# *Air Pollution Reductions from Ice Energy's Energy Storage Technology in Los Angeles California*

*Submitted to:*

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March 2007

## Background

E3 Ventures previously investigated the electricity market in the Sacramento area and estimated the potential air emission benefits from shifting daytime peak electricity demand to the nighttime due to installations of Ice Energy's ice storage air conditioning technology (Ice Bear).[1] In this analysis E3 Ventures reviewed several previous studies related to thermal energy storage technologies, in particular "Source Energy and Environmental Impacts of Thermal Energy Storage" by the California Energy Commission, and a number of electric generation and air emission databases maintained by California agencies (e.g., the California Energy Commission, the California Air Resources Board) and the federal government (e.g., the Energy Information Administration, the Environmental Protection Agency). The Sacramento Municipal Utility District (SMUD) also provided detailed information and was particularly helpful in describing the historic and future electricity demand and generation resources. In light of the available generation and emissions data and key characteristics of the generation use and patterns in the Sacramento area, E3 Ventures developed a methodology, based largely on capacity factors of the fleet of generation facilities in the region, to estimate the air emissions benefits of shifting air conditioning generation demand from daytime peak periods to nighttime periods.

The analysis in Sacramento showed that significant reductions in air emissions (especially NOx, but also CO2) could occur with the installation of Ice Bear units. These units would reduce summertime NOx emissions associated with air conditioning use by over 60 percent; the NOx emissions from *all* electricity use in the summer would be reduced over half at a typical house equipped with the Ice Bear unit.

Following the analysis in Sacramento, Ice Energy requested that E3 Ventures conduct a preliminary or "first cut" analysis of the Ice Bear air emissions benefits in the Los Angeles area. To narrow the scope of this effort, the focus would be specifically on the electricity demand in the Los Angeles Department of Water and Power (LADWP) service area. Importantly, the LADWP owns and operates generation facilities within its service area and owns significant shares of power generation from facilities outside of California. Thus, even a "first cut" analysis for Ice Bear air emission benefits would need to consider the generation patterns associated with facilities both within and outside the region.

## LADWP generation patterns and facilities

There are about four million people in the LADWP service, which makes the LADWP the nation's largest municipal utility. LADWP has a generation capacity of about 7,300 MW, and recent peak loads have exceeded 5,700 MW with annual sales exceeding 23 million MWh. Unlike many other utility districts (e.g., SMUD for Sacramento) which must supplement their "owned" generation assets with substantial contracted power and "spot market" purchases, the LADWP generally functions as a "vertically integrated" company, both owning and operating its generation, transmission and distribution systems.[2]

[1] "NOx Emissions Reduction Benefits of Ice Energy's Energy Storage Technology in Sacramento, California," September 2005; "Ice Bear Air Quality Benefit in Sacramento, CA: Proposed 'AQ-15' Credit," December 2005.

[2] The LADWP appears to purchase a small amount of power from cogen units (<1%). Also, up to 10% of their power may come from wholesale purchases. The timing and potential sources of this purchased power were not investigated for this study.

The relative capacity and the actual "energy use" among the major generation types (e.g., coal, nuclear, hydro) is illustrated in Figure 1 (using information from the Draft 2006 Integrated Resource Plan). The largest single generation source type on a capacity basis is associated with natural gas for combined cycle units, simple-cycle units, and even some steam generators. However, coal resources are "used" to a higher degree, largely due to the lower costs associated with these facilities. The LADWP coal assets include part ownership in out-of-state plants (Navajo and Intermountain Power Project). The LADWP also has part ownership in the nuclear plant Palo Verde, and this asset, like those for coal, is used more than would be suggested by its relative capacity among available generation sources.

