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DATE: 05/16/2006

ONCE-THROUGH COOLING & ENERGY

1. How Critical Are the Coastal OTC Plants to the State's Energy Supply?

The steam plants have low usage rates. Combined, the 21 coastal plants using OTC in California have a capacity of approximately 21,000 MW.[i] Of this capacity a total of approximately 14,000 MW is from natural gas-fired steam plants.[ii] These steam plants are old and inefficient and have low usage rates as a result, averaging less than 20 percent in 2004.[iii] The power production from the coastal steam plants accounted for less than 10% of California's power demand in 2004.[iv]

The two nuclear plants are used more extensively. In contrast, two nuclear plants (Diablo Canyon and San Onofre) with a combined capacity of approximately 4,250 MW, operated at nearly 80 percent capacity in 2004.[v] These two nuclear plants accounted for well over half the once-through cooling water utilized by the state's combined population of coastal nuclear and steam boiler plants in 2004.

2. Aren't the Coastal Steam Plants Needed in the Summer When Power Demand Is Highest?

This power can be generated by steam plants or modern replacement plants. There is nothing unique about the steam plants. As the CEC notes in its April 12, 2006 letter to the SLC, "*Over time, it is anticipated that many of the steam boilers will be replaced with more efficient generating technologies*."

3. Does California Have a Commitment to Modernizing the Coastal Steam Plants?

Yes. Modernization of coastal steam plants with high efficiency, gas turbine combined-cycle plants is a stated goal of California's Energy Action Plan and recent California energy legislation, and better supports California's progress toward reducing greenhouse gases.[vi] Most steam plants are 30 to 50 years old and at or beyond their expected service life.[vii] An OTC ban by 2020 or earlier would simply reinforce an <u>existing</u> state commitment to phase-out coastal steam plants.

4. Will Eliminating OTC Add to the Cost of New Coastal Plants?

Not significantly. The cooling system is a small part of the overall cost of a new power plant. There is very little difference in the cost of a new combined-cycle plant whether it incorporates OTC, closed-cycle wet cooling, or dry cooling.[viii]

5. Will the New Coastal Plants Increase or Decrease Air Emissions?

The new plants will decrease air emissions. Air emissions from gas turbine plants using closed-cycle wet or dry cooling will be lower than air emissions from steam plants using OTC, due to the much higher efficiency of combined-cycle in baseload operation.[ix,x]

6. Will Retrofitting to Wet Towers Jeopardize the Reliability of the State's Electrical Grid?

No. Both nuclear and steam plants have been cost-effectively and efficiently retrofit to closed-cycle wet cooling in the United States.[xi] Retrofits more costly and complex than a wet tower retrofit are already planned for California's two nuclear plants.[xii]

7. Is Space Available at the Coastal Plants for Cooling Towers?

Yes. For example, any steam plant with space available for a large desalination plant generally has adequate space for a wet cooling tower retrofit.[xiii] Many coastal steam plants are considering the co-location of desalination plants. A review of aerial photographs of San Onofre and Diablo Canyon nuclear plants indicates there should be adequate space at both facilities for wet towers.[xiv]

8. Will the Retrofits Cause a Drop in Plant Efficiency and/or an Increase in Air Emissions?

No. The overall energy penalty of a nuclear plant wet cooling tower retrofit is approximately 1.5%, not 10% as cited by SCE in its March 20, 2006 letter to SLC.[xv] The air emissions that SCE attributes to this energy penalty are overstated by a factor of 7 in the same letter. The energy penalty for a steam plant wet tower retrofit is less than that at a nuclear plant, at approximately 1%.

