Tapping Earth's Geothermal Energy: *"Green" Panacea Or Pandora's Box?*

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Time by nature is as a river, always in fluid transition. Did any who lived across these lands centuries ago wonder, as they enjoyed nature's beautiful bounty, at the changes yet to come? Could any then have foreseen changes as locally and globally dramatic as have come to be? What changes will emerge a century or more hence, if current societal growth and demands continue to rise? What unforeseen dramas hide amidst future's obscuring mists?

Human population and demands upon Earth's natural resources continue to grow exponentially. Our impacts are altering not only once natural open lands around us, but interwoven climatic and ecological systems worldwide. Scientific and societal concerns over resource depletion and the early manifestations of global warming are rising. Desires for energy sources that allow both continued growth and global ecological well-being have led to a quest for "green" energy solutions. Across the earth, people are searching for ecologically acceptable energy production sources to augment or replace today's reliance on harmful oil and coal fossil fuels.

Proposed as a future source to meet the region's growing energy needs, geothermal production brings both potential energy and economic benefits as well as ecological and health harms. Geothermal energy is not a new phenomenon. It has been used where naturally existent, perhaps throughout the evolution of our species. From ancient empires to tribal peoples, geothermal hot springs have long been used for bathing, heating, and cooking. Not only humans but other species, including monkeys in Asia, use geothermal energy. Literally meaning "earth heat," it is found naturally in hot water and steam rising from magma heated rocks below earth's surface.

Localized use of naturally flowing hot springs and steam continues globally – from Asia to Iceland to Oregon. Klamath Falls and Breitenbush communities use geothermal fluids to heat homes, buildings, and greenhouses, as well as for rejuvenating spas. Circulating geothermal waters beneath the sidewalks of Klamath Falls melts snow and ice. On this scale, employing natural flows, geothermal's ecological impacts are benign or even beneficial.

Tapping geothermal steam to produce electrical energy is reported to have first begun at Laredo, Italy in 1904, and continues there today. Since then geothermal electrical energy production has spread to 21 nations across the world. US geothermal plants exist in California, Hawaii, Utah, and Nevada. US production capabilities range from a few hundred kilowatts to over 130 megawatts, with an estimated total capacity of 3,200 megawatts –which industry claims equals the production of three nuclear power plants.

Geothermal energy production utilizes natural heating in the earth, most accessible along active fault lines, such as the Pacific Rim's volcanic earthquake-prone "Ring of Fire," which includes the Cascade Mountains. Not dependent on natural surface springs, it employs wells drilled thousands of feet into the earth, tapping into hydrothermal fluids and reservoirs. Using pumps and closed loop system pipes, hydrothermal fluids are most often used to heat more efficient secondary fluids, such as flammable isobutane, which then spin turbines, producing electricity. Contained within system pipes, cooling geothermal fluids are usually reinjected back into the earth. Geothermal is glowingly touted by industry as a sustainable renewable energy source, with water replenished by rainfall and heat perpetually produced by the earth. Citing polluting emissions produced by fossil fuel plants, ominous dangers inherent in nuclear energy, and the ecologically harmful consequences of hydropower dams, geothermal proponents claim by comparison that it is an ecologically responsible "green" energy source. However, most geothermal advocates have vested financial interests that perhaps filter their vision, accounting for discrepancies and omissions from the realities of geothermal's track record - which is not without its environmental and human health harms.

Among early indications of inherent problems, abrasive particles and corrosive impurities impaired pipes and turbines, causing failure of the first US geothermal production attempt at Geysers, California in 1922. Geothermal fluids and steams are far from "pure" or "safe." Water, percolating and pooling beneath earth's surface, contacts hot rocks heated by magma deep in the earth. Minerals, metals, and gases from deposits below surface mix with heating waters, brewing a geothermal brine containing toxic gases, impurities, and heavy metals similar to those found in rock tailings from mining. Geothermal's highly toxic contaminants include hydrogen sulfide, arsenic, boron, benzene, various forms of ammonia, radon-222, vanadium, and mercury, among others.

During "normal" production operations, toxic fluids are contained in pipes, reinjected into deep earth reservoirs, and not released as atmospheric, soil, or water polluting emissions. However, during initial geothermal exploration, plant construction, expansions, periodic routine maintenance and repairs, as well as "non-normal" incidents and accidents – toxic emissions regularly occur unabated for extended periods. During drilling and testing toxic muds, oils, and geothermal bines are collected as sludge in sumps on site. Containing numerous toxins and heavy metals, sludges pose a danger to workers, underground aquifers, area streams and lakes, as well as area vegetation, wildlife, and aquatic species. Well blowouts are another source of unabated emissions. Efforts to stop emissions from blowouts have proven unsuccessful, and have resulted in continuous venting of hydrogen sulfide and other dangerous gases, pollutants, and particulates. While hydrogen sulfide changes in approximately 12 to 18 hours through oxidation to sulfur dioxide, both forms are hazardous to plant and animal life. Regulations for permissible levels of these sulfides, and other toxins, allow emission levels many times higher than harmful. Workers at geothermal plants in California have reported serious health harms from exposure to geothermal toxins, including heart attacks, respiratory ailments, liver and other internal organ damage, and a range of lesser impacts including nausea, rashes, nose bleeds, dizziness, bronchitis and other problems, some of which have also been reported by area residents.

A five year study by Livermore National Laboratory on geothermal production impacts in the Salton Sea area concluded: "the Salton Sea will turn even saltier, the air will be polluted with noxious gases, the valley will sink due to hot brines drawn up from underground, and inadvertently spilling of salt fluids onto surrounding farmlands." A publication by the Northwest Power Planning Council titled "New Resources Supply Curves and Environmental Effects" (Feb, 1989) states: "Impacts of production affect air and groundwater. Hydrogen sulfide, a toxic substance with the odor of rotten eggs is produced, although it can apparently be controlled. Mercury, boron, and radon gases appear in trace amounts and ammonia, methane, carbon dioxide, and argon result from the air injector system and the cooling system. Recently reports from California say that whole crops have been destroyed by periodic emissions from geothermal plants. The airborne emissions have fallen on crops destroying the crops and contaminating the ground." In another study, the California Energy Commission concluded that acid rain and boron salts from geothermal production spread over considerable distances, resulting in vegetation losses to native trees.

Scientists with the US Geological Survey concluded geothermal production induces seismic activity. The tapping of geothermal reservoirs depletes subsurface pressure buildup, while reinjection of spent fluids is done at different surface levels and locations, altering pressure patterns, which is thought to be the cause of plate shifts. Plants at both Mammoth Lakes and Geysers California have experienced minor quakes ranging up to 3.5 or 4 on the Richter scale, with the Mammoth Lakes having "swarms of quakes." Notable land subsidence has also been recorded in areas above geothermal production reservoirs. Pipe systems, spill containment basins, and sludge sumps are at risk of rupture due to frequent quake activity, and must be monitored, again posing risks to aquifers and waterways. Reinjection of geothermal fluids has the potential to contaminate underground aquifers.

Geothermal's industrial plant complexes cover large areas, including turbines, power transmission lines, wellfields, sumps and football field sized dump ponds at each well site, 3 foot diameter pipelines, and injection wells. Exploration, construction, and continuous operation generate incessant noise, smells, and irretrievably alter the natural qualities of wherever they are located.

Elsewhere in the world, geothermal's record has also produced environmental harms, with reports of toxic atmospheric emissions, harmful health impacts, water pollution, and damaged crops and fisheries. Citizen activists from California to the Philippines are fighting geothermal plants. However, discovering information raising questions about geothermal's environmental track record is difficult with web searches flooded by industry sites.

Reviewing the wide varieties and impacts of geothermal production elsewhere, technological development, and possibilities inherent in our region, we can assess the impacts of different types of geothermal energy production upon our natural environment, communities, and quality of life. Questions needing to be addressed include: who is the power for and at what risk? Currently geothermal industries have proposed plants at Newberry Monument near Bend, on the slopes of Mt. Jefferson on Warm Springs, and near Lakeview, among other possibilities. Electrical power produced by these plants would primarily go to California, not the area where plants are proposed, as costs of geothermal production are still unable to compete with hydropower from dams. However, as fossil fuels become scarce, and concerns for ecologically sustainable energy production sources grow, geothermal speculators hope to cash in, acquiring "green energy" status, subsidies, and investments.

