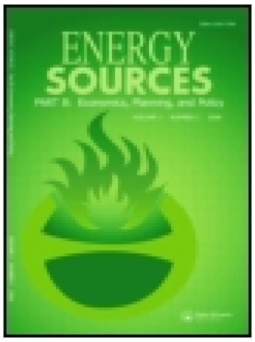

Taylor & Francis
Taylor & Francis Group

Energy Sources, Part B: Economics, Planning, and Policy

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/uesb20

Will dispatchability be a main driver to the European Union cooperation mechanisms for concentrated solar power?

Christoph P. Kiefer, Natalia Caldés & Pablo Del Río

To cite this article: Christoph P. Kiefer, Natalia Caldés & Pablo Del Río (2021): Will dispatchability be a main driver to the European Union cooperation mechanisms for concentrated solar power?, Energy Sources, Part B: Economics, Planning, and Policy, DOI: 10.1080/15567249.2021.1885526

To link to this article: https://doi.org/10.1080/15567249.2021.1885526

Published online: 07 Mar 2021.

ENERGY SOURCES, PART B: ECONOMICS, PLANNING, AND POLICY
https://doi.org/10.1080/15567249.2021.1885526

Will dispatchability be a main driver to the European Union cooperation mechanisms for concentrated solar power?

Christoph P. Kiefer[a], Natalia Caldés[b], and Pablo Del Río[a]

[a]Institute for Public Policies and Goods, CSIC, Madrid, Spain; [b]Energy Systems Analysis Unit, CIEMAT, Madrid, Spain

ABSTRACT
The use of the European Union cooperation mechanisms for concentrated solar power (CSP) projects could kill two birds with one stone. First, CSP electricity can cover demand when variable renewables cannot generate. Second, CSP projects deployed under the cooperation mechanisms could contribute to a European-wide optimization of resource use and grid management. This paper analyzes whether the dispatchable nature of CSP is a main driver to the use of the cooperation mechanism for this technology. Based on an expert elicitation and a survey to different types of stakeholders, our results show that, indeed, dispatchability will be the main driver to the use of the cooperation mechanisms for CSP projects in the future. The findings suggest that two types of policy interventions will be required to encourage the use of these mechanisms for CSP. Some policy measures should be directed at the technology itself, whereas other policies should target the cooperation mechanisms.

KEYWORDS
Cooperation mechanisms; concentrated solar power; European Union (EU)

1. Introduction

The energy transition of the European Union (EU) and its Member States (MS) has fundamentally been based on the integration of (variable) renewable energy technologies (RETs) in national electricity grids. However, this "national variable RETs" strategy has its problems and calls for the deployment of dispatchable renewable energy sources and more EU cooperation on renewables.

Both issues (the integration of variable renewables and EU cooperation on renewables) share a common ground. On the one hand, a high share of variable RETs entails considerable challenges for grid management and reinforces the need for dispatchable sources. Taking into account the decarbonization and renewable energy targets set in the EU, these sources should be renewable. Concentrated solar power (CSP) with storage meets both conditions (being renewable and dispatchable).[1]

On the other hand, cooperation on renewable electricity means that a Member State can comply with its targets by supporting RET projects in a different country. Renewable energy cooperation would facilitate the optimization of the deployment of RETs on a European level and would result in a more efficient use of natural resource availability and existing grids across the EU. Such an EU-wide optimization could lead to a cost-effective renewable energy transition, which contributes to the security of supply, coordinates energy transition measures amongst MS and maximizes social benefits (Caldés-Gómez and Díaz-Vázquez 2018; EC DG ENER, 2018). Indeed, according to the Directorate General on Energy of the European Commission (DG-ENER), renewable energy cooperation among MS (and third countries) in the post-2020 time

CONTACT Christoph P. Kiefer christoph.kiefer@csic.es CSIC, Madrid, Spain.

[1]We are aware that CSP with storage is only one among other alternatives contributing to such goal, such as demand-side management, storage linked to consumption and electricity exchanges across countries. However, it is beyond the scope of this paper to provide a comparative analysis of the advantages and drawbacks of the different options.

frame has four objectives: (i) joint planning, development, and cost-effective exploitation of renewables and EU target achievement, (ii) contribution to the strategic uptake of innovative renewable technologies, (iii) contribution to the EU's long-term decarbonization strategy, and (iv) better integration of RETs through energy storage and conversion facilities (which is particularly relevant for CSP)(Holl 2019).