9. How Much Would Air Emissions Increase if the Two Nuclear Plants Are Retrofitted to Wet Towers?

A very small and insignificant amount. About 1.5%, or 30 MW, of the output of each nuclear plants' 2,100 MW capacity would be dedicated to the wet towers, primarily to meet wet tower pumping and fan energy requirements. If this 30 MW is generated by a combined-cycle plant, the annual NO_x and PM_{10} emissions from this 30 MW would be a maximum of 9 tons/year (0.05 tons/day) and 5 tons/year (0.03 tons/day), respectively.[xvi,xvii,xviii]

10. How Much Will It Cost to Retrofit the Coastal OTC Plants?

Relatively little, as only a few plants are likely to be affected. CCEEB claims in its March 24, 2006 letter to the SLC that the capital cost to retrofit all existing facilities, approximately 20,700 MW of capacity, ranges from $2.0 billion for wet cooling to $2.5 billion for dry cooling. This is not a credible scenario. In reality only the two nuclear plants and a few of the steam units that have recently been upgraded are likely to still be operational in 2020. It is probable that all other steam plants will have converted to combined-cycle using closed-cycle wet or dry cooling technology (which have only minimal additional costs if done during conversion as noted above), or been retired by that time.

11. How Will the Cost of the Retrofits Affect the Cost to Generate Power?

The overall cost of power production from coastal plants will decline over time as more fuel-efficient combined-cycle plants displace steam plants and OTC technology is replaced at those converted plants. At those few plants that are not converted, the cost of power production related to an OTC retrofit will increase 3 to 4%.[xix]

12. What Will Be the Source of Water for the Cooling Towers?

Recycled water is preferred for use in the wet towers. However, seawater is a viable option and is used in cooling towers at numerous large nuclear and steam plants in the United States. Use of seawater in closed-cycle cooling towers at either San Onofre or Diablo Canyon would reduce seawater usage by 95 percent or more.[xx] Seawater may also be used to augment recycled water supplies if these supplies are not sufficient.

13. Will the Cooling Towers Emit Visible Plumes?

Not necessarily. Wet towers can be equipped with plume abatement technology to minimize or eliminate vapor plumes. This is now standard practice in California for power plant cooling towers in urban areas. See Figures 1 and 2.

14. Will the Cooling Towers Emit Particulates?

Yes, some particulate (salt drift) emissions would be generated by the cooling tower. Advanced "drift" eliminators are incorporated into cooling towers to minimize this water droplet carryover. Cooling towers using recycled water account for only a small amount of overall power plant PM_{10} emissions.[xxi] An industry survey of operators of seawater cooling towers notes these operators have not reported any problems associated with salt drift at their facilities.[xxii]

15. How Are Other States and Regions Addressing OTC Plants?

Other states and regions are aggressively pursuing wet tower retrofits. EPA Region 1 (New England) has required the retrofit of a 1,600 MW coal plant (Brayton Point Station, Massachusetts) to wet towers.[xxiii] New York Department of Environmental Conservation (NYDEC) has recommended that the 2,000 MW Indian Point nuclear plant be retrofitted to wet towers. NYDEC determined that a wet tower cost impact of less than 6 percent of revenue was not an unreasonable financial burden on the owner.[xxiv]

ENDNOTES

[i] CEC comment letter to SLC dated April 12, 2006, p. 3. MW capacity for each coastal plant category in 2004 (steam, nuclear, combined-cycle, combustion turbine) is calculated from data provided in table on p. 3. Total MW for all four plant categories is calculated at 20,650 MW.

[ii] Ibid.

[iii] Ibid.

[iv] Ibid.

[v] Ibid.

[vi] AB 1576 (2005) - authorizes utilities to enter into long-term contracts for the electricity generated from the replacement or repowering of older, less-efficient electric generating facilities.

[vii] CEC report, *Aging Natural Gas Power Plants in California*, July 2003, Table 1.

[viii] John Maulbetsch presentation on cost of cooling technologies to the State Water Resources Control Board on behalf of California Energy Commission, December 7, 2005.

[ix] Utility boiler NO_x limit is generally 0.15 lb/MW-hr in California coastal air districts. NO_x limit is 0.10 lb/MW-hr in Ventura County.

