NOx Emissions Reduction Benefits of Ice Energy's Energy Storage Technology in Sacramento, California

Draft Final

Submitted to:

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Overview

This paper summarizes the development of a methodology for estimating the emission reduction benefits of the Ice Bear™ energy storage technology applied to refrigerant based air conditioning applications in the Sacramento, California area. Developed by Ice Energy, Inc., the Ice Bear technology shifts a substantial portion of the electricity demand of a common rooftop or split system air conditioning unit from daytime hours of peak usage to nighttime hours of off-peak usage and reduces total electricity consumption on a 24 hour basis. The Ice Bear energy storage technology has the potential to reduce air pollutant emissions by reducing overall electricity consumption and by reducing the use of relatively high emitting generation sources that are especially needed to meet the high cooling demands of hot summer days. Moving the demand for electricity to nighttime increases the utilization of generally more efficient and less polluting baseload generation sources. The difference in emission rates of generation sources used to meet peak electricity demands and those used to meet off-peak demand results in an emissions reduction for each kilowatt-hour of electricity shifted by the Ice Bear technology. Additional emissions reductions are achieved due to an overall energy savings associated with use of the Ice Bear technology and from lower transmission line losses when electricity is delivered at nighttime. The shift in generation from daytime to nighttime also will result in air pollutant emissions (particularly NOx) during hours when their role in ozone smog formation is much more limited.

The initial focus of this methodology is the potential use of Ice Bear units as a measure for land developers who are required to offset a portion of the air pollution impacts associated with their major developments under Sacramento's "AQ-15" requirement. Current measures available to developers under the AQ-15 requirement stress reduction of motor vehicle emissions (*e.g.*, promoting bike usage, reducing the number or distance of vehicle trips, *etc.*) as well as reduction of electricity use (*e.g.*, compliance with SMUD or EPA energy standards, use of solar energy, *etc*.). A key benefit of these measures is the reduction in NOx emissions since NOx plays a critical role in ozone smog formation in the Sacramento area.

Development of a methodology for evaluating the air quality benefits of Ice Energy's technology has involved consideration of a number of factors about electricity supply in the Sacramento area and the availability of data to assess the emissions characteristics of that supply during different times of the day. The effort undertaken can be summarized as follows:

> ***Goal:*** Determine the air quality benefits of the Ice Bear technology when applied to air conditioning units in the Sacramento area.
>
> ***Important considerations:*** The following considerations have significant implications on the development of an air quality analysis methodology in the Sacramento area.

* A variety of generation types provide the power that meets electricity demand in Sacramento.
* The Sacramento Municipal Utility District (SMUD) has historically used a combination of its own generation sources and contracted or "market purchased" power to satisfy the demand for electricity in the area. Because SMUD's power purchase contracts are not typically tagged to a specific facility, determining the specific generation sources associated with contract or market-purchased power is problematic.
* In 2006, SMUD's new combined cycle, 500 MW capacity Cosumnes Power Plant in Sacramento County will significantly increase the generation source supply directly owned and operated by SMUD. Although contract and market-purchased power are expected to remain important components in meeting electricity demand (especially peak electricity demand) in Sacramento, SMUD's baseload power needs will be significantly affected by the addition of Cosumnes. SMUD has indicated that Cosumnes has the potential to add an additional 500 MW of capacity several years into the future.
* Because natural gas-fired generation is used during peak usage times to meet marginal load requirements, natural gas-fired generators tend to be the units that are turned on or off when electricity demand changes during peak periods.

Overall approach: For generation sources in the Sacramento area, determine and compare the emissions characteristics of sources that are used during peak hours (in particular, the summer peak load period of 11:00am to 7:00pm) and those that are used during off-peak hours (10:00pm to 6:00am). Calculate the reduction in NOx emissions resulting from equipping an air conditioning unit with the Ice Bear load-shifting and energy savings technology.

As discussed below, the methodology for evaluating the emissions savings associated with Ice Bear load-shifting compares the emissions characteristics of generating sources used primarily to serve SMUD energy needs during summer peak energy demand periods with the emissions characteristics of generating sources used to serve SMUD energy needs during summer off-peak (nighttime) periods. The analysis finds that generating sources used primarily during peak periods have an average NOx emissions rate of 0.603 lb/MWh, while sources used to serve off-peak energy needs at night have an average emissions rate of 0.264 lb/MWh. The difference in emission rates of 0.339 lbs/MWh (a 56 percent reduction in the NOx emissions rate) is multiplied by the amount of energy shifted by an Ice Bear unit to estimate the emissions savings attributable to the shift in the timing of the energy demand.

Additional emissions benefits are also calculated based on the overall energy savings associated with an Ice Bear installation and reduced transmission line losses during off-peak periods.

According to another analysis[1] conducted for Ice Energy, the overall energy savings from Ice Bear applications in the Sacramento area is 4 percent. These energy savings are multiplied by the average NOx emissions rate during off-peak periods (0.264 lb/MWh) to calculate the additional emissions reduction from absolute energy savings.[2] Similarly, since transmission line losses are about 5 percent lower during off-peak times compared to peak times,[3] additional emissions savings are calculated by multiplying the reduced losses times the average NOx emissions rate during peak periods (0.603).[4]

Taking into account 1) the difference between the emissions rates of baseload generation sources used during the nighttime and the emissions rates of generation sources needed to meet daytime peak loads, 2) the absolute energy savings associated with Ice Bear applications in the Sacramento area, and 3) reduced line losses at night, the methodology in this report estimates overall NOx emissions savings from an Ice Bear installation with a 5-ton air conditioning unit to be about 8 g/day. Smaller or larger air conditioning units would have correspondingly lower or higher emissions savings as indicated near the end of this report.

Background

Ozone air pollution has been a persistent air pollution problem in Sacramento and many other urban areas in the United States for decades. NOx emissions from motor vehicles (*e.g.*, automobiles, trucks, agricultural and construction equipment, *etc.)* and stationary sources (*e.g.*, power plants, factories, *etc.)* play a major role in ozone formation; and numerous federal, state, and local government programs and measures have been established to reduce NOx emissions. Sacramento County's "AQ-15" requirement is one of many programs that helps reduce NOx emissions in the area.

