

EcoLogo^{CM} Program Criteria Review Certification Discussion Document

CCD-003: Electricity-Renewable Low-Impact
(D) GEOTHERMAL-POWERED ELECTRICITY

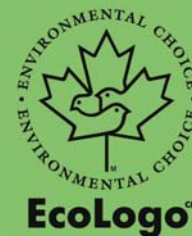


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1 Instructions

EcoLogo^{CM} is inviting stakeholders to participate in the review of CCD-003: Electricity-Renewable Low-Impact. This standard is being revised to assure that the current requirements continue to define environmental leadership for renewable low-impact electricity.

Currently, both the scope and the criteria statements found in CCD-003 determine what the EcoLogo^{CM} Program considers to be environmental leadership amongst all types of electricity production in North America. During this review, the EcoLogo^{CM} Program will re-examine both the scope and the criteria statements. As such, leadership will continue to be defined by first determining what types of electricity can be considered as “renewable low-impact” (i.e. scope), and second what requirements should be established to assure that facilities which produce these types of electricity are following best environmental practices according to the market (i.e. criteria statements).

Stakeholder contributions play a pivotal role in the EcoLogo^{CM} standards development process.

To begin your participation and register for the review process:

- Send a request to forums@ecologo.org and specify your name (first and last name), indicating your affiliation, and your wish to participate in the CCD-003: Electricity-Renewable Low-Impact.

While the EcoLogo^{CM} Standard Development Forum is the main tool for compiling comments, the EcoLogo^{CM} program will also accept comments by e-mail and fax. These comments may also be posted to the online forum and will be viewable by all registered forum participants involved in the discussion.

This stakeholder consultation period will be open for 52 days beginning Nov 18, 2008. Comments must be received by January 9, 2009.

Your time and input in helping us to establish the most stringent environmental standards are very much appreciated. We will send you a reminder as our closing date for comments approaches.

Sincerely,

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2 Introduction

Geothermal electricity is not currently included in EcoLogo^{CM} certification criteria document (CCD) for Renewable Low-Impact Electricity and therefore, no geothermal plants have yet been third-party certified by the EcoLogo^{CM} Program. However, based on a preliminary review of life cycle information, it seems that geothermal electricity products, if properly built, could offer considerable environmental benefits and meet strict requirements for *inter alia* a reduction in noxious air emissions, water emissions and hazardous waste.

The purpose of this section of the Certification Discussion Document is to provide you with broad market information for geothermal-powered electricity in Canada and the U.S., and to initiate a discussion to help identify which criteria the EcoLogo^{CM} Program should consider including in CCD-003 to ensure that geothermal-powered electricity represents environmental leadership as “renewable low-impact electricity”.

The EcoLogo^{CM} Program is designed to support a continuing effort to improve and/or maintain environmental quality by reducing energy and materials consumption and by minimizing significant life cycle environmental impacts. Life cycle review is an ongoing process and as such, EcoLogo^{CM} CCDs are regularly updated. Products are also re-audited regularly to ensure certified products continue to offer significant environmental benefits.

3 Description

The types of geothermal plant technologies are often defined as containing either open or closed loops systems. The U.S. Department of Energy (DoE, 2006c) further divides geothermal power plant technologies in 3 sub-categories: dry steam, flash and binary cycle, depending on the state of the fluid (whether steam or water) and its temperature.

- Open-Loop Systems: In this system, the geothermal steam or fluid drives the turbine.
 - Flash: These plants use water at temperatures greater than 360°F (182°C) that is pumped under high pressure to the generation equipment at the surface. Fluid is sprayed into a tank held at a much lower pressure than the fluid, causing some of the fluid to rapidly vaporize, or “flash.” The vapor then drives a turbine, which drives a generator. According to the DoE (2006c) flash steam plants are the most common type of geothermal power generation plants in operation today.
 - Dry Steam: The DoE (2006c) states that: “dry steam power plants ...use the steam from the geothermal reservoir as it comes from wells, and route it directly through a turbine/generator units to produce electricity. These plants emit only excess steam and very minor amounts of gases.”
- Closed-Loop Systems: In this system a working fluid drives the turbine, not the geothermal steam or fluid.
 - Binary Cycle: According to the DoE (2006c):
Binary cycle geothermal power generation plants differ from Dry Steam and Flash Steam systems in that the water or steam from the geothermal reservoir never comes in contact with the turbine/generator units. Hot geothermal fluid and a secondary (hence, “binary”)

fluid with a much lower boiling point than water pass through a heat exchanger. Sometimes iso-butane is used to move the turbine (Ghomshei & Meech, n. d.). Heat from the geothermal fluid causes the secondary fluid to flash to vapor, which then drives the turbines. Because this is a closed-loop system, virtually nothing is emitted to the atmosphere. Moderate-temperature water is by far the more common geothermal resource, and most geothermal power plants in the future will be binary-cycle plants.

