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ENVIRONMENTAL ADVANTAGES OF BINARY POWER PLANTS CAN ENHANCE DEVELOPMENT OPPORTUNITIES

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ABSTRACT

There has been considerable discussion in the last few years about the environmental advantages of geothermal power when compared to fossil fuels, nuclear power and other alternative energy sources. In the restructuring of the geothermal industry, these advantages may give geothermal power an added competitive edge. These environmental advantages increase when binary power systems are utilized. As we look to future developments in the Basin and Range Province, binary power plants offer two key advantages: 1. The reduced water demand for air cooled plants, which is important in the water-scarce west, and 2. Enhanced reservoir management, by utilizing a closed loop system that extracts the heat and does not deplete the fluids. This paper emphasizes the additional environmental benefits of binary power plants, while summarizing the related environmental advantages of geothermal power when compared to fossil fuels and other alternatives.

INTRODUCTION

To review some of the benefits of geothermal power when compared to other power supplies:

Geothermal power offers a secure long term fuel supply unaffected by climatic conditions, foreign governments or fluctuating pricing schedules.

Geothermal power plants do not consume fuels that must be transported from another site eliminating the potential for spills, fires or other disasters.

Geothermal facilities occupy less than one third the land area per unit of energy produced when compared to other energy sources (U.S. DOE 1994), a definite environmental advantage. *Table BPA FEIS to be added.*

Geothermal power with current proven technology is cost effective when compared to fossil fueled power on a risk adjusted total life cycle basis (Geothermal Resources Subgroup, 1993).

Modular units, particularly binary ones allow for power development in increments from less than 1 Mw to 50 Mw. These can be installed with time frames as short as six months between stages, allowing for phased development of the geothermal resource. Phased development allows power to be added in increments that match the increasing demand.

Reliability, is not considered a direct environmental benefit. However, geothermal power has a proven on-line record of 97% as a baseload power supply. Geothermal power is 22% more reliable than coal and 32% more reliable than nuclear power (BPA,1993). Reliability gives geothermal power an advantage over renewables that are dependent on climatic conditions such as solar, wind and hydropower. It also provides a more dependable fuel source than biomass, when you consider the transportation and supply issues (BPA,1993, Harding Lawson Associates, 1987). In addition, geothermal power plants do not require fossil fuel back-up power supplies, which are often required for other renewables by financing entities. This is a direct environmental benefit.
BPA Figure to be added

Regarding air quality issues, to summarize what has been previously published by, U.S. DOE 1994, Union of Concerned Scientists 1990 and Goddard & Goddard 1988, 1990, geothermal power plants emit no nitrous oxides (NOx), only a small percentage of carbon dioxide (CO_2) and minimal amounts of *sulfur oxides (SOx), unlike fossil fuel (including natural gas) or nuclear power plants. Binary power plants offer the added advantage of emitting no CO_2, NOx or SOx emissions.

* Adapting hydrogen sulfide emissions to SOx; also not all geothermal resources have hydrogen sulfide emissions.

These advantages all contribute to making geothermal power more attractive as a power source for replacing outdated fossil fuel plants, decommissioned nuclear facilities, as well as new power supplies. The environmental advantages unique to binary power plants are presented below.

ENVIRONMENTAL ADVANTAGES OF BINARY POWER PLANTS

Binary power plants offer several environmental advantages over other generating technologies, which may be particularly appealing in the future for Basin and Range Province projects as well as other parts of the U.S. and the world. Specifically, these advantages include:

- No non-condensible gases released during normal plant operations.
- No visible steam plume from air cooled power plants.
- No chemical biocides or corrosion inhibitors needed with air cooled power plants.
- No cooling tower drift to affect vegetation.
- Reduced water demand for air cooled plants (although water storage is needed for fire protection).
- Enhanced reservoir management due to closed loop system using the heat, not the fluids.
- No expensive H_2S abatement equipment is needed eliminating the potential for generating hazardous wastes and their costly disposal.

The two advantages (mentioned above) that are particularly well suited to the Basin and Range province are:

1. The reduced water demand for air cooled plants, which is important in the water-scarce west, and
2. Enhanced reservoir management, by utilizing a closed loop system which extracts the heat and does not deplete the fluids.

These advantages,and why they may be of interest when developing new projects in the Basin and Range are discussed in greater detail below.

