JRC SCIENCE FOR POLICY REPORT

Promoting solar electricity exports from southern to central and northern European countries

Extremadura case study

Caldés-Gómez, N., Díaz-Vázquez, A.R.

2018

EUR 29087 EN

Contact information
Name: Ana Raquel Diaz Vazquez
Address: European Commission, Joint Research Centre, Expo Building - C/ Inca Garcilaso 3 - 41092, Seville Spain
Email: ana.diaz-vazquez@ec.europa.eu

JRC Science Hub
https://ec.europa.eu/jrc

JRC110332

EUR 29087 EN

PDF	ISBN 978-92-79-77885-8	ISSN 1831-9424	doi:10.2760/673989
Print	ISBN 978-92-79-77886-5	ISSN 1018-5593	doi:10.2760/329178

Luxembourg: Publications Office of the European Union, 2018

How to cite this report: Caldés-Gómez, N., Díaz-Vázquez, A. R., Promoting solar electricity exports from southern to central and northern European countries: Extremadura case study, EUR 29087 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-77885-8, doi:10.2760/673989, JRC110332

Promoting solar electricity exports from southern to central and northern European countries: Extremadura case study

Under the auspices of the Smart Specialization platform, this report presents the benefits of cross-border solar electricity trade in Europe. A pre-feasibility assessment of a first of a kind solar plant in Extremadura is conducted to demonstrate the possibility to combine EU financing support mechanisms and the cooperation mechanisms of the RES Directive.

Contents

Authors

Caldés-Gómez, Natàlia – CIEMAT

Díaz-Vázquez, Ana R. – European Commission, Joint Research Centre

Executive summary

Policy context

In the 2014-2020 programming period, the European Structural and Investment Funds (ESIF) are supporting 11 investment energy priorities, also known as thematic objectives (TO). In this context, the Smart Specialization Platform on Energy (S3PEnergy) is supporting the European Regions in better taking up the allocated ESIF for energy. The S3PEnergy assists the regional managing authorities to identify the technologies and innovative solutions that support, in the most cost-effective way, the EU energy policy priorities.

To this end, the S3PEnergy has facilitated the creation of Smart Specialization Energy Partnerships, offering interactive and participatory arenas for interregional cooperation along shared priorities related to energy. Among other thematic areas, solar energy has been selected by various regions. As a result, a solar European partnership has been created to promote solar electricity generation and distribution in Europe and maintain the European solar power industrial leadership.

Key conclusions

Europe must find ways to decarbonize its economy in a cost-effective manner while improving its energy security, social and economic development. Simultaneously, it must maintain its industrial leadership and move towards an integrated and well-functioning electricity market. In this context, this report concludes that cross border solar electricity trade from Southern to Northern Europe can contribute to achieve many European energy and climate strategic goals, bringing multiple benefits at the regional, national and European level.

Among other barriers that currently prevent cross-border electricity trade; this report focuses on two existing hurdles: the limited political support towards solar electricity exports in Europe and the financial gap between the electricity generation cost and the market pool price. In an attempt to shed some light to these challenges, this report aims at responding two questions: (i) "What is the value proposition of solar exports in Europe?" and (ii) "How can such projects become economically viable?"

This report concludes that the value proposition of solar exports in Europe is remarkable and that by combining existing EU financial support instruments and the use of the cooperation mechanisms of the 28/2009/EC Directive, it would be possible to make solar electricity cross-border trade projects bankable. Supported by the Solar Smart Specialization Partnership, Extremadura could, under the right framework conditions, host a cross-border solar electricity First-Of-A-Kind (FOAK) project in Europe. Such project would not only demonstrate its financial and regulatory viability but, most important, the associated benefits.

Main findings

As for the answer to the first question –"*What is the value proposition of solar exports in Europe?*"-, this report concludes that the value proposition of solar electricity exports within Europe is noteworthy. Besides contributing to energy and climate objectives, exporting solar electricity from South to Central/North Europe can also contribute to job creation and economic growth in some of the less developed regions in Europe. Furthermore it could help maintain the European industrial and research leadership in solar technologies and in concentrated solar power (CSP) in particular. Finally, deploying such projects could also contribute to improve the techno-economic performance of solar technologies in Europe.

With regards to the answer to the second question – "*How can such projects become economically viable?*"-, this report also concludes that there exist various and complementary alternatives to make these type of projects bankable. As for the possibility to make use of the Cooperation Mechanisms of the Directive 28/2009/EC, an important challenge resides in mobilizing the required political interest and support from both host and off-taker countries. In this context, interested regions and institutions in Europe can play an important role in advocating and raising the interest from their corresponding national government representatives as well as from the private sector and the civil society. As for the EU funding, among other financial support mechanisms at the EU level, this policy report highlights InnovFin Energy Demonstration Project (EDP) facility as a suitable instrument for FOAK commercial scale projects.

Finally, as a way to validate the findings from the previous sections, this report analyses the possibility to deploy a solar FOAK project in Extremadura, a region in Spain that has the perfect framework conditions to host this project. Despite some preliminary steps have been taken in the right direction, more coordinated efforts by all relevant stakeholders need to be put in place to move forward in the right direction.

Related and future JRC work

As for the next steps required to materialize a cross-border solar FOAK electricity project, the authors highlight the need for a strong collaboration between European industrial players along the value chain, regulators, managing authorities, research institutions, civil society and relevant European Commission representatives.

In this context, the Solar Smart Specialization Partnership can play a very important role in continuing their support in not only identifying the opportunities and challenges but, most important, finding the enabling conditions to make cross-border renewable electricity projects in Europe a reality.

Quick guide

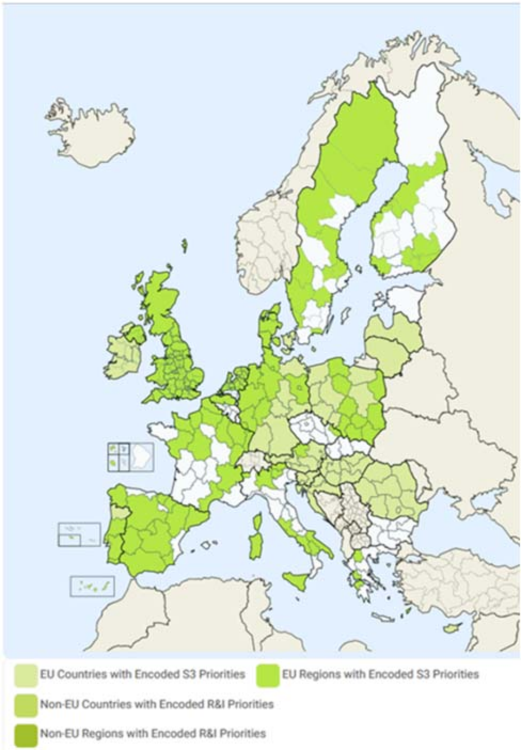
In the light of the Paris Agreement and the EU Climate and Energy framework, Europe must find ways to decarbonize its economy in a cost-effective way while improving its energy security, fostering social and economic development, gaining leadership in the Renewable (RES) industry and moving towards an integrated and well-functioning Energy Union. Having this in mind, producing and exporting solar electricity from Southern to Central/Northern European countries can contribute to achieve many of such goals. On the one hand, regional renewable generation can help decarbonize the European power system in a cost-effective manner by generating renewable electricity where the resource is most abundant and generation and/or system costs are lower. On the other hand, regional cooperation is a step forward towards a more integrated, well-functioning and cohesive Energy Union and ultimately to the 2020 and 2030 European strategy. Finally, since the best solar resource potential is found in the less developed regions in Europe, the deployment of such projects could create remarkable social and economic impacts for such regions, contributing to reduce regional disparities within Europe.

1 Introduction

1.1 Introduction to the Smart Specialization Platform on Energy (S3PEnergy)

The S3PEnergy is a joint initiative of the Directorates-General for Regional and Urban Policy, Energy, and the Joint Research Centre (JRC). The S3PEnergy is planned to become an enabling tool for regions to coordinate, rationalize and plan their respective energy strategies, develop a shared vision on knowledge-based energy policy development and set up a strategic agenda of collaborative work. The Smart Specialization (S3) is aligned with the Energy Union R&D and competitiveness priorities and promote the energy related Thematic Objective (TO) TO1, Research and innovation, TO4, Low carbon economy and TO7, sustainable transport, together with the commitment to the Strategic Energy Technology Plan (SET plan) 10 key actions.

Figure 1 Regions with energy priorities included in their S3 Strategy[1]



Source: JRC EYE@RIS3

The main objective of the S3PEnergy is to support the optimal and effective uptake of the Cohesion Funds (CF) for energy and to better align energy innovation activities at national, local and regional level through the identification of the technologies and innovative solutions that support in the most cost-effective way the EU energy policy priorities. The S3PEnergy contributes to EU energy policy priorities by facilitating partnerships between EU regions that have identified renewable energy technologies and innovative energy solutions as their S3 priorities and by promoting alignment between local, regional, national and European activities on energy sustainability, competitiveness and security of supply. In this context, cooperation across EU regions and MS sharing solar energy as priorities has been materialized in the creation of the Solar S3 Partnership.

The Solar S3 partnership[2] is focused on the export of solar electricity from South to Central/North Europe which is aligned with the TO4 generation and distribution of

[1] http://s3platform.jrc.ec.europa.eu/map

renewable energy across Europe. As such, the S3 in solar energy is supported by three pillars: regional development, maintaining the competitiveness of full value chain of the CSP European industry and strengthening its technological development.

1.2 Background, motivation and objectives of the study

From a technological point of view, solar technologies will play an important role in the future European power market and system because of various reasons:

As for CSP, with 5017MW of installed capacity in 2016, the ability to equip CSP plants with Thermal Energy Storage (TES) allows them to produce high-value, dispatchable power on demand. On the other side, trading CSP from Southern to Central and Northern Europe could increase the stability of future power system with high-renewables participation and lower the total system costs. Additionally, deploying more technologically advanced CSP plants in Europe could also contribute to maintaining the CSP global industrial and research leadership in Europe. Furthermore, in line with the 2016 CSP implementation plan of the SET Plan, by deploying more CSP plants in Southern Europe, it would be possible to further contribute to decline the technology costs and improve its performance.

As for photovoltaics (PV) technologies, a recent report by the National Renewables Energy Laboratory, highlighted that the installed cost fell to record lows in the first quarter of 2017 because of the continuing decline in photovoltaic module and inverter prices, higher module efficiency, and lower labour costs (Fu et al. 2017). The same report shows that the levelised cost of electricity (LCOE) benchmarks without subsidies for the first quarter of 2017 fell to between 12.9 and 16.7 cents per kilowatt-hour (kWh) for residential systems, 9.2-12.0 cents a kWh for commercial systems, 5.0-6.6 cents a kWh for utility-scale fixed-tilt systems, and 4.4-6.1 cents a kWh for utility-scale one-axis tracking systems. Despite the EU has lost its leadership against China in PV cell and module manufacturing, the EU PV industry is still strong in equipment and inverter manufacturing as well as in project development and installation and has various leading and world-renowned research institutes on PV on which a strategy to rebuild the EU PV manufacturing sector could be based (EurObserv-ER, 2017). While PV growth is expected to boom mostly in developing countries -ranging from 16 to 40-fold growth in PV installed capacity by 2050-, the PV growth in Europe is somewhat limited due to its intermittent nature. That's why the role of dispatchable technologies, like Solar Thermal Electricity (CSP) can play an essential role in the Sunbelt countries since the possibility to develop hybridized systems (PV/CSP) opens a new spectrum of opportunities for PV technology.

Despite the above mentioned benefits, there is not a single solar project for export in Southern Europe. As for the possible explanations, most consulted experts recognize that there is limited information and political support towards this concept. Furthermore, whereas several studies have assessed the drivers and barriers to regional cooperation and cross-border electricity trade in Northern Europe (Baltic Energy Market Interconnection Plan, The North Seas Countries' Offshore Grid Initiative (NSCOGI), etc.) or the potential role of solar imports from Northern Africa (e.g.: Better Project), the drivers and potential barriers to CSP/PV expansion and electricity exports from Southern Europe to Central/Northern Europe has not yet been analysed in detail[3]. Such limited information and awareness about the potential benefits of solar exports in Europe is perceived as one of main obstacles to gain political support among relevant decision and policy makers in Europe.

In this context**, the first objective of this policy report is to present the value proposition of solar exports in Europe in order to increase the awareness and support among decision makers**.

---

[2] http://s3platform.jrc.ec.europa.eu/s3-energy-partnerships-solar-energy

[3] Just recently (Oct 2017) the H2020 project MUSTEC (Market Uptake of Solar Thermal Electricity through cooperation) was officially launched to address this issue.

The next possible obstacle is related to the need for financial support to cover the gap between the Public Power Purchase Agreement (PPA) and the electricity market price so that the project becomes feasible. While PV generation costs are cost-competitive, the striking CSP cost reductions experienced over the last few years have not yet reached the break-even point[4]. Furthermore, if we consider the deployment of solar FOAK[5] projects, their higher risk profile and lower supply of equity and debt is much lower than the financing of proven low carbon technologies. This requires complex financial structures to enable such projects to achieve financial close. Thus, **the second goal of this policy report is to explore options to make solar projects feasible.** In particular, this report will explore the possibility to make use of (i) the Cooperation Mechanisms of the Renewable Energy Directive 28/2009/EC and (ii) other EU financial support instruments.

As for the possibility to use the Cooperation Mechanisms, the Renewable Energy Directive 28/2009/EC –also known as RED- provides the regulatory framework to allow for cross-border electricity trade while providing the possibility to grant financial support to solar FOAK projects for exports in Southern Europe. Back in 2009, the RED set national binding RES target and allowed MS to cooperate to partially achieve their target jointly by making use of the Cooperation Mechanisms defined in Articles 6, 7, 9 and 11 of such Directive. The use of such cooperation mechanisms was intended to help MS by providing them more flexibility in reaching their RES targets as well as to achieve their 2020 RES target in a more cost-effective. As demonstrated by various studies, the costs savings associated to the utilization of the cooperation mechanisms are remarkable (Resch et al. 2015). However, as of today, only four cooperation mechanisms cases exist. This can be explained by the combination of factors of heterogeneous nature ranging from political, legal, technical, financial, social acceptance, geopolitical, etc., which have prevented MS from using them. Lessons learned from both failed and successful attempts in implementing the cooperation mechanisms are key to understand and put in place the necessary measures to unlock the existing renewable energy cooperation potential in Europe. Furthermore, as for the regulation beyond 2020, on November 30th 2016, the European Commission (EC) published a proposal for a revised Renewable Energy Directive to make the EU a global leader in renewable energy and ensure that the target of at least 27% renewables in the final energy consumption in the EU by 2030 is met. Of particular relevance for regional renewable energy cooperation is Article 5 of the Renewables Directive proposal which establishes a gradual and partial opening of support schemes to cross-border participation in the electricity sector. Alongside, the proposal for Governance for the Energy Union aims at facilitating the coordination of National energy policies fostering regional cooperation between MS. This provides a new framework for cooperation under a more ambitious decarbonisation scenario without National binding targets. Both legislative proposals together seem to indicate that the 2030 renewable energy framework presents an opportunity to boost regional cooperation as a way meet the EU-wide target while making a step forward towards a well-functioning internal energy market.

Complementary, the EC has developed financial instruments aimed at supporting commercial scale strategic projects (such as FOAK projects) and mobilizing resources from the private sector. By making use of EU financial instruments, it would be possible to reduce the project risk, ease the participation of private investors and contribute to make these projects feasible.

In a nutshell, this work aims at shedding some light to the above mentioned issues by discussing and conducting a preliminary assessment of the drivers and opportunities for electricity exports from solar technologies from Southern to Central/Northern European countries and propose solutions to unlock the existing potential in Europe.

[4] This statement just considers the electricity generation costs and not the value to the system (NREL, 2015)

[5] FOAK are defined as commercial-scale “First-of-a-Kind” energy demonstration projects focused on Sustainable Energy Technology (SET) sectors in Europe (EC, 2016)

To achieve this goal and under the auspices of the S3PEnergy, the specific objectives of this policy report are:

- Present the associated benefits (value proposition) of solar electricity exports at the European, National and regional level as well as the political, geographical and technological rationale underlying this concept.
- Present alternative ways to make such projects feasible through the use of (i) the cooperation mechanisms of the RED and (ii) other possible EU financing instruments and RES support mechanisms.
- Conduct a preliminary assessment of a case study in Extremadura, Spain.
- Derive some conclusions.

1.3 Methodology and report structure

The analysis presented in this report is based on desk research of a wide range of policy documents, academic studies, industry reports as well as other information that is publicly available. Furthermore, interviews with representatives of relevant institutions as well as involved stakeholders from MS, regional authorities, financial institutions, CSP industry and academy were conducted. Finally, a preliminary assessment of a case study in Extremadura (Spain) was analysed in order to shed some light to the above mentioned research questions through a concrete case study.

The target audience includes policy makers from MS -potential exporters and off-taker countries- as well as EC decision makers. Project developers, CSP industry representatives, European scientific community as well as regulators and grid operators may also find some useful insights about the enabling conditions required to unleash the potential benefits of regional cooperation and solar technologies in Europe. Finally, European regions´ authorities, and Extremadura in particular, may learn about their case specific opportunities, barriers, enabling conditions as well as recommended measures needed to deploy solar projects for exports. In summary, the outcomes of this report and related ongoing initiatives[6] can contribute to boost the market uptake of solar technologies in Europe, foster regional cooperation, improve the cost-effectiveness of meeting the EU 2020 and 2030 renewable targets, contribute to reduce regional disparities, market integration, energy security in Europe, help maintain the EU industrial and research leadership in solar technologies as well as contribute to improve CSP and PV technological performance and further reduce its costs while creating green jobs and economic opportunities in Southern European regions.

As illustrated in **Error! Reference source not found.**, this policy report is structured around three research questions that shape its script.

After this introductory section, **Section 2** of this policy report presents the value proposition from a European, National as well as regional point of view. Furthermore, the rationale supporting the concept of solar exports from Southern to Northern European Countries will be presented around three pillars: (i) technological, (ii) geographical and (iii) political drivers.

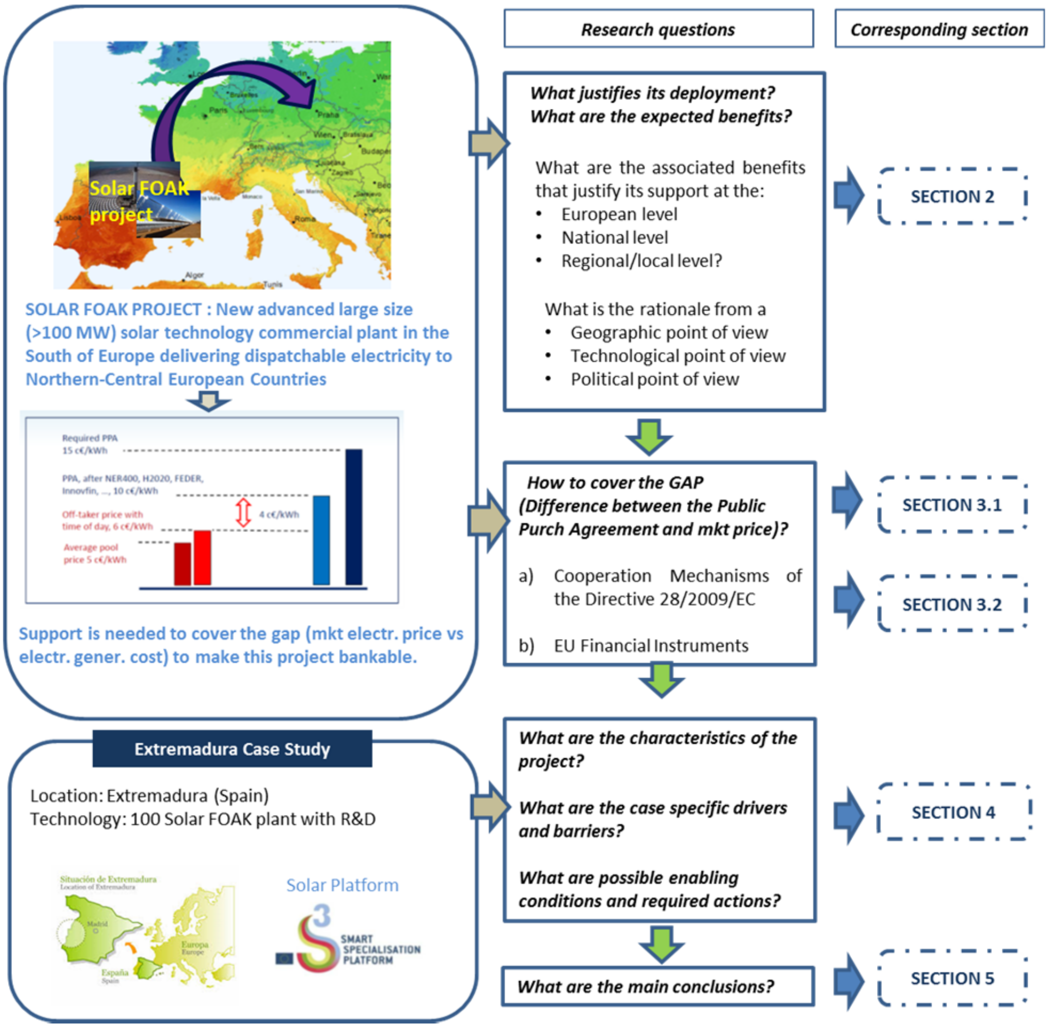
Section 3 presents possible ways in which a solar FOAK project can become feasible. Among others, this report looks at the possibility of using (i) the Cooperation Mechanisms of the RES directive and/or (ii) using EU financial instruments.