[x] EPA AP-42, Table 1.4-2 Emission Factors for Natural Gas Combustion – External Combustion (utility steam boilers), 1998, p. 1.4-6. Particulate emission factor is 7.6 lb/10^6 cubic feet of natural gas. Average heat rate of coastal boilers is approximately 10,000 Btu/kw-hr (see footnote 7). Each cubic foot of natural gas has a heating value of approximately 1,000 Btu. Therefore the emission factor for coastal boilers is 0.076 lb/MW-hr.

[xi] Retrofitting to a wet tower is fundamentally simple - the OTC pipes going to and from the ocean are rerouted to a cooling tower. At facilities that have been retrofit, the hook-up of the new cooling system has generally been carried-out without requiring an extended unscheduled outage. The cost to retrofit 800 MW Palisades Nuclear (MI) was to wet towers was $68/kW (1999 dollars). The cost to retrofit 750 MW Pittsburg Unit 7 (CA) was $46/kW (1999 dollars) [ref: EPA 316(b) Phase II Technical Development Document, Chapter 4].

[xii] 2,100 MW Diablo Canyon was recently authorized by the CPUC to replacing aging steam generators at a cost of $700 million [ref: California Energy Circuit, *CPUC Approves $706 million for Diablo Canyon*, February 25, 2005, p. 1]. A steam turbine replacement project authorized by the CPUC for 2,100 MW San Onofre is estimated to cost $680 million [ref: CPUC San Onofre Steam Generator Replacement Proceeding, Decision 05-12-040 December 15, 2005] These steam generator retrofits will cost in the range of $320/kw to $330/kw, much higher than the probable cost to retrofit these plants to wet towers.

[xiii] For example, a 50 million gallon a day desalination plant is under evaluation for an 11-acre site at the AES Huntington Beach steam plant [ref: City of Huntington Beach, Seawater Desalination Project at Huntington Beach - Draft Recirculated EIR, May 2005, p. 3-1]. Units 3 and 4 steam units at Huntington Beach, a total of 450 MW, were recently repowered [ref: CEC, Huntington Beach project description, http://www.energy.ca.gov/sitingcases/huntingtonbeach/index.html]. Less than 2 acres of land would be needed for inline wet towers for Units 3 and 4.

[xiv] For example, San Onofre has two reactors and sits on a 257 acre site [ref: Utilities Service Alliance, San Onofre webpage: http://www.usainc.org/sanonofre.asp]. The cooling tower for each 1,100 MW reactor would require from 2 to 6 acres of land, depending on whether an inline or round cooling tower is used. Inline wet cooling towers can provide 500 to 600 MW of steam plant cooling per acre (210 feet by 210 feet area) [ref: B. Powers, direct and rebuttal testimony, Danskammer Power Station draft permit proceeding – SPDES NY-0006262, October 2005 and December 2005]. Testimony describes design basis for retrofit plume-abated tower measuring 50 feet by 300 feet for 235 MW of steam plant capacity. Only 2 to 4% of the San Onofre site would be needed for the towers.

ENDNOTES

[xv] EPA 316(b) Phase II Technical Development Document, Chapter 5, Sections 5.6.1 through 5.6.3, p. 5-34. The measured annual efficiency penalty at 346 MW Jeffries Station is 0.16%. The cooling tower pump and fan energy demand for steam plants is estimated by EPA at 0.73%. Total energy penalty for Jeffries Stations would be approximately 0.9%. EPA also estimates the overall energy penalty for Catawba and McGuire nuclear plants at 1.7%, and for the Palisades nuclear plant at 1.8%. The generic annual efficiency penalty calculated by EPA (Table 5-10) for nuclear plants operating at 100% load is 0.4%. The generic nuclear plant cooling tower pump and fan energy demand is estimated by EPA (Table 5-16) at 0.9%. The total generic energy penalty for nuclear plants operating at 100% load is estimated by EPA at 1.3%. EPA shows a mean annual nuclear plant energy penalty of 1.7% in Table 5-1. However, when nuclear plants are operational they generally operate at 100% load.

