New Generation of Solar Thermal Systems

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PROPOSAL of TR/TS for ENVIRONMENTAL LCA of SOLAR THERMAL SYSTEMS

REPORT No1 in WP4.9

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SUMMARY

The NEGST group suggests to establish rules for how to make an Environmental fact sheet so that it will be possible to compare different environmental investigations of solar thermal systems and assess between different solar thermal products and different heating systems.

The aim with the Environmental fact sheet is both to objectively declare an thorough presentation of an inventory of resource use (energy and material), emissions, waste, recycling etc for the STS product's complete life cycle and at the same time give an immediate objective and easy understandable overview of the most important assessments of the STS's environmental impact.

Therefore the Environmental fact has the following content:

- Rules for performing a life cycle inventory
- Declarations of the STS product
- Energy payback time
- Avoided global warming impact

The Environmental fact sheet should be a certified declaration and may be the basis for future labelling of Solar Thermal Systems. An example of an environmental fact sheet is given in the Appendix.

State-of-the-art survey

The main objective with NEGST WP 4.9 is to agree on procedures for evaluating the environmental Life Cycle Assessment of solar thermal systems (STSs). The work started with a literature survey together with knowledge information collection from all NEGST participants. The gathered information has been described in a state-of-art-article /Wahlström05/.

The state-of-the-art survey showed two important aspects. The first aspect is that there are several ways of performing an LCA of STS. The different studies use different assumptions, boundary conditions, functional units, data bases and assessment methods, as well as reference systems (conventional system). This makes direct comparison between different assessments impossible. There is a need for common procedures for environmental LCA of STS as well as for all water and space heating systems.

The second aspect is that an environmental impact description can be expressed in different ways, depending on the objective and scope of the LCA and which environmental impact that is considered. The literature survey shows that there are two common ways of performing the environmental impact description. The first describes the environmental impact in respect of primary energy use. In this context, primary energy considers not only the energy input in each life cycle phase, but also how this energy input is produced with the production unit's efficiency. This means that the LCA considers the kind of energy used in each life cycle phase in order to determine the primary energy use. The second describes the environmental impact with emissions to air. Here, the kind of energy used in each life cycle phase must be considered in order to determine the primary energy use, as well as the specific energy source's life-cycle emissions. Besides these two common ways an environmental impact description may also consider use of rare material sources as heavy metals, hazardous waste of heavy metals or radioactive deposit.

Environmental fact sheet

The NEGST group suggests to establish rules for how to make an Environmental fact sheet so that it will be possible to make an environmental assessment between:

- different solar thermal products
- different heating systems

even though the environmental investigation has been performed by different persons or in different European countries. The purpose with the Environmental fact sheet is that is should be a certified environmental product declaration of the STS product and that life cycle assessment (LCA) has been considered of the product's total environmental impact from "cradle to grave". The Environmental fact sheet may be the basis for future labelling of Solar Thermal Systems.

The rules for making the Environmental fact sheet are divided into:

- Rules for performing a Life cycle inventory
- Declarations of the STS product
- Energy payback time
- Avoided global warming impact

Here the first point is needed to get relevant information for the second point which is needed in order to calculate the third and forth points. The content of the Environmental fact sheet aims to give an objective and thorough presentation of the STS product's environmental impact so that it would be possible to compare different environmental impacts with a limited additional calculations and/or assessments. Therefore the Environmental fact sheet consists of a declaration of the STS product.

At the same time the content should give an immediate objective and easy understandable overview of the most important assessments of the STS's environmental impact. Therefore the Environmental fact sheet includes an Energy payback time which considers the STS's embodied energy that is important since STS systems are mostly added as a complementary installation, without replacement of a conventional system. The reason to use energy payback time is that it is easy to understand and to communicate and that is already commonly used. However, an assessment of energy payback time alone could give a wrong evaluation as demonstrated in Figure 1. Therefore we suggest considering the energy payback time together with lifetime and avoided global warming in order to get a complete environmental assessment. It must be clear in the Environmental fact sheet that small differences in real energy payback times are not important. The importance is that the STS unit has a low payback time.

Avoided global warming impact is considered because it is one of the most important environmental impacts. We have here limited consideration of emission impact to one environmental effect since this will give an objective evaluation without complications with subjective assessment between different environmental effects. The assessment with avoided global warming will cover for the possible wrong evaluation demonstrated in Figure 1 since STS unit B will get a higher value for avoided global warming impact than unit A even though it will get a longer energy payback time.