Section 4 assesses a hybrid CSP/PV concept case study in Extremadura. After introducing the techno-economic characteristics of the project and its framework conditions, the main drivers and challenges of this particular case study are discussed.

Finally, **Section 5** of this report presents some key conclusions.

[6] For example, other initiatives within the Solar Platform of the S3, H2020 MUSTEC Project and SET plan CSP implementation plan.

Figure 2 Structure of the report and key questions



Source: Own elaboration

2 Value proposition of the Solar FOAK project in Europa

In order to assess the potential benefits of a solar project for export in Europe, a solar FOAK project concept is considered. According to (Burnham et al. 2013), FOAK commercial demonstration projects are essential to demonstrate the technical and commercial viability at industrial scale of new generations of energy technologies and solutions to achieve a cost-competitive, sustainable and secure energy sector by 2050.

The Solar S3 partnership is currently facilitating the exploration of a solar FOAK project to be deployed in Extremadura (the Solar S3 partnership leading region) and helping create a cooperation network of companies and research centres among the participating regions to push their contributions in this sector with a global market perspective.

As displayed in Box 1 and according to the SET Plan CSP Temporary Working Group (TWG), "a solar FOAK project would not only include technological innovation but would also be the first project in implementing the exchange of dispatchable solar thermal electricity among European regions using the cooperation mechanisms scheme of the RES Directive. This plant would sell its production on commercial basis to a central European off taker with a given spread over the average pool price as the electricity would be delivered on the selected window time over the day by the off taker. At the same time this plant could profit from other EU financial sources as well as European Structural Funds".

Box 1 Solar FOAK projects main requirements

— Demonstrate at commercial scale crucial technology solutions.

— Include storage to provide fully dispatchable power and to allow for more flexible generation.

— Have high potential of replication in Europe and worldwide.

— Make use of cooperation mechanisms of the RES Directive to facilitate access to new markets in Europe.

— Combine financial instruments (loans, guarantees) with grants, structural funds and promoters´ equity.

— Have a business plan including PPA agreement with off-taker interested in value of CSP dispatchable power.

— Have an overall cost estimated at a minimum of 900m€.

Source: SET Plan CSP Temporary Working Group (2017)

2.1 Benefits at the European, national and Regional level

As summarized in Figure 3, the deployment of a solar FOAK project in Europe could bring various benefits at the European, National as well as at the regional and local level. The identification, quantification of such benefits are of paramount importance for communication and advocacy purposes as a way to raise political support where it does not yet exist.

At the **European level**, this concept is aligned with various EU policy objectives. For example, as to European research and innovation policy objectives, the deployment of solar FOAK projects in Southern Europe is explicitly included as one of the goals of the 2016 CSP implementation plan of the SET Plan as a way to contribute to further decline the technology costs and improve its technical performance. Similarly, as for the alignment with EU regional policy objectives, by investing in low carbon economy and R&D projects, it is possible to contribute to the foster prosperity and growth in some of the less developed regions in Europe. In turn, by creating jobs and economic growth in these regions, social and economic disparities in Europe are reduced. Finally, as to EU energy and Climate policy objectives, the deployment of the solar FOAK project in Europe could contribute to maintain European leadership in renewables, decarbonize the European

Energy System, increase the stability of the energy system thanks to the storage capacity of CSP, help meet the 2020 RES target in a cost effective manner as well as contribute to create a more cohesive and well-functioning Energy Union through renewable energy regional cooperation. Furthermore, through a concrete case study, it would be possible to demonstrate the value of increased interconnection and cooperation between MS.

At the **National level**, assuming that the solar FOAK project was deployed in Spain[7], some of the immediate benefits include the possibility to maintain Spanish CSP industry and research leadership. Furthermore, it would be possible to contribute to reduce costs and increase the technological performance of a technology that is expected to play a key role in the future Spanish system without compromising public funds or affecting the final electricity consumer prices. Additionally, the deployment of new plants in the rural and sunniest parts of the country would contribute to generate economic and employment opportunities in rural areas that have been severely hit by the crisis. Next, by deploying a solar FOAK project in Spain it would be possible, in the longer term, to contribute to further decarbonise of the Spanish Energy Mix (this is true even in the case when cooperation mechanisms are used as the export period is limited and the plant will eventually generate to satisfy the Spanish electricity demand). Finally, the deployment of the solar FOAK project could be used by the Spanish Government as a way to advocate about the multiple benefits of cross-border renewable electricity trade in Europe and as an additional argument to advocate for an urgent increase of the limited interconnection capacities between Spain and France (the existing interconnection capacity is sufficient for a reduced number of projects but limits the amount of electricity that could be exported in case more of such projects would be deployed).

Finally at the **Regional level**, as demonstrated by several impact assessment studies (Rodriguez et al. 2017, Caldés et al. 2009, Deloitte 2011), these type of projects generate important economic activity and job creation in a diverse range of economic sectors as a result of the direct, indirect and induced effects. Similarly, investments in research and development as well as in low carbon economy often trigger new investments opportunities in other sectors. Furthermore, the possibility to articulate this project within the S3PEnergy could trigger cooperation opportunities with different regions in Europe. Finally, the deployment of such project would benefit the region and municipality by providing visibility at the national and international level.

[7] As of today, this is the most likely country since almost all CSP projects in Europe have already been deployed in Spain.

Figure 3 Benefits of a solar FOAK project at the European, National and Regional level

European level

- Maintain European CSP industrial leadership
- Contribute to the decarbonisation of the European Energy System
- Contribute to increase the stability of the electricity system (thanks to CSP storage capacity)
- Contribute to meet the EU RES target in a cost-effective manner (taking into account value)
- Contribute to the creation of the Energy Union through more RES regional cooperation
- Contribute to reduce costs and improve technological performance of a hybridized PV/CSP plant
- CSP SET-PLAN implementation plan (CSP FOAK projects)
- Contribute to reduce disparities in Europe through R&D and clean energy investments
- Through regional cooperation, contribute to have a more cohesion EU Union.
- Demonstrate the value of increased interconnection
- Possibility to replicate this model in other regions/other technologies

National level

- Contribute to maintain Spanish CSP industry and research leadership
- Contribute to reduce costs and increase technological performance of a valuable technology for Spain without compromising Spanish Public funds nor affecting final electricity consumers´ price.
- New jobs and economic activity in rural areas in deprived areas of the country severely hit by the crisis
- Contribute to decarbonize the energy mix
- Have further arguments to advocate for urgent increase of interconnection capacity between SP/FR

Regional level

- Job creation and economic stimulation
- R&D investments that increase R&D capacity - driver for new investments
- New R&D and industrial collaboration with other regions
- Further decarbonisation of Extremadura energy system – global and local environmental effects.
- International and national visibility

Source: Own elaboration

2.2 Underlying geographical, technological policy rationales

2.2.1 Geographical rationale

Beyond its abundant solar resource, various other reasons support the choice of Southern Europe, Spain and Extremadura in particular, as optimal locations to host a solar FOAK project. As a way to justify this choice, Table 1 below shows, for the considered variables, the corresponding figures for Southern Europe, Spain and Extremadura.

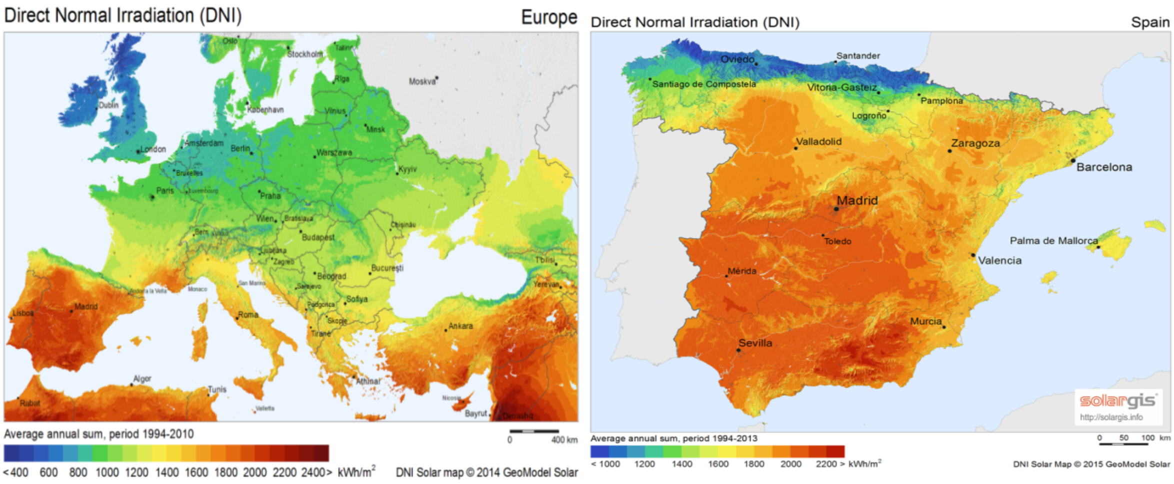
Table 1 Data on the various drivers for Southern Europe/Spain/Extremadura

Driver	Southern Europe(1)	Spain	Extremadura
Existing potential (2) (DNI-kwh/m^2/y)	2070	2250	2000-2200
CSP Installed capacity (MW) (3)	2313.7	2303.9	849 (4)
CSP industry (5)	11/14	13/14	N/A
Research capacity (6)	24/40	21/40	N/A

(1) Southern European Values: Average value of the figures for Greece, Portugal, Italy, Malta and Spain
(2) DNI values from (Müller-Steinhagen. 2004) CSP in the Mediterranean region and SolarGis (2017)
(3) Eurobserv-ER 2017 – Figures includes all CSP plants in operation at the end of 2016.
(4)As of 2015, there were 17 CSP facilities in Extremadura generating 2038 GW (Junta de Extremadura, 2017)
(5) Measured as participation in the 14 possible capabilities within the CSP value chain. Data from ESTELA, Data from Eurosolaris project
(6) % GDP change from 2007-2017 as a measure of the severity of the crisis.

The first factor to consider is the **solar resource** in Southern Europe, Spain and Extremadura. As shown in Table 1, the average DNI value (kWh/m^2/year) in the Southern European Region -comprising Greece, Portugal, Italy, Malta and Spain- is 2070 kWh/m^2 yearly with the highest value found in Spain with an average of 2250 kWh/m^2 yearly (Müller-Steinhangen et al. 2004) and Extremadura with up to 2200 kwh/ m^2.

Figure 4 Solar potential (Direct Normal Irradiation in Southern European Countries and Spain (kWh/m2 yearly))



Source: Solargis (2017

The second factor to consider is the existing **CSP installed capacity** that demonstrates the optimal conditions for CSP deployment. According to REN21, out of the 4.81 GW total installed capacity of CSP at the end of 2016 (REN21, 2017), 2313 MW were located in Southern Europe. Of such installed capacity, 99.7% is located in Spain and almost 40% is found in Extremadura (REN21, 2017).

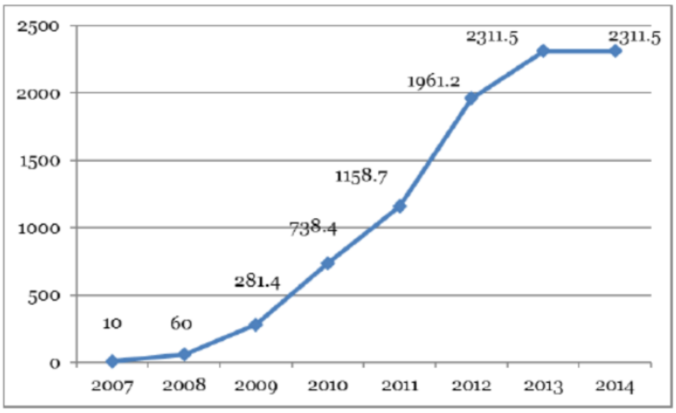
Table 2 CSP projects in Europe

	In operation		Under development	
	Capacity (MW)	**N° of Projects**	**Capacity**	**N° of projects**
Spain	2303,9	50	50	1
Italy	5,35	2	361,3	17
Germany	1,5	1		
France	0,75	2	21	2
Cyprus			50,8	1
Greece			125	2
TOTAL EU	2311,5	55	608,1	23

Source: REN21 (2017)

Against the increasing global trend -the number of CSP installations is set to rise from 2018 onwards, when many projects currently under construction in Morocco, South Africa, China and the Middle East will be commissioned-, the European CSP sector is lagging behind. According to the STE EurObser-ER report 2017, the EU CSP capacity meter has been practically stuck at its current level since 2013. Among other reasons, the lack of favourable National support policies as well as to the uncertainty generated by some retroactive measures implemented by some MS have prevented new investments to take place in Europe. In this context, regional cooperation and electricity solar exports from South to Central/Northern European countries could be a key element to install new plants in Southern Europe while enhancing the mobility of solar thermal power between the best production sites and the main consumption regions (EurObserv-ER, 2017).

Figure 5 Evolution of CSP installed capacity in the EU (MW)



Source: EurObserv-ER 2015

Another important factor is the need to preserve the European **industrial leadership in CSP.** Preserving such industrial leadership is aligned with one of the priorities of the Energy Union which is to "become world leader in Renewables". As demonstrated by Rodriguez et al. 2017, such industrial leadership will bring multiple socio-economic benefits in the form of employment and economic stimulation across many sectors in Europe. This is particularly the case for CSP as most of the value chain is spread throughout various countries in Europe. As shown in Table 3, technology manufacturers along the CSP value chain are found in more than ten countries in Europe (ESTELA, 2017). Furthermore, out of the fourteen capabilities that comprise the CSP value chain, Spain ranks first participating in thirteen of those.

Table 3 European countries capabilities on the value chain of CSP plants

	BEL	CZ	DEN	FR	GE	NL	IT	PT	SP
Promoters				X	X		X		X
Civil Works							X	X	X
Heliostat field					X				X
Tower						X	X	X	X
Receptors			X		X				X
Storage					X	X			X
Control systems			X	X	X		X	X	X
Piping / Valves / Pumps	X				X		X	X	X
Steam Generator			X		X		X		X
Turbine		X		X	X	X	X		
Cooling system							X	X	X
Electrical system		X	X		X		X	X	X
Auxiliary sytem							X	X	X
Assembly							X	X	X

Source: S3 PARTNERSHIP ON SOLAR ENERGY/ESTELA. (This is a non-exhaustive list of capabilities).

So far, Europe is still a technological leader in this sector, but this situation could quickly change due to the ambitious initiatives recently launched in other world regions. According to the consulted experts, besides the expansion of CSP around the world, the installation of new plants in Europe is a pre-requisite to protect the European industry´s leadership from erosion in the global market. Many voices led by the European Solar Thermal Association (ESTELA), claim that "*such leadership is in danger and that new CSP plants must be widely deployed in European soil as a pre-requisite to maintain such leadership position while further lower production costs and improve the technical performance of the plants*". Along this line, ESTELA also indicates that "*it is important to be aware about the growing threat on EU technology leadership with serious take-overs at lower costs of industry know-how holders and R&D infrastructure by non-EU companies acting on non-market economy grounds*" (ESTELA, 2017). Similarly, according to European Energy Research Alliance joint programme, "*the existing absence of commercial CSP projects in Europe severely threats the viability of the whole industrial sector*" (EERA CSP, 2017).

The next factor to consider is the existing **CSP R&D expertise and facilities in Europe**. As can be seen in the table 4, Southern European countries and Spain in particular host the majority of research facilities and capabilities in Europe. Out of the 40 facilities identified in the EU-Solaris project[8], more than half of those are located in Southern Europe, and twenty one of those are located in Spain (Weizmann, 2014).

[8] www.eusolaris.eu

Table 4 Overview of CSP R&D facilities in Europe

Partner country	Solar tower	Parabolic Through	Parabolic Dish	Solar Furnaces	Solar Simulators	Linear Fresnel
CNRS/France	1	1	1	13		
PSA/Spain	2	6	6	3	1	1
METU/Turkey						
DLR/Germany	1	2		1	1	
WIS/Israel	1					
APTL/Greece			1		1	
CTAER/Spain	1	1				
LNEG/Portugal				1		
Total facilities in EU	6	10	8	18	3	1

Source: EU-Solaris project (2016)

Over the last few years, the EU research community has launched and mobilized resources around various EU research cooperation initiatives such as the EU-Solaris, STAGE-CSP program, EERA CSP program. Supported by such initiatives, the collaboration between research and industry has played a key role in maintaining EU-industries in the market and developing the next generation technologies. Aligned with the SET Plan targets, the EU research community is now steering its efforts towards the following objectives: (i) supporting the CSP industry, (ii) clustering EU R&D activities on CSP, (iii) defining a limited and clear priority of scientific and technological targets/challenges for the effective cost reduction and increase the environmental and socio-economic benefits, (iv) increasing the integration of CSP into the energy system and (v) addressing all previous challenges in the context of aligned European and MS research and innovation objectives (STAGE-STE, 2017)

As mentioned earlier, the fourth reason that supports the choice of Southern Europe/Spain and Extremadura as optimal locations for the solar FOAK project are the remarkable potential **socio-economic impacts associated** to PV, but most important, CSP deployment in terms, among others, of job creation and economic stimulation across a wide range of sectors in the economy (Rodriguez et al. 2017; Deloitte 2011; Caldés et al. 2009). Compared to other regions in Europe, these are regions where the consequences of the crisis have become most salient and where such social and economic stimulation would be most needed to reduce income inequality across Europe. Furthermore, within Spain, the region of Extremadura would particularly benefit from such benefits as it is one of the regions with lowest GDP[9] in Europe.

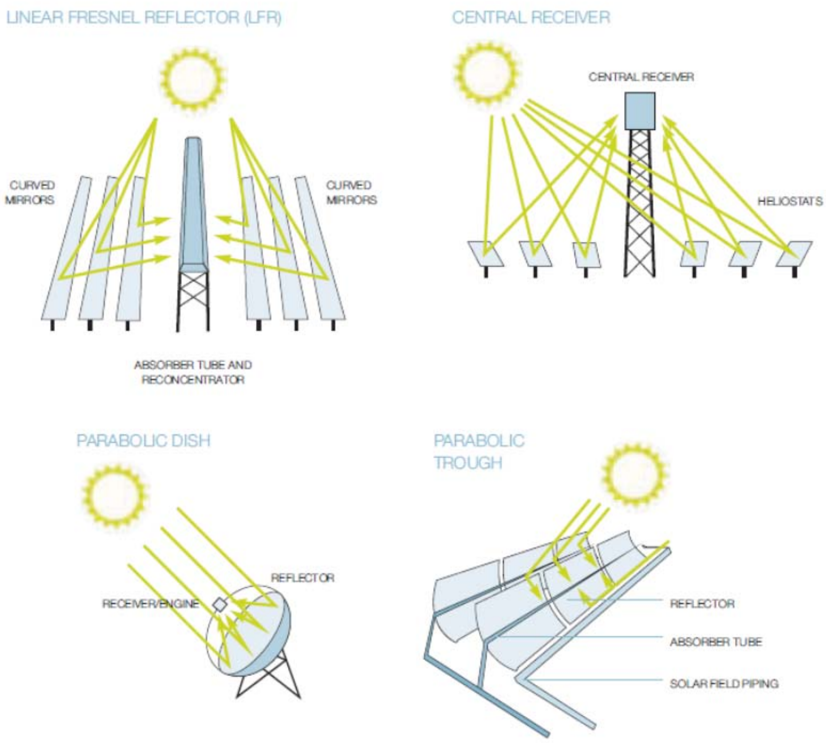
Finally, at the regional level, one key aspect for Extremadura is its unquestionable **political support and commitment towards renewable energies** and, in particular, towards solar technologies and CSP. Within the Spanish territory, Extremadura is a leader region in the field of solar energy, holding the first world position in solar coverage of the electricity demand and solar installed capacity power per inhabitant. As to solar technologies, Extremadura gathers more than 40% of the Spanish installed CSP capacity and 30% of installed PV capacity. In 2015, the electricity solar production covered 65% of the electricity demand. Finally, besides leading the European Sectorial Alliance in CSP skills (2015-2018) for defining the required training for EU Solar Operator Profile, Extremadura is leading the Solar Specialization Platform (Junta de Extremadura, 2017).

[9] Its GDP per capita is less than 75% of EU-average

2.2.2 Technology rationale

CSP technologies generate electricity when mirrors concentrate solar energy onto a heat medium, which is then used to drive a conventional turbine. Designs either concentrate to a few hundred degrees (Parabolic/Fresnel designs) or to a maximum temperature for steam power cycles in power tower designs (around 600 degrees Celsius) (IRENA 2014). Currently, there exist four CSP plant typologies: Parabolic Trough (PT), Fresnel Reflector (FR), Solar Tower (ST) with a central receiver and Solar Dish (SD), which differ depending on the design, configuration of mirrors and receivers, heat transfer fluid used and whether or not heat storage is involved. While PT and FR plants concentrate the sun's rays on a focal line and reach maximum operating temperatures between 300-550°C, ST and SD plants focus the sunlight on a single focal point and can reach higher temperatures. PT is currently the most mature and dominant CSP technology. In PT plants, synthetic oil, steam or molten salts are used to transfer the solar heat to a steam generator and molten salts are used for thermal storage. ST is presently under commercial demonstration, while FR and SD are less mature (IEA 2014).

Figure 6: CSP technologies (PT, ST, FR, SD)



Source: Greenpeace, 2009

Despite the technology has already reached the commercial stage, significant improvements can be expected in the future, as the industry scales up, operating experience improves, technology improvements are adopted and a larger and more competitive supply chain develops, both locally and globally (IRENA, 2016; Lilliestam et al. 2017).

