CALIFORNIA'S FRESHWATER ENVIRONMENTAL PROBLEMS

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ABSTRACT:

Limited water resources in California have resulted in intense competition for available supplies. Environmental and institutional constraints presently limit the potential for siting thermal electric power plants near coastal waters of California. Consequently, the search for viable sites has moved inland, away from the coast, where the utility companies must compete with various interests such as agriculture, for water supplies necessary for cooling purposes. A power plant siting proposal before the Energy Commission serves as an example of the varied considerations which must be made as a result of the current dilemma.

INTRODUCTION

Electric power production, distribution, and regulation in California have been going through a period of profound change in recent years. Historically, large electric utilities have operated in a relatively stable planning environment. Electricity sales and revenues grew at steady rates, costs of facilities and the time required to build new plants changed very little, fuel was plentiful and prices stable, while environmental regulations posed few major problems for both expansion of facilities and costs of operation. In addition, the regulatory constraints faced by the utilities were comparably simple and the outcome of facility proposal review by regulatory agencies was predictable.

Uncertainty in electrical generation development has increased greatly during the past several years. At the same time that future electricity demand is becoming more difficult to estimate, rate reform is making revenues more uncertain; production costs are being pushed up by rapid inflation in plant costs and substantially lengthened construction periods; and regulatory review for a multitude of purposes is becoming more complex and its outcome less certain. Construction of a large generating facility can require ten or more years to complete. One of the most important considerations which must be investigated when screening potentital sites for a thermal electric power plant is the availability of a satisfactory water supply for cooling.

Water is a critically important resource in California. The diversity of California's geography and climate have led to conflicts between competing interests and available water sources. These competing interests include the industry of agriculture in the state, use of fresh water for municipal and industrial purposes, and fish and wildlife sustenance and enhancement. A basic concern of agricultural interests and water managers is that while the total statewide run-off of 71 million acre-feet (MAF) would more than meet projections of water demand (36.4 MAF to 46 MAF in the year 2020), the projected dependable water supply of 36.4 MAF may not (DWR 1974). The deficit could be as high as 9.6 MAF without additional water projects. Without these projects, the shortfall would be met by additional groundwater overdraft, water conservation, waste water reclamation, greater irrigation efficiency, and as a last resort, removal of agricultural land from production. Of course, the current result is intense competition for the existing supply. Present water use is at about 36.4 MAF, which is divided between the beneficial uses as follows:

Agriculture - 84%

Municipal and Industrial - 14%

Wildlife and Recreation - 2%

By contrast, California utilities used only 60,000 acre-feet (0.17%) for power plant cooling during 1977 (CEC 1978). Most power plants in California are located in coastal areas where once-through cooling with ocean or estuarine water has been feasible, and thus, only minor amounts of fresh water are presently used.

Agricultural interests suggest that new power plants should be sited on the coast, using ocean water for cooling. However, power plant proposals in the coastal zone face various technical and institutional constraints. Stringent federal seismic safety criteria have followed suit due to the perception that adequate coastal sites acceptable to the California Coastal Commission cannot be found.

Water Requirements

Water is used for a variety of purposes in power plants. The most significant use is for cooling, while lesser uses include water and waste treatment, transport of wastes, air pollution control processes, and a number of small volume uses. In the process of cooling a power plant, large quantities of heat must be rejected from the condenser to the earth's atmosphere. Several systems of heat transfer from the condensers are used, although water is the common medium for heat transfer in each of the systems. The methods used in these systems are once-through cooling, evaporative cooling, combined wet-dry cooling, and dry cooling.

Once-Through Cooling

Once-through cooling is the most common method now in use for thermal power plants in the United States (USEPA 1969). This process requires large quantities of water for effective condenser cooling and as an example, for a 1,000 MW generating unit, the continual flow of water through the system would be about 1,500 cfs (about 1,086,000 acre-feet per year). This is about equal to the flow of the Colorado River Aqueduct, or can also be compared to the American River flow near Sacramento in midsummer. In a system of this type, the design temperature for heat rise across the condenser is usually about 11 C (20 F). Because of regulatory limitations on the use of inland water for power plant cooling, inculding restrictions on the discharge of thermal waste, once-through cooling in California is generally limited to coastal waters.

