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EDISON'S GEOTHERMAL PROGRAM – 1980 UPDATE

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Introduction In 1975, negotiations were initiated with two major resource developers toward initiating power plant projects at three of the Imperial Valley resource areas, Brawley, Salton Sea and Heber.

The projects at Brawley and Salton Sea are substantially different from that at Heber in objective, size and design. The reasons for these differences are related to the different nature of the geothermal brines and to different operating philosophies of the resource developers involved.

The projects at Brawley and Salton Sea include the construction and operation by Edison of 10 MW (gross) units. The contracts with the field developer for these resources are such that Edison will purchase steam. It is, therefore, the developer's responsibility to drill and complete the geothermal production and injection wells, and to construct and operate the steam separators and flash vessels, brine processing equipment, injection pumps, and steam scrubbing equipment. These units are 10 MW rather than 50 to 100 MW due to the technical risks associated with producing, handling and injecting the very high salinity brines at these locations. In addition, the reliability of turbine operation with relatively impure steam is a major concern.

The Heber plant, on the other hand, will utilize a much cleaner resource. The technical risk is, therefore, judged to be substantially lower. The plant at Heber will be a commercial 45 MW unit. Edison will buy brine, and will own and operate all of the brine handling equipment except for the wells and collection manifolds.

A description of these power plant programs follows.

Based on IEEE Geothermal Power Generation – An Aggressive Utility Program, George K. Crane prepared for presentation at IEEE 1980 Joint Power Generation Conference, Pheonix, Arizona. 9/29/80

Brawley 10 MW Power Plant Project As of this writing, construction of the Brawley plant is scheduled for completion in May 1980. It is scheduled for firm operation during the second quarter of 1980.

It is the objective of the Brawley power plant program to assess the technical feasibility of generating electricity utilizing the high salinity Brawley geothermal resource. The plant design is similar to the proven Geysers units, simple, reliable, and where possible, designed for low capital cost. It is designed to be a model of a full scale commercial plant, using systems and components which likely will be utilized in large scale follow-on units.

The power plant and steam production facilities are located on a 4 hectare, (10 acre) site about 3 km (2 miles) north of the town of Brawley.

The turbine has an output of 10 MW; the plant auxiliary loads total about 1 MW. The net plant heat rate is approximately 28,000 Btu/kWhr. The capital cost of the plant is approximately $11 million. The total project cost including some costs for prior research work is approximately $16.3 million. The cost of power generated by the plant is forecast to be about 17¢/kWhr (30 year levelized.)

A few of the notable design features of the project follow:

Steam Condition and Turbine The steam from the supplier is expected be delivered at a rate of 87,000 kg/hr (209,000 lb/hr.) at a single pressure, 800 kPa (115 psia) at approximately saturation temperature of 170 °C (340 °F) with a maximum average .25% moisture, a maximum noncondensable gas level of 2% by weight of steam, and a maximum of 50 ppm TDS including mostly chlorides with some silica. These are obviously very different steam conditions than those associated with high pressure fossil units.

The turbine is a 10,000 kw, 3600 rpm,

single flow, single cylinder unit with five impulse stages, and a design back pressure of 13.5 kpa (4in Hg.) The last stage blade length is 280 mm (11.2 in.) The unit was first conceived as portable; the turbine generator was, therefore, built as a single skid mounted unit installed at grade with a top exhaust and overhead cross-over exhaust duct to a side located condenser.

Condenser & NC Gas Removal As it is desired to retain the steam condensate for process use, a shell and tube condenser is provided. It is a cylindrical vessel with three passes on the water side and a single pass on the steam side. Corrosion resistant stainless steel materials are used because of the oxidation potential of the oxygen and H_2S present in the system.

Approximately 1800 kg/hr (4000 lbs/hr) of NC gasses are drawn from the condenser with a steam jet air ejector requiring 7200 kg/hr (16,000 lbs/hr) or about 8% of the motive steam. Two 200 BHP Nash vacuum compressors with ceramic coated impellors are provided to remove the noncondensables from the first stage ejector intercondenser. A second stage ejector is provided as a backup to the vacuum pumps.

Cooling Water System A conventional two cell, induced draft, counterflow wet cooling tower with a rated heat load of 200 MM Btu/hr provides 870 l/sec (14,400 gpm) cooling water with a 5.5 °C (10 °F) approach to wet bulb temperature.

The tower basin was epoxy coated for protection in the event that the acidic condensate is used for makeup at a later date. Initially makeup at a rate of about 740,000 m^3/y (600 acre ft/year) will be Colorado River water provided to the plant via two alternate irrigation canals operated by the local water district. As the Imperial Valley is a rich agricultural area with a limited water supply, alternative makeup water supplies and cooling systems are being investigated toward minimizing the use of agricultural irrigation water. A candidate approach will be to retrofit the plant with a dry tower to be operated with the wet tower.

Depending on the steam suppliers ultimate need for steam condensate for process use and injection, condensate may become an alternative cooling water makeup source. Another potential source is the high TDS agricultural drain water which will require substantial treatment prior to use as makeup and may also necessitate the use of large evaporation ponds.

The net plant output will be connected to and sold to the local electric utility. Ultimately if the technology proves out, the output of this and follow-on commercial plants will be exported to the Edison system.

Following establishment of firm operation, a one year testing and evaluation program will be performed, leading to a recommendation whether to proceed with a 50 MW or 100 MW commercial power plant at Brawley.

Heber 45 MW Power Plant Project The Heber plant is in the early design phase. The forecast operating date is late 1982. The 11 hectare (28 acre) site is located approximately 8 km (5 miles) south of the city of El Centro. It is the objective of the Heber program to establish a commercial geothermal power plant utilizing the low salinity brines from the Heber KGRA.

