EcoLogo^CM Program Criteria Review

Certification Discussion Document

CCD-003: Electricity-Renewable Low-Impact
(E) SOLAR-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,

EcoLogo^CM Program Management
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2 Introduction

Solar-powered electricity is currently considered in the EcoLogo[CM] certification criteria document (CCD) for Electricity-Renewable Low-Impact and 1 solar-powered generating facility amounting to a total capacity of 0.0134 MW has already been third-party certified by the EcoLogo[CM] Program.

Solar-powered electricity products can sometimes offer considerable environmental benefits and meet strict requirements for solid waste disposal and recycling.

The purpose of this section of the Certification Discussion Document is to provide you with broad market information for solar-powered electricity in Canada and the U.S., and to initiate a discussion to help identify which criteria the EcoLogo[CM] Program should consider revising to ensure that solar-powered electricity generating facilities continue to represent environmental leadership as "renewable low-impact electricity" generating facilities.

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

CCD-003 currently defines solar-powered electricity as electricity generated by converting the sun's light energy and/or heat energy into electricity, and includes *inter alia* photovoltaic technologies and concentrating solar thermal technologies. This definition agrees with the main solar electricity generating technologies described by Natural Resources Canada (2006), and the The U.S. Department of Energy (DoE, 2007) which can be summarized as:

A) Photovoltaics (PV)

Key PV technologies include higher grade monocrystalline silicon PV, polycrystalline silicon, thick film polycrystalline cells, amorphous silicon, Hybrid Heterojunction with Intrinsic Thin-layer modules, silicon ribbons and sheets, and gallium arsenide modules. Some other potentially promising PV technologies known as second generation cells include those made with thin films of copper indium diselenide, copper indium gallium diselenide and cadmium telluride. Futhermore, new third generation PV technologies are currently being developed that use new materials: nanocrystalline structures, quantum dots and nanostructured conducting polymers (Boyle, 2004). Also, most PV cells cannot work without sun and therefore must rely on batteries. They also contain inverters to convert DC into AC current (Dey & Lenzen, 2006).

B) Concentrating Solar Power Technologies

a) Trough Systems

This system uses a series of long troughs in the shape of a parabola. The parabola concentrates the light onto a receiver tube that is positioned along the focal line of the parabolic trough. Temperatures at the receivers can reach 400°C and produce steam for generating electricity. Usually, but not always, the troughs track the sun as it moves during the day (Pollution Probe, 2003).

b) Dish/Engine systems

A parabolic dish system uses parabolic dish-shaped mirrors to focus the sun's radiation onto a receiver positioned at the focal point of the disk. There is fluid in the receiver, which, when the sun's rays hit it, heats up to 750 to 1,000°C. The very hot fluid is then used to generate electricity in a small engine attached to the receiver. Like the parabolic trough, a parabolic dish also tracks the sun's movements (Pollution Probe, 2003).

c) Power Towers

A power tower uses a number of large, sun-tracking, flat-plane mirrors to focus the sun's light onto a central receiver at the top of a tower. The system pumps a fluid, either a high temperature synthetic oil or molten salt, through the receiver where it is heated to 550°C and then used to generate electricity (Pollution Probe, 2003).

4 Market Overview

Despite its small global market share (approximately 0.016 % (International Energy Agency, 2005a) of the global energy market and 0.1 % (International Energy Agency, 2005b)), according to Boyle (2004), the solar power market has seen a growth of 40% worldwide per annum. Also, in 2002, the dominant solar power technologies were monocrystalline and polycrystalline modules at 88%, thin-film amorphous silicon cadmium telluride and copper indium diselenide modules at 12%, and crystalline silicon ribbon and sheet at 5% market shares of production worldwide.

4.1 Canadian Market

According to Pollution Probe, in 2003, there were 110 photovoltaic solar systems in Canada, representing 352 kilowatts of power from solar electricity. In 2004, there was an estimated 360-500 firms in Canada who were primarily involved in the solar industry (The Canadian Solar Industries Association, 2005).