No non-condensible gases released during normal plant operations.

As mentioned previously, binary power plants offer the advantage of emitting no CO_2, NOx or SOx emissions, while flash or direct steam geothermal power plants emit a small percentage of carbon dioxide (CO_2) and minimal amounts of *sulfur oxides (SOx), unlike fossil fuels (including natural gas) or nuclear power plants.

The importance of these findings is emphasized when evaluating the environmental impacts of these emissions. Nitrous oxides combine photochemically with hydrocarbon vapors to form ground-level ozone, a gas which harms crops and human health. Sulfur Dioxide emissions are the main source of acid rain and CO_2 emissions are the predominant contributor to global warming (California Energy Commission, 1991, DOE, 1994).

Furthermore, the United States contributes slightly over one-fifth of the world's total carbon dioxide, with electrical utilities ranking as the single largest source of CO_2 emissions (BPA, 1993). Utilizing geothermal power plants, particularly binary facilities could provide significant reductions in CO_2 emissions, where geothermal resources are available.

* Adapting hydrogen sulfide emissions to SOx; also not all geothermal resources have hydrogen sulfide emissions.

However, there are no federal emissions limits for CO_2 which would make this advantage quantifiable (Clean Air Act, 1990).

No visible steam plume from air cooled power plants.

In some sensitive locations concerns have been raised regarding the visual impact of geothermal facilities and operations on scenic view sheds. Visual impacts include the sight of steam plumes that are emitted from venting wells and operating cooling towers. Air cooled binary facilities emit no visible steam plumes. Examples include those facilities designed by Ormat, Inc. at Soda Lake and Stillwater, Nevada, or Barber-Nichols units at Wendel-Amadee, which are already located in the Basin and Range province, or the Ben Holt Co. design installed Mammoth Lakes, California. Although well venting does create a visible steam plume, those events are usually of a short duration, whereas power plant operations are generally continuous.

The lack of steam plume when combined with revegetation programs, vegetative screening (if needed), and painting the facilities to blend with the surrounding area, can greatly reduce the visibility of the facilities. This is a valuable advantage when dealing with concerns regarding sensitive viewsheds.

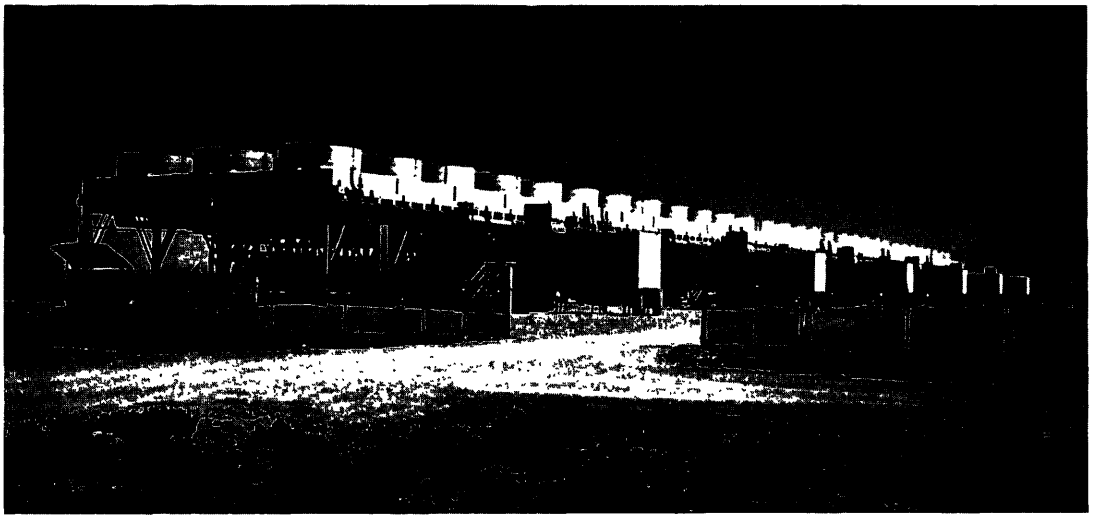

Photo - Soda Lake, Nevada 14 MW air cooled binary facility, Ormat design. Note lack of steam plume (plant was operating at time of photo), low profile, and nearby vegetation.

No chemical biocides or corrosion inhibitors needed with air cooled power plants.