Under the AQ-15 requirement, land developers must offset a significant portion of the air pollutant emissions associated with the construction and operation of their major developments. In practice, developers generally select from a list of potential measures that are acceptable to the Sacramento Metropolitan Air Quality Management District (SMAQMD), and implement a sufficient number of these measures to produce a combined "point value" at or above the required level. Ice Energy, LLC has proposed that the air quality benefits of its distributed energy storage technology (Ice Bear) could justify the addition of this product to the list of measures that developers can use to satisfy the AQ-15 requirement.

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[1] "Preliminary Energy Analysis of the Ice Bear System: Comparison with Conventional Package DX Systems," Architectural Energy Corporation, June 2004.
[2] The off peak average emissions rate is used in this calculation because the reduction in electricity use occurs at night.
[3] California Energy Commission, Source Energy and Environmental Impacts of Thermal Energy Storage, February 1996, p. 25. Using data from California utilities, the report indicates that transmission line losses are about 5% lower during off-peak times compared to peak times (due to the lines being less fully loaded and ambient temperatures being lower).
[4] The peak period average emissions rate is used in this calculation because the reduced line losses are an additional reduction in source energy production and emissions during peak periods.

The Ice Bear technology can be applied to off-the-shelf residential split and commercial rooftop refrigerant based air conditioning systems. The technology modifies the normal operating pattern of the air conditioning compressor by using the compressor late at night to produce ice that is used the next day to provide cooling with the compressor switched off. Shifting the demand for powering air conditioner compressors from daytime to nighttime hours shifts the electricity needed from higher-emitting power plant generating units that are typically used to meet peak loads to lower-emitting generating units that are used to meet off-peak, or nighttime, loads. Furthermore, this shift in generation and emissions occurs at the particular time—hot, summer daytime hours—when ozone levels are likely to be highest.

Figure 1 illustrates the shift in electricity use resulting from the Ice Bear technology when used to meet the cooling demand for an example building load. Figure 2 illustrates the dramatic shift in the timing of the energy load from daytime to nighttime when the Ice Bear technology is applied to a typical 13 SEER air conditioner.

Figure 1 Typical Building Load Shifting Profile

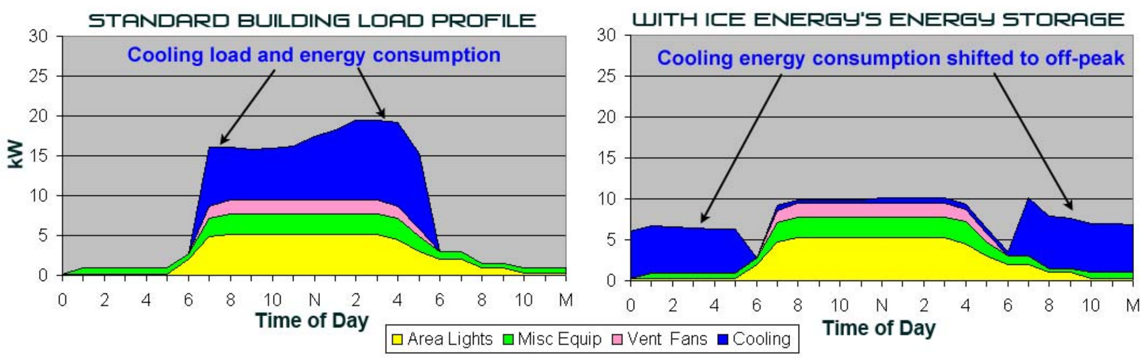
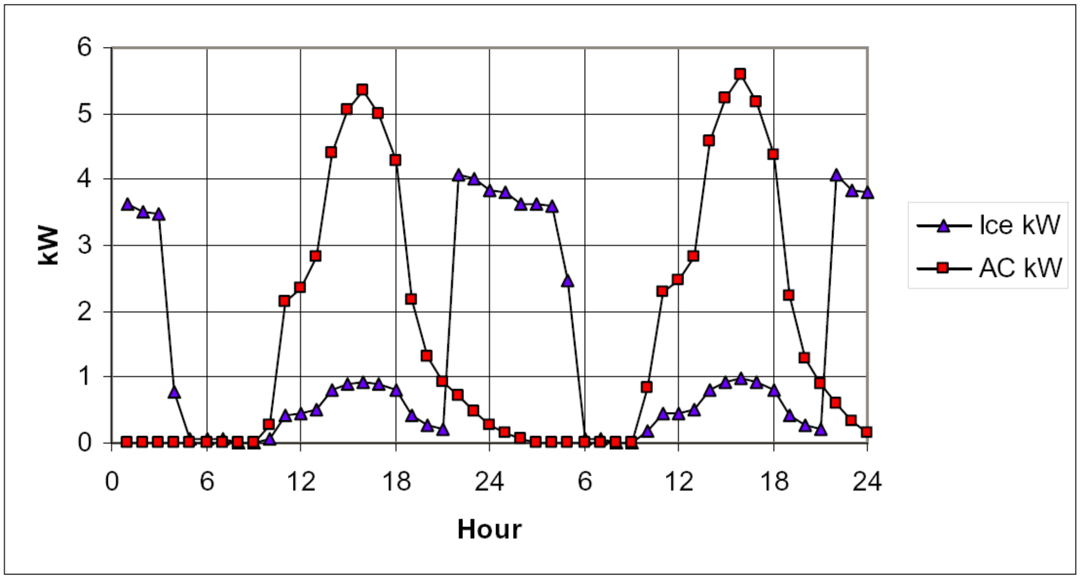
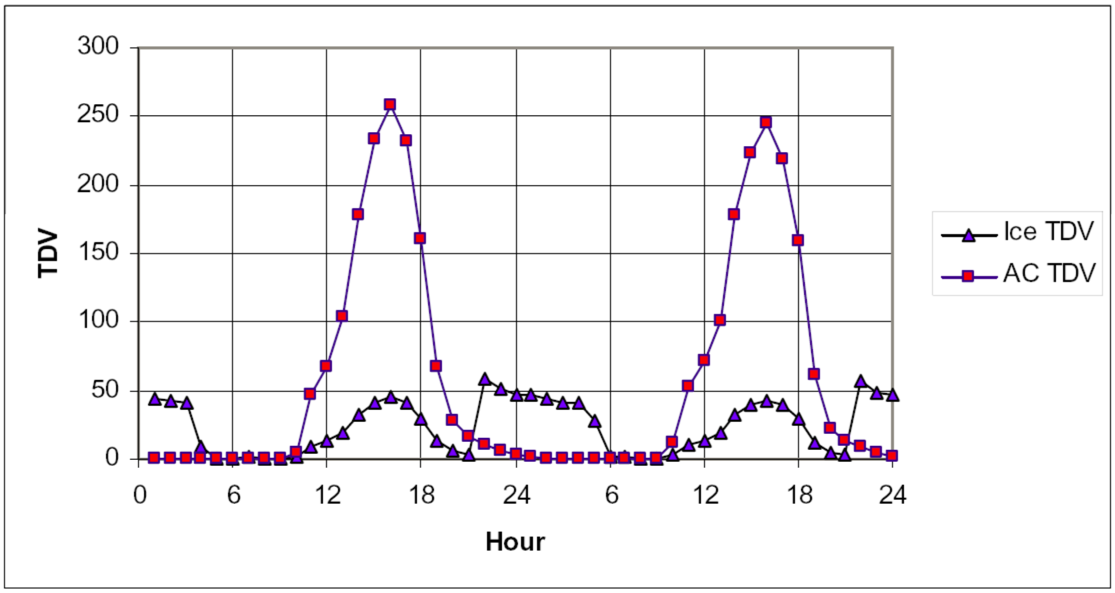


