost and is most protective of the future environment.

- The aging coastal natural gas plants operate almost exclusively to meet this summer demand. These plants are mostly idle the rest of the year. The 15,000 megawatts of aging plant capacity nearly matches the peak air conditioning demand in California. Thus, every megawatt of appropriate air conditioning efficiency and conservation measures could directly remove the need for a megawatt provided by the aging natural gas power plants. The California Energy Commission and CPUC have recognized in the 2007 Integrated Energy

Policy Report that widespread adoption of the most efficient appliances available can reduce peak demand by 46 percent in homes and 13 percent in industrial building.[37]

- By meeting the state's goal of 33 percent renewable energy by 2020, while implementing required efficiency measures, once through cooling power plants can be reduced or eliminated without building any more large natural gas plants.

- Regional peak load can be served by solar power, which is most productive on sunny, warm days when electricity demand is high, as well as by efficiency measures such as better insulation, and more efficient air conditioners and shade trees — all intended to keep buildings cool by using less energy.

- The cost of the Green Energy Replacement scenario, using solar power, ranges from 22 to 29 per kilowatt-hour.

- If efficiency savings are included in the portfolio accounting, the average cost of green electricity is estimated to go down to about 17 to 21 cents per kilowatt-hour. This assumes that the cost of efficiency is zero. However, the state's efficiency program is more likely to result in a net savings in which case the cost of efficiency will actually be less than zero—it will generate a profit.

- The proposed Green Energy Scenario for aging power plants eliminates the prime externalities: damages to marine life, public health, and the global climate. Thus, the full cost of a portfolio of the Green Energy Scenario may be less than half that of new natural gas power plants.

- All the aging OTC coastal plants should be retired on a schedule consistent with the rate at which renewables and efficiency can be brought on line, so that the state is not bound by a long-term commitment to new natural gas plants that would be around for 30 to 50 years. Coordinating the retirement of aging plants with the deployment of green energy supplies would allow the state to meet environmental commitments while assuring electric system reliability.

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[37] California Energy Commission, "Integrated Policy Energy Report 2007," Page 95.