4 Market Overview

4.1 Canadian Market

According to Natural Resources Canada (NRCan, 2006), since 1973, an effort which is still in progress has been made to identify and assess geothermal resources within Canada. Low-, medium-, and high-temperature geothermal fluids are available across Canada with particular high-temperature resources close to Vancouver in British Columbia. Two areas have been examined in some detail: the recent volcanic complex of Meager Mountain, British Columbia, and the Western Platform in British Columbia, Alberta and Saskatchewan. It has been found that there are substantial resources associated with both, but of different character. Only the high-temperature water at Meager Mountain [can] be used for the generation of electrical power. BC Sustainable Energy Association (BCSEA, 2004) has mentioned that South Meager has been classified as a "high temperature" geothermal field with maximum temperatures to date up to 275°C. Western GeoPower Corp is proceeding with environmental and other studies relevant to the completion of a Feasibility Study and preparation of an Application for an Environmental Assessment Certificate under B.C.'s Environmental Assessment Act. They are anticipating using dual-flash turbine technology with two standard 55 MW (gross) generating units (Western GeoPower Corp, n.d.).

4.2 American Market

According to the Geothermal Energy Association (GEA, 2007a), the U.S. continues to be the world leader in the generation of geothermal electricity. The net electricity generation from geothermal power in 2006 in the U.S. was of approx. 1290.052 millions KWh or 0.38% of U.S. annual electricity generation (Energy Information Administration, 2007). According to Western GeoPower Corp (n.d.), geothermal electrical facilities in California, Hawaii, Nevada and Utah had generated about \$1 billion of electricity in 2000. In January 2000, the United States government announced a program to develop geothermal energy in the western states. They plan to generate 10 percent of that region's electricity with geothermal technology by the year 2020.

Total Annual Average Net Capacity (MW) of Main American Geothermal Plants

Number of Power Plants/Region	Power Plant Technology						Total
	Double (or Dual) Flash	Double Flash & Binary	Binary	Single Flash	Dry Steam	Single Flash Binary	
15/Nevada	89	22	70.3	32.5	0	0	213.8
1/Alaska	0	0	0.4	0	0	0	0.4
41/California	337	0	132.5	20	892	0	1381.5
3/Utah	0	0	4	27	4	0	35
1/Hawaii	0	0	0	0	0	20	20
85/U.S.	426	22	207.2	79.5	896	20	1650.7

5 Other Eco-label Standards

The EcoLogo^{CM} Program does not know of any standard that specifically determines specifications for environmentally preferable geothermal powered electricity. However, the Green-E certification program does make all sources of geothermal power in its National Standard Version 1.5 available for certification without discrimination (Green E, 2008).

6 Life Cycle Research Findings

6.1 Life Cycle Definition

According to our preliminary research, the potential life cycle impacts for geothermal generating facilities most discussed in the literature include those that may occur during the use life cycle stage. At present time, the EcoLogo^{CM} Program recognizes that more research is needed and is seeking input from the public to help define the scope and boundaries of the life cycle analysis. In other words, we need to determine what environmental impact categories and related stressor need to be further investigated.

6.2 Summary of Major Environmental Impact Categories and Related Stressors

Below you will find some of the major environmental stressors associated to geothermal-powered electricity as well as specific biomass stressors associated with wood wastes, dedicated energy crops and liquid fuel powered generating facilities.

Stage of the life cycle	Environmental Stressors (numbers in the table refer to specific sections in the document) according to various Life Cycle Stages and Impact Categories					
	Energy	Resources	Emissions to			Other
	Renewable/ Nonrenewable	Renewable/ Nonrenewable	Water	Air	Soil	
Resource Extraction						
Production						
Distribution						
Use	6.3.1		6.3.1, 6.3.2, 6.3.4, 6.3.7, 6.3.8	6.3.4.1, 6.3.3, 6.3.4, 6.3.7	6.3.1, 6.3.4, 6.3.6	6.3.1, 6.3.2, 6.3.4, 6.3.6
Disposal	6.3.5	6.3.5, 6.3.8, 6.4.1	6.3.5, 6.4.1	6.3.5, 6.4.1	6.3.5, 6.4.1	6.3.9, 6.4.1

6.3 Discussion Points on New Broad Environmental Impact Categories and Related Stressors for Geothermal-Powered Electricity

This section draws attention to the broad environmental impact categories and stressors the EcoLogo^{CM} Program intends to address for geothermal-powered electricity in CCD-003. Each section below contains questions pertaining to the environmental impact categories and stressors under investigation.