[xvi] CARB, Guidance for the Permitting of Electric Generation Technologies, Stationary Source Division, July 2002, p. 9 (NO_x emission factor = 0.07 lb/M-hr combined-cycle plants)

[xvii] San Diego County Air Pollution Control District (APCD), Otay Mesa Power Project (air-cooled), Authority To Construct 973881, 18 lb/hr particulate without duct firing (510 MW output), equals ~ 0.04 lb/MW-hr.

[xviii] San Onofre is located in San Diego County. The NO_x and PM_{10} emissions offset thresholds defined by San Diego County APCD Rule 20.1 – New Source Review General Provisions, are 50 tons/year for NO_x and 100 tpy for PM_{10}. Diablo Canyon is located in San Luis Obispo County. The NO_x and PM_{10} emissions offset thresholds defined by San Luis Obispo APCD Rule 204 - Requirements, where Diablo Canyon is located, are 25 tons/year for NO_x and 25 tpy for PM_{10}.

[xix] A large capital investment like a wet tower retrofit would be amortized over 20 to 30 years. CCEEB estimates the cost to retrofit 20,700 MW of coastal power plant capacity with wet towers at $2 billion, or $100 million per 1,000 MW of capacity. Assuming 30 years and 7% interest, the payment per year on the $100 million capital cost would be $8 million per year. A baseload power plant, meaning one that operates most of the time at a fairly high load like 1,000 MW Encina (Carlsbad) prior to deregulation, would generally have a usage rate of 70% or more. This means the plant averages 70% of its power production potential over the entire year. Total kw-hr produced by 1,000 MW Encina per year at 70% usage rate is: 1,000 MW x 1,000 kw/MW x 8,760 hours/yr x 0.70 = 6,132,000,000 kw-hr per year. Therefore, the annual cost to pay for cooling system is: $8,000,000 ÷ 6,132,000,000 kw-hr = $0.0013/kw-hr (0.13 cents per kw-hr) The average wholesale power price in Southern California (SP-15) in 2005 was approximately $70/MW-hr ($0.07/kw-hr) [ref: Energy News Data – Western Price Survey, 2005 weekly archives: http://www.newsdata.com/wps/archives.html]. Therefore the cost of the cooling system would add ~2% to the cost of power production at baseload plants that are retrofit. For low usage power plants (20%) the retrofit would add ~6% to the cost of power production. The energy penalty imposed by the retrofit would be the same for high or low usage plants and would add another 1 to 2% to the cost of power production (see footnote 15).

[xx] Dr. Shahriar Eftekharzadeh – Bechtel, *Feasibility of Seawater Cooling Towers for Large-Scale Petrochemical Development*, Cooling Technology Institute Journal, Summer 2003, Vol. 24 No. 2, pp. 50-64. Operators of seawater cooling towers have not reported any problems associated with salt drift at their facilities. Site inspections of two long-time saltwater cooling tower installations did not exhibit any visible signs of salts fallout.

[xxi] U.S. DOE, Final EIS - Imperial-Mexicali 230 kV Transmission Lines, December 2005. Table G-1, Power Plant Emissions, p. G-4.

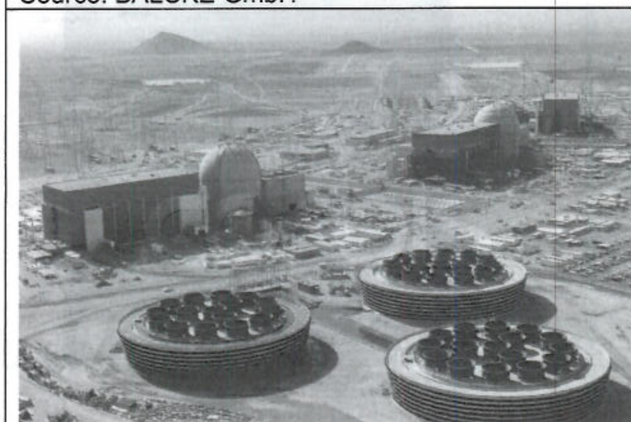
[xxii] Dr. Shahriar Eftekharzadeh – Bechtel, *Feasibility of Seawater Cooling Towers for Large-Scale Petrochemical Development*, Cooling Technology Institute Journal, Summer 2003, Vol. 24 No. 2, pp. 50-64. Operators of seawater cooling towers have not reported any problems associated with salt drift at their facilities. Site inspections of two long-time saltwater cooling tower installations did not exhibit any visible signs of salts fallout.

