New Technologies for modular geothermal power plants in oil & gas settings

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ORMAT Experience

- Design, Engineer, supply, install & operate renewable & sustainable energy products since 1965
- 800 MW of geothermal and heat recovery power generation in 21 countries
- Over 1.5 billion in project financing of geothermal power projects including ORMAT equity ownership of 350 MW.

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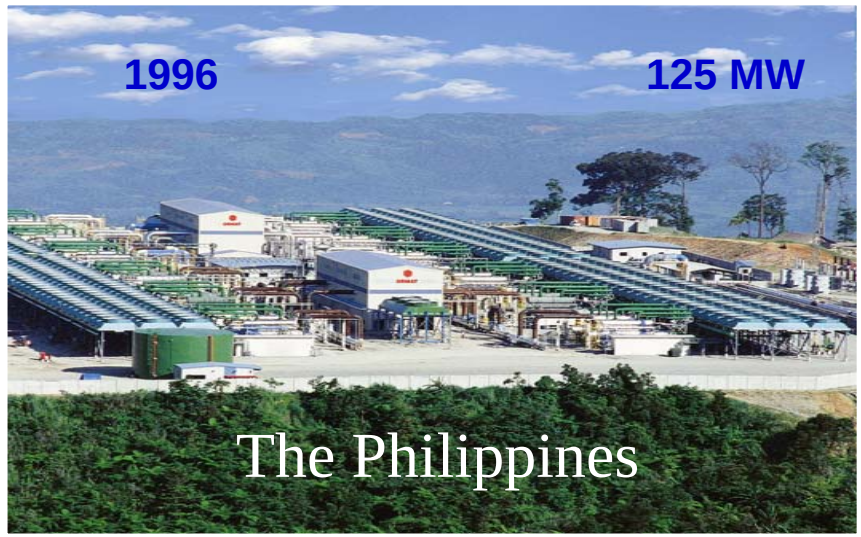
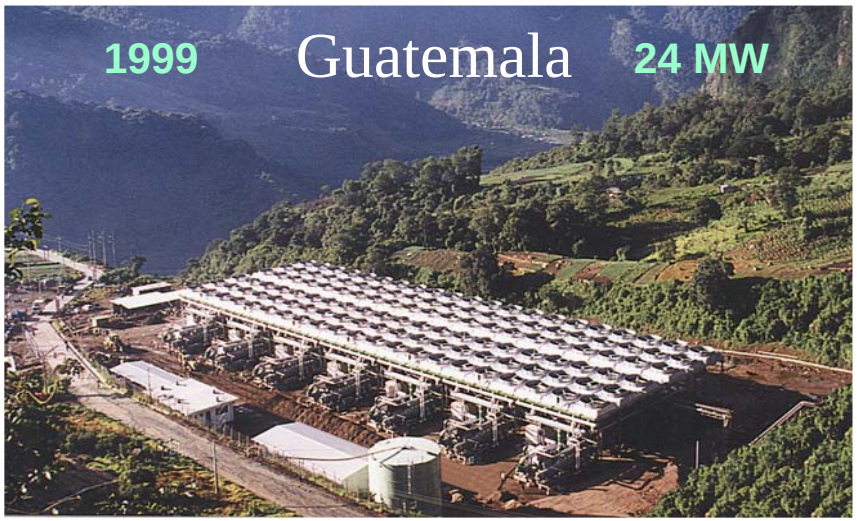
ORMAT geothermal power plants