4.2 American Market

According to the Energy Information Administration (2008), in 2007, the solar electricity market represented 0.14% of the total renewable energy market in the U.S. with a production of 606,082 Thousand Kilowatthours of electricity. The market there saw a growth of 13.5% between 2002 and 2007.

5 Other Eco-label Standards

The American *Green-E National Standard Version 1.5* (2007) includes solar power as an eligible source of green-e power. However, Green-E does not specify specific criteria for its solar power sources.

6 Life Cycle Research Findings

6.1 Life Cycle Definition

According to our preliminary research, the most significant life cycle impacts for solar generating facilities discussed in the literature include those from the production 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 solar-powered electricity 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	6.3.2.5	6.3.2.4, 6.3.2.5, 6.3.2.6, 6.3.2.7	6.3.2.5	6.3.2.3, 6.3.2.5	6.3.2.5	6.3.2.5
Production	6.3.2.2, 6.3.2.5	6.3.2.5, 6.3.2.6	6.3.2.5	6.3.2.1, 6.3.2.3, 6.3.2.5	6.3.2.5	6.3.2.5
Distribution	6.3.2.2, 6.3.2.5	6.3.2.5, 6.3.2.6	6.3.2.5	6.3.2.3, 6.3.2.5	6.3.2.5	6.3.2.5
Use	6.3.1.1, 6.3.2.5	6.3.1.1, 6.3.2.5, 6.3.2.6	6.3.2.5	6.3.2.3, 6.3.2.5	6.3.2.5	6.3.2.5
Disposal	6.3.2.5	6.3.1.2, 6.3.2.4, 6.3.2.5, 6.3.2.6	6.3.2.5	6.3.2.3, 6.3.2.5	6.3.2.5	6.3.1.2, 6.3.2.5

6.3 Discussion Points on Major Environmental Impact Categories

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

6.3.1 Current Broad Environmental Impact Categories and Related Stressors under Review for Solar-Powered Electricity

6.3.1.1 Efficiency

According to the National Renewable Energy Laboratory (2008):"Capacity factors for current parabolic trough systems under development range from 25% for solar only plants to greater than 40% for plants with thermal storage." Moreover they suggest that as the cost of thermal storage is reduced, future parabolic trough plants could yield capacity factors greater than 70%, competing directly with future baseload combined cycle plants or coal plants." According to Boyle (2004), commercially available PV modules have generally low efficiencies that range between 10 and 17%. Despite the generally low efficiencies of solar power technologies, "A simple calculation shows that if PV modules of 10% average efficiency were to be installed on 0.1% of the earth's total surface (some 500 000 km^2, equivalent to 1.3% of the earth's total desert area), they would produce enough electricity to supply all of the world's current energy requirements (Boyle, 2004)."

6.3.1.2 Waste Management

Alsema & Nieuwlaar (n.d.) have performed a life cycle analysis of multi-crystalline silicon, amorphous silicon, cadmium telluride, and copper indium selenide solar cells. Part of the conclusion was that waste management of solar cells needs due attention.

CCD-003 currently states that: "To meet the requirements of this criteria document, solar-powered electricity must be generated in such a manner that adequate arrangements (i.e., financial reserves) have been made for the proper disposal or recycling of all solid waste resulting from the generation of electricity, including the disposal of equipment or machinery used in the generation process itself, that contains measurable levels of cadmium."

1.Q) Do you think that CCD-003 still demonstrates environmental leadership for the waste management question pertaining to solar cells? If so, how and why? If not, why not?

6.3.2 New Broad Environmental Impact Categories and Related Stressors for Solar-Powered Electricity

6.3.2.1 NOx, SO_x, CO and Particulate Matter Emissions

The Canadian Solar Industries Association (CanSIA, 2006) states that solar PV's "air pollution emissions relate mostly to the production of the solar modules and the source of electiricity used in their manufacture". According to CanSIA, the life cycle emissions of SO_2 for solar power in Canada are of 0.25 g/kWh while they claim that the Ontario Power Authority's estimate is of 360 g/kWh. CanSIA also shows that NOx variance in emissions, on the other hand vary between 16-340 mg/kWh. According to TerraChoice Environmental Services Inc. (1999), life cycle emissions for CO and PM for a 30 yrs life cycle are of 1 and 1 kg/GWh respectively. These are leading figures for these types of emissions compared to other energy sources.