Compared to other renewable technology, the main technological advantage of PT and ST is the possibility of integrate thermal storage and is able to store energy collected during day and use it for generation at a later time, including sundown (Viebahn et al. 2011). As thermal storage allows a CSP station to operate at a higher capacity factor, adding storage increases dispatchability but adds little or nothing to the LCOE compared to a plant with no storage, making CSP a valuable option for producing dispatchable renewable electricity, both for bulk power and especially for balancing intermittent renewable sources (Lilliestam et al. 2017). According to most consulted experts, the dispatchability attribute of CSP is and will be extremely valuable in the future EU electricity system with large shares of fluctuating renewables. Furthermore, beyond the still available overcapacities and transfer capacities for balancing power in Europe, the complementarity between variable and dispatchable renewable technologies should lead in due time to better balance between variable and manageable technologies (ESTELA, 2017; Denholm et al. 2015).

Worldwide, CSP has experienced a substantial increase in deployment in the last years. According to EurobservER (2017), total installed capacity in solar thermoelectric (CSP) at the end of 2016 amounted to 4.81 GW, up from 600 MW at the end of 2009. As mentioned before, in the past, this growth was concentrated in Spain (2304 MW) and the United States (900 MW), but the technology is also being deployed in other countries, including the United Arab Emirates, India, Morocco, South Africa, Algeria, Australia, Egypt, Italy and Iran. Despite around 15 solar tower projects or more in operation, the current CSP market is dominated by the PT technology, both in terms of number of projects and total installed capacity (around 85% of capacity) (del Río et al. 2018).

As for its costs, substantial costs reductions in LCOE (between 30 to 50%) are expected for both PT and solar tower (IRENA, 2016). As shown by the recent offers in Dubai, the industry has been able to divide CSP costs by 3 in the last 10 years (with only 1% of the wind or 2 % of the PV global market volume). According to ESTELA, such cost level alone makes CSP solutions applicable and competitive today against any combination of variable renewables with storage in battery, via power to gas, etc. that still need to be demonstrated respectively brought to maturity for bulk power storage purposes. Furthermore, such a cost drop opens a realistic perspective on further cost reductions towards 6 cts/kWh as soon as some 10-20 GW of CSP will be installed worldwide (ESTELA, 2017). According to Del Río et al. (2018) the drivers for such cost reductions include economies of scale, learning effects (both at the industrial and plant level), increased size and technological improvements due to innovation. As indicated by the same authors, the first two are the result of deployment whereas innovation is the result of R&D and, to a lesser extent, deployment. The literature suggest that the main decrease in costs for CSP plants will be related to an increase in deployment rather than to basic R&D (Lilliestam et al. 2017, del Río et al 2017).

According to most consulted sources and highlighted in del Río et al. (2018), CSP is expected to play a promising role in the future energy system worldwide. For example, according to the analysis of the IEA (2014), CSP could represent as much as 11% of electricity generation in 2050 and 954 GW of installed capacity. Similarly, in its CSP technology roadmap (IEA 2014b), the International Energy Agency (IEA) updates those figures upwards, expecting 982 GW in 2050, with only 28 GW of those being deployed in the EU. These numbers are in line with the ESTELA, which expects a worldwide diffusion of 1080 GW in 2050, 90 GW of which will be in Southern Europe (ESTELA, 2017).

However, the materialization of these figures will depend on the combination of various factors that will act either as barriers or drivers for CSP deployment. According to del Río et al. (2017), key techno-economic drivers for the take-off of CSP include its high technological dynamism and competition between different designs, its potential for cost reductions, the possibility for hybridization, its higher value compared to other RETs and industry consolidation. The authors also indicate that political drivers may also play a relevant role. Examples of drivers include targets (RES deployment and greenhouse gases (GHG) emission reduction) in efforts to primarily combat climate change and energy security threats, and supporting policies, such as financial support. As for the barriers to further CSP deployment, the same authors point at higher costs relative to other (non-RES based) technologies generating electricity as well as challenging permitting procedures. Other key barriers include limited resource potentials in the EU (in particular in Northern EU), high costs, uncertain cost reductions, and retroactive cuts in remuneration, which has led to greater investor uncertainty.

Taking into consideration the key drivers and barriers identified by del Río et al. (2018) and the information provided by consulted experts, table 5 shows how the solar FOAK project relates to the identified CSP barriers and drivers.

Table 5 Drivers and Barriers for CSP deployment and the solar FOAK project.

DRIVERS	Relevance for the solar FOAK project	BARRIERS	Relevance for the solar FOAK project
Techno-economic drivers		*Techno-economic barriers*	
Different designs and technological competition	As an innovation project, the FOAK project will have different/novel designs	**Limited resource potentials in Europe**	With the proposed cross-country cooperation scheme the best solar resources would be exported to Cent./Nort. Europe
Technological development in niches	N/A	**High costs**	There would be a great incentive to bring the costs down as much as possible. Such deployment would also contribute to bring costs further down
Hybridization	It is very likely that the FOAK will include a hybridization between PV/CSP	**Lower and uncertain cost reductions**	A tender scheme and the resulting bid would contribute to demonstrate the downward cost trend
Significant cost reductions	The FOAK project may test new technological developments aimed at further reducing CSP costs.	**Competition with solar PV**	The hybridization scheme would demonstrate the possibilities and advantages of the PV/CSP hybridization (the technologies would not compete but cooperate)
Higher value compared to other, intermittent renewable energy sources	The FOAK project would operate as a "peaker" by generating and exporting the electricity when is most needed.	**Access to credit**	The proposed scheme could potentially combine various funding sources (coop. mex and/or blend of other financial sources)
Industry consolidation (mergers and acquisitions) and vertical integration	N/A		N/A
Policy Drivers		*Legal and administrative barriers*	
Deployment support	The FOAK project would make use of the cooperation mechanisms as a support	**Legal and administrative barriers**	
		Policy barriers	
Innovation support	Given its R&D component, the project would be eligible to receive such type of support	**Uncertainty and retroactive policies**	The FOAK would not depend on National Support policies. The funding scheme would provide certainty.
Social Acceptability drivers		*Social Acceptability barriers*	
Support for CSP by the general population of the country	In Spain and Extremadura there is a wide acceptance to this technology.		

Source: Adapted from Del Río et al. (2018)

Hybridisation PV-CSP

Over the last few years, the possibility to hybridise solar PV and CSP integrated with thermal energy storage (TES) technologies has attracted increasing attention in the solar energy field. The combination of, on the one side, low PV generation costs and, on the other side, the dispatchability attribute of CSP leads to a high capacity factor solar power plant with a reduction in the LCOE in comparison to CSP alone (Parrado et al. 2016). This advantage comes from the abundant and cheap daytime generation from PV that could be supported by CSP with storage and integrated with production of power during evening peak hours. According to Xing (2017), the PV-CSP configuration results in a gain of delivering baseload electricity capacity with a potentially more cost-effective system compared to the two technologies alone. As a result, a PV-CSP solar energy plant reduces the project capital expenditures in comparison to CSP alone. The result is a fully solar dispatchable power at lower costs

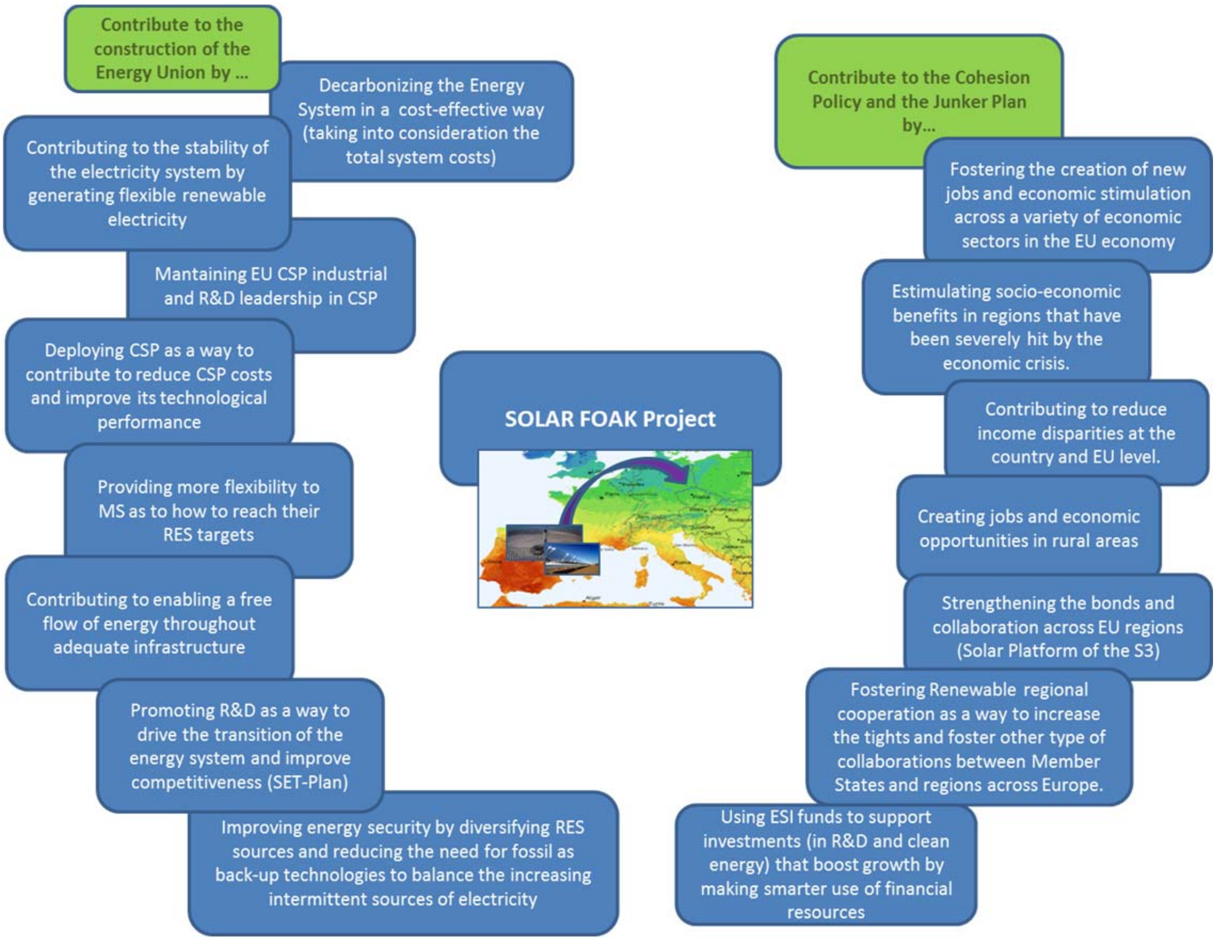
Figure 7 PV and CSP plant

Source: Pictures courtesy of Cobra

2.2.3 Technology rationale

This section aims at discussing in more detail in which way solar electricity exports from Southern to Central/Northern countries could help achieve various EU strategic policy goals. In particular, the focus will be on the EU Energy and climate policies underlying the formation of the Energy Union as well as the Cohesion Policy and Junker plan aimed at fostering jobs, growth and investment.

Figure 8 Solar FOAK project and EU policy goals



Source: Own elaboration

Figure 8 illustrates the potential links between deployment of a solar FOAK project and various EU policy goals. The potential contributions to the construction of the Energy Union –that is energy and climate change policies- are located on the left while those related to the EU Cohesion Policy and the Junker Plan -related to creating of jobs and boosting growth- are located to the right.

As for the **European Energy and climate objectives**, the purpose of the European Energy Union is to ensure that Europe has secure, affordable and climate-friendly energy. In turn, fighting climate change is both a spur for new jobs and growth and an investment in Europe's future (EC, 2017). As shown in the box 2, the EU's Energy Union strategy is made up of five closely related and mutually reinforcing dimensions:

Except for the energy efficiency dimension, the figure below shows the potential contribution of a solar FOAK project to the achievement of each one of the Energy Union strategy dimensions: (i) achieve a fully integrated internal energy market, (ii) Climate action through the decarbonisation of the economy and (iii) foster research, innovation and competitiveness.

Box 2 Dimensions of the EU Energy Union Strategy

- *A fully integrated internal energy market*: Enabling a free flow of energy throughout adequate infrastructure and without any technical or regulatory barriers – an efficient way to secure supply and give consumers the best energy deal.

- *Energy efficiency* – Improvements in energy efficiency will reduce energy imports, GHG emissions and will also drive jobs and growth.

- *Climate action – decarbonizing the economy*: An ambitious climate policy is integral to creating the Energy Union. Actions include the EU Emissions Trading system (EU ETS), strong but fair national targets for sectors outside the ETS to UT GHG emissions, a roadmap towards low-emissions mobility and an energy policy which makes the EU world leader in renewables. The EU is committed to a quick ratification of the Paris Agreement, an ambitious new global climate change agreement approved in Paris in December 2015.

- *Research, innovation and competitiveness*: Supporting breakthroughs in low-carbon and clean energy technologies by prioritising research and innovations to drive the transition of the energy system and improve competitiveness.

Within this pillar, the European SET Plan was set up to develop low-carbon technologies and make them economically viable. It aims to accelerate the uptake of new technologies by reducing their costs and increasing efficiency. The SET Plan includes the SET Plan Steering Group, European Industrial Initiatives, the European Energy Research Alliance, and the SET Plan Information System.

Source: COM (2017) 53 final

Figure 9 Contribution to EU Energy and Climate policy goals

EU ENERGY & CLIMATE POLICY GOALS	RELEVANCE FOR THE SOLAR FOAK PROJECT FOR EXPORT IN EUROPE
A fully integrated internal energy market	By fostering regional cooperation between Member States, we are increasing their flexibility when collectively reaching the EU-wide target. Additionally, through regional cooperation, the EU also seeks to maximize cross-border benefits, including balancing options, to increase flexibility in the energy system and to help plan supply and infrastructures in a more integrated and synchronized way (Ecofys, 2015). By exporting flexible electricity from CSP it is possible to provide more stability to the European electricity system.
Climate action – decarbonizing the economy	By deploying CSP in Europe, we are contributing to reduce the costs and improve the technological performance of a renewable technology that not only contributes to decarbonize the EU energy system but also provides flexibility to the system. By fostering such type of renewable technologies we are also reducing the need for fossil back-up technologies that provide stability to the system and compansate the variable profile of other renewable technologies. Furthermore, when it comes to fligth climate change globally (it is a global problem that requires global action), this renewable technology will be key in sunbelt countries located in less developed countries. Thus any contribution to reduce its costs and technological performance will contribute to the interantional efforts in fighting climate change.
Research, innovation and competitiveness	By deploying the first solar FOIK project (which must have an innovation content) we´ll be contributing to foster research and innovation in a renewable technology in which Europe still has a global industrial and research leadership position. Furthermore, with this type of projects, we´ll be supporting breakthroughs in low-carbon and clean energy technologies by prioritising research and innovations to drive the transition of the energy system and improve competitiveness. Furthermore, the FOIK solar project is totally aligned with the European Strategic Energy Technology Plan (SET-Plan) which was set up to develop low-carbon technologies and make them economically viable. As an example, the deployment of solar FOIK projects in Southern Europe is explicitly included as one of the goals of the 2016 CSP STE implementation plan.

Source: Own elaboration

Similar to the contribution to the Energy and Climate Policy objectives, the solar FOAK project could also contribute to the **EU Cohesion policy**, which is the European Union's strategy to promote and support the 'overall harmonious development' of its MS and regions. Enshrined in the Treaty on the Functioning of the EU (Art. 174), the EU's cohesion policy aims to strengthen economic and social cohesion by reducing disparities in the level of development between regions. The policy focuses on key areas which will help the EU face up to the challenges of the 21st century and remain globally competitive. In this sense, the EU regional policy supports job creation, competitiveness, economic growth, improved quality of life and sustainable development. Furthermore, in response to the financial crisis and the resulting low investment levels, the Investment Plan for Europe, also known as Juncker Plan, focuses on creating jobs and boosting growth by making a smarter use of financial resources, removing obstacles to investment and providing visibility and technical assistance to investment projects (EC, 2017).

Figure 10 shows, for several of the above mentioned objectives, what is the relevance and potential contribution of the solar FOAK project to the achievement of many of such goals.

Figure 10 Contribution to EU Cohesion Policy and Junker Plan

EU COHESION POLICY AND JUNKER PLAN OBJECTIVES	RELEVANCE FOR THE SOLAR FOAK PROJECT FOR EXPORT IN EUROPE
Foster job creation and economic growth	The deployment of a solar FOAK project would create jobs and economic stimulation (through direct, indirect and induced effects) across a variety of economic sectors in the EU economy
Reduce disparities in the level of development of regions	The project would generate positive socio-economic impacts (in the form of jobs, economic activity, visibility, investments and other spillover effects) in regions that have been severely hit by the economic crisis.
	The project could contribute to reduce income disparities at the country level as well as at the EU level.
	The solar FOAK project would create new employment and economic opportunities in deprived rural areas (contributing to reverse the migratory flow from rural to urban areas)
Foster regional cooperation and integration among European regions	The project would strengthen and generate additional bonds and collaboration across EU regions (facilitated by the Solar Smart Specialization Platform)
	Renewable regional cooperation could help increase and reinforce tights and collaborations between Member States and regions across Europe.
Make a smart use of financial resources and remove obstacles to investment	This project would be eligible to receive funds from ESI funds (in R&D and clean energy) that boost growth by making smarter use of financial resources. Furthermore, given its R&D component, this project would also be eligible for other types of EU financial instruments suited for FOAK projects (for example, the InnovFin Energy Demo project Pilot facility).
Improved quality of life and sustainable development	Thanks to the creation of new jobs and economic activity, the quality of life of many people could be improved. Furthermore, the decarbonization of the electricity system contributes to reduce local air pollution as well as to reduce GHG emissions globally and fight climate change (and its harmful consequences to the population).

Source: Own elaboration

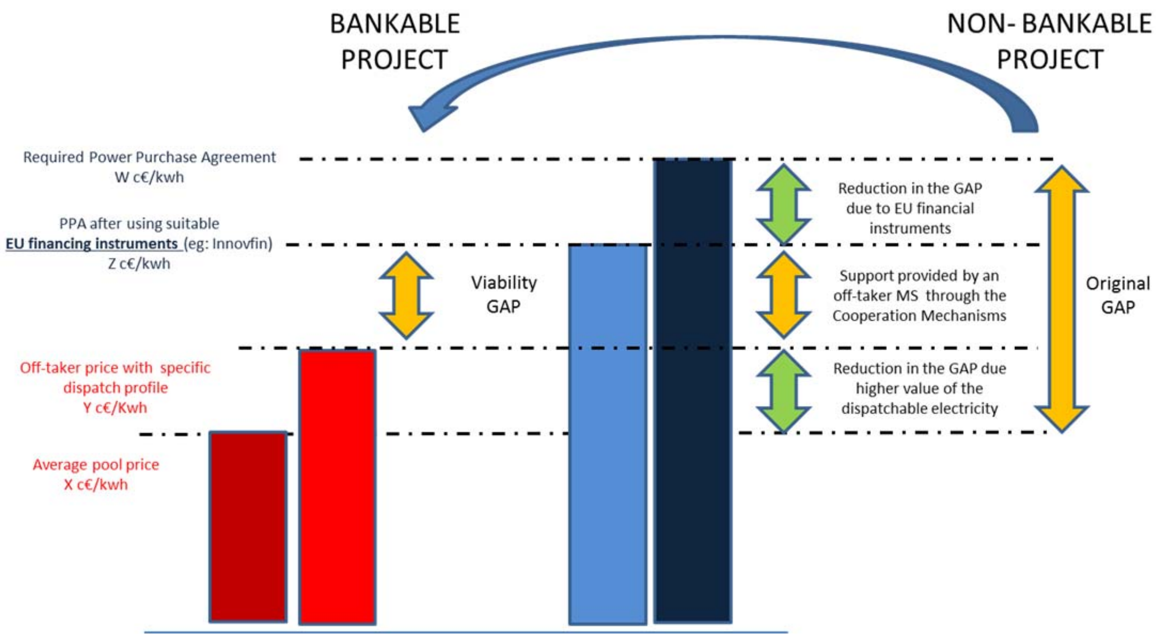
3 Making the solar FOAK project feasible

FOAK project is the limited financial resources for high risk/return demonstration projects. Even though the CSP technology is already commercialised, with 5GW installed capacity worldwide, the electricity export concept across Europe is to be tested. Such projects are usually too risky for commercial finance and therefore considered as "not bankable" (Burnham, 2013).

To address this challenge, two alternative (and possibly complementary) types support schemes are presented in this section: (i) the cooperation mechanisms of the Renewable Directive 28/2009/EC and (ii) available EU financial instruments.

As an example, figure 11 provides a graphical example about possible ways in which the gap -defined as the PPA of a solar FOAK project and the average electricity market pool price- could be reduced using different types of support schemes so that the project becomes bankable.