In fact, the European Union's Renewable Energy Directive (or RED) 2009/28/EC was set up with the aim to provide MS with sufficient flexibility to reach the national 2020 energy targets in a cost-effective manner and to encourage cooperation between the MS to meet the overall EU renewable energy target (20% in 2030). Specifically, the RED sets the legal framework for four cooperation mechanisms: statistical transfers (Art.6), joint projects with or without physical transfer (Art.7), joint projects with third countries (Art.9), and joint harmonization schemes (Art.11). This means that renewable electricity is generated in one EU country (exporter), but can be virtually and in some cases also physically exported to another country (importer) through the use of those mechanisms. In addition to setting a 32% renewable energy target for 2030, the new Renewable Energy Directive (Directive 2018/2001/EU, or REDII), adopted in December 2018, also includes those mechanisms, although in different articles (8, 9, 11 and 13, respectively). Box 1 includes a description of these mechanisms.

Box 1 Cooperation mechanisms for renewable energy

Statistical transfers: MS_1 virtually transfers (part of) its renewable energy production to MS_2 renewable energy statistics counting toward MS_2 renewable energy target (as described in articles 6 of the Directive 2018/2001/EU and 8 of Directive 2009/28/EC).

Joint projects between EU MS: Two or more MS decide to finance a renewable energy project by sharing the costs and agreeing on a set of framework conditions such as which share of the energy production statistically counts toward each MS´ target (as described in articles 7 of Directive 2009/28/EC and article 9 of Directive 2018/2001/EU).

Joint projects with third countries: One or more MSs implement a joint project with a country outside the EU (third country). A prerequisite is that an equal amount of renewable electricity produced by this joint project is physically imported to the EU (as described in articles 9 of Directive 2009/28/EC and articles 11 of Directive 2018/2001/EU).

Joint support schemes: Two or more MS coordinate or merge (part of) their renewable energy support schemes and jointly define which share of the resulting renewable energy counts toward each MS target (as described in article 11 of Directive 2009/28/EC and article 13 of Directive 2018/2001/EU).

Source: Adapted from Caldés-Gómez and Díaz-Vázquez (2018).

However, the use of these mechanisms has been very limited in the past, as shown by Caldés et al. (2019) and Caldés et al. (2018). There has not been any use of joint projects, whereas there have only been two experiences with statistical transfers (Luxembourg with Estonia and with Lithuania) (Caldés et al. 2019, 3). Joint support schemes have only been used twice. In January 2012, the first ever cooperation agreement of the RED was signed between Sweden and Norway under article 11 in the form of a Joint Certificate Scheme applicable to all renewable energy technologies. In June 2016, Denmark and Germany signed the second cooperation agreement under article 11, encompassing a mutually opened auction scheme for ground-mounted PV installations (see Caldés et al. 2019, 2018 for further details).

The cooperation agreement between Germany and Denmark has been regarded as a reference for other countries which are willing to make use of the cooperation mechanisms and, in particular, for the implementation of mutually opened auctions. Although reciprocity was one of the main principles for cooperation in this case, dispatchability could have been one of the specific auction conditions in a technologically neutral, mutually opened auction.

Given the limited use of the cooperation mechanisms under the RED, the regulatory framework aimed at fostering renewable energy cooperation in Europe beyond 2020 had to undergo some changes. First, instead of setting binding national renewable energy targets, the "Clean Energy for all Europeans" (CE4ALL) regulatory package defined an EU-wide renewable energy target of 32%, setting a stronger basis and impetus for collaborative renewable energy deployment among EU Member States. Furthermore, in addition to the four cooperation mechanisms established since 2009, new modes of collaborative renewable energy deployment were conceivable under the "enabling framework" and the "EU financing mechanism". These are instruments that are supposed to prevent a potential collective delivery gap, although they still have to be designed in detail (Boie and Franke 2020).