Evaporative Cooling

In the evaporative cooling process, heat is transferred from circulating water to the atmosphere primarily through evaporation, but also through convection. This is accomplished by use of natural draft cooling towers, mechanical draft cooling towers, or cooling ponds. A water supply of about 20,000 acre-feet per year per 1,000 MW generating capacity is consumed by this process. The actual amount of water necessary for evaporative cooling is determined by the efficiency of the power plant systems, the quality of the water supply, and whether sidestream treatment is employed to reduce scale producing constituents of the recirculating water. If chemical scale forms in the condenser tubes, heat-exchange efficiency is reduced thereby reducing the electrical output of the power plant per unit of fuel consumed. The number of concentration cycles in recirculating systems can be increased by the process of sidestream chemical softening. This results in reduced make-up water requirements.

Wet/Dry Cooling

Wet/dry cooling offers the potential for water savings of up to 80% of the annual usage of 100% wet systems. Combined wet/dry cooling adds to the cost and complexity of the system and its economics has yet to be proven in large scale operation. The value attached to the water saved by this method is roughly an order of magnitude higher than the current (1978) water supply prices charged in the state.

Dry Cooling

Dry cooling is a relatively new development. The largest dry cooling installation in existence is located in England and has a generating capacity of 120 MW (Bookman Edmmson Engineering 1976). This cooling method operates on a principle similar to the automobile radiator. No evaporation takes place and very little water is consumed, but efficiency of this system decreases as ambient air temperatures increase, which is a problem in the interior valleys and deserts of California.

ALTERNATIVE SOURCES OF COOLING WATER SUPPLY

The use of waste waters for cooling tower make-up has been established as having technical feasibility where appropriate conditions of availability and quality exist. Costs for wastewater use primarily depend upon conveyance and treatment requirements. The geographical occurrence of municipal wastewater in California presents severe locational constraints in regard to its use for power plant cooling. Virtually all municipal effluent with "new supply" potential is discharged to the ocean from urban areas near the cost (CEC 1979). Siting of power plants in proximity to these wastewater sources is often in conflict with air quality regulations, land use concerns, and other social and environmental factors. Construction of long conveyance pipelines could allow this wastewater to be used at feasible inland sites; but with accompanying increases in capital and pumping energy costs.

Collected agricultural wastewater presently occurs only in the Southeast Desert Region. Potential use of this water has its problems due to its existing role in maintaining the level and quality of the Salton Sea and providing return flows to the Colorado River. Use of this water by power plants will normally be possible only if replacement with a similar quantity of fresh water can be achieved. An example is the Sundesert Nuclear Project, where San Diego Gas and Electric Company (SDG&E) proposed to use agricultural return water in the Palo Verde Valley for cooling the power plant. Agricultural return flows from the Palo Verde Outfall Drain augment flows in the Colorado River where downstream beneficial reuse of that water occurs. To offset this impact, SDG&E arranged for purchase of agricultural land presently under cultivation, planned to reduce production on that land to reduce irrigation water consumption, and arranged to have "fresh" water released to the Colorado River at Parker Dam to mitigate flow reduction in the river.

Although San Joaquin Valley agricultural wastewater is often discussed as a potential cooling water source, it is not presently collected in significant quantity in any surface drainage system. Unitl firm plans for valley drainage facilities are implemented, along with a mechanism for ensuring installation of the necessary on-farm drainage systems, waste water in the San Joaquin Valley is only a hypothetical source of cooling water.