Figure 11 Example; how to reduce the financial gap between PPA and pool price



Source: Adapted from ESTELA (2017)

3.1 The Cooperation Mechanisms of the RES Directive 2009/28/EC

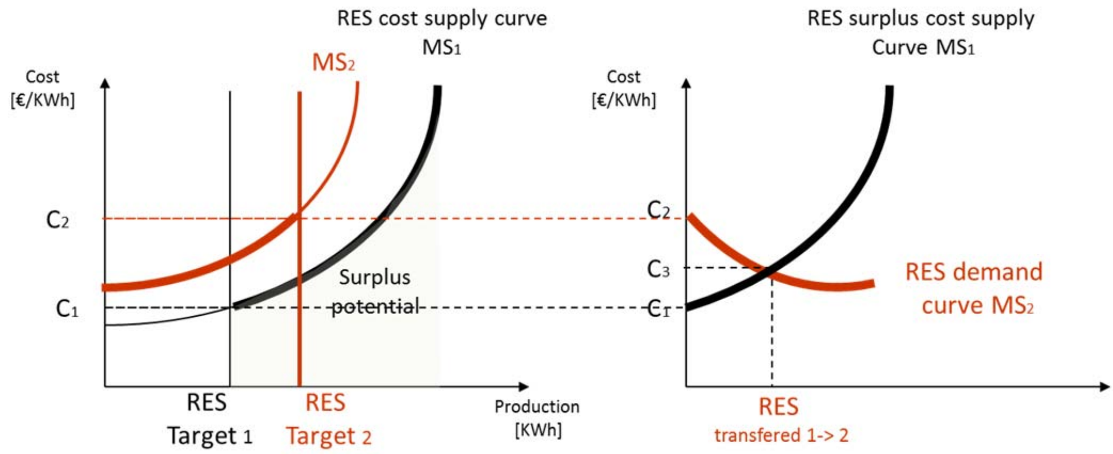
After introducing the cooperation mechanisms of the Renewable Energy Directive 28/2009/EC, the remaining of this section will be structured around two relevant questions for the solar FOAK project: (i) what have we learned from past renewable cooperation attempts? and (ii) what can we expect from regional cooperation in the future?.

On the one side, lessons learned from both past failed and successful attempts to implement the cooperation mechanisms can provide useful information about drivers and barriers which could potentially be relevant for the considered solar FOAK project. On the other hand, having a good understanding about the way renewable energy cooperation is likely to be articulated in the post 2020 framework can equally provide relevant information for solar FOAK projects.

As for the **Renewables Energy Directive2009/28/EC** (also known as the RED directive), back in 2009, it defined a EU 20% RES target as well as National binding RES targets (expressed as a percentage of RES gross energy consumption). Such targets were set based on “flat rate approach” that only considered MS gross domestic product and their historical RES deployment. As a result, National targets were not necessarily correlated with MS RES potentials nor with their RES generation costs. As a result, some MS with scarce RES resources or high generation costs found it challenging to meet their targets domestically while for others –with abundant resources and/or cheaper generation costs- it was easy to meet their target and even go beyond such target. In order to provide MS with more flexibility and achieve the EU target in a more cost-effective way, the RED Directive 2009/28/EC set the legal framework for the use of cooperation mechanisms. While the Directive specified the general accounting rules of these mechanisms, it is important to note that their design and implementation is left to the cooperating MS.

Figure 12 illustrates, with a simplified example, the efficiency gains that could be obtained from the use of the cooperation mechanisms. For example, let´s consider a MS with cheap and/or large potential for RES-E generation (MS1) that comes together with another MS with limited and/or expensive potential for RES-E generation (MS2). Furthermore, let´s assume that MS1´s RES target is less ambitious than MS2´s RES target (such situation is illustrated by the different renewable cost supply curves of the two MS and the different RES targets). In this situation, a certain share of the RES-E generation target in MS2 could be achieved by the surplus generation from MS1. Such transaction would lead to cost savings for MS2 while the support cost in MS1 would increase (at a lower rate than the support costs decrease in MS2). As a result, net support cost savings can be realized through cooperation

Figure 12 Economic rationale from cooperation



Source: Own elaboration

As for the benefits from the use of the cooperation mechanisms, several studies have demonstrated, from a theoretical point of view, the efficiency gains of the use of the cooperation mechanisms (Resch et al. 2015 as well as reports from the Re-Shaping, RES4LESS and BETTER projects). Such studies assessed different cooperation scenarios which led to different magnitudes of efficiency gains. For example, in the Re-Shaping project, the “strong cooperation” scenario compared to pure “national thinking” as specified in the case of “limited cooperation” reduced additional generation cost and capital expenditures as well as significantly decreased support expenditures (-10.8% or 31bn€ over the whole period up to 2020 at EU level compared to “limited cooperation”). The “moderate cooperation” scenario, which seemed more realistic considering MS preferences, still showed reductions in support expenditures of -5,8% (17bn€) over the whole period up to 2020 at EU level (Resch et al. 2015).

There exist four possible cooperation mechanisms that MS can choose from. Box 3 summarizes the four types of cooperation mechanisms of the RES Directive. Article 6, 7 and 11 are suitable for cooperation agreements within the European territory whereas

Article 9 is only suitable for cooperation agreements between EU MS and Neighbouring countries.

Box 3 Cooperation mechanisms of the RES Directive (2009/28/EC)

Article 6: Statistical transfers

In this case, renewable energy (electricity, heat or transport energy) which has been produced in one MS is virtually transferred to the RES statistics of another MS, counting towards the national RES target of that MS.

Article 7: Joint Projects between EU MS

Allows EU MS to finance a RES project jointly thus sharing the costs and benefits of the project and developed under framework conditions jointly set by two or more MS (i.e. a specific new plant is identified and the output of the plant is shared (statistically) between to cooperating MS). The involved MS define which share of the energy production counts towards which MS target.

Article 9: Joint Projects with third countries

Joint projects can also be implemented between MS and third countries (i.e.: countries outside the EU). A precondition is that an amount of electricity that equals the electricity amount generated from RES and subject to this joint project is physically imported in o the EU (For more information on this option, see www.better-project.net).

Article 11: Joint Support Schemes

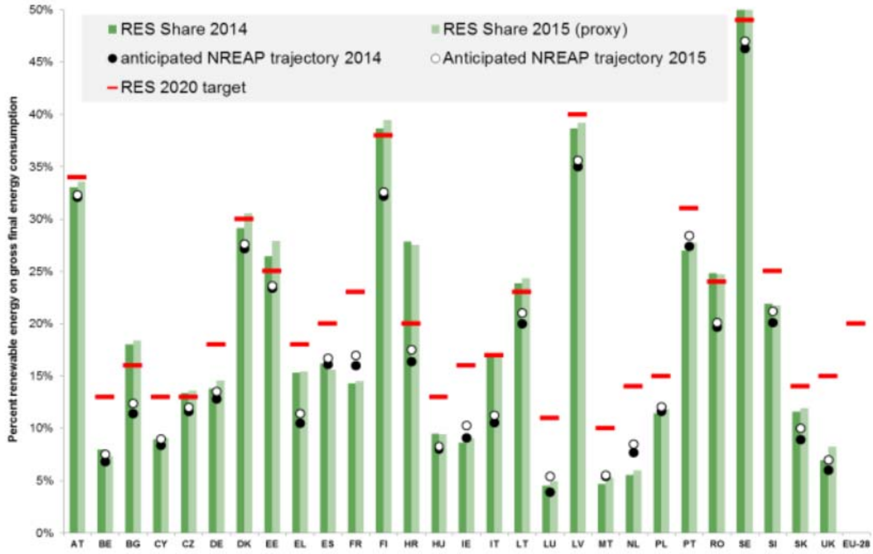
Under this scheme, MS merge or coordinate (parts of) their RES support schemes and jointly define how the renewable energy produced is allocated to their national targets.

Source: RES Directive (2009/28/EC)

When considering potential interested off-taker countries in Europe, according to consulted experts and the information provided in the Renewable Energy Report that includes the MS current progress towards their current progress and their indicative RES targets (EC, 2017), those countries likely interested in using cooperation mechanisms as a way to meet their 2020 RES targets are Luxemburg, Ireland, the Netherlands, Cyprus, Germany, Malta and the UK.

It must be taken into consideration that Figure 13 is based on 2014 figures. Therefore, as of today, some Member states have already implemented measures with which it is expected that they will meet their renewables 2020 target. For example, in the Spanish case, as a result of the latest 8000 MW renewable energy auctions, it is expected that Spain will meet its 20% target by 2020.

Figure 13 MS current progress towards their RES targets



Source: Renewable Energy Progress Report COM(2017) 57 final

Furthermore, as a result of State Aid decisions, some countries may opt for cross-border opening as a way to remedy discrimination[10] under Articles 30/110 of the Treaty (discriminatory charges on goods). Besides Germany (see box below), other countries may follow the same example such as Luxemburg, Denmark, Estonia, Romania, Greece, Italy, Portugal and Belgium.

Box 4 The German revised Cross-Border Renewable Energy Ordinance

In June 2007, the German Cabinet adopted the revised Cross-Border Renewable Energy Ordinance (GEEV) in order to implement the requirements of the 2017 Renewable Energy Sources Act (EEG 2017), according to which 5% of new renewables capacity to be installed each year (approx. 300 megawatts) would be opened up to installations in other EU MS in auctions. This was the result of an agreement with the EC in the context of the state aid approval procedure for the Renewable Energy Sources Act.

The first opened pilot auctions were put in place for ground-mounted photovoltaic installations with Denmark but the new GEEV also makes possible cross-border auctions for onshore wind energy installations and further cross-border auctions are planned to be carried out (subject to the successful conclusion of negotiations with partner countries).

According to the Renewable Energy Sources Act, three requirements must be fulfilled for cross-border opening: the opening must be based on the principle of reciprocity, i.e. the German funding system can be opened to installations from other EU MS only if the other MS also open their funding systems to installations in Germany. For this purpose, intergovernmental agreements need to be concluded between the cooperation partners. Furthermore, it must be possible to physically import the electricity to Germany, i.e. a real impact on the German electricity market must be guaranteed.

Source: https://www.bmwi.de/Redaktion/EN/Pressemitteilungen/2017/20170614-kabinett-verabschiedet-novelle-der-grenzueberschreitenden-erneuerbare-energien-verordnung.html

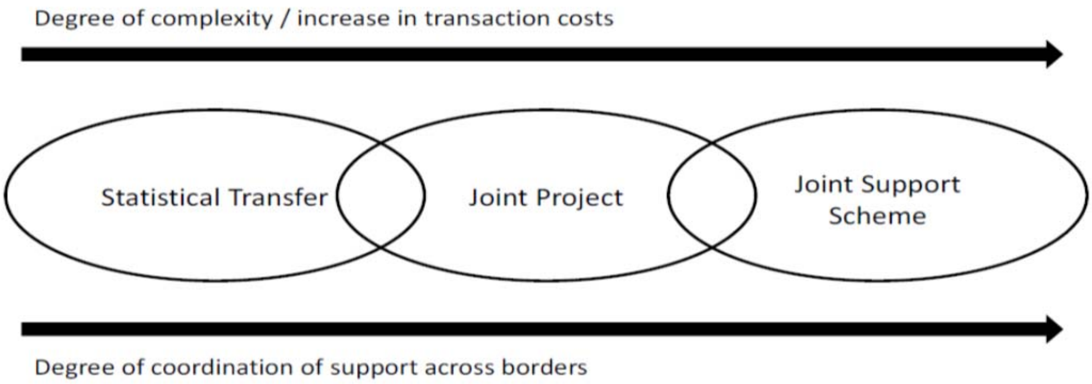
[10] Articles 30 and 110 of the Treaty on the Functioning of the European Union (TFEU) prevent Member States from imposing charges or taxes that discriminate against imports.

3.1.1 What have we learned from the past?

Beyond cost-savings and compliance with State aid decisions, there exist other direct and indirect drivers but also hurdles that must be taken into account when considering a cooperation agreement. For example: grid-related bottlenecks, avoided local and global air pollution, security of supply, employment effects, innovation effects, etc.

The objectives pursued by each MS and the particularities of each cooperation case will determine the choice of the cooperation mechanism and its particular design. For example, when one of the potential cooperation countries is not in the EU, the only feasible mechanism is Article 9, -that was specifically design for cooperation with third countries. When both parties are located in the European territory, MS must choose between statistical transfer (Art 6), joint projects (Art 7) with or without physical transfer and Joint support Schemes (Art 11). In general terms and as shown in figure 14, for intra-European cooperation agreements, the choice of mechanisms is often done based on the consideration of the trade-off between the degree of complexity and the degree of coordination of the support instrument which both increase along the spectrum of possible mechanisms (Klessmann, 2014)

Figure 14 Choosing between alternative intra-European Cooperation Mechanisms.



Source: Ecofys, 2013

The three intra-European cooperation mechanisms provide opportunities for different depth, scope and duration of cooperation between MS. Thus, when MS choose the type of cooperation mechanisms and its design, they first need to clearly identify what is their interest for cooperation (Klessmann, 2014). Consulted MS indicate that some of the most commonly reported reasons to cooperate include: (i) lowering the costs of reaching the national 2020 RES targets, (ii) closing the potential gap between RES production and RES target and/or interim target, (iii) cooperation for technology development and (iv) long term cooperation and electricity imports/exports (Klessmann, 2014; Ecofys, 2013; CA-RES).

Klessmann, (2014) indicates that in general terms: **Statistical transfer** is particularly suitable to quickly achieve cost-efficient fulfilment of the RES targets. There is no direct effect on domestic support schemes and, compared to the other cooperation instruments, it is easy to establish. As the 2020 deadline approaches, this option seems to be the preferable one. On the other side, **Joint projects** can be suitable to jointly develop technologies, save costs of RES target fulfilment and prepare long-term electricity imports/exports. They have a higher complexity degree but they are suitable for a limited amount of projects with some kind of strategic component. Finally, **joint support schemes** provide the highest degree of cost-efficiency as well as policy and market integration. The downside is that they require deep cooperation between MS, which often implies that they share similar technology preferences and have well integrated electricity markets (Ecofys 2013). Taking this information into consideration, a possible option for the solar FOAK project considered here could be a joint project (Article 7) with physical transfer. In any case, once the typology of cooperation mechanisms has been chosen, its specific design must be defined from a wide range of options to address the involved MS needs and particularities (see table 6 and Annex 1). In this regard, the EC's Guidance on the Use of Renewable Energy Cooperation[11] (EU SWD(2013) 442) and Held et al. (2014) provide very useful information for MS in this respect.

Table 6 Example of the cooperation mechanisms design options

Design element	Example of alternative options
Type of cooperation	Number of involved parties, single or multi-project cooper.
Scope of cooperation	Technology and duration of the support
Flow of support	Determination of support level/transfer price
Contractual arrangements	Arrangements for non-compliance

Source: Ecofys (2014)

As mentioned earlier, since 2009, the cooperation mechanisms have not delivered as expected and, as of today, only four cooperation mechanisms have successfully been implemented in Europe. In an attempt to explain such low implementation and derive some useful insights for the solar FOAK project, the next section adresses the drivers but most important the barriers that have prevented a wider use of the cooperation mechanisms in Europe. Furthermore, the four successful cases of cooperation mechanisms in Europe will be presented.

3.1.2 Drivers and barriers to the use of the Cooperation Mechanisms

Compared to a fragmented approach in meeting the MS renewable targets, the utilization of the cooperation mechanisms may bring various advantages. As shown in table 7, based on the literature review as well as consulted experts and MS representatives, a range of potential benefits that could emerge from a cooperation agreement (Klessmann 2015, Gephard et al. 2015; RES4LESS, Lilliestam et al. 2016, Caldes et al. 2015, CA-RES reports; Ecofys 2013).

[11] https://ec.europa.eu/energy/sites/ener/files/documents/com_2013_public_intervention_swd05_en.pdf

Table 7 Drivers for enhanced RES-E cooperation within Europe (Art. 6, 7 and 11)

Drivers for importer / off-taker countries	Drivers for exporter countries
• Achieve RES targets more cost-efficiently • Foster economic relations with other MS • Benefits for domestic industry (open new markets) • Diversify energy portfolio & supply regions - increasing security of supply. • Get flexible renewable power supply to complement own variable RES-E (eg: in the case of CSP) • When applicable, comply with National legislation as to the obligation to open RES support schemes.	• Generate revenues from domestic resources • Attract foreign investments/support to deploy new RES plants without compromising domestic funds. • Create new jobs and industrial opportunities • Foster technology research and knowledge transfer • Create economic and political interdependences with other MS • Contribute to the decarbonisation of the domestic energy mix in the longer term. • Create economies of scale in RES-E deployment (that lead to improvements in technology performance and cost reductions)
Drivers for both cooperating countries and for the EU as a result from mutual cooperation	
• Cooperation with regards to specific technologies of interest and thus focus on technology developments and industrial policies. • Jointly test new support scheme elements (eg: the introduction of specific premium calculations in a FIP system or the introduction of auction schemes for specific technologies). • Enable savings of different kinds compared to purely national RES deployment (Resch et al. 2015). • From an EU perspective, support costs savings because RES installations are built at preferable sites in a wider geographical region, requiring less support to be economically feasible • From an EU perspective, reductions of capital expenditure: with the cooperation of several countries, better sites require less RES capacity to produce the same amount of electricity. • From an EU perspective, it can help increase the tights and foster other type of collaborations between MS and regions across Europe • From an EU perspective, it is a way to improve energy policy coordination of MS, policy convergence and move towards the creation of the internal energy market.	

Source: Adapted from RES4LESS, CA-RES, BETTER projects and Klessmann (2015).

However, despite the potential benefits mentioned above, the use of the cooperation mechanisms has been very limited with only four intra-European cooperation mechanisms in place and not a single cooperation mechanism with neighboring countries. There exist many reasons of diverse nature that explain this underutilization of the cooperation mechanisms which will be described in the detail in the remaining of this section. Given the distinct nature of the barriers, this section focuses on the barriers that have prevented the use of intra-European cooperation mechanisms (Articles 6, 7 and 11). For more information on barriers to implement Article 9 -that is cooperation with neighboring countries-, see Lilliestam et al. (2016) and Caldés et al. (2015).

According to Klessman (2015), some of the most remarkable barriers include: (i) social opposition (ii) lack of physical interconnections, (iii) discrepancy of electricity market design and specific rules for market access and operation of power plants across MS, (iv) regulated energy prices, (v) oligopolies (lack of realized competition), (vi) different RES support schemes across Europe which prevent a more efficient allocation of RES investments, (vii) MS disparities towards their preferred energy mix and their resistance to lose control over their energy policy.

Based on the views from consulted experts and literature review, Table 8 lists and categorizes the potential hurdles to the implementation of the cooperation mechanisms in Europe.

Table 8 Potential hurdles to the use of the cooperation mechanisms

Barriers for the implementation of the cooperation mechanisms		
Political barriers	**Technical Barriers**	**Legal barriers**
Challenges in market & grid integration (MS have different electricity market design and rules for market Access and operation of power plants)	Uncertainty of post-2020 framework ("Winter package" currently being discussed) and non-ambitious 2030 RES targets.	Uncertainty on state aid compliance
Lack of sanctions for non-compliance with 2020 RES targets.	Potential public position from buying country role (i.e: for spending public money to support RES projects abroad)	Heterogenous regulated energy prices and support schemes across MS
Uncertainty about the design options to implement cooperation mechanisms.	Potential public opposition from exporter or host country role (i.e: NIMBY)	Oligopolies (or lack of realised competition).
Potential resistance from transit countries	Challenges in quantifying, monetizing and accounting for indirect costs & benefits of the agreement.	
Uncertainty in forecasting RES target compliance	"First movers risk"	
Social opposition and difficulties in communicating the benefits of cross-border electricity trade	Limited interconnection capacity between some MS (for example, the Iberian peninsula and the rest of Europe)	
Resistance of some MS to loose sovereignty and control over Energy policies and markets.		

Source: Own elaboration based on expert consultation and literature review

3.1.3 Existing cooperation initiatives

As of today, four cases of cooperation mechanisms exist in Europe (table 9)[12].

Table 9 Existing cases of use of cooperation mechanisms in Europe

Cooperating Countries	Coop. Mechs.	Type of agreement	Technology	Year
Sweden/Norway	Art. 11	Joint Certificate Scheme	All RES technology	January 2012
Germany/Denmark	Art. 11	Mutually-opened auctions	Ground Mounted PV installations	July 2016
Luxemburg/Lithuania	Art.6	Statistical Transfer	All RES technologies	October 2017
Luxemburg/Estonia	Art.6	Statistical Transfer	N/A	November 2017

Source: Own elaboration

[12] For more detailed information on such agreements as well as on the failed attempts between other MS, see Gephard et al. (2015).

- **Sweden and Norway (Joint support scheme / 2012 / Article 11)**

In January 2012, the first cooperation mechanism was formally signed between Sweden-Norway with the form of a joint certificate scheme (corresponding to Article 11 of the RED Directive). Sweden´s participation in the scheme implied extending the electricity certificate scheme that had been operating since 2003. In Norway, the revenues from certificates replace the former investment support for wind farms provided by the government.

As described in Held et al. (2014), the green certificate scheme rules implied that for every unit of electricity produced, the State offered green certificates to RES generation facilities. Each issued certificate represented 1 mega-watt hour (MWh) of electricity. In turn, the certificates were commercially tradable assets and increased the income for renewable producers. Companies that sold power had the obligation to sell a certain share of electricity produced from renewable sources and needed to buy a certificate to prove that by redeeming the respective amounts with the government agency once per year. The final costs were then passed on to the end consumer bills. Despite both countries operate a joint support scheme together, the two countries decided that they didn´t have to agree on every detail such as tax regimes, regulations, etc. so that each country implemented the scheme slightly different.

The common goal for the joint market was to increase electricity production based on RES in Sweden and Norway by 25.4 TWh from 2012 to 2020 so that both countries have the responsibility of realizing an additional production of 13.2 TWh independently of where the production capacity is built. In this way, the electricity produced by the plants included in the common electricity market would be equally divided between the two parties.

The expected benefits from such agreement include: (i) a better functioning of the market, (ii) increased cost efficiency and (iii) increase long term stability. Such outcomes would benefit both countries in a way that Sweden has lower support costs and Norway can join an existing support scheme and have more installed RES capacity developed in their country.