6.3.1 Impacts due to Re-Injection

According to Bargali et al. (1997), “the old geothermal power plants had an environmental impact (per unit of power produced) that was higher than or comparable to that of coal-burning power plants (Axtmann 1975). In the last decade this impact has been sharply reduced in new plants by re-injection of condensable spent fluids into the ground.” However, in the U.S., 20% of 70 geothermal fields investigated show environmental damages due to re-injection such as cooling down of the reservoir fluids by time, contamination of aquifers, ground heaving and induced seismic activity (Sanyal, Granados, & Menzies, 1995). According to Dogdu & Bayari (2004):

The cessation of thermal water production or re-injection of thermal water to prevent pollution in stream water may also lead to elevated hydraulic pressure in thermal aquifer, which in turn may increase the upward leakage to the freshwater aquifer. The release of geothermal fluids in surface environment will apparently lead to damages whose cost may far exceed the benefits gained from the heat energy. For this reason, [contaminants] brought to surface for any purpose should to be removed from the surface environment by using the most economically feasible way. Chemical treatment methods may be employed to remove compounds of Na, Li, K, and As etc. Such an approach will not only remove the contaminants from the surface environment, but would also result in additional economic gains. Another alternative solution to removal of Afjet thermal return water (ATRW) seems to be sequential precipitation of minerals via evaporation as applied in salt pans.

Because of the risk of water contamination, the Defenders of Wildlife (2008), believe that it is critical that waste waters be re-injected in a way that ensures groundwater aquifers are not polluted, including ensuring well casings do not have leaks. According to the GEA (2007b), it is common practice that geothermal fluids used for electricity are injected back into geothermal reservoirs using wells with thick casing to prevent cross-contamination of brines with groundwater systems. Besides being a potential risk to groundwater, according to Majer (2006), water injection seems to be one of the most common causes of induced seismicity. The largest occurrence of seismic activity believed to have been caused by re-injection had a magnitude of 5.3. At this site, 30 million liters/month were being re-injected over 4 years causing too much pressure. A level 5 seismic activity can cause major damage to structures. Pasqualetti (1979), points out that the withdrawal of condensate could also lead to seismicity. However, despite risks of seismicity and groundwater contamination, some argue that re-injecting spent geothermal fluids back into reservoirs to sustain resources helps prevent another problem: land subsidence. This, however seems to be a rare problem. In fact, according to the Defenders of Wildlife (2008), the problem of land subsidence has so far only been detected at one site located in New Zealand. Also, according to Bargagli et al. (1997), land subsidence may occur especially if fluid withdrawal exceeds the natural inflow.

- 1.Q) Is there a maximum threshold level of water re-injection that does not pose a risk of surface water contamination?

- 2.Q) Are there alternative methods to re-injection used to remove contaminants that demonstrate greater environmental leadership when one compares the life cycles of these methods? If so, which one and why?
- 3.)Q) Do you have confidence that the technologies used to prevent groundwater contamination work are effective when re-injection is applied? Why? To what degree of confidence?
- 4.Q) Are there any measures/technologies currently used to prevent seismicity? If so, what are they?
- 5.Q) Do all geothermal plants pose a risk of seismicity? If so, is there an acceptable level of seismicity that does not pose a risk of groundwater contamination?
- 6.Q) Should the EcoLogo^{CM} Program address risks of land subsidence in CCD-003? If so, how and why? If not, why not?