Similar to the use of municipal wastewater, the use of agricultural wastewater for power plant cooling is subject to significant locational constraints, as well as supply availability and procurement uncertainties. Public rejection in Kern County of the proposed San Joaquin Nuclear Project occurred despite plans to use agricultural wastewater for cooling, and agreement to fund a major drainage system sorely needed by the County. Siting areas considered as potentially acceptable with respect to air quality tend to be remote from sources of wastewater. The concerns with reasonable conveyance distances and pumping energy requirements are, therefore, manifest with both agricultural wastewater, and municipal wastewater.

The use of wastewaters as cooling tower make-up has raised some significant environmental concerns. The issue of cooling tower drift deposition has received considerable attention in the U.S. where brackish natural waters are used for cooling. Effects of deposition of emitted salts on natural and cultivated vegetation represent a major area of continuing environmental study for both existing and proposed applications of saline water in cooling towers. The California Air Resources Board has recently become interested in this area and is assessing possible regulatory approaches to control of particulate emissions from cooling towers.

Even less is know about the potential public health significance of cooling tower emissions. Aerosol emissions of a fraction of all impurities in cooling tower circulating water can be expected. For wastewaters of various types and sources, constituents can include micro-organisms, pesticides, and trace metals. The subsequent fate of emitted wastewater constituents and the extent of the environmental/public health hazard they might represent has received only minimal investigation to date. Promoting (or mandating) the use of wastewaters for cooling implies a determination that such concerns are of minor significance, despite the apparent lack of supportive evidence for such a conclusion.

A second environmental concern related to the use of low quality waters for cooling is the disposal of cooling system wastewater (blowdown). Concentrated impurities in the plant make-up water supply will always be present in the blowdown stream which, as supply quality decreases, will usually become greater in quantity as well as lower in quality. Disposing of blowdown in an environmentally acceptable manner (including the possibility for reuse in other plant water-using systems) is thus a much more difficult proposition when wastewater is the cooling water source.

Now that we have disucssed an overview of power plant siting relation to water requirements, let us focus in on the detail of a specific project proposal.

A CASE IN POINT

Fossil 1 and 2 is a proposed 1600 MW coal-fired power plant presently under review in the siting process of the Energy Commission. Pacific Gas and Electric Company (PG&E) has proposed to build this facility at one of four sites in Central California. The four sites are known as "Willows", "Butte", "South Yuba", and "Montezuma", which are located north to south, respectively, in the Central Valley area. Cooling water supplies for the Willows, Butte, and South Yuba facilities are proposed to be withdrawn from fresh water sources, while brackish water from the Lower Sacramento-San Joaquin Delta is proposed to be used at the Montezuma site.

Air emissions from a coal-fired power plant are no small matter of concern. Air quality restrictions in the Central Valley have resulted in only dim hopes for the possibility of locating the facility at inland valley sites, presently leaving only the Montezuma - Salano County area as a likely candidate siting location.

The Montezuma Site is located near Collinsville on the Sacramento River just upstream from the Suisun Marsh. Opposition to this site location because of potential impacts on wetlands and an endangered species, the Salt Marsh Harvest Mouste, has resulted in the investigation of an alternate location for the facility in the Montezuma area, hereafter known as the Alternative Site. At this alternate location more remote from the Delta, there are no local water sources that could be developed to provide a source of cooling water. Originally, PG&E proposed utilization of riparian water rights to supply cooling water to the power plant. Because it appears the facility can no longer be located on a riparian parcel of land, alternative water sources must now be investigated. The advantages and disadvantages of these alternatives must be identified and evaluated to provide a basis for choosing the alternative with the least potential for biological impacts.

POTENTIAL WATER SUPPLY SCENARIOS

Numerous scenarios exist to provide the water requirements of the power plant at the Alternative Site. The most reasonable appear to be as follows:

Alternative A: Removal of brackish water thorugh an intake structure from the Sacramento River at Collinsville and convey it via pipeline to the site.

Alternative B: PG&E purchase of the groundwater portion of the Sacramento Regional Wastewater Treatment Plant (SRWTP) discharge and conveying this reclaimed wastewater to the site via pipeline.

