Environmental labelling of green electricity with LCA key parameter models

Dr. Niels Jungbluth, Kanzleistrasse 4, CH – 8610 Uster, Switzerland, T. +41 1 940 61 32, F. +41 1 940 61 94, jungbluth@esu-services.ch, www.esu-services.ch

Dr. Rolf Frischknecht, ESU-services, Kanzleistrasse 4, CH – 8610 Uster, Switzerland, T. +41 1 940 61 32, frischknecht@esu-services.ch

Abstract

Since the opening of European electricity markets, companies are launching green electricity products. In Switzerland the privately initiated eco-label "naturemade star" ensures the environmental and ecological quality of electricity from renewable energy sources on a local scale and from a life cycle perspective. For the life cycle perspective, a simplified and partly site-specific life cycle assessment (LCA) is applied using the Eco-indicator 99 (Hierachist perspective) impact assessment method. In a first step, detailed LCAs case studies are made for power plants and technologies that are candidates for the „naturemade star" label. They allow identifying technology-specific parameters that dominate the outcome of the LCA and for which data are available for the owner or operator of the power plant at issue. Based on this knowledge, key parameter models for photovoltaic, wind and hydroelectric power and electricity from biogas have been established on a spreadsheet-basis. With the help of the parameter models, operators of power plants can carry out the required LCA within a few hours. At the same time, they can check whether the plant fulfils the "naturemade star" threshold or not, which has been set to 50% of the environmental impact of a gas combined cycle power plant. Within a few months since the introduction of the labelling scheme, companies successfully applied the parameter models on nearly 50 photovoltaic and on several hydroelectric power plants. LCA is, in combination with other tools, a useful method for the definition of standards for environmental labelling of green electricity.

Introduction

Since the opening of European electricity markets, companies are launching so called "green" electricity products. Therefore, in several countries different criteria exist how to define and label "green electricity", as the product itself has no specific green characteristics. In Switzerland, the privately initiated eco-label "naturemade star"[1] ensures the environmental and ecological quality of electricity from renewable energy sources on a local and regional scale as well as from a life cycle perspective.

Method

Global and local criteria are used within the certification scheme for electricity from renewable resources with the level *naturemade star*. Local criteria are specific for every type of electricity production. Hydro power plants, i.e. have to fulfil certain ecological criteria for the amount of by-passed water. The global criterion, with one threshold for all systems, is based on life cycle assessment (LCA) case studies. Fig. 1 shows the decision tree for the labelling of electricity and the role of LCA in this scheme. A second, less stringent label is *naturemade basic* that is used for all types of electricity production with the main criterion that it is based on renewable energy carriers.

[1] See information for the "Verein für Umweltgerechte Elektrizität (VUE)" (*Association for environmental sound electricity*) on http://www.naturemade.org for details. The association is formed by representatives of electricity companies and environmental NGO's.

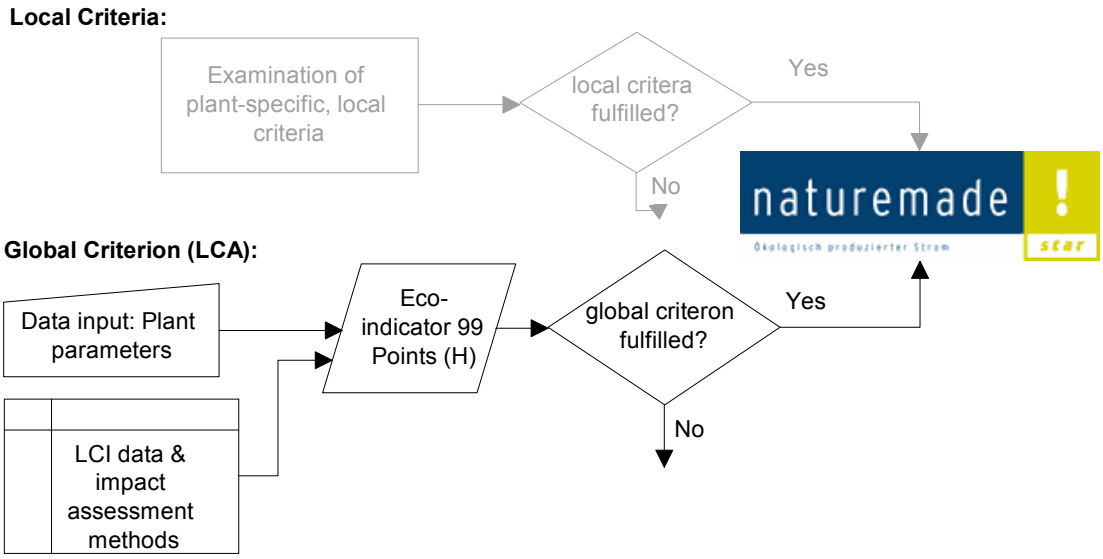

Fig. 1 Local and global criteria for the labeling of electricity.