At this point, weighing environmental harms and risks, large scale geothermal electrical production cannot accurately claim to be ecologically "green." Reports that it slowly depletes geothermal reservoir resources over twenty or more years indicate that it cannot be considered truly sustainable – at least not at production levels that require pumping hydrothermal fluids at volumes in excess of 300,000 gallons an hour, such as at Mammoth Lakes. On a small scale, as used at Klamath Lakes, Brientenbush and elsewhere across the world, geothermal is a welcome natural addition to thermal energy needs. On a large scale, the technology needs to correct its environmental harms and be held truthfully accountable to the ecological well-being of affected communities.

Ultimately, we need to address the root causes of contemporary global societies insatiable demands. More than "sustainable energy sources," we need sustainable human societies - with ecologically sustainable limits on growth and consumption. Populations cannot continue to exponentially grow without disastrous consequences to the quality of life for us all. By reigning in growth, converting to ecologically appropriate and energy efficient structures, building materials, life-styles, and resource use, as an informed community we can best ensure an ecologically viable future for the generations yet to come.

Informed Democracy

In addressing the growing societal demands for energy development, allusions to geothermal's purported "green" energy, political energy development agendas and legislation, and the growing number of geothermal exploration and development plans proposed by economically motivated commercial ventures; it is helpful to become fully informed regarding geothermal energy exploration and production environmental, agricultural, community, and worker safety and health impacts. The following compilation of research information on the impacts of geothermal energy was first completed in 1990, while working with a consortium of conservation interests, including Greenpeace and Puget Sound area ecological activists. Recent (2007-08) consultation and review by geothermal proponents has verified that the same basic technologies, impacts, issues and concerns remain accurate and pertinent to geothermal projects operating and/or being proposed today. Additionally, the original report has been updated to incorporate more recent geothermal issues, including issues associated with Oregon's Newberry exploration project of 2008. With informed citizen involvement, and adherence to democratic process, communities affected by proposed and existing geothermal production can best assess the prospects and consequences of geothermal energy development, arriving at informed decisions that uphold the public's best long-term interests and protect the natural heritage of those here today, including Earth's many imperiled species, as well as those yet to be born.

Environmental Impacts & Methods of Commercial-Scale Geothermal Energy Production

Geothermal power production extracts heated fluids or dry steam by means of wells tapping into heated reservoirs and rocks within the earth. The heated fluid is used to drive turbines, generating electricity.[i] They type and temperature of geothermal reservoirs varies, each often somewhat unique to its own area.[ii] Temperatures of reservoirs utilized for electrical production range from 120° C to above 260° C.[iii] Fluids from these reservoirs can be in the form of dry steam or hot brines or water. Geothermal fluids varying compositions of toxins and heavy metals, are the primary source of geothermal energy production's environmental problems and challenges. Geothermal production methods and processes most often involve atmospheric emissions, condensation drift from cooling towers, wastewater, sludge, and reinjection of geothermal effluent – all containing various amounts of dangerous toxins.[iv]

Basic geothermal electrical generation processes consist of: dry steam, single flash, double flash, and binary cycle power plants. The type of geothermal fluids and the degree of temperature in part determine the typed of plant utilized.[v]

Dry steam: Geothermal reservoirs comprised of dry steam are geologically rare. It is this type however, where electrical power generation from geothermal fluids began; in 1904 at Lardarello, Italy.[vi] Within the U.S. geothermal energy production began in 1955 at the "Geysers" located in California. At the time of this report, 1990, these were still the only dry steam reservoirs commercially generating electricity with the U.S.[vii] Geysers area geothermal resources and energy production have been the locus of significant research and ongoing study. In the dry steam method wells tap the steam sending it through a "rock catcher" and afterwards into a turbine. To increase efficiency a vacuum is created at the turbine's exhaust by means of condensers. Cooling towers are used for the spent steam, with the collected condensation injected back into the reservoir.[viii]

Single flash: Designed for geothermal reservoirs with water temperatures in excess of 220° C, these utilize wells, directing water "production separators." The pressures within the separators are kept at a lower level causing 15 to 20% of the hot fluid to flash into steam. From here the steam travels through scrubbers to power the turbine. Cooling towers and condensers are utilized similar to dry steam. Condensate and fluid from the separator is collected and reinjected into the geothermal reservoir.[ix]

Double flash: This method is similar to the single flash system but, as its name implies, flashes the fluid into steam a second time at a lower pressure, maximizing the energy production potential of the geothermal fluid. As with the single flash system the excess fluids are collected and reinjected.[x]

Binary cycle: This method does not use the geothermal fluid directly to power the turbine(s) as do the others. Instead, it directs the fluid through a heat exchanger where a secondary fluid is flashed into steam. Called the "working fluid", the secondary fluid is usually isobutane or freon (or similar/derivative fluids)

– due to the low boiling point of these substances. It is the “working fluid” which powers the turbine. The geothermal fluid remains enclosed within pipes and is reinjected into the reservoir.[xi] During *normal* operations this type of plant does not expose the geothermal brine to the air. Consequently there is reported to be little harmful atmospheric emissions, liquid, or sludge wastes from *this part* of the binary production process.[xii] Industry sources tout it as being ecologically clean and indicate that future geothermal plants may employ these methods. However, atmospheric emissions still result during initial exploration drilling and well testing. Additionally, variances from emissions requirements may be needed during routine periodic maintenance and/or plant expansion, etc. Problems with system malfunctions and leaking pipes exist as well.

Flammable Leaks

The “working fluid” within the pipes, such as isobutane, is regulated with “*permissible*” levels for loss due to “*fugitive*” leaks. At the time of this writing, an allowable limit of 250 lbs./day has been established, with leaks of up to 10,000 parts per million (ppm) permitted before repairs are required to be initiated to fix the leak. Plant operators are allowed 15 days for repair completion before further reporting is required. Meanwhile operations can continue, despite unchecked leaking fluids.[xiii]

Leak detection is required on a monthly basis. Isobutane is highly flammable.[xiv] In March, 1990, isobutane in a piping system at the Mammoth Lakes California plant ignited. Two workers conducting maintenance on the system were burned – one severely. The resulting fire burned for 16 hours. Fire suppression efforts involved fire-fighting personnel from six different agencies. Preliminary government and industry investigations determined no safety violations had occurred.[xv] The fire apparently was determined to be part of *normal* operations, with the plant meeting the requirements of permit regulations, allowing profitable energy production to continue relatively unabated.

The binary method of geothermal production was initially developed for use where reservoir fluid temperatures were low, requiring working fluids with a low boiling point, such as isobutane, freon, etc. Binary, with its enclosed piping system, heat exchanger, and secondary fluids can be more costly to design and finance than other systems. In the economic profit/cost motivated energy production industry there are no guarantees that more costly methods, designs, and equipment – allowing greater environmental protection and community/worker safety - will be utilized when less resource and time-costly methods are available. With the differing temperatures and composition of geothermal reservoirs, less maintenance intensive, or technologically more feasible methods may be utilized due to high heat, large quantities of particulate matter, or corrosive fluids.

Geothermal’s Toxic Tea

The corrosive nature of geothermal fluids, particularly their effect on various metals, initially challenged technological capabilities and delayed exploitation of geothermal as an energy source. Geothermal fluids contain varied chemical substances; some highly toxic such as hydrogen sulfide, arsenic, and mercury – among others. Geothermal reservoirs are located in tectonically active areas where fissures exist beneath the surface of the earth. Precipitation pooling below the surface is heated by contact with hot rocks below, which are in turn heated by magma. Minerals, metals, and gases from deposits below the surface, mix with waters forming the composition of the geothermal brine or steam.

