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THE ORMESA POWER PLANTS AT THE EAST MESA CALIFORNIA RESOURCE AFTER 12 YEARS OF OPERATION

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1. ABSTRACT

The United States Department of Energy (DOE) Loan Guaranty Program was created in 1974 with the objective of overcoming the financing risk barriers to the development and operation of projects utilizing the then newly emerging geothermal technologies. The program was to accomplish its objectives by providing for the US government to guaranty the repayment of loans for project costs of up to $100 million per project, for qualified projects and sponsors. One of the most notable successes of this visionary program was the ORMAT East Mesa Project, where a $50 million guaranteed loan for the 24 MW net Ormesa I project, was prepaid in full approximately 1 year after this loan was funded. This project was subsequently expanded, from its initial 30 MW nameplate capacity in 1986 to 72 MW nameplate capacity by 1989, with three additional incremental expansions.

The successful execution of the East Mesa project established the technical and economic feasibility of large scale commercial modular binary geothermal power plants, as well as the benefits of a single integrated plant and field operations and management team. After twelve years, currently under the capable operation of FPL Energy, Inc., the four Ormesa power plants are operating at their original contractual capacity levels, demonstrating the reliability and sustainability of geothermal power generation.

2. BACKGROUND

2.1 Introduction

In 1977, Republic Geothermal Inc., an industry pioneer successfully explored and defined the East Mesa Geothermal Field. After acquiring the development rights from Republic in 1984, ORMAT, utilizing a $50 million US DOE loan guaranty as the cornerstone of the project's financing, went on to successfully complete the development of the 30 MW nameplate Ormesa I Project. With its December 1986 grid synchronization and subsequent continued successful operation, the Ormesa I project established the technical feasibility of larger scale commercial modular binary power plants and liquid dominated geothermal resources.In the period from 1986 on, the East Mesa projects were expanded by: (a) the 20 MW Ormesa II project in 1998; (b) the 10 MW Ormesa IE project in 1988 and (c) the 12 MW Ormesa IH project in 1989. (Schochet and Mock, 1994)

2.2 ORMAT Binary Geothermal Power Plant Technology

In 1984, there were a number of non-Geysers geothermal projects under development, however except for the 600 kW modular binary power plant at TAD's Enterprises in Wabuska, Nevada, none were operating commercially. At the time ORMAT had been involved for 20 years in research and development, as well as manufacturing, of organic rankine cycle modular power plants. These plants, known as ORMAT® Energy Converters (OECs), were used to generating electricity from: (a) solar energy from flat plate collectors; (b) locally available fuel sources for remote power applications; (c) industrial unused process heat; (d) low temperature brine from solar ponds, and (e) geothermal brine.

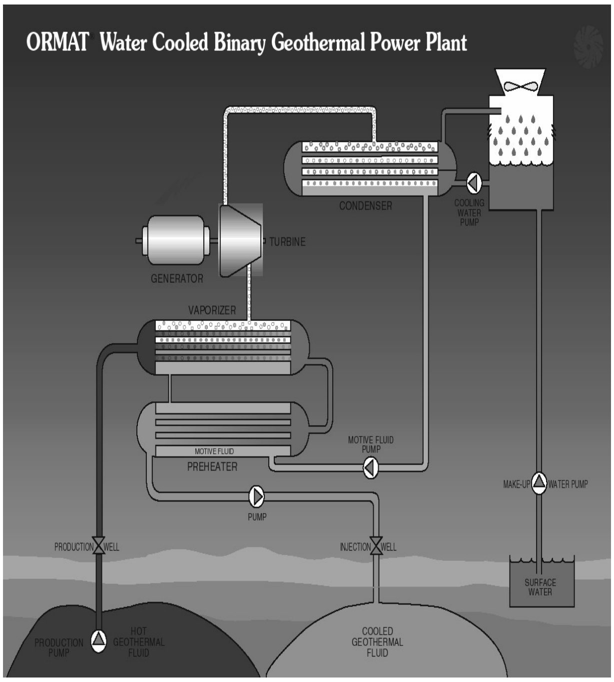


Figure 1. Process Schematic, Water Cooled Binary Geothermal Power Plant

The basic organic Rankine cycle is shown in the process schematic of Figure 1. Utilizing a sub-critical cycle the geothermal energy increases the organic motive fluid temperature to its boiling point without superheating, as shown in the TS diagram of Figure 2. The motive fluid is then vaporized at constant temperature and pressure. The organic vapors drive the turbine, which is coupled to the shaft of the generator. The spent vapors are condensed in either a water or air cooled condenser, and pumped back into the vaporizer (a tube and shell heat exchanger) to continue the Rankine cycle. The geothermal fluid is maintained under pressure and 100% of all produced fluids and gases are injected. The use of the sub-critical cycle results in lower internal power consumption and lower internal pressures than encountered in the super critical cycle. As a result the power plant design, is simpler and the operation is more reliable.