Among the new support instruments, the window for cross-border renewable energy cooperation projects under the "Connecting Europe Facility" (CEF) provides a new financial incentive for MS to engage in renewable cooperation agreements with other MS. In order for CSP cross-border projects to be eligible, they must demonstrate significant EU-added value and show a commercial viability gap (Holl 2019). Clearly, dispatchability is likely to be one of the most outstanding EU added-values for cross-border CSP projects compared to other RET cooperation projects. However, Boie and Franke (2020) argue that the degree to which CSP projects will benefit from these new measures and instruments in the future will depend on the individual Member States' interests to engage in renewable energy cooperation and to expand the flexibility of their electricity systems based on CSP (as opposed to other technology solutions such as, e.g. storage, increased demand response or sector coupling).

A main question is whether there can be synergies between both issues and, particularly, whether the greater need for dispatchable RETs can be a driver for the use of the EU cooperation mechanisms. This paper investigates this issue for the case of CSP. Being able to store thermal energy and, thus, to generate dispatchable electricity, is a distinctive feature of CSP with respect to variable RETs.[2] This allows shifting generation to those hours with peak electricity demand or without solar irradiation. Its flexibility of dispatch (dispatchability) is certainly a valuable feature in many places where the penetration of variable renewable electricity is increasing (Guebebia and Jomâa 2017; Mehos et al. 2015).

A higher penetration of variable RETs increases the amount of imbalances (Otner and Thosti 2019) and, thus, a higher amount of balancing is required. The balancing market is the institutional arrangement that deals with the balancing of electricity demand and supply (Reinier and van der Veen 2016) and is designed to manage those imbalances. Balancing will thus be an integral part of future electricity systems (Gyalai et al. 2020). Although balancing markets are currently national, there is an increasing level of international cooperation. According to Otner and Thosti (2019, 111), "transmission system operators across Europe progressively coordinate their actions in order to increase the efficiency of balancing markets and, thus, mitigate the rise of imbalances". Balancing services are shared across European countries, with their prices going down (see ENTSOE 2020).

Therefore, since electricity systems cannot store electricity, there is a need for balancing, which can be provided by different technologies. The increase of variable renewable electricity will lead to a higher relevance of storage in order to match supply and demand (Gyalai et al. 2020). Therefore, electricity systems in Europe will increasingly require dispatchable power, such as the one provided by CSP, among other alternatives. CSP with storage is a flexible option that can handle imbalances arising from mismatches in the fluctuating demand and fluctuating supply.

Several authors stress the role that CSP can play in this context. For example, as observed by Lilliestam et al. (2020), CSP has a relevant role to play as a dispatchable electricity source to balance the fluctuating renewables, Lilliestam et al. (2018, 11) argue that "CSP would be necessary (to stabilise a high-renewables system) or beneficial (by offering the cheapest balancing option), because other measures cannot provide the same level of flexibility, not at the scale needed, or only at a higher cost than CSP". According to Welisch (2019), CSP could become a reserve/flexibility provider in future energy systems. Referring to a study by the Deutsche (2014), Welisch (2019) observes that, if peak loads in 2030 increase substantially, this could make electricity storage competitive and less costly than keeping conventional power plants for balancing services and would improve the business case for cooperation and for dispatchable electricity providers such as CSP. As suggested by the analysis carried out in the EU-funded MUSTEC project, this might be the case in several EU Member States, including Spain and Germany (BMWi 2017b; Welisch 2019).[3]

[2]Other technologies share both features (being renewable and dispatchable), including biomass, pumping and hydro.

This paper analyzes the role of the dispatchability of CSP as a driver to the use of the cooperation mechanisms in the EU. Based on the analytical framework developed in del Río et al. (2018) and Del Río and Kiefer (2019) in the context of the MUSTEC project, it compares its relevance with other drivers. This article builds directly on the work that has been carried out in that project. The method is based on a survey targeted at stakeholders in a potential exporting country for CSP cooperation mechanisms (Spain) and a potential importer country (Germany). In addition, an expert elicitation has allowed us to identify the perception of experts regarding the most attractive features that CSP projects should have in order to be used as part of the cooperation mechanisms. The results allow us to identify the perceived relevance of dispatchability with respect to other factors (see section 3 for more details on the methodology).