Figure 2 Electricity Use (kW) of an Ice Bear (Ice kW) vs. a typical 13 SEER air conditioner (AC kW)



Recent actions by the California Energy Commission (CEC) and the Public Utilities Commission (PUC) are placing even greater value on technologies, such as the Ice Bear product, that effectively reduce energy demand during peak periods. The CEC and the PUC have adopted a new measure of energy efficiency known as the Time Dependent Valuation (TDV) of energy. The use of TDV aligns the methods of modeling and regulating building energy use with the actual costs to users, to the utility system, and to society. For example, the savings of an energy measure that is very efficient during hot summer weekday afternoons would be valued more highly than a measure that achieves efficiency during the off-peak. This kind of savings valuation reflects the realities of the energy market, where high system demand on summer afternoons drives electricity prices much higher than prices during nighttime hours in mild weather. Figure 3 illustrates the impact of Ice Bear when applied to a standard 13 SEER air conditioner using the TDV metric. In comparing Figures 2 and 3, it is clear that the TDV approach emphasizes the difference between daytime and nighttime energy demand and results in a significant energy value for the Ice Bear technology.[5]

Figure 3 TDV Energy of an Ice Bear (Ice TDV) versus a typical 13 SEER air conditioner (AC TDV)



[5] When applying the CEC's established TDV valuation of energy weighting factors for each climate zone in California, the benefits of an Ice Bear unit rise considerably. For example in Sacramento the number of TDV energy credits earned by upgrading a 13 SEER 2006 standard efficiency air conditioner to a 16 SEER would be 1.26 TDV credits, but adding an Ice Bear to a 13 SEER air conditioner generates 7.87 credits. In hot climates such as El Centro the effect is even more dramatic: 16 SEER = 2.46 as compared to an Ice Bear at 33.96 credits.

Not only does the Ice Bear product shift a substantial portion of the energy load for air conditioning from daytime to nighttime, the technology results in an overall reduction in energy demand. Ice Energy reports the addition of Ice Bear to a 13 SEER air conditioning condensing unit improves overall energy savings by up to 20 percent in certain hot high desert climates areas in California (climate zones 14 & 15) and a 4 percent saving is calculated for the Sacramento area.

Prior efforts to evaluate Thermal Energy Storage (TES) air quality benefits in California

One of the most intensive efforts to evaluate the air quality benefits of TES technologies occurred in 1996 as part of a larger study undertaken by the CEC Thermal Energy Storage Systems Collaborative. This study produced a report, *Source Energy and Environmental Impacts of Thermal Energy Storage,* which evaluated the potential TES impacts in the service areas of Pacific Gas & Electric (PG&E) and Southern California Edison Company (SCE). The CEC study concluded that, due to the peak shifting, TES systems could realize 36 to 43 percent source energy and source emissions savings for SCE and 20 to 30 percent savings for PG&E.

The methodology used in the CEC study examined changes in the marginal cost of electricity and marginal environmental costs at peak and off-peak times to determine both the source energy and the air emissions savings. Underlying this methodology was the assumption that natural gas generation provided the marginal generation during peak and off-peak periods. Assuming that natural gas is the marginal generation source, economic differences between different times of the day will reflect differences in the efficiency of generation at different times of day. This is because, at a given price of natural gas, differences in variable generating costs reflect differences in the amount of fuel consumed (*i.e.* energy use) at different times of day. Although the study also analyzed marginal environmental costs to evaluate differences in environmental performance, the researchers ultimately concluded that differences in marginal energy costs (*i.e.* source energy savings) were the best proxy for emissions savings.

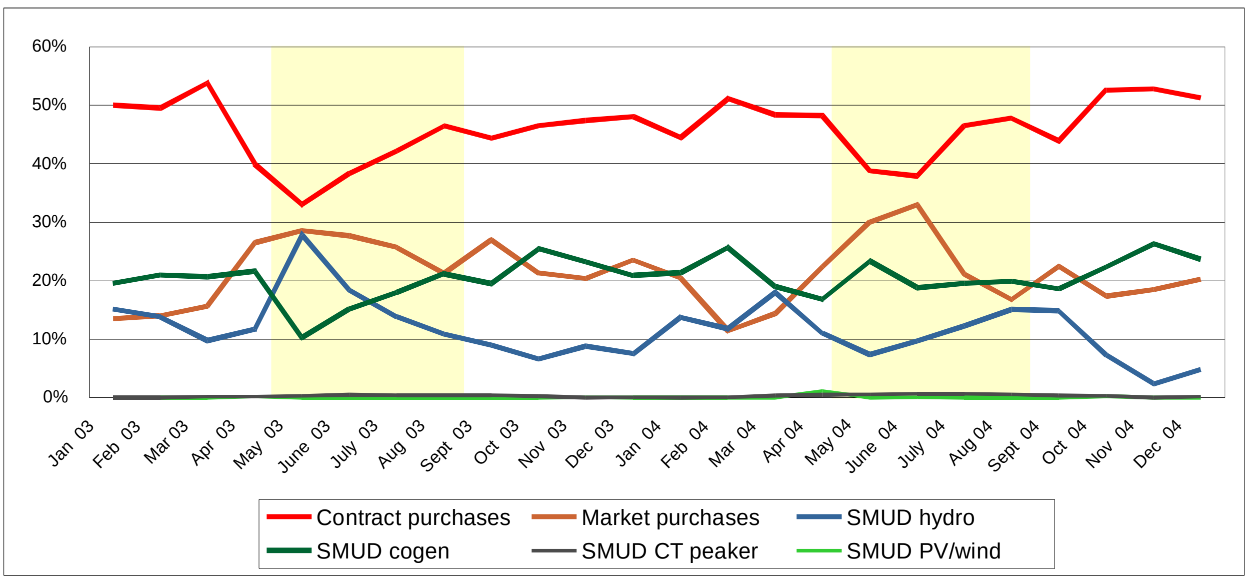
Hourly marginal electricity price information is required to use this methodology to evaluate the Ice Bear technology in the Sacramento area. However, following the California electricity market problems encountered in 2000-2001, marginal economic data are no longer readily available. Numerous attempts to retrieve marginal price information were not successful. Without detailed marginal price information, it is not possible to apply the methodology used by the CEC-TES Systems Collaborative to the Ice Bear analysis in Sacramento. Therefore, an alternative methodology has been developed that focuses on the reported emissions performance of units that are typically used to meet demand during peak periods and those that are used to meet off-peak, or nighttime periods and takes into account absolute energy savings and the differential in transmission line losses during peak and off-peak periods.

