



The Bad-Blumau Geothermal Project

A LOW TEMPERATURE, SUSTAINABLE AND ENVIRONMENTALLY BENIGN POWER PLANT

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Summary

The 250 kW geothermal project at Bad Blumau is the first geothermal project developed in Austria by the private sector following the deregulation of the electricity industry in this country. What makes the project unique besides it's private ownership structure is it's ability to generate electrical power and district heating for the RognerBad-Blumau Hotel & Spa by using a low temperature geothermal resource.

Installed in the record time of less than a week, the air-cooled ORMAT® Energy Converter (OEC) CHP module has been in commercial operation since July 2001. With an annual availability exceeding 99%, between October 2001 and December 2002 the plant delivered 1,560,000 kWh to the local grid. The geothermal CHP module utilizes brine at ~110°C available from a 3,000 m deep production well. Exiting the OEC unit at a temperature of ~85°C, the brine is then fed into the district heating system providing heat for the RognerBad-Blumau Hotel & Spa. The geothermal brine is returned from the district heating system and injected into a 3,000 m depth reinjection well.

The system is a pollution-free, unattended operating power generation module, which has avoided more than 1,100 kg of CO₂ emissions over it's first operating year.

BACKGROUND

It is estimated that there are a large number of rural and remote areas where moderate temperature geothermal resources are capable of supporting local electrical power generation. In some countries, including the USA, these geothermal areas are connected to the national power grids, with local small-scale generators providing the additional benefits of clean, cost effective and sustainable electricity supply.

ORMAT® has developed and supplied small scale modular power units for biomass, waste heat recovery and geothermal power in the range of 1.5 MW or less, for over 20 years. These have included modular organic Rankine cycle binary power plants in sizes from 50 kW for biomass power in the Philippines (see Figure 1), to arrays of 1 and 1.5 MW modular power units comprising the 73 MW Ormesa Geothermal complex in Imperial County, California. In all over 200 such ORMAT® Energy Converter power modules have been deployed worldwide.

Recognizing the need for a standard small-scale modular geothermal power plant, ORMAT designed its Series 250 (250 kW nominal rating) to fill this niche. The Series 250 power units are specifically designed for distributed energy applications using locally available heat sources such as geothermal hot water or steam, incineration of agricultural and municipal waste, unused process heat, etc.

The RognerBad-Blumau Hotel & Spa application draws on ORMAT's experience with small-scale geothermal power plants including: (a) Tad's Enterprises, Nevada USA, with 2 modules rated at 1,750 kW total since 1986; (b) Empire Geothermal, Nevada USA, with 4 modules rated at 4,800 kW total since 1987; (c) EGAT Fang Geothermal, Thailand, with one module rated at 300 kW since 1989 (Figure 2) (d) NAGQU geothermal, Tibet PRC, with one module rated at 1,000 kW since 1993 and (e) Svartsengi, Iceland with 3 modules rated at 3,900 kW since 1989 and 4 modules rated at 4.2 MW since 1992.

The ORMAT Series 250 and the RognerBad-Blumau Hotel & Spa application confirm that with small scale geothermal power plants and well utilization technologies that are proven, automatic, unattended operation is feasible, power costs are acceptable, and such installations are compatible with the most demanding environmental conditions.