Alternative C: PG&E purchase of fresh potable water from the Department of Water Resources or Solano County and utilize the proposed North Bay Aqueduct, plus a relatively short pipeline, to convey this water to the site.

Alternative D: Reclaimed wastewater could also possibly be supplied through a planned irrigation project using wastewater effluent from the SRWTP in Solano County. As demand for water increases from this project, a reduction in water available to the Fossil 1 and 2 project will occur. The deficit could be supplied by the Fairfield Wastewater Treatment Plant. Water could be conveyed to the site via pipeline.

GENERAL DISCUSSION IN REGARD TO ALTERNATIVES

The Sacramento-San Joaquin Delta and Suisun Marsh comprise the most important estuary for fish and waterfowl production on the Pacific Coast of the United States (CWRCB 1978). While the Delta and Suisun Marsh provide habitat for vital fish and wildlife resources, water from the Delta also supports California's important agricultural economy, provides municipal supplies for over 14 million people, and serves a major water-related industrial corridor in the vicinity of Antioch and Pittsburg. Competition for Delta water supplies is already intense, and is expected to substantially increase in the future (CWRCB 1978).

The California State Water Resources Control Board has been given the responsibility to regulate both water quality and quantity relationships in the Delta to best serve and provide for the beneficial uses of Delta waters. The beneficial uses identified and fish and wildlife, agriculture, and municipal and industrial.

PG&E has proposed an industrial use to withdraw water from the Lower Delta to supply the Fossil 1 and 2 power plant. The State Water Resources Control Board (SWRCB) and the Central Valley Regional Water Quality Control Board (CVRWQCB) have not opposed the proposed water withdrawal, but have strongly recommended that reclaimed wastewater be considered for use, rather than the surface waters of the Delta. Major concerns of the SWRCB in regard to water withdrawal for power plant cooling are related to water quality and quantity, and the technology utilized to divert water to minimize entrainment and impingement of organisms. The concern for the diversion of water from the Lower Delta has come to the forefront in comments submitted by the agencies responsible for fish and wildlife protection.

The SWRCB has actual statutory authority to enforce Federal Clean Water Act Section 316(b), which was enacted to protect the aquatic life in a waterway adjacent to a power plant from unnecessary entrainment mortality and impingement losses. This is to be accomplished by permit conditions to regulate the location, design, construction, and capacity of a cooling water intake structure.

PG&E has submitted a 316(b) Study Plan for withdrawal of water at the Montezuma site and this plan is presently being reviewed and commented upon by concerned agencies. The objective of PG&E is to provide information sufficient for regulatory agencies to determine the best technology available to minimize adverse environmental impact on the aquatic community. However, positions of the fish and wildlife agencies generally indicate the following:

1) The incremental effect of the withdrawal of cooling water on the aquatic life of the Lower Delta is unacceptable unless it is demonstrated that no alternative sources of cooling water are available.

2) That cumulative impacts of water withdrawal by power plants in the Lower Delta must be offset before additional impacts can be permitted.

3) The use of Delta water for cooling would have adverse impacts on anadromous fish which migrate past the site and on small organisms that are essential elements in the diets of fish, and therefore, it has been recommended that the facility be constructed at an alternative site, such as Willows, where impacts on fisheries resources would be negligible.

ANALYSIS OF ALTERNATIVES

A. Alternative A: This alternative involves the withdrawal of water from the Sacramento River near Collinsville. Previous discussion has identified various concerns with this alternative, including those voiced by agencies responsible for the protection of fish and wildlife resources.

The advantages of this alternative are as follows:

1) Use of this brackish water reduces the potential of this project to affect the supply of fresh inland waters available to the State. This benefit is somewhat offset by the need for increased releases of fresh water to the Delta to offset any increase in salinity not in conformance with Delta Water Quality Standards.