As for the lessons learned, Held et al. (2014) concluded that the fact that both countries have similar RES cost was important for the success of the joint support scheme. Furthermore, another key to success was the existing interconnection between the two countries and operation in a common electricity market. As for hurdles along the way, there were difficulties in agreeing to a burden sharing arrangement until a political agreement to share the costs and benefits 50-50 unlocked the negotiations.

Source: Held et al. (2014)

- **Germany and Denmark (Joint support scheme / 2016 / Article 11)**

The second cooperation mechanism took place in July 2016 between Denmark and Germany in the form of mutually-opened auctions for ground-mounted PV installations (Article 11). Under this agreement, both partners agreed on the main principles for their cooperationbut every country implemented its own auction and was free to design the auction itself (price system, maximum amount, auctioning KW or KWh, etc). However, as regards the local investment conditions (e.g: licensing law, permitted areas and sites) the terms and rules of the country of location apply (for example: the rules of the country where the installation will be built)

As described by BMWI (2016), "in a joint auction, the partner countries conduct one joint auction that is open to installations in both partner countries and funding for the renewables installations is provided from the existing national support schemes of the two countries. A predetermined distribution rule is used to determine the country from which a successful bidder will receive support. Partner countries have to agree on the auction design before conducting the auction. With regard to location-specific aspects (planning and construction rules, taxes and levies, etc.), the conditions of the country where the installation will be located will apply unless otherwise agreed by the partner countries. Consequently, bidders will have the necessary information about the funding terms and investment conditions when they submit their bid. The only thing bidders will not know ahead of the bid is which funding scheme they will be assigned to (who will pay the bill)".

As for the involved players in the agreement, on the German side, the cross-border support was disbursed directly by the transmission system operator (TSO) managing the closest interconnector. The distribution system operator of the partner country where the installation is located supplies the necessary data to the German TSO. In Germany, the regulatory body for inviting the bids is the Federal Network Agency (BNetzA).

The German ordinance for implementing this concept provided for the different design options and for possible deviations from the German auction design. The cooperation agreement between the partner countries defined specific conditions for each and every auction opened to EU MS. These specific auction conditions were published by the regulatory body inviting the bids. The agreement also included a balanced cost-benefit ratio and defined rules for accounting towards national and EU renewable energy targets in accordance with Directive 2009/28/EC[13] (BMWi, 2016)

Source: (BMWI,2016)

- **Luxemburg and Lithuania (Statistical Transfer / 2017 / Article 6)**

The agreement signed between Lithuania and Luxembourg[14] on October 26th 2017 is the first ever cooperation agreement using a statistical transfer of renewable energy amounts (Article 6 of the RED). The agreement will help Luxembourg achieve its national renewable target for 2020 by receiving statistical transfer of a specified amount of renewable energy produced in Lithuania.

Lithuania´s national 2020 RES target is 23%. However, by 2015, Lithuania had already overpassed such goal as it reached 25,75% of renewable energy in its gross final energy consumption. Contrary, Luxemburg 2020 RES target was set at 11% while by 2015 Luxemburg had only achieved 5%. Not surprising, Luxemburg had already stated in its national renewable energy action plan as well as in its latest renewable energy progress report that it relied on using statistical transfers to reach its 2020 RES target[15]

The agreement foresees that, starting in 2018 up to 2020, Lithuania will transfer to Luxemburg a certain amount of its renewable energy surplus. According to consulted sources, a financial benefit that may amount to 10m€ will be invested in energy projects and scientific research in Lithuania.[16]

Source: DG-ENER (2017)

- **Luxemburg and Estonia (Statistical Transfer / 2017 / Article 6)**

In this case, the agreement signed between Estonia and Luxembourg on November 13th is the second cooperation agreement using a statistical transfer of renewable energy amounts. According to the available information[17], the agreement stipulates that Estonia will transfer a minimum volume of renewable energy target amounts in 2018 and 2020 to help Luxembourg fulfil its 2020 national renewable energy target. The agreement includes the option for additional transfers in the future. According to consulted experts, the revenues received by Estonia from Luxembourg are going to be used to finance projects in

[13] The information included here was provided by BMWI. For more information, see BMWi, (2016)
[14] More information on this agreement is expected to be disclosed within the next few months.
[15] https://ec.europa.eu/info/news/agreement-statistical-transfers-renewable-energy-amounts-between-lithuania-and-luxembourg-2017-oct-26_en
[16] https://enmin.lrv.lt/en/news/an-agreement-between-lithuania-and-luxembourg-in-the-field-of-energy-is-the-first-contract-of-this-type-in-the-eu
[17] https://ec.europa.eu/info/news/second-agreement-statistical-transfers-renewable-energy-amounts-between-estonia-and-luxembourg-2017-nov-13_en

the areas of renewable energy or energy efficiency. As for their renewables target trajectories, Estonia's national renewable energy target for 2020 is 25%. In 2015, Estonia achieved a share of 28.6% of renewable energy in its gross final energy consumption. On the other side, Luxembourg's national renewable energy target for 2020 is 11%. Luxembourg achieved a 5% renewable energy share in its gross final energy consumption in 2015.

Source: DG-ENER (2017)

3.1.4 Renewable cooperation in the post 2020 framework: What to expect?

As the 2020 deadline approaches, MS are already feeling the urgency to find ways to comply with their 2020 National RES targets. As a result, the use of the Cooperation Mechanisms is likely to increase as the trajectory becomes steeper. According to consulted experts, Statistical transfer agreements will likely be the most popular cooperation mechanism due to its ease of implementation and the limited time remaining until 2020.

However, when MS energy policy makers consider renewable cooperation agreements with other MS, they must look beyond 2020 and consider what will be the regulatory framework affecting renewable cooperation agreements in the post 2020 period so that the appropriate decisions are taken. According to Gephard et al. (2015) and as shown in the figure 15, “a more coordinated European approach will be a cornerstone to achieve a more climate-friendly, affordable and secure energy system for the EU. In this context, regional cooperation is expected to open up the black box of national energy policy-making and bridge gaps between the EU and national levels”.

Figure 15 Pillars of the 2030 Renewable Energy framework

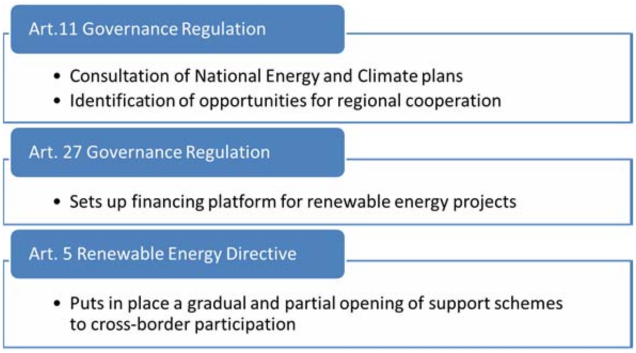
Source: EC (2016)

Despite the important role that regional cooperation is expected to play in the 2030 framework, the way in which this cooperation is going to be incentivized and regulated is still under discussion. Despite this uncertainty, the purpose of this section is to provide a glimpse of what seem to be the key points in the proposed legislation that may determine the regulation affecting regional cooperation.

Despite the European 2030 renewable energy target is already set at 27%, the accompanying legislative framework is not yet finalized. In this regard, las November 30th 2016, the EC presented the “Clean energy for all Europeans´ package” legislative proposals that covers various aspects such as, among others, energy efficiency, renewable energy, the design of the electricity market, security of electricity supply and governance rules for the Energy Union (COM(2016) 860 final).

Out of the various pieces of legislation that conform the Clean Energy for all Europeans package, the proposed revised Renewable Energy Directive and the Energy Union Governance are the most relevant elements that shape renewable energy cooperation in the post 2020 framework in Europe.

Figure 16 Cooperation in the Clean Energy for All Europeans package



Source: revised Renewable Energy Directive

On the one side, the proposed regulation on **Governance of the Energy Union**[18] (COM (2016) 759 final/2) has been designed to integrate and simplify planning, reporting and monitoring obligations of the EC and the EU MS in the 2030 Climate and Energy Framework. The regulation mandates the creation of national energy and climate plans to be prepared by MS biannually on the basis of binding templates and monitored annually by the EC. It also lists some measures that the EC can take to ensure that MS collectively meet their RES energy and energy efficiency targets. In particular, the governance system is expected to be reliable and should encourage enhanced regional cooperation and consultation as well as exchange of information and best practices in constructive dialogue between MS and the EC[19] (EPRS, 2017).The regulation also empowers the EC to request additional measures from MS in the event that the 2030 climate and energy goals risk not being met. To this end, the EC may request MS to adjust the share of renewable energy used and/or contribute financially towards setting up a financing platform at the EU level to develop renewable energy projects. MS would be required to contribute to this financing platform if they fail to meet their baseline share of energy from renewable sources.

Consulted experts indicate that it will be challenging for the prosed Governance to compensate for the lack of national binding targets after 2020 as the EC leaves it entirely to MS to ensure that their contributions add up to the EU target.

As for the proposed **revised Renewable Energy Directive** (COM(2016) 767 final/2), its objectives are to: (i) lower the overall system costs of reaching the 27% RES target and (ii) drive a gradual alignment of support schemes (at discretion of MS) and generate fewer distortions in the internal market. In this sense, Article 5 of the proposed revised Renewable Energy Directive indicates that "*MS shall open support […] to generators located in other MS under the conditions laid down in this Article*". The proposal indicates that it should apply to at least 10% of newly-supported capacity over 2021-2025 and 15% over 2026-2030. Furthermore, it indicates that the allocation between MS of electricity supported through opened schemes shall be subject to a cooperation agreement "*following the principle that energy should be counted towards the MS funding the installation*". Finally, the proposal also states that EC may propose to increase those percentages based on the assessment of the benefits by 2025.

Again, according to consulted experts, current discussions focus around (i) the mandatory vs voluntary nature of the opening of the RES support, (ii) the percentage of newly-

18 https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union
19 http://www.europarl.europa.eu/RegData/etudes/BRIE/2017/599279/EPRS_BRI(2017)599279_EN.pdf

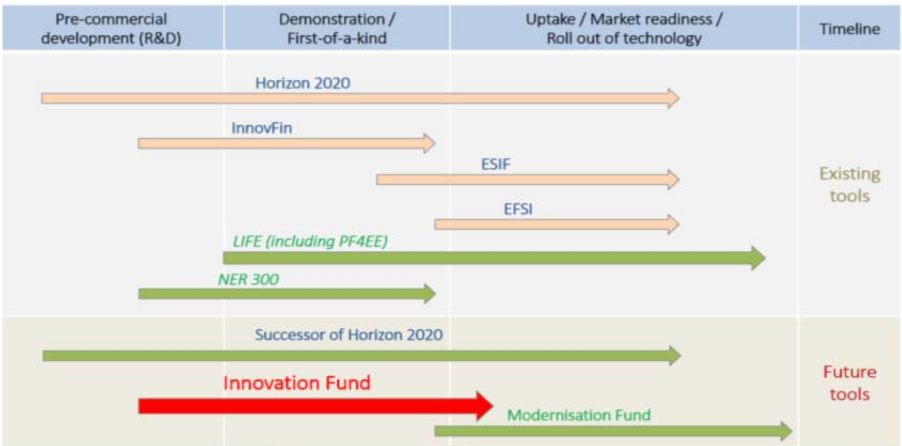
supported capacity and (iii) the possibility to linking such obligations to the actual interconnection levels or limiting the obligations to direct neighbours.

3.2 EU Risk sharing financial instruments suited for the Solar FOAK project

Meeting the EU's energy goals for 2020 and beyond will require the development and commercialisation of new generations of low-carbon energy technologies and systems. However, a major problem for investors in new low carbon technologies in the EU is overcoming the so-called 'valley of death' between the demonstration and commercialisation phase. Bringing innovation into the market through capital intensive and risky FOAK commercial scale demonstration projects requires an upscaling of investment. But it also put in place common strategic framework (SET Plan, Energy Union) as well as an effective coordination and complementarity between the different financial programmes for energy research and innovation. In particular, considering the specific challenges faced by the innovation of the low carbon energy sector (capital intensive, long lifetimes, infrastructure needs, R&D investment etc.) is important to exploit the strengths of the combination of different funds in order to archive a critical mass of financing.

Figure 17 provides an indication of both the existing funds and programmes available to foster innovation of low-carbon energy technologies, and of future tools. It becomes obvious that in order to successfully support innovation in the energy sector throughout all phases of the innovation process, the different tools should be combined.

Figure 17 Funding sources supporting low-carbon energy-related technologies



Source Climate Strategy (2017a)[20]

In this respect, this policy report focuses on the combination of EU financial instruments to support commercial scale FOAK projects by incentivising and catalysing investment and finance from the private sector in Europe. By doing so, the EC reduces the risk level for other investors facilitating the mobilization of private risk finance in order to leveraging of the EU budget resources. Specific funds have been set up that tackle this critical stage in the innovation process. These include, mainly, under H2020 the InnovFin EDP21; and the NER30022 –financed outside the EU budget. In figure 18 there is a theoretical example of an ideally combination of funding sources for a solar FOAK project.

[20] Climate Strategy (2017a): Finance for Innovation: Towards the ETS Innovation Fund. Presentation of Peter Sweatman, CEO Climate Strategy as Rapporteur for Industry Stakeholders in Brussels on 12th June 2017.

[21] InnovFin EDP, as part of the H2020, was launched after the ICF, 2016 study to address the financial gaps found

[22] The publication of further NER 300 calls for proposals is not foreseen and the programme should be considered closed. The EC is now focusing on the implementation of the projects selected for funding, visible on an interactive map here: https://setis.ec.europa.eu/NER300.

Although traditionally, the different risk sharing mechanisms have been mostly grants. Recently there is a strong shift towards blending with other financial schemes as loans, guaranties, debts, and equity, see box 5. According to this new trend, project promoters would need to finance from their own resources a minimum of 25%[23] of the solar FOAK demonstrator costs themselves, in order to ensure that the project will be supported with sufficient resources and demonstrate their own commitment to higher-risk projects. Despite of prolific usage, grant provision, especially at MS level, is often not large enough to adequately support FOAK project funding requirements.

The Investment Portal[24] is a useful source of information for investors that was set up as part of the European Fund for Strategic Investments (EFSI) and is designed to boost the transparency of the EU investment project pipeline to make information accessible to potential investors, COM (2015).

[23] Innovfinn energy Demo Projects – Eligibility Questionnaire: http://www.eib.org/attachments/documents/innovfin_energy_demo_projects_eligibility_questionnaire_en.pdf

[24] https://ec.europa.eu/eipp/desktop/en/index.html

Box 5 Overview of Financial Instruments

Grants: This is the most common support with interventions up to 50% of eligible costs. Examples include NER300 and H2020. For FOAK projects is typically forecasted between 10-30% for some isolated cases (e.g. CSP with a strong R&D component).

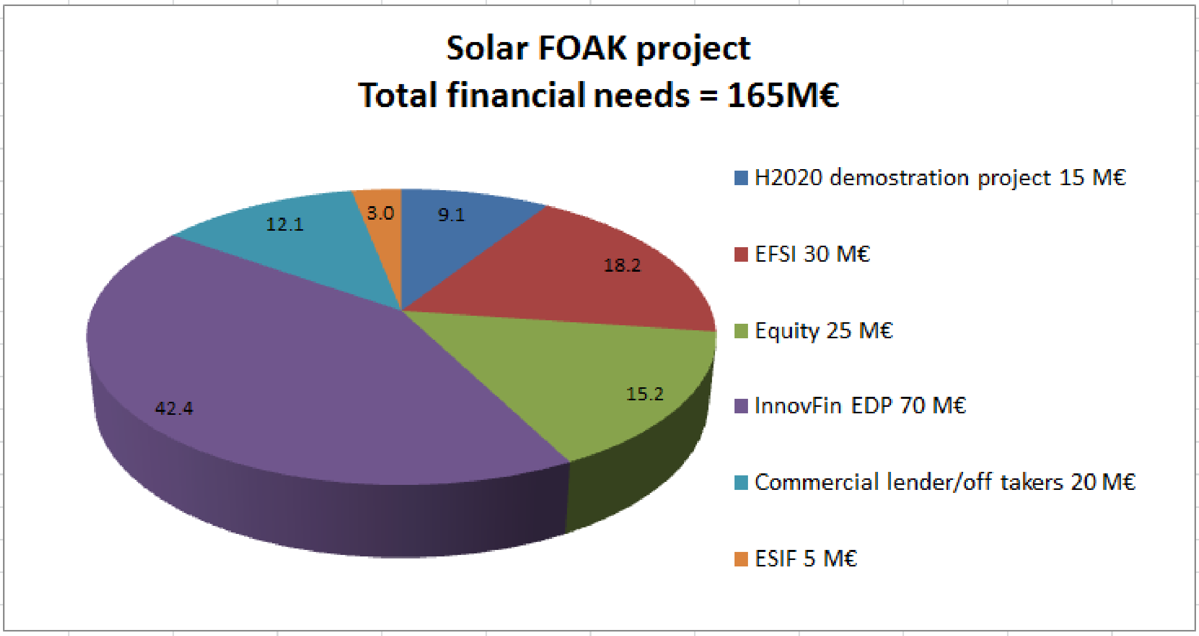
Loans and guarantees: Present modest use at EC and MS level, but shows a promising future application as a risk-sharing component focused on TRLs 8-9, (for projects capable to generate revenues). They can represent a wide range of the total funding (from 10 to 70%). The recently established EDP debt facility, operated by EIB, that has got off to a good start in raising its profile to FOAK sponsors, by attracting over 70 enquiries.

InnovFin EDP is structured with a first-loss piece which allows the facility to take on more of the risk than other debt providers. However, the current size of the facility needs to be increased in order to support and enable at least 10 to 20 FOAK projects across different SET sectors.

Equity investment into projects has been rarely used, with a maximum equity level around 10-30%. Corporate sponsors are a key constituent party in the supply of equity, but utilities no longer have resources to spare for such innovation funding and major engineering companies are highly selective about what they sponsor. Nowadays, the European Investment Fund (EIF) is the largest Venture Capital (VC) and private equity (PE) investor in the EU. But EIF does not provide equity at the scale required by FOAK projects, (ICF, 2016). There is a clear complementarity between equity and the InnovFin Energy Demo Projects (EDP) or EFSI.

Source: Own elaboration

Figure 18 A theoretical example of a combination of funding sources for a solar FOAK project



Source: Own elaboration

Table 10 provides an overview of the most suitable EU financial schemes for solar FOAK projects including the main delivery bodies, as the MS, EC or the European Investment Bank (EIB).

Table 10 Financial schemes supporting solar FOAK projects in the EC (to TRL 9 with its emphasis on deployed and proven technologies)

Scheme	Type of instrument	Delivery body	Status	Budget	Project Funding level	Suitability For the solar FOAK project
InnovFin EDP	loans and guarantees	EC: (DG RTD 100% guarantees)+ EIB	First come first served	300 m€ + 436m€([1]) (to 2020)	7.5m€-75m€ (most common) 50-60% co-financing([2])	**Very High**: Innovative demonstration projects in the fields of energy system transformation, helping them to bridge the gap from demonstration to commercialization.
Innovative Funds	Grants, debt, equity	EC (DG CLIMA), EIB, MS	Proposed (2021-2030) Inspired at InnovFin EDP	2bn€		**High**: Next financial perspective
European Funds for Strategic Investment	Loans and loan guarantees	EC and EIB		21bn€	50m€-75m€([3])	**Medium**: Current projects have not shown high appetite for risk
H2020 Demonstration projects	Most grants	EC	Work program 18-19([4])	30bn€	10M€-15m€	**Low:** Applications for Innovation Actions bringing the technology from TRL 5-6 to 6-7
InnovFin large project	Loans and guarantees	EIB		25bn€ (to 2020)	25 - -300 m€	**Medium:** It has shown low appetite for risk**.**
European Structural and Investment Funds	Grants, loans, equity	EC (DG REG) + MS	Work program 2014-20	5,8 bn€ for TO4-RES		**Medium:** no evidences for SET FOAK at Inter regional level.

([1]) The InnovFin EDP instrument has already been amended to enable it to absorb unspent NER 300 funds. Consequently, extra resources coming from NER 300 are foreseen to become available through InnvoFin EDP towards the end of 2017The instruments that are foreseen to be used for this exercise, as they can ensure timely support to projects of a similar scope, are InnovFin Energy Demo Projects (EDP) and Connecting Europe Facility (CEF) Debt. The former can finance projects in innovative renewable energy, CCS, smart energy systems and storage; the latter the use of renewables in the transport sector. Both are managed by the European Investment Bank
([2]) The threshold for NER 300 is 50% although smaller interventions have been committed. Under the proposed Innovation Fund, up to 60% of relevant project costs may be supported
([3]) Unspecified. However, in the renewables and resource efficiency space, projects to date suggest that a minimum of 50-75m€ is put forward for a guarantee under the Fund
([4]) The adoption and the publication of the work programme by the EC are expected in October 2017
Source: Own elaboration

Among the alternatives presented in table 10, when considering the characteristics and financial needs of solar FOAK project, the following options were identified as the most suitable investment support for a solar FOAK project:

InnovFin Energy Demo Project (EDP) Facility is an entirely market driven instrument that appears to be the most suitable financial instrument for the Solar FOAK projects analysed in this policy report. As of December 2017, InnovFin EDP has already 300m€ available, and will add 436m€ more, thanks to the redeployment of unspent NER 300 funds. Support is thus provided to eligible projects on a first-come-first-serve basis. Launched in June 2015, this new facility provides loans and loan guarantees. InnovFinn EDP is conceived to address the financing bottleneck identified in the EU SET plant implementation road map[25] in the field of energy at TRL 7/8, particularly in the field of renewable energy technologies, smart energy system, energy storage and carbon capture and utilisation and storage. The selected projects shall through their design and scale, contribute to de-risking the technologies and reassuring financial investor of their commercial viability. The goal is to help bridge the "valley of death "from demonstration to commercialisation, supporting the further rollout of innovative low-carbon energy technologies to the market. Until 2020 InnovFin is offering a range of tailored products which provide financing in support of research and innovation by small, medium-sized and large companies and the promoters of Research infrastructure. InnovFin EDP is managed by the EIB and 100% guarantees by the EC. The possible blending with grants and equity is under examination. Ideally, the EIB financing supporting FOAK technology projects is limited to 50%[26] of the total eligible costs of the projects, which include all the costs necessary for the successful demonstration of the technology, service, manufacturing or business process.