Fang, THAILAND

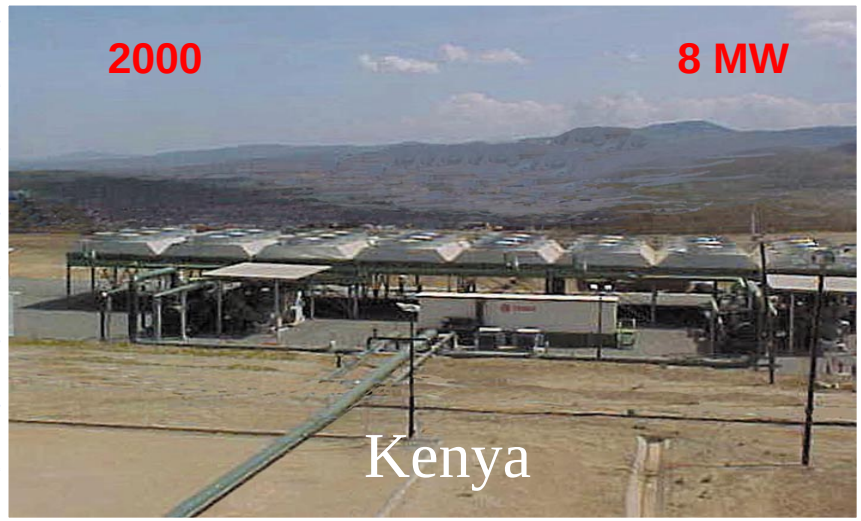
Upper Mahiao, The Philippines



Zunil, GUATEMALA



Olkaria, KENYA



Modular Geothermal Power Plant Technology

- **Most Likely Choices**
  - **Binary: Temp of 210 to 350 F**
  - **Flash Steam: Temp over 350F**
- **Small binary modular power plants**
  - **Is transported as 2 or 3 modules**
  - **Can accommodate 250 to 1000 KW in ISO container frames**
  - **Water cooled units require modular cooling tower**
  - **Installation simply requires interconnecting modular units.**

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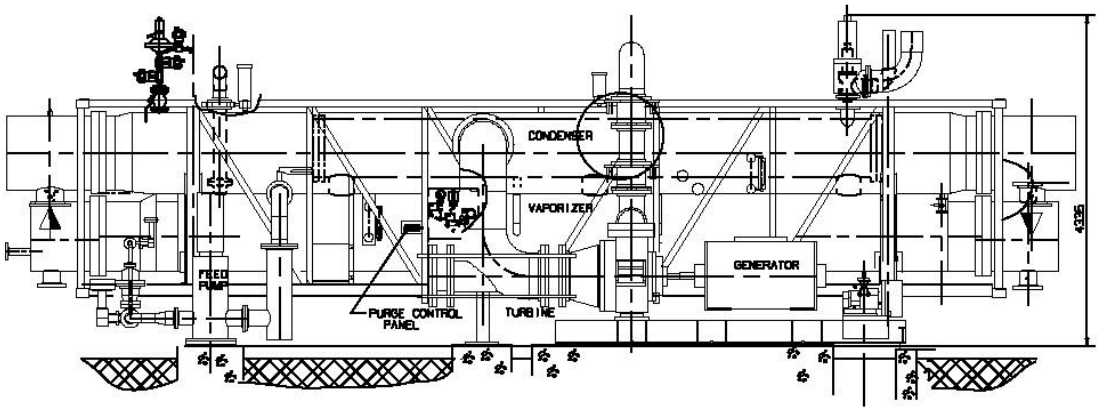
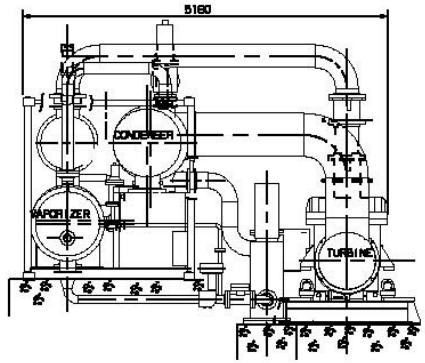
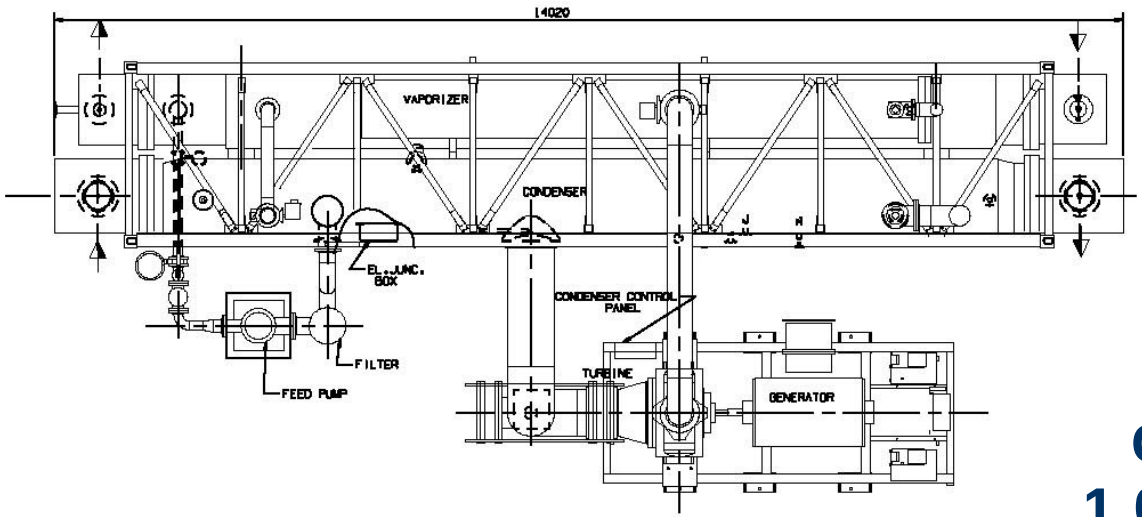
1000 KW Modular Binary Geothermal Power Plant