There seems to be a significant variance of data of life cycle NOx and SOx emissions for solar power and these reported emissions sometimes surpass conventional energy sources (Meier, P. 2002).

2.Q) Should the EcoLogo^{CM} Program establish a life cycle emissions threshold level within its criteria for these two emissions sources? If so, how and why? If not, why not?

6.3.2.2 Impacts due to Energy Use

According to the Ontario Power Authority & Senes Consultants Limited (2005):

> *The energy requirements needed to produce present-day crystalline silicon vary considerably depending on wafer thickness and the silicon feedstock that is used. These energy requirements are projected to decrease over time because of better feedstock, expected decreases in the amount of feedstock required to produce a cell and efficiencies in manufacturing. For PV, most of the environmental impacts are generated during the production phase. As technology rapidly advances, these impacts are being reduced. As well, the environmental impacts are also related to the type of electrical generation used to produce the PV systems. Newer technology is less polluting and thus newer PV systems have a smaller environmental impact.*

Moreover, according to Reich-Weiser, Fletcher, Dornfeld & Horne (2008), the primary energy demand for a kWh of electricity in Canada is of just over 8 MJ/kWh. Also, "An Initial Assessment of SolFocus Inc. concentrator photovoltaic systems found transportation to be 10-20% of the lifecycle energy demand when panel transportation to installation and glass transportation to assembly were included." Furthermore, the energy payback time (EPBT) which indicates the number of years a technology must produce electricity to offset the total energy required over its lifetime may vary between 0.6 to 5 years depending on installation and manufacturing locations.

3.Q) Do you think that certain solar power generating facilities in Canada and the U.S. have achieved environmental leadership because of a reduction of a source and amount of energy used during their manufacturing and/or transportation phases of their life cycle? If so, should the EcoLogo^{CM} Program establish a criterion that reflects this environmental leadership difference? If so, how and why? If not, why not?

6.3.2.3 Greenhouse Gas Emissions

According to Dey & Lenzen (2006), greenhouse gas emissions generated over the lifetime of solar thermal and solar PV range between 6 kg of CO_2 eq/kWh and 151 kg of CO_2/ kWh. They compare this amount emitted to conventional sources of energy which range from a minimum of 418 $CO_{2\ eq}$/kWh for fuel cell cogeneration to a maximum of 1033 $CO_{2\ eq}$/kWh for coal. However, this data conflicts with other greenhouse gas emissions data. For example, the Canadian Solar Industries Association (2006) states that life cycle greenhouse gas emissions for solar energy production in Canada could be estimated at 0.25 g/kWh CO_2 eq, a substantial difference to the Dey & Lenzen data.

4.Q) Do you think that the EcoLogo^{CM} Program should establish an emissions threshold level for greenhouse gas emissions (CO_2 eq) for solar power generating facilities even though they are already the environmental leaders for these emissions when they are compared to other energy sources? If so, why? If not, why not?

6.3.2.4 Recyclability of Materials

According to Alsema & Nieuwlaar (n.d.), solar module recycling deserves further attention both from manufacturers and researchers. For example, they state that the use of lead-acid batteries is primarily responsible for the environmental impacts of solar home systems and therefore suggest that battery recycling schemes are of great importance for these types of systems.

According to Müller, A., Karsten, W., & Alsema, E. (n.d.), the recycling of solar modules using the Deutsche Solar recycling process is more environmentally advantageous than a landfill-incineration process or a shredder process with subsequent sorting. The principle reason is that this recycling process ensures that no new wafers need to be produced. This is especially important considering the scarcity of silicium. To reduce the impact of the recycling process, it might be possible to decrease the energy and chemicals demands further.

5.Q) Are there battery and other solar recycling schemes available in Canada and the U.S. for PV? If so, where? Are they abundant enough that the EcoLogo^CM Program could reasonably mandate that PV cells be recycled?