European Funds for Strategic Investment (**EFSI**) can support energy sector investments that are difficult to finance through the market. Jointly launched by the EIB Group and the EC, it is focused on sectors of key importance to the EU economy and areas in which the EIB already has a track record and expertise. Projects under the EFSI need to address sub-optimal investment situations and market gaps as part of the eligibility criteria. The EC should be coordinated with MS so that EFSI promotes close-to-market energy projects. A key element of any successful proposal is a further reinforcement of the concept of additionality for projects supported under the EFSI. In other words, only projects that would not have happened at the same time or to the same extent without EFSI financing should be chosen. Also, in view of their importance for the electricity single market, cross-border infrastructure projects (including services) have been identified as providing additionality. An important objective of the extension to 2020 of the EFSI is to enhance the geographical coverage of the EFSI and to reinforce the take-up in less developed regions. In this respect, the EC aims to make it easier to combine EFSI with other sources of EU funding. To date, EFSI's portfolio of "investments" into SET (non-FOAK) projects (including research facilities) is too small to draw any real conclusions, other than to observe that there is potential for crowding out of private finance, (ICF, 2016).

The grant-based **H2020 programme** is applied for innovation actions to support low-carbon technologies and services. Horizon 2020 will continue to support Public-Private Partnerships (PPPs) with industry in key sectors. The H2020 work programme 2018-2020 contains specific proposals for solar technologies including CSP and PV, to bring the technology from TRL 4-5 to TRL 6-7. The EC considers proposals requesting a contribution from the EU budget ranging between 2-5m€ to 15-20m€ for higher TRLs. For the solar FOAK projects, this can be applied to open the project's test sites, pilot and demonstration facilities.

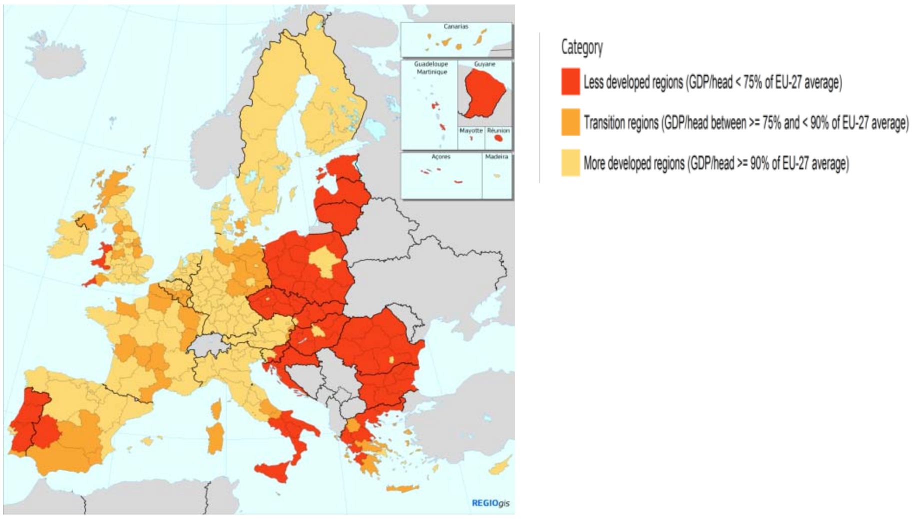
InnovFin for large projects facility delivers direct loans and guarantees from EIB for R&I projects emanating from larger firms; universities and public research organisations; R&I infrastructures (including innovation-enabling infrastructures); public-private

[25] https://ec.europa.eu/research/energy/index.cfm?pg=policy&policyname=set
[26] http://www.eib.org/attachments/thematic/innovfin_energy_demo_projects_en.pdf

partnerships; and special-purpose vehicles or projects (including those promoting FOAK, commercial-scale industrial demonstration projects). This facility has shown lower appetite for risk than InnovFin EDP. Its tracks record is established under Risk Sharing Finance Facility (RSFF), although no evidence to date supports FOAK projects under SET (hence rationale for establishing EDP facility)[27]. Furthermore, the experience with the NER300 instrument has highlighted the need of an off-taker buying the energy generated by the FOAK demonstration project with a PPA.

The **European Structural and Investment Funds** (ESIF) represent over half of EU funding jointly managed by the EC and the MS. The purpose of the ESIF is to invest in job creation and sustainable economy growth. There exist five ESI Funds: European regional development fund (ERDF), European social fund (ESF), Cohesion fund (CF), European commission fund for rural development (EARDF), European maritime and fisheries fund (EMFF).

Figure 19 Cohesion Policy eligibility Regions for 2014-2020 period



Source: European commission Regional Policy
(http://ec.europa.eu/regional_policy/sources/graph/poster2014/eu28.pdf)

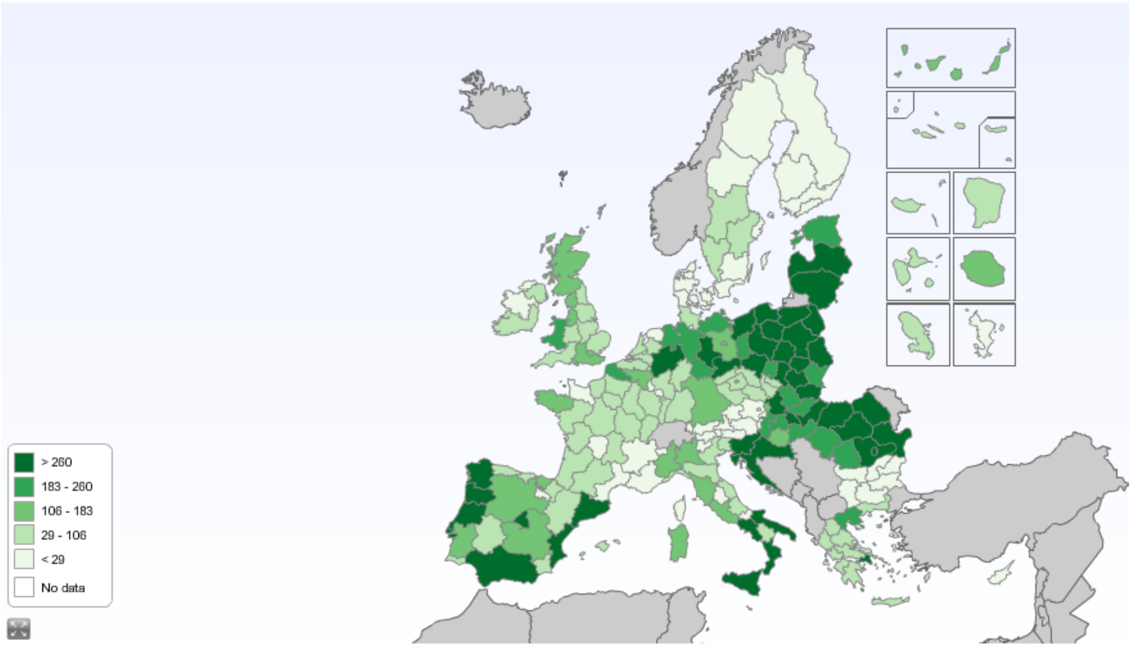
Cohesion Policy has set **11 thematic objectives** supporting growth for the period 2014-2020. The solar FOAK project mainly combines two supported thematic objectives, TO1 (Strengthening research, technological development and innovation) and TO4 (Supporting the production and distribution of energy derived from renewable sources across Europa)[28].

ESIF represents the largest allocation of the EU budget to be channelled into low-carbon economy, mostly materialises through the TO4, largely through the CF (i.e. ERDF, CF, ESF) with the EARDF and EMFF having much more limited contributions. At the same time, energy research is one of the most important topics as concerns the Cohesion policy funding for research and innovation under TO1[29]. More precisely, the following breakdown of the energy-related support can be drawn from the ESIF Operational Programmes (OP) through the JRC ESIF viewer[30], see figure 20, in line with other publications (EC 2015): For the 2014-2020 programming period, TO4 has a total budget of 45bn€, which is more than twice the amount of funds available to the low-carbon

[27] EC DG RTD. Innovative Financial Instruments for First-of-a-Kind, commercial-scale demonstration projects in the field of Energy ICF *in association with London Economics* September 2016
[28] http://ec.europa.eu/regional_policy/en/policy/how/priorities
[29] The Cohesion policy funding for research and innovation (TO1) amounts to around 41bn€.
[30] http://s3platform.jrc.ec.europa.eu/esif-viewer

economy in previous programmes. In particular, this encompasses investments in energy efficiency, renewable energy and sustainable urban mobility.

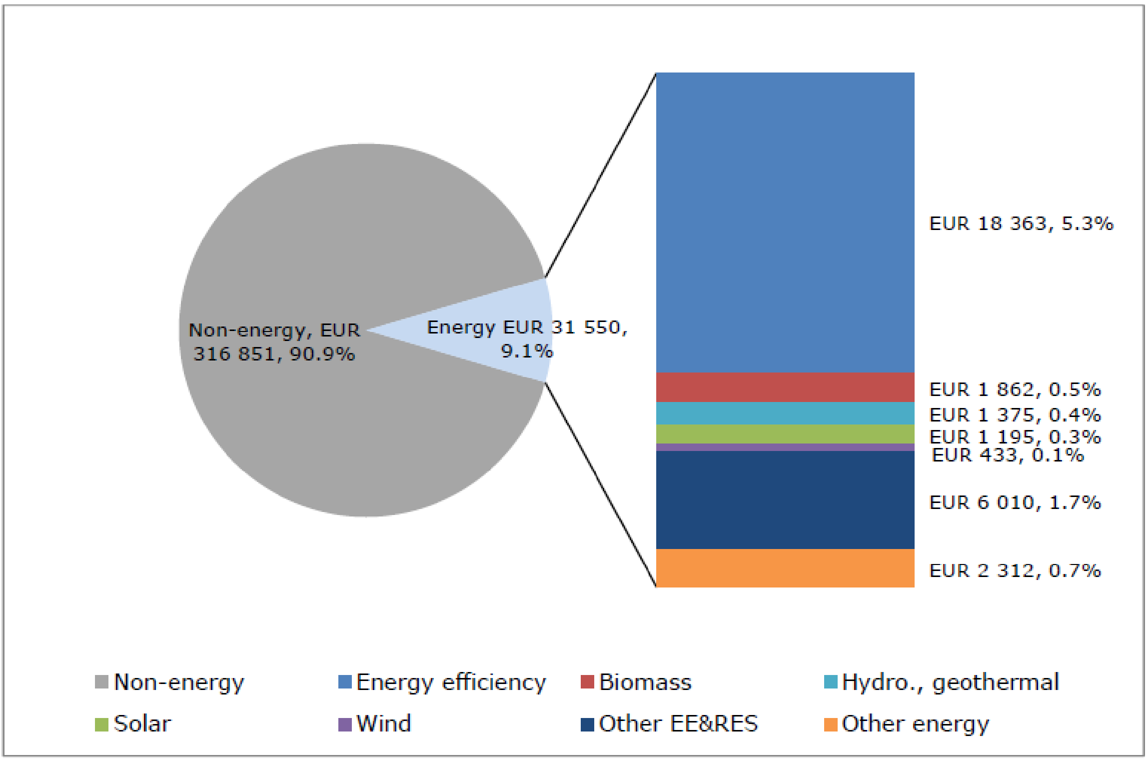
Figure 20 Planned investments in TO4



Source: JRC ESIF viewer (http://s3platform.jrc.ec.europa.eu/esif-viewer)

Energy related allocation under ESI Funds reach 31,5m€ for the 2014-20 period, see figure 21, according to Wishlade (2017). Furthermore, a series of **targets relating to concentration of resources** are specified, including that at least 20 percent of total ERDF resources at national level must be allocated to thematic objective 4 (TO4) in the more developed regions, at least 15% in transition regions and 12% in less developed regions. CF resources can be used by less developed regions to achieve the minimum fund allocation to TO4, in which case the minimum percentage of funding directed to the objective increases to 15%, (Wishlade, 2017).

Figure 21 Energy related allocation under ESI Funds 2014-20 m€, Wishlade (2017)



Source: Wishlade et al. (2017)

In order to best mobilise and support the regional strengths concerning innovation in the ESI-Funds, in the current Multiannual Financial Framework (MFF) a strategic bottom-up approach with a medium to long term perspective has been followed requiring regions to develop Smart Specialisation Strategies[31] (RIS3). The Research and innovation strategies for S3 have been supported by the regional stakeholders through the Entrepreneurial Discovery process (EDP). Such RIS3 strategy set out the national or regional framework for investments in research and innovation not only from ESI funds, but also from H2020, InnovFin and other EU programmes shall thus be associated in this process. The EC (2014) provides guidance for policy-makers and implementing bodies for further analysing synergies between ESIF and the different financial instruments for energy research and innovation.

At the same time, the **EC has expanded the role for financial instruments** in Cohesion policy delivery. Financial instruments mainly take the form of loans, guarantees and equity. For most ESIF Managing Authorities, financial instruments are relatively new tools to be used within their programmes, and in 2014-20, the role of financial instruments is being reinforced both in breadth of policy areas and scale of funding.

They way in which H2020 and ESIF can complement each other throughout various phases of the innovation chain is illustrated in the box 6.

[31] http://s3platform.jrc.ec.europa.eu/s3-platform

Box 6 Complementarities of ESIF and Horizon 2020

Synergies between **ESIF and Horizon 2020** can take many forms, as the modes of planning and delivery vary between the Framework Programme/Horizon 2020 and the ESI Funds. The "Enabling synergies between ESIF, Horizon 2020 and other research, innovation and competitiveness-related Union programmes Guidance for policy-makers and implementing bodies" provided a taxonomy of five synergy-type actions at the project implementation level:

— **Sequential funding from different sources**:

— Upstream sequential combination: ESIF investment that enables Horizon 2020 participation

— Downstream sequential combination: Horizon 2020 or FP project results are used or further developed with subsequent ESIF investments

— **Parallel funding** (Parallel use of funds in separate projects): ESIF and Horizon 2020 funding are running in parallel and are mutually supportive that complement each other;

— **Alternative funding** (through ESIF): Reorientation of FP7/Horizon 2020 projects that were positively evaluated, shortlisted, but not funded given the limited budget, towards SF/ESIF.

— **Simultaneous/cumulative funding** that brings together Horizon2020 and ESIF funds in the same project aiming at achieving greater impact and efficiency (i.e. ESIF used for costs non-eligible under Horizon 2020. This new combination is possible under the new regulation of Horizon 2020 (Art. 37 Rules for Participation), provided that the grants do not cover the same cost items.

When combining funding from Horizon 2020 and ESI Funds for synergetic actions, the legal frameworks and the specific rules for the management, project selection and implementation of the respective programmes still apply. In particular, the basic rules apply:

— No double funding of the same cost item, i.e. no pooling of Horizon 2020 and ESI Funds funding in the same grant agreement

— No substitution of national, regional or private co-funding to Horizon 2020 / ESI Funds projects or programmes with funds from other instrument

— No diversion of funding from the purpose of the respective instrument or ESI Funds programme

The JRC is assessing such synergies through its Stairway to Excellence (S2E) initiative, launched in 2014 with the objective to raise awareness of major stakeholders on (1) how to exploit synergies between Horizon 2020 (and other funding programmes) and ESIF and (2) bottlenecks emerging when R&D&I actors start implementing available tools for synergies between funds. The project provided support to the 13 post-2004 MS on enhancing synergies in the use of different EU funding sources for research, development and innovation (ESIF and Horizon 2020, also taking account COSME, ERASMUS+, Creative Europe and so on). In a next phase, the project's coverage extends to the EU28.

Source: Stairway2Excellence

As to future perspectives for new financing instruments, the grant-based programme **Innovation Fund** will draw on an endowment of 400 million emission allowances, an increased co-funding and a scope enlarged also to low carbon innovation in industrial sectors, including for small-scale projects. This facility should rectify the identified NER300 challenges in delivery for the period 2021-2030, but some budget could be assigned before 2021.

3.2.1 Renewable energy support schemes for electricity

It is possible that the different financials instruments describe above together with the energy markets alone cannot deliver a competitive cost (€/kWh) for the electricity generated by a solar FOAK demonstration plan. In such cases, National support schemes may be needed to overcome this market failure and spur increased investment in renewable energy. However, their implementation may not always result in the most efficient market outcome. As indicated in the State aid guidelines (COM (2014/C 200/01), in order to incentivise the market integration of electricity from renewable sources, it is important that beneficiaries sell their electricity directly in the market and are subject to market obligations (COM, 2014).

In this sense, the EU provides guidance (COM 2013) for MS when designing and reforming renewable energy support schemes suggesting that:

- financial support for renewables should be limited to what is necessary and should aim to make renewables competitive in the market
- support schemes should be flexible and respond to falling production costs. As technologies mature, schemes should be gradually removed. For instance, feed in tariffs should be replaced by feed in premiums and other support instruments that incentivize producers to respond to market developments
- unannounced or retroactive changes to support schemes should be avoided as they undermine investor confidence and prevent future investments
- EU countries should take advantage of the renewable energy potential in other countries via the cooperation mechanisms. This would keep costs low for consumers and boost investor confidence.

The various support instruments used across Europe are shown in the table 11. For more detailed and updated information, visit the RES-LEGAL project web site[32]

Table 11 Support instruments in Europe

	Feed in Tariffs	Feed in premium	Quota	Net metering	Tax Regualtion	Subsidy	Loans
Austria	X					X	
belgium			X	X		X	
Bulgaria	X					X	X
Croatia	X						X
Cyprus		X				X	
Czech Rep.	X	X				X	X
Denmark		X		X		X	X
Estonia		X				X	
Finland		X				X	
France	X				X		
Germany	X	X					X
Greece	X				X	X	X
Hungary	X					X	
Ireland	X				X		
Italy	X	X	X	X	X		
Latvia	X						
Lithuania	X				X	X	X
Luxembourg	X				X	X	
Malta	X						
Netherlands		X		X	X	X	X
poland			X		X		
Portugal	X						
Romania			X			X	
Slovakia	X				X		X
Slovenia	X	X				X	X
Spain	X	X			X		
Sweden			X		X	X	
UK	X		X		X		

Source: RES Legal project

[32] http://www.res-legal.eu/home/

4 Extremadura Case Study

The project case study considered in this report is the construction of a large-scale CSP plant in the Spanish region of Extremadura. This project, which is still in its concept phase, would be considered as a FOAK because of various reasons: First, it would be the first commercial-scale demonstration project to prove the commercial readiness of a hybrid PV-CSP solar plant with storage and, second, it would also demonstrate the technical and commercial viability of a solar generation plant installed in Southern Europe exporting renewable electricity to Northern European countries.

According to the consulted regional authorities and ESTELA, the aim of this project is to: "*generate and export dispatchable solar electricity from Extremadura (Spain) to other MS so that they can achieve their renewable energy targets and provide an R&D centre dedicated to research and development of solar technologies and energy storage*"

Despite the details of the techno-economic configuration, business and commercial case are still under discussion -among other reasons because the needs and requirements of the off-taker country also need to be taken into consideration-, this case study appears to have the right framework conditions to investigate the questions addressed in the previous sections of this report.

The remaining part of this case study section is structured as follows: first, the preliminary techno-economic configuration of the project and key features of the hosting region Extremadura will be presented. Next, based on the case-specific framework conditions, a preliminary assessment of the two questions addressed before will be conducted:

- *What is the value proposition of this project?*
- *How can this project become economically feasible?*

Based on the answers to these questions, a preliminary SWOT[33] analysis, roadmap and action plan will be presented.

4.1 Project techno-economic characteristics

The plant would consist of a hybridized CSP plant with a PV plant to demonstrate the complementarity and added value that both technologies can provide when working together in the same installation. Furthermore, a backup system would allow an increase in stability and flexibility of the power supply.

Additionally, this project would also include a unique research facility of global interest. Such infrastructure would have a wide potential for international utilisation, both for public and private collaborations, mixing funding of regional, national and international institutions and providing a field of cooperation to any actor interested in solar research.