The literature on the use of cooperation mechanisms for CSP is relatively tiny. An exception is the EU-funded BETTER project (Bringing Europe and Third countries together through renewable energies) and a few contributions resulting from such project. In the context of Article 9 of the RED 2009/28/EC ("cooperation mechanism with third countries"), Lilliestam et al. (2016) analyzed the reasons for the lack of renewable electricity imports to the European Union, with a special focus on CSP. Papapostolou et al. (2016) carried out a country risk assessment in the context of the Renewable Energy Directive 2009/28/EC that allows EU Member States to carry out joint renewable electricity generation projects with third countries. The authors used a multicriteria decision support methodology and applied it to five North African countries. They found that Morocco and Tunisia were the most suitable countries for such a cooperation from a foreign investment perspective. Karacosta et al. (2016) found that there were significant barriers for energy cooperation in the West Balkans and questioned the suitability of the region to engage in EU energy cooperation. These barriers included high investment risks, fragmented electricity markets and the need for power market reforms. Caldés-Gómez and Díaz-Vázquez (2018) investigated the value proposition of cross-border solar electricity trade in Europe. They assessed the pre-feasibility of a first-of-a-kind (FOAK) CSP plant in the region of Extremadura (Spain) and demonstrated the feasibility to combine EU financing support mechanisms and the cooperation mechanisms of the RED (2016).

Two reports of the EU-funded MUSTEC project are particularly relevant in this context (del Río et al. 2018 and Del Río and Kiefer 2019). Del Río et al. (2018) empirically identified drivers and barriers to the use of cooperation mechanisms for CSP deployment in the EU. Those authors focused both on the technology/project level (micro) and the country/policy level (macro) and investigated the effects and the changes in these effects from the present situation until 2020. The authors combined research on two dimensions (CSP deployment on the one hand, and EU cooperation mechanisms on the other), and found that each of those dimensions was associated with a set of specific drivers and barriers. Del Río and Kiefer (2019) identified those CSP project features which could make them more attractive for CSP cooperation in the future, illustrating the discussion with data for specific projects. This article draws on del Río et al. (2018) and Del Río and Kiefer (2019) but, in contrast to those two reports, where dispatchability is only one amongst several factors being analyzed, this article focuses on the relative importance of dispatchability as a driver to the use of cooperation mechanisms for CSP. To our best knowledge, this is the first paper in the literature specifically addressing this topic.

This article is structured as follows. Section 2 depicts our analytical framework for the identification of the drivers and barriers to the use of the cooperation mechanisms for CSP in the EU. Section 3 provides details on the methodology. The results of the analysis are discussed in section 4. Section 5 concludes.

2. Analytical framework

The identification of the drivers and barriers to the use of the cooperation mechanisms for CSP in the EU can benefit from the integration of two different streams of the literature: the analysis of the drivers

[3]See work carried out in this project in https://www.mustec.eu/

and barriers to the use of the cooperation mechanisms and the assessment of the drivers and barriers to the deployment of CSP in the EU. The former were analyzed in Caldés et al. (2018), whereas Del Río and Kiefer (2018) focused on the latter. Therefore, our analytical framework integrates both sets of drivers/barriers. It is based on del Río et al. (2018), which provided an initial list of 59 factors (drivers and barriers) to the use of cooperation mechanisms specifically applied to CSP in the EU. However, the factors had to be simultaneously relevant for both CSP and the cooperation mechanisms. Therefore, those factors which were relevant for the cooperation mechanisms, but not for CSP, as well as those which were relevant for CSP but not for the cooperation mechanism, were excluded. The final list of 19 drivers and barriers which were considered potentially relevant to the cooperation mechanisms and CSP deployment are listed in Table 1.

The focus of this research is on dispatchability as a driver to the use of the cooperation mechanisms. As mentioned in the introductory section, dispatchable electricity generation, such as CSP, plays a particularly important role with higher shares of variable RETs, providing flexibility and reducing the need for fossil-fuel back-up capacity to balance such variability. This is certainly the case in the exporter country, but would also be true in the importer country if there were electricity interconnections. As mentioned by Lilliestam et al. (2020, 11), "storage and balancing can be interchangeable terms, as storage is a technical toolset within balancing". CSP power generation is a clean source which, due to its capability to adjust its power output to some extent, can play a role in balancing the

Table 1. Potential drivers and barriers to the use of cooperation mechanisms for CSP in the future.