2) It is possible to decrease the cost of supplying the power plant with this brackish water source if blowdown can be discharged to Suisun Marsh. This would reduce the cost of pipelines for this alternative approximately $20,000,000 ($67,000,000 to $47,000,000). Information in the Suisun Marsh Protection Plan provides data which indicate that discharge of blowdown to the Marsh may prove to be beneficial.

Removal of the potentially toxic blowdown discharge from the Lower Delta would be an additional benefit of this option.

Reasons why the use of this water source may not be an advantage are as follows:

1) Opposition to this proposal by the fish and wildlife agencies because of potential entrainment and impingement impacts on aquatic organisms.

2) The cost (potentially about $67,000,000) for the pipelines to supply water to the plant and the return of blowdown to the Sacramento River is significantly greater than alternatives C and D.

B. <u>Alternative B</u>: This alternative involves the use of a pipeline to convey reclaimed wastewater from the SRWTP to the power plant. Major benefits of this alternative are as follows:

1) Withdrawal of cooling water from the Lower Delta would not be necessary, thereby eliminating concerns associated with impingement and entrainment.

2) Because the salt content of the wastewater is normally less than brackish water in the Lower Delta, the discharge of blowdown may not be necessary.

Reasons why the use of this wastewater may not be an advantage are as follows:

1) The SRWTP effluent will be an inland wastewater of relatively low total dissolved solids (TDS) content. The presence of this wastewater in the Sacramento River does not significantly degrade water quality, and, in fact, the presence of its quantity in the river to augment Delta outflow is beneficial. Benefits accrue by both repelling salinity intrusion and by enhancing fishery resources. More discussion on flow versus fishery benefits is included under the discussion on Alternative D.

2) The expense of transporting this wastewater to the power plant through a pipeline is significant. Less expensive and acceptable water supply alternatives may exist. ERCDC staff engineers have estimated the cost for the pipeline to be $67,700,000.

3) Construction of the approximate 28.7 mile pipeline will cause disruption of the environment along its course. However, it is expected that such impacts can be adequately mitigated.

4) Use of the wastewater could affect power plant reliability if a break in the pipeline should occur, or if the SRWTP treatment process is disrupted for some reason.

C. <u>Alternative C</u>: Alternative C suggests utilization of fresh potable water from the proposed North Bay Aqueduct to supply the power plant. Advantages of this alternative are similar to Alternative B, and can be characterized as follows:

1) Withdrawal of cooling water from the Lower Delta would not be necessary. However, this benefit would be partially offset by the withdrawal of water from Linsey Slough.

The DFG has done some preliminary sampling of Lindsey Slough to determine fish species present and their density. Data available to date indicate that an intake at this location would have significantly fewer numbers of striped bass.

2) Because of the low salt content of the fresh water, the discharge of blowdown will not be necessary.

3) This appears to be the overall least expensive alternative if the power plant is constructed at the Alternative Site. ERCDC staff engineers have estimated the cost for the pipeline to be $14,700,000.

4) Because of better water quality, the volume of water necessary to operate the power plant will be reduced from an estimated 50,000 acre-feet per year (brackish supply) to about 20,000 acre-feet per year. Reduced water requirements will also decrease the potential for entrainment and impingement of organisms. However, water withdrawn from Lindsey Slough is fresh, potable water whereas water in the Lower Delta is brackish most of the year.

Disadvantages of this alternative are as follows:

1) The withdrawal of water by the North Bay Aqueduct at Lindsey Slough will increase 20,000 acre-feet per year in order to supply the power plant. This would result in an estimated increase of one-third in withdrawal from 42,000 acre-feet per year to about 62,000 acre-feet per year. Entrainment and impingement impacts caused by the intake structure can be expected to increase proportionately. Data available indicate that these potential biological impacts at Lindsey Slough would be less than those which could occur in the Lower Delta, making this a more favorable location for withdrawal.