SMUD Energy Sources

The starting point for evaluating Ice Bear's potential air quality impacts in the Sacramento area is understanding historical generation patterns associated with the area's electricity demand. Data provided by SMUD give a basic understanding of the general types of generation sources supplying power to the area in recent years. Figure 4 shows the historic importance of contract power and market purchases to meet energy demands in Sacramento. In the 2003-2004 period, SMUD facilities accounted for 33 percent of the agency's power supplies, and purchased power (both market and contract) accounted for 67 percent. The figure also illustrates the importance of cogeneration facilities. SMUD-operated cogeneration facilities, which include Campbell Soup, Carson Ice and Proctor & Gamble SCA and Carson, supplied 20 percent of SMUD's power during this period. [6]

Importantly, in 2006 the new 500MW Cosumnes Power Plant will begin generating electricity. The capacity of the new Cosumnes power plant is equal to about 40 percent of SMUD's off-peak load (typically at or below 1,200 MW) and will significantly reduce the amount of power purchased by SMUD during off-peak periods. In addition, Cosumnes could be expanded in the future with another similar size unit — *i.e.*, another 500 MW unit.

Figure 4: SMUD power sources as percent of total power supply (2003-2004)



[6] Note that Figure 4 is based on total generation across all hours of the day. This information is useful for illustrating the historic importance of power purchased by SMUD and the role of cogen facilities. However, in order to evaluate the benefits of the Ice Bear TES application, it is necessary to understand how generation patterns vary between peak and off-peak periods of the day.

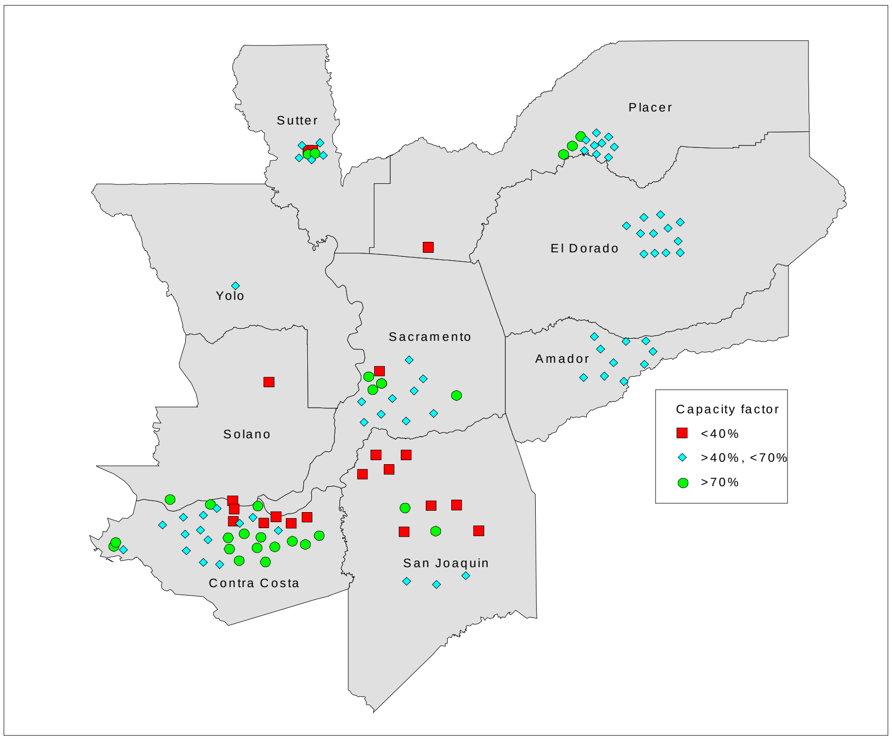
Methodology for Evaluating Ice Bear Emissions Savings

The methodology to evaluate the emissions savings of the Ice Bear technology focuses on developing estimates of 1) the emissions characteristics of generating sources used primarily to serve SMUD energy needs during summer peak energy demand periods (daytime periods associated with high cooling demand) and 2) the emissions characteristics of generating sources used to serve SMUD energy needs during off-peak (nighttime) periods. The emissions savings associated with Ice Bear's shifting of energy use from peak to off-peak times (and from reduced overall energy consumption and transmission line losses) can then be estimated using the emissions characteristics of the generation sources that provide power during these different time periods.

Scope of analysis

The geographic region selected for analysis includes Sacramento and adjacent counties, which include Amador, Contra Costa, El Dorado, Placer, San Joaquin, Solano, Sutter, and Yolo counties. Figure 5 illustrates the power plants in this nine county region.[7] Facilities are classified by their average capacity factor during the six month ozone seasons (April through September) of 2001, 2002 and 2003. Capacity factors play a key role in the analysis methodology, as discussed below.

