Integrating National Research Agendas on Solar Heat for Industrial Processes

Project Deliverable 6.2:

D 6.2 – REPORT ON SHIP INFRASTRUCTURES/COMPONENTS NEW REQUIREMENTS	
WP	6
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1. Content of deliverable

This report is a deliverable of INSHIP's **Task 6.1 'Mapping of RTD SHIP infrastructures & resources to collaborative framework establishment'**, allocated within **WP6: Integrated SHIP Research Infrastructures**.

In this report, we assess the results of a survey carried out among the SHIP R&D community involved in this ECRIA. A questionnaire has been designed and distributed trying to gain insights on which kind of facilities are missed by the people who is working in the SHIP field every day.

Though a dispersion can be seen in the answers to some questions, the views gathered regarding other questions point very clearly to specific missing facilities.

Besides the statistics, which are summarized in charts, all comments provided by the respondents are gathered in **Annex II**.

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2. Introduction

2.1. Main activities within Task 6.1

The work package 6 '***Integrated SHIP Research Infrastructures***' aims at further developing the cooperation between the SHIP research community at full European level (within the EERA Joint Programme on Concentrated Solar Power, EERA JP-CSP) by targeting two specific requirements of the call:

a) Extensive sharing of existing research facilities, models and databases to optimize Research Infrastructures (RI) capacity;
b) Definition of an exchange program of key staff researchers to use the previously indicated shared facilities as well as to facilitate co-operation and substantially reinforcing the partnership among the whole consortium.

Both aforementioned initiatives will be defined in the context of scientific research activities previously defined into WP2, WP3, WP4 and WP5.

Additional objectives of this WP6 are:

- To create a formal European network of SHIP facilities.
- To provide further national or in-kind funding to the INSHIP ECRIA.
- To provide selected additional research ideas and activities, on top of defined WP2, WP3, WP4 and WP5 ones, to further increase the outcome and foreground of INSHIP ECRIA.

With the aim of bridging the existing gaps among European RTD organizations and developing a real critical mass of research capacity in Europe around SHIP topics, this WP6 has addressed a number of actions which are expected to substantially increase the research capability as well as promoting a pan-European inclusive approach by defining a joint research agenda.

It further aims at acting as liaise between the related EERA Joint Programme (EERA JP-CSP) and the RI initiatives, looking to fine-tune the synergies between the various on-going initiatives relevant to the enhancement of SHIP Research Facilities cooperation (such as SFERA-III, EU-SOLARIS, etc.), in order to diminish overlaps and enhance complementary.

This deliverable is related to ***Task 6.1. Mapping of RTD SHIP infrastructures & resources to collaborative framework establishment.***

Although there are already significant SHIP research facilities in Europe, this task has been aimed to mapping all of them jointly with the assessment of core capacities (who/which ones are the best in any specific topic or application) and associated existing resources (personnel and average yearly budget). The result of such mapping (see **Figure 1**, below) exercise can be found at the INSHIP web site, at the following URL: http://inship.eu/research_infrastructures.php

Also, the mapping will help to check if the current existing facilities fulfil all present and future needs of the scientific community and industrial sector. This enables the definition the **new needed RTD facilities together with the best potential locations** (organizations) to such improvement.

Once this RTD SHIP Research Infrastructure (RI) map has been completed, the second key objective of this Task is the establishment of collaboration framework among existing European RTD SHIP

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infrastructures, which is expected to strongly facilitate future research and collaboration initiatives, as well as better coordinate such efforts.

Figure 1. A view of the web site 'SHIP Research Infrastructures'.

To the proper achievement of this goal, the following activities will be addressed:

- Checklist of the current and planned activities to be carried out within each research initiative and the centres and researchers that are involved. The alignment with stakeholders and related industry sector necessities will be stressed.
- This information will be compared to the wider community in Europe, maybe smaller centres not currently involved in the initiatives but whose knowledge or facilities could add value to the joint SHIP research effort in Europe.
- The services currently offered by each initiative will be analysed to determine the most suitable options for a collaborative framework that would cover future market needs.
- Finally, with all the available inputs, the basis for an appropriate collaboration framework will be established in order to coordinate the efforts of the various European initiatives in SHIP, always within the context of the EERA JP-CSP.