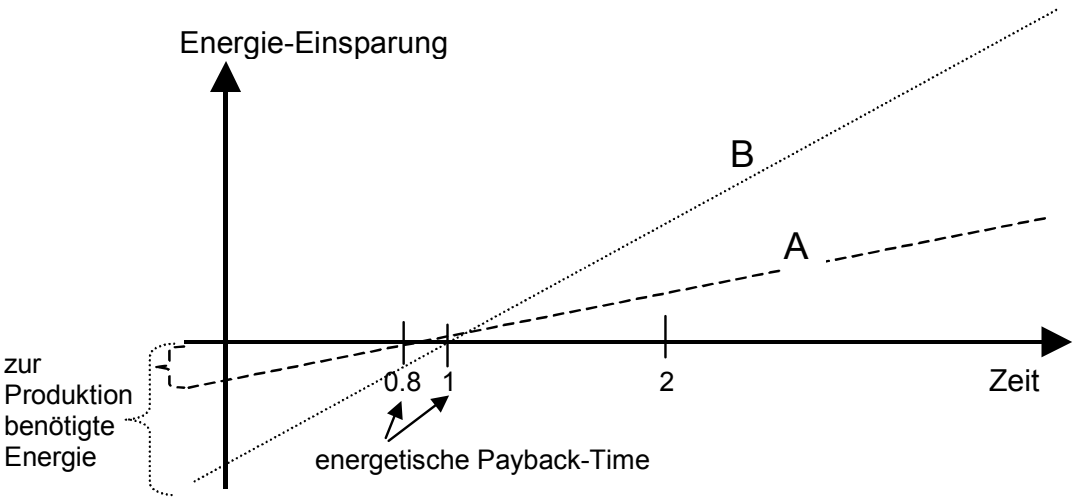

Figure 1: Illustration of two STS systems with small and similar energy payback times /Haller,Vogelsanger05/.

Rules for performing the life cycle inventory

The rules are needed in order to make comparison of LCI of different products within the same group even though the LCIs are done by different persons or in different countries. An LCI is a quantitative description of a products environmental characteristic but without assessment. The objectives with the rules are to get:

- *Credibility*: ensuring transparent, independent and competent control of data.
- *Relevance*: ensuring that the main environmental aspects have been analysed.
- *Comparability*: allowing the user to compare different products on the basis of their environmental impacts.

The ISO 14040 – ISO 14043 standards (/ISO 14040 -14043/) should be followed when performing the LCI. The rules will primarily define how to consider the following criteria within the life cycle inventory:

- Functional unit
- System boundary conditions
- Assumptions
- Databases of primary energy for different materials
- Databases of emissions for different energy sources

Declarations of the STS product

The results from the LCI should be declared in the Environmental fact sheet. Information needed to calculate Energy payback time or avoided global warming impact should be normative while it should also be possible to add other information that may be used for other environmental assessments. The declaration includes the following information:

- Material used in the STS unit (*normative*)
- Energy needed for production, demolition and maintenance of the STS unit
  - Primary energy use (*normative*)
  - Renewable, non-renewable and electricity
- Emissions during production, demolition and maintenance of the STS unit
  - Global warming gases (*normative*)
  - *Ozone depletion gases*
  - *Acidification gases*
  - *Eutrophication gases*
  - *Photochemical ozone formation gases*
  - *Fine particles*
  - *Toxic substances*
- Waste
  - Dangerous waste
  - Material resources to recycling

Energy payback time

A real payback time considers the energy saved by the solar system as equal to the primary energy that should have been used for tap water or space heating by a conventional system, reduced by the amount of operational energy:

$$E_{PT} = \frac{Embodied\ Energy_{system}}{\frac{E_{delivered}}{\eta_{conventional}} - E_{operation}}$$

where:

E_{PT} = Real energy payback time (year),

$Embodied\ Energy_{system}$ = Primary energy assembled in the STS during its complete life cycle (kWh),

$E_{delivered}$ = Energy delivered for tap water or space heating by the STS (kWh/year),

$E_{operation}$ = Operational energy needed by the STS (mainly the circulation pump) (kWh/year)

$\eta_{conventional}$ = efficiency of the conventional system that the STS is replacing.