The following is a list of geothermal pollutants, their various threshold limits and the toxicological effects:

Health Effects of Air Pollutants from Geothermal Development

Ammonia (NH_3). Odor threshold: 5.2 ppm (Amoore et al, 1983); Eye irritation: 5 ppm (NIOSH, 1974), 72 ppm (Industrial Bio-Test Labs, 1973); Inhalation irritation: 20 ppm (EPA, 1977); Nasal irritation: 32 ppm; Chest irritation : 134 ppm (Industrial Bio-Test Labs, 1973); Increased morbidity and mortality: 70-105 ppm (Bittersohl, 1971); Pulmonary edema: 1,700-4,500 mg/m3. Low levels: no permanent adverse health effects (EPA, 1977). Leaf damage in sensitive plats: 8 – 12 ppm for 4 hours (Benedict et al, 1955).

Ammonium Bisulfide (NH_4HS). Penetrates the skin more rapidly than hydrogen sulfide. Since it is an inherently unstable solid, it readily dissociates back to hydrogen sulfide and ammonia gases.

Ammonium Sulfate ($(NH_4)_2S0_4$). Toxic to plants (Malloch et al, 1979; Sharp, 1976).

Anthraquinone Disulfonic Acid, ADA. No health effects from its industrial use have been reported (PG&E, 1979). Toxic to fish: 3 gms or more per liter of water (Ralph M. Parsons Col, 1975).

Arsenic (As). All forms of arsenic are toxic at various levels; some are potentially carcinogenic (Lee and Fraumeni, 1969; Tseng et al, 1968; Lander, 1975; NIOSH, 1975). Odor threshold: 0.50 ppm (Amoore et al, 1983). The fatal dose is 70-180 mg/m3.

Benzene (C_6H_6). Causes blood disorders including anemia and leukemia (Layton et al, 1981). Odor threshold: 12 ppm (moore et al, 1983).

Boron (B). Data related to humans are limited. Several forms of Boron are irritants to skin and mucous membranes. Ingestion of 15-20 gm of borax caused acute poisoning. Boron particulate fallout damages plants (Malloch et al, 1979; Sharp, 1976). Exact levels are not given but, for comparison, irrigation water with 10-100 ppm boron content is toxic to plants (Eaton, 1935).

Carbon Dioxide (CO_2). 2% in air can stimulate human respiration. Not considered hazardous when adequate oxygen present (Gennis, 1978). Odor threshold: 74,000 ppm (Amoore et al, 1983).

Chlorides. Not expected to produce adverse health effects (OXY, 1981).

Ethane (CH_3CH_3). A simple asphyxiant. No hazard known in well-ventilated environments (Gennis, 1978). Odor threshold: 120,000 ppm (Amoore et al, 1983).

Hydrogen Peroxide (H_20_2). Not expected to produce adverse health effects (PG&E, 1982).

Hydrogen Sulfide (H_2S). Odor threshold: 0.0081 (Amoore et al, 1983). Increased neurasthenic effects (fatigue, dizziness, nausea) with long-term exposure: above 0.1 ppm. Eye irritation threshold: 10 ppm. Inhalation irritation threshold: 50-100 ppm. Sense of smell stops: 150 ppm. Fatal: 700 ppm. Damage to sensitive plants: more than 0.30 ppm (Thompson, 1976); 40 ppm for five hours (McCallan et al, 1936).

Mercury (Hg). The human lung absorbs 75-85% at concentrations of 50-350 mg/m3, almost completely at lower concentrations (Kudsk, 1966). Inhalation produces many adverse effects. Mercury may also be absorbed through the skin or by ingestion. Elimination is slow, resulting in long-term effects, which are only partially reversible. Children appear to be especially susceptible (Britt et al, 1976**).** Methylmercury (CH_3HG^+), the most toxic form, may cause growth deformities (Walton et al, 1978). Inhalation of 100 ug/m3 can cause chronic mercury poisoning, of 1,200-8,500 ug/m3 can cause acute poisoning. Occupational exposure to 10-30 ug/m3 of elemental mercury may cause slight anemia, hypothyroidism and increased excitability. Prolonged exposure may cause neurological disorders (Walton et al, 1978).

Mercury is toxic to plants at levels in the parts per billion range over several days (Jacobson et al, 1970). Over 10 ppm dry weight in plant tissue is toxic.

Methane (CH_4). Odorless. Not known to induce ill effects even at high concentrations in ambient air.

Nitrogen (N_2). No known hazard from its increased presence in ambient air.

Nitrogen Dioxide (NO_2). Odor threshold: 0.39 ppm (Amoore et al, 1983). Irritation threshold: 1-4 ppm. Lethal: 50-300 ppm.

Radon 222 (222 Rn). Adverse health effects, including lung cancer, may result from inhalation of Radon-222 and its short lived, alpha-particle emitting associates (BEIR, 1972). There is at present no known level of exposure to radiation below which no biological damage occurs (Kestin et al, 1980).

Sulfur Dioxide (SO_2). Annual concentrations of 0.05 ppm (130 ug/m3) led to increased frequency of respiratory illness. The threshold for increased chronic bronchitis in adults and increased acute lower respiratory disease in children is 95-200 ug/m3 (EPA, 1974; 1975). Hospital admissions with respiratory illness increased when 24-hour sulfur dioxide concentrations were 0.12-0.19 ppm (Finklea, 1973). Odor threshold: 1.1 ppm (Amoore et al, 1983). Irritation threshold: more than 3 ppm (Case et al, 1977). 1-10 ppm (2,600-26,000 ug/m3) increased airway resistance in humans and other animals. More than 400 ppm caused death. 0.3 ppm for 8 hours is toxic to plants (Gauch et al, 1954).

Sulfates. Taste/odor threshold: 700 ug/m3. Irritation threshold: 350-2000 ug/m3. 10-3000 ug/m3 can cause illness (Case et al, 1977; Layton et al, 1981). Brief exposure to 700-5000 ug/m3 sulfuric acid mist (H_2SO_4) resulted in increased airway resistance.

Suspended Particulate Matter. The health effects of suspended particulate matter depend on the particle size and chemical composition. “No effects” threshold: 100 ug/m3 (Case et al, 1977). Morbidity threshold: 300-375 ug/m3 (DHEW, 1970). Mortality threshold: 200-750 ug/m3. Particles larger than 0.5-2 um diameter are usually trapped in the upper respiratory system and cleared in a few minutes. Smaller particles may remain in the body for months or years (Case et al, 1977).

Vanadium (V). Little evidence is available on the health effects of vanadium. At concentrations more than 50 ug/m3, insoluble vanadium compounds accumulate in the lungs and cause irritation (Babu, 1975). Large amounts cause toxicity and death (OXY, 1981). Toxicity of vanadium to fish depends on water hardness and can be fatal (Ralph M. Parsons Co., 1975).

[The above is from “Goddard & Goddard Engineering – Environmental Studies” pg. 44-46, Table 10 “Health Effects of Air Pollutants from Geothermal Development.”]

The above substances, in varying compositions and amounts, are released into the environment during construction, maintenance, and operation of geothermal power plants. During drilling and testing muds, oil, and geothermal fluids are collected in “sumps” at the site. The composite sludges formed from these contain numerous toxins and heavy metals, such as mercury. Geothermal sludges can pose a danger to workers, underground aquifers, area streams, lakes, and other water courses. Also at risk are plants and fauna dependant upon these areas for sustenance and habitat.

Gases are also released, with the most significant amounts escaping into the area atmosphere during initial drilling, testing, and periodic maintenance. In some plant designs during “stand by”, when the steam is still being pumped up form the reservoir but not utilized for production, there is direct venting to the atmosphere. Some plants at the Geysers have employed this method, though current practices utilize pollution abatement scrubbers. Well blowouts are another source of unabated geothermal emissions. A “wild well” located in the Geysers Wild Horse area, emits about 306,000 lb./yr. of hydrogen sulfide (8.2% of the Geyser’s total). Efforts to stop these emissions have proven unsuccessful. Uncontrolled blowouts have the potential to vent up to 55,000 lb./hr. of geothermal steam and its pollutants into the surrounding environment.

Hydrogen sulfide (H2S) is one of the more notorious toxins resultant from geothermal operations. It and lesser amounts of other sulfuric forms have been “broadly disseminated as aerosols across areas surrounding geothermal development, especially along lines of prevailing wind patterns. H2S becomes sulfur dioxide (SO2) through oxidation. Both forms are hazardous to plant and animal life. Varying amounts of these and other pollutants listed in the preceding chart are released into the atmosphere.