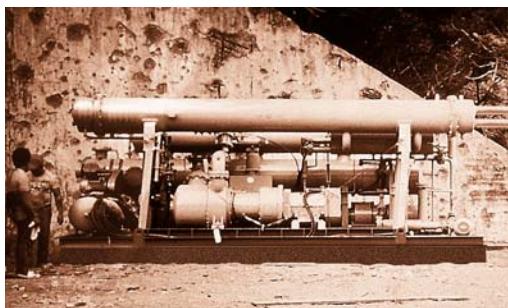


Figure 1 – 50 kW Forest Fuel Biomass



Figure 2 – 300 kW Geothermal Unit at Fang in Thailand

Over 300 ORMAT[®] Energy Converter (OEC) power modules have been installed, ranging in size from 0.3 MW to 6.5 MW, either singly as small power plants or in combination as larger power plants, with an aggregate total of some 700 MW. These binary-based power plant modules operate with geothermal fluids at temperatures from 95°C to 315°C. Small-scale geothermal plants will operate from low-temperature fluids from 95°C to 180°C, where modular Organic Rankine Cycle (ORC) binary technology is the most appropriate. In this technology the heat from the flow of the geothermal fluid is transferred to the organic working fluid in a heat exchanger. The working fluid is vaporized and the vapor drives the turbine and the generator. These field-proven power units are simple to install and operate, and have virtually zero environmental impact. ORMAT pioneered the concept of modular power units packaged in the configuration of ISO standard shipping containers. This can be seen from the photos of Figures 1, 2 and 3, which illustrate the use of this approach to packaging over a span of nearly two decades. In this period a number of technological advances were introduced, including higher efficiency turbines, heat exchangers and advanced computerized controls.



Figure 3 – Series 250 Air-Cooled Modular Binary Power Unit
at Rogner-Bad Blumau Hotel & Spa

SERIES 250 MODULAR GEOTHERMAL POWER UNIT

ORMAT's new Series 250 organic Rankine cycle power units are specifically designed for distributed energy applications using locally available heat sources such as geothermal hot water or steam, incineration of agricultural and municipal waste, and unused process heat. The units are designed as an "easy to install / easy to operate" power plant for the 100 to 250 kW range. All system components are factory pre-assembled and tested. No previous experience in geothermal power plant construction is required for installation at the site. The operation of the OEC Series 250 is fully automatic and unattended, with no operators required during ongoing operation.

The minimal maintenance needed does not require skilled technicians, and multiple modules can be set up for larger capacities and progressively installed to accommodate consumption growth.

The standardized design was optimized for operation with a wide range of low- and medium-heat source conditions, thus minimizing the cost of customized site-specific engineering that small power applications cannot afford. The air-cooled OEC Series 250 does not need a water cooling tower and it is ideal for existing, unused, geothermal production wells or other existing hot geothermal fluids that are currently either re-injected to the ground or otherwise disposed of.

THE BAD BLUMAU GEOTHERMAL PROJECT

The first-Series 250 production unit was sold, literally, while undergoing inspection tests, to the RognerBad-Blumau Hotel & Spa in Austria, where the low-profile, quiet, air-cooled unit blends itself into the surroundings of the picturesque Rogner Hotel, which was designed by the famous Austrian artist Hundertwasser. The unit which is shown in Figure 3, was installed within 5 days of arrival on site in July 2001 and has been in continuous commercial operation since then. The unit, shown in the layout diagrams of Figures 5 and 6, consists of the skid-mounted turbo-generator and heat exchanger components which are packaged within the frame of a 20-foot ISO shipping container. The air-cooled condenser is packaged in two 40-foot ISO shipping containers. The control cabinet is mounted on the 20-ft container frame.

The heat and mass balance diagram are shown in Figure 6. The unit utilizes 30 lit/sec of geothermal fluid at an inlet temperature of 110°C. The geothermal fluid temperature at the outlet of the unit is 88.5°C. The outlet fluid is utilized to provide district heating to the Hotel, as shown in Table 1.

The Series 250 unit at the RognerBad-Blumau Hotel & Spa utilizes pentane, and no additional motive fluid has been required in the first 15 months of operation. No on-site motive fluid storage system is needed and all operational and maintenance tasks are performed by local staff and technicians.

The hotel and surrounding village are an international world class artistic and eco-tourist destination resort. The ORMAT Series 250 geothermal power plant is an integral part of this eco habitat.