General Arrangement
1,000kW OEC Power Unit

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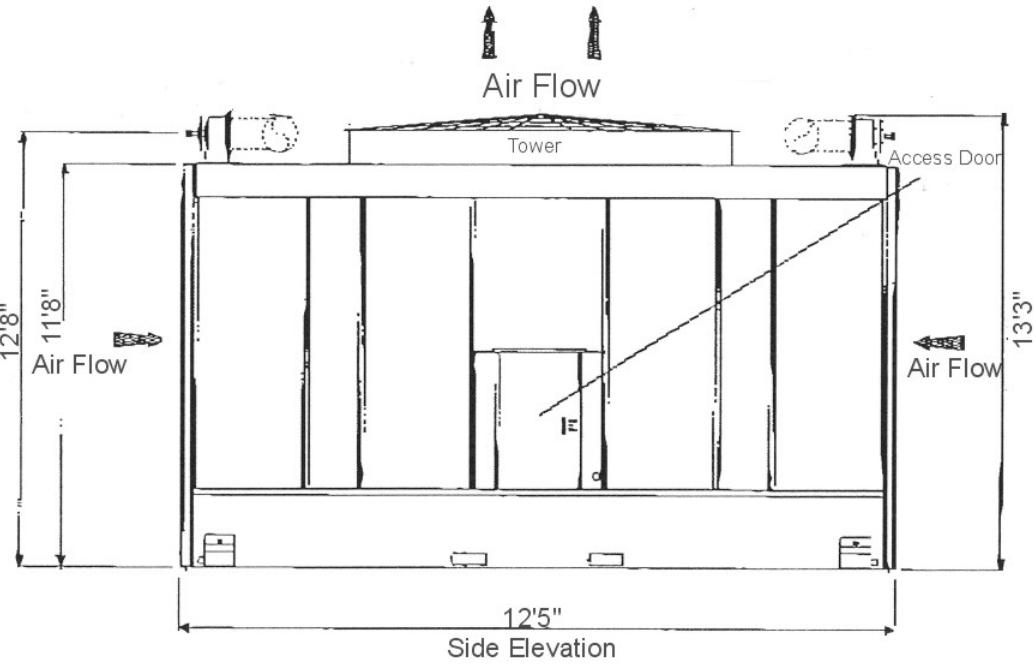
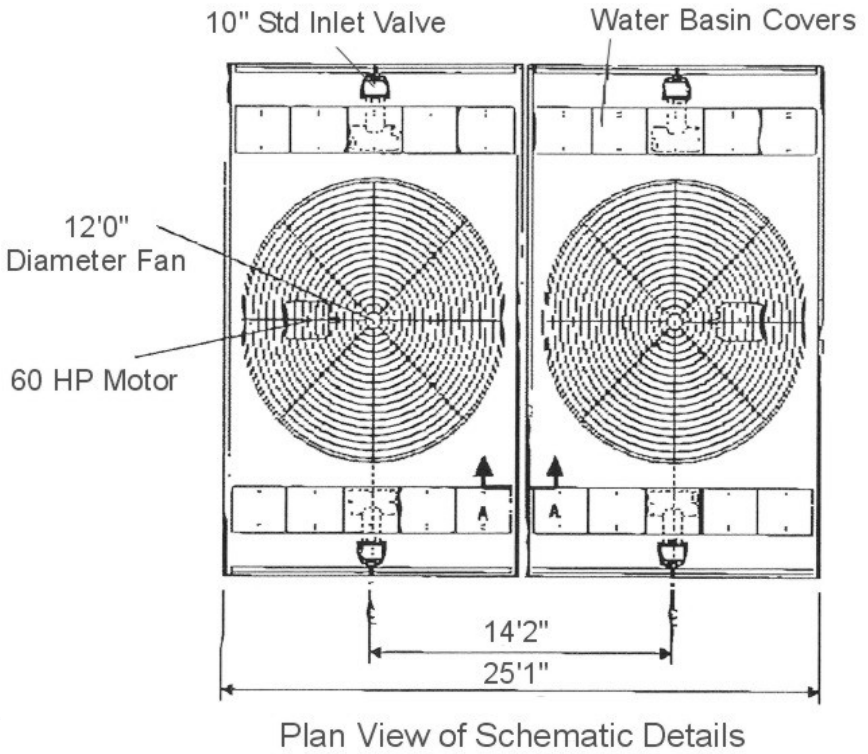
Modular Cooling tower for support of 1000KW Modular Binary Power Plant