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2.2. Expected impact of coordination activities with respect to Research Infrastructures

The following table summarizes the expected impact of these coordination activities.

Table 1. Expected impacts of coordination activities with respect to Research Infrastructures at INSHIP

Project objective	Expected impact	Beneficiaries
#1. Adapt the European research infrastructures to the needs of the industrial sector	Provide the industrial sector with the R&D infrastructure required to accomplish the expected "learning curve" and achieve a significant cost reduction	- Industrial sector - R+D community - Project developers - The public at large
#2. To create a formal European network of SHIP R&D facilities	Optimization of Research Infrastructures capacity at European scale	- Industrial sector - R+D community - European Commission
#3. Exchange of researchers and definition of common practices for the access and use of the R+D facilities	Standardized procedures and rules for access to R+D infrastructures. Definition and implementation of standard testing procedures	- Industrial sector - R+D community - Project developers

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3. Assessment of missing R&D facilities for INSHIP applications

3.1. Methodology

The main source of information that we have used is a survey carried out within the INSHIP community.

The questionnaire can be found as **Annex I** of this report.

There, we have asked directly to the researchers participating at this project whether they consider that any important research infrastructure for the goals of INSHIP is missing. A distinction has been made between a 'solar facility' and a 'lab facility'.

We have got a number of 46 responses from all participating countries, which can be considered a fairly representative answer from a highly qualified community.

3.2. Main conclusions extracted from the survey results

In this section we analyze the results of the survey, going through it question by question and trying to extract some conclusions on what the INSHIP R&D community considers necessary but missing in terms of RI.

The first proposed question is about **the need of new R&D solar thermal (or lab) facilities** to boost R&D on SHIP applications. In this case, there is a clear 'YES' in the answers, with more than ¾ of respondents in favor of this option (see **Figure 2** below).

Nevertheless, it is worth mentioning here that some respondents do not consider it absolutely necessary (see **Annex II**), with responses betting for getting resources to utilize and maybe adapt the existing ones to the current needs.

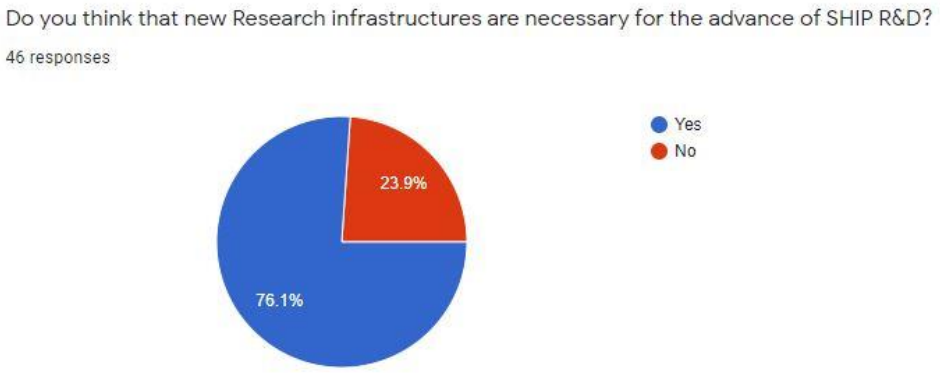

Figure 2. Do you think new RRII are necessary for the advance of SHIP R&D?

When asking about '**solar' or 'lab' facilities**, there is a clear majority of respondents in favor to build a new 'solar' facility (51.4%), though another 14.3% propose the construction of a new '*solar laboratory*' complex to deal with SHIP issues (**Figure 3**).