The cycle selected is a double flash arrangement. Geothermal brine as a two phase mixture is delivered to the Edison plant at a temperature of 140 °C (290 °F) and a maximum pressure of 410 kPa (60 psia) at a rate of approximately 3,600,000 kg/hr (8,000,000 lbs/hr). The brine is piped to a first stage brine/steam separator operating at 380 kPa (57 psia). The steam is piped to the front end of the turbine. The unseparated brine from the first stage separator is then flashed in a second stage vessel producing steam at 110 kPa (16 psia) which is directed to the low pressure turbine stages. Two parallel strings of 50% capacity separator/flash vessels are planned.

The steam separators and turbine generator were purchased under a single order.

The turbine has a rating of 52 MW (gross) at a 12 kPa (3.5 in. Hg) back pressure and is being designed as a single cylinder, double flow bottom exhaust unit operating at 1800 rpm.

Condenser/NC Gas Rmeoval A shell and tube condenser will be provided. First stage NC gas removal will be accomplished with a steam ejector with a vacuum pump provided for second stage removal. Because the H_2S and other noncondensables are at such a low level at the Heber reservoir, no special treatment will be required.

Cooling Water System The steam condensate at the Heber plant is retained by Edison and is used for cooling tower makeup. Since 100% injection is required at Heber, approximately 3.7 million m^3/year (3000 acre - ft/year) of nearby river water will be injected into the reservoir. To avoid plugging of the injection wells, this makeup injection water will undergo treatment prior to injection. A conventional 10 cell induced draft wet tower will be used for heat rejection.

It is planned that the output from the Heber plant will be exported to the Edison system through a soon-to-be-closed intertie with the Imperial Valley utility. Electrical power will be generated at 13.8 kv and then stepped up to 34.8 kv to tie into the utility grid.

The anticipated heat rate of this unit is 30,000 Btu/kWh based on preliminary heat balances. The plant capital cost is estimated at $69 million. The levelized power cost, (1982 basis) is projected to be approximately 18¢/kWh based on a 75% capacity factor. For comparison this figure is close to the cost of oil generation but is substantially higher than an equivalent figure for new coal generation.

Salton Sea 9 MW Power Plant Project Since this project is similar to that at Brawley and is now only in the early design phase, its design will not be discussed in detail. There are, however, several noteworthy differences between this and the Brawley programs.

The Salton Sea KGRA is believed to be the largest and hottest of the Imperial Valley resources; it would appear therefore to have the highest commercial value. Unfortunately, however, numerous well tests have shown it to have the highest TDS level brines, some up to 300,000 ppm.

As mentioned, this area was the first Imperial Valley resource which Edison attempted to develop. During this early development effort, Edison's wholly-owned fuel resource development subsidiary, Mono Power Co., became an undivided 25% owner of about 10,000 hectares (25,000 acres) of geothermal leases. As such, they are participating with two other lease owners in a field development research program to determine the best method to handle the brine and produce steam. To date, four wells have been drilled, and a system including flash tanks, steam condensers and an injection system has been constructed and operated. This program will lead to the design and construction of facilities which will provide steam to the Edison plant.

Some unique structural design considerations may be required as the plant site is surrounded on two sides by, and is immediately adjacent to, the Salton Sea. The sea is rising at a rate of several inches per year; the plant site is now several feet below sea level and is protected only by earthen dikes. The water table is kept below grade by an agricultural tile drain system. The suitability and reliability of these dike and drain systems will have to be assessed in light of the substantial plant investment they may be called upon to protect.

The economics of the Salton Sea plant are forecast to be similar to those of the Brawley Project; the scheduled operation date is July, 1982.

Related Geothermal Activities In addition to these three power plant projects, Edison is pursuing a number of corollary activities including resource exploration and assessment and new technology assessment.

Resource Exploration Edison's subsidiary, Mono Power Co., is involved in a continuing program of resource exploration and assessment. In addition to participation in developing the Salton Sea resource, Mono is working with another resource development company in exploration and leasing of geothermal prospects in areas of California outside the Imperial Valley. Together they own several thousand acres of leases at various sites in the Mono/ Long Valley area.

When Edison is approached by "third party" resource developers with offers to sell Edison geothermal steam or hot brine, Mono's staff geologists perform analyses of the resource in terms of its potential size and quality, and prepare recommendations as to whether Edison should pursue the prospect. This "in-house" "below ground" expertise is an invaluable complement to Edison's geothermal utilization activities.

Technology Assessment Through participation with the Electric Power Research

Institute monitoring of the U.S. Department of Energy's geothermal program, and contact with numerous individuals and companies, Edison maintains awareness of, and in some cases participates in the development of new technologies or new applications of existing technologies for geothermal utilization. For example, Edison intends to participate in the construction and testing of the 50 MW binary cycle demonstration power plant to be constructed near Edison's flashed steam plant at Heber.

Other new technologies for geothermal include improved and advanced steam separators, mixed phase expanders as prime movers, direct contact heat exchangers, down hole heat exchangers, upstream (of the turbine) and downstream H_2S removal systems, as well as systems to utilize hot rock and magma where water is not present for heat transport.

EXPECTED RESULTS

As the three Edison plants and those developed by others come on line and are operated for several years, critical issues will be monitored and assessed including:

- Turbine reliability as a function of steam purity
- Power plant O&M costs
- Steam supply system equipment reliability
- Reservoir temperature/pressure degredation
- Overall plant efficiency
- Subsidence
- Air quality
- Water consumption
- Noise
- Busbar energy cost

With positive results from these programs, water dominated geothermal systems can provide hundreds and perhaps several thousand megawatts of baseload generation in Southern California in the next two decades.

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