General Arrangement, Modular 2 Cell Cooling Tower

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Binary Power Plant Powers Eco-Tourist Resort 250 kW Factory Integrated Plant Provides Power & Heat

Series 250 Containerized ORMAT Energy Converter Power Unit at Rogner Hotel & Spa, Bad Blumau, Austria

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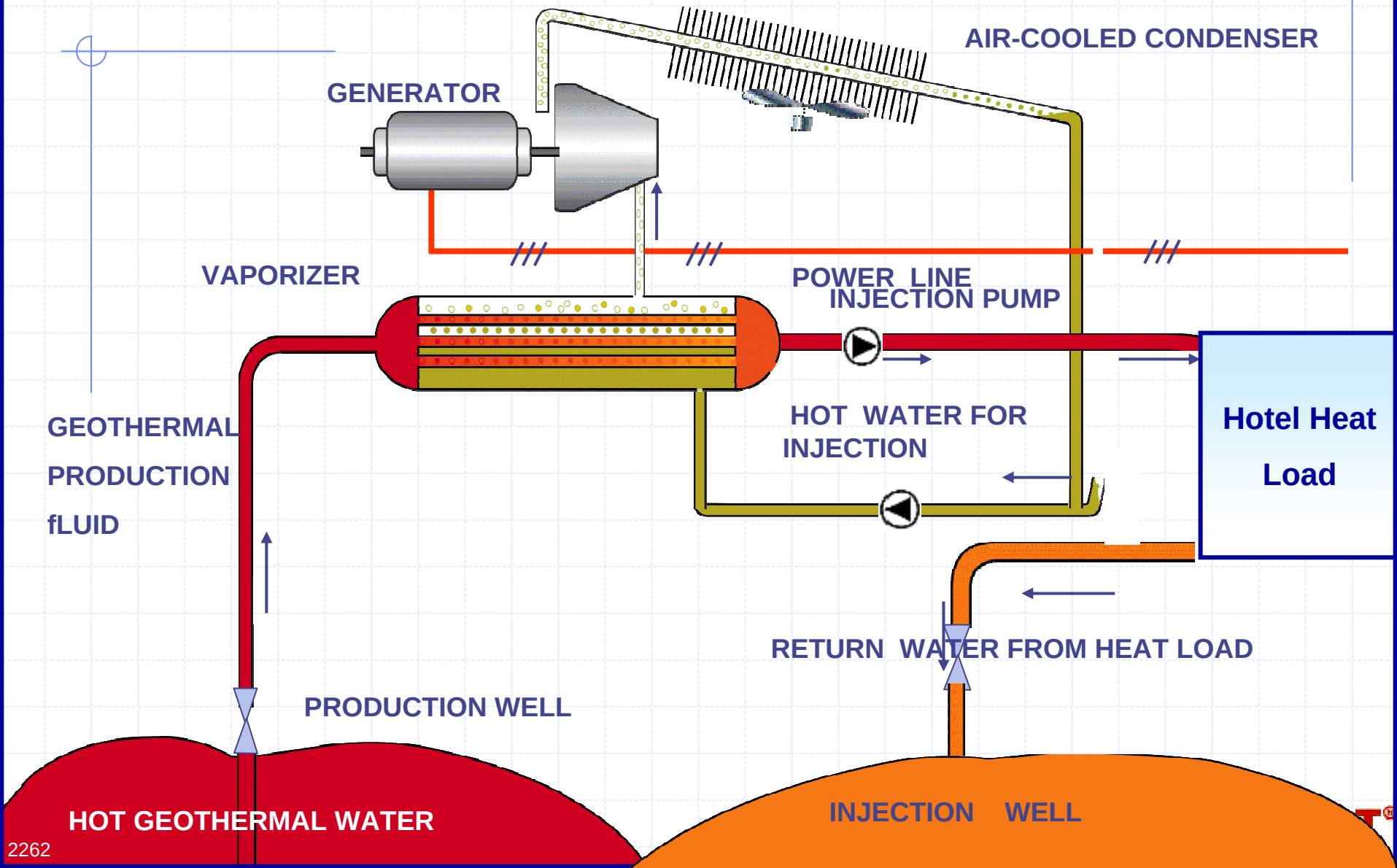
GEOTHERMAL HEAT AND POWER
AIR-COOLED ORMAT® ENERGY CONVERTER