**Figure 1: Generation Capacity and Energy Use Among Major Generation Types**

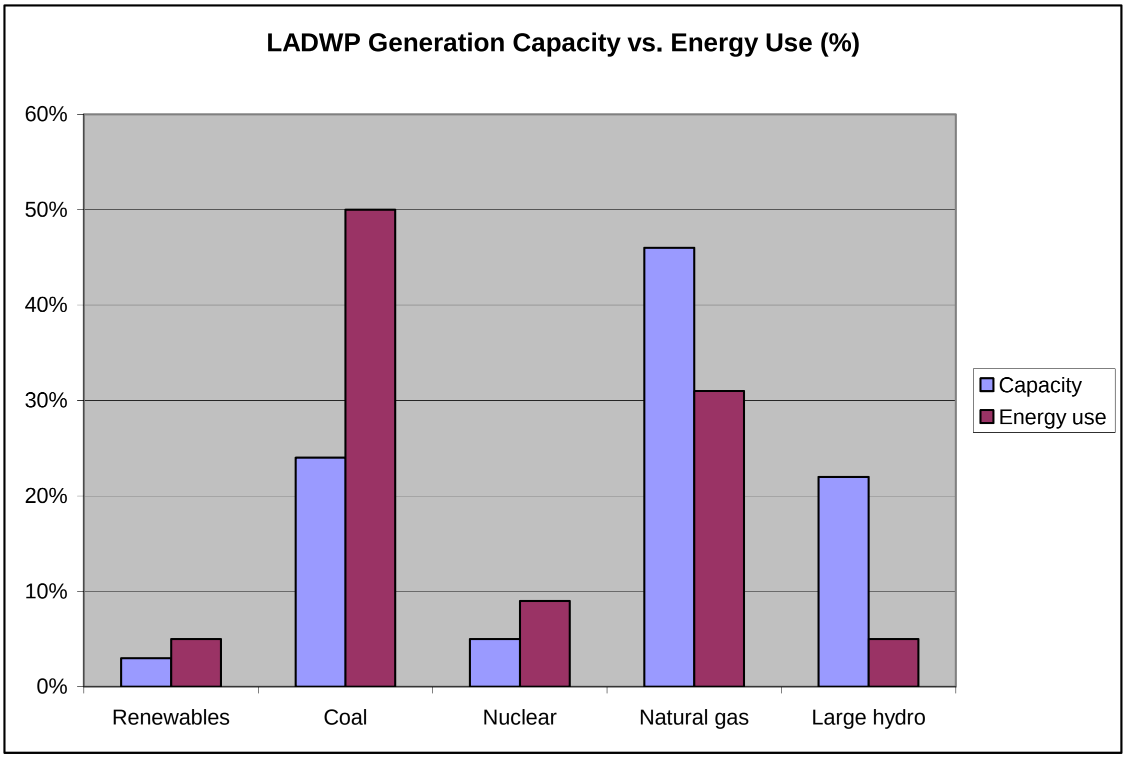


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Figure 2 is based on recent EIA data and illustrates the role of various generation sources providing electricity to the LADWP service area throughout the year. The very large portion of out-of-state coal and nuclear power (resulting from part ownership in Navajo, Intermountain Power Project, and Palo Verde) is clearly illustrated in the chart. The largest source of in-state power comes from LADWP's fleet of combined cycle units. Simple-cycle gas turbines (often associated with meeting the highest peak demands) represent a very small percentage of generation using the scale of Figure 2. However, in Figure 3 the generation from the large, baseload-type facilities has been removed to highlight the roles of those sources needed most during peak demand periods.