Figure 4 Electric generating units in Sacramento region[2]



[7] The available latitude/longitude information for almost all of these units referred to the closest major city or some other "central location" rather than the actual location of the unit. Therefore, a number of units

The rationale for selecting this multi-county region is three-fold. First, emissions from power generation sources in this nine county region are likely to directly impact air quality in Sacramento. Secondly, the region contains a significant number of power plants (approximately 70) that have a combined generating capacity far in excess of SMUD's peak demand. For example, in 2002 non-SMUD generation sources in these counties produced 2.4 times the power generated and purchased by SMUD in that year. Finally, although sources outside these counties may provide power to Sacramento during both peak and off-peak periods, purchases from distant sources are likely to occur predominantly during off-peak times because sources used to meet peak loads tend to be sources that are located near demand pockets. Therefore, the selection of this relatively constrained region provides a conservative estimate of emissions impacts during peak and off-peak periods.

A limited number of units were omitted from the analysis, as follows:

- Generating units smaller than 10 MW, which provide less than 2 percent of the region's energy supply;
- Generating units with negative generation values in the CEC power plant database; and
- Generating units in the CEC power plant database with heat rates of 18,000 btu/kWh or higher (about 1 percent of regional power).

Critical Considerations

The methodology for estimating the emissions characteristics of the two categories of generating sources (those serving load primarily during peak periods and those serving off-peak demand) recognizes four key factors in the Sacramento area:

1. Gas-fired power is expected to continue to be critical in satisfying future peak electricity demand (*i.e.*, summertime air-conditioning peaks) and, specifically, to meet changing energy needs at the margin during peak periods.
2. SMUD's new Cosumnes power plant will begin generating power in 2006 and will significantly reduce the amount of power SMUD purchases.
3. With the exception of "green" power purchases, SMUD's power purchase contracts are not tagged to specific generating facilities. Therefore, precise NOx emissions rate estimates for SMUD's purchased power (either during peak or off-peak periods) cannot be developed.
4. To account for purchased power, estimates of the emissions performance of that portion of SMUD's energy portfolio can be developed using reasonable assumptions regarding

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were "collocated" at the same point. For illustration purposes, many of the generating units have been manually dispersed in the counties.

the types and locations of facilities likely to be supplying power purchased by SMUD during peak and off-peak periods.

Using capacity factors to identify units meeting peak (daytime) & off-peak (nighttime) demand

Given the considerations above, the methodology focuses on identifying and calculating an average NOx emissions rate for natural gas-fired units whose capacity factors indicate that they are likely to be used during periods of peak demand, and comparing that rate to the average NOx emissions rate of units whose capacity factors suggest that they are likely sources of nighttime power.[8]

Calculated capacity factors and emissions rates are based on monthly generation and emissions data for 2001, 2002 and 2003 as reported in CEC's Power Plant database. For each reported unit, an average capacity factor is calculated based on that unit's total generation during the six-month period – April through September (corresponding to the increased cooling demand) – of 2001, 2002 and 2003. This multi-year averaging approach minimizes the impact of any unusual disruptions in power generation that may have occurred in a single month. (A similar analysis of a three month ozone season– June through August–yielded results similar to the six month analysis.)

For this analysis, gas-fired units with an average capacity factor below 40 percent during the six-month period (averaged over the three years) are assumed to be called on to meet peak (daytime) demands in the warm summertime months. All units with an average capacity factor of 70 percent or higher during the six-month period are assumed to be used in meeting off-peak (nighttime) demand during the summertime months. Based on information provided by SMUD, the new Cosumnes plant is assumed to be operated in a baseload manner. (Attachment A provides a list of units included in the analysis.)

Average NOx Emissions Rates

Using the CEC Power Plant Database, a weighted average NOx emissions rate of 0.603 lbs/MWh was calculated for gas-fired units that have operated below a 40 percent capacity factor in recent years (*i.e.*, 2001-2003). This estimate serves as the average NOx emissions rate for generation sources used in meeting the daytime peak demand (between 11:00 am and 7:00 pm) associated with high cooling requirements.

[8] Hydroelectric facilities that provide power during peak periods were not included in the analysis of the emissions rate of facilities serving peak load. These facilities were excluded because, according to SMUD, their operations are unlikely to be changed by shaving peak period demand with TES technologies such as Ice Bear. TES is unlikely to affect their operations because they operate at low variable costs and therefore are called on first when available. On the other hand, the operating pattern of natural gas-fired facilities (from which SMUD purchases considerable amounts of power during peak periods) with higher variable costs are most likely to be affected from demand reductions that might be associated with TES technology. This assumption is consistent with assumptions made in the CEC report analyzing TES technologies, which focused strictly on changes in natural gas generation patterns.

The estimate of the average NOx emissions rate for sources used in off-peak periods (between 10:00pm and 6:00am) is based on the assumption that, in the future, nighttime energy demand will be met through a combination of existing SMUD sources that are used in a baseload manner (*i.e.*, operated with capacity factors above 70 percent), the new Cosumnes plant, and purchases from non-SMUD facilities in surrounding counties that are operated in a baseload manner (*i.e.*, have capacity factors above 70 percent). The amount of purchased power required for future off-peak use is assumed to be equal to SMUD's 2004 off-peak purchases less Cosumnes' expected generation beginning in 2006. Using the CEC Power Plant Database, a weighted average NOx emissions rate of 0.264 lbs/MWh is then calculated for units used in a baseload manner, using their rated capacities to indicate their potential contribution in meeting nighttime demand. This estimate serves as the average NOx emissions rate for generation sources used during periods of off-peak demand (between 10:00pm and 6:00am) in the analysis.

Generating sources used to meet demand for power	**emissions rate* (lbs/MWh)**
Off-peak demand (10:00pm – 6:00am)	0.264
Peak demand (11:00am – 7:00pm)	0.603
Difference	0.339

* weighted average emissions rate for generating sources used to meet demand for the period

Calculation of Ice Bear's Emissions Reduction Benefit

The *difference* between the daytime NOx emissions rate (*i.e.*, the calculated peak generating source emissions rate) and the nighttime rate (*i.e.*, the baseload generating source emissions rate) can be multiplied by the amount of energy shifted from peak to off-peak by the Ice Bear technology to estimate the emissions reduction associated with the energy shift.

The table below quantifies the amount of peak energy shifted by an Ice Bear *application* for a range of cooling system capacities and typical electricity demands (at the site of the air conditioner).

