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# Replacing traditional materials with polymeric materials in solar thermosiphon systems – Case study on pros and cons based on a total cost accounting approach

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**Abstract**

The pros and cons of replacing traditional materials with polymeric materials in solar thermosiphon systems were analysed by adopting a total cost accounting approach. In terms of climatic and environmental performance, polymeric materials reveal better key figures than traditional ones like metals. In terms of present value total cost of energy, taking into account functional capability, end user investment cost, O&M cost, reliability and climatic cost, the results suggest that this may also be true when comparing a polymeric based thermosiphon system with a high efficient thermosiphon system of conventional materials for DHW production in the southern Europe regions.

When present values for total energy cost are assessed for the total DHW systems including both the solar heating system and the auxiliary electric heating system, the difference in energy cost between the polymeric and the traditional systems is markedly reduced. The main reason for the difference in results can be related to the difference in thermal performance between the two systems. It can be concluded that the choice of auxiliary heating source is of utmost importance for the economical competiveness of systems and that electric heating may not be the best choice.


*Keywords:* Solar thermosiphon system; Polymeric solar collectors; DHW production; Total cost accounting; Economic competiveness

## 1. Introduction

It has been pointed out that in many cases, polymeric materials would be a better alternative to materials currently used in solar thermal energy systems; see e.g. the work recently conducted in Task 39 of the IEA Solar Heating and Cooling Programme (IEA SHC Task 39, 2010; Köhl et al., 2012) and the work of the EU funded FP7 project SCOOP (SCOOP, 2015). The introduction of new polymeric materials and technologies is today considered essential in order to meet the market requirements for heating applications in the medium and high temperature range. This requires, however, that the end user investment cost and the service-life of the new polymeric based solar thermal systems are comparable to those of conventional products.

To assess the suitability of solar collector systems in which polymeric materials are used versus those in which more traditional materials are used, a case study on solar

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heating combisystems was previously undertaken in the IEA task mentioned (Carlsson et al., 2014). In that case study a solar heating system with polymeric solar collectors was compared with two equivalent but more traditional solar heating systems: one with flat plate solar collectors and one with evacuated tube solar collectors. For the analysis, a typical Swedish one-family house from 1980 in Stockholm was used. The comparison was made by adopting a total cost accounting approach, which aims at taking into account all relevant factors in designing a solar heating system by simultaneously considering not only functional quality and cost effectiveness, but also reliability, long-term performance, ecological soundness, and recoverability. The difference in thermal performance between the three solar combisystems studied was compensated for by adjusting the size of the solar collector area so that the solar fraction of the three systems became the same. When considering the end-user investment cost for the three equivalent solar heating systems obtained this way, it was found that the polymeric solar collector system would be competitive with the reference flat plate solar collector system and the reference evacuated tube collector system. In this work also climatic costs per amount of solar heat collected were estimated for the three systems. It could be concluded that the climatic cost of the three kinds of collector systems were small when compared with existing energy prices. Thus, the climatic cost seemed significantly less important when compared to the end user investment cost.

In countries with a high solar irradiance and a low gross domestic product, cheaper low-tech products are preferred and the by far dominant solar thermal systems on the market are thermosiphon systems (Mauthner and Weiss, 2014). Due to low wages and low production costs, price of solar thermosiphon systems in such countries depends strongly on material costs. A reduction in price would therefore be possible by replacing traditional materials like metals with polymeric materials. In the project SCOOP previously mentioned (SCOOP, 2015), polymeric based thermosiphon systems were developed for that purpose and the systems studied in the project SCOOP were taken as the point of the departure for the present study. The aim was to assess the suitability of polymeric based solar thermosiphon systems by adopting a total cost accounting approach in the same way as was practised in the first Task 39 case study (Carlsson et al., 2014).

## 2. Total cost accounting approach for suitability assessment

The total cost accounting approach adopted for the present study, takes the end-user or consumer perspective and the ecological long-term perspective as a basis for compiling the contributions from all the various factors that might be important to the life cycle of a functional unit of a product or a system. In the assessment of total cost you have to take in consideration the direct costs associated with the different phases of the life cycle of a functional unit of a product or system as you do in the life cycle cost assessment (LCC). Also, indirect costs, which are associated with damage to environment and that occur in the different phases of the life cycle have to be taken into account as in life cycle analysis (LCA); see Fig. 1.

The point of departure is not a particular design alternative of the functional unit and its life cycle, but its intended function over time. When adopting the total cost accounting approach, it is, however, not the absolute value of the total cost that is of main interest, but the difference in the total cost between two design alternatives of the functional unit of the product considered (Carlsson et al., 2014; Carlsson, 2010, 2007). If one design alternative of the functional unit is chosen as reference, the model to be adopted can be described as follows: For a fixed service time, the difference in total cost ($\Delta C_T$), between a test unit and a reference unit associated with maintaining the same specific function defined for the unit, is estimated from:

$$\Delta C_T = \Delta C_{EUI} + \Delta C_{NIP} + \Delta C_{O\&M} + \Delta C_F + \Delta C_{EoL} + \Delta C_E \quad (1)$$

where $\Delta C_{EUI}$ = the difference in end user investment cost between the two systems; $\Delta C_{NIP}$ = the difference in cost associated with initial non-ideal function or performance between the two design alternatives; $\Delta C_{O\&M}$ = the difference in O&M cost, operational and maintenance costs, between the two design alternatives; $\Delta C_F$ = the difference in cost of probable failures and damage between the two design alternatives; $\Delta C_{EoL}$ = the difference in end-of-life cost between the two design alternatives; $\Delta C_E$ = the difference in environmental cost associated with probable ecological damage between the two design alternatives. Detailed information on assessment of how different cost terms contribute to total cost can be found in previous work by Carlsson et al. (2014) and Carlsson (2010, 2007).

Comparing different design alternatives using the total cost accounting approach requires systematic suitability analysis. The design alternatives must therefore be clearly defined and suitability analysis be conducted, preferably in the form of a case study.

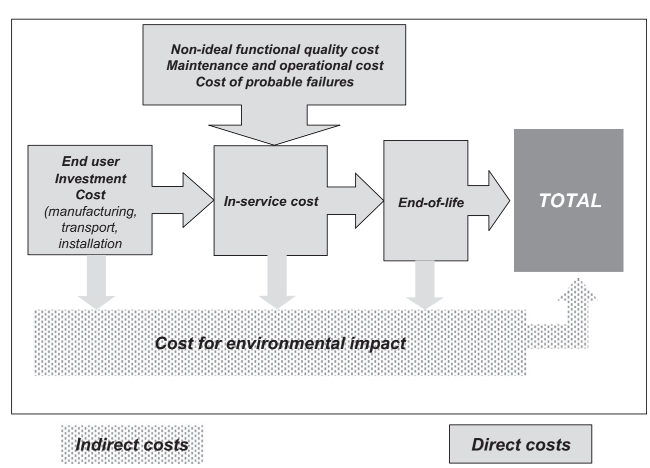


Fig. 1. Principle scheme for assessment of total cost.