[33] (Analysis of the Strengths, Weaknesses, Opportunities and Threats)

Table 12 Possible techno-economic configuration of the solar FOAK plant

Assumed metrics	Value	Notes
Capacity (MW)	100 CSP (with 6-8 hours of storage) + 50 PV	Hybridized PV/CSP plant
Capex (m€)	400-500	May vary depending on the final techno-economic configuration
Opex (k€/MW/yr)	75-90	
Technology	Tower / Parabolic Trough	Depending on the developer choice
Support scheme duration (yrs)	25	The life span could reach 40 years
Location	Extremadura	
DNI (kwh/m2)	2100	
Debt/Equity ratio	70/30	To be defined based on the resulting business case
Cost of debt %	3-6%	Depending on the share of soft loans from various institutions
Tax rate		Depends on the country regulation
Estimated LCOE (€/MWh)	100-110	Depends on the final techno-economic configuration
Energy Production (GWh/yr)	300-380 on demand with physical transfer	Depends on the off-takers needs and plant design features
Estimated off-taking price €/MWh	50-70	May vary depending on the off-taker willingness to pay and needs
Import supporting scheme /Duration (viability gap) €/Mhw/yr	30-60	This may vary based on MS needs/willingness to pay (eg: peak energy in EU is around 70 €/MW)
Hybridization	with PV/Biomass/gas.. (tbd)	Reduces costs and improve firmness

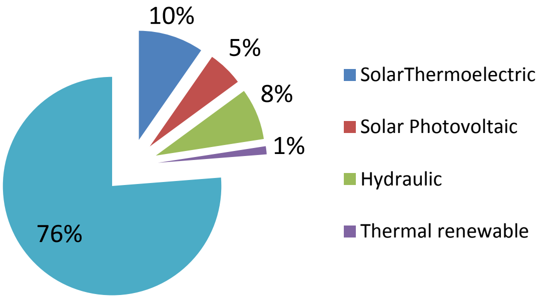
Source: Adapted from ESTELA (2017)

As highlighted by consulted regional authorities and industrial experts, the figures included in the table above should be considered as preliminary ones but not as binding specifications for a real FOAK. The final techno-configuration parameters will have to be defined by the project developers based on, among others, the requirements of the off-taker country, technical and regulatory requirements as well as the eligibility criteria defined by other support mechanisms at National, Regional and/or the EU level.

4.2 Location and institutional framework

Extremadura is a region in Spain with one million habitants approximately. Besides having very abundant solar resources (with 2000-2200 DNI-KWh/MW/year), it has a very committed Government with Renewable energies. As an example, as of today, Extremadura covers its electricity demand with renewable sources (mainly solar, biomass and hydro) and solar energy covers 65% of such demand.

Figure 22 Renewables contribution in Extremadura in 2016



	Net Electricity production in Extremadura (Gwh)
SolarThermoelectric	2038
Solar Photovoltaic	1111
Hydraulic	1612
Thermal renewable	253
Non-renewable Production	16088
Net total production	21102

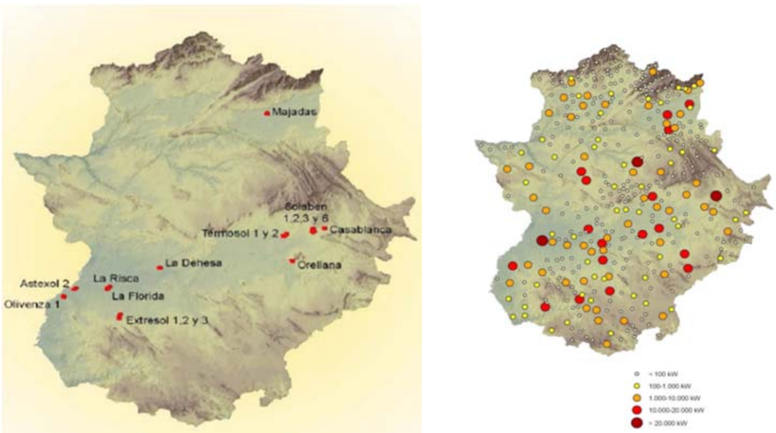
Source: Balance Eléctrico de Extremadura (JE, 2016

Extremadura is a leader region in the field of solar energy, holding the first world position in solar coverage of the electricity demand and solar installed power per inhabitant. Extremadura gathers more than 40% of the Spanish installed CSP capacity and 30% of the installed PV capacity (S3 Partnership on Solar Energy, 2017).

As for CSP, there are 17 solar thermoelectric facilities in Extremadura with a total installed capacity of 849 MW. Back in 2016, the electricity production generated by this technology reached 2.038 GWh, representing 40,65% of the total renewable electricity generated. As for the total net electricity production, solar thermal electricity represented 10%.

As for PV, in 2016 there were 589 solar photovoltaic facilities working in Extremadura with a total installed power of 562 MW. In the same year, the total electricity production with PV amounted 1.061 GWh, representing 22,16% of the total net renewable electricity production and 5% of the total net electricity production (Junta Extremadura 2017)

Figure 23 CSP facilities (left) and PV facilities (right) in Extremadura.



Source: Junta de Extremadura

Furthermore, Extremadura is currently co-leading, with the region of Alentejo (Portugal), the S3 Partnership on Solar Energy. As introduced before, the S3 Partnership on Solar Energy was launched in May 2017 with the participation of various regions across Europe. As of today, the Solar partnership is led by Extremadura and counts on the participation of Alentejo (PT), Asturias (ES), Andalucía (ES), South Estonia (EE), Sicilia (IT), Slovenia, TR33 (TU), Etela-Karjala (FI) and, Vaasa (FI), involving the participation of 26 research centres, and different European Networks.

Figure 24 S3 Solar partnership

Source: S3 Solar Partnership, 2017

Currently, through the S3 Solar Platform, DG-REGIO is providing support to Extremadura and the other interested EU regions in exploring opportunities to deploy solar FOAK projects in Southern Europe to generate and export solar electricity to Central and Northern countries. Such international support and institutional framework is fundamental in order to raise support from other regions and their corresponding National authorities.

4.3 Other key framework conditions and next steps

Besides the techno-economic configuration and location characteristics, this case study is characterized by various other framework conditions which will be presented here. The framework conditions are first presented in a list form (box 7). Next, the framework conditions are also presented in table 13 showing the relevance and applicability at the regional, national and European level. Finally, the particularities of this case study will be displayed using a SWOT framework (Strengths, Weaknesses, Opportunities and Threats) displayed in figure 25.

Such information is useful to make a preliminary diagnostic of the current situation as well as to shape the answers to the questions addressed in this report: -(i) What is the value proposition of this project? and (ii) How can this project be feasible?-. Finally, this information will also steer the next steps towards making this project a reality (figure 25).

Box 7 Key framework conditions of the solar FOAK project in Extremadura

— This solar FOAK project can bring multiple benefits at the EU/National/Regional level taking into consideration its geographical/technical/political characteristics (see section 2)

— The estimated PPA is higher than the market pool price– there is a GAP which requires some kind of financial support to make this project bankable.

— Currently, there is no support for this type of plants in Spain

— There exist various EU funding opportunities (section 3.2) that this project could apply to.

— There exist the possibility to make use of the cooperation mechanisms of the RES directive (section 3) but there is a need to further explore the interest and requirements of potential off-taker countries in Europe.

— Extremadura is leading and being supported by the Solar S3 partnership.

— Among the possible cooperation mechanisms (statistical transfers, joint projects and joint support schemes), joint projects (as defined in Article 7 of the Renewable Directive 28/2009/EC) appear to be the most appropriate mechanisms for such a unique and strategic project.

— So far, no MS has ever used Art.7, implying a “first mover risk” but, at the same time, the EC has great interest in seeing a first Art. 7 pilot project.

— The interest and support at the EU level is high (DG-ENER, DG-RTD, DG-REGIO have shown their interest and are currently providing different degrees of support).

— The political will and support at the regional level is very high.

— There is a raising interest and support at the National level.

— Other countries and regions may have interest in cooperating with Extremadura in the solar FOAK project for reasons that go beyond cost-savings (industrial, research, commercial interest, etc). Need to further investigate their potential interests.

— Other regions in Europe with high renewable energy potential (like the North Sea region) are positioning themselves as potential supplier of renewable electricity to Central Europe.

— The requirements and needs from potential off-taker countries will determine the final techno-economic configuration of the plant.

— There is the need to inform and advocate about the value proposition of this project and further engage with relevant stakeholders (Spanish authorities, potential interested off-taker MS, regulators, TSOs, energy traders, financial institutions and industrial players, civil society, etc)

— Currently, there is a strong social support for CSP in Extremadura. However, in order to avoid public opposition elsewhere, it is important to inform about the value proposition of this project and engage with civil society organizations in all involved countries

Source: Own elaboration

As introduced above, Box 7 lists some characteristics of this case stud y relating them to the corresponding section in this policy report.

Second, for the issues that have been addressed in this report, table 12 presents the relevance and applicability at the regional, National and European level for this particular case study. For this purpose, a colour legend has been used. For those issues that are relevant and positive at the regional/National or European level, a green colour has been used. For medium relevance, an orange level and for low to very low level of applicability, a red colour has been used. The last two columns of the table include a short explanation justifying the colour choice and proposing some measures to improve the situation.

Third, in an attempt to classify and structure the framework conditions of this case study, figure 25 displays some of the most relevant characteristics of this project classified either as strengths, weaknesses, opportunities and threats (SWOT analysis). The information derived from a SWOT analysis can be useful to make a diagnostic of the status quo, prioritize actions and shape an action plan while being aware about the advantages and limitations of this particular case study.

Finally, based on the information presented in the previous tables and figures, the authors propose a preliminary set of actions (figure 26) which could be classified within the “project related process” and “political related process”[34].

As for the “project related process”, the most important actions is to better define of the techno-economic configuration of the project as well as its business and commercial case. As for the “political related process”, there is a need to inform policy makers and relevant stakeholders about the value proposition of the project -at the regional, national and European level- in order to gain the political support needed to materialize this project. It must be highlighted that such communication efforts should be directed towards Spanish authorities as well as to those policy makers and relevant stakeholders from potential off-taker countries and transit countries.

Actions belonging to each process -project and political- should be conducted in a simultaneous and coordinated manner as the outcomes of both processes influence each other. For example, based on the off-taker country´s requirements and needs as well as the amount of support they are willing to provide, the techno-economic configuration of the project may vary. Similarly, if a cooperation agreement is achieved between two or more MS, the tender procedure and its underlying conditions must be mutually agreed between the involved countries.

Finally, and as highlighted by Gephard et al. (2015), when going through the political process, key success factors include a shared understanding between the involved MS governments on what the exact objectives of the cooperation are. Furthermore, to the extent possible, flexibility should be provided so that it is possible to account for different situations and cooperation preferences of different MS and regions. Additionally, the potential gains of cooperation must be evident to political leaders and the public in the involved countries to facilitate political and public acceptance. Finally, the views and interests of all relevant stakeholders (particularly market participants) should be considered in the process to ensure pragmatic and practical solutions.

[34] By “project related process”, authors refer to those actions required to further define the techno-economic specification and business model of the solar FOAK project. On the contrary, by “political related process”, authors refer to those actions needed to gain the support from policy makers in all involved countries and regions as well as other relevant decision makers required to materialize the project.

Table 13 Framework conditions of the solar FOAK project in Extremadura

1) Value Proposition	EU	SP	EXT	Relevance for this case study / Comments	Possible Action
Energy and Climate policy goals (DG-ENER)					
Decarbonization				CSP is a valuable technology for decarbonizing systems everywhere	Estimate GHG emission savings compared to other technologies
Energy Union				Regional cooperation is a building block of the future Energy Union	Inform Ec about this case study so they increase the support
System stabilization				CSP can compensate other fluctuating RES technologies in the EU	Advocate in favor of the CSP "value" to the system instead of just LCOE (and try to quantify this value)
Electricity market integration				This project can demonstrate the benefits of cross-border electricity trade	Use this project to demonstrate the benefits and need for greater/faster interconnection for Spain
Reduce CSP costs				CSP cost reductions without domestic support is good for SP and EU	Advocate about the expected benefits in terms of cost reductions and tech performance improv.
Mantain industrial leadership in CSP				CSP/PV EU and Spanish industries could greatly benefit from FOIK	Use this as a key argument to raise support from SP and EU (as already done by ESTELA)
Research and Technology goals (DG-RTD)					
SET impl. CSP Plan				This is one item in the CSP implementation SET Plan actions.	Use the SET plan to increase support for this project (EU & SP)
Increase R&D facilities in EU				This project would have a strong R&D component for EU/SP/Ext	Need to create added value (do not duplicate existing facilities)
Foster regional and EU research colaborartion				Through S3 Solar Platform it is possible to drive regional cooperat.	Need to map regional capacities and interests to identify mutually beneficial coloborations
Economic Develop goals (DG-REGIO & DG-GROW)					
Reduce regional inequalities				Extremadura is the region in Spain with lowest GDP	Advocate and communicate the expected socio-economic benefits for Extremadura and Spain
Create jobs and economic activity				Many jobs and economic activities could be created in EU/SP/Ext	Demonstrate the job creation potential & try to max EU content
Foster cooperation across regions in EU				There exist many potential interested and cooperating regions in EU	Conduct a mapping of existing capacities/interests around FOIK
2) Financial support to cover the GAP	EU	SP	EXT		
Are there FOAK tailored support instruments?				At the EU amd Regional level there exist various possible optios (InnovFin and ESIF funds)	Explore the InnoFin and explore ESIF options with regional authorities
Interest in using Cooperation Mechanisms?				EU would support DG-ENER and DG-RTD. No clear off-taker. Increasing interest from Spain	Need to look for an interested off-taker MS, explore design options and inform/advocate in Spain.
3) Assessment of Political will and support	EU	SP	EXT		
Currently, is there interest in the solar FOAK project?				EU and Ext. Are very interested. In Spain, relevant ministries´ interest is increasing.	Elaborate a report about the value proposition and communicate/advocate in Spain and in other potential off-taker countries. Provide a comprehensive pre-feasibility assess.
Are they well informed?				EC (DG-ENER, DG-REGIO, DG-RTD) and Ext are informed. More advocacy is needed at the National level and with other potential off-taker MS.	Need to properly communicate to the Spanish Government the value proposition/benefits at the National/Regional level. Also need to inform and explore the interest of other MS
If well informed, could they potentially provide support?				EU is providing support through S3 S.P and H2020 and funds. Ext. is leading and host region. In SP, MINECO, who is leading the steering group is supporting the concept.	If the Spanish government was fully supportive they could, together with the EU, find could initiate talks with other MS in order to start negotiations with potential off-takers
4) Assessment of private sector and civil society involvement and support/opposition	EU	SP	EXT		
Is the industry informed and involved?				The EU and Spanish CSP industry is involved. They see this as an opportunity to deploy CSP in Europe which can be replicated in the future.	Further engage with EU industry (through ESTELA) to influence host and off-taker countries. Mapping of regional interests
Is there any public opposition or support?				Some public opposition in potential off-taker countries.	Need to inform civil society organizations and media in Spain and in other MS.

Source: Own elaboration

Figure 25 Extremadura Case study SWOT analysis

STRENGTHS

- Possibility to generate high-value dispatchable power
- CSP can generate remarkable socio-economic impacts (jobs and economic activity) in Europe
- High political commitment from the regional government of Extremadura and from the EC through the S3P
- Ideal geographical location and solar conditions
- Existing interconnection capacity (FR-SP) would allow to export the electricity produced
- Demonstrate the possibility to hybridize with PV to lower the production costs
- Possibility to apply for EU funding for FOAK projects
- Demonstrate the benefits of cross-border electricity trade and contribute to the stability of the EU system.
- Maintain European industrial and research leadership in CSP (the solar FOAK is included in the CSP SET plan)
- Possibility to collaborate with other interested MS due to the European dimension of the CSP value chain

WEAKNESSES

- High investments costs require support to make this project bankable.
- Uncertainty of the optimal design option
- No clear identification of suitable off-taker countries
- Despite they have shown their interest, more direct engagement and support from the EC and National authorities would be desirable.
- Lack of information about a the interests and needs of potential interested off-taker countries.
- Limited time to negotiate before 2020 (other countries are opting for statistical transfers to meet their 2020 targets).
- So far, MS have not used Article 7 of the RES Directive. (First mover risk)
- Need to quickly coordinate the political with the project process in order to finalize the techno-economic configuration of the plant.

OPPORTUNITIES

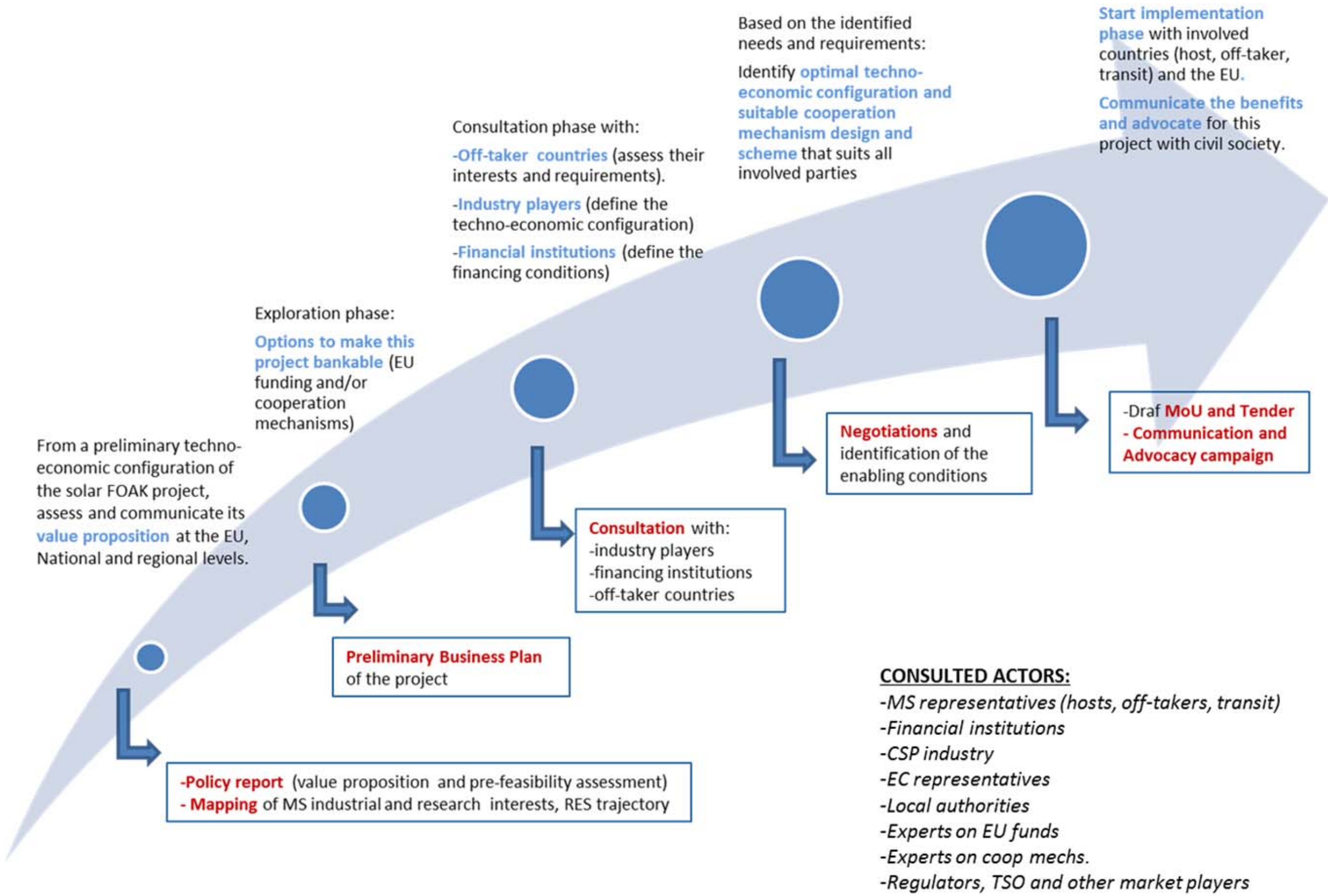
- Supply high electricity in periods of peak demand and contribute to the EU system stability
- Contribute to EU climate objectives and diversify RES sources.
- Create a new European R&D infrastructure/center.
- Employment, social well-being and opportunities for a less developed region like Extremadura
- Experts predict a sustainable growth of CSP technologies in the coming years
- Demonstrate the feasibility of Article 7 (joint project) of the cooperation mechanisms.
- Contribute to reduce income disparities across regions at the National and European level.
- Contribute to reduce CSP costs and improve techn. performance.
- Contribute to reinforce the EU industrial and research leadership
- Use this project to demonstrate the benefits of cross-border electricity trade and advocate for an urgent increase of the interconnection capacities between France and Spain.

THREATS

- Decision makers may not appreciate the value of dispatchable renewable electricity over cheaper but variable technologies.
- Other regions in Europe (eg: North Sea region) are quickly positioning themselves as optimal suppliers of renewable electricity to central Europe.
- The post 2020 framework is not yet totally defined and there exist some kind of uncertainty as to how regional cooperation will be incentivized/articulated.
- Non-EU countries are willing to take the lead in CSP sector with ambitious programs for the next few years
- Unless the interconnection capacity between Spain and France is increased rapidly, it will not be possible to increase the number of such type of projects in the Iberian Peninsula.

Source: Own elaboration

Figure 26 Roadmap for the solar FOAK project in Extremadura



Source: Own elaboration

5 Conclusions

Cross-border solar electricity exports from Southern to Central and Northern European countries could bring multiple benefits for Europe as well as for the involved countries and regions. However, despite the expected benefits, some obstacles currently prevent the materialization of these types of projects.

Under the auspices of the Solar S3 partnership, this policy report aims at exploring and finding ways to overcome two barriers: the lack of political support towards this project in the potential involved countries and the need for some kind of financial support to make this type of project bankable. To address these hurdles, this report attempts to (i) explore the value proposition of solar electricity exports in Europe and (ii) assess options to make such projects economically feasible. To do so, an extensive literature review, expert consultation and case study analysis in Extremadura have been conducted.