Current Emissions Regulations: *Loopholes of Harm*

While H2S emissions are regulated, required to be no more than 0.03 ppm, provisions exist that weaken this requirement. First, while drilling, geothermal contractors are permitted to vent up to 500 ppm of H2S into the atmosphere. This is 5 to 10 times above the inhalation irritation threshold and over 1,666 times the level at which H2S causes damage to sensitive plants (0.30 ppm). The fatal exposure level for H2S is 700 ppm, however, concentrations above 500 ppm can result in respiratory paralysis leading to death. Only if emissions are found to be above 500 ppm, are contractors required to notify air pollution control districts, after which they have twenty-four hours to act before they need to either close the well or install air pollution abatement equipment.

Yet another loophole is permissible sulfur dioxide (SO2) emissions levels. H2S gas oxidizes in a 12 to 18 hour period becoming SO2 as it is exposed to air. The permissible limit for SO2 is up to 1000 ppm, yet over 400 ppm of SO2 can be fatal. The irritation threshold is only 3ppm, respiratory irritation occurs at 1 to 10 ppm and 0.3 ppm for 8 hours is toxic to plants. This calls into question who these permissible levels are intended to protect? The surrounding environment, workers, community, and animals – or the uninterrupted economic production interests of geothermal commercial ventures? Why are these permissible levels set 2 ½ times higher than the level fatal to human life? Why are they set over 3,333 times higher than the level toxic to surrounding plants?

At the Geysers, however, these permissible levels have not always been high enough. In 1982 a petition for a variance from complying with the 1,000 ppm SO2 emission standard was filed by Pacific Gas and Electric Co. Apparently during plant start up operations, which involves direct atmospheric venting (in systems other than binary), it was deemed necessary to exceed this limit. SO2 , in addition to being toxic and potentially life threatening – especially at these “permissible” levels – is also a major component of acid rain. As it combines with cloud or ground moisture, it converts to sulfuric acid.

Within the geothermal fluids, concentrations of the different pollutants vary. Total dissolved solids contained within these fluids vary as well, from several hundred ppm to over 350,000 ppm. Particles of these toxic chemicals are carried from the geothermal emission source, rising with the prevailing wind currents. Those particles, ranging between 5 and 15 microns, generally fall out within 1 to 5 miles. Between .5 to 5 microns they remain airborne for longer periods, allowing chemical reactions to occur changing the nature of the substance (H2S to SO2 to sulfuric acid). Smaller particles ranging from .1 to .5 microns or less remain airborne “indefinitely.” These particles can enter the body through the respiratory system. Those less than 1 to 2 microns can penetrate deep into the respiratory tract and are readily absorbed into the blood stream through lung tissue. Some of these substances, such as mercury, accumulate without being eliminated. Hydrogen sulfide emissions tend to be in the penetrating smaller-size particles.

Polluting to Clean:

Air pollution abatement systems have been implemented in geothermal plants, including the Geysers. To lessen the H2S emission levels, Hydrogen Sulfide is oxidized into elemental sulfur and water, which is then incorporated into sludge. A National Institute of Occupational Safety and Health (NIOSH) analysis of geothermal sludge revealed sampled compositions to be 63% sulfur, 19% iron, 17% oxygen, with the remaining 1% containing over twenty mineral and metals in trace quantities. However, to achieve the "safe" emissions levels that have been found in tests by NIOSH and three major independent environmental and health firms the Geysers uses 'thousands of tons" of toxic chemicals. Vanadium pentoxide is among those used in a scrubbing process to reduce the levels of arsenic, H2S, and other suspended particulate matter to government regulated standards for atmospheric emissions. Toxic "cleaning" chemicals have been associated with cases of workers' illness and acute toxic exposures.

The "Creeping Geysers Crud" & Debilitated Health

Workers at various geothermal facilities have experienced severe health impairing consequences from geothermal emissions exposure. Abnormally high occupational incidences of heart attacks, respiratory ailments, major liver damage, bodily disfigurement, lung scarring, pulmonary disease, high blood pressure, and damage to various internal organs have been reported. Workers have experienced bloody noses, chronic coughs, and other respiratory problems, headaches, stomach ailments, eye irritations, sluggishness, dizziness, vomiting, and a persistent skin rash they've named the "creeping Geysers crud." Doctors, including Dr. Philip Rasonri of Healdsburg, Ca, have concluded the symptoms workers have experienced indicate short-term chemical poisoning. In an eight-month period Dr. Rasori treated about thirty-five workers for illnesses caused by brief acute over exposure to toxic chemicals. In 1984 30% of significant work related injuries reported on the job were respiratory ailments. Complaints have been filed by various Geysers geothermal workers, some seeking compensation for what has been diagnosed as permanent work related disabilities. One former employee has developed a rare form of asthma, dehydration, pneumonia, and a chronic cough requiring medication. A geothermal electrician suffers from permanent disability from liver damage due to cumulative exposure to toxic chemicals while employed at the Geysers. Another worker, a former power plant mechanic, reportedly developed a chronic rash, bronchitis, acute cough, and "an anal fistula which had to be surgically removed." Two unions, local 342 of Concord and local 38 picketed and initiated legal action as a result of health and environmental concerns. In another lawsuit, a Geysers' drilling rig worker charged that Loffland Brothers Co. Inc., a drilling company, used geothermal "plant waters" containing various toxic and hazardous substances to wash down drilling rigs; including arsenic - a known carcinogen and skin irritant. The worker was fired, apparently as an example to other employees, when he complained of a bodily skin rash from the "plant water."

Ratios of Evasions

In 1978 NIOSH found that an "unknown toxic agent" occurring within geothermal steam or used to control pollution emissions was causing skin rashes and respiratory problems. In a more recent study in the mid 1980's by the California Occupational Safety and Health Administration (Cal-OSHA), deposits of arsenic and vanadium dust were found after a malfunction in the steam cleaning process. The arsenic tests showed concentrations of 430 ppm – over two times the state's safety standard. Vanadium, for which test results showed concentrations of 4,200 ppm, had no set safety standard, though it is a known toxin. While cleaning up a chemical spill resulting from the malfunction, twenty-four workers developed nosebleeds, nausea, and other illness symptoms. Of these 13 were unable to work for "an average of two weeks."

In 1980, NIOSH conducted an environmental and medical survey at the request for a health hazard evaluation by Geyser's employees' union IBEW local 1245 in Healdsburg, Ca. Workers were concerned with a high incidence of heart attacks, high blood pressure, fatigue, and respiratory as well as digestive problems. The NIOSH report however, dismissed the workers' concerns, especially as to heart attacks, by claiming that the five heart attacks that occurred were the normal amount to be expected with the size of the worker population. Apparently the circumstances in which the heart attacks occurred were either not investigated or were otherwise omitted from the report. NIOSH determined the average population to heart attacks statistical ratio to be sufficient as an answer to worker concerns. Independent communication with a former employee however, told of heart attacks occurring simultaneously or shortly after acute exposure to high levels of geothermal steam containing H2S. This issue was not sufficiently investigated and addressed.

Chronic Exposure

The cumulative effects and likelihood of synergistic reactions of the various toxic emissions and chemicals generated or used during geothermal energy production need to be adequately investigated and responsibly addressed. Short-term acute exposures have resulted in debilitating illnesses. Chronic long-term exposure may result in far more serious health-damaging consequences. More research, conducted independently of government and industry sources if possible, is needed to fully understand the extent of the hazards posed to the health of workers, their families and offspring, as well the surrounding area residents.

Periodic Devastation

Area environmental studies have fared no better for the prospects of geothermal's ecological viability. Livermore National Laboratory conducted a five year study on geothermal production in the Salton Sea area, concluding:

> "the Salton Sea will turn even saltier, the air will be polluted with noxious gases, the valley will sink due to hot brines drawn up from underground, and inadvertently spilling of salt laden fluids unto surrounding farm lands."