6.3.2.5 Choice of Materials

As demonstrated in part 3 of this *Certification Discussion Document*, there are many different types of solar electricity systems. According to Raugei, Bargigli & Ulgiati (n.d.), CdTe photovoltaic modules have "been shown to be the least impacting photovoltaic technology currently available from several important points of view like the amounts of materials input required, the acidification potential, global warming potential, abiotic depletion, and eco-toxicity potential. A Life Cycle Impact Assessment by Alsema & Wild-Schollten (2004), on the other hand, has demonstrated that "Solsilc silicon feedstock and RGS wafer technology can yield a 50% reduction of 10 environmental impact categories (incl. *inter alia* abiotic depletion human toxicity, terrestrial ecotoxicity etc) in comparison with present day standard technology".

6.Q) Are there any environmentally preferable materials that could be used in Solar-Powered Electricity Generating Facilities that demonstrate environmental leadership in Canada and the U.S? If so, what are they and why? If not, why not?

6.3.2.6 Impacts due to PV Inverters

According to Alsema & Nieuwlaar (n.d.), points of attention with regards to inverters include the impacts of copper usage in cables.

7.Q) Do you think that the EcoLogo^CM Program should consider researching the environmental impacts of copper usage in PV inverters? If so, how and why? If not, why not?

8.Q) Are there other concerns that the EcoLogo^CM Program should be aware of regarding PV inverters?

6.3.2.7 Battery Impacts

According to Alsema (2000), devising measures to improve battery life time in an efficient manner is a desirable way of lessening the environmental impacts of solar systems that run on battery.

9.Q) Are you aware of preferable batteries that are currently being used in solar systems? If so, what are these types of batteries and why? If not, why not?

6.3.2.8 Land Use

In terms of land use, PV facilities use 0.0013 km^2/MW and therefore rank fairly low compared to other energy sources (Ontario Power Authority & Senes Consultants Limited, 2005). According to Boyd & Dornfeld (2005), "there is a significant drawback in employing ground-based installations, including 30-50% increase in air pollutant emissions." Mounted solar is therefore considered more environmentally benign.

10.Q) Do you think that the EcoLogo^{CM} Program should specify a threshold level for land use for solar power? If so, how and why? If not, why not?

11.Q) Do you think that the EcoLogo^{CM} Program should ensure that where preferable, the technology should be mounted as opposed to ground-based?

6.3.2.9 Toxicity

Alsema & Nieuwlaar (n.d.) have performed a life cycle analysis of solar cells. They concluded that "during module production substances are used which may be harmful for workers, the public or the environment. Therefore manufacturers should take proper measures to avoid harmful exposures or emissions." In 2004, Alsema also found that the 3 greatest sources of human toxicity for a PV module (RGS) were from the aluminum module frame, the backfoil and the solar cell. Moreover, they showed that for this same module: the solar cell, the electricity consumption for module assembly, and the aluminum module frame, where the 3 greatest sources of terrestrial ecotoxicity. These sources as well as the backfoil were the 4 greatest sources of fresh water aquatic ecotoxicity.

Cadmium has previously been addressed in CCD-003 because of its potential risk on health.

12.Q) Are there other toxic chemicals of concern used in solar technologies that the EcoLogo^{CM} Program should be aware of and consider in this review?

13.Q) Are there specific existing health & safety standards in place for the production of solar modules? If so, what are they and should the EcoLogo^{CM} integrate them within CCD-003? If not, why not?

6.4 General Considerations

14.Q) Do you think that all of the potential significant environmental impact categories and related stressors for solar-powered electricity have been properly addressed in this Certification Discussion Document? If not, which impact and/or stressor do you think is missing and why?

15.Q) The literature shows that some environmental impacts can vary according to solar power generating technologies. Do you think that the differences are significant enough to warrant the development of separate criteria for these? If so, why and how? If not, why not?

7 Performance Testing

16.Q) Do you know of performance tests the EcoLogo[CM] Program should be aware of for solar-powered generating facilities?

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