Cooling System Capacity	**Site - Peak Cooling Electricity Required**		**Site Electricity Consumption shifted to Off-Peak**	**Charge Capacity***	**Total Site Peak Energy Shifted to Off-Peak**	**Peak/Off-Peak Emission Rate Savings/Day**	**Grams/day**
	Compressor kW	Ice Bear kW	kW	Hours	kWh	lbs	
6 tons	7	0.3	6.7	8	53.6	0.018	8.24
5 tons	6	0.3	5.7	8	45.6	0.015	7.01
4 tons	5	0.3	4.7	8	37.6	0.013	5.78

* The Ice Bear module can provide up to 12 hours of daytime cooling for the 2.5 ton unit and 9 hours for the 5 ton unit. For this analysis, however, the charge capacity has been "capped" at 8 hours to more closely reflect the peak period of the day.

For example, a 5-ton rated air conditioning unit without an Ice Bear unit might require about 6 kW of energy on average during the peak time of the day. Since only 300W of power is needed during the peak daytime period with the use of an Ice Bear energy storage unit, the difference, 5.7 kW, is multiplied by the time period (expressed as "charge capacity") to determine, in this case, 45.6 kWh. The total energy shifted to off-peak is multiplied by the daytime-nighttime emissions rate difference (0.603-0.264=0.339 lb/MWh) to determine the NOx emissions reductions,[9] resulting in about 7 grams/day for a 5 ton system.

There is also an "absolute" energy savings (and emissions savings) associated with the Ice Bear technology that can be added to the above estimate. In the Sacramento area, the addition of an Ice Bear module is expected to improve overall energy efficiency by 4 percent when compared to an air conditioner alone.[10] The amount of energy saved can be multiplied by the average NOx emissions rate during the nighttime period to calculate additional NOx emissions reduction associated with the Ice Bear technology.

Similarly, there is an energy benefit from shifting load to nighttime due to a reduction in transmission line losses. As documented in the 1996 CEC report, it is reasonable to assume a 5 percent reduction in line losses during off-peak periods compared to peak periods. This reduction in line loss can be multiplied by the NOx emissions rate associated with generation sources used especially during peak periods to calculate the NOx emissions reduction associated with reduced line losses.

The table below illustrates the calculated emissions reductions associated with the absolute energy savings and reduced line losses during off peak periods for various sizes of air-conditioning systems.

		4% Improved Efficiency of Ice Bear module			5% Reduction in Line Loss			
Cooling System Capacity	Total Site Peak Energy Shifted to Off-Peak	Energy Savings	Average Nightime Period NOx Rate	NOx Emissions Savings	Energy Savings	Average Peak Period NOx Rate	NOx Emissions Savings	Total emission reduction
	kWh	kWh	lb/MWh	lbs	kWh	lb/MWh	lbs	g/day
6 tons	53.6	2.14	0.264	0.0006	2.7	0.603	0.0016	0.99
5 tons	45.6	1.82	0.264	0.0005	2.3	0.603	0.0014	0.84
4 tons	37.6	1.50	0.264	0.0004	1.9	0.603	0.0011	0.69

The total amount of site peak energy shifted to off-peak is multiplied by the percent energy efficiency improvement and average nighttime NOx emissions rate to calculate the emissions savings. The percent reduction in line losses is multiplied by the energy shifted to off-peak and the average peak period NOx rate to calculate emissions savings. In the case of a 5 ton system the total savings related to efficiency and line losses would be 0.84 grams/day.

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[9] The 6 kW load during the daytime period represents a simplified pattern of electricity use during this period. More precise data on the hourly shift in load (kW's) can result in a more precise estimate of the emissions reduction when applying an Ice Bear module.

[10] "Preliminary Energy Analysis of the Ice Bear System: Comparisons with Conventional Package DX Systems," Architectural Energy Corporation, June 12, 2004

The total emissions “savings” calculated from peak/off-peak emission rate differences—absolute energy savings and reduced line losses—are shown in the table below.

Cooling System Capacity	Energy Savings and Reduced Line Losses	Total Site Peak Energy Shifted to Off-Peak	Total savings
	g/day	g/day	g/day
6 tons	0.99	8.2	**9.2**
5 tons	0.84	7.0	**7.9**
4 tons	0.69	5.8	**6.5**

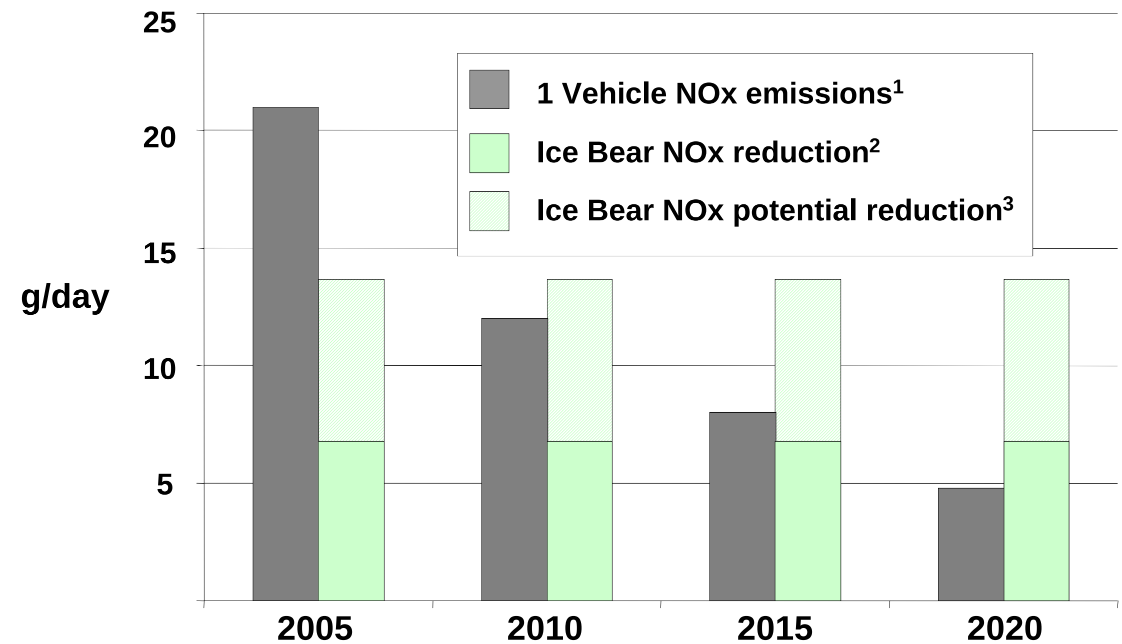
The total emissions “savings” attributable to an Ice Bear energy storage module for the illustrated range of cooling systems is between 6.5 and 9.2 g/day.