A publication by the Northwest Power Planning Council entitled "New Resources Supply Curves and Environmental Effects" (Feb 28, 1989, pg. 35) in its section on geothermal energy production states:

> "Production of Electricity: Impacts of production affect the air and ground water. Hydrogen sulfide, a toxic substance with the odor of "rotten eggs" is produced, although it can apparently be controlled. Mercury, boron, and radon gases appear in trace amounts and ammonia, methane, carbon dioxide and argon result from the air ejector system and the cooling system. Recently reports from California say that whole crops have been destroyed by periodic emissions from geothermal plants. The airborne emissions have fallen on crops destroying the crops and contaminating the ground."

The California Energy Commission, in 1981, studied the chronic effect of Geysers emissions upon local vegetation. While H2S emissions were recorded as low, acid rain and boron salts from the geothermal plant spread over "considerable distances." This caused vegetation losses to a "long list of California's native trees." Another study, in 1979, found that plant stress and damage from boron affected an area of 247 acres. Climatic induced change by steam emissions increased the air temperature, cloudiness and humidity of the area. This induced change has been shown to be responsible "for fungal disease and branch die off in black oaks" at the Geysers.

Swarms of Seismicity

One of the major 'faults' with all geothermal plants is that they are almost always located directly above or very near a fault. By its nature geothermal occurs in technically active areas. Power production practices of re-injection, serving both to dispose of toxic geothermal fluids while at the same time helping to replenish and somewhat prolong reservoir use, have been linked with induction of seismic activity. Studies conducted by scientists with the U.S. Geological Survey concluded that geothermal power production induces seismicity. One of the possible means is that re-injection of the spent fluids, which is generally done at a deeper level than the original tapping well, lubricates the different fault line plates as well as altering the pressure upon them, causing them to "slip." Another theory is that tapping the geothermal reservoirs depletes the pressure built up underground causing the plates to shift. Perhaps both of these factors work synergistically to cause minor quakes of 3.5 to 4.0 on the Richter scale. The Geysers area has experienced quakes of these magnitudes that have been associated with geothermal production. Geothermal production areas in Mammoth Lakes, California have also experienced "swarms" of quakes. Studies are ongoing attempting to further understand the correlation between commercial geothermal energy production and tectonic activity. One indicator has been notable land subsidence in the areas above geothermal reservoirs.

Aquifers, Tectonics and Toxicity

Possible stream, ground water, and aquifer contamination are additional environmental problems resulting from geothermal production. Toxic contaminant harms can occur through mishaps in production processes, as well inherent potential due to the complexity of geologic features and production requirements. Reinjection is one danger area wherein potential exists for fluids to enter an underground aquifer. Another is that of well pipeline rupture or other production fluid leakage. Fluids could escape and enter area streams and ground water, poisoning aquatic fauna and area plants. To counter this, the plant at Mammoth Lakes has spill containment basins, dikes, gates and shut off valves. However one fault of all these systems remains the potential for a major quake, which is especially high in these tectonically active areas, occurring sometime with in the projected 30 years use-time of the plant. Speculation remains despite industry assurances to the contrary, that "fail safe " spill prevention systems remain as fragile as glass built upon a herd of sleeping buffalo. The large quantity of fluid flowing through the pipes (at Mammoth it is 300,000 gallons per hour) coupled with the possibility of the structural integrity of the facilities, spill containment ponds, dikes, and gates being compromised by the force of a quake - where these are no longer able to fulfill to their intended function; the potential for ecological disaster is relatively high. Generally the industry operates under the assumption that plant personnel will be able to respond to leaks within minutes. In an emergency situation this may be very likely prove implausible. If gates are so damaged they cannot shut, and/or dikes are breached, geothermal fluids with all their toxins would f low unabated into surrounding area waterways, soils, and aquifers.

Yet another probability of ground water contamination exists: geothermal sludge. Geothermal sludge is composed of geothermal fluids, oils, and drilling muds; containing sulfur compounds as well as arsenic, other toxins, and heavy metals. Sludge is stored in sumps on the site, which could potentially fail contaminating surrounding streams and ecosystems. Plans to solidify sump contents, becoming part of the soil or subsoil ignore the long-term effects of the release of geothermal sludge's toxic components through erosion and precipitation.

Abandoned unreclaimed geothermal sump sites, such as the Cal Energy exploration sites on Deschutes National Forest lands near Newberry National Monument that have been left abandoned and unreclaimed for well over a decade, can become compromised over time, leaching potentially toxic compounds into the soils, ground waters, and aquifers. Additionally, the Cal Energy site holds seasonally standing water open to wildlife, with tracks of deer, birds, and mammals evident in its edge-water muds.

Renewable Depletion

Under current energy production demands, geothermal viability as a "renewable, sustainable" energy source is largely a phantom whose myths have come home. Plant construction is expensive, with a 20MW plant estimated in 1990 to cost approximately $38 to $50 million dollars. These costs are considerably higher today as both a consequence of growing inflation and the devalued dollar, as well as higher technological and construction costs. For example, geothermal exploration wells being drilled at central Oregon's Newberry Monument area sites in 2008 reportedly cost between $5 to $7 million each, with 9 to 10 test wells permitted and no guarantee that a feasible production source will be found or that a production plant would be permitted.

Production plants are projected to have a "use time" of thirty years. Yet this projection is not always consistent with reality. The volume of fluid pumped from underground reservoirs is immense, such as Mammoth's 300,000 gallons per hour. At the Geysers as of 1990 there were already indications of reservoir depletion. Steam pressure had decreased 20 percent since 1987 and was expected to drop by half that in the next 10 years. The actual use time of these plants may in reality be only 10 to 15 years - only half of what was originally projected. Even Mammoth, which became operational in November of 1984, began showing signs of depletion by 1990. At this time, hot springs in the immediate area had dried up and land subsidence had occurred. But whether geothermal reservoirs can last ten or even forty or more years, they are not truly sustainable. The current methods of energy production require too large a volume of reservoir fluids. Depletion at such rates eventually is inevitable, with reservoir renewal time estimated to be considerably longer than the production use time of approximately 30 years.

Opposition to Geothermal: Hawaii's Puna

In 1990, plans to construct a major geothermal plant in a Hawaiian rainforest resulted in considerable environmental opposition. The proposed area, near the Puna volcano, has a geothermal fluid H2S content six times that of the Geysers, at 1,300 ppm concentration. The area is one of extreme geological instability. Yet the project was being pushed through by big industry with government help. The unstable nature of the volcanically active area is a cause of significant concern. The area first being considered for geothermal production was inundated by new lava flows following test drilling. The lava covered 25,000 acres destroying former rainforest and burying the original proposed geothermal site. Many of the Hawaiians feel that the volcanic lava flows were triggered by the drilling of geothermal wells. The government response was to "trade" 27,000 acres of public rainforest trust lands to the geothermal development company in exchange for the lava covered devastated lands. The area traded is the "last original rainforest within the U.S." It was to be held in public trust to protect the native Hawaiian plants and fauna as well for public use. However the public is now forbidden entrance.

Some of the initial Puna test wells had to be suspended when workers tapped into volcanic lava tubes and attempts to plug geothermal leaks through the passages were unsuccessful. Being able to regulate dispersal of reinjected geothermal effluent as planned may prove implausible in these areas. The "highly fractured" nature of subsurface formations also carries the potential for contamination of ground waters aquifers. Well bores are equipped with casings cemented to the subsurface formations designed to prevent this. However fractures within the formations put stress upon the cemented castings and can result in their failure. By 1990, three of the area wells had already experienced leakage from casing failures. A casing leak at ground water level was found in one of these wells in addition to two other leaks at split and separated casings. This leakage was occurring very early in this planned geothermal plants' projected operating time of thirty years. The likelihood of more leaks due to stresses on cement bonds over time is significantly greater. The development of geothermal energy production in such an unstable volcanically active geological area carries the potential for ground water contamination and severe impacts upon the health of the surrounding environment.