6.3.2 Water Use and its Impacts on Water Ecosystems

As previously mentioned, Brophy (1997), has argued that by injecting fluids back into the geothermal system, reservoir pressures and groundwater flow can be maintained as close as possible to pre-development levels. In some cases, like at the Geysers, in California, 11 million gallons of recycled water is pumped each day. Before the Geysers Recharge Project, this filtered UV treated tertiary recycled water which meets or exceeds the highest level recognized in California water recycling regulations would have been discharged into the Russian River (City of Santa Rosa, 2004-2007). As shown in the section on seismicity above, the amount of water could induce seismic activity. Also, this amount of water exceeds by approx. 1000 times the amount of water or freshwater use of average geothermal plants which is of 5 gallons (18L) of freshwater/MWh or 0 gallons/MWh for binary air-cooled plants (GEA, 2007b). In terms of water use, according to the Defenders of Wildlife (2008), there is also the potential for conflict with other water users for water resources where water is not plentiful that need to be addressed. Also, according to them, a large amount of water is needed for cooling and other purposes in most geothermal plants. Heated waters should not be disposed of into naturally cooler streams due to the negative impacts on aquatic ecosystems, and withdrawals of cooling water should not be allowed to de-water streams or otherwise disrupt the ecological functions in aquatic environments. Geothermal plants can use cooling towers or air-cooled condensers to reject waste heat into the atmosphere instead of waterways unlike most nuclear and fossil fuels power plants. The IFC (2007) also recommends that geothermal plant operators assess the hydrological records for short and long-term variability of streams serving as source water, to ensure critical flows are maintained during low flow periods so as to not obstruct passage of fish or negatively impact aquatic biota.

- 7.Q) Do you think that the amount of water used by geothermal plants should not exceed a certain threshold level? If so, do you think that a threshold of 18 L of water/MWh is a safe level?
- 8.Q) Do you think that it is acceptable to pump water from waterways into geothermal plants to ensure they can keep producing in a renewable manner?
- 9.Q) Do you think that the EcoLogo^{CM} Program should ensure that no waste heat from geothermal power plants is emitted into waterways? If so, how and why? If not, why not?
- 10.Q) Do you think that the EcoLogo^{CM} Program should ensure that critical flows are maintained during low flow periods so as to not obstruct passage of fish or negatively impact aquatic biota? If so, how and why? If not, why not?

6.3.3 Major Air Emissions

Geothermal power plants could release from the non-condensable fraction of the steams: CO₂ (98%), H₂S (1.5%), methane (0.4%), hydrogen (0.1%) (Bargagli et al., 1997).

6.3.3.1 Greenhouse Gas Emissions

According to Brophy (1997), the average CO₂ emissions from geothermal power plants in the U.S. is of 0.48 kg/MWh while according to NRCan (2006), new facilities emit 0.1 kg of carbon/MWh of electricity generated, compared with 185 kg of carbon/MWh for a coal-fired facility. Rybach (2003), on the other end, mentions that different geothermal power generation technologies range between 0 and 0,4 kg of CO₂ equivalents/kg.

- 11.Q) Do you think that the EcoLogo^{CM} Program should establish a maximum threshold level of greenhouse gases emissions (CO₂ eq) for geothermal plants? If so, why and how? If not, why not?

6.3.3.2 H₂S Emissions

According to Ellis (1978), H₂S emissions of geothermal plants can approach those of coal fired power plants in extreme cases. Casualties have also occurred in isolated areas of unusually high concentrations of H₂S such as well-pits and thermal baths (Ellis, 1978). The oxidation of H₂S to SO₂ and its subsequent reaction to sulphate ions within the atmospheric produces aerosols representing a major component of acid rain (Birkle & Merkel, 2000). Some plant technologies can be used to convert H₂S gases into sulphur. Sulfur can then potentially be recycled to use as a feedstock for sulfuric acid. However, this is not necessary for all plants since some emit very small quantities of H₂S comparatively to others.

According to Skrtic (2006):

The non-lethal effects of exposure to H₂S can be summarized as: neurological-consisting of symptoms such as dizziness, vertigo, agitation, confusion, headache, somnolence, tremulousness, nausea, vomiting, convulsions, dilated pupils, and unconsciousness, and pulmonary – with symptoms including cough, chest tightness, dyspnea (shortness of breath), cyanosis (turning blue from lack of oxygen), hemoptysis (spitting or coughing up blood), pulmonary edema (fluid in the lungs), and apnea with secondary cardiac effects.

- 12.Q) Do you think that the EcoLogo^{CM} Program should identify a maximum threshold level of H₂S emissions for geothermal plants? If so, what do you think this threshold should be? If not, why?
- 13.Q) Should the EcoLogo^{CM} Program require that H₂S emissions be treated to remove and recycle sulfur? If so, how and why? If not, why not?
- 14.Q) Do you think that the manufacturers that use recycled sulfuric acid can in turn make products that pose small environmental risks? What are some of the examples of the new uses of sulfuric acid?

6.3.3.3 Hydrogen Emissions

The general risks associated to hydrogen include: explosivity, flammability and high concentrations in the air cause a deficiency of oxygen with the risk of unconsciousness (ISOC Technology. (n.d.)).

- 15.Q) Do you think that the EcoLogo^{CM} Program should identify a maximum threshold level of hydrogen emissions for geothermal plants? If so, why and what do you think this threshold level should be? If not, why not?