[xxiii] EPA Region 1, MA0003654 - Brayton Point Station Final NPDES Document, July 22, 2002, Chapter 7, p. 7-128. http://www.epa.gov/boston/braytonpoint/

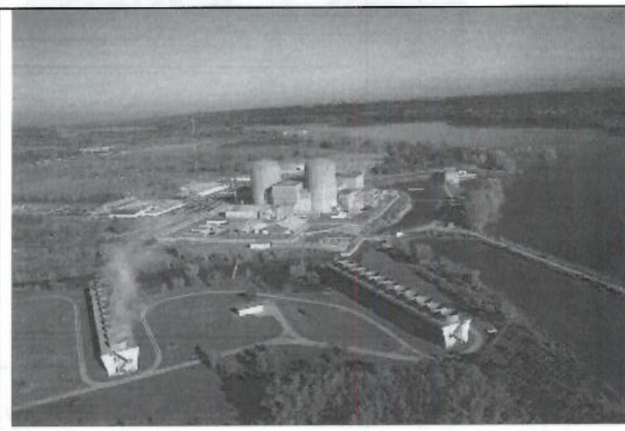
[xxiv] New York Department of Environmental Conservation, *Fact Sheet - New York State Pollutant Discharge Elimination System (SPDES) Draft Permit Renewal With Modification,* Indian Point Electric Generating Station, Buchanan, NY - November 2003.

Figure 1. Retrofit Cooling Tower Options for California Nuclear Power Plants

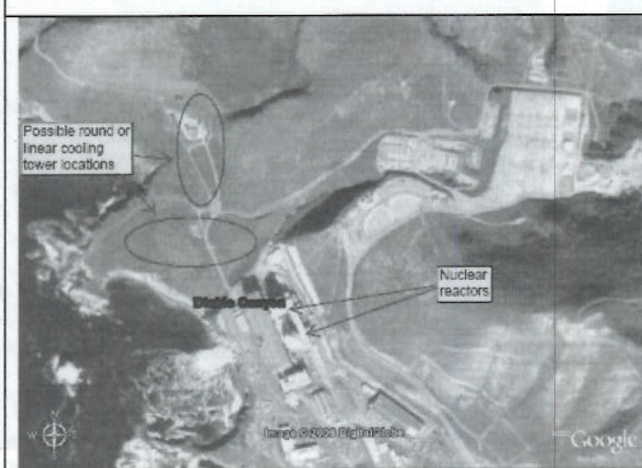
500 ft. diameter, 160 ft. tall plume-abated round wet tower, GKN2 1,300 MW nuclear reactor (Germany), 1 billion gal/day cooling water flow. Left photo – plume abatement off. Right photo – plume abatement on.
Source: BALCKE GmbH



Conventional round towers, Palo Verde Nuclear (AZ)



Conventional linear towers, Prairie Island Nuclear (MN)



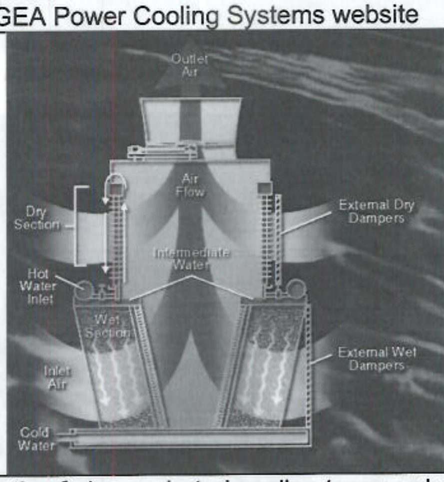
2,000 MW Diablo Canyon - possible wet tower sites

2,000 MW San Onofre - possible wet tower sites

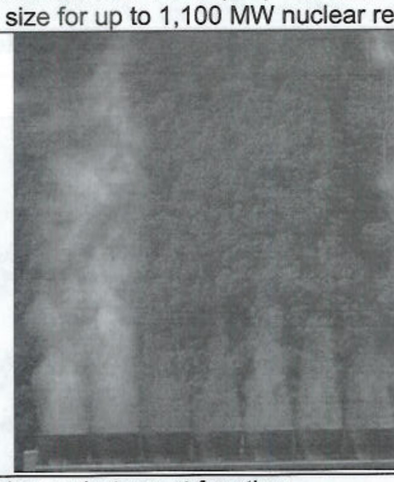
Figure 2. Back-to-Back Inline Wet Towers and Inline Plume-Abated Towers

36-cell, space saving back-to-back inline conventional cooling tower.
From: GEA Power Cooling Systems website

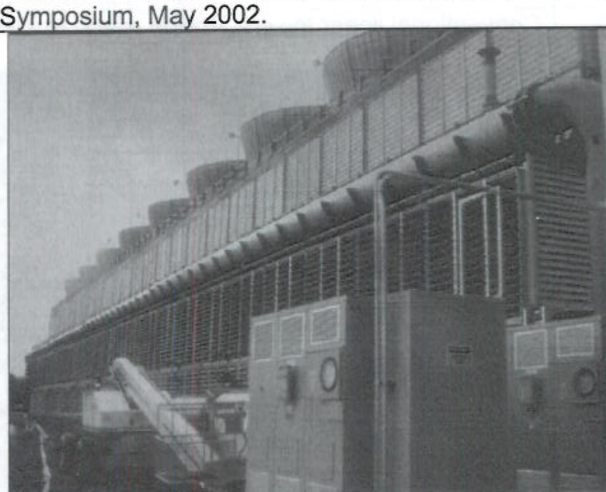
Retrofit 40-cell back-to-back inline conventional cooling tower, coal-fired Plant Yates (GA) – 40 cells is adequate size for up to 1,100 MW nuclear reactor.



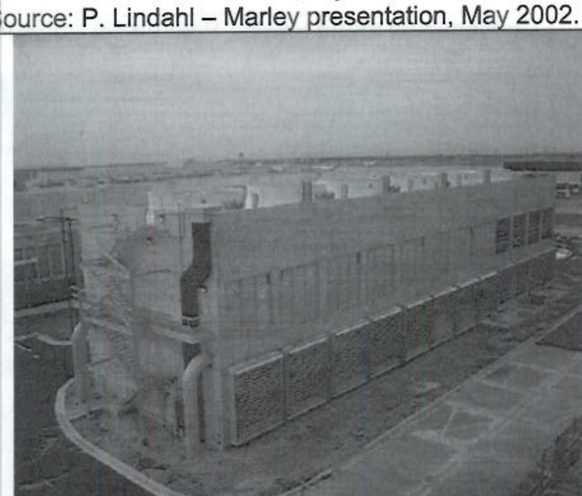
Schematic of plume-abated cooling tower – dry (radiator) section above, conventional wet below.
Source: P. Lindahl – Marley presentation, Dry Cooling Symposium, May 2002.



Effect of plume abatement function –
Plume abatement off, left two cells.
Plume abatement 100% on, adjacent two cells.
Source: P. Lindahl – Marley presentation, May 2002.



Operational plume-abated tower, ~60 ft. tall – Selkirk 2 Cogen, 330 MW (NY)
Source: P. Lindahl – Marley presentation, May 2002.



Operational plume-abated tower, ~50 ft. tall – Chicago O'Hare Airport
Source: P. Lindahl – Marley presentation, May 2002.