As for its value proposition, exporting solar electricity from South to Central/North Europe can help achieve many EU strategic goals. Among others, the deployment of such projects could help maintain the European industrial and research leadership in solar technologies and contribute to improve the techno-economic performance of these technologies. This would, in turn, help decarbonize the European economy in a cost-effective manner and mitigate climate change globally. Furthermore, these projects could create jobs and economic growth in some of the less developed regions in Europe and help reduce socio-economic disparities across regions and countries in Europe. Additionally, when combined with thermal storage, solar electricity exports can also contribute to the stability of the electricity system and reduce the need for fossil fuels as back-up technologies to balance the increasing intermittent sources of electricity.

The value proposition presented in this policy report distinguishes the European, National and regional relevance and is justified from a geographical, technology and policy point of view. As such, this value proposition can be used for communication and advocacy purposes among decision makers in potential cooperating countries. In this context, the regions participating in the Solar S3 partnership can also play a very relevant role in triggering the interest from their corresponding National authorities.

As for ways to make these projects economically feasible, the report concludes that there exist various options to reduce the financial "gap", understood as the difference between the required power purchasing agreement (PPA) and the average electricity pool price.

As for the possibility to make use of the cooperation mechanisms, past experience indicates that it may take a some time to get the interest and the support from both host and off-taker countries This is due to the existence of several barriers of heterogeneous nature (eg: uncertainty about the post 2020 framework, social acceptability, first mover risk, limited interconnection capacity, etc). In any case, after identifying potential interested cooperating countries, there is a need to carefully assess and find the right framework conditions and the design elements of the cooperation agreement that lead to win-win outcomes for all involved actors.

In this case, when considering a solar FOAK project, the interest of the off-taker country should go beyond purely costs savings and include, for example, industrial and technology interest, the need for dispatchable renewable electricity or/and research interests. For this matter, it seems that the most suitable cooperation mechanism would be a "Joint Project" as defined in Article 7 of the Renewable Energy Directive.

As for the possibilities to make use of EU financial instruments, The EC together with the EIB provide the means to address the gaps in the financing demonstration, deployment and market uptake of low carbon energy technologies in relation to the SET Plan. In this respect, the InnovFin EDP facility appears to be the most suited facility for a solar FOAK commercial plant. Furthermore, the Horizon 2020 programme, the ESIF and the EFSI funds may also provide additional support.

Finally, a preliminary assessment of a solar FOAK case study in Extremadura (Spain) has been conducted in order to validate the findings from the previous sections of this report. Furthermore, this preliminary case study assessment has shed some light about the case specific opportunities, hurdles and required next steps to make this project a reality.

Despite this project case study is still at its concept phase, its value proposition is unquestionable and needs to be communicated to relevant stakeholders and decision makers to gain the required political support at the National level but also among potential off-taker countries in Europe. Starting from a preliminary techno-economic configuration, the requirements of the interested off-taker countries will shape the final technical and economic specifications of the project. When it comes to make this project feasible, both EU support mechanisms (e.g.: InnovFin EDP facility, ESIF funds, etc) and the possibility to use the cooperation mechanisms to cover the remaining viability gap should be explored. Given the higher cost than other renewable technologies and the strategic nature of this project, an Article 7 “joint project” appears, as of today, the best cooperation mechanism alternative possible.

As to possible next steps, two distinctive processes lie ahead which must be conducted in a simultaneous and coordinated manner as their outcomes will influence each other. On the one hand, there is the so-called “project related process” which requires, among others, the definition of a more detailed techno-economic configuration of the project as well as the definition of the optimal business and commercial case. On the other side, there is the so-called “political related process” which requires, among others, raising the interest and political support from both National government as well as potential off-taker and transit countries.

In this respect, it is recommended that a shared understanding between involved MS governments exist on what are the exact objectives of the cooperation and that the potential gains of cooperation are evident to political leaders and the public in general. Finally, the views and sometimes conflicting interests of all relevant stakeholders must be considered in the process to ensure pragmatic solutions.

The fact that Extremadura is leading the Solar S3 partnership will help Extremadura collaborate and join forces with other interested regions and their National Goverments. Finally, lessons learned from the Extremadura case study will help other regions with similar circumstances better exploit their renewable energy export potential across Europe.

References

BETTER project at: http://www.better-project.net

Burnham J., Debande O., Jones O., Mihai C., Moore I., Temperton I., Report on Innovative Financial Instruments for the Implementation of the SET Plan, First-Of-A-Kind projects. EUR26058, Publications Office of the European Union, Luxemburg 2013, doi:10.2790/89984 Available at: https://setis.ec.europa.eu/sites/default/files/reports/Set-Plan-Financial-Instruments.pdf

Caldés, N., de la Rua, C., Lechón, Y., Rodríguez, I., Trieb, F., Frieden, D., Tuerk, A., Frühmann, C., Ortner, A., Welisch, M., Resch, G., Totschnig, G., Veum, K., Uslu, A., Kraan, C., Menichetti, E., Elgharras, A., Karakosta, C., Marinakis, V., Papapostolou, A., Beneking, A., Ellenbeck, S., Lilliestam, J., Pasicko, R., Kordic, Z. (2015): BETTER summary report, CIEMAT, Madrid Available at: http://better-project.net/sites/default/files/BETTER_Summary%20Report_0.pdf

Caldés N, Varela M, Santamaría M, Sáez R. Economic impact of solar thermal electricity deployment in Spain. Energy Policy. 2009;37(5):1628–36.

Climate Strategy (2017a): Finance for Innovation: Towards the ETS Innovation Fund. Presentation of Peter Sweatman, CEO Climate

Concerted Action on the Renewable Energy Sources Directive (CA-RES) project. www.ca-res.eu

Denholm P., Jorgenson J., Miller M., Zhou E., Methods for Analyzing the Economic Value of Concentrating Solar Power with Thermal Energy Storage. Golden, Co. 2015. NREL/TP-6A20-64256

Del Río P., Peñasco C., Mir-Artigues P., An overview of drivers and barriers to concentrated solar power in the European Union. Renewable and Sustainable Energy Reviews 81 (2018) 1019–1029

Deloitte. Impacto macroeconómico del sector solar termoeléctrico en España. Editado por Protermosolar, Madrid 2011. ISBN: 978-84-8198-855-0

Ecofys. Cooperation between EU Member States under the Res Directive. A report compiled within the European project “Cooperation between EU MS under the Renewable Energy Directive and interaction with support schemes”. Ecofys 2013. Available at: http://www.ecofys.com/files/files/ec-ecofys-tuvienna-2014-cooperation-member-states-res-directive.pdf

ESTELA (2017). S3 Partnership on Solar Energy (working document).

EurObserv´ER (2017). Photovoltaic and Solar Thermal and Concentrated Solar Power Barometers.

European Commission (2009): Directive 2009/28/EC of the European Parliament and of the Council (l 140/16)

European Commission (2013): Guidance on the use of renewable energy cooperation mechanism. Accompanying the document. SWD(2013) 440 final

European commission (2013) European commission guidance for the design of renewable support schemes, SWD(2013) 439 final

European commission (2014): Guidelines on State aid for environmental protection and energy 2014-2020 COM (2014/C 200/01)

European Commission (2014): Enabling synergies between European Structural and Investment Funds, Horizon 2020 and other research, innovation and competitiveness-related Union programmes

European Commission (2016): Governance of the Energy Union (COM (2016) 759 final/2)

European Commission (2016): Revised Renewable Energy Directive (COM(2016) 767 final/2)

European Commission (2014): A policy framework for climate and energy in the period from 2020 to 2030. COM (2014) 15 FINAL

European Commission (2014): EU Investment Plan.

European Commission (2015): Contribution of the European Structural and Investment Funds to the 10 Commission Priorities: Energy union and climate

European Commission (2015): Energy Union Package. A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy COM (2015) 80 FINAL.

European Commission (2016): Regulation of the European Parliament and of the Council. COM (2016) 860 final.

European Commission (2014). Guidelines on State aid for environmental protection and energy 2014-2020. COM (2014) 2322; SWD(2014) 140

European Commission (2017): The Energy Union's five dimensions: policy observations at Member State and EU level COM(2017) 53 final

European Commission (2017): Renewable Energy Progress Report COM (2017) 57 final

EU-SOLARIS project. http://www.eusolaris.eu/

European Energy Research Alliance Joint programme (EERA-CSP) The EERA Joint Programme on Concentrating Solar Energy. Position Paper. March 2017.

Federal Ministry for Economic Affairs and Energy (BMWi). Pilot Opening Auction For Ground-Mounted PV To Bidders From Other EU Member States, 2016

Fu R., Feldman D., Margolis R., Woodhouse M., Ardani K. U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017. NREL Technical report. Golden-Colorado 2017, NREL/TP-6A20-68925. Available at: https://www.nrel.gov/news/press/2017/nrel-report-utility-scale-solar-pv-system-cost-fell-last-year.html

Gephart M., Tesnière L. and Klessmann C., Driving regional cooperation forward in the 2030 renewable energy framework Ecofys and Heinrich-Böll-Stiftung report, Brussels 2015. D/2015/11.850/3 Available at: https://eu.boell.org/sites/default/files/hbfecofys_regional_cooperation.pdf

Richter C., Teske S., Short R. Concentrated Solar Power. Global Outlook Greenpeace 2009. Available at: https://www.greenpeace.org/archive-international/Global/international/planet-2/report/2009/5/concentrating-solar-power-2009.pdf

Held A., Ragwitz M., Gephart M., Visser E., Klessmann C., Cooperation under the RES Directive. Case studies. Ecofys Report. A report compiled within the European project "Cooperation between EU MS under the Renewable Energy Directive and interaction with support schemes". Ecofys 2014 Available at https://www.ecofys.com/files/files/ec-fraunhofer-isi-ecofys-2014-design-features-of-support-schemes.pdf

Held A., Ragwitz M., Gephart M., Visser E., Klessmann C., Cooperation between EU MS under the Renewable Energy Directive and interaction with support schemes. Design features of support schemes for renewable electricity. A report compiled within the European project "Cooperation between EU MS under the Renewable Energy Directive and interaction with support schemes". Ecofys 2014 Available at: https://www.ecofys.com/files/files/ec-fraunhofer-isi-ecofys-2014-design-features-of-support-schemes.pdf

ICF. Innovative Financial Instruments for First-of-a-Kind commercial-scale demonstration projects in the field of Energy. European Commission (2016)

International Energy Agency/IEA. STE Technology Roadmap. París, France 2014 Available online at: https://www.iea.org/publications/freepublications/publication/TechnologyRoadmapSolarThermalElectricity_2014edition.pdf

IRENA. Renewable Energy Technologies: Cost Analysis Series- Concentrating Solar Power. Abu Dhabi, 2012. Available online; http://www.irena.org/documentdownloads/publications/re_technologies_cost_analysis-csp.pdf

IRENA. Renewable Energy and Jobs - Annual Review 2016. Abu Dhabi 2016

IRENA. Renewable Power Generation Costs. Abu Dhabi 2014. Available online; 2015.http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Power_Costs_2014_report.pdf

Junta de Extremadura (2017). FOAK project concept draft.

Junta de Extremadura (2017) Balance eléctrico de Extremadura 2016

Lilliestam, J., Labordena, M., Patt, A., & Pfenninger, S. (2017). Empirically observed learning rates for concentrating solar power and their responses to regime change, in: Nature Energy (2)17094. doi: 10.1038/nenergy.2017.94

Lilliestam, J., Ellenbeck, S., Karakosta, C., Caldés, N. (2016). Understanding the absence of renewable electricity imports to the European Union, in: International Journal of Energy Sector Management 10 (3), pp. 291-311. doi: 10.1108/IJESM-10-2014-0002

Müller-Steinhagen H, Trieb F. (2004) Concentrating solar power A review of the technology. Stuttgart, Germany: Institute of Technical Thermodynamics, German Aerospace Centre

NSCOGI 2013/2014 progress report – August 2014

Trinomics B.V. (2017). Assessment of Photovoltaics (PV). Final report (JRC report eur 27985 EN)

Parrado, C., Girard, A., Simon, F., Fuentealba, E., 2050 LCOE (Levelized Cost of Energy) projection for a hybrid PV (photovoltaic)-CSP (concentrated solar power) plant in the Atacama Desert, Chile. Energy, Vol 94, January 2016, Pg. 422-430, Elsevier.

REN21. Renewables 2017. Global Status Report. Paris. Available at http://www.ren21.net/gsr-2017/

Resch et al. (2015) Integrative Assessment of Long-term Prospects for RES Cooperation. Technical report of the BETTER project. Available at: http://www.better-project.net/sites/default/files/D6.4%20Integrative%20assessment%20of%20long-term%20prospects%20for%20RES%20cooperation.pdf

RE-SHAPING project http://www.reshaping-res-policy.eu/

RES4LESS project https://ec.europa.eu/energy/intelligent/projects/en/projects/res4less

Rodríguez-Serrano I, Caldés N, de la Rúa C, Lechón Y. (2017) Assessing the three sustainability pillars through the Framework for Integrated Sustainability Assessment (FISA): Case study of a Solar Thermal Electricity project in Mexico. Journal of Cleaner Production 149 (2017) 1127e1143.

SOLARGIS https://solargis.com/

STAGE-STE project. http://www.stage-ste.eu/

Viebahn P, Lechon Y, Trieb F. The potential role of concentrated solar power (CSP) in Africa and Europe-A dynamic assessment of technology development, cost development and life cycle inventories until 2050. Energy Policy; 39(8):4420–30. (2011)

Weizmann (2014). Status report on existing capacities, technological and human resources. Technical report within the EU-SOLARIS project (The European SOLAR Research Infrastructure for Concentrated Solar Power). Avaialble at: http://www.eusolaris.eu/Portals/0/documents/EUS_WP3_MS15_Final.pdf?ver=2016-02-25-193705-483

Wishlade, F, Michie, R, & Vernon, P, (2017) Research for REGI Committee – Financial instruments for energy efficiency and renewable energy, European Parliament, Policy, Department for Structural and Cohesion Policies, Brussels.

Xing Ju, Chao Xu, Yangqing Hu, Xue Han, Gaosheng Wei, Xiaoze Du (2017), A review on the development of photovoltaic/concentrated solar power (PV-CSP) hybrid systems, Energy, vol. (161), March 2017, pg. 305-327, Elsevier

List of abbreviations and definitions

CF - Cohesion Fund

CSP – Concentrated Solar Power

EARDF - European Agricultural Fund for Rural Development

EC - European Commission

EDP - Energy Demo Project

EFSI - European Funds for Strategic Investment

EIB – European Investment Bank

EMFF - European Maritime and Fisheries Fund

ERDF - European Regional Development Fund

ESF - European Social Fund

ESIF - European Structural and Investment Funds

ESTELA - European Solar Thermal Electricity Association

FOAK – First Of A Kind

FR - Fresnel Reflector

GHG – Green House Gases

IEA – International Energy Agency

JRC - Joint Research Centre

LCOE - Levelised Costs of Electricity

MFF - Multiannual Financial Framework

MS – Member State

PPA - Power Purchase Agreement

PT - Parabolic Trough

RED – Renewable Energy Directive

RES – Renewable Energies

R&D – Research and Development

S3 - Smart Specialization

S3P - Smart Specialization Platform

S3PEnergy – Smart Specialization Platform on Energy

SD – Solar Dish

SET plan - Strategic Energy Technology Plan

ST – Solar Tower

STE – Solar Thermal Electricity

TES - Thermal Energy Storage

TSO - Transmission System Operator

TO - Thematic Objective

List of boxes

List of figures

List of tables

Annexes

Annex 1. Possible design options for the case study (Joint project / Art 7)

Annex 1: Possible design options for the case study (Joint project / Art 7)

Note: Taking into consideration the particularities of the Extremadura case study, a preliminary assessment of what could be the best design option is marked with (*)

POSSIBLE ARTICLE 7 DESIGN FOR EXTREMANDURA CASE STUDY			
Design aspect	Design options	Suitable under which conditions?	Comments
TYPE OF COOPERATION			
Number of countries involved	Bilateral agreement (*)	Early implementation possible Lower transaction costs to set up the cooperation Precondition: none	
	Multilateral agreement	Suitable for large-scale projects Better risk sharing between participating MS Precondition: Inclusion of all relevant/necessary parties	
Individual vs. multiple project framework	Individual project (*)	Less experience required Suitable for swift development of a specific project Suitable for first pilot projects that can initiate long-term cooperation Precondition: None	
	Multiple project framework	Suitable for mid-to long-term strategic cooperation No definition of single projects required Precondition: interest in longer cooperation	

Design aspect	Design options	Suitable under which conditions?	Comments
SCOPE OF COOPERATION			
Additional deployment or existing project	Triggering additional deployment (*)	Additional RES deployment Choice of technology, size, site can be tailored to interest of cooperation MS Precondition: willingness to finance additional deployment	
	Co-financing existing project(s) that entered into operation after 2009	Less barriers and less transaction costs as existing site, technology and size selection already occurred Does not trigger new RES deployment Precondition: Host country does not need additional RES amounts	
Physical transmission of electricity (if technically feasible)	Physical transmission required (*)	Particularly suitable for long-term cooperation (increases energy security of buying MS, support transformation to sustainable energy system in host MS Public in buying MS expect physical transmission Requirement: either neighboring countries or all transferring countries need to be included Precondition: sufficient interconnection and grid infrastructure	Spain has overcapacity, so it would prefer to "evacuate the produced electricity". The existing grid interconnection capacity between Spain and France would allow for such physical transfer.
	No Physical transmission	Electricity flows are determined by market prices and not by political rationales Less complexity and less technical barriers to overcome Physical transmission not always feasible and/or technically and economically recommendable in context of European market coupling Precondition: none	
Distribution of target credits	Target credits serve only one MS(*)	Negotiated distribution of costs and benefits Possible starting point/precondition: host country is already likely to meet targets, but is interested in local benefits (jobs, etc.) and/or strategic cooperation Precondition: cost-benefit allocation compensates for missed RES amounts.	As for the negotiation of costs and benefits see section below
	Target credits evenly split between MS	Equally (or otherwise agreed) shared benefits Precondition: Both MS need RES targets credits.	

Design aspect	Design options	Suitable under which conditions?	Comments
Joint project support: Level of specificity	Technology specific (*)	Technology development and innovation in target technologies can be shared	There is a strategic objective in CSP There might be an interest in the high value dispatchable electricity. Both countries could have an industrial interest in further deploying CSP in Europe (SET plan) Both countries may have an interest in R&D
	Technology neutral	Choice of technology left to investor Maximizes short term cost efficiency of joint project Precondition: shared objective of cost reduction	
Amount of electricity	Defined fixed amount (or corridor), including penalty payment for non-compliance (*)	-Increased reliability for buying MS on target compliance. -Precondition: Delivery risk for project developers does not increase required support significantly	Not only the amount but also the time profile
	No fixed amount	High insecurity on potential output and target compliance of buying MS Reduced risk for project developer Precondition: Buying MS mitigates risk of non-delivery	

Design aspect	Design options	Suitable under which conditions?	Comments
SUPPORT FLOWS			
Support scheme for the RES installations	Set-up of a dedicated, new support scheme (*)	Preferred by many MS Support can be tailored to coop. projects and optimized based on best practices Does not endanger integrity of existing support schemes Precondition: Willingness to address administrative costs of setting up new scheme	Given the strategic and uniqueness of the solar FOAK project it would probably require a dedicated support scheme.
	Using existing support scheme of one MS	Preferred by many MS Support can be tailored to cooperation projects and optimized based on best practices Does not endanger integrity of existing support schemes Precondition: Willingness to address administrative cost of setting a new scheme	
Type of support	Upfront support	Accounts for high investment costs Specifically adequate for capital –intensive pilot projects with high technology or regulatory risks Does not incentivize maximized output Precondition: Risk mitigation for non-delivery necessary	TBD
	Production support	Incentive to maximize output Precondition: Financing costs for project developers are adequate.	TBD
	Combination of upfront and production support	Suitable for pilot projects and less mature technologies Combination reduces risk for project developers, reduces the risk premium and thus the required support and burden on consumers/tax-payers Precondition: Agreement on mix of support	TBD

Design aspect	Design options	Suitable under which conditions?	Comments
Determination of support level	Tender/auction	Suitable for single large project ("project tender" or a larger number of undefined projects ("volume tender"). Competitive elements increase efficiency of support Risk of strategic bidding/non-implementation of won projects Tender procedure might also be used to determine competitive level of feed-in premium Precondition: sufficient number of bidders to create competition	
	Administratively define premium/tariff	Suitable for a large number of small projects as transaction costs for project developers are low Precondition: suitable mechanisms and sufficient information to set premium/tariff	
	Negotiated solution (*)	Suitable in case of missing competition for very first, high-risks projects. Potentially not in line with EU public procurement rules Precondition: high political priority, too little competition for tender	A priori it seems like a good alternative for the solar FOAK project.
CONTRACTUAL AGREEMENTS			
Rules against non-compliance of RES projects	Penalties for delays and non-delivery of RES projects	Ensure RES amounts transfer for target fulfilment of buying MS Precondition: Risk does not overburden developer; low implementation risk in host country	
	Bid bonds for tender qualification	Increase certainty that tender-winning project developer will implement the project, but increase barrier for participating in tenders Precondition: Risk does not overburden project developer; low implementation risk in host country	
	Performance bond for tender	Increase timely implementation and transfer of RES amounts of awarded projects, but increase barrier for participating tenders Precondition: Risk does not overburden developer; low implementation risk in host country	

Source: Adapted from Held et al. (2014)

Note: Additionally: must include arrangement for tracking and verification and Define procedures for the annual notification to the EC (notification requires that a letter is sent from the MS government explaining the quantity and price of renewable energy that is to be virtually transferred).

KJ-NA-29087-EN-N

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub
ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

Joint Research Centre

EU Science Hub

Publications Office

doi:10.2760/673989

ISBN 978-92-79-77885-8