6.3.4 Trace Air and Water Emissions

Geothermal power plants could also release, from the non-condensable fraction of the steams, trace amounts (0,001%) of ammonia, radon, boron, arsenic, cadmium, and antimony (Bargagli et al., 1997). Also, according to Ellis (1978), geothermal power plants can emit saline fluids which also contain fluoride and minor amounts of other heavy metals like lead and cadmium into waterways. Ammonia and mercury may also enter local waters from geothermal steam condensate. These trace emission are investigated in more detail below.

6.3.4.1 Boron Emissions

According to Koc (2007), typical boron concentrations in North American waters are below 0.1 ppm, with about 90% at or below 0.4 ppm (WHO, 1998a). According to Ellis (1978), common compositions of geothermal well waters is of 1-1000 (often 20-50) ppm and of 0,01-1 ppm in steam condensates. Boron is an essential element for plant growth. Boron is needed in relatively small amounts, however, and if present in amounts appreciably greater than needed, it may become toxic. For plants, 1 to 2 ppm of boron may be toxic. While crops may suffer toxicity, the concentrations found in crops, typically 12 ppm (Atwell, Kriedemann, & Turnbull, 1999), generally do not pose a threat to human health and no recommended dietary intake for humans has been set. According to Ellis (1978), while the presence of boron in geothermal effluents may threaten irrigation waters, it is not a critical element from the health viewpoint. Normal diets include 10-20 mg of boron per day and concentrations of up to 20 ppm are permitted in drinking water (Waggott, 1969).

In general, treatment methods, such as reverse osmosis and ion exchange, could be used to remove boron as well as other trace elements. According to the GEA (2007), new geothermal plants are now required to install high efficiency drift eliminators for particulate control regardless of boron content in the water, and these eliminators reduce boron emissions. Boron salt compounds may be emitted in cooling tower drift, but boron emissions are generally not regulated.

- 16.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level for boron emissions for geothermal plants? If so, what do you think this threshold level should be? If not, why not?

- 17.Q) How many and which geothermal plants on the market in the U.S. have installed drift eliminators?

6.3.4.2 Ammonia Emissions

In Ellis (1978), it is mentioned that common concentrations of ammonia in geothermal plants is of 100 (often 1-10) ppm in well waters and of 1-50 ppm in steam condensates (Ellis and Mahon, 1977; Reed

and Campbell, 1975). According to Pasqualetti (1979), the most harmful ingredients for surface discharges of geothermal plants include ammonia at about 100-200 ppm. He mentions that the ammonia is harmful to fish.

18.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level of ammonia emissions for geothermal plants? If so, what do you think this threshold should be? If not, why not?

6.3.4.3 Lead Emissions

According to Ellis (1978), it is seldom that concentrations of lead in the dilute neutral-pH chloride waters tapped in volcanic geothermal areas exceed those permitted in drinking waters of 0.05 ppm. However, concentrations are higher in the very saline thermal waters of sedimentary systems such as in the Cheleken Peninsula (Lebedev, 1972), the Salton Sea geothermal area (White, 1968) or in very acid geothermal areas such as Matsao, Taiwan (Ellis and Mahon, 1977). Contamination problems from lead should be anticipated with geothermal waters of salinity over about 10,000 ppm.

19.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level of emissions for geothermal plants? If so, why and what do you think this threshold level should be? If not, why not?

6.3.4.4 Cadmium Emissions

According to Ellis (1978), it is seldom that concentrations of cadmium in the dilute neutral-pH chloride waters tapped in volcanic geothermal areas exceed those permitted in drinking waters of 0.01 ppm. However, concentrations are higher in the very saline thermal waters of sedimentary systems such as in the Cheleken Peninsula (Lebedev, 1972), and the Salton Sea geothermal area (White, 1968). Contamination problems from lead should be anticipated with geothermal waters of salinity over about 10,000 ppm.

20.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level for cadmium emissions for geothermal plants? If so, why and what do you think this threshold level should be? If not, why not?

6.3.4.5 Radon Emissions

According to Birkle & Merkel (2000), Radon-222 represents a potential health risk for humans. The particular hazard from radon involves the inhalation and deposition of the short-lived daughters. According to Pasqualetti (1978), the 222Rn does not deposit on lung tissues when inhaled, but is merely exhaled. The short-lived daughters, however, are usually deposited, and these can cause cancer. Maximum measurements of radon from the steam at a well geyser of 8.3 picocuries/liter have been recorded. The state health standard for radon in an uncontrolled area is of 3 pCi/l (Pasqualetti, 1978).