ORMAT's Modular Geothermal Power Plant Advantage.

- **Modular Geothermal Power Plants can serve:**
  - Rural electricity needs,
  - Remote locations-displace diesel power,
  - Eco-tourist resorts,
  - Agricultural industries,
  - Schools, fire fighting camps, hospitals and remote facilities,
  - Remote load centers, displacing need for uneconomical transmission lines, and
  - Local small entrepreneurs interested in renewable energy projects.

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ORMAT's Modular Geothermal Power Plant Advantage.

- Easy to transport and install,
- Accommodate wide range of temperatures,
- Accommodate changing loads,
- Accommodate changing resource conditions,
- Operate unmanned and automatically

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ORMAT's Modular Geothermal Power Plant Advantage.

- Lowest environmental impacts,
- Use shallow or existing wells,
- Used with air or water cooled condensers,
- Power may be used on-site, and
- Slow speed turbine (1800 rpm)

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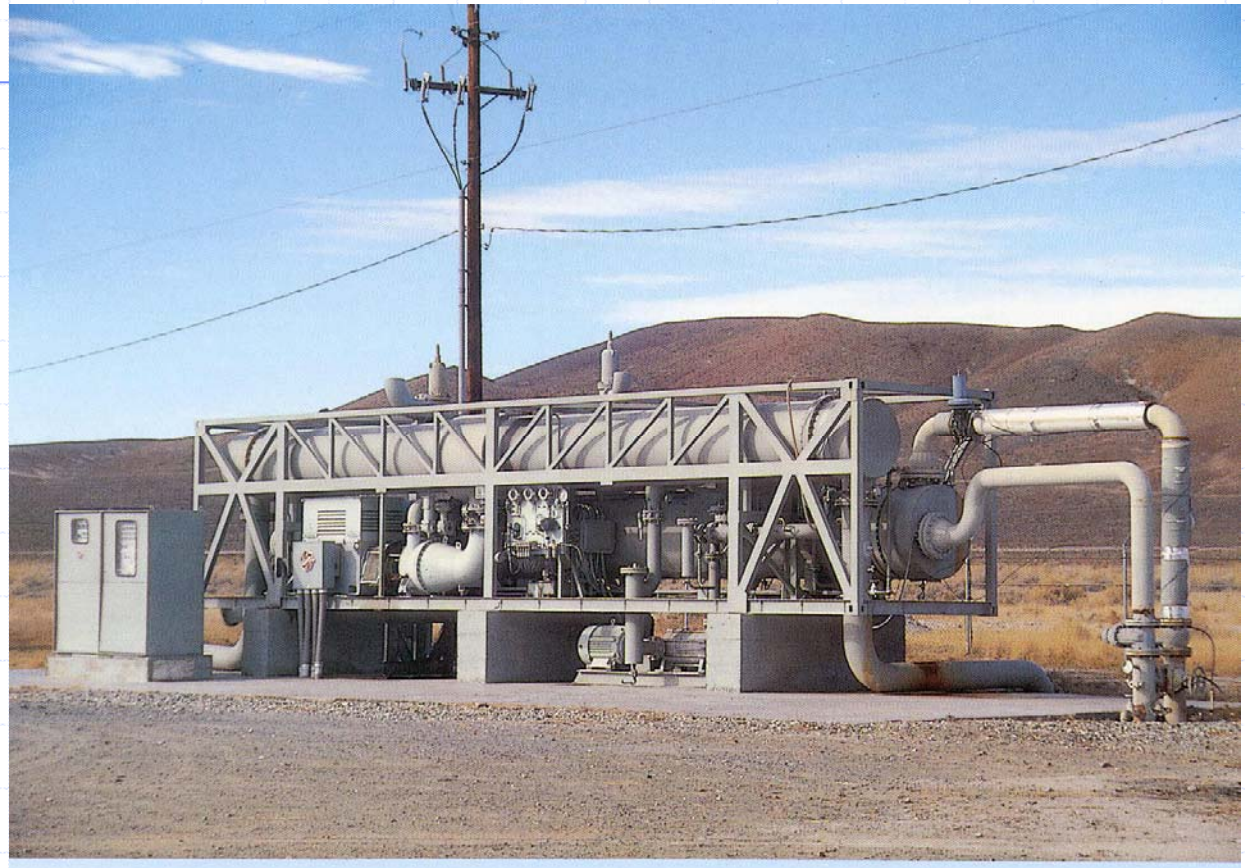
Containerized Small Power Plant

750 kW - Tad's Binary Power Plant, Wabuska NV



Geo-fluid supplied 215º F, water cooled from spray pond
Power sold to Sierra Pacific Power under long term PPA

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Ancillary Benefits of Binary Technology

- Heat from cooled geothermal fluid may be used for direct heating or agro-industrial processes,
- Enables local industry and development,
- Low environmental impacts
- Cost savings for “inside the fence” installations in high energy tariff areas.