LCA Case Studies

For the life cycle perspective, a simplified and partly site-specific life cycle assessment is applied. In a first step, detailed LCA case studies are made for power plants and technologies which are candidates for the "naturemade star" label (FRISCHKNECHT & JUNGBLUTH 2000a, b). They allow identifying the technology-specific parameters that dominate the outcome of the LCA and for which data are available for the owner or operator of the power plant at issue. So far detailed case studies have been made for wind (FRISCHKNECHT *et al.* 1996), hydro power (BAUMGARTNER & DOKA 1998, FRISCHKNECHT *et al.* 1996), photovoltaics (JUNGBLUTH & FRISCHKNECHT 2000b), biogas from composting (SCHLEISS 1999) and manure (EDELMANN *et al.* 2001) Further case studies are planned for the electricity production from wood and biogas from effluent treatment plants. The Hierachist perspective of the Eco-indicator 99 method (GOEDKOOP & SPRIENSMA 2000, JUNGBLUTH & FRISCHKNECHT 2000a) is used for the impact assessment.

Key Parameter Model

Based on the knowledge gained with the detailed LCA, parameter models for photovoltaic, wind and hydroelectric power and electricity from biogas have been established on a spreadsheet-basis. They are easy to handle for non-experts. With the help of the parameter models, operators of small and medium size power plants can carry out the required LCA within a few hours. Fig. 2 shows an example for the input mask in EXCEL. For photovoltaic plants for instance, key parameters are the annual production, the type of solar cell (single- or multi crystalline) and the kind of installation (building integrated or mounted).

Data input:			
Name of facility	Zurich, central railway station		
Weighting method	EI'99-aggregated, Hierarchist		
Type of photovoltaic plant	Slope roof, monocristalline, mounted		
Peak power	kWp	3	
Output			
Electricity sold per year	kWh/a	2'203	
Results			**percentage of threshold**
Zurich, central railway station	EI-99-points	9.48E-03	
Threshold Eco electricity Switzerland	EI-99-points	9.49E-03	99.9%
Eco electricity criterion fulfilled			

Fig. 2 EXCEL mask for the key parameter model.

Threshold Limits

The user of the key parameter model can check whether the plant fulfils the "naturemade star" threshold or not. The threshold for existing plants has been set by the Verein für umweltgerechte Elektrizität (VUE) to 50% of the environmental impact in Eco-indicator 99 (hierarchist) points of a gas combined cycle power plant. Tab. 1 shows the limit for electricity with the "naturemade star" label and the range of environmental impacts for different types of power plants in Eco-indicator 99 Micro points (Hierachist) per kWh of electricity. Hydro and large wind power plants do normally have no problems to fulfil the global criterion for the naturemade star label. Electricity made from biogas in composting plants shows even negative figures for the environmental impacts due to the better environmental performance in comparison to conventional treatment facilities for organic wastes. Photovoltaic plants do not fulfil the criteria in all cases, because environmental impacts for their production are relative high and the annual production varies considerablly between different plants. Fossil fuel based power plants show much higher environmental impacts. Electricity from nuclear power plants has Eco-indicator 99 scores below the threshold for "green electricity" but as it is not from renewable resources, it cannot fulfil the criteria for the naturemade label.

		Certified Systems for Renewable Energy				Conventional Reference Systems				
Threshold Limit		Hydro Power	Wind Energy[1)]	Biogas[2)]	Photovoltaic[3)]	Gas Combined Cycle - Natural Gas	Nuclear Power	Fuel Oil	Hard Coal	UCPTE-Electricity-Mix
13'950	Min	367	1'160	neg.	6'730	27'900	6'260	61'600	28'000	24'600
	Max	637	9'680	neg.	14'900					

1) Figures for plants with more than 30 kW capacity.
2) Fermenting plants have a lower environmental impact than composting plants. Thus, there are negative figures for environmental impacts, which are calculated as the balance between conventional treatment and co production of biogas.
3) Plants built before 1995.

Tab. 1 Threshold limits for power plants in Eco-indicator 99 (H) micro-points. Results of the key parameter models for different certified systems for renewable energy and comparison with existing facilities and conventional reference systems.

Fig. 3 shows a comparison of Eco-indicator 99 (H) scores for different wind energy plants with the threshold (13950 EI99(H) points/kWh) for naturemade star. Positive figures go beyond the threshold, e.g. a figure of 100% indicates twice the environmental impacts in comparison to the threshold. Large wind power plants do normally fulfil the criterion while smaller wind power plants have difficulties. This is due to a larger specific use of materials for the smaller plants.