Air cooled systems eliminate the need to add biocides and corrosion inhibitors to the cooling tower water. This results in a cost savings from not purchasing expensive chemicals, which in concentrated form are usually regulated hazardous materials. The risks associated with possible spills or handling problems are also eliminated. In addition, the potential liability for chemical contamination of the site is reduced. In addition, air cooled facilities eliminate the need and expense of a concrete cooling tower basin.

No cooling tower drift to affect vegetation.

Cooling tower drift from non-binary facilities can cause damage to surrounding vegetation depending on the chemical content of the water vapor (Lake County, 1989).

Airborne effluents in the form of cooling tower drift are a product of steam cycle plants with wet cooling towers, which presently are the most common type of cooling tower used. The largest of the airborne emissions is water vapor. In some locations, this release of water vapor can result in local fogging and icing conditions. In addition, vegetation stress has occurred at some resource sites in the immediate area of power plants (Lake County, 1989).

Typically, foliar damage will occur from naturally occurring boron in the cooling tower drift as well as high levels in soils near the towers. Boron is toxic to vegetation, and must be kept below 10ppmw* in agricultural water by regulation in California. Typical drift distances that may produce foliar damage and some soil toxicity occur within 300 to 500 feet of geothermal cooling towers (Lake County, 1989). Since boron is a common element in many of the soils in the Basin and Range province, by utilizing air cooled binary power plants, the surrounding vegetation, as well as post-construction revegetation programs would not be affected by this potential problem.

Air cooled binary power plants eliminate cooling tower drift, which can contain in addition to boron, small quantities of natural occurring gases such as carbon dioxide, methane, ethane, radon-222, arsenic, mercury and ammonium thiosulfate. If sodium hypochlorite is used in the cooling tower water to control biological growth, it forms free chlorine. This will react rapidly with oxidizable substances to form chlorides, which are included in the cooling tower drift (Sonoma County, 1990).

Air-cooled cooled binary facilities eliminate both water vapor and chemical emissions.

* Parts per million by weight

Reduced water demand for air cooled plants (although water storage is needed for fire protection)

The fresh water consumption is greater during the drilling and construction phases of a project than normal operations. However, if a modular binary facility is used, such as the Ormat Inc. units, the site construction time can be reduced. When construction time is reduced you also reduce the amount of fresh water used during the construction process as well as the biological and air quality impacts from dust associated with construction sites. It also means site revegetation can begin sooner. In the west, where water use concerns are a high priority, any reduction in water use can help to clear obstacles to development.

Due to the flammability of most of the working fluids used in binary facilities, a substantial on-hand water storage is required for fire protection. The Ormat designs at Stillwater and Soda Lake, Nevada have storage tanks holding 500,000 gallons.

Enhanced reservoir management due to closed loop system using the heat, not the fluids.

Because binary power plants operate in a closed loop system, utilizing a working fluid in the heat exchange process such as isopentane or isobutane, the geothermal resource (hot water) never comes into contact with the atmosphere. Only the heat is extracted. The liquids are then injected to promote injection recovery, and prevent subsidence. No geothermal fluids are lost in the process, therefore enhancing the sustainability of the reservoir.

Wet cooling towers, lose water vapor to evaporation as part of the process. Therefore, there is a net loss of geothermal fluids reducing the amount of available fluids for injection and reservoir maintenance. This is an important issue in the water scarce west. In the past, reservations were raised by concerned parties regarding:

- Possible contamination or depletion of potable surface or ground water supplies;
- Fears of subsidence due to extraction of the resources (Sifford, 1988).

Ground water supplies are protected by competent well casing programs that are reviewed by regulators prior to well drilling. Subsidence fears can be minimized with injection of 100% of the geothermal fluids.

No expensive H_2S abatement equipment is needed eliminating the potential of generating of hazardous wastes and their costly disposal.

Not all geothermal resources contain H_2S in quantities that require mechanical abatement. However, for those resources that do contain measurable amounts of H_2S, and utilize abatement equipment the by-products of abatement often contain some quantity of hazardous wastes. Even if they are not hazardous, the by-products require off site disposal, which can be costly (Sonoma County, 1990). Abatement equipment also requires maintenance, and personnel training. All of these activities increase the costs of a project. Binary facilities eliminate the need for power plant abatement systems, since the closed loop prevents atmospheric releases.