**Figure 2: LADWP 2005 Generation**

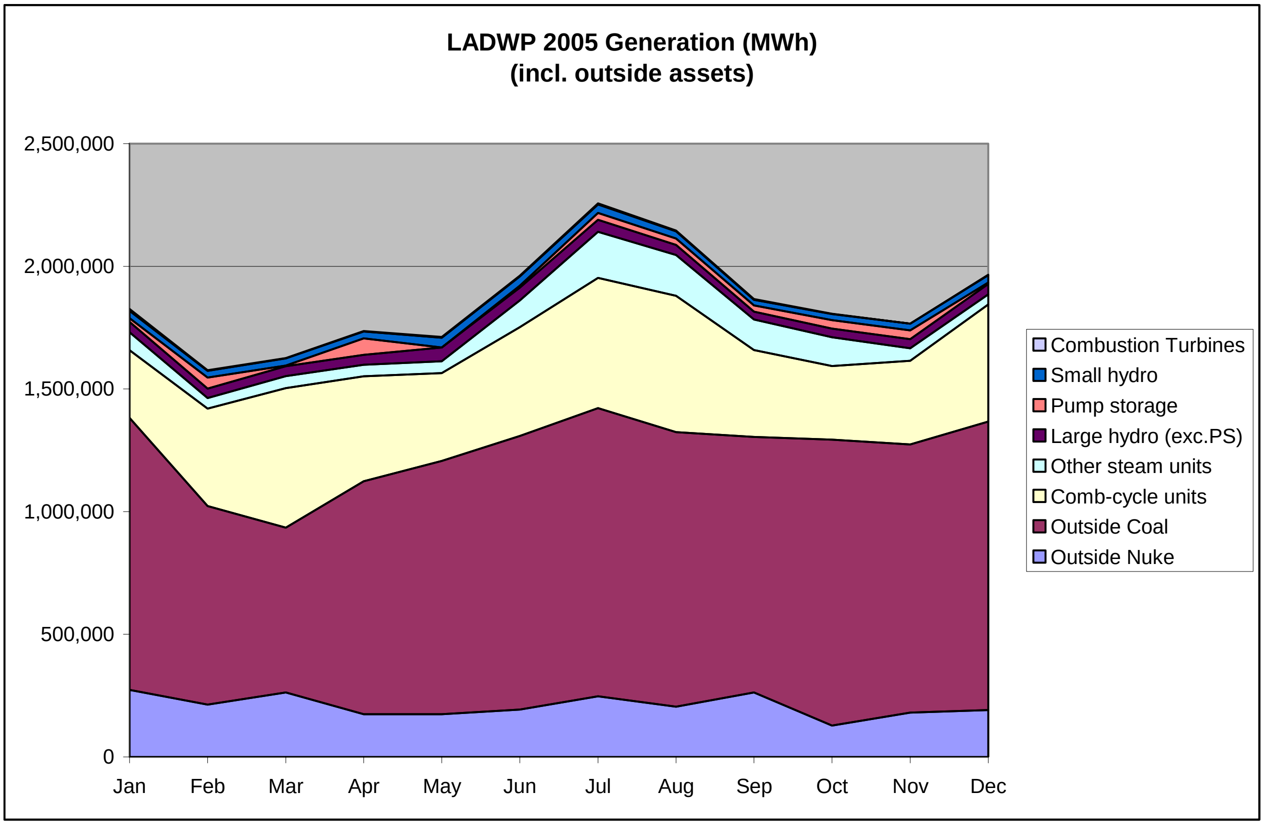



**Figure 3: LADWP Generation from Sources Associated with Peak Demand Periods**

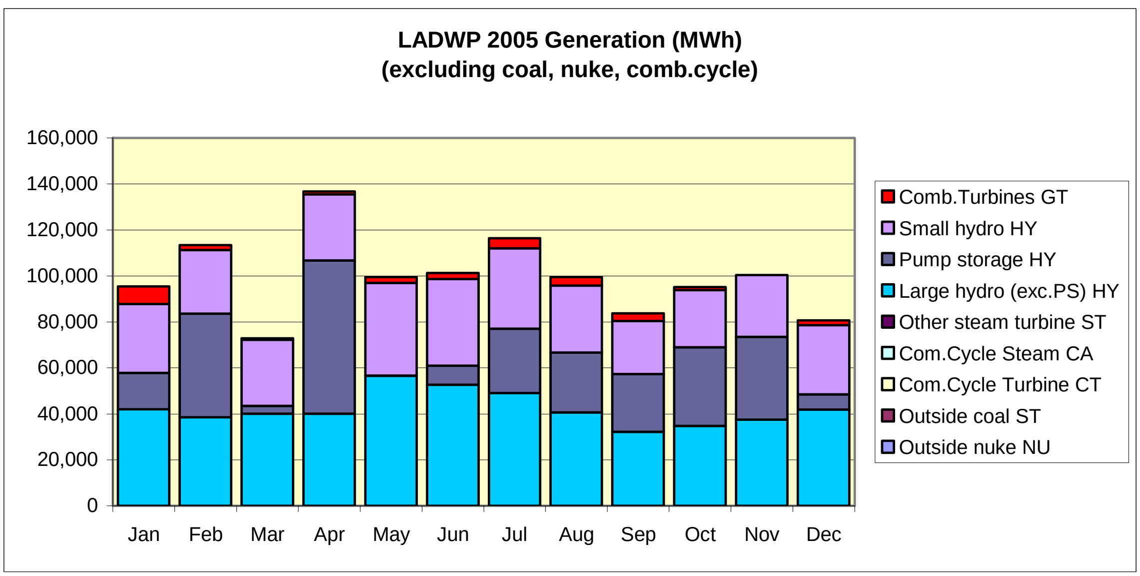
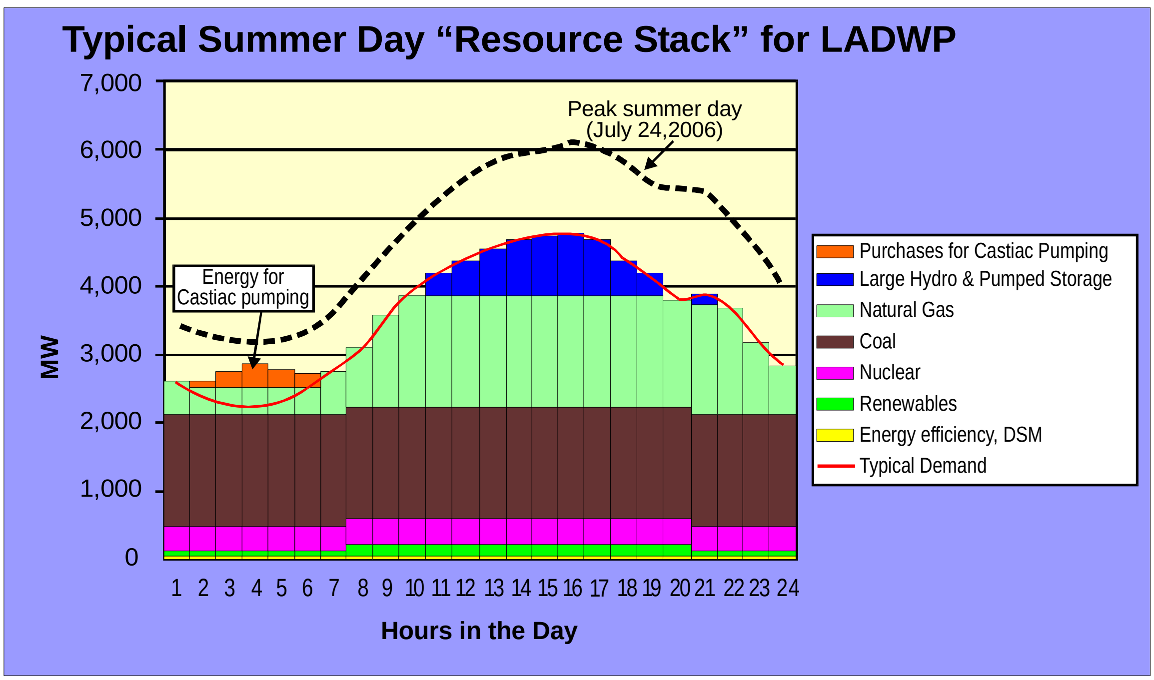