21.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level for radon emissions for geothermal plants? If so, why and what do you think this threshold level should be? If not, why not?

6.3.4.6 Arsenic Emissions

According to GEA (2007), the *Safe Drinking Water Act* currently mandates that arsenic not exceed 50ppb in drinking water. Legislation is presently under review that would reduce the number to 10 ppb, as per the recommendations of a government sponsored study. EPA limits exposure to arsenic in industrial facilities, but power plants remain unregulated. Individual states can have specific regulations for individual facilities, but no federal ambient air arsenic standards exist in the U.S. In general, geothermal plants are not considered to be high arsenic emitters even though arsenic is common to volcanic systems. When arsenic is present in a geothermal system, it typically ends up in the solid form in the sludge and scales associated with production and hydrogen sulfate abatement. Arsenic emission levels have been well documented over the years through two emissions inventories in California: the Air Toxic Hot Spots Program and The Geysers Air Monitoring Programs (GAMP), both of which have shown limited arsenic emissions. Results of these programs have shown arsenic emissions levels from geothermal power plant to be very small, if they are even detectable. A study of The Geysers showed that arsenic emissions were not of significant concern: the average level at The Geysers at around 1.6 ng/m³ (1.6 10⁻⁶ ppb), was found to be very close to the statewide average of 1.5 ng/m³ (1.6*10⁻⁶ppb). However, according to another study of arsenic in geothermal steam condensate by Reed and Campbell (1975), a range of 0.3-18 ppb was found at The Geysers steam with an average of 5 ppb which presents no health hazard (Ellis, 1978, p.182). Although arsenic in the U.S. does not seem to pose a risk, in El Salvador, arsenic concentrations of 11.3 ppm were found at several wells of a power plant (Pasqualetti, 1979).

22.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level for arsenic emissions for geothermal plants? If so, why and what do you think this threshold level should be? If not, why not?

6.3.4.7 Mercury Emissions

According to Bargagli et al. (1997), Phelps and Buseck (1980) proved that there is a high emission of mercury from geothermal sources. Based on research performed in Hawaii and Iceland, Siegel and Siegel (1975) pointed out the potential long-term toxic hazards associated with mercury and other elements. They also stressed the need to establish appropriate monitoring programs in conjunction with plans for the development of geothermal power. According to GEA (2007), although mercury is not present in every geothermal resource, where it is present, mercury abatement equipment typically reduces emissions by 90 percent or more. The comparatively highest mercury emitters, two facilities at The Geysers in California, release mercury at levels that do not trigger any health risk analyses under strict California regulations.

23.Q) How many and which geothermal plants on the market in the U.S. have installed mercury abatement equipment that reduces mercury emissions by 90% or more?

24.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level of mercury emissions for geothermal plants? If so, why and what do you think this threshold should be? If not, why not?

6.3.4.8 Chloride Emissions

The Defenders of Wildlife (2008) and the IFC (2007) both mention that geothermal plants could emit chloride emissions at levels that may pose environmental risks. Ellis (1978) mentions that well waters concentrations of NaCl range from 500-200,000 in geothermal plants and 0-1 in steam condensates.

25.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level for chloride emissions for geothermal plants? If so, why and what do you think this threshold level should be? If not, why not?

6.3.4.9 Nickel Emissions

The Defenders of Wildlife (2008) and the IFC (2007) both mention that geothermal plants could emit nickel emissions at levels that may pose environmental risks.

26.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level for nickel emissions for geothermal plants? If so, why and what do you think this threshold level should be? If not, why not?

6.3.4.10 Vanadium Emissions

According to CERM3 (2002), scrubbers reduce air emissions but a low-density sludge high in vanadium is produced. Vanadium can be toxic in high concentrations but it can also be recovered for market from this source. According to the Agency for Toxic Substances and Disease Registry (n.d.), the TWA air quality guideline set by the World Health Organization in 1984 for vanadium emissions was of $1\mu\text{g}/\text{m}^3$ during a 24 hour period.

27.Q) Do you think that the EcoLogo^{CM} Program should identify a threshold level of vanadium emissions for geothermal plants? If so, why and what do you think this threshold level should be? If not, why not?

28.Q) Which air emissions are reduced by scrubbers that can lead to sludge containing vanadium?

29.Q) What is vanadium used for once it is recovered?

6.3.4.11 Fluoride Emissions

According to Ellis (1978), fluoride concentrations in geothermal waters usually do not pose a disposal or a health problem. Only rarely do levels as high as 20-40 ppm occur, and only moderate dilution is required to bring fluoride levels down to the accepted level of 1 ppm in potable waters.