In addition, the air quality benefit might actually be larger since the nighttime NOx emissions are expected to make a minimal contribution to ozone smog. Thus, the air quality benefit for these size units could range from about 10 to 14 g/day if nighttime NOx emissions are assumed to have no role in ozone formation.

Figures 6 compares the range of total emissions savings for these Ice Bear installations to the typical NOx emissions of a light duty vehicle in California. Figure 7 expresses the emissions benefit of the Ice Bear installation with a 5-ton air conditioning unit (about 8 g/day) as a percent of the typical daily NOx emissions of the California light duty vehicle. As the figure demonstrates, the benefit is equivalent to about 40 percent of the emissions of a typical vehicle in 2005, and that amount increases to almost 70 percent by 2010 as tighter vehicle emissions standards and fleet turnover improve the emissions performance of the light duty fleet over time. The Ice Bear technology has an even larger relative impact in future years.

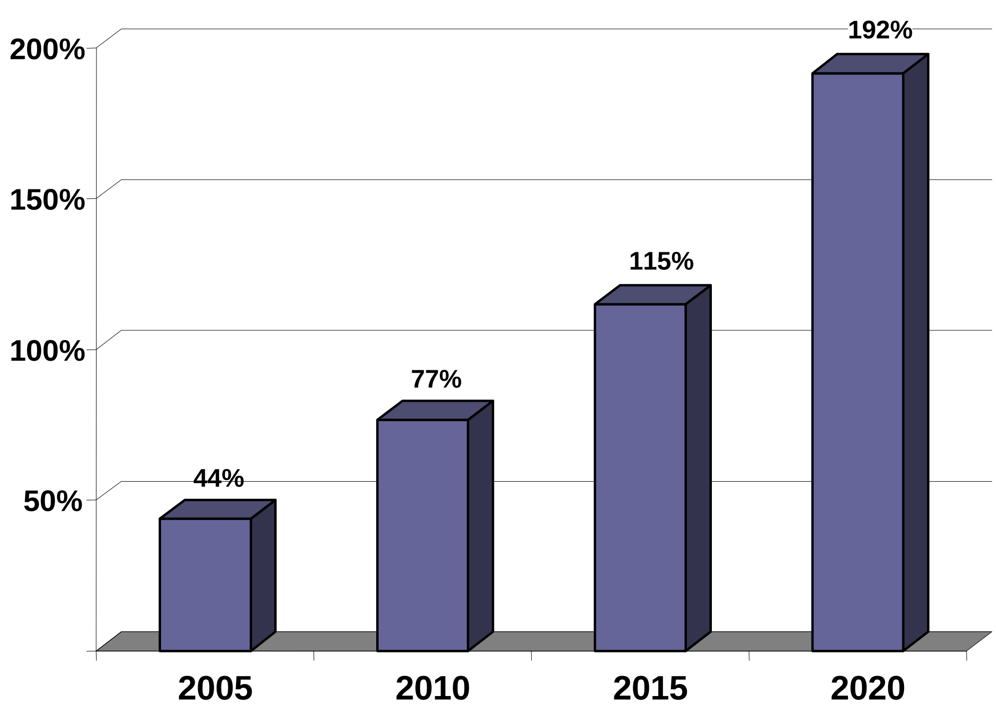
The typical sized air conditioning unit in new residential developments in Sacramento is about 4 tons. Therefore, from the table above, equipping a unit of this size with the Ice Bear module would result in an overall emissions reduction of about 6.5 g/day

Figure 6 Vehicle NOx emissions vs. Ice Bear NOx emissions benefit



[1]NOx grams/day for vehicle are based on emission rates and travel statistics from recent CARB emission inventory information.
[2]Ice Bear installed with 4-ton AC unit. Emission reduction based on difference in daytime and nighttime emission rates.
[3]Ice Bear installed with 6-ton AC unit and nighttime NOx emissions are assumed to have no impacts on ozone formation.

Figure 7 Daily Ice Bear NOx Reduction as Percent of NOx Emissions from a Typical California Light Duty Vehicle*



*Vehicle NOx emissions are based on the fleetwide data and projections from CARB. Ice Bear benefit is based on installation at a 5-ton air conditioning unit.

Attachment A

(Data for generation and emissions represent totals for the 6-month period — April-September — for 2001-2003.)