Figure 3 shows a more important role for simple-cycle gas turbines in meeting electricity demand during high demand periods, particularly during the summer months having high air conditioning use.

Figures 2 and 3 illustrate the annual generation pattern and the relative roles among the key generation types. More important when comparing peak vs. off-peak generation and emissions is the daily electricity demand and the sources used to meet that demand. Figure 4 (based on information provided in the Draft 2006 IRP) shows the generation resources needed to meet demand throughout a "typical summer day" in the L.A. area. The red line shows the demand during this "typical day"; however, the black dotted line (based on data provided by LADWP staff) shows how some peak demand days can create unusually large demands during the day and nighttime. The chart suggests that the power available from the primary baseload-type sources (i.e., coal and nuclear power) might not be adequate to meet even the nighttime demand during some summer periods.

**Figure 4: LADWP Generation Resources Associated with Summer Demand**




The LADWP has made many improvements to its fleet of generators, including the installation of combined-cycle units and relatively efficient simple-cycle units. These changes and additional SCR controls have, according to the LADWP, lowered NOx emissions over the last four years by 90 percent. In addition, the LADWP has recently installed six new combustion turbine peakers with a total capacity of 280 MW. The LADWP is also pursuing similar "renewable" goals that have been set for investor-owned utilities in California. By 2017 the city plans to achieve 20 percent of energy sales by using renewable resources.

## Estimation of peak vs. off-peak emission rates

Since the LADWP operates essentially as a vertically integrated company and satisfies the electricity demand largely through generation from its own assets, both in-state and out-of-state, it seems reasonable to assume that their own peaker units will be called on to meet high peak demand (e.g., during summer days when air conditioning use is high). Therefore, the average emission rate among the peaking units will be calculated to represent the emission rate associated with meeting additional air conditioning demand during the hot summer days.

The Energy Information Administration's Form 906/920 database has been used to collect information on 2005 generation from LADWP's power plants. EIA Form 906/902 reports monthly and annual generation data by plant, fuel type and "prime mover." Prime movers are devices that convert fuel or heat energy into mechanical energy and include steam turbines, simple and combined cycle combustion turbines, reciprocating turbines, and water turbines. The Environmental Protection Agency's Clean Air Markets database has been used for information on 2005 NOx and CO2 emissions from units at LADPW power plants. The LADWP Draft 2006 IRP has been used to provide unit-specific information that allows the EIA generation data to be reconciled with EPA emissions data where necessary and estimate emission rates for simple cycle (and combined cycle) units. The emission rates for the simple-cycle units (i.e., peaker units) operated by the LADWP have been weighted by 2005 generation to arrive at the overall "peak" emission rate for NOx of 0.264 lbs/MWh. The comparable emission rate for CO2 is 1340 lbs/MWh.