The danger to the rainforest and its fauna from geothermal's toxic emissions is considerable. H2S emissions oxide into even more phytotoxic S02 in about twelve hours. This is released as sulfuric acid in acid rain and suspended in acid fog. Short-term effects hit young, rapid growing plants, those growing in drier soils, and the more sensitive species hardest. Long-term chronic acidification of the surrounding area, and the resulting imbalance of the natural soil chemistry can threaten the survival of the entire area's ecosystem. The toxic effect on area plants from the H2S, S02, and boron, with the absorption of these into plant tissues, will likely result in the mortality of many plant species. Cumulatively, these dangers are further augmented by the area's natural volcanic emissions.

As of 1990, from the initial drilling phase of geothermal construction, Puna's area residents had experienced: burning nasal passages, mucus discharges of eyes and nose, burning eyes, screaming noise, constant headaches, respiratory problems, bronchitis, asthma attacks, ear infections, and a burning rubber smell. Arsenic, mercury, hydrogen sulfide, selenium, hydrogen selenite, and sulfur dioxide were expected to become present in increasing concentrations within the area's ambient air. Two of the substances are known carcinogens (arsenic and selenium) and another is a "co-carcinogen" (sulfur dioxide), bringing higher risk of cancer to geothermal plant workers and area residents. Children, elderly, people with chronic illness, pregnant women, and "men anticipating fathering children" will be most affected. Some of the potential harmful health impacts include adverse affects upon the central nervous system, the gastrointestinal system, the respiratory system, kidneys, peripheral nerves, etc. These impacts affect not only humans but the rainforests fauna as well. Some of the smaller species, due in part to less body weight, have less tolerance for these toxins and are affected more severely - in the long run threatening their ability to survive.

In addition to the dangers inherent within the potential release of geothermal fluids and emissions, there are the dangers posed by fragmentation of the forest. Due to plant site clearing and swaths cut through the rainforest for power transmission lines (expected to average 500 acres for 25 MW) it is feared that non-native species will invade these cleared areas, displacing native plants, insects and fauna. Many of these native species are found nowhere else on earth. Fragmentation threatens their survival and the rainforest's viability as a functioning eco-system. During 1990, local and international opposition to this plant's construction resulted in a series of public protests and related arrests. While native Hawaiians and conservationists struggled to halt the plant, the Hawaiian government and industry, motivated by projected energy and profits, chose to ignore the growing evidence of ecological and human health harms.

Philippine's Mt. Apo

In 1990, Mt. Apo in the Philippines was another site for a geothermal plant being opposed by area residents. The plant was planned within a park regarded "as one of the richest botanical mountains in the region. It is also the last major habitat for the endangered Philippine eagle. The area known as the Bac-Man Project planned thirty or more geothermal wells. Stack source measurements for H2S emissions found 990 ppm; 290 ppm over the fatal threshold limit, and many times the 40 ppm for 5 hours damage to sensitive plants. Well sites are expected to significantly impact the area's forest; disturbing natural habitat and adversely affecting the region's fauna's ability to survive. Another geothermal project, the "Southern Negros", released spent drill fluids, injuring fish and shrimp within the area's river. Effluents containing arsenic are projected in quantities that pose a danger to aquatic fauna. Gayong River's health as an ecosystem has declined rapidly since the drilling started in the early 1980's. By 1990 it appeared to be "close to the point of biological death." Long-term operation of planned geothermal plants is expected to result in the cumulative build up of heavy metals and other toxins in the area's rivers and seacoast. The consequent absorption of geothermal toxins into the food chain would adversely affect the fishing-dependant coastal population, as well as the fish themselves. Area farmers are also expected to suffer from geothermal toxic emissions, many of which are harmful to plants. As in Hawaii as of 1990, local oppositions to these projects was considerable.

Mammoths of Extinction?

Mammoth Pacific, a plant the geothermal industry cites as ecological clean, has had significant local opposition as well as adverse environmental impacts. It is located within a forest recreation and hot springs area. Considerable concerns for area streams and creeks, as well as a local fish hatchery, were raised. Local groups and the Sierra Club Legal Defense Fund of California were involved in the opposition. Potential long-term harmful effects (as addressed earlier) on the area's environment remain. Problems exist with environmental impacts from periodic maintenance, the potential for earthquakes, as well as leaks and the high permissible emission levels of S02.

"Green Energy?"

A non-profit conservation organization in California has stated "the only thing green about geothermal energy production is the money." Painting large industrial scale production plants green, and attempting to blend these huge facilities into the surrounding landscape, while more aesthetically desirable perhaps, is tantamount to taping cosmetic bandages over unhealed bleeding wounds – unless environmental harms are addressed and prevented. Despite all the available information on the toxicity of geothermal energy production, government subsidized industry promotion and development continues which largely fails to adequately disclose and address geothermal energy production's known harmful environmental and human health impacts. Geothermal proponents continue to write glowing reports on its increasing economic viability while down playing or ignoring ecologically harmful impacts. The industry has gone so far as to begin claiming that geothermal energy is "green energy," comparing its impacts to that of coal powered electrical production plants. While, depending upon which toxins and environmental impacts are addressed, geothermal may appear more "green" than coal, such allusions are akin to comparing a murderer to a batterer and calling the latter "socially responsible" as their harms are less reprehensible.

Comparisons with Coal

Societal desires for the replacement of coal powered energy production are important and valid, given all coal energy's known direct and indirect environmental and health harms. But coal use for energy production has been ongoing since the advent of electricity. Its impacts have grown both exponentially with the rise of societal electrical energy dependence, and cumulatively over time. Pollutant emissions, acid rain, hazy skies, impaired health, and the impacts of widespread coal mining have increased significantly over the decades of industrial societies use of coal. The small scale geothermal plants of today may initially appear far more benign than coal, however they are not without their own inherent harms. As a society, we have a responsibility to protect and restore living Earth's natural ecosystems, and provide for the health and well-being of current and future generations. We must comprehensively and realistically address the full impacts and long-term repercussions of geothermal energy production – well before this path is taken. It is essential that we do not repeat the mistakes of the past with our use of coal or for that matter nuclear, merely replacing known environmental harms with yet new ones to come.

Reigning in Societal Energy Excess

Additionally, as a society we need to reign in our ecologically harmful excessive energy demands, learning to live in better harmony and care for our natural environments. Wasteful resource and energy use; inefficient building designs; excessive and needless production and consumption; and inferior products with short use-life; account for a significantly high proportion of current energy use and growing demands. Exponentially expanding human population growth continues to add untenable stress upon the Earth's environments. By beginning to effectively address these serious energy uses, needs, and impacts we can better meet real energy and resource needs, while ensuring viable natural environments and a healthy quality of life for current and future generations.

Similarities with Early Wind Power

Similar to wind power in its early stages of development, when structural designs, location, and blade speeds resulted in unacceptably high numbers of avian species deaths and injuries, geothermal must first responsibly address its actual environmental impacts. Similar to wind power, it may be that improved technological advances and designs could significantly reduce large-scale geothermal energy production's harms to more acceptable levels.

At present however, as with other proposed alternative electrical energy production methods, ecological viability is being sacrificed for economic feasibility, excessive energy demands, and industry profit desires. Public funds and lands are increasingly in danger of being misappropriated and misused to further industrial energy production goals over environmental responsibilities.

Towards Ecologically Responsible Common Ground

As the perceived need and varied societal proposals for geothermal production development are already underway, the following can help establish ecologically and legally responsible common ground.

The Need for Meaningful Public Involvement of Affected Communities

Interested and concerned citizens, area residents, state agencies and local governments, and members and staff of regional non-profit conservation organizations within the affected geographical scope of proposed geothermal energy production projects must receive sufficient advance notice and adequate information to reasonably and meaningfully participate in sighting, environmental analysis, and decision-making processes. It is important that citizens have the opportunity to comment and meaningfully participate in analysis and decisional processes regarding geothermal energy production proposals, their impacts and related issues.

