Standardized Economic Evaluation Criteria of Solar Process Heat in Hybrid Systems – Results from IEA SHC Task 64 Subtask E

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Abstract

Industry accounts for more than 30% of the total energy demand and faces significant challenges in achieving the set decarbonization goals. Therefore, it is crucial to provide end users with state-of-the-art technologies like solar process heat and optimized combinations with other technologies like excess heat recovery and heat pumps. A barrier, that hinders industrial end users from implementing available solutions, is the challenge of assessing developed concepts not only from technical perspectives but also applying economic parameters The objective of the Subtask E of the joint IEA SHC Task 64 / SolarPACES Task IV is to identify existing barriers, used assessment criteria of all relevant stakeholders and the definition of mandatory parameters, merging the perspectives of solar process heat with other technologies. To achieve this, a survey was performed to collect feedback from the stakeholders concerning technical and economic criteria. Analysis of the results reveals the relevance of various criteria with respect to different project phases. Different economic parameters and the CO_2 abatement costs turn out to be highly relevant throughout all project phases, while the relevance of investment and operating costs exhibits peaks in the detailed planning and operating/implementation project phase respectively.

Keywords: economic indicators, standardized evaluation criteria, SHIP, industrial energy systems

1. Introduction

The industrial sector accounts for about 30% of the total energy demand in the EU and OECD countries, of which about 60% is used to cover process heat demand (Eurostat, 2022, Werner, 2006, Eurostat, 2023). This corresponds to more than 1,900 TWh per year in the EU27 and is also valid for worldwide statistics on energy demand and consumption (IEA, 2021). If the sector is to be decarbonized sustainably, in addition to the buzzwords electrification and hydrogen with significant research demand, solutions are needed that are immediately available and do not shift the challenges to the generation of very large amounts of renewable electricity. Solar process heat is a proven technology, especially in the temperature range up to about 400°C, which is highly significant as already mentioned about 60% of industrial heat demand is in this temperature range (Werner, 2006). In order to achieve high coverage rates of renewable heat, the focus is increasingly shifting to the design and operation of hybrid systems in which solar process heat is combined with excess heat recovery, heat pumps and PV. This results in the challenge of already introducing uniform criteria for all technologies in the planning of these projects, which allow an objective technical and, above all, economic evaluation over the utilization period of all technologies (Braumann, 2020, AEE INTEC, 2016, Avila, 2015, Brunner, 2015). This is well reflected in the demand for tailor-made funding and financing instruments (Fluch, 2015, Giralda, 2016), also based on the outcome of performed energy audits and the development for decarbonization concepts (Kulterer, 2015a, 2015b) Within the framework of the joint IEA SHC Task 64 / SolarPACES Task IV, Subtask E (Guideline to Market) and Subtask A (Integrated Energy Systems) specifically address whether currently used typical evaluation parameters such as payback periods from the perspective of solar process heat will also be suitable in the future to support industrial companies and project developers in the implementation of such hybrid systems and how new approaches must be taken into account in the different project phases from the idea to implementation and operation. This is becoming more and more important as in the Energy Directive of the European Commission, the defined objectives are defined, including the demand for decarbonisation (European Commission, 2023).

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2. Methodology

Through Subtask E, relevant parameters for the assessment of renewable technologies were collected and categorized by involving all relevant stakeholders of solar process heat (technology suppliers, project developers, industrial companies, research and investors). Based on identified and evaluated available funding programmes on Solar heat for industrial processes (Nitz, 2021), performed within the Subtask E of the SHC Task, this demand is already highlighted. A total of 65 criteria were assigned to four categories (general project information as well as economic, technical and methodological parameters) and subsequently evaluated for different project phases from the idea to a feasibility study, rough and detailed planning, implementation/commissioning and operation. These results were finally transferred into a representative survey with the aim of ascertaining whether the importance or the necessary level of detail of the different parameters changes in these project phases.

The survey was done in a two-step approach. First the questions were shared within the participants of the IEA SHC Task 64 / SolarPACES Task IV group and afterwards spread, using the communication channels of the whole SHC Task as well the lead partner of the Subtask E. The survey was integrated in a web-based platform (SurveyMonkey) and included in total 26 questions, subdivided into the following sections:

- General questions on the background of the participants as company's main area of operation, industrial sector, size of the company, home country as well position, background and experience with renewable energy and solar heat specifically of the person filling in the survey
- Importance of different pre-defined economic (CAPEX and OPEX) parameter/KPIs in different project phases (pre-feasibility, detailed engineering, implementation/operation)
- Importance of ecologic and technical parameter in project phases
- Interest and if possible, share of personal contact data

The survey was done in two rounds including a reminder sent via email. Afterwards the feedback was evaluated by downloading the data and fed in tables and figures, as shown below.