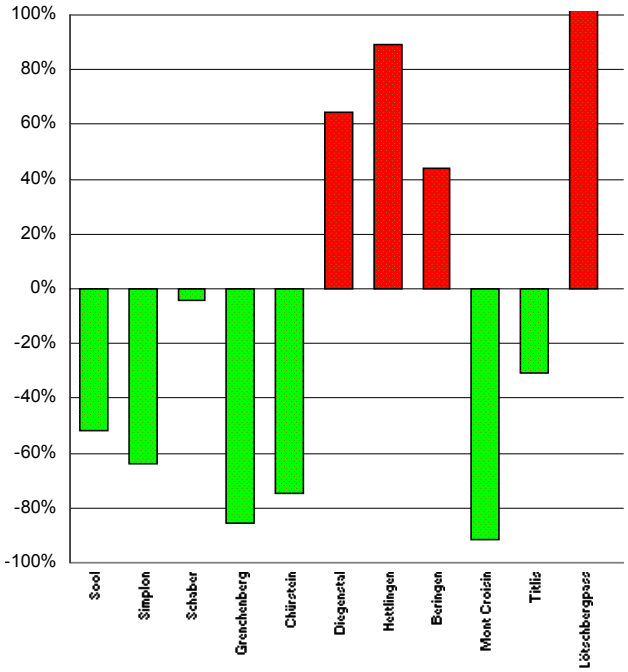

Fig. 3 Comparison of Eco-indicator 99 (H) scores for different wind energy plants with the threshold for naturemade star. Positive figures go beyond the threshold.

Conclusions & Outlook

Within a few months since the introduction of the labelling scheme, utilities successfully applied the parameter models on nearly 50 photovoltaic and on several hydroelectric power plants (NATUREMADE 2000). It is planned to certify further types of renewable energy, e.g. wood or biogas from effluent treatment plants with the same method. LCA is, in combination with other tools, a useful method for the definition of principles for environmental labelling of green electricity. It guarantees a consistent standard for all types of power plants that is used for such a label.

References

BAUMGARTNER, W. & DOKA, G. 1998: *Energiebilanzen von Klein-Wasserkraftwerken; Energierückzahldauern - Energieerntefaktoren.* 2. Auflage, DIANE 10 Klein-Wasserkraftwerke, ITECO Ingenieurunternehmung AG, Affoltern am Albis.

EDELMANN, W., SCHLEISS, K., ENGELI, H., BAIER, U. 2001: *Ökobilanz der Stromgewinnung aus landwirtschaftlichem Biogas.* arbi GmbH, Baar.

FRISCHKNECHT, R., BOLLENS, U., BOSSHART, S., CIOT, M., CISERI, L., DOKA, G., DONES, R., GANTNER, U., HISCHIER, R., MARTIN, A. 1996: *Ökoinventare von Energiesystemen. Grundlagen für den ökologischen Vergleich von Energiesystemen und den Einbezug von Energiesystemen in Ökobilanzen für die Schweiz.* Auflage No. 3, Gruppe Energie - Stoffe - Umwelt (ESU), Eidgenössische Technische Hochschule Zürich und Sektion Ganzheitliche Systemanalysen, Paul Scherrer Institut, Villigen, www.energieforschung.ch, Bundesamt für Energie (Hrsg.), Bern, CH.

FRISCHKNECHT, R. & JUNGBLUTH, N. 2000a: "Bewertung von "grünem Strom" mit Ökobilanzen." In *Energiewirtschaftliche Tagesfragen* Vol. **50** (12): 922-925, www.et-energie-online.de.

FRISCHKNECHT, R. & JUNGBLUTH, N. 2000b: *Globale Umweltkriterien für Ökostrom.* ESU-services im Auftrag des Vereins für umweltgerechte Elektrizität, Zürich, 28 Seiten, http://www.naturemade.org/common/texte/Stromlabel_7.2000.PDF, Uster.

GOEDKOOP, M. & SPRIENSMA, R. 2000: *The Eco-indicator 99: A damage oriented method for life cycle impact assessment.* Methodology Report, 2nd revised ed. PRé Consultants, www.pre.nl/eco-indicator99/, Amersfoort, The Netherlands.

JUNGBLUTH, N. & FRISCHKNECHT, R. 2000a: *Eco-indicator 99 - Implementation: Assignment of Damage Factors to the Swiss LCI database "Ökoinventare von Energiesystemen".* ESU-services, www.esu-services.ch, Uster.

JUNGBLUTH, N. & FRISCHKNECHT, R. 2000b: *Literaturstudie Ökobilanz Photovoltaikstrom und Update der Ökobilanz für das Jahr 2000.* Programm Aktive Sonnenenergienutzung: Photovoltaik No. 39489, ESU-services for Bundesamt für Energie, www.esu-services.ch, Uster.

NATUREMADE 2000: *Naturemade bringt Strom aus der Natur.* Naturemade, www.naturemade.org, Zürich.

SCHLEISS, K. 1999: *Stromproduktion aus der Vergärung; Ökobilanz im Auftrag des Biogasforum Schweiz.* Baar.