2) The Delta Master Recreation Plan designates the Upper Lindsey Slough/Calhoun Cut area as a natural area of significant wildlife value and is designated for preservation under the Plan. The proposal of the North Bay Aqueduct has led to DFG investigation into measures to mitigate potential impacts of the aqueduct. Increase in the capacity of the aqueduct could possibly increase the magnitude of impacts necessary to be mitigated, but may not significantly change the nature of mitigation measures already under consideration by the DFG and the Department of Water Resources (DWR).

D. Alternative D: Generally, this alternative involves the use of reclaimed wastewater supplied through an irrigation project pipeline constructed by the Solano Irrigation District. As the yearly demand for irrigation water increases, additional wastewater necessary to supply the power plant could be supplied by the Fairfield Wastewater Treatment Plant. Advantages of this alternative are as follows:

1) Withdrawal of water from the Delta would not be necessary, thereby eliminating impacts of entrainment and impingement at an intake structure.

2) Because of low salt content of the wastewater in comparison to the Lower Delta, no discharge of blowdown would be necessary.

3) Cost of the pipeline would probably be significantly less than in other alternatives because the power plant would be located close in proximity to the reclammation project.

The disadvantage of this alternative is as follows:

1) The SRWTP effluent will be an inland wastewater of relatively low TDS. The presence of its quantity in the Sacramento River to augment its flow is beneficial. In a report by the Solano Irrigation District, the percentage of flows which the SRWTP will contribute to the Sacramento River based on flow data at Sacramento ranges between .4% and 5%, dependent upon the month and water year. Information submitted to date indicates that

agencies, including DWR and the U.S. Bureau of Reclamation oppose the use of SRWTP wastewater for purposes other than augmentation of flow in the Sacramento River because of the benefits of in-stream uses, including repelling salinity in the Lower Delta.

In-stream benefits of the SRWTP effluent also can be expected to benefit fishery resources. In a paper by Chadwick et al. (1977) it is explained that "The measurements of young, striped bass abundance and of adult recruitment indicate that the principal variations in survival occur within about the first two months of life. These variations are correlated with, and apparently largely controlled by, the magnitude of water diversions from the estuary and magnitude of delta outflow." Fish and wildlife agencies have indicated that in comparing a water diversion at Collinsville versus a reduction in Delta outflow caused by diversion of the SRWTP effluent to Solano County, they would definitely favor use of the SRWTP effluent for cooling of the facility.

DISCUSSION

From the standpoint of protection of aquatic resources, it appears that use of wastewater for cooling Fossil 1 and 2 will be the favored choice. The final decision, of course, will be based upon weight given to the various opposing forces (i.e., biology, public health, agriculture, water quality). Benefits and impacts of a decision must, and will be, evaluated, but the end result inevitably cannot totally satisfy each special interest. The objective is to identify the alternative that presents the greatest number of benefits and at the same time provides adequate mitigation for impacts. Hopefully, this approach will ensure that power plant siting does not become an extinct art.

CONCLUSION

Investigation into available water supplies is an important piece of the power plant siting picture. Unfortunately, each water supply choice seems to be wrought with potential impacts. The result is that regardless of the choice, the concerns of some specific interest groups and/or agencies are inevitably set aside. Those that have their interests set aside must the settle for mitigation. It encourages me to see the various fish and agencies taking a strong posture on the nature and adequacy of mitigation. To date, in the case of Fossil 1 and 2, it appears that fish and wildlife protection has taken the offensive. Although there is no doubt that results of power plant construction and operation will create impacts on biological resources, these impacts can be significantly reduced if power plants are sited away from wetlands and utilize wastewater for cooling. Siting of facilities must be done on a case by case basis, whereby the merits of each case can influence decisions reached on that case. But what of public health, or economics, or agriculture, etc.? The objective must be to reach a decision which will protect the welfare of the public. The public uses electricity and pays utility bills, expects a healthy environment in which to live, fishes and hunts, and benefits from agriculture. As you can see, power plant siting is not an easy task.

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