3. Results

The survey included 51 participants at 18 different sites, see Figure 1, with no significant impact of survey participants' location on the results. It is important to understand, that the importance of investment (CAPEX) and operating (OPEX) costs varies over the 3 different phases of project development (pre-feasibility, detailed engineering, implementation/operating). The survey results demonstrate the need to consider new approaches to evaluation that go beyond simply looking at payback time. In Fig. 3, it can be seen that the payback period, the levelized cost of heat and the internal rate of return are of high importance in all project phases. The depreciation, P50/P90 value as well as the net present value are considered moderately important in the pre-feasibility phase but gain importance in the later project phases.

Fig. 1: Location of survey participants

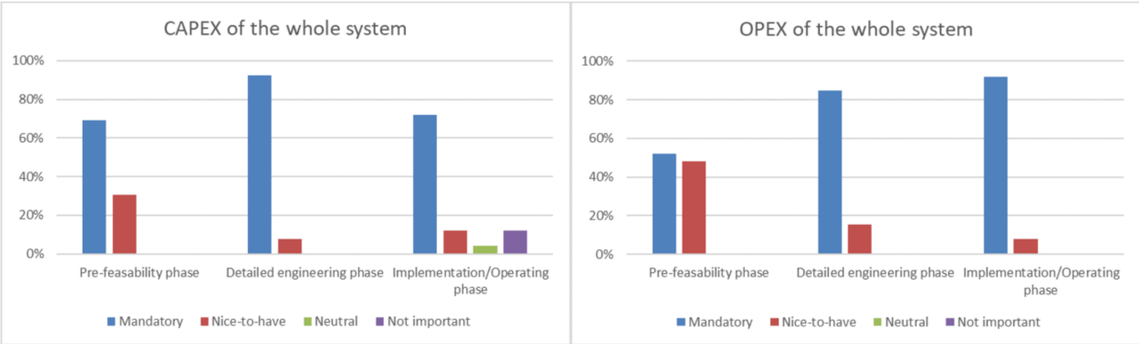

Fig. 2: Survey results regarding the criteria "OPEX of the whole system" (top) and "CAPEX of the whole system" (bottom) and their relevance in project phases: mandatory, nice-to-have, neutral, not important (n=51)