Potential driver or barrier	Brief description of the driver or the barrier
DRIVERS	
Dispatchability	See text
Costs savings in MS target achievement	Cost associated with the achievement of MS' targets with and without cooperation.
Contribution to improve technical performance and cost reduction in CSP	Investment in CSP may be associated to further technological improvements and cost reductions due to an increased diffusion of the technology.
EU guidance in implementing the cooperation mechanisms	Easiness or difficulty in implementing cooperation mechanisms between MS and corresponding guidance from the EU.
New domestic jobs and industrial opportunities	Job creation and economic growth.
Move toward creation of internal energy market	Contribution of the cooperation mechanisms between MS to an EU-internal/EU-wide energy market.
Obligation to open support schemes	Compliance with legislation requiring openness of renewable energy support schemes.
Alignment with the Paris objectives	Includes specific targets and commitments as well as related aspects such as pursuing climate leadership.
BARRIERS	
Public reaction in importer countries (taxpayers money use)	Includes investing tax-payers' money abroad.
Heterogeneous regulated energy prices and support schemes	Easiness or difficulties for cooperation under different regulations and support schemes as well as on different markets and with different energy prices.
Difficulties in communicating benefits	Includes both difficulties in communicating benefits from cooperation to citizens and difficulties in quantifying indirect costs and benefits.
Resistance to lose sovereignty over energy market	MS disparities toward their preferred energy mix and their resistance to lose control over their energy policy.
First mover risk	Risk associated with being the first in applying such a cooperation mechanism in CSP.
Public reaction in exporting country	Includes the so-called NIMBY effect ("not in my backyard" effect).
Public reaction in transit country	Includes issues associated with the visual impact of electricity grids.
Complementarity with PV	The value of CSP is expected to increase further as PV is deployed in large amounts and, thus, they may complement each other.
Policy ambition (renewable energy targets)	Aspects of policy and corresponding framework conditions related to renewable electricity support but outside the support system itself (Del Río & Bleda 2012; Bergmann et al. 2008, p.133).
Higher cost of CSP than other renewables	(on a LCOE-basis)
Low levels of deployment support	(in the exporting country)

Source: Own elaboration based on del Río et al. (2018) and Caldés et al. (2018).

growing intermittency of the production from a large share of wind and solar power in the energy mix due to its flexibility (dispatchability), a role currently played by, among others, fossil-fuel electricity generation technologies (Gyalai et al. 2020). Thus, CSP with storage would allow to diversify the technologies which can support balancing and rely less on a single or fossil-fuel source, such as natural gas.

Therefore, the attractiveness of projects with more dispatchable capacity would obviously be higher if countries have dispatchability as one of their main goals. If there are physical connections, this is the case in both the importer (off-taker) country and the exporter (host) country. In the absence of such electricity interconnections, CSP would only contribute to dispatchability in the exporter country (and energy cooperation between these countries would only be a virtual one).

In an exporter country with a high penetration of variable RETs (and high shares of PV), such as Spain, CSP (as well as other dispatchable technologies such as biomass, pumping, and hydropower) can provide low-carbon power when the sun starts setting and until the morning of the next day, complementing PV generation. This dispatchable electricity generation could replace at least part of fossil fuel back-up capacity.

However, the importing country would also need dispatchable power. For example, although the current need for dispatchable (renewable) electricity seems to be relatively moderate in Germany, it will probably be higher in the future (Welisch 2019). Importing CSP electricity would be one alternative for balancing in a high-renewables scenario, but this would require proper interconnection capacity in order to make physical transfers possible. Since this is currently not the case, a lower relevance of dispatchability for the importer country compared to the exporting country can be expected.

However, this search for flexibility, which is related to the minimization of system costs, is only one among several policy goals of European Member States. Other goals could include the efficient fulfillment of targets for renewable energy, high socio-economic benefits and low environmental impacts in the exporting and/or importing countries (Del Río and Kiefer 2019). Depending on the importance of those policy goals for the national policy-makers, a given project may be more or less attractive for CSP cooperation.

Furthermore, the priority attached to a given goal may differ depending on whether the country is an exporting or an importing country. The most attractive CSP cooperation projects for exporting countries would be those which are dispatchable and lead to low support costs, low environmental impacts and high local socioeconomic benefits in those countries. For the off-taker country, the most appealing projects would be those which contribute to meet the renewable targets and do so at low costs. In case of physical transfers across countries, it would also be those enabling flexible dispatch (Del Río and Kiefer 2019).