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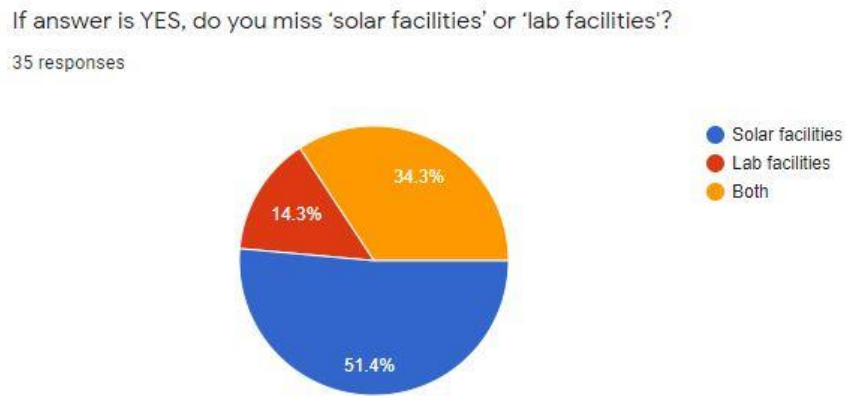

Figure 3. If answer is YES, do you miss 'Solar' or 'Laboratory' facilities?

Among those respondents who think that a new solar testing facility would be necessary, most of them bet for the 'classic' technologies, though a number of respondents propose other options (see figure 3 below):

- Solar tower (25.7%)
- Parabolic trough collector (17.1%)
- Linear Fresnel collector (17.1%)

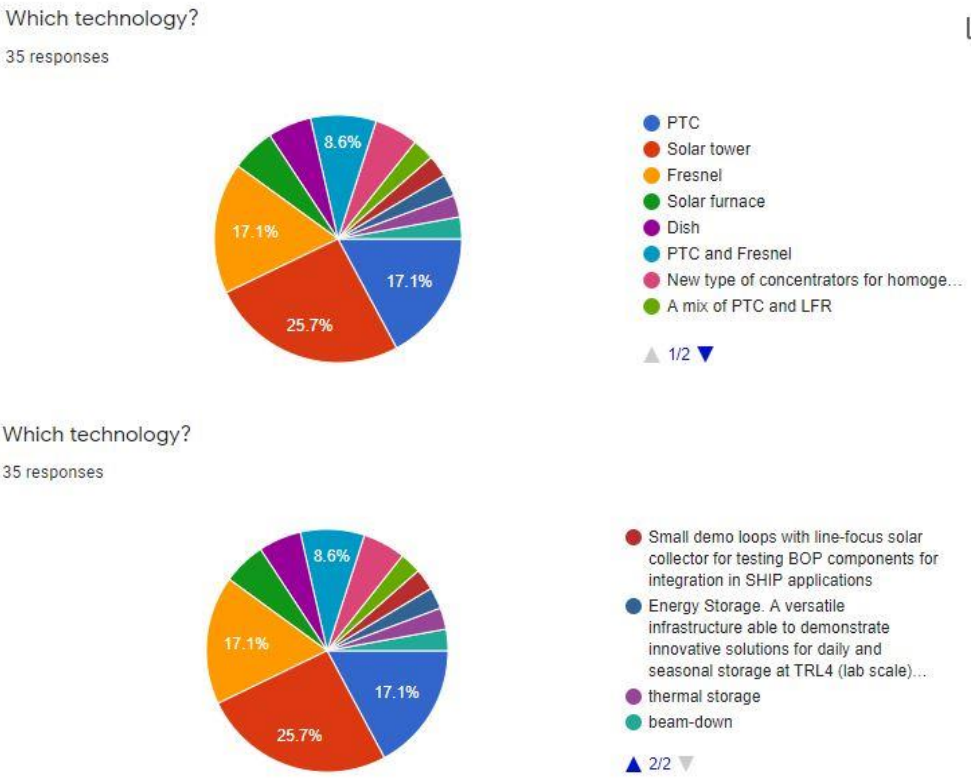

Figure 4. In the case of 'Solar' facilities, which technology?

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As can be seen in **Figure 5** below, there is a clear majority of those who would prefer **a solar facility with a thermal power of 100 kW or higher (75%)**. The value of 100 kW, specifically, is proposed by a 40.6% of respondents.

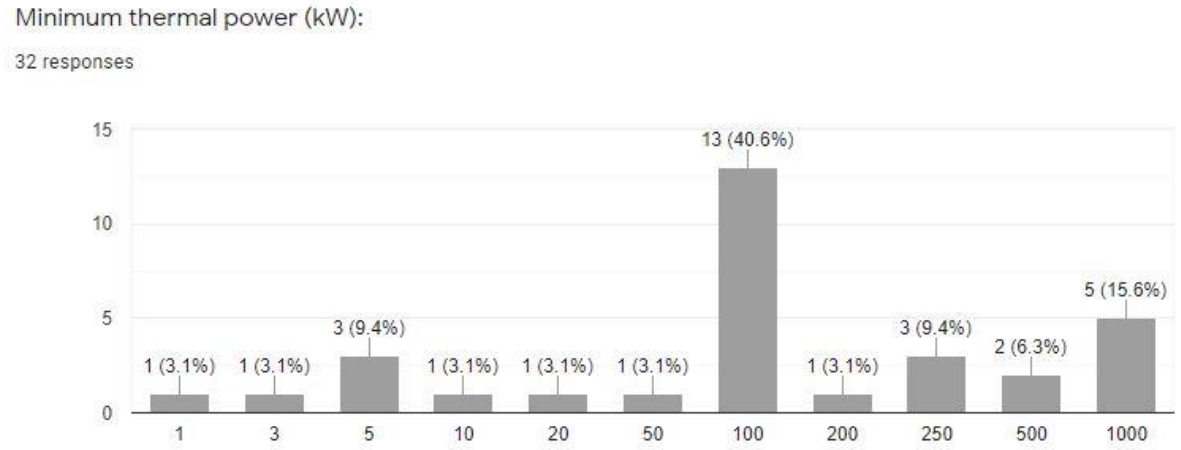

Figure 5. For 'Solar' facilities, which is the minimum thermal power you recommend?

When asking about the **purposes to build a new 'solar' facility**, the four most preferred responses have been:

- Modelling and simulation (61.1%)
- Thermal conversion (52.8%)
- Hybridization (50%)
- Materials (50%)

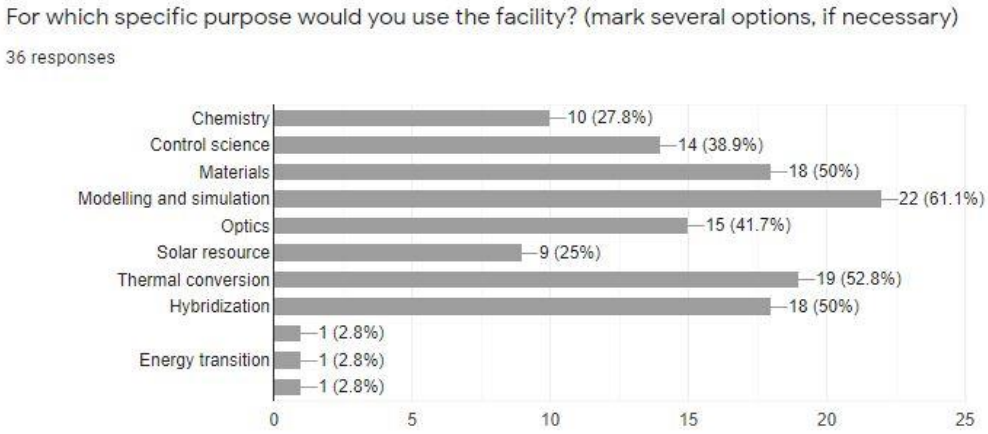

Figure 6. For which applications would you use the new solar facility?

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When talking about a supposed **new laboratory**, the three most preferred purposes are (see **Figure 7** below):

- Materials (65.2%)
- Thermal conversion (65.2%)
- Modelling and simulation (60.9%)

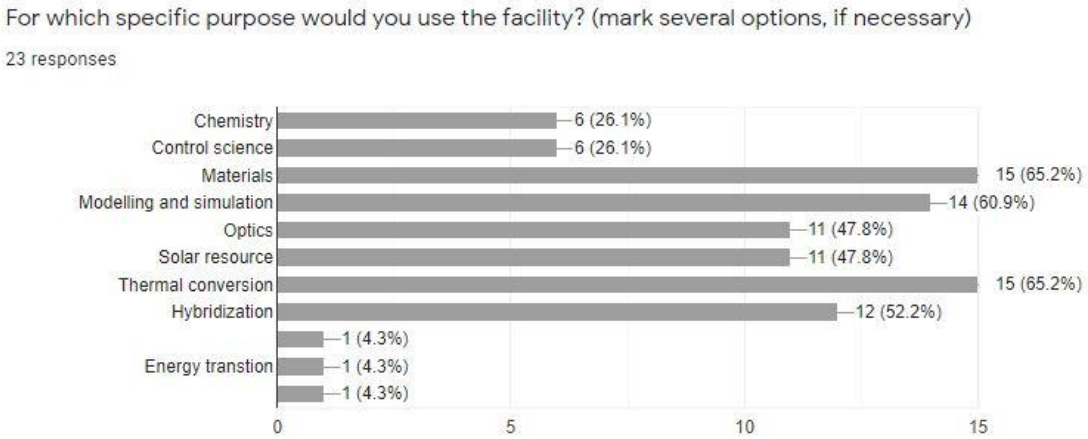

Figure 7. For which applications would you use the new laboratory facility?

As can be seen in **Figure 8** below, there is a wide majority supporting the idea to build this supposed new facility in an existing R&D center (78.8%). On the other hand, when asked 'where?' there is a wide dispersion of answers, seeming that almost every single respondent bets for his/her own institute (see Annex I).

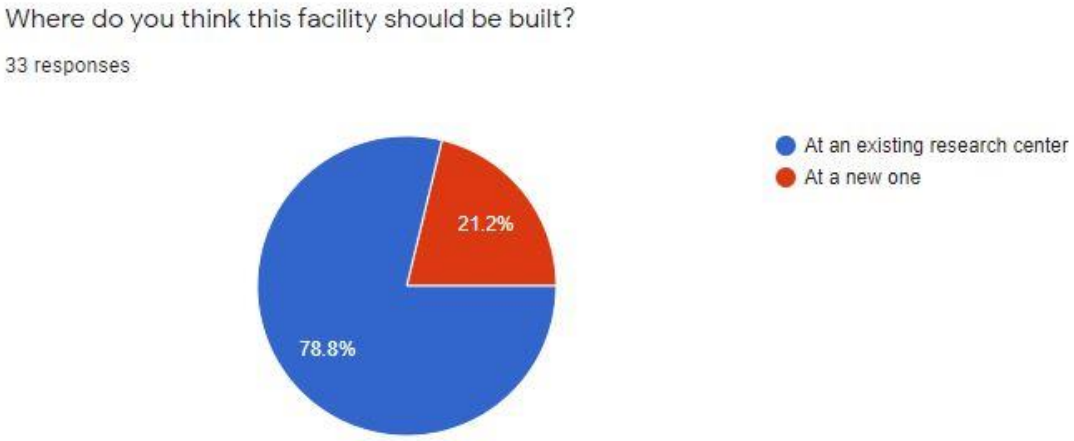

Figure 8. Preferred location for the new facility

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ANNEX I - Questionnaire on missing R&D infrastructures for SHIP

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Questionnaire to build a report on SHIP infrastructures/components new requirements

This survey is developed as part of the INSHIP project (Integrating National Research Agendas on Solar Heat for Industrial Processes), led by the Fraunhofer Institute for Solar Energy Systems (FISE), and which focuses on engaging major European research institutes with recognized activities on Solar Heat for Industrial Processes (SHIP), into an integrated structure that could successfully coordinate the achievement of the following objectives:

- More effective and intense cooperation between EU research institutions in this field
- Alignment of different SHIP-related national research/funding programs, avoiding overlaps and duplication & identifying gaps
- Acceleration of knowledge transfer to the European industry

We kindly ask you to complete this short questionnaire (it should not take more than 15 minutes), to help us identify any missing R&D facilities in the European landscape.

A landscape of already existing RTD infrastructures in the countries participating in this Project is available at:

http://www.inship.eu/research_infrastructures.php

Likewise, another source of information about existing resources can be found at the following study carried out within the framework of SFERA-III project:

https://sfera3.sollab.eu/deliverables/#

YOUR CONTACT DATA (for stats purpose only):
* Required

1. Email address *

2. Full name *

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3. Position *

4. Institute / Company *

5. Country *

Questionnaire:

6. Do you think that new Research infrastructures are necessary for the advance of SHIP R&D? *

Mark only one oval.

- ◯ Yes
- ◯ No

7. If answer is YES, do you miss 'solar facilities' or 'lab facilities'?

Mark only one oval.

- ◯ Solar facilities
- ◯ Lab facilities
- ◯ Both

In case of solar facilities

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8. Which technology?

Mark only one oval.

- ◯ PTC
- ◯ Solar tower
- ◯ Fresnel
- ◯ Solar furnace
- ◯ Dish
- ◯ Other: _____

9. Minimum thermal power (kW):

_____

10. Where do you think this facility should be built?

Mark only one oval.

- ◯ At an existing research center
- ◯ At a new one

11. If you have chosen option 1, please indicate the name of the centre in which you consider it should be built

_____

12. If you have chosen option 2, please indicate in which country you consider it should be built

_____

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13. For which specific purpose would you use the facility? (mark several options, if necessary)

Check all that apply.

- [ ] Chemistry
- [ ] Control science
- [ ] Materials
- [ ] Modelling and simulation
- [ ] Optics
- [ ] Solar resource
- [ ] Thermal conversion
- [ ] Hybridization

Other: [ ] _____

14. Give any further details about this facility you consider necessary

_____

_____

_____

_____

_____

In case of lab facilities

15. Please describe briefly the new lab facility you consider necessary

_____

_____

_____

_____

_____

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16. For which specific purpose would you use the facility? (mark several options, if necessary)

Check all that apply.

- [ ] Chemistry
- [ ] Control science
- [ ] Materials
- [ ] Modelling and simulation
- [ ] Optics
- [ ] Solar resource
- [ ] Thermal conversion
- [ ] Hybridization

Other: [ ] _____

17. Where do you think this lab facility should be built?

_____

ANNEX II - Summary of textual answers collected through the on-line questionnaire

Responses received per country and per Institute/Company

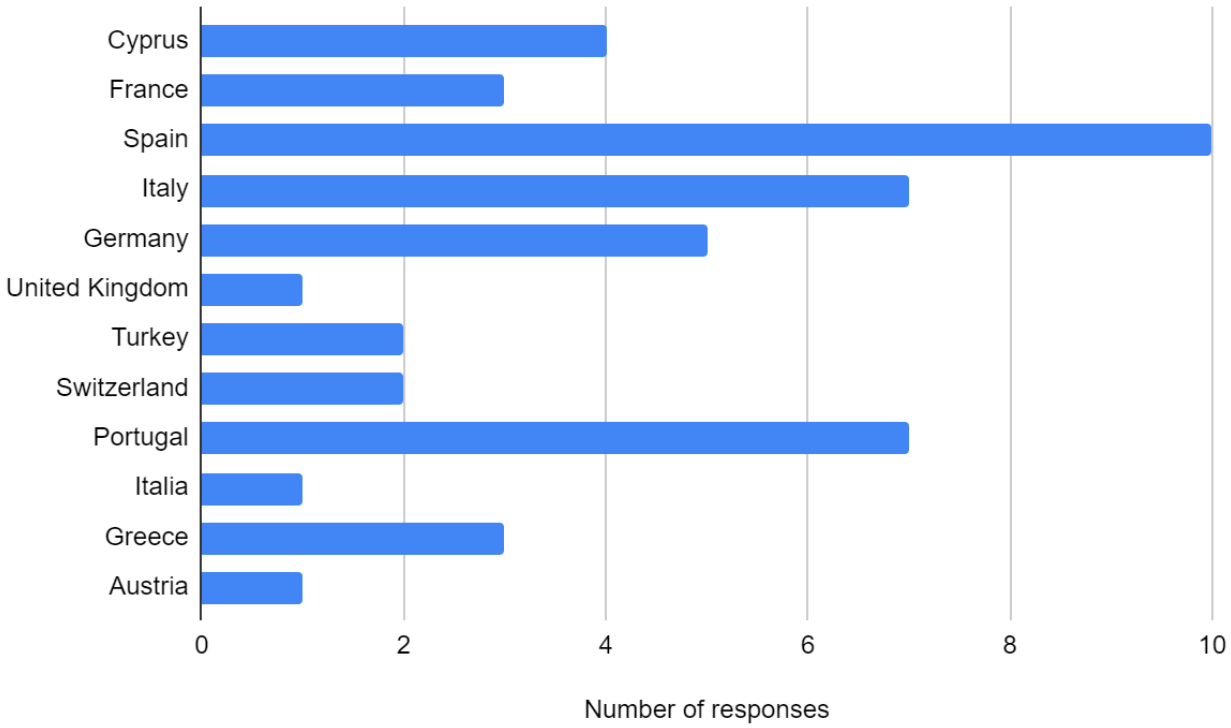

Figure 9. Number of responses received per country.

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Table 2. Number of responses received per institute/company

Institute / Company	Number of responses
AEE INTEC	1
CEA	2
CENER	2
CIC energiGUNE	1
CIEMAT	3
CNR-INO	1
CNRS-PROMES	1
Cranfield University	1
CRES	3
DLR	3
ENEA	1
ETH Zurich	2
FBK	2

Institute / Company	Number of responses
Fraunhofer ISE	2
IMDEA	1
IST-ID	3
LNEG	1
METU	2
Tecnalia	1
TEKNIKER	1
The Cyprus Institute	4
Università di Palermo	1
Universitat Politècnica de Catalunya (UPC)	1
University of Evora	3
University of Florence	1
University of Naples Federico II	2

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Give any further details about this facility you consider necessary

17 responses

1. Linear Fresnel Reflector prototype, critical thermal power depending on aperture, 100 kW for a large-size LFR, easier to install on industrial roof.

2. I think there are enough solar facilities. The difficulty may arise when connecting them to industrial systems. That is to say, the complication may be when it comes to simulating the demand to which they have to supply the heat. Concentrating all the systems in a single installation where a variety of solar systems and systems that simulate industrial demands are available can be advantageous. In this sense, the Plataforma Solar de Almería would be the ideal location.

3. A facility, connected to an industrial park, to demonstrate that hybridization of mid-temp SHIP under moderate climates can be cost-competitive.

4. Turkey's SHIP R&I and industrial capacities are promising but undeveloped. We need to synergistically develop our RIs in parallel with growing these capacities.

5. Fully controlled solar plant with storage and hybridization to deliver heat on-demand.

6. Homogeneous Flux Distribution in High-Flux Solar Furnaces, (2020), JCG Pereira, J Rodríguez, JC Fernandes, LG Rosa, Energies 13 (2), 433; https://doi.org/10.3390/en13020433.

7. Hybridization concepts with other renewable energies to replace the fossil backup-heater -> 100% RE concepts High temperature facility for energy intensive processes.

8. I do not consider a new facility necessary in general (existing facilities may be used and modified, if required). However, from specific projects the need for new (or modified) facilities may arise.

9. Storage and pinch network.

10. I think the facility is necessary to improve thermal conversion efficiency for solar dish and PTC in order have more competitive devices to produce thermal and electrical energy.

11. Homogeneous Flux Distribution in High-Flux Solar Furnaces, (2020), JCG Pereira, J Rodríguez, JC Fernandes, LG Rosa, Energies 13 (2), 433; https://doi.org/10.3390/en13020433.

12. Facility to perform an integrated evaluation of SHIP co-generation systems: a test rig for co-generation of heat, electricity and cold using small scale CST systems as driving technology. Such facility would need to have a test rig consisting of a hydraulic circuit with a set of heat exchangers (and direct connection possibilities) as well as heat sources and sinks (and the corresponding instrumentation and data acquisition systems). This would allow the connection of a small scale CSP collector (or set of) to turbines (e.g., ORC), absorption chillers, etc. and could allow industry to study, develop, demonstrate, or certify their equipment working as integrated co-generation systems.