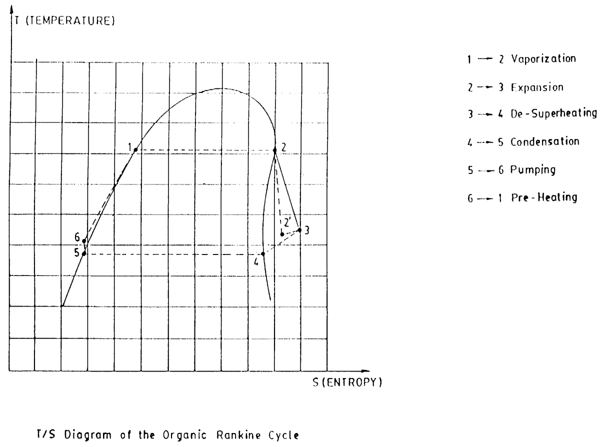
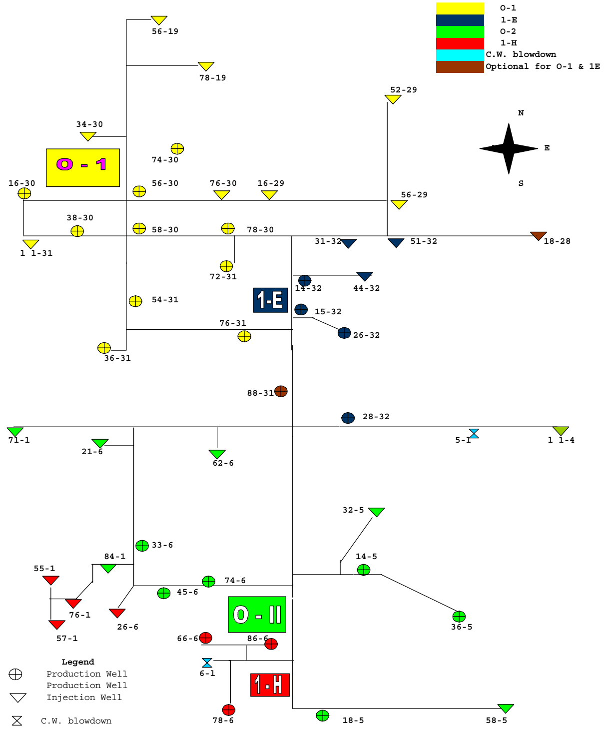


Figure 2. T-S Diagram of The Organic Rankine Cycle



2.3 Cascade Design Principle

To maximize conversion efficiency of the binary power plants a proprietary Cascade design principle was employed. For example, the Ormesa I power plant employs 26 OEC units consisting of, 16 Level I units, 8 Level II units and 2 Level II units. The brine pumped from all 12 wells enters all 16 Level I vaporizers at 306°F (152°C), exits at 240°F (116°C). The brine then flows directly into all 8 Level II vaporizers. Exiting at 190°F (88°C) the brine flow enters the 2 Level III vaporizers, where the fluid temperature is further reduced to 165° (74°C). Before being injected back into the geothermal field the brine enters all 26 pre-heaters in parallel to preheat the organic motive fluid.

The Cascade Principle is employed in current ORMAT binary power plant design by means of an Integrated Two Level Unit (ITLU) which incorporates two geothermal energy conversion levels into a single module to reduce piping and installation complexity. (Elovic, 1994).

These modular geothermal binary power plants are computer controlled, with each module capable of operating independently. The overall plant central control is an automatic computerized system which allows for unattended operation with fail safe controls and annunciator alarms.

The modular design of these power plants allows single modules to be shut down for maintenance with the entire geothermal fluid flow passing through the remaining modules. As a result very high plant availability factors are achieved, as shown in Table 1, with high operational capacity factors.