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Multiple Use Containerized Small Power Plant Fang, Thailand 300 kW Geothermal Power Plant

Geo-Fluid flow is at temp. of 230^{o} F, injection fluid heats spa, provides for refrigeration and crop drying. Plant availability is 94%
Power Plant is water cooled by once through flow of river.

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Binary Power Plant Powers Eco-Tourist Resort 250 kW Factory Integrated Plant Provides Power & Heat

Series 250 Containerized ORMAT Energy Converter Power Unit at Rogner Hotel & Spa, Bad Blumau, Austria

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Binary Power Plant Powers Eco-Tourist Resort 250 kW Factory Integrated Plant Provides Power & Heat

- OEC utilizes 500 GPM of Geo Fluid at an inlet temp. of 220 F
- Geo-Fluid temperature at outlet of unit is 185 F
- Outlet Geo- Fluid provides heating to the hotel
- OEC unit utilizes pentane, with no additional on-site motive fluid storage required,
- All operations and maintenance performed by hotel staff and technicians – installed in one week,
- Binary plant is part of eco-tourist attraction in Austria

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Rogner Hotel-Bad Blumen Austria

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Technological Advancements and Support

- Field Proven Technology
- Improved Turbine Efficiency
- Full continuous factory support

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Technological Advancements and Support

Field Proven technology

- 750 MW of Installed Capacity
- Over 50 power plants in 21 countries
- Over 300 Turbogenerators Installed Since 1982
- Over 30 million turbine hours of operation
- Slow Speed Turbines – 1800 rpm