30.Q) Do you agree with Ellis and think that the EcoLogo^{CM} Program should not consider fluoride emissions from geothermal plants? If not, why not?

6.3.4.12 NO_x and SO_x Emissions

SO₂ emissions from geothermal plants are minimal (DoE, 2006a). A typical 100 MW plant will reduce NO_x and SO_x emissions by 120,000 tonnes/yr compared to a natural gas plant of equal size (Western GeoPower Corp, 2003). According to the GEA (2007), geothermal plants emit only trace amounts of nitrogen oxides and almost no sulfur dioxide. This is echoed by Brophy (1997) who states that in 1991, the average emissions by plant type was of 3.66 kg NO_x and 9.23 kg SO_x from coal, 1.75 kg NO_x and 4.95 kg SO_x from petroleum and zero NO_x and 0.03 kg SO_x from geothermal sources.

31.Q) Do you think that the EcoLogo^{CM} Program should not be preoccupied by NO_x and SO_x emissions from geothermal plants? If not, why not?

6.3.5 Hazardous Waste Disposal

According to the IFC (2007), geothermal technologies do not produce a substantial amount of solid waste. Sulfur, silica, and carbonate precipitates are typically collected from cooling towers, air scrubber systems, turbines, and steam separators. This sludge may be classified as hazardous depending on the concentration and potential for leaching of silica compounds, chlorides, arsenic, mercury, vanadium, nickel, and other heavy metals. Moreover, as mentioned previously, isobutane is used in binary geothermal cycle plants. According to Butterfield (n.d.), another fluid used in this type of plant is isopentane. This fluid, according to the International Labor Organization (2008), is harmful to aquatic organisms. Both are extremely flammable substances. Therefore, it is important that these substances be handled carefully at all stages of the life of geothermal plants.

The EcoLogo^{CM} Program already addresses hazardous waste in CCD-003. Indeed, the current *General Requirements* state that:

To meet the requirements of this Criteria document, the electricity - renewable low-impact must:

(b) be generated in such a manner that all steps of the process, including the disposal of waste products arising therefrom, will meet the requirements of all applicable governmental acts, by laws and regulations including, for facilities located in Canada, the Fisheries Act and the Canadian Environmental Protection Act, 1999, (CEPA, 1999).

32.Q) Does CCD-003 already sufficiently address the potential risk posed by the hazardous waste disposal from geothermal plants and if so, why? If not, how could the EcoLogo^{CM} Program mitigate the risk of hazardous waste from geothermal electricity further?

6.3.6 Land Use and its Impacts on Land Ecosystems

According to the DoE (2006d), an entire geothermal field uses 1-8 acres per MW versus 5-10 acres per MW for nuclear operations and 19 acres per MW for coal power plants. The use of advanced directional or slant drilling technology reduces amounts of land needed. Slimhole wells are only 4-6 inches in diameter while traditional geothermal exploration wells have been 8-12 inches in diameter. Slimhole drilling also reduces the amount of land needed for site preparation and road construction.

Reducing the use of land due to geothermal electricity production is especially important since according to the Union of Concerned Scientists (2005):

The development of hydrothermal energy faces a special problem. Many hydrothermal reservoirs are located in or near wilderness areas of great natural beauty such as Yellowstone National Park and the Cascade Mountains. Proposed developments in such areas have aroused intense opposition. If hydrothermal-electric development is to expand much further in the United States, reasonable compromises will have to be reached between environmental groups and industry.

33.Q) Should the EcoLogo^{CM} Program ensure that geothermal plants have a minimal impact on land by using methods such as *inter alia* slimhole and slant drilling? If so, why? If not, why not?

6.3.7 Releases due to Blowouts

According to the IFC (2007):

Although very rare, well blowouts and pipeline failures may occur during well drilling or facility operations. Such failures can result in the release of toxic drilling additives and fluids, as well as hydrogen sulfide gases from underground formations. Pipeline ruptures may also result in the surface release of geothermal fluids and steam containing heavy metals, acids, mineral deposits, and other pollutants. Recommended pollution prevention and control methods to address well blowouts and pipeline ruptures include:

- *Regular maintenance of wellheads and geothermal fluid pipelines, including corrosion control and inspection; pressure monitoring; and use of blowout prevention equipment such as shutoff valves; and*
- *Design of emergency response for well blowout and pipeline rupture, including measures for containment of geothermal fluid spills*

34.Q) Do you think that the EcoLogo^{CM} Program should adopt the recommendations of the IFC pertaining to the management of well blowouts?