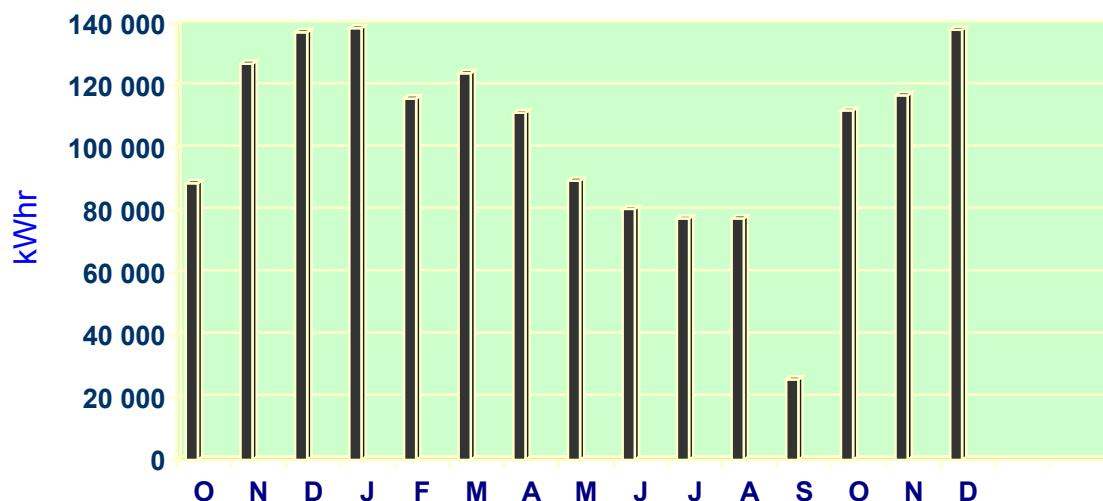
Gross output at generator terminals	250 kW _e
Heat flow available for district heating	2,500 kW _t
Cooling media	Air
Generator rated power	280 kW
Generator output voltage/frequency	400 V / 50 Hz
Geothermal Fluid Flow/Temp	30 l /sec at 110°C
Yearly Availability	Above 98 %

Table 1-OEC performance data

OPERATING EXPERIENCE

As shown in Fig. 4, during the indicated period the power unit generated a total exceeding 1.5 million MW/hr. Furthermore, it shows that during the said period, the unit operated without interruption and that the changes in the output reflect the off design performance with change of ambient conditions.

Fig. 4 Generated power between October 2001 till December 2002



CONCLUSIONS:

The ORMAT Series 250 small-scale modular geothermal power unit is based on 37 years of experience with over 200 such power units supplied for some 700 MW of geothermal power projects. By combining this experience with feedback from the field, the company has produced a small unit that is factory-packaged, easily installed and operates reliably with minimal maintenance and operating expense.

Our conclusion is that small-scale geothermal power projects, utilizing locally available low-temperature resources, are technically and economically feasible. Power plant technologies and well-field production and utilization technologies are proven.

Project owners find the costs of power production commercially acceptable. Operational issues relating to infrastructure, well field facility maintenance and power plant maintenance may be properly addressed by utilizing local staff with adequate training and motivation. The success of these small-scale geothermal power projects is largely due to the involvement of local interested parties and agencies as active participants in the development, financing, ownership and operation of the projects. The new Series 250 line was installed and in July 2001 began delivering electricity to the Rogner Hotel & Spa in Bad-Blumau, Austria, utilizing as its energy source 110°C hot water from a local geothermal well. The low profile, quiet, air-cooled geothermal power unit blends into the surroundings of the picturesque Rogner Hotel, which was designed by the famous Austrian artist Hundertwasser (see Figure 3). This distributed generation power plant has been operating continuously from (110° C) geothermal fluid, in an unattended mode with incremental operating costs estimated at less than \$0.003 per kWh