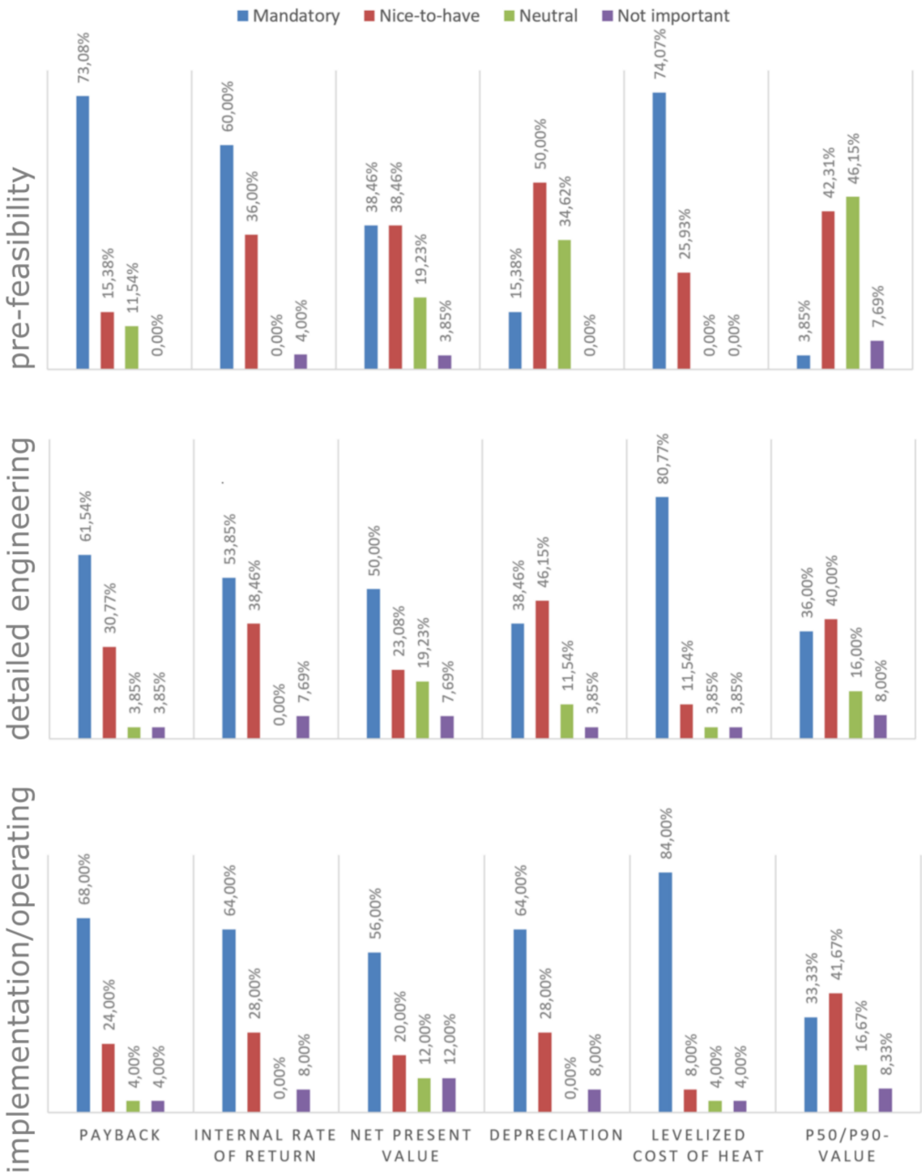

Fig. 3: The importance of the economic parameters in all three phases of a project

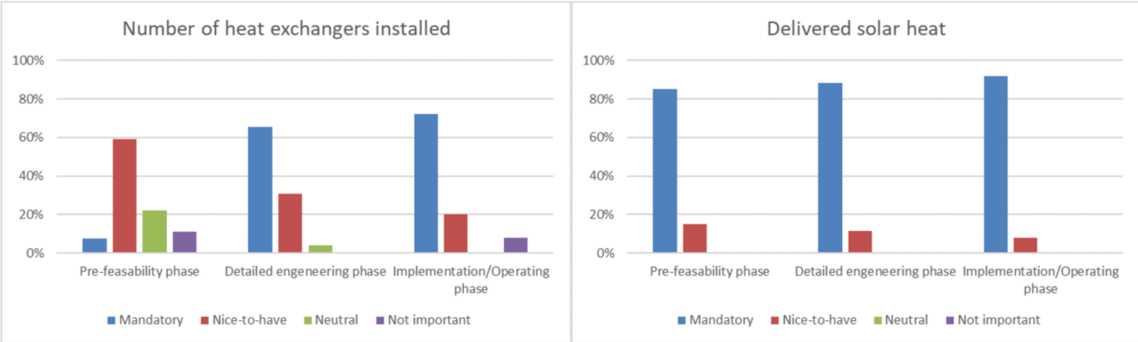

Fig. 4: Survey results regarding the technical criteria "number of heat exchangers installed" (left) and "delivered solar heat" their relevance in project phases: mandatory, nice-to-have, neutral, not important (n=51)

The OPEX (operating expenditures) of individual components and the entire system are considered moderately important in the pre-feasibility phase, with significant increases in importance in the later project phases, see Fig. 3. The CAPEX (capital expenditures) are generally of high interest, with the importance of CAPEX of all system components, as well as that of the entire system (see Fig. 2 and Fig. 3) and process integration, being highest in the detailed planning phase. The increase in the relevance of the OPEX parameters in the later project phases and the peak in the relevance of the CAPEX parameters in the detailed planning phase confirm our expectations and correspond to the general prioritization in the course of a project.

The analysis of the technical parameters shows that the relevance of the delivered solar heat, the storage size and the installed area is considered to be very high in all project phases. The number of installed heat exchangers is of lower importance, especially at the beginning of the design, but increases in the later project phases, see Fig. 4.

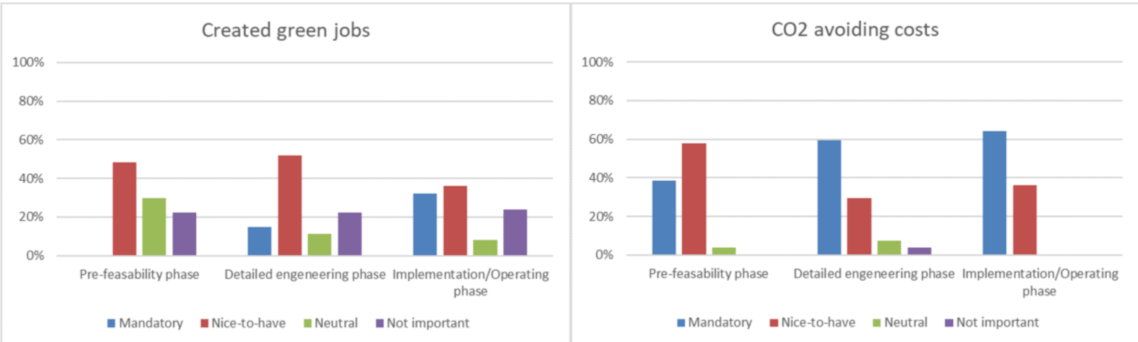

Fig. 5: Survey results regarding the green economy criteria "created green jobs" (left) and "CO_2 abatement costs" their relevance in project phases: mandatory, nice-to-have, neutral, not important (n=51)

As expected, CO_2 abatement costs are considered as relevant parameter in all phases. Surprisingly, the green jobs created (Green Jobs) are in contrast of relatively less interest and even in the implementation and operation phases the relevance of this parameter remains low, see Fig. 5.