6.3.8 Impacts of Drilling Fluids and Cuttings

According to the IFC (2007):

Steam production and re-injection wells may be installed during exploration, development, and operational activities. Drilling fluids employed during drilling activities may be water- or oil-based, and may contain chemical additives to assist in controlling pressure differentials in the drill hole and to act against viscosity breakdown. Cuttings from oil-based mud are of particular concern due to the content of oil-related contaminants and may necessitate special on-site or off-site treatment and disposal. Recommendations for the management of drill cuttings and fluids include:

- *Recovery and storage of oil-based drilling fluids and cuttings in dedicated storage tanks or sumps, lined with an impervious membrane, prior to treatment (e.g. washing), recycling, and/or final treatment and disposal;*
- *Reuse of drilling fluid, where feasible;*
- *Removal of tanks or sumps to avoid the present or future release of oil-related materials into soil and water resources and treatment/disposal of contents as a hazardous or non-hazardous waste depending on its characteristics (see General EHS Guidelines);*
- *Disposal of water-based drilling fluids into the bore hole following toxicity assessment. Water-based cuttings are typically reused if they are non-toxic (e.g. as construction fill) or disposed of in a landfill facility;*
- *During acid treatment of wells, use of leak-proof well casings to a depth appropriate to the geological formation in order to avoid leakage of acidic fluids to groundwater.*

35.Q) Should the EcoLogo^{CM} Program require that the management of drill cuttings and fluids of geothermal plants are performed according to the IFC (2007) *Environmental, Health, and Safety Guidelines for Geothermal Power Generation*?

6.3.9 Noise

According to Ellis (1978), noise levels at geothermal plants can be extremely high, reaching 120 dB and may cause damage to hearing at distances of 50-100m. Silencers can reduce noise to below 100dB.

36.Q) Should the EcoLogo^{CM} Program require that noise levels be below 100 db at 50-100m from the geothermal facilities? If so, why and how? If not, why not?

6.4 General Considerations

6.4.1 Renewable and Low-Impact

According to CCD-003, "renewable" means replenished through natural processes or through sustainable management practices so that a resource is not depleted at current levels of consumption. The requirements that define the general nature of low-impact electricity are specified in sections 3 and 4 of the current CCD. Low-impact is also further defined in the *Product Specific Requirements* included in separate sections of the CCD.

According to the Centre de Recherche en Géothermie (2008), the earth's heat is unlimited on the human scale and will be available for a long time for future generations. In a general sense, a geothermal resource can be considered as renewable if energy production does not exceed the natural heat or fluid flux. This is echoed by Stefansson (2000) who mentions that any balanced production of fluid/heat in geothermal utilization scheme which does not produce more than the natural discharge, can be considered as fully renewable. According to the DoE (2006b), the long-term sustainability of geothermal energy production has been demonstrated at the Lardarello field in Italy since 1913, at the Wairakei field in New Zealand since 1958, and at The Geysers field in California since 1960. However, pressure and production declines have been experienced at some plants, and operators have begun re-injecting water to maintain reservoir pressure. For example, the City of Santa Rosa, California, pipes its treated wastewater up to The Geysers to be used as re-injection fluid, thereby prolonging the life of the reservoir while recycling the treated wastewater. Brophy (1997) states that by injecting fluids back into the geothermal system, reservoir pressures and groundwater flow can be maintained as close as possible to pre-development levels.

37.Q) Do you think that a geothermal generator can be considered renewable if the balanced production of fluid/heat in the geothermal utilization scheme does not produce more than the pre-development discharge?

38.Q) Do you think that re-injecting fluids is an environmentally sound management practice to ensure that the geothermal resource can remain renewable (see section 6.3.1.2 for more information on the impacts of re-injection)? If yes, why and do you think that there are exceptions to this? If not, why not?

6.4.2 Other General Considerations

- 39.Q) Do you think that all of the potential significant environmental impact categories and related stressors for geothermal electricity have been properly addressed in this Certification Discussion Document? If not, which impact and/or stressor do you think is missing and why?
- 40.Q) The literature shows that some environmental impacts can vary between binary, flash and dry steam technologies. Do you think that the differences between the types of plants are significant enough to warrant the development of separate criteria for each type of plant technology? If so, for which category of impact and/or stressor do you think that this approach is necessary?

7 Performance Testing

- 41.Q) Do you know of performance tests the EcoLogo^{CM} Program should be aware of for geothermal-powered generating facilities?

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