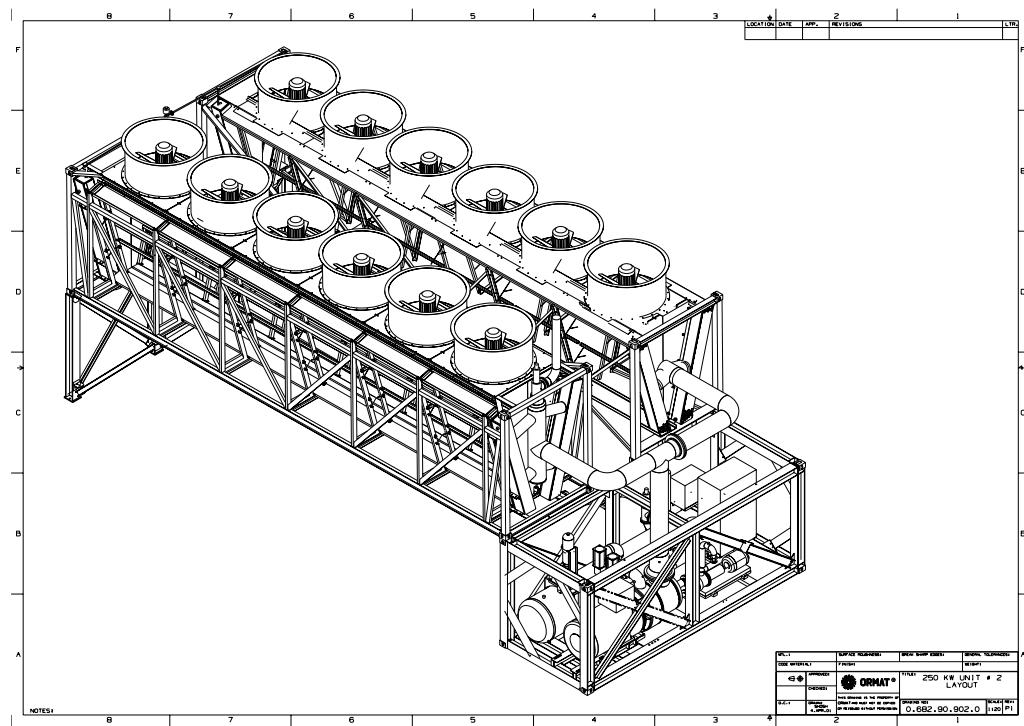


Figure 5 – Perspective View of Series 250 Power Plant at Rogner Hotel

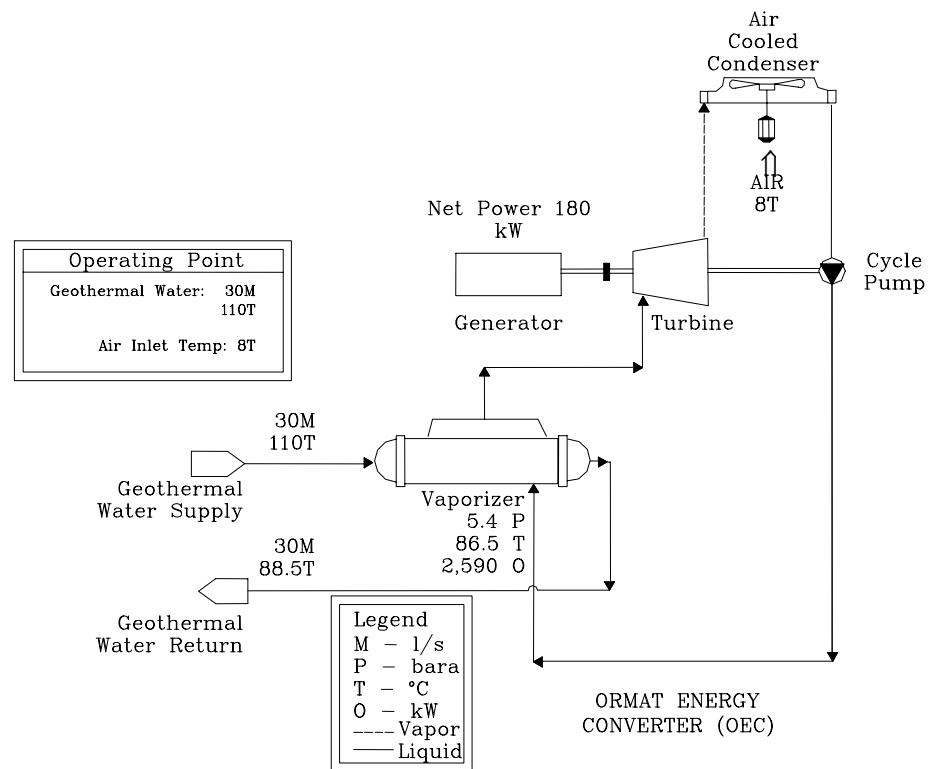


Figure 6 – Heat and Mass Balance Diagram Series 250 Power Plant at Rogner Hotel