4. Outlook

The overall goal of IEA SHC Task 64 / SolarPACES Task IV is to place solar process heat as an important component of future hybrid supply systems in the industrial sector. For this purpose, the results from Subtask E will be further processed and the most relevant evaluation criteria will be defined. Defining a standardized calculation method for the different parameters is the core task. This method is mainly based on results from previous projects and will enable comparison with aforementioned technologies like waste heat recovery, heat pump or PV. Additionally, the importance of different criteria regarding different project development phases is analyzed. Finally, these findings will be incorporated into the work of Subtask A on the design of integrated energy systems and thus contribute to sustainably strengthening the role of solar process heat.

In summary, the following key findings of the survey can be stated:

- **Economic parameters** such as heat production costs, payback time or internal rate of return are considered highly relevant in all project phases. Innovative approaches such as P50/P90 are of increasing interest to investors.
- **Operating costs** of individual components and of the whole system are considered moderately important in the first project phase of feasibility studies, increasing significantly in the later project phases.
- **Investment costs** are generally of high interest, with importance peaking in the detailed design phase.
- **CO_2 abatement costs** are considered an extremely relevant parameter in all phases, while the created **green jobs** are surprisingly of lesser interest.
- There is **no significant impact of the location of the survey participants** on the survey results.

The survey results confirm the need for new evaluation criteria for SHIP (technical, economic, environmental, non-energy benefits) while calling for a clear definition of these criteria for the entire sector. This will enable comparability of the technology with other renewable energy sources and strengthen the role and recognition of SHIP in future industrial energy systems. In addition, specific target groups require different criteria.

5. References

AEE INTEC, Fraunhofer ISE, reenag, eceee, Universidade de Évora, und ainia, „TrustEE - Report on current status of Process heat in Europe: sectors, processes, geographical distribution, system layouts and energy sources“, 2016. [Online]. Verfügbar unter: https://www.trust-ee.eu/files/otherfiles/0000/0008/TrustEE_D1_1.pdf

Avila C., et.al., 2015. Transnational Survey on Funding and Financing Instruments, Deliverable, IEE project GREENFOODS IEE/12/723.SI2.645697

Braumann W., et.al, 2020. TrustEE – Innovative market based Trust for Energy Efficiency investments in industry, publishable report, H2020 project GA number 696140 - TrustEE - H2020-EE-2014-2015/H2020-EE-2015-3-MarketUptake

Brunner C., et.al., 2015. GREENFOODS – Towards zero fossil CO2 emission in the European food and beverage industry, publishable report, IEE project GREENFOODS IEE/12/723.SI2.645697

European Commission, „Energy efficiency directive“. https://energy.ec.europa.eu/topics/energy-efficiency/energy-efficiency-targets-directive-and-rules/energy-efficiency-directive_en#the-2012-energy-efficiency-directive (zugegriffen 19. April 2023).

Eurostat, „Final energy consumption in industry - detailed statistics“, Nov. 2022. [Online]. Verfügbar unter: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Final_energy_consumption_in_industry_-_detailed_statistics

Eurostat, „Energy Efficiency statistics“. 2023.

Fluch J., et.al., 2015. Development of funding and financing instruments, Deliverable, IEE project GREENFOODS IEE/12/723.SI2.645697

Girlada R., et.al., 2016. Comprehensive analysis of funding mechanisms, Deliverable, H2020 project GA number 696140 - TrustEE - H2020-EE-2014-2015/H2020-EE-2015-3-MarketUptake

IEA, „World Energy Balances: Overview“, Paris, License: CC BY 4.0, 2021. [Online]. Verfügbar unter: https://www.iea.org/reports/world-energy-balances-overview

Kulterer K., et.al., 2015a. Best practice Guide financing instruments, Deliverable, IEE project GREENFOODS IEE/12/723.SI2.645697

Kulterer K., et.al., 2015b. Mapping of existing funding programmes and financing instruments, Deliverable, IEE project GREENFOODS IEE/12/723.SI2.645697

Nitz P., Fluch J., 2021. Collection of available solar process heat related national and transnational research and funding programmes, report from SHC Task 64 / SolarPACES Task IV: Solar Heat and work performed in Subtask E: Guideline to market, Deliverable Report D.E1

Werner S., 2006. ECOHEATCOOL—Workpackage 1. The European Heat Market. Final Report IEE ALTENER Project, Brussels, Belgium, http://www.euroheat.org/Files/Filer/ecoheatcool/documents/Ecoheatcool_WP1_Web.pdf