The advantage with expressing the environmental performance of the STS in terms of simple payback time is that it is independent of the type of conventional system that the renewable system replaces. A real payback time is more correct, but requires information on the application of the STS. Furthermore, energy output from the system is highly dependent on the solar radiation input, which means that the payback time will differ, depending on where the STS is placed. To use real energy payback time in a common LCA procedure requires a definition of a reference system and climate. An assessment of payback time ought to take lifetime into account. A short payback time will not be beneficial if the lifetime is short. The payback time is independent of the functional unit.

In order to be able to compare real energy payback time directly between different investigations the Environmental fact sheet will give rules for definition of:

- A reference system (the conventional system that the STS is replacing)
- Climate application of the STS
- Lifetime declaration

Avoided global warming impact

The actual avoided emissions provide another way of describing the environmental impact, instead of using the payback time. This analysis is done by comparing the emissions caused by the STS with the emissions caused by the replaced system over a defined period of time (for example, the lifetime of the STS).
Assessment of life cycle inventories in general may be done with several assessment methods intended for different purposes that have been developed during the last decade. They weigh different environmental effects and resource consumption into one or a few figures. The weighting factors could be based on society aspects, resource availability etc., and are decided with limited scientific background. In order to get a scientific evaluation only global warming is considered.

In order to be able to compare avoided global warming impact directly between different investigations the Environmental fact sheet will give rules for definition of:

- A reference system (the conventional system that the STS is replacing)
- Climate application of the STS
- Period of time considered

References

/Wahlström05/	Wahlström Å. (2005): Towards procedures for environmental performance assessment of solar thermal products. Proceedings of ISES 2005, Paper 1361, Solar World Congress, Orlando, Florida, USA, August 8-12.
/Haller,Vogelsanger05/	Haller M., Vogelsanger P. (2005): Payback-Time als Kriterium zur Förderung von thermischen Solaranlagen. SPF, Hochschule Rapperswil HSR, 25. April.
/ISO 14040/	Environmental management – Life cycle assessment- Principles and framework, 1998
/ISO 14041/	Environmental management – Life cycle assessment- Goals and scope definition and inventory analyses, 1999
/ISO 14042/	Environmental management – Life cycle assessment- Life cycle impact assessment, 1998
/ISO 14043/	Environmental management – Life cycle assessment- Life cycle interpretattion, 1998

	Environmental Fact Sheet for Solar Thermal Systems	Certification No: *Example*

Manufacturer: **Address:** **Telephone:**	**Brand Name:**	**Type of STS:**	**Certification performed by**: Organisation: Address: Telephone:

The life cycle environmental assessment is performed according to the NEGST's rules. Reference:

Results from Life Cycle Inventory
Environmental product declaration of the STS unit

Material used in the STS unit (*normative*)			Emissions during production, demolition and maintenance of the STS unit		
Material	**Amount (kg)**		**Environmental effect**	**Equivalent gases of the environmental effect**	
Glass			Global warming gases (*normative*)		CO_2- eq
Cupper			Acidification gases		mol H^+
Aluminium			Eutrophication gases		g O_2-eq
Chrome			Photochemical ozone formation gases		g C_2H_2-eq g NO_x
Plastic			Fine particles		mg
Steel			Toxic substances		mg
Iron			Ozone depletion gases		CFC11-eq
Etc……..					
			Energy needed for production, demolition and maintenance of the STS unit		
Waste	**Amount (kg)**		**Primary energy use**	**Amount (kWh)**	
Dangerous waste			Renewable		
Material resources to recycling			non-renewable		
Other waste			electricity		
Total waste			Total primary energy use (*normative*)		

Environmental Life Cycle Assessment of the STS unit
(*normative*)

Reference system			**STS unit**		
Replaced system	*Natural gas boiler*		Real energy payback time		Years
Climate application	*Central Europe*		Avoided global warming impact		CO_2-Equivalents
Period of time considered	*10 years*		Life time of the STS unit		Years
Reference system			**STS unit**		
Replaced system	*Electric boiler*		Real energy payback time		Years
Climate application	*Central Europe*		Avoided global warming impact		CO_2-Equivalents
Period of time considered	*10 years*		Life time of the STS unit		Years

Date:	Signed by: