

*Scientific and Technological Alliance for Guaranteeing the
European Excellence in Concentrating Solar Thermal
Energy*



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**Report on the alignment of national
research programmes and funding of STE
technologies**

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Executive Summary

The STAGE-STE project developed coordination and support actions aimed at promoting an alignment of the different national research and funding programmes for Concentrating Solar Power (CSP). Activities were developed under Work Package 2 to enhance working relations between the CSP research community and funding agencies, policy makers and other stakeholders, highlighting the added value of pooling resources for enhanced impact and fostering the coordination of CSP research and funding programmes.

Exploratory meetings between the STAGE-STE partners and national institutions, such as ministries of energy, industry and research, national energy or environment agencies, national research funding agencies and other stakeholders, were performed in Cyprus, France, Germany, Italy, Portugal, Spain, Switzerland and the United Kingdom. These meetings established and intensified communication links between the research institutions and relevant stakeholders, enabling the creation of National Working Groups (NWG) for CSP operating within the scope of this project.

These NWGs have been a vehicle for advocating the value of CSP in the overall energy mix, the need for further basic and applied research, and the development of coordinated funding programmes for CSP research and demonstration activities in order to achieve the desired target of maintaining the European leadership in the sector through the development in Europe of the next generation technologies, while improving the cost-effectiveness of the technology.

It was proposed to each group to discuss how to advance in the alignment of national CSP research and funding programmes (among themselves and with the European programmes) in order to avoid overlaps and duplications, enabling them to be synchronized to provide a larger pool of resources in order to have greater impact. Concept notes regarding the group position on CSP research and funding programmes and its possible alignment were prepared, being discussed at the Alignment of National CSP RTD Funding and Policies International Workshop held on April 20th 2016 in Madrid.

From the concept notes analysis and the discussions held at the Madrid workshop it is possible to conclude that a CSP research programme alignment is feasible between the regional, national and European level, considering the many common points in the positions stated by the different NWGs. Such aligned research programme should have three main objectives: increase of system performance; reduction of costs; improvement of the technology environmental profile. It should encompass the development and improvement of key components and systems (increasing their cost-efficiency), the development of new concepts to improve cost-effective dispatchability of energy, the improvement of plant's durability, the development of solar resource assessment and prediction methodologies and tools, and the promotion of standardization activities. Three specific technical areas have been repeatedly mentioned by the NWGs and should be part of the research programme: thermal energy storage systems; solar fuels; hybridization with other energy sources.

The NWGs identified several possible funding instruments, however, additional discussions at national and European level are required to find and fine tune the best mechanism to align funding. A CSP RTD funding model aligning national and European Commission funds will

have to be an adaptation of an existing funding programme or result from a new development. Such aligned funding scheme should couple regional, national and European funds, having a suitable pool of resources, both in quantity and quality, and a common research programme to drive funding. It should be fitted with a flexible funding allocation policy and present a single access point with simplified evaluation procedures to reduce the time from application to grant.

Achieving funding alignment will require further work since the views expressed in the concept notes regarding research funding present more differences than the ones related with the activities and priorities for the research programmes.

Following the concept notes discussion at the Madrid workshop it was decided to focus efforts in the definition of the SET-Plan CSP Implementation Plan which could work for the near future as the focal point for the alignment of national research programmes and funding. The national stakeholders (through the NWGs and other bilateral contacts) have been involved in the discussions related with the definition of the CSP Implementation Plan in collaboration with their national members of the EERA JP-CSP and representatives at the Temporary Working Group which was developing the plan. The plan was finally approved by the SET-Plan Steering Group in September 2017.

To fund the activities foreseen in the CSP Implementation Plan it is necessary to coordinate public funding at both national and European level with private investments. Currently the feasibility of implementing a Public-Public-Private Partnership is under analysis by all stakeholders, including the European Commission and interested countries. Further efforts are ongoing to promote a successful aligned CSP research and funding programme under the framework of the SET-Plan CSP Implementation Plan.

1. Introduction

The transition to a low carbon economy and the reduction of European Union's external energy dependence requires a change of paradigm of the energy system in the medium to long term, which will require significant Research and Technological Development (RTD) efforts to reduce costs and increase efficiency.

Public interest and resource scarcity require judicious choices regarding the allocation and management of RTD activities funding. In the European Union (EU), public RTD funding is provided by a diverse range of entities at several levels (European, national and regional), each level with its different programmes and objectives. Such fragmented landscape promotes the dispersion of resources and efforts, hindering a cost-efficient development of the research activities. Furthermore, the development and demonstration of Concentrating Solar Power (CSP, also known as Solar Thermal Electricity, STE) technologies at medium to high Technical Readiness Level (TRL) requires significant resources due to the high cost of building CSP research infrastructures and prototypes at relevant scale. Thus, the alignment of efforts between the regional, national and supra-national level is of the utmost importance in order to achieve a cost-effective development of the CSP technology in Europe, avoiding overlaps and duplication of efforts, while pooling together enough resources to significantly advance the technology and drive cost reductions while maintaining the European leadership in the CSP sector.

The STAGE-STE project aimed, among other goals, to synchronize the different national research programmes for CSP in order to avoid duplication and to achieve better and faster results. The project also intended to create added value at European scale by enhancing the cooperation between research institutions in the EU, establishing the European reference association for promoting and coordinating international cooperation in concentrating solar energy research.

To promote the synchronization of national research and funding programmes, Work Package 2 (WP2) of the STAGE-STE project stimulated the enhancement of working relations between the CSP research community and leading decision making bodies, such as national research funding agencies, in order to foster the development of coordinated funding programmes for STE research in Europe and to raise awareness for the importance of this technology for the future energy mix of Europe and neighbouring regions, promoting a two-way flow of information on CSP.

At the start of the project a survey was performed under Task 2.1 to understand the status of the CSP research programmes and funding up to 2014 in the European countries participating in the project (Cyprus, France, Germany, Italy, Portugal, Spain, Switzerland and the United Kingdom). It concluded that CSP is a marginal field in Europe in terms of funding, number of projects and number of institutions working on the subject, when comparing with other energy technologies (results published in D2.1 – Report: national programmes and objectives in STE research). This contrasts with the current growth period within the worldwide CSP

sector and the relevance given to this technology in European and international documents¹ - due to CSP singular characteristics (as the cost-effective use of thermal energy storage) which increase their interest in a world with very high renewable energy share, since it is able to provide stability and dispatchability to the power grid. Currently it is clear that in order to sustain and improve the European leadership in renewable energy technologies, and particularly in STE, it is necessary to improve the current status quo regarding its research and demonstration activities and funding programmes.

To accomplish the aforementioned goals, and considering the conclusions from Task 2.1, activities were developed under STAGE-STE Task 2.3 in order to establish and improve relations with public bodies relevant to CSP research such as ministries of energy, industry and research, national energy or environment agencies, national research funding agencies and other leading decision-making bodies, the purpose being to foster coordination of research programmes and highlight the added value of pooling resources for enhanced impact.

Taking advantage of the partners' existing connections with their countries' public bodies, a set of exploratory meetings with national authorities were performed during the first year of the project (under Task 2.1) within the 8 countries previously mentioned. These meetings promoted an introduction and further information sharing regarding the STAGE-STE project, the CSP technologies and the latest developments in this field, establishing a direct communication link between the partners and the relevant stakeholders. Building upon these meetings, National Working Groups (NWG) were established, bringing together relevant CSP stakeholders such as academia, industry and national authorities. The NWGs focused on monitoring CSP research and funding programmes at national and regional level, as well as on fostering the alignment of such programmes among the different countries and the European Commission.

This report presents the main activities developed by the project partners and the NWGs within Task 2.3 to promote the alignment of national research programmes and funding of STE technologies, summarizing the results achieved within the project timeframe.

Section two describes the goal behind the creation of NWGs, their composition and activities developed in the different countries. Section three presents the conclusions of the NWGs activities related with the alignment of national CSP research programmes and funding. Section four briefly presents STAGE-STE contributions towards the SET-Plan CSP Implementation Plan. Finally, section five discusses how the research community is and continues to contribute towards the alignment of CSP research and funding programmes.

¹ For example the International Energy Agency's Technological Roadmap: Solar Thermal Electricity – 2014 edition (<https://www.iea.org/publications/freepublications/publication/technology-roadmap-solar-thermal-electricity---2014-edition.html>), the U.S. D.O.E.'s Sun Shot Vision Study (<http://energy.gov/eere/sunshot/sunshot-visionstudy>) or the SET Plan's Towards an Integrated Roadmap: Research & Innovation Challenges and Needs of the EU System (<https://setis.ec.europa.eu/towards-an-integrated-SET-Plan>).

2. The National Working Groups

The STAGE-STE partners from the 8 European countries participating in the project (Cyprus, France, Germany, Italy, Portugal, Spain, Switzerland and the United Kingdom) carried out meetings with several relevant national and regional stakeholders (funding agencies, ministries, energy and environment agencies, among others). These so called “exploratory meetings” were previously described in the Report on relations with national funding agencies and other relevant public bodies (Project Deliverable 2.4). During these meetings information regarding the CSP sector was shared and the STAGE-STE project was presented. The meetings enabled the establishment or intensification of communication links between the research institutions and the relevant stakeholders. Moreover, they represented the basis for the establishment of National Working Groups operating within the scope of the STAGE-STE project.

The NWGs intended to be a privileged contact point between CSP stakeholders, ensuring a suitable exchange of information regarding the developments of the technology, relevant policies and funding. Furthermore, the groups focused on monitoring CSP research and funding programmes at national and regional level and on fostering the alignment of these programmes among the different countries and the European Commission (EC). Being a platform congregating the relevant CSP research stakeholders, the NWG were conceived to have the leadership of consultations on RTD and funding priorities for CSP in each country. Moreover they have been a tool to advocate and foster the development of coordinated actions and funding programmes for CSP research within the national and regional policy makers.

The NWGs were also used as vehicle for advocating to the authorities the value of CSP in the overall energy mix, the need for further basic and applied research, and the development of coordinated funding programmes for CSP research and demonstration activities in order to achieve the desired target of maintaining the European leadership in the sector through the development in Europe of the next generation technologies, while improving the cost-effectiveness of the technology.

The maturity and size of the CSP sector significantly differs among European countries, both at research and industrial level. This variability was translated into the establishment, composition and operation of the NWGs. A typical functional NWG gathers representatives from industry, research institutions, national research funding agencies, ministries (mostly the ones related with energy, industry, research or international cooperation) and other leading decision making bodies (such as regional agencies), promoting at least one meeting every year.

Up to the time of writing, NWG have been formally established by the project partners in five countries: Cyprus, Italy, Portugal, Spain and Switzerland. Additionally, contacts with relevant national agencies have been maintained throughout the project in all three countries where a formal NWG has not been established: Germany, France and UK.

The next paragraphs will present for each country the composition of each NWG during the STAGE-STE project.

Cyprus

The Cypriot NWG was formally established in 2015, with a proposed biannual meeting periodicity, having convened 10 times. Currently it is composed by representatives of the following institutions:

- The Cyprus Institute;
- Cyprus Energy Institute;
- Cyprus Technical Chamber;
- Directorate-General for European Programmes, Cooperation and Development;
- Research Promotion Foundation;
- Advanced Energy Laboratory;
- Cyprus Chamber of Commerce and Industry;
- University of Cyprus;
- Cyprus Technical University;
- Cyprus Employers and Industrialists' Association;
- Electricity Authority of Cyprus;
- Energy Service of the Ministry of Commerce, Industry and Tourism;
- Cyprus Energy Agency;
- Cyprus Energy Regulatory Authority.

Italy

The Italian NWG was formally established in 2016, with a proposed annual meeting periodicity, having convened twice. Currently it is composed by representatives of the following institutions:

- Italian representative to the Energy Committee of Horizon 2020;
- Italian SET-Plan delegate;
- Italian National Agency for New Technologies, Energy and Sustainable Economic Development;
- University of Florence;
- National Research Council;
- Bruno Kessler Foundation;
- University of Palermo;
- University of Naples Federico II;
- Center for Advanced Studies, Research and Development in Sardinia.

Portugal

The Portuguese NWG was formally established in 2015, with a proposed annual meeting periodicity, having convened four times. Currently it is composed by representatives of the following institutions:

- Foundation for Science and Technology;
- IAPMEI – Innovation and Competitiveness Agency;
- National Innovation Agency;
- Directorate General for Energy and Geology;
- Alentejo Regional Coordination and Development Commission;
- Algarve Regional Coordination and Development Commission;
- Competitiveness and Technology Cluster for Energy;
- Horizon 2020 Promotion Office;
- National Laboratory for Energy and Geology;
- University of Évora;
- Innovation and Competitiveness Operational Programme;
- Institute for Systems and Computer Engineering, Research and Development of Lisbon;
- Association of Instituto Superior Técnico for Research and Development.

Spain

The Spanish NWG was formally established in 2014, with a proposed biannual meeting periodicity, having convened three times. Currently it is composed by representatives of the following institutions:

- Ministry of Economy and Competitiveness;
- Centre for the Development of Industrial Technology;
- Centre for Energy, Environment and Technology;
- Madrid Institute for Advanced Studies - Energy;
- National Renewable Energy Centre;
- Tecnalia Research & Innovation;
- IK4 – Tekniker.

Switzerland

The Swiss NWG was formally established in 2015, with a proposed annual meeting periodicity, however it never formally convened. Currently it is composed by representatives of the following institutions:

- Swiss Federal Office of Energy;
- Paul Scherrer Institute;
- Swiss Federal Institutes of Technology Zurich;
- University of Applied Sciences and Arts of Southern Switzerland;
- Airlight Energy Manufacturing SA.

It should be noted that although the Swiss NWG has never formally convene, their members, namely the STAGE-STE partners and the Swiss Federal Office of Energy have been involved

in information sharing and discussions regarding the alignment of research and funding programmes.

Other countries (Germany, France and UK)

STAGE-STE partners from Germany, France and the United Kingdom promoted contacts and exploratory meetings with national research funding agencies and other institutions in order to establish NWGs. Although NWGs were not formally established in these countries, the main stakeholders have been identified and involved, especially during the development of concept notes regarding the national position on CSP research and funding and its possible alignment at European level (discussed in the next section).

3. Towards Aligned National CSP Research

It was proposed to each group to discuss ways to advance in the alignment of different national CSP research programmes in order to avoid overlaps and duplications and enable national and European research and funding programmes to be synchronized.

Each NWG elaborated a concept note regarding the group position on CSP research and funding programmes and its possible alignment (between them and with the ones from the European Commission). Afterwards, representatives from each NWG, the project partners (including the CSP industry association ESTELA) and EC personnel, met to analyse and discuss all eight concept notes at a workshop – the Alignment of National CSP RTD Funding and Policies International Workshop, which was held in Madrid on April 20th 2016 – aiming to find common ground and the basis for such programme and funding alignment.

3.1. Concept Notes

In order to simplify and harmonize this discussion, each group developed its concept note around a common template. Table 1 presents the topics proposed for analysis and discussion.

Table 1: Topics proposed in the concept note template.

Topic	Objective
Background and context	To describe the current RTD research programmes and funding for CSP at the national/regional level, referencing to the National or Regional SMART specialisation strategies.
Future orientations	To identify ideas for future national research goals for the next 5 years in the field of CSP.
Resources	To describe current research infrastructure and existing resources available to pursue the future orientation goals.
Needs assessment	To identify additional resources required to fulfil the future orientation goals.
International cooperation	To identify current (existing and/or desired) international cooperation efforts of each country/region in the field of CSP
Stakeholders	To identify and quantify the types (e.g.: research, small and medium enterprises, industry, government bodies, civil society organizations) of stakeholders currently involved in supporting CSP research and innovation.
Possible funding	To list possible models for funding alignment, shortly indicating

alignment models	pros and cons of each one (from your country perspective).
Proposed funding model to be developed	To identify the preferred model for implementation, discussing main reasons and main expected challenges (at EU level).
Tentative conditions required for suitable projects	To list the conditions that potential projects should fulfil (scope, budget and consortium size, TRLs, etc.) to be eligible to your proposed funding model.

Concept notes discussing the national position on CSP research and funding and its possible alignment at European level were prepared for all eight countries, being presented and discussed in the aforementioned workshop. Although France, Germany and the U.K. had not established a NWG, relevant stakeholders were contacted and involved in the development of the concept notes.

A summary of the 8 concept notes and an analysis of its content are presented in the following subsections. The differences on the organization and development of the CSP RTD sector in each country are reflected in the concept notes. Moreover, every NWG was fully free to decide on the approach and extent of detail of each section of the note. Despite the differences, it is possible to draw some conclusions, including general trends, identifying the main similarities and differences between the NWGs preferences and CSP RTD sector status in each country.

The concept notes' content and ensuing analysis can be considered as a first contribution to the discussion of a wide CSP research and funding programme aligning regional, national and European level activities and funds for the post Horizon 2020 period.

3.2. Aligning Research Programmes

The first six topics of the concept notes (see Table 1) deal with the current characteristics of the CSP RTD sector in each country and its prospective objectives and resources. Together they shed light onto the current situation and the possibility of further aligning the CSP research programmes existent or under development in each country and at the EC level.

Background and context

As previously stated the information presented by Deliverable 2.1, *Report: national programmes and objectives in STE research*, indicates that CSP is a small area within the renewable energy sector in terms of RTD expenditure. The concept notes clearly show that most of the countries do not have a specific CSP RTD programme. Switzerland and Germany are the major exceptions. Switzerland has a broadly defined RTD programme for High-Temperature Solar Energy (part of the Swiss Energy Research Master Plan from the Swiss Federal Office of Energy), covering areas such as STE plants, solar thermochemistry for fuels production, and high temperature solar energy for industrial processes. In Germany the CSP RTD programme is defined under the 6th Energy Research Programme of the Federal Government (Research for an environmentally sound, reliable and affordable energy supply), focusing on solar thermal electricity production.

The inexistence of a specific RTD programme for CSP does not mean a given country has a lack of strategy for the CSP sector. Such is the case of France, where there is a national roadmap² but no specific RTD programmes for CSP.

CSP has also been considered in the development of some of the National/Regional Research and Innovation Strategies for Smart Specialisation for the 2014-2020 period (RIS3). A noticeable case is the Cypriot RIS3, where CSP is explicitly included (since 2015) within the Energy priority sector, following consultations with the NWG. CSP is also included in the RIS3 of the French region of Languedoc-Roussillon and explicitly mentioned in the Portuguese Alentejo region RIS3.

However, it is worth noting that in most countries the CSP technologies are usually overlooked in favour of established renewable technologies such as wind power and solar PV due to a lack of awareness which crosses from policy makers to the general public.

Future orientations

The definition of future national research goals in the field of CSP can be performed from different approaches including: definition in terms of specific or broad technical areas; definition in terms of objectives and/or applications; definition in terms of technical readiness. Most NWGs stated their vision using a mix of these approaches.

Considering the general objectives for CSP technologies, the future goals should include:

- Reduction of capital and operational costs as stated in concept notes from France, Germany and Spain;
- Increasing system performance as proposed by the French and German NWGs;
- Improvement of the technologies environmental footprint as preconized in the German and Spanish concept notes;
- Provision of cost-effective dispatchable power as proposed in the German concept note;

Some countries also defined national research goals in terms of CSP applications, namely:

- Development of systems for thermochemical applications such as solar fuels production as preconized by the NWGs from France, Italy, Portugal, Switzerland and the U.K.
- Development of CSP systems targeting Solar Heat for Industrial Processes (SHIP) systems as preconized in the French, Portuguese and Swiss concept notes;
- Development of CSP applications aiming at solar energy in the built environment as proposed by concept notes from Cyprus and the U.K.;
- Development of CSP applications for island environments as proposed by the Cypriot NWG.

² The *Feuille de route solaire thermodynamique* published in 2011 by the French Environment and Energy Management Agency (ADEME) after consultations with the main CSP French stakeholders.

In terms of broad technical areas the NWGs proposed that national CSP RTD activities in the next five years should be focused on:

- New components and systems (Portugal, Spain and the U.K.);
- Plant durability and long-term performance - includes RTD on Operation and Maintenance (France, Germany and Spain);
- Standardization actions (France, Germany and Italy);
- Solar resource assessment and prediction (Germany and Spain);
- Small to medium scale CSP systems for electricity and heat production (Cyprus and Italy);
- New concepts aiming to improve feasibility and dispatchibility (Spain).

Figure 1 summarizes the main specific technical areas indicated by the NWGs’ concept notes when defining the national research goals for the next five years. It should be stated that blue squares do not represent opposition or disagreement, instead indicating that the concept note from a given country does not include or clearly state such specific technical area.

Specific technical areas	Cyprus	France	Germany	Italy	Portugal	Spain	Switzerland	United Kingdom
TES	Yes	Yes	Yes	Yes	Yes			Yes
Key components and systems		Yes	Yes		Yes	Yes		Yes
Power block (small to medium scale)				Yes	Yes			Yes
Hybridization	Yes			Yes	Yes			Yes
Linear focusing				Yes	Yes			
Materials				Yes	Yes			
Solar Desalination	Yes							
Control systems				Yes				Yes

Figure 1: Summary of the specific technical areas indicated by the NWG’s concept notes as being part of their future research goals.

It is clear that these objectives are in line within the goals of other roadmaps such as the one developed by ESTELA³ and present several points of contact, thus an alignment of national and European level priorities is possible, requiring further interactions to reach an agreement on a common CSP RTD agenda. A more detailed list of the main goals identified in the national concept notes is presented in Table 2.

³ European Solar Thermal Electricity Association, *Solar Thermal Electricity – Strategic Research Agenda 2020-2025*, ESTELA, Brussels, December 2012.

Table 2: Main goals identified in the national concept notes.

COUNTRY	FUTURE ORIENTATIONS
CYPRUS	<ul style="list-style-type: none"> • CSP for Island Environments: devices well suited to operate autonomously or in small isolated grids, primarily for electricity production but also (in co-generation) with seawater desalination, solar air conditioning, heating, etc. Includes downscaling CSP systems below the 5.0 MW power range and endowing them with storage capability. • Solar Desalination: robust, price competitive and low maintenance desalination plants, able to operate in a distributed fashion and powered independently through CSP (remote environments). • Thermal Energy Storage: molten nitrate and chlorine salts, PCMs, thermal storage technologies, comparative studies of different storage systems for small-islands, isolated grids and intermittent operation. • Energy systems and techno-economic studies: CSP plants and natural gas hybridization. • Solar Energy in Built environment: provide it with energy from solar energy systems. • (Re-) examining Energy Pathways in Eastern Mediterranean and Middle East
FRANCE	<ul style="list-style-type: none"> • To help French industry to access international markets: acquisition of already existing companies or participation in consortium as a provider of critical components. • To increase the system performance by increasing efforts on RTD on key components. • To reduce the cost of components: optimization and standardization for cost efficiency. • To identify development opportunities in all application domains: process heat, electricity, chemical synthesis. • To maximize the heat and electricity production by: <ul style="list-style-type: none"> ○ developing design and optimization tools; ○ choosing the best options for hybridization of solar heat with other primary energy sources; ○ improving the energy production and storage in real-time regarding the solar resource forecast and the electricity demand ○ adapting the CSP plants conception regarding the local electricity demand; ○ adding value to the waste heat. • To convince the investor: important investment must be offset by a fast return on investment or with a guaranteed income.
GERMANY	<ul style="list-style-type: none"> • Cost reduction of solar thermal electricity through: <ul style="list-style-type: none"> ○ Efficiency improvement and cost reduction of key components;

	<ul style="list-style-type: none"> ○ Cost-effective dispatchable power by advanced storage systems; ○ Reduce cost of O&M; ○ Plants durability and long-term performance improvement; ○ Assessment and prediction of solar resource; ○ Standardization for solar key components and subsystems; ○ Improvement of environmental footprint.
ITALY	<ul style="list-style-type: none"> ● Competitive and reliable CSP in form of linear focusing technology coupled with standard thermoelectric plants, based on molten salts. ● Small-medium scale CSP systems for both electricity and industrial process heat production, also with hybridisation with other renewable energy sources, and innovative cycles. ● Hybrid solar plant for solar to fuel applications. ● Key enabling technologies will be supported through research on the following main topics: <ul style="list-style-type: none"> ○ Innovative coating materials/treatments for solar receivers, reflective materials, cost-effective collectors; ○ Thermal energy storage systems, small scale power blocks, control systems, solar biofuels; ○ System integration with hybridization with other sources and fuels and standardization of integration schemes.
PORTUGAL	<ul style="list-style-type: none"> ● New line-focus and point-focus concentrators aiming at higher conversion efficiencies. ● Development of concentrating solar collectors for operation at medium ($100^{\circ}\text{C} < T < 250^{\circ}\text{C}$) and high ($T > 250^{\circ}\text{C}$) temperatures aiming at industrial applications. ● New fluids and concepts for thermal energy storage and full energy dispatchability. ● Development of solar fuels production systems. ● Development of new components for power cycle units connected to concentrating solar collectors. ● Development/optimisation of CSP hybrid systems (biomass, etc.). ● Development of new materials and components for high temperature applications.
SPAIN	<ul style="list-style-type: none"> ● Cost reduction of solar thermal electricity through: <ul style="list-style-type: none"> ○ capital cost reductions; ○ development of key components and systems, including new concepts aiming to improve plant feasibility and dispatchability; ○ Improve plants durability and long-term performance (O&M); ○ Assessment and prediction of solar resource; ○ Improvement of environmental footprint.
SWITZERLAND	<ul style="list-style-type: none"> ● Strengthening Switzerland's position as an exporter of know-how and technology in the CSP and solar thermochemistry fields. ● Basic and applied research and demonstration activities for the

	application of concentrated solar thermal plants to produce industrial process heat.
UNITED KINGDOM	<ul style="list-style-type: none"> • Provide a platform and focal point for CSP activities in the U.K. • Raise the profile of CSP to the level of solar PV. • Combine CSP with solar thermal for policy alignment and funding opportunities. • Development of solar field component design, manufacture and assessment. • Development of TES including sensible, PCM and thermochemical storages. • Research applications of CSP for fuel production. • Study hybridization with other power and heat generation technologies.

Resources

All concept notes identify research centres and universities with significant RTD activities devoted to CSP technologies and applications. Table 5 from the STAGE-STE project deliverable 2.1, *Report: national programmes and objectives in STE research* shows, however, that the number of such institutions is very low in each country, only surpassing 10 in Italy and Spain. The reduced number of research institutions working on CSP is translated to an even smaller number of institutions equipped with research infrastructures dedicated to CSP RTD. Research infrastructures devoted to CSP have been identified in:

- France, Italy, Portugal and Spain for the development of line focusing technologies;
- Cyprus, France, Germany and Spain for the development of point focusing technologies;
- Cyprus, Germany, Italy and Spain for thermal energy storage;

Additionally, solar furnaces (of different capacities) are installed in France, Germany, Portugal, Spain and Switzerland, while high-flux solar simulators are installed in Germany, Spain and Switzerland. Supporting the development of CSP research and the operation of the aforementioned research infrastructures are several laboratories for component testing, material development and characterization, etc.

Needs assessment

The different development stage of the CSP RTD sector in each country was expected to influence the identification of additional resources required to fulfil the goals for CSP RTD in the next five years. However, despite the differences it is possible to find common needs. The U.K. concept note skipped this section, considering that the major necessity is the increase of awareness of CSP within the U.K. funding agencies and government but also within to U.K. companies and academic institutions.

Figure 2 schematically presents the major areas identified by the NWGs as requiring additional resources and improvements to fulfil the national objectives for the CSP RTD in the next five years. Once again, blue squares represent lack of available information in the country’s concept note about a given subject.

The necessity to improve funding of CSP research and development activities is present in all concept notes, with the exception of the U.K. (as previously explained) and the German case, which we should recall is one of the few countries with an existing research and funding programme specifying CSP activities. However, the funding improvement is not a simple request for funding increase, being instead the identification of a necessity for a stable and suitable funding of CSP RTD activities coupled with a RTD strategy. The funding necessity appears closely connected with the need for a long term RTD strategy with dedicated calls for CSP activities.

Both the request for stable funding coupled with a long term RTD strategy are related with the necessity to promote a stable research environment, reducing uncertainty and sharp funding fluctuations which significantly hinder the development of the European CSP RTD sector, particularly when considering the effects of such fluctuations on human resources and corresponding availability of know-how.



Figure 2: Major areas requiring additional resources and improvements to fulfil the national objectives for the CSP RTD in the next five years.

The availability of qualified human resources for CSP research and industrial activities is also a necessity identified by France and Portugal. Linked to this necessity is the need to improve the exchange of experience between the research sector institutions and to promote innovation and technology transfer to the industry. In fact, the relation with industry is crucial for the CSP research sector, being possible to raise the case for the necessity to provide support to the industry development activities, particularly for industrial demonstration and scale-up and

also for its activity by providing a stable regulatory framework and eventually a long-term deployment programme.

The Cypriot and Spanish NWG included in their concept note the necessity to improve funding coordination between regional, national and European RTD funding programmes, aiming at a national and European alignment. Such alignment would avoid funding dispersion, enabling the implementation of larger projects such as the ones required for demonstration activities at higher TRLs.

Table 3 presents with greater detail the needs assessment performed by each NWG.

Table 3: Main needs identified in the national concept notes to fulfil the national objectives for the CSP RTD in the next five years.

COUNTRY	NEEDS ASSESSEMENT
CYPRUS	<ul style="list-style-type: none"> • More incentives at the Cyprus⁴ and EU level for further developing CSP. • More dependable financial governmental backing. • Further alignment at the European level between structural funds (to build the necessary infrastructure) and Horizon 2020 Funding mechanisms (leveraging the infrastructure to implement projects in cooperation with leading European partners). • A section specifically dedicated to research into Solar Thermal Energy (STE) and Concentrated Solar Power (CSP) in future calls at national level.
FRANCE	<ul style="list-style-type: none"> • Supporting CSP stakeholders: <ul style="list-style-type: none"> ○ Need to set a clear and constant policy of funding to enable market to take off. ○ Funding: level of funding to be adjusted to challenges, for a technology that is less mature than PV. Funding must be adapted to technological upgrading. ○ Call for projects : adapted levels of TRL compared to PV • Skills and know-how: <ul style="list-style-type: none"> ○ Qualified engineers and PhD dedicated to the CSP technologies, implying the need to develop specific trainings; ○ Exchanges with other foreign platforms to benefit from technological breakthrough and feedback from demonstrations. ○ Reach a critical mass, achieving a similar work force as compared to PV RTD activities.
GERMANY	<ul style="list-style-type: none"> • Improved research infrastructure to qualify and demonstrate the use of molten salt as heat transfer fluid in troughs and towers.
ITALY	<ul style="list-style-type: none"> • Additional funding for R&D Programmes at national and

⁴ In October 2017, the Republic of Cyprus Ministry of Energy, Commerce, Industry and Tourism launched a new scheme for an open energy market in Cyprus, where 50MW are allocated to CSP (<http://www.mcit.gov.cy/mcit/EnergySe.nsf/All/66ECFCBBA9BE2BE0C22581AE0030D439?OpenDocument>).

	<p>regional levels to guarantee continuity of the long term activities.</p> <ul style="list-style-type: none"> • Implementation of a National strategy to help the Italian CSP supply chain to better deploy the technology into the market.
PORTUGAL	<ul style="list-style-type: none"> • Increase of the funding devoted to contract new human resources. • Development of new facilities and improvement of the existing ones. • Dedicated resources for general scope studies (e.g. surveys on national industry or integration of CSP technologies in the Portuguese and European energy system), advanced training, technology demonstration actions and technology transfer activities.
SPAIN	<ul style="list-style-type: none"> • RTD Programmes at both regional and national levels for pilot projects with a significant budget to achieve the targeted goals. • Definition of a long-term RTD strategy guaranteeing the continuity of the activities requiring mid and long-term research, linked to intermediate assessments. • Coordination of regional and national RTD programmes, financing instruments and goals to advance in the alignment at European level.
SWITZERLAND	<ul style="list-style-type: none"> • Additional resources for applied research, especially for industrial scale-up.

International cooperation

From the analysis and discussion of the concept notes it is visible a high level of cooperation among national research institutions from EU countries as well as with research institutions, industry and other CSP stakeholders of other countries. This is particularly true in terms of collaboration within the European Union countries, driven mostly by EU-funded projects, with all eight countries stating to have research institutions involved in research projects with European partners.

Considering that most of CSP markets will be located outside Europe, there are also efforts to strength research and development cooperation with non-European countries. Such cooperation is mostly established between CSP stakeholders, namely research institutions and do not necessarily imply direct support or coordination by the national governments. Figure 3 shows current international collaboration efforts as stated by the concept notes.

Additionally, the majority of these countries are also collaborating through participation in international organizations such as IRENA, SolarPACES and IEA-SHC.

Some countries also mentioned the necessity to continue to improve international cooperation activities, by clearly including CSP in research collaboration agreements and programmes and increase the knowledge sharing through the development of enhanced collaborative programmes between research and technology organizations from different countries.



Figure 3: Current international collaboration activities.

Stakeholders

The stakeholders supporting the CSP sector identified by the different NWGs are very similar. All identified as stakeholders their national scientific community and industry (including non-industrial enterprises such as service providers). The major difference between countries is the size of the industry stakeholder group, with some countries presenting a relevant amount (in quantity and/or industrial dimension) of industries and enterprises working in this sector, while others have a lower industrial representation. Figure 4 presents the stakeholder groups currently involved in supporting CSP research and innovation identified in each concept note, being visible the differences in terms of the industry stakeholder group.



Figure 4: Stakeholder groups currently involved in supporting CSP research and innovation in each country.

Some countries also included other stakeholder groups, namely civil society organizations and government bodies (this in a smaller degree), encompassing entities such as industrial associations, chambers of commerce and governmental institutions and offices. It is worthwhile mentioning that some of these stakeholders have been involved in the support of CSP research and innovation due to the contacts established under the STAGE-STE project and ensuing actions.

The possibility for CSP RTD programme alignment

Considering the concept notes content dealing with CSP research and development programme it is possible to conclude that an alignment between the different national programmes and between the national and European programmes is possible since there are many common themes between the positions stated by the different NWGs in their concept notes.

Additionally, all eight countries present RTD capabilities in this sector, having several institutions working in the CSP field. With the exception of the U.K. all countries have significant research infrastructures dedicated to CSP research and development. Although there is risk of overlapping for some capabilities, there are plenty of synergies to be created and harnessed, strengthening the case for an alignment of RTD programmes in order to promote a more efficient use of resources to avoid duplication and to achieve better and faster results while fostering the European leadership in the CSP sector.

An aligned CSP RTD programme (between regions, countries and the EC) should have three main objectives (corresponding to the common themes proposed in the concept notes):

- Increase of the system performance;
- Reduction of capital and operation and maintenance costs;
- Improvement of the environmental profile

This programme should include the following technical activities:

- Development of new/improved key components and systems (cheaper and/or more efficient);
- Development of new concepts to improve cost-effective dispatchability;
- Improvement of the plants' durability and long-term performance;
- Development of solar resource assessment and prediction methods and tools;
- Promotion of standardization activities for key components and subsystems.

Three specific areas were repeatedly mentioned by the NWGs future orientations and should therefore be part of the aligned research programme: thermal energy storage; solar fuels; hybridization with other energy sources.

Further activities should be developed in order to improve over the common ground extracted from the concept notes. Additional iterations with the relevant stakeholders and decision makers are required in order to draft and later on agree on an alignment of the national and European research programmes. Such process can continue in a bottom-up approach by taking advantage of the communication channels created by the NWGs and the European

Energy Research Alliance Joint Programme on CSP (EERA JP-CSP) but will also require up-down actions, namely support and coordination by the European Commission in order to help to involve the national decision makers (possible through the channels established within the scope of the SET-Plan).

3.3. Aligning Research Programme Funding

The first and last three topics of the concept notes (see Table 1) present the current status of CSP RTD funding and address the possible alignment of national and European funds through the adaptation or development of a new funding mechanism.

Background and context

The lack of specific RTD programmes for CSP technologies result in the inexistence of funding sources specifically devoted for these technologies. Some exceptions occur, where RTD programmes for CSP technologies exist, like in Switzerland.

An interesting feature of the Swiss programme is the combination of specific funding possibilities through the Swiss Federal Office of Energy with other funding possibilities at regional, national and European level. However, for most countries, CST RTD funding is obtained under general calls open by national or regional research funding agencies or industrial innovation and development agencies, such as general calls for scientific research and technological development or related to broad themes such as energy, renewable sources, environment, or similar topics.

Actually, European funding schemes represent, for most countries, the source for the major share of funding specifically devoted to CSP RTD activities. These funding schemes range from structural funds and specific CSP calls under the Framework Programmes (currently the Horizon 2020 Programme) and ERA-NET initiatives, which also require a significant share of national resources).

Table 4 presents the main national funding sources available to the CSP sector for RTD activities (other sources may be available at national and regional level).

Table 4: Main national funding sources for CSP RTD activities.

Country	Funding Source
Cyprus	<ul style="list-style-type: none"> • Directorate General for European Programmes, Coordination and Development (DGEPCD); • Research Promotion Foundation (RPF).
France	<ul style="list-style-type: none"> • Environment and Energy Management Agency (ADEME); • National Research Agency (ANR).
Germany	<ul style="list-style-type: none"> • Federal Ministry for Economic Affairs and Energy (BMWi); • Federal Ministry of Education and Research (BMBF).
Italy	<ul style="list-style-type: none"> • Ministry of Education, Universities and Research (MIUR); • Ministry of Economic Development (MISE)
Portugal	<ul style="list-style-type: none"> • Foundation for Science and Technology (FCT); • Regional Coordination and Development Commissions (CCDR).
Spain	<ul style="list-style-type: none"> • Ministry of Economy and Competitiveness (MINECO);

	<ul style="list-style-type: none"> • Regional governments.
Switzerland	<ul style="list-style-type: none"> • Swiss Federal Office of Energy (SFOE); • Commission for Technology and Innovation (CTI).
United Kingdom	<ul style="list-style-type: none"> • Department of Energy and Climate Change (DECC); • Department for International Development (DFID); • Engineering and Physical Sciences Research Council (EPSRC).

Possible funding alignment models and proposed model to be developed

The concept notes present a wide range of possible funding models. Each NWG has a particular view of the available funding models and the requirements of the models available to support the alignment of research funding. The following paragraphs will briefly present the funding models presented by each NWG, the main considerations included in the concept notes regarding the subject and the preferred model for implementation. The exception to this is the U.K. which is in a previous development stage of their CSP RTD activities, considering that their main priority is not the alignment of funding but the development of the activities already existing whilst attracting more partners.

Cyprus

The Cypriot concept note describes as main priority the alignment of structural funds programmes with the Horizon 2020 programme and these with the SET-Plan priorities related to CSP. A single funding model is mentioned in this concept note: the *Berlin model*, according to which a group of partners present a project proposal which must receive the agreement from the Member States for funding, with the European Commission offering a top-up to the Member States funding. The Cypriot NWG warns however, that although interesting, the feasibility of this model, namely its acceptance by the EC, must be clarified.

France

The French NWG define as main challenge the establishment of an European consortium gathering the main players along the CSP value of chain to reach a competitive size able to face international competition and to drive the alignment of national and European policies in order to create a common policy that would drive funding and its distribution.

Two possible funding alignment models were specified. The first would take the form of the current ERA-NET model, creating an European fund integrating national funds dedicated to CSP. The second possibility would be the development of a Public-Private Partnership (PPP), to benefit from joint research and mutualize infrastructures. This PPP would be based on a research and innovation programme resulting from an open consultation process and thorough evaluation by the EC through independent experts, providing a common policy for the sector. From the two proposed models, the French NWG prefers the PPP model to be developed, considering that combining private and public funding could offer the European industry a leading position on world markets besides the desired alignment of CSP policies, including RTD programmes and funding.

Germany

The German concept note presented two possible funding models: the ERA-NET model and the Berlin model, whose suitability for this kind of cooperation is deemed to be untested. Table 5 presents their perspective regarding both models.

Table 5: German perspective on the possible funding models.

Funding model	TRLs	Funding rate over real total costs (estimation)	Time to contract	Bureaucracy
ERANET	4-7	Up to 100%	Up to 1,5 years	Apparently simple, but must be repeated at EU and regional/national level
Berlin model	4-7	Up to 100%	Up to 1 year	Medium

From the two proposed models the German concept note states as preferred the ERA-NET model, mainly due to its flexibility. This model provides transnational cooperation based on excellence of partners, available funds and national interests. However, the model presents some limitations such as the synchronization with national calls and the budget limitations per partner. According to this concept note, such limitations could be eased by providing a more flexible allocation of budgets and keep the programme calls open throughout the year in order to allow for a fast implementation.

Italy

For the Italian NWG the main priority lies on the alignment of the Italian funding with the Horizon 2020 Programme according to the SET-Plan strategy. It is also necessary to improve coordination between regional funding in order to improve the participation in co-funding actions, promoting a suitable integration of local resources with EC resources. In this internal aspect the Italian NWG proposes the creation of a balanced polycentric model for co-funding, combining resources from individual regions in order to create critical mass and foster synergetic collaborations between institutions spread in different Italian regions.

The Italian concept note preconizes co-funding models for the development of the main strategic targets of CSP. The ERA-NET model, integrating national funding to boost European collaboration and a second co-funding scheme connected to the KIC Innoenergy programme for the Italian CSP chain of value. Additionally it presents arguments regarding three possible models (Table 6).

Table 6: Funding alignment models mentioned by the Italian concept note.

Funding model	Arguments in favour	Arguments against	Challenges
ERANET model	It stimulates virtuous behaviour.	Not suitable for Member States that do not apply enough funds for the ERA-NET Programme.	<p>The model should be corrected with the introduction of the following rules:</p> <ul style="list-style-type: none"> – introduction of a minimum and maximum level of funding from individual countries; – the overcoming of the funding maximum quota by a single country; – introduction of EU funding share to be distributed among countries less financially strong.
Cohesion funds (PON Metro)	This funding model allows to finalize the national accompanying actions at the Horizon 2020 projects using a quota of regional funds that are supported by EU cohesion funds.	Coordination between national and regional level does not exist.	<p>Need to build a coordination board between the local regional government and the research institutions.</p> <p>The coordination board should:</p> <ul style="list-style-type: none"> – support the preparation of the calls; – co-finance single projects of interest for the regions.
Recovery of well-evaluated proposals not financed (SME or H2020)	Reduces evaluation costs with more accurate and meaningful results.	System to conceive in concert with other countries, being necessary a review of the ERA-NET model, where a portion of the ERANET funds must be made available to make room for well-evaluated projects considered strategic for the submitting country but which have not been funded.	<p>Requires a funding mechanism similar to ERA-NET where the different countries allocate funding to support approved proposals considered strategic by individual countries that lacked funding from the SME or Horizon 2020.</p> <p>Creation of a preferential channel in ERA-NET for these types of proposals</p>

After these considerations, the Italian NWG proposes a combination of the ERA-NET instruments with trans-regional funds, including funds available on Energy and Green Technologies according to regional RIS3 and other regional funds from the European Regional Development Fund. The ERA-NET instrument would support research and

innovation actions while the demonstrations and innovation actions would be internally supported by trans-regional funds.

Portugal

The Portuguese concept note presents three different funding models for the alignment of national and European funding: ERA-NET; European Joint Programme; Coordination and Support Actions.

The adoption of an ERA-NET model would allow to coordinate research efforts in the CSP sector, implementing joint transnational calls for proposals with EC co-funding.

Coordination and Support Actions support primarily measures such as standardisation, dissemination, communication, networking, policy dialogues and mutual learning exercises and studies. Joint transnational calls can be launched using this model however there is no top-up funding from the EC.

The European Joint Programme model is designed to support coordinated national research and innovation programmes, aiming at attracting and pooling a critical mass of national resources and achieving economy of scale by adding related Horizon 2020 resources to the joint effort. This is considered to be the most interesting funding model.

Spain

The Spanish NWG identified three possible models for funding alignment, being described in Table 7.

Table 7: Funding models proposed in the Spanish concept note.

Funding model	TRLs	Aid rate over real total costs	Procedure	Problems
Based on ERA-NET cofund	4-7	> 50 %	Approval by the Commission (defining the contribution) followed by approval of individual involved countries (also defining specific contributions).	Coordination of national calls/submission periods needed to avoid long time to contract process.
Based on BERLIN model	4-7	> 50 %	Approval by individual involved countries (defining specific national contributions) followed by the Commission (also defining the contribution). Very limited experience so far.	Coordination of national calls/ submission periods needed to avoid long time to contract process. Current administrative / legal problems at several countries and/or the Commission.
ECRIA	2-5	>50% (100% of the EU part)	Approval by the Commission (defining the contribution) followed by approval of individual involved countries.	Not clear how national commitment would be ensured for future projects.

The ERA-NET tool is considered by the Spanish NWG to be a proven and effective tool to align and leverage national funding with EU priorities. However, they warn it leads to

multiple funding commitments (when used to support the different sectors), risking to generate inequalities among countries due to their different availability of resources. Although the application process is simple it requires the submission of two independent proposals, one at national and another at EU level. There is also a lack of synchronization between the national and international calls, leading to longer times until the grant is approved (normally the national decision takes up to 9 months after the European level decision). The duration of the funding period is not guaranteed to be equal implying risks for the European project. For this NWG the chosen model, which must be further discussed, should have a single submission point, present a reduced overall time to grant and have a two-stage process.

Switzerland

In Switzerland most agencies use a bottom-up approach for funding, with limited resources available for programmatic funding and calls. However, projects can be supported by bi- or multilateral cooperation between countries. Support for Swiss private and public applicants could be available:

- Up to 100% for non-profit research organizations;
- Up to 50% for industry;
- Up to 40% of non-appreciable costs for pilot and demonstration actions.

The Swiss concept note does not preconize a specific funding model, considering instead that the chosen model should establish a collaborative network with calls, where national funding organizations finance their national participants.

Tentative conditions required for suitable projects

The NWGs were inquired about the conditions deemed to be needed for suitable projects to be funded under a given aligned funding model. The main conditions are presented in Figure 5. It is clear that the projects should join research and industrial partners and cover applied research and demonstration. The suitable timeframe and budget is to be decided (TBD), being the NWGs divided in relation to the possibility of funding projects dealing with basic research.

								
	Cyprus	France	Germany	Italy	Portugal	Spain	Switzerland	United Kingdom
R&D Partners	3 EERA JP-CSP			1 EERA JP-CSP	3 countries	Minimum size	1 Swiss	
Industry Partners	Yes		1 German		Yes	Minimum size		
Basic Research		No	No	Yes	Yes	Yes	No	
Applied Research		Yes	Yes	Yes	Yes	Yes	Yes	
Demonstration		Yes	Yes	Yes	Yes	Yes	Yes	
Budget		TBD	Flexible			TBD		
Timeframe	>4 years					TBD		

Figure 5: Tentative requirements for projects to be funded under a joint funding scheme.

The possibility for CSP RTD funding alignment

Several NWGs agree that the first priority is the alignment of already available regional and national funds with European funds (both structural funds and Horizon 2020) under the scope of the SET-Plan, in order to reach a single common policy to drive CSP RTD funding.

However, unlike the case for the alignment of CST RTD programmes, where many common themes between the positions stated by the different NWGs in their concept notes can be found, the possibility to align CST RTD funding is not so clear since the views expressed in the concept notes differ more. The NWGs identified several possible funding instruments, with the ERA-NET model being referenced more times. However, this model, which has some positive characteristics, also presents issues (see for example the position expressed in the Spanish concept note) that need to be improved in order to be considered as a suitable candidate.

Additional discussions at national and European level are required to find and fine tune the best mechanism to align funding. However, from the analysis of the concept notes it is possible to conclude that a CSP RTD funding model aligning national and EC funds will have to be an adaptation of an existing one or result from a new development. Anyway, such funding scheme should:

- Have a common RTD programme driving funding;
- Couple regional/national and European funds;
- Have flexible funding allocation;
- Have a suitable pool of resources both in quantity and quality;
- Enable demonstration projects;
- Present a single access point and a simplified evaluation procedure in order to reduce the time from application to grant.

4. SET-Plan CSP Implementation Plan

The concept notes, whose main content is presented and analysed in the previous section of this report, were presented and discussed in a workshop organized by the STAGE-STE project and held under the auspices of the Spanish Ministry for Economy and Competitiveness. At the same workshop EC representatives presented the CSP provisions within the current European Strategic Energy Technologies Plan (SET-Plan) roadmap, highlighting the need to work in the definition of a CSP Implementation Plan to achieve the targets defined in the SET-Plan. Additionally, the European STE industry organization (ESTELA) presented their view on the research priorities and target project types that could be potentially addressed with a new funding tool.

All these contributions were analysed and discussed during the workshop. At the end it was decided to focus efforts in the definition of the SET-Plan CSP Implementation Plan which could work for the near future as the focal point for the alignment of national research programmes and funding. A Temporary Working Group (TWG) was tentatively defined in order to develop the Implementation Plan. This TWG included representatives from the interested countries (Spain, Belgium, Cyprus, Germany, France, Hungary, Italy, Norway,

Portugal and Turkey) and the European Commission, and the stakeholders (ESTELA, EERA JP-CSP, and the European Association of Gas and Steam Turbine Manufacturers – EU-TURBINES). Following the workshop the interested NWGs have been involved in the discussions related with the definition of this Implementation Plan in collaboration with the members of the TWG and the EERA JP-CSP.

The SET-Plan sets two strategic targets for CSP:

- A short term target of achieving in 2020 cost reductions higher than 40% of the CSP costs, using the year 2013 as basis. This target corresponds to a targeted price within a 25 years Power Purchase Agreement of less than 0,1€/kWh for dispatchable power at a location with an annual DNI value of 2050 kWh/m².
- The development of the next generation of CSP technology as a long term target. Namely the development of CSP using new power cycles (i.e. other than superheated steam cycles), including supercritical cycles and the deployment of a first demonstrator by 2020.

This Implementation Plan, entitled Initiative for Global Leadership in Concentrated Solar Power⁵ was approved in September 2017 after several meetings of the TWG encompassing four main axis deemed necessary to reach the aforementioned targets:

- Priority technology actions aiming for the technological development of key components of a CSP plant needed to achieve the strategic targets;
- Demonstration projects at commercial scale promoting the installation of at least three *First-of-a-kind* (FOAK) plants in Europe with high potential of replication;
- Non-technological actions, namely the improvement of framework conditions such as improved financing schemes and regulatory framework;
- Support to internationalization through the development of international cooperation on CSP with extra-EU countries mostly focused on RTD but with the possibility to go beyond RTD in order to support the global competitiveness of the European industry.

The STAGE-STE project contributed towards the development of the CSP Implementation Plan not only through the creation and promotion of the National Working Groups and respective concept notes but also by involving its members (which represent the majority of the EERA JP-CSP members) in the discussions related with the TWG, significantly contributing to the development of the priority technology actions and the framework of the plan, bringing together industry and the research community. A detailed description of the project contribution towards the technology actions can be found in the project deliverable 2.3, *Final R&D input to Implementation Plan technological research programme to CSP/STE defined targets achievement*. Additionally, the research community gathered in the STAGE-STE project contributed to the identification of national priorities within the 12 priority technological actions defined in the Implementation Plan.

The CSP Implementation Plan will require a significant investment in research and demonstration actions. The plan estimates that the priority technology actions will require up

⁵ Available through the Strategic Energy Technologies Information System (SETIS) at https://setis.ec.europa.eu/system/files/set_plan_-_csp_initiative_implementation_plan.pdf

to 200 million euros (covering 12 groups of RTD activities) and at least 1 billion euros for the FOAK plants.

To fund these activities it is necessary to coordinate public funding at both national and European level with private investment. Currently the feasibility of implementing a Public-Public-Private Partnership is under analysis by all stakeholders, including the European Commission and interested countries.

Priority technology actions funding

After the Initiative for Global Leadership in Concentrated Solar Power approval, the research sector through the EERA JP-CSP and the STAGE-STE project promoted a discussion at national level to identify the potential interest regarding the execution of each priority technology action for each country (within the countries involved in this initiative). A tentative proposal for the national financing of each research action was presented as a starting point for the definition of the projects and activities to be funded.

This first proposal considered the budget of each action as published in the CSP Implementation Plan and excludes research actions with explicit interest from one country. The proposal only considers countries with a level of interest greater than low and assumes a total contribution from national funding of 50% of the total action budget. The remaining 50% are deemed to be covered by companies and as in-kind contributions from the research organizations.

This proposal (presented in Table 8 to Table 15) is now under consideration at national level among all national stakeholders (in some cases through the NWGs) and also at European level, being addressed in the final workshop of the STAGE-STE project, held on January 23rd in Brussels.

Table 8: Tentative proposal of national funding for the priority technology action 1, Advanced Linear Fresnel technology.

Activity no. 1: Advanced Linear Fresnel technology				
Total needed estimated budget:		Tentative proposal of needed contribution from National Financing organizations:		
30 M€		15 M€		
Country	Industrial interest	Tentative national contribution (%)	Tentative needed contribution (M€)	Comments (about financing possibilities)
Portugal	Very High	≈ 37%	≈ 5,5 M€	Regional Funds (CCDRA). Contributions from national CSP companies In-kind contribution from research organizations
France	Very High	≈ 37%	≈ 5,5 M€	European Regional Development Funds (already used) Investment for the Future

				(already used) National Agency for Research (ANR) National Agency for the Environment and Energy Management (ADEME)
Italy	High	≈ 27%	≈ 4,0 M€	Regional funds; National funds. Contributions from national companies In-kind contribution from research organizations. EU-funded projects. Industrial funding as follow up of Industrial project, SOLARGRID-ENEA (National founded research) proposal submitted in November 2017, Local (Regional) fund

Table 9: Tentative proposal of national funding for the priority technology action 2, Parabolic Trough with Molten Salt.

Activity no. 2: Parabolic Trough with Molten Salt				
Total needed estimated budget:		Tentative proposal of needed contribution from National Financing organizations:		
11,5 M€		5,75 M€		
Country	Industrial interest	Tentative national contribution (%)	Tentative needed contribution (M€)	Comments (about financing possibilities)
Portugal	Very High	≈ 33%	≈ 1,9 M€	Regional Funds (CCDRA). Contributions from national CSP companies In-kind contribution from research organizations
Germany	Very High	≈ 33%	≈ 1,9 M€	Energy Research Framework Programme: Topic High Temperature Solar Thermal Technologies (annual budget of about 10 Mio€/a: applicable to German industry or research partners) at a level of 35-50% cost sharing. Helmholtz Program on Renewables; Topic Concentrating Solar Power: Research on advance heat transfer fluids 1.5 Mio€/a funding is linked to research in DLR. Up to 3 M€ national total funding additionally available (to whole German participation)
Italy	Very High	≈ 33%	≈ 1,9 M€	Regional funds; National funds. Contributions from national

				<p>companies</p> <p>In-kind contribution from research organizations. EU-funded projects. Industrial funding as follow up of MIRA AH project (4.5 M€), National funding + follow up of EU ALONE and REPLICATE SCC1 Project, (WG) ENEA PROG.EU. FP7 STAGE-STE GA 609837 - RECEIVER TUBE + SOALR FUELS + SOLARGRID (National founded research) proposal submitted in November 2017, ASE resources, SOLARGRID ENI, (WG) ENEA PROG.EU. FP7 HITECO GA 256830 + (WG) ENEA PROG.EU. FP7 SFERA II GA 312643 RECEIVER TUBE + SOALR RESEARCH INFRASTRUCTURE R FUELS, SOLARGRID ENIMED, EU MATS (Industrial interest is 17.0 M€ "tentative needed contribution" (5.3 M€) represents the co-funding of Italian partners, SOLARGRID-PoliMI</p>
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Table 10: Tentative proposal of national funding for the priority technology action 3, Parabolic Trough with Silicon Oil.

Activity no. 3: Parabolic Trough with Silicon Oil				
Total needed estimated budget:		Tentative proposal of needed contribution from National Financing organizations:		
8 M€		4 M€		
Country	Industrial interest	Tentative national contribution (%)	Tentative needed contribution (M€)	Comments (about financing possibilities)
Spain	Medium	≈ 20%	≈ 0,8 M€	Support from CDTI to technological development and industrial innovation Support/grants from MEIC to research activities Contributions from national CSP companies In-kind contribution from research organizations
Germany	Very High	≈ 50%	≈ 2,0 M€	Energy Research Framework Programme: Topic High Temperature Solar Thermal

				Technologies (annual budget of about 10 Mio€/a: applicable to German industry or research partners) at a level of 35-50% cost sharing Helmholtz Program on Renewables; Topic Concentrating Solar Power: Research on advance heat transfer fluids 1.5 Mio€/a funding is linked to research in DLR. Up to 3 M€ national total funding additionally available (to whole German participation)
Italy	High	≈ 30%	≈ 1,2 M€	FBK funding to develop project Bricker, ASE Are considering that technology important for future application is going to invest on it

Table 11: Tentative proposal of national funding for the priority technology action 4, Open Volumetric Air Receiver.

Activity no. 4: Open Volumetric Air Receiver				
Total needed estimated budget:		Tentative proposal of needed contribution from National Financing organizations:		
5,5 M€		2,75 M€		
Country	Industrial interest	Tentative national contribution (%)	Tentative needed contribution (M€)	Comments (about financing possibilities)
Turkey	Medium	≈ 15%	≈ 0,4 M€	TÜBİTAK International Industrial R&D Projects Grant Programme. Objective: to create market focused R&D Projects between EU countries and to increase cooperation between Europe wide firms, universities and research institutions, by using cooperation tools such as EUREKA. Eligible applicants: SMEs and large companies settled in Turkey. Budget limit determined per call. Scientific and Technological Research Projects Funding

				<p>Program. Purpose: to support research in Turkey for generating new information, interpreting scientific findings, or solving technological problems on a scientific basis. Eligible applicants: university, public research institutes, industry and SMEs settled in Turkey. Budget limit determined per call. R&D Funding Program supporting and coordinating national result oriented R&D projects (traceable targets on scientific and technological fields within the National Science, Technology and Innovation Strategy). Research & Technology Development and Innovation Program with Priority Fields support and coordinate result-oriented, observable, national R&D and Innovation projects that are well-matched with the priority fields determined within the scope of the National Science Technology and Innovation Strategy.</p>
Belgium	High	≈ 30%	≈ 0,8 M€	3,4 M€ potentially available to participate in just one project (either no 4, 5 or 6)
Italy	Medium	≈ 15%	≈ 0,4 M€	Funding: FBK on this activity related to novel technologies.
Germany	Very High	≈ 40%	≈ 1,15 M€	Energy Research Framework Programme: Topic High Temperature Solar Thermal Technologies (annual budget of about 10 Mio€/a: applicable to German industry or research partners) at a level of 35-50% cost sharing. Helmholtz

				<p>Program on Renewables; Topic Concentrating Solar Power: Research on advance heat transfer fluids 1.5 Mio€/a funding is linked to research in DLR.</p> <p>Up to 3 M€ national total funding additionally available (to whole German participation)</p>
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Table 12: Tentative proposal of national funding for the priority technology action 5, Improved Central Receiver Molten Salt technology.

Activity no. 5: Improved Central Receiver Molten Salt technology				
Total needed estimated budget:		Tentative proposal of needed contribution from National Financing organizations:		
22 M€		11 M€		
Country	Industrial interest	Tentative national contribution (%)	Tentative needed contribution (M€)	Comments (about financing possibilities)
Spain	Very high	≈ 27%	≈ 3 M€	Support from CDTI to technological development and industrial innovation. Support/grants from MEIC to research activities. Contributions from national CSP companies. In-kind contribution from research organizations
Germany	Very High	≈ 27%	≈ 3 M€	Energy Research Framework Programme: Topic High Temperature Solar Thermal Technologies (annual budget of about 10 Mio€/a: applicable to German industry or research partners) at a level of 35-50% cost sharing. Helmholtz Program on Renewables; Topic Concentrating Solar Power: Research on advance heat transfer fluids 1.5 Mio€/a funding is linked to research in DLR. Up to 3 M€ national total funding additionally available (to whole German participation)
Cyprus	High	≈ 9%	≈ 1 M€	Possible grants from Research Promotion Foundation under the RESTART calls and other

				structural funds.
Turkey	High	≈ 18%	≈ 2 M€	<p>3.5 M€ Euro potentially available.</p> <p>TÜBİTAK International Industrial R&D Projects Grant Programme. Objective: to create market focused R&D Projects between EU countries and to increase cooperation between Europe wide firms, universities and research institutions, by using cooperation tools such as EUREKA. Eligible applicants: SMEs and large companies settled in Turkey. Budget limit determined per call.</p> <p>Scientific and Technological Research Projects Funding Program. Purpose: to support research in Turkey for generating new information, interpreting scientific findings, or solving technological problems on a scientific basis. Eligible applicants: university, public research institutes, industry and SMEs settled in Turkey. Budget limit determined per call.</p> <p>R&D Funding Program supporting and coordinating national result oriented R&D projects (traceable targets on scientific and technological fields within the National Science, Technology and Innovation Strategy).</p> <p>Research & Technology Development and Innovation Program with Priority Fields support and coordinate result-oriented, observable, national R&D and Innovation projects that are well-matched with the priority fields determined within the scope of the National Science Technology and Innovation Strategy.</p>
Belgium	High	≈ 18%	≈ 2 M€	<p>3,4 M€ potentially available to participate in just one project (either no 4, 5 or 6)</p> <p>Support from Wallonia, General Directorate for Economy, Employment and Research. Support from cluster MECATECH.</p>

				Contributions from national CSP companies. In-kind contribution from research organizations
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Table 13: Tentative proposal of national funding for the priority technology action 6, Next generation of Central Receiver power plants.

Activity no. 6: Next Generation of Central Receiver power plants				
Total needed estimated budget:		Tentative proposal of needed contribution from National Financing organizations:		
25 M€		12,5 M€		
Country	Industrial interest	Tentative national contribution (%)	Tentative needed contribution (M€)	Comments (about financing possibilities)
Spain	Very High	≈ 30%	≈ 3,75 M€	Support from CDTI to technological development and industrial innovation. Support/grants from MEIC to research activities. Contributions from national CSP companies. In-kind contribution from research organizations
France	High	≈ 20%	≈ 2,5 M€	European Regional Development Funds. Investment for the Future. National Agency for Research (ANR). National Agency for the Environment and Energy Management (ADEME)
Cyprus	High	≈ 10%	≈ 1,25 M€	Support from CDTI to technological development and industrial innovation. Support/grants from MEIC to research activities. Contributions from national CSP companies. In-kind contribution from research organizations
Turkey	High	≈ 20%	≈ 2,5 M€	2.5 M€ Euro potentially available. TÜBITAK International Industrial R&D Projects Grant Programme. Objective: to create market focused R&D Projects between EU countries and to increase cooperation between Europe wide firms, universities and research institutions, by using cooperation tools such as

				<p>EUREKA. Eligible applicants: SMEs and large companies settled in Turkey. Budget limit determined per call.</p> <p>Scientific and Technological Research Projects Funding Program. Purpose: to support research in Turkey for generating new information, interpreting scientific findings, or solving technological problems on a scientific basis. Eligible applicants: university, public research institutes, industry and SMEs settled in Turkey. Budget limit determined per call.</p> <p>R&D Funding Program supporting and coordinating national result oriented R&D projects (traceable targets on scientific and technological fields within the National Science, Technology and Innovation Strategy).</p> <p>Research & Technology Development and Innovation Program with Priority Fields support and coordinate result-oriented, observable, national R&D and Innovation projects that are well-matched with the priority fields determined within the scope of the National Science Technology and Innovation Strategy.</p>
Belgium	High	≈ 20%	≈ 2,5 M€	<p>3,4 M€ potentially available to participate in just one project (either no 4, 5 or 6)</p> <p>Support from Wallonia, General Directorate for Economy, Employment and Research. Support from cluster MECATECH.</p> <p>Contributions from national CSP companies. In-kind contribution from research organizations</p>

Table 14: Tentative proposal of national funding for the priority technology action 8, Multi-Tower Beam Down System.

Activity no. 8: Multi-Tower Beam Down System				
Total needed estimated budget: 8 M€		Tentative proposal of needed contribution from National Financing organizations: 4 M€		
Country	Industrial interest	Tentative national contribution (%)	Tentative needed contribution (M€)	Comments (about financing possibilities)
Portugal	Medium	≈ 30%	≈ 1,2 M€	In-kind contribution from research organizations
Italy	High	≈ 60%	≈ 2,4 M€	The activity is a part of SOLARGRID-ENEA (National founded research) proposal submitted in November 2017, Follow up of National POR&PON, Regional founded project, SOLARGRID-MAGALDI Regional funds; National funds; Contributions from national companies; In-kind contribution from research organizations; EU-funded projects.
Cyprus	Medium	≈ 10%	≈ 0,4 M€	Possible grants from Research Promotion Foundation under the RESTART calls and other structural funds.

Table 15: Tentative proposal of national funding for the priority technology action 9, Advanced Thermal Energy Storage.

Activity no. 9: Advanced Thermal Energy Storage (TES)				
Total needed estimated budget: 10 M€		Tentative proposal of needed contribution from National Financing organizations: 5 M€		
Country	Industrial interest	Tentative national contribution (%)	Tentative needed contribution (M€)	Comments (about financing possibilities)
Spain	High	≈ 20%	≈ 1,0 M€	Support from CDTI to technological development and industrial innovation. Support/grants from MEIC to research activities. Contributions from national

				CSP companies. In-kind contribution from research organizations
France	Very High	≈ 30%	≈ 1,5 M€	Investment for the Future. National Agency for Research (ANR). National Agency for the Environment and Energy Management (ADEME)
Portugal	High	≈ 10%	≈ 0,5 M€	Regional Funds (CCDRA). Contributions from national CSP companies In-kind contribution from research organizations
Turkey	High	≈ 20%	≈ 1,0 M€	3 - 3.5 M€ Euro potentially available TÜBİTAK International Industrial R&D Projects Grant Programme. Objective: to create market focused R&D Projects between EU countries and to increase cooperation between Europe wide firms, universities and research institutions, by using cooperation tools such as EUREKA. Eligible applicants: SMEs and large companies settled in Turkey. Budget limit determined per call. Scientific and Technological Research Projects Funding Program. Purpose: to support research in Turkey for generating new information, interpreting scientific findings, or solving technological problems on a scientific basis. Eligible applicants: university, public research institutes, industry and SMEs settled in Turkey. Budget limit determined per call. R&D Funding Program supporting and coordinating national result oriented R&D projects (traceable targets on scientific and technological fields within the National Science, Technology and Innovation Strategy). Research & Technology

				Development and Innovation Program with Priority Fields support and coordinate result-oriented, observable, national R&D and Innovation projects that are well-matched with the priority fields determined within the scope of the National Science Technology and Innovation Strategy.
Italy	High	≈ 20%	≈ 1,0 M€	Regional + Private contribution + follow-up of EU REPLICATE SCC1 Project, (WG) PROG.EU. H2020 IN-POWER GA 720749, (WG) PROG.EU. H2020 RESLAG GA 642067, (WG) PROG.EU. H2020 ORC-PLUS GA 657690. Regional funds; National funds; Contributions from national companies; In-kind contribution from research organizations; EU-funded projects.

5. Contributions from the CSP research community

Since 2014 the CSP research community gathered in the EERA JP-CSP has been promoting a set of activities under the STAGE-STE project (mainly under the scope of Work Package 2) to increase the cooperation between European countries and institutions, promoting the alignment of CSP RTD programmes and funding.

With the end of the STAGE-STE project these activities will continue under the scope of the EERA JP-CSP and related projects. Currently, some will be continued under the umbrella of the *Integrating National Research Agendas on Solar Heat for Industrial Processes* (INSHIP) project, which also gathers a large number of the EERA JP-CSP members. In this particular aspect some of the NWGs developed within the STAGE-STE project are now starting to act independently from these projects and/or collaborating within the frame of the INSHIP project as National Task Forces for Solar Heat for Industrial Processes.

The CSP research community is therefore a driving force in the promotion of the collaboration in this sector and the alignment of CSP RTD programmes and funding alignment. Through its actions during the last years the EERA JP-CSP community has been able to increase the cohesion in the CSP/STE sector, improving the links and communication channels between the CSP stakeholders, generating an improved interaction with all stakeholders when addressing questions such as the creation/alignment of RTD research and funding programmes. This community succeeded in creating an efficient collaborative group

at the European level with a pan-national view, being an active supporter of the integration of national and European research efforts and objectives.

The efforts to promote an aligned CSP research and funding programme will continue in the near future under the framework of the EERA JP-CSP and the SET-Plan CSP Implementation Plan.