The working fluids used for binary facilities are often isobutane or isopentane. These are classified as reactive/volatile organic compounds when in contact with the atmosphere. These are considerably less hazardous than butane or bottled propane, because they have a lower vapor pressure and a higher boiling point.

Sources of emissions at a binary plant may include small leaks from seals, valves, flanges and other components in the system. The largest contributor is often the turbine seal, due to the amount of vibration. Fluid losses can range from less than 1 pound per day to 100 pounds or more per day (Ralph, 1991) of fugitive emissions. These fluids/gases are not classified by the federal government as criteria pollutants and there are no federal ambient air quality standards established (PG , 1990).

Newer facilities, such as the Ormat units installed at SIGC/Heber, California or Soda Lake, Nevada, have fugitive emissions at negligible levels. Primarily, because their units operate with lower turbine speeds (1,800 rpm-3,600 rpm instead of 9,000 rpm) and pressures (200 psi vs. 500 psi), which reduces turbine vibrations and therefore the wear on the turbine seal (Gropper, 1994; Campbell, 1991). The Barber Nichols remote operated Wendel Hot Springs plant, although utilizing a different working fluid and smaller in size (330 kW), has also had negligible fugitive emissions (Nichols, 1991). As with any power plant, proper maintenance and inspection can prevent most emissions.

CONCLUSION

To summarize, geothermal power offers several environmental advantages over fossil fuel,nuclear and most renewable power sources. Binary power plants offer additional environmental benefits that may further increase the viability of future projects in the Basin and Range province (as well as other areas of the U.S. and the world). In the restructuring of the power industry, geothermal power must become synonymous with environmental sustainability. This message, when combined with the information that the technology is proven, as well as the long-term economic benefits of utilizing indigenous power sources, it should enhance the competitiveness of geothermal energy with other power sources.

* There is no ambient federal H_2S standard (Clean Air Act, 1990). Some states have adopted ambient level standards.

REFERENCES

Bonneville Power Administration, Final Environmental Impact Statement, Resource Programs, Vol.1: Environmental Analysis, U.S. Department of Energy (DOE/EIS-0162) 1993

California Energy Commission, Global Climate Change, Potential Impacts & Policy Recommendations, Vol. 2, 1991.

Campbell, Richard, and Harvey, Claude, Expanding the Mammoth Geothermal Project,Geothermal Resources Council Bulletin, Vol. 20, No.6,162-163, 1991.

Federal Clean Air Act Amendments, H.R. 3030, 1990, Section 301, Technology-based Standards for Hazardous Air Pollutants, Section 112, 42 U.S.C. 7412

Geothermal Resources Subgroup, of the Renewable Resources Work Group, Report and Recommendations to Portland General Electric Company, 17, December, 1993

Goddard, W.B.and C.B.Goddard, Energy Fuel Sources and Their Contribution To Recent Global Air Pollution Trends, Geothermal Resources Council Trans. Vol.14, 643-649, 1990

Gropper, J., Yarimi, A. Ormat Modular Geothermal Binary Power Plants in Latin America, Geothermal Resources Council Bulletin, Vol.23, No. 2, 45-46, 1994.

Harding Lawson Associates, Honey Lake Power Plant Project, Wendel, California, Final Environmental Impact Report, 1987

Lake County, Geothermal Resources and Transmission Element , Vol. 2, Planning & Environmental Analysis, 1-54, 1989.

MacDonald, G.J., Scientific Basis for the Greenhouse Effect, Journal of Policy Analysis and Management, Vol.7, No.3, 4 25-444, 1988 by the Association for Public Policy Analysis and Management, Published by John Wiley & Son, Inc.

Nichols, Ken, Forsha, M.D., Factors Affecting the Capital Costs of Binary Power Plants, Geothermal Geothermal Resources Council Trans. Vol. 15, 99-104, 1991.

Ralph, Chris, State of Nevada, Bureau of Air Quality, Personal Communication, 1991.

Sifford, Alex, Western States Market for Geothermal Power in the 1980's, Geothermal Resources Council, Vol.12, 85-86, 1988.

Sonoma County Draft Geothermal Resources Management Plan, Vol.2, 5-8, 1990.

Union of Concerned Scientists, Cool Energy, The Renewable Solution to Global Warming, 1990.

U.S. Department of Energy, Geothermal Fact Sheet, Environmental Aspects, April, 1994