13. Pilot demonstration plants at commercial scale with high potential of replication, standardization, and digitization of systems.

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14. I think there are enough test facilities for SHIP applications.
15. It is already well equipped. It was enhancing an existing centre of excellence.
16. PTC facility with steam generator that provides the analysis of flexible operation strategies, control schemes and details about the integration of SHIP applications.
17. We have enough test facilities / infrastructures. We need resources to utilize and maybe adapt them.

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In case of lab facilities

Please briefly describe the new lab facility you consider necessary.

21 responses

1. My knowledge on solar facilities is limited, but I am not aware of a facility in which solar thermal solutions can be tested in combination with other technologies, such as heat pumps, from a system perspective.
2. I do not identify any particular lab facility that is especially relevant/missing. Given the wide variety of tests and characterizations required and development cases, it is difficult to specify a particular installation. Most institutions have been building the equipment they need. That is why it is important to keep the list of equipment that has been collected during the SHIP project accessible and updated.
3. Small tower system to demonstrate all components.
4. Fully controlled solar plant with storage and hybridization to deliver heat on-demand.
5. Lab facilities, highly instrumented, on experiments related to TES and critical parts of PTC, CR and LFR.
6. New lab facilities to address specific RTD questions may be easier to implement than using/modifying/operating large solar facilities; smaller lab facilities may be set up project related and focussing on specific RTD questions. Examples may be soiling and cleaning; material and component prototyping and testing; BoP or control testing using model systems, hardware-in-the-loop or similar.
7. I consider necessary a laboratory able to analyse on low scale all devices inside a thermal solar power. The future challenge is to analyse how to improve the efficiency of the thermodynamic transformation. So, it is necessary consider a laboratory that can simulate all the components of a solar thermal source and then, on a small scale, verify the carried-out data by building an experimental prototype to analyse them. So, the laboratory needs a strong numeric unity and the possibility to reproduce the simulation experimentally.
8. Homogeneous Flux Distribution in High-Flux Solar Furnaces, (2020), JCG Pereira, J Rodríguez, JC Fernandes, LG Rosa, Energies 13 (2), 433; https://doi.org/10.3390/en13020433.
9. Small tower to test reactors.
10. Energy Storage. A versatile infrastructure able to demonstrate innovative solutions for daily and seasonal storage at TRL4 (lab scale) for both thermal and thermos-chemical energy store concepts.
11. New RI for testing Fresnel and PTC components and systems (min 100 kW).
12. Digital twin.
13. A little thermal storage facility using different materials as thermal capacity.
14. I think there are enough test facilities for SHIP applications at present.

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15. High temperature materials and process testing for solar receivers and hybridization equipment.
16. 100 kW testing facility for evaluation of new technologies in storage, materials, subcomponents.
17. Thermal energy storage at temperatures above 1000 C.
18. Solar furnace and concentration system, testing materials properties.
19. SHIP Lab with source of heat for multiple process temperatures and pressures.
20. Up-date some existing facilities with systems for the utilization of solar heat to drive specific processes with real constraint.
21. Small scale PTC installation.

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Where do you think this lab facility should be built?

21 responses

1. Any place in which there are resources and knowledge on other thermal systems, not only solar technologies.
2. When it comes to laboratory testing, each institution may require certain facilities and it is probably less relevant and even less effective to try to concentrate them in one place.
3. Same question that above??
4. Research groups with experience on the specific fields mentioned above (TES, PTC, CR, LFR).
5. Project related (no specific country dependency if built in the lab).
6. It is not so important the city but the latitude.
7. Italy.
8. LNEG, Lisbon.
9. Portugal.
10. CENER.
11. CRES, Greece.
12. Anywhere in Europe - but share the lab space online.
13. Department of Industrial Engineering – UNINA.
14. I think here are enough test facilities for SHIP applications at present.
15. Anywhere.
16. At a site with an operating solar tower.
17. CRES Greece.
18. Lisbon.
19. CIEMAT PSA.
20. At least one in each country.
21. CRES.

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