During many times of the year, the nighttime electricity demand for the LADWP service area can be satisfied by LADWP's baseload-type facilities — i.e., the out-of-state coal and nuclear generation. Under these conditions, the shift in generation from daytime to nighttime resulting from the Ice Bear installation would essentially "zero out" the daytime NOx emissions that would have contributed to the notorious ozone smog levels in the Los Angeles region.

As indicated earlier in Figure 4, at times in the summer the available generation for LADWP's out-of-state baseload-type facilities may not be sufficient to meet the nighttime electricity demand. During these times, it seems likely that the LADWP would operate its most efficient resources (i.e., its combined-cycle units) to meet the additional demand. In this case, the air emission benefit from an Ice Bear installation would be based on the *difference* between daytime peak rate (i.e., the 0.264 lbs.NOx/MWh for simple cycle units, from above) and the emissions rate for the combined-cycle units used to meet the marginal nighttime demand. Using the EPA Clean Air Markets database for 2005 and weighting the emission rates by the generation at each unit, the average emission rate for the LADWP fleet of combined-cycle units is 0.056 lbs.NOx/MWh. The comparable CO2 rate is 1185 lbs/MWh.

Table 1 shows the range of emissions reductions resulting from the above two cases for different sizes of air conditioning units. The "Removal of peaking emissions" refers to the case where the nighttime NOx emissions would occur outside of the Los Angeles region (actually, outside of the state). For example, for the 9-ton air conditioning unit, an Ice Bear installation would reduce peak daily emissions of NOx by about 9.3 gm/day.

**Table 1: NOx Reductions from Ice Bear Installation**

| Cooling System Capacity | Site - Peak Cooling Electricity Required | | Site electricity shifted to Off-Peak | Charge Capacity | Total Site Peak Energy Shifted to Off-Peak | Peaking units minus nighttime CC units | | Removal of peaking emissions | |
|---|---|---|---|---|---|---|---|---|---|
| | Compressor kW | Ice Bear kW | kW | Hours | kWh | lbs/day | gm/day | lbs/day | gm/day |
| 9 tons | 10 | 0.3 | 9.7 | 8 | 77.6 | 0.016 | 7.31 | 0.020 | 9.28 |
| 6 tons | 7 | 0.3 | 5.7 | 8 | 45.6 | 0.009 | 4.30 | 0.012 | 5.45 |
| 4 tons | 5 | 0.3 | 4.7 | 8 | 37.6 | 0.008 | 3.54 | 0.010 | 4.50 |

If combined-cycle units in the region are being used to satisfy the incremental nighttime demand, the emission savings for the Ice Bear installation would be about 7.3 gm/day. For comparison, this range (7.3-9.3 gm/day) would be about one half to three-fourths of the daily emissions of a motor vehicle in the Los Angeles area in 2007.

The same type of calculations (using the same sources of data) can be done for CO2. The results of these calculations are shown in Table 2. For comparison, the emission reductions from the Ice Bear installation at a 9-ton air conditioning unit, assuming the nighttime demand is met by combined cycle units in the region, would be over half of the CO2 emissions from a passenger car in the current California fleet.

**Table 2: CO2 Reductions from Ice Bear Installation**

| Cooling System Capacity | Site - Peak Cooling Electricity Required | | Site Electricity shifted to Off-Peak | Charge Capacity* | Total Site Peak Energy Shifted to Off-Peak | Peaking units minus nighttime CC units | | Removal of peaking emissions | |
|---|---|---|---|---|---|---|---|---|---|
| | Compressor kW | Ice Bear kW | kW | Hours | kWh | lbs | gm/day | lbs | gm/day |
| 9 tons | 10 | 0.3 | 9.7 | 8 | 77.6 | 12.0 | 5,454 | 104 | 47,172 |
| 6 tons | 7 | 0.3 | 5.7 | 8 | 45.6 | 7 | 3,205 | 61 | 27,720 |
| 4 tons | 5 | 0.3 | 4.7 | 8 | 37.6 | 6 | 2,642 | 50 | 22,856 |

## Summary

This preliminary analysis of the air pollutant emission reduction benefits from Ice Bear installations in the LADWP service area indicates that the technology could produce important reductions of NOx and CO2 emissions from generation sources. The reductions estimated in the Los Angeles area are somewhat less than those calculated in the earlier, more detailed analysis in the Sacramento area. This difference could be due to the different methodologies that were used, the generally "cleaner" generation sources in the Los Angeles area, and possibly other factors.