3. THE ORMESA PROJECT

By late 1984, Republic had proven the existence of a major resource in the East Mesa area, and had executed two SO4 power sales agreements with Southern California Edison. Ormat, purchased these development rights along with the assignment of the power sales agreements.

The East Mesa Geothermal Resource is contained in a porous sedimentary formation, with highly productive zones at depths of 5,000 to 8,000 feet (1,500 to 2,400 meters). Well spacing to minimize interference is a key issue, and well maintenance on a regular basis is required. (See Figure 3)

3.1 Ormesa I

The Ormesa I project utilizes 26 modular OECs, in three cascading levels, with a total nameplate capacity of 30 MW. The projected resource temperature of 306ºF (152^{o}C) was well suited for the OEC binary technology. A total of 9 production wells and 9 injection wells are used, with the production pumps set at depths of 1,200 to 1,400 feet. Figure 4 is a photograph of the Ormesa I power plant. Actual produced fluid temperatures were different than predicted but were accommodated by the power plant design. (Ram and Krieger, 1989)

In December 1986, the 24 MW net Ormesa I Project, was completed and synchronized to the Imperial Irrigation District Grid for transmission of power to Southern California Edison. The project has been in continuous operation at its temperature adjusted contractual capacity since it was commissioned, with its current performance is summarized in Table 1.

Figure 4. Ormesa I Binary Geothermal Power Plant

3.2 Ormesa II

Based on the successful development of the Ormesa I well field it was determined that an expansion of the project was feasible. The Ormesa II project was planned as a build out of the first plant, utilizing an unesed portion of the East Mesa resource. Because of financing considerations at that time, the Ormesa II project was owned and operated by a different operating team, with a coordinating committee to oversee common areas of interest.

The Ormesa II power plant was developed in 1987, and synchronized to the IID grid in December of that year. The power plant utilizes 20 modular OECs, in two cascading levels, with a total nameplate capacity of 20 MW. (See Figure 5). The well field delivers geothermal fluid at a temperature of 315^{o}F (157^{o}C) from 6 production wells, with 6 injection wells, as shown in Figure 3.

Ormesa II has been in continuous operation since it was commissioned, producing at its temperature adjusted contractual level and with a high availability factor as shown in Table 1.

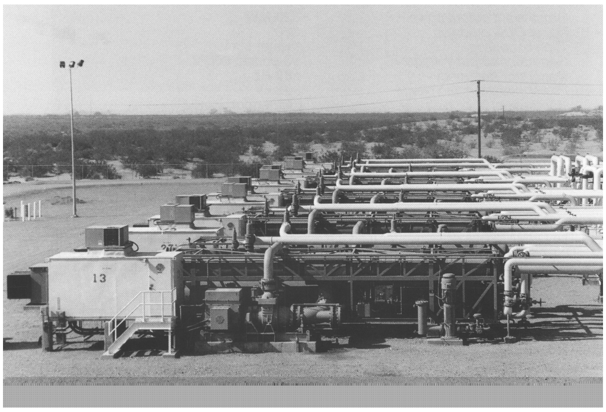


Figure 5. Ormesa II Binary Geothermal Power Plant

3.3 Ormesa IE

Following the successful development of Ormesa II, the 10 MW total nameplate capacity Ormesa IE expansion plant was developed. This power plant utilizes 12 OEC modules in two cascading levels, producing 8 MW net power with 279^{o}F (137^{o}C) geothermal fluid from 4 production wells. Spent fluid is injected into 5 wells. (See Figure 6.)

As the utilization of the East Mesa geothermal resource became more complex, the location of the injection wells was carefully managed by the coordinated field management team.

The power plant was placed in service in late 1988, and has been in continuous operation since it was commissioned. This plant, which was remotely operated in an unattended mode from the Ormesa I plant, has been producing at or near its contractual levels with a high availability factor, as shown in table 1.