Plant/Unit ID	County	Capacity MW	Average Capacity Factor	3-yr Generation MWh	3-yr NOx lbs	NOx Rate lbs/MWh	Primary Fuel
SMUD units operated at 70% or higher cap factor							
SPA&Unit ST	SACRAMENTO	56.0	0.753	555,890	51,586	0.093	GAS
SPA&Unit CT	SACRAMENTO	118.0	0.707	1,099,781	113,662	0.103	GAS
Folsom&1	SACRAMENTO	66.2	0.753	657,253	0	0.000	HY
Total SMUD		**240.2**		**2,312,924**	**165,249**	**0.071**	
Cosumnes	Sacramento	500	0.800	5,270,400	479,606	0.091	GAS
Non-SMUD units (purchased power) operated at 70% or higher cap factor							
East Third Street Power Plant&GEN 1	CONTRA COSTA	19	1.000	250,391	170,317	0.680	COL
Wilbur West Power Plant&GEN 1	CONTRA COSTA	19	0.987	233,118	157,921	0.677	COL
Loveridge Road Power Plant&GEN 1	CONTRA COSTA	19	0.980	245,242	170,329	0.695	COL
Gaylord Container Corp Antioch&Gen 1	CONTRA COSTA	46	0.977	165,055	293,168	1.776	GAS
Wilbur East Power Plant&GEN 1	CONTRA COSTA	19	0.967	242,078	170,331	0.704	COL
Nichols Road Power Plant&GEN 1	CONTRA COSTA	19	0.943	236,107	163,019	0.690	COL
Wise&573	PLACER	12	0.923	145,876	0	0.000	HY
Middle Fork Powerhouse&UNIT 1	PLACER	61	0.909	730,782	0	0.000	HY
ConocoPhillips Company, San Francisco Refinery&38355	CONTRA COSTA	51	0.906	542,532	116,819	0.215	GAS
Martinez Refinery&TG-101-T1	CONTRA COSTA	40	0.905	476,737	63,252	0.133	GAS
Martinez Refinery&TG-102-T2	CONTRA COSTA	40	0.893	470,724	53,966	0.115	GAS
Martinez Refinery&TG-103	CONTRA COSTA	20	0.863	227,549	22,366	0.098	GAS
Stockton CoGen&GEN1	SAN JOAQUIN	55.1	0.858	623,136	424,235	0.681	COL
Valero Cogeneration Unit #1&GTG 4901	SOLANO	47.7	0.824	172,523	19,124	0.111	GAS
Greenleaf 1&GL1JT1	SUTTER	46	0.802	486,148	378,119	0.778	GAS
Ripon Cogen&UNIT 1	SAN JOAQUIN	49.9	0.798	524,494	95,439	0.182	GAS
Pittsburg&PT1JT3	CONTRA COSTA	24	0.797	252,165	70,558	0.280	GAS
Martinez Cogen Limited&TG-102-T2	CONTRA COSTA	44.98	0.782	463,554	685,355	1.478	GAS
Martinez Cogen Limited&TG-101-T1	CONTRA COSTA	44.98	0.778	461,010	685,355	1.487	GAS
Greenleaf 2&GL2JT1	SUTTER	50	0.772	508,579	44,998	0.088	GAS
Chevron Richmond Refinery Cogeneration&Cogen1	CONTRA COSTA	62.64	0.770	635,537	165,962	0.261	GAS
Port of Stockton District Energy Facility&GEN 1	SAN JOAQUIN	49.9	0.752	494,146	219,318	0.444	COL
Chevron Richmond Refinery Cogeneration&Cogen2	CONTRA COSTA	62.64	0.739	610,232	165,731	0.272	GAS
Halsey&Unit 569	PLACER	11	0.734	106,425	0	0.000	HY
Monticello&1	YOLO	11.5	0.729	36,796	0	0.000	HY
Rio Bravo Rocklin&Unit 1	PLACER	24.4	0.723	219,872	786,295	3.576	OGW
Tracy Biomass Plant&Gen 1	SAN JOAQUIN	23	0.715	180,739	692,720	3.833	OGW
Delta Energy Center&DE1CT1	CONTRA COSTA	182.4	0.701	935,911	77,739	0.083	GAS
Total purchased power		**1,155.1**		**10,677,458**	**5,892,438**	**0.552**	
Gas-fired units operated at < 40% cap factor							
Contra Costa Power Plant&CCPP6	CONTRA COSTA	340	0.395	1,476,581	1,041,997	0.706	GAS
Yuba City Cogeneration Partners LP&GEN 1	SUTTER	49	0.380	245,385	208,735	0.851	GAS
Pittsburg&PT1JT1	CONTRA COSTA	17.7	0.360	79,301	19,274	0.243	GAS
Pittsburg Power Plant&PPP6	CONTRA COSTA	325	0.354	1,434,612	739,964	0.516	GAS
Contra Costa Power Plant&CCPP7	CONTRA COSTA	340	0.345	1,460,376	1,053,186	0.721	GAS
Pittsburg Power Plant&PPP4	CONTRA COSTA	163	0.337	400,916	297,564	0.742	GAS
Pittsburg Power Plant&PPP3	CONTRA COSTA	163	0.318	341,751	251,034	0.735	GAS
Pittsburg Power Plant&PPP5	CONTRA COSTA	325	0.313	1,116,551	546,218	0.489	GAS
San Joaquin Cogen&LM5000	SAN JOAQUIN	48	0.308	194,728	88,375	0.454	GAS
Chevron Richmond Refinery Cogeneration&FCC	CONTRA COSTA	10.52	0.305	42,295	7,868	0.186	GAS
Greenleaf 1&GL1ST1	SUTTER	26	0.275	94,120	67,048	0.712	GAS
SCA&CT1C	SACRAMENTO	44	0.232	134,430	16,526	0.123	GAS
Carson Ice CG&Unit 1	SACRAMENTO	54	0.188	133,609	20,713	0.155	GAS
McClellan&1	SACRAMENTO	74.2	0.125	40,854	8,343	0.204	GAS
Lodi CC (NCPA STIG)&1	SAN JOAQUIN	50	0.109	48,057	41,061	0.854	GAS
Riverview Energy Center&RP1JT1	CONTRA COSTA	47.3	0.080	13,878	1,160	0.084	GAS
Wolfskill Energy Center&WS1JT1	SOLANO	48.1	0.064	13,552	1,160	0.086	GAS
Yuba City Energy Center&GL3JT1	SUTTER	48.1	0.064	13,538	1,234	0.091	GAS
Lambie Energy Center&LA1JT1	SOLANO	48.1	0.061	10,708	1,174	0.110	GAS
Creed Energy Center&CD1JT1	SOLANO	48.1	0.058	10,156	567	0.056	GAS
Goose Haven Energy Center&GH1JT1	SOLANO	48.1	0.055	9,791	874	0.089	GAS
Feather River Energy Center&GL4JT1	SUTTER	48.1	0.048	10,162	33	0.003	GAS
CalPeak Power - Vaca Dixon&4	SOLANO	49.95	0.045	17,927	1,661	0.093	GAS
McClellan&Unit 1	SACRAMENTO	74.2	0.032	13,701	2,798	0.204	GAS
Roseville&2	PLACER	25.24	0.022	4,538	8,254	1.819	GAS
Roseville&1	PLACER	25.24	0.022	3,207	5,833	1.819	GAS
Tracy Peaker Plant&TPP 2	SAN JOAQUIN	83	0.019	4,738	2,737	0.578	GAS
Tracy Peaker Plant&TPP 1	SAN JOAQUIN	83	0.017	4,028	3,498	0.868	GAS
Lodi&1	SAN JOAQUIN	25	0.010	2,493	1,775	0.712	GAS
Gianera&1	SAN JOAQUIN	32.31	0.010	3,396	6,548	1.928	GAS
Gianera&2	SAN JOAQUIN	32.31	0.008	3,199	6,095	1.905	GAS
Total gas-fired units < 40% cap factor		**2,795.6**		**7,382,578**	**4,453,307**	**0.603**	