The Need for Involvement of Appropriate & Affected Management & Oversight Agencies

Not only should both federal and state Department of Energy offices be involved in geothermal production proposals, but additional federal and state agencies as appropriate should review and participate in proposals. DOE expertise is relevant primarily to energy production related portions of geothermal proposals. As the analysis of geothermal impacts, and selection of acceptable and appropriate locations, affects natural ecological resource concerns throughout the regions involved, additional federal and state agencies with management jurisdiction and oversight on potentially affected natural resources, including aquatic, terrestrial, avian, and botanical biodiverse ESA listed species and species of concern, must also be included and consulted during geothermal environmental analysis processes. USFWS must be consulted regarding potential impacts to federally ESA listed species and recovery plans for these species and other species of concern. National Oceanic and Atmospheric Administration (NOAA) must similarly be consulted and included in this process (salmonid species populations, and current and historical habitat, exist in many regions where geothermal production has been proposed. The EPA, which addresses atmospheric emissions, environmental pollutants, and water quality issues, regulations, and concerns must similarly be involved in this interagency process. Additionally, as this process and subsequent impacts will affect state natural resource management plans and concerns, including affected state-listed biodiverse species and recovery plans for these species, as well as state environmental quality requirements and concerns, appropriate state agencies must also be involved and consulted in this process. In Oregon this would of necessity include the ODFW and the DEQ, among others. Similarly, appropriate oversight agencies in affected states must be included in assessing geothermal proposals in their territories.

Additional Ecological and Legal Considerations

Geothermal energy may not be a panacea helping to solve current societal energy production dilemmas and problems. However, assessed comprehensively and used responsibly, geothermal energy production may have a significant contribution to make in helping resolve current energy issues and needs.

Geothermal Projects:

- Geothermal resources are often associated with significant surface features such as geysers, volcanoes and hot springs with scenic, cultural, and flora and fauna diversity value, and tend to be in ecologically sensitive areas.
- The need for surveys: in addressing specific geothermal resource sites, responsible agencies must also assess and disclose site-specific resource issues and concerns. Proposed exploration areas must be surveyed for biodiverse ESA listed species and regional species of concern, and these must be disclosed in a public NEPA process. Direct, indirect, and potential impacts to these species must be addressed.
- Geothermal energy production processes can also require sizable sources of water, affecting aquifers and area environments over time.
- Documented evidence of significant harmful impacts upon natural environments, human communities, aquifers and watersystems, and agricultural operations underscore the responsibility of federal and state agencies to responsibly and carefully assess site impacts and acceptability.
- Efficient transmission of electrical energy produced at geothermal plant facilities requires either existent power transmission line systems or the opening of new power line routes and construction.
- Geothermal energy production can have significant short and long-term regional and site-specific environmental impacts. Consequently, agency analysis procedures and criteria employed to assess environmentally appropriate and socially acceptable location issues for geothermal energy exploration and production are crucially important.
- Proposed geothermal exploration and test drilling irrevocably alters and often degrades public lands in and surrounding the project area(s).
- Exploration drilling directly impacts and irretrievably alters natural ecological conditions and functioning at and adjacent to geothermal resource sites.
- Geothermal exploration and production requires significant irretrievable commitment of natural resources, among these are:
    a. road construction and/or road reconstruction, including widening road beds (usually to a minimum of 14 feet width), adding turnouts, and reconstruction improving curves for associated large trucks and heavy equipment.
    b. Construction of well pads, holding ponds, waste and storage areas, equipment and personnel areas, etc. Well pad sites for exploration purposes are often approximately 5 acres or more in size, with ongoing exploration often requiring the establishment of several well pad and related management sites.
    c. Production plants can require significantly vast areas, irretrievably altering natural ecological appearance and functioning in and adjacent to production sites.
    d. Power transmission routes and associated construction of necessity accompany energy production. If transmission routes are not already established in the resource leasing area, efficient location of additional routes would have to be assessed as part of this process.
    e. If geothermal development is not to irretrievably alter, degrade, or fragment existent inventoried and uninventoried roadless areas and areas of significant ecological, recreational, and/or community concern; direct, indirect, and cumulative impacts resulting from geothermal leasing, exploration, and production development and energy transmission must be thoroughly assessed for each site-specific project, with management direction and decisions based upon protection and retention of ecologically significant natural resources and related priorities and concerns.

- Exploration construction (well pads, roads, holding ponds, related features) is often ongoing for extended periods of time, covering many months or years. Drilling often requires two or more months of continuous operation to complete each exploratory test hole, often occurring ceaselessly 24 hours a day throughout extended periods of time. Impacts to human recreational experiences in affected public lands natural environments, including the impacts of construction and related noise upon the solitude, peace, and tranquility of nature, as well as impacts to biodiverse native species and natural habitats, must be addressed, with protection provided ensuring public lands are not unduly degraded, and that natural recreational experiences are not harmed.
- Overall, proposed exploration construction and test drilling can run anywhere from months to years to complete, with incessant drilling noise, construction, and associated impacts, including often unchecked highly toxic emissions from exploratory test holes.
- Exploration, to varying degrees dependent upon geologic subsurface structure, geothermal pressures, and localized tectonic activity, inherently includes the risk of well blowouts, which often have proven to be unstoppable, resulting in ongoing highly toxic emissions.
- Well blowouts elsewhere have resulted in highly toxic emissions of hydrogen sulfide and other dangerous pollutants that continued unabated for years (as occurred at Geysers California, among other locations).
- Geothermal resource areas are often geologically active and tectonically "young," with pumping of geothermal fluids known to result in shifting subsurface pressures, subsidence, and increased tectonic activity. Geothermal production can alter subsurface geothermal fluid flows, and research concludes it can induce seismic activity, including "swarms of small earth quakes."
- Geothermal exploration and production over time across the region can incrementally cumulatively substantially alter and degrade a significant extent of the nation's natural public lands environments.
- Geothermal exploration represents a considerable financial expenditure of resources that could not be reasonably recouped without the eventual approval, construction, and decades long operation of related geothermal production plants. NEPA analysis for proposed geothermal exploration must not be segmented from the full impacts of geothermal production. Impacts for proposed exploration projects and must be fully assessed in conjunction with the environmental impacts of production, as well as the cumulative impacts of related and geographically proximate management actions as well.
- Wilderness areas, Wilderness Study Areas, Research Natural Areas, Roadless Areas (inventoried and uninventoried), National Monuments, Wildlife Refuges, popular recreational areas, areas of significant ecological values, habitat location areas for ESA listed species and biodiverse native species of concern, and areas near human communities and residences are likely highly inappropriate for geothermal exploration and production activities, and as such should be administratively withdrawn. Federal regulatory and management agencies must responsibly develop management analysis and decision provisions ensuring the prioritization and protection of these above areas of ecological significance and concern. In particular, responsible agencies should identify potential land-characterized policy approaches that would provide for "protected areas" and "restricted areas" where geothermal development is either off limits or permissible only with the most stringent conditions and monitoring.
- Federal laws require the agency assess the ecological appropriateness, or lack thereof, of proposed geothermal exploration and production sites, including direct, indirect, foreseeable, and cumulative impacts. Areas where actions could result in significant harms to the environment should be withdrawn from geothermal exploration, production, power transmission, and related actions.