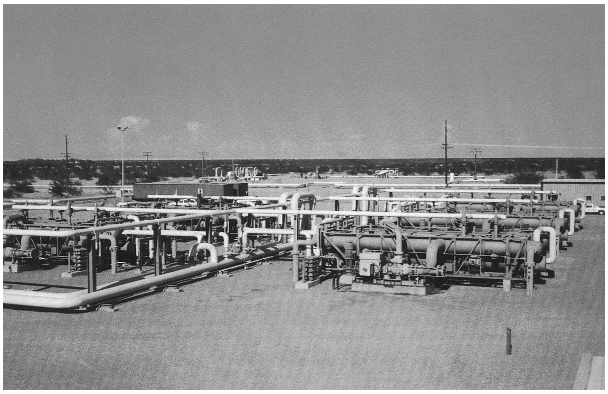


Figure 6. Ormesa IE Binary Geothermal Power Plant

3.4 Ormesa IH

The last of the three East Mesa expansions, designated as Ormesa IH was developed in 1989, with the 13.2 MW total nameplate capacity plant placed in service in the last part of that year. The Ormesa IH plant utilizes 12 OEC modular units in two level cascading configuration, with two active production wells supplying 286^{o}F (141^{o}C) geothermal fluid. In this case the spent fluid is returned to the geothermal reservoir by means of 4 injection wells. (See Figure 7.)

The power plant has been in continuous operation since it was commissioned. This plant has also been remotely operated and has been producing at or near its contractual level with a high availability factor.

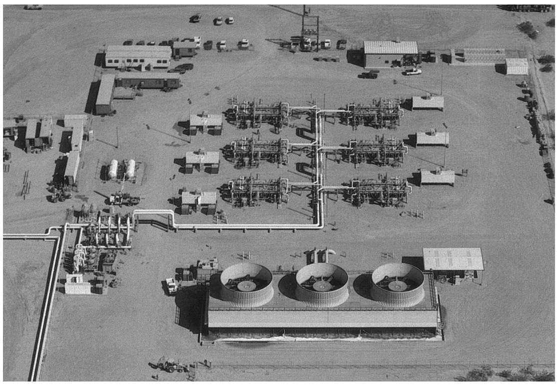


Figure 7. Ormesa IH Binary Geothermal Power Plant

4. CURRENT STATUS

In 1992 FPL Energy Inc., a member of the FPL Group, acquired an ownership interest and became the operator of the Ormesa II power plant and well-field. Subsequently in 1998 FPL and Caithness Energy LLC acquired the ownership and FPL became the operator of the Ormesa II, IE and IH power plants and well-fields, as well as other geothermal properties in the East Mesa Resource area. With all East Mesa operations integrated under a single management team the projects are performing at optimized levels, as shown in Table 1. The integrated resource management has allowed FPL to accommodate the changes in geothermal fluid temperatures to the individual plants by control of wellfield utilization.

FPL has further automated the operation and remote monitoring of the individual Ormesa power plants so that all four plants in the 73 MW complex may now be operated unattended with the operations monitored and controlled from the FPL East Mesa control center. In addition FPL has instituted a comprehensive condition maintenance policy, including in depth analysis of failed components and use of upgraded equipment and components where appropriate. These programs have been instrumental in the continued operational reliability and profitability of the 12 year old Ormesa geothermal complex.

(The Ormesa Projects paved the way for the successful binary development of the Heber geothermal resource. In 1993 the resource area, (originally dedicated to the decommissioned Heber Binary Project), was utilized to support the 48 MW nameplate SIGC binary project, operated by Ogden Geothermal. Utilizing six modular binary ITLUs, this plant was commissioned in July 1993, 6 months from ground breaking. The SIGC plant is currently producing power at or above its contractual design level.)

5. SUMMARY

The Ormesa Geothermal power plants have demonstrated that field proven ORMAT geothermal power plant technology, coupled with careful engineering, high quality operations and maintenance and qualified well field and reservoir management, the following may be successfully achieved:

- Geothermal power generation can be sustainable, reliable and cost effective;
- Modular power plant design permit effective and timely incremental expansions;
- Modular binary power plants can operate with availability factors approaching 100%;
- Automatic unattended operation of binary power plants is a viable option;
- Geothermal project operation is optimal with a single integrated plant and field operator;
- Prudent geothermal resource management, with power plants matched to the resource, is key to the economic and technical success of geothermal power projects.

6. REFERENCES

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Table 1. Current Performance of Ormesa Power Plants

Plant Name	Geo.-Fluid Temprature (Deg.F/C)	Geo-Fluid Flow Rate (GPM)	Average Energy Production (MWhr/Mo)	Plant Availability Factor
Ormesa I	294°F/146°C	11,428	13,398	99.50%
Ormesa II	315°F/157°C	8,818	12,109	98.05%
Ormesa IH	286°F/141°C	6,066	4,576	99.73%
Ormesa IE	279°F/137°C	5,969	6,116	97.62% ed