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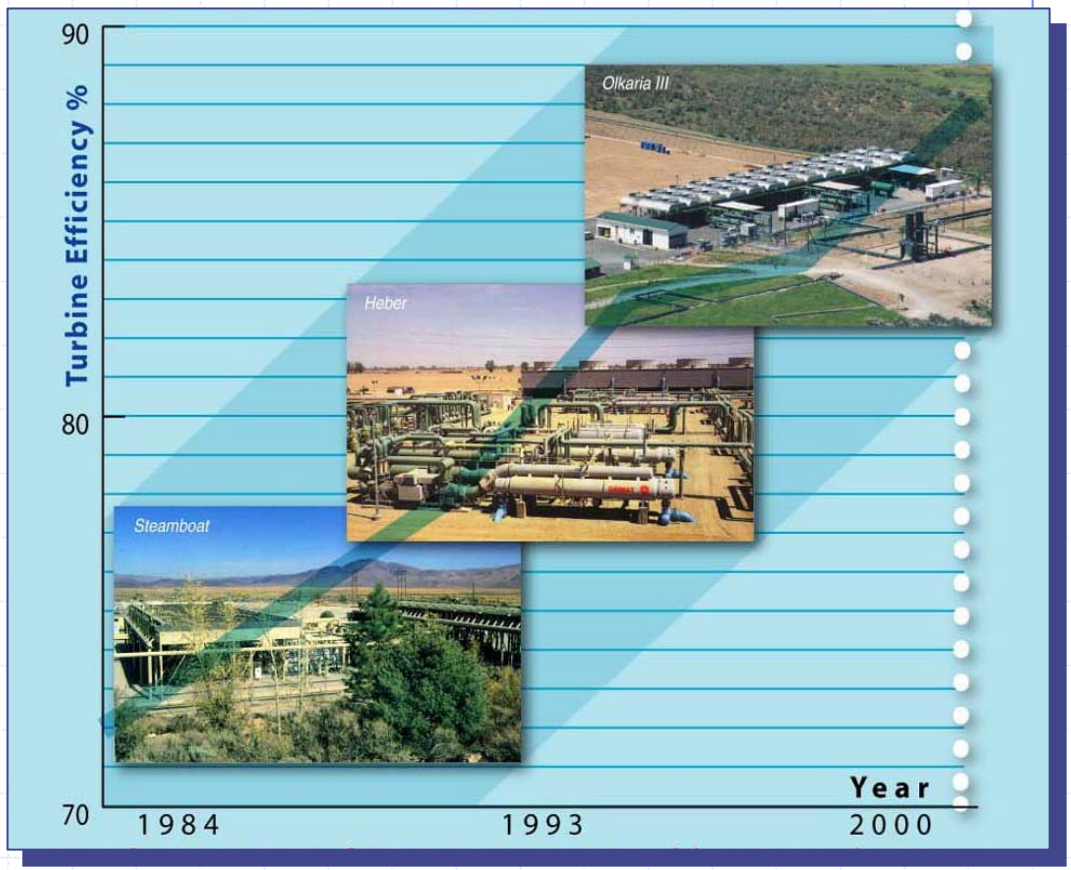
Technological Advancements and Support

Continuous Improvement to Turbine Efficiency

YEAR OF FIRST USE	REPRESENTATIVE PROJECTS	TURBINE EFFICIENCY %
1984	Steamboat	72
1985	Ormesa	75
1989	Puna	78
1993	Heber	83
1996	Rotokawa	84
2000	Olkaria	88



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Technological Advancements and Support

- **Full continuous factory support, including**
  - **Factory integration and testing of OEC power modules before shipment,**
  - **Remote monitoring by ORMAT engineers,**
  - **35 year unbroken record of spares supply and service in the field,**
  - **Refresher training for staff and upgrading of plant equipment available.**

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Conclusion: Oil & Gas field application

- Factory integrated small binary power plants are field proven and reliable,
- Containerized modular power plants may be deployed and installed easily,
- On a multiple use site small binary plants can provide cost effective power and heat,
- Success of small plant projects includes matching the plant to the resource, spares, training and support services.

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