- Federal policy laws require the agency hold public hearings in affected communities and regions on proposed geothermal projects. Provisions for meaningful public notice and involvement must be made for all proposed site-specific project areas.
- Federal policy laws FLPMA and NEPA require BLM and the USFS conduct a joint inter-agency EIS for proposed geothermal projects on USFS administered public lands, assessing the full impacts of geothermal power production in affected areas as well as the impacts of exploration and test drilling (as noted above these may not be segmented into separate analysis processes).
- Federal policy laws and judicial caselaw prohibit analysis segmentation of geothermal projects, preventing such projects from being implemented piecemeal, incrementally irrevocably altering and/or degrading affected proposed geothermal locations.
- The comment timeline for proposed geothermal production must responsibly provide for sufficient timely public notice.
- The public environmental assessment process must disclose and address the full range of significant issues, environmental impacts, and concerns. BLM and participating and affected federal and state public lands, environmental and oversight agencies need to provide for meaningful public involvement, an adequate public comment period, and conduct public hearings in proximity to geothermal resource areas, with adequate public notice throughout the affected regions of this nation.
- The notice of intent to conduct an EIS or an EA for geothermal production projects must be published in the federal register, and published in notices and articles across the greater affected region's community newspapers.
- Federal courts have affirmed the responsibility and ability of federal agencies to uphold the intent of Congress by basing their approval or denial of proposed exploration projects on public lands in part on whether the minerals exploration and/or operation would result in unnecessary or undue degradation to public land (referred to as UUD). This standard allowing the withdrawal of subsurface resources from exploration and development to protect natural resource concerns and human communities, must be applied to agency management options across all public lands.
- BLM and the USFS must develop provisions directing decision-makers to wisely deny geothermal exploration and development where natural resource and human community concerns clearly take precedence over proposed geothermal plans, either by withdrawing affected areas from subsurface exploration, by a UUD-type determination, or other responsible provisions, thereby protecting the ecological integrity of natural ecosystem's and surrounding human communities as necessary.
- Development throughout the greater region has already resulted in the loss, degradation, and fragmentation of significant areas of wildlife habitat, including corridor habitat. Direct and cumulative impacts on a landscape scale to connectivity for biodiverse species, especially far-ranging terrestrial, aquatic, and avian species, and to natural ecosystem functioning and integrity must be addressed in assessing geothermal production proposals.
- Direct, indirect, and cumulative impacts to archeological and cultural resource areas must be addressed in proposed geothermal projects, with provisions incorporated protecting significant known, suspected, and potential sites from adverse harm and undue disturbance.
- There is a need to list all studies, maps, GIS layers and other resources being used by BLM/USFS in addressing geothermal development proposals.
- Geothermal testing and production can result in the direct and indirect release of dangerous quantities of highly toxic emissions into the atmosphere, and can result in contamination of surface and subsurface aquifers with dangerous toxins. Proposed projects must fully disclose and assess these potential impacts – including those resulting from proposed testing and exploration, during which period geothermal site explorations can cause substantial severe harms to area ecosystems, aquifers, and atmosphere, as well as result in severe harms to citizens and the human environment.

- Seasonal fires are common throughout substantial areas of western states public lands ecosystems. Geothermal analysis must address potential severe fire impacts to geothermal drill and production sites, including the potential impacts that may result in the unplanned release of dangerous toxic emissions.
- Similarly, tectonic activities in this geologically active area are not uncommon. Proposed projects must assess and disclose potential impacts of increased tectonic activity associated with geothermal exploration and production upon the sites themselves, including unchecked toxic emissions, and cumulative impacts upon the greater region.
- Significant social, political, and recreational issues exist with proposed exploration and production of geothermal resource areas. These issues are of great concern to affected communities, as well as many of the nation's and world's citizens who visit the region's public lands for recreation and natural inspiration. Proposed projects must fully address geothermal exploration and production issues and impacts upon public lands as related to recreation and the enjoyment of natural ecosystems.
- Much of the western U.S. is internationally recognized as the heartland of numerous indigenous peoples cultural heritage sites. Many western public lands areas are world renowned for their indigenous historical and spiritual significance. Proposed projects must address the direct, indirect, and cumulative impacts of proposed geothermal explorations, and related production, upon significant historical and spiritual heritage sites throughout the western region.
- Federal environmental policy law requires that members of the public and the decision-maker have adequate and accurate information necessary to make an informed decision before a proposed project on public lands may be approved. Federal law clearly requires that proposed projects such as the test drilling may not be segmented from the proposed geothermal production with which it is inextricably tied, but must instead be addressed in one comprehensive NEPA/FLPMA EIS process. Proposed projects must incorporate and comply with the letter and intent of federal policy laws, ensuring project impacts are fully assessed and disclosed.
- Expediting backlogged geothermal lease proposals must not be done at the sacrifice of public lands ecosystems, native species biodiversity, or the well-being of human communities as well as the heritage of future generations.

Cumulative Impacts & Reclamation

Before any new exploration proposals can be considered, that may compound existent adverse cumulative impacts across affected regions, the following questions must be addressed:

1. What type of subsurface minerals and energy resource claims have been filed in proposed lease areas area, and by whom?
2. Have former minerals/resource claimants fulfilled their responsibilities to restore impacted claim-site areas?
3. Have claimants posted monetary bonds of a sufficient amount to compensate for the restoration of abandoned project claims and surrounding areas should irreparable environmental and/or human health impacts occur?
4. When there are unresolved reclamation issues, will current and/or future claimants inherit the responsibility to restore the area from past abuses? If so, what measures what measures will be required to complete needed restoration work? If not, who is responsible to ensure that the needed restoration is completed, and to pay the costs of this work?
5. Given the increased leasehold proposals and subsequent related oversight responsibilities of federal agencies, how do the agencies propose to effectively accomplish their responsibilities to oversee and monitor current and additional proposed geothermal operations, as well as other management oversight responsibilities (grazing, OHVs, mining, recreation, etc.). How do the

agencies propose to ensure required restoration is completed once proposed projects are terminated – or if a project(s) results in significant adverse environmental impacts, including unforeseen impacts that can be associated with geothermal exploration? What funding provisions for oversight, monitoring and reclamation enforcement will be included?

Regarding potential reclamation and restoration needs, in many locations there exist a poor track record of such reclamation ever occurring. Provisions in word alone, without adequate funding and enforcement mechanisms, have proven insufficient to accomplish essential reclamation. This is especially so for mining operations, however, there are also geothermal exploration well test sites that also have never been subject to reclamation. As reclamation of affected sites is required by federal environmental policy laws, proposed projects must include provisions for the financial and enforcement capabilities necessary to ensure this is effectively completed.

Forest Service & BLM Public Lands; Oversight and Responsibility

As part of the responsibility entrusted in both BLM and the USDA-Forest Service, by Congress and the public, to steward national forest public lands, it is requisite common sense that before the agencies would approve proposals, or sign contracts, they would first conduct research into the legality and environmental track records of business ventures and individuals seeking to operate on, or otherwise impact public lands resources. As the first responsibility of federal agencies is to the public's best interest on these lands, information from this research must be disclosed to the public (as is also required by federal policy laws). Federal agencies must address this significant issue for all proposed geothermal production projects on, or affecting, public lands.

From Hot Springs to Heated Homes – Geothermal's "Green" Future

Alternatives to hazardous uses of geothermal energy exist. Direct use of naturally available geothermal fluids for heating exists in Iceland, and within the U.S. at Breitenbush and Klamath Falls, Oregon. Such use does not require pumping huge volumes of geothermal fluids with the consequent presently inevitable release of their toxins into the environment. Instead, on a much smaller scale they tap into and direct geothermal fluids and steams that rise naturally from the earth, using it directly for heating or other localized purposes other than mass electrical energy production.

If geothermal is to have ecological viability as a truly renewable "green" energy source, it is first in such limited scale uses where this is found. As with other natural energy sources; designing systems compatible with the natural functioning of the environment is a priority. Viable systems should not substantially adversely alter ecological systems that have taken millennia's to evolve. Humans, with our limited understanding and shortsighted goals, have wreaked far too much havoc upon the environment around us. Geothermal can work by tapping into naturally flowing hot springs for direct use heating. Together with wind and solar thermal, or small-scale "free standing" hydro, direct-geothermal can be part of functioning localized "green energy" systems.

Geothermal cannot be considered sustainable or "green" by drilling, pumping and spreading huge quantities of toxins while depleting their source. If the geothermal production industry truly wishes to create ecologically responsible, sustainable, "green" geothermal energy production, the onus of research addressing environmental impacts and health harms, and developing ecologically acceptable benign production methods falls to them, their investors, and proponents. The practice of spending our children's futures to meet industrial societies' assumed needs has to appreciably change before this, acting synergistically with other ecologically harmful societal practices, further impairs the survival and quality of life of us all.

Footnotes:

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[i] **Renewable Energies,** P.D. Dunn, pg. 54-56 (**R.E.,** Dunn). **Staff Issue Paper: Geothermal Resources,** Northwest Power Planning Council, Oct. 1989, pg. 3 (**S.I.P.,** NPPC).

[ii] **Resource Assessment: Evaluation and Ranking of Geothermal Resources for Electrical Generation or Electrical Offset in Idaho, Montanan, Oregon, and Washington, Vol. 1,** Bloomquist et al, pg. 142 (**R.A.,** Bloomquist et al).

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