3. Methods

Two complementary methodologies were adopted in order to answer the research question. One was a survey directed to different types of stakeholders. Its aim was to identify the perceived relevance of several factors (whether drivers or barriers) for their country to get involved in CSP cooperation projects in the post-2020 time period. The other was an elicitation to experts whose aim was to identify their perception on the most appealing features that CSP projects should have (for both potential host and off-taker countries) in order to be used as part of the cooperation mechanisms.

Regarding the stakeholder survey, the final list of 19 factors was the basis for an assessment in the survey. The interviewees were asked to quantify the importance of each factor as a driver or a barrier to the use of the cooperation mechanisms for CSP in the future.

Different types of stakeholders in a potential exporter and a potential importer country were asked to fill a short on-line questionnaire. Spain and Germany were selected as the host and off-taker countries, respectively. Spain was chosen as the exporting country, since it accounts for most of the CSP capacity deployed in Europe, and because this country has a considerable remaining potential (relative to other EU countries) to generate electricity with CSP. The choice of Germany can be justified for several reasons: it has a sufficiently large electricity market, has the political will to engage in cross-border cooperation (as shown by the aforementioned successful cooperation agreement with Denmark), has a potential industrial interest in CSP, has a favorable public opinion (or at least not one which rejects European cooperation) and has a need for further decarbonization (i.e., it is not already overachieving the decarbonization targets). Acting as an importer country of CSP cooperation projects deployed in Spain could be an appealing option for Germany in the light of a considerable increase in variable renewables to meet ambitious decarbonization targets and the need for flexible dispatch, although this would only be so if there are electricity interconnections across countries.

CSP project managers, energy experts, public decision-makers and grid operators were deemed suitable interviewees in the host country, whereas, public decision makers, electricity distribution companies and grid operators were considered appropriate stakeholders in the off-taker country. The aim was to get a balanced view on the subject by different stakeholders. Different actors working in different areas generally have a different perception of energy matters and the aim was to capture those different perspectives. The selection of stakeholders followed a strict protocol. First, several categories of stakeholders that were deemed relevant for the research question were created: Policy (public decision-makers and legislative representatives), Research, Supply (firms in the sectors of project development and electricity distribution), Demand (industry and household consumers), Support Organizations (firms in the sectors of finance and consulting) and Influencers (public opinion leaders, civil society, and local groups). These categories were derived from the technological innovation system (TIS) framework and its application to the CSP sector (see Dütschke et al. 2018b). Second, within these categories, firms and specific individuals were identified. This was done by researching the European CSP market for firms which were active between October 2017 and February 2018, by consulting the members of CSP associations such as ESTELA, Deutscher Industrieverband CSP and SolarPowerEurope, and by consulting public databases, including NREL/SolarPACES and the CSP Guide of CSP World.

The survey was launched in September/October 2018, and potential participants could fill the questionnaire until December 14, 2018. The interviewees were asked to indicate how different factors could act as either a driver or a barrier for their country to get involved in joint projects for CSP in the post-2020 time period. They were asked to indicate the degree of importance of each barrier/driver (from −3, very important barrier, to 3, very important driver). 36 stakeholders accessed the survey and 21 completed it.

As it can be observed in Table 1, dispatchability was one of those factors. Others can also be expected to influence the use of the cooperation mechanisms specifically for CSP. The aim of this survey was to isolate the influence of the driver which is the focus of this research (dispatchability), while controlling for the impacts of the other drivers.

As mentioned above, an expert elicitation was carried out. Expert elicitations, which have been used in (renewable) energy research in the past (e.g., Bosetti et al. 2012; Verdolini et al. 2018), are special survey tools designed to extract deep knowledge which is not available elsewhere. They provide a structured approach for obtaining expert judgments. Therefore, an expert elicitation was targeted at experts with knowledge on both CSP and the EU cooperation mechanisms. The need to target experts which were familiar with both CSP and the EU cooperation mechanisms left us with 16 experts being deemed appropriate for our elicitation. Their responses were treated as confidential. Experts were also asked to self-assess their degree of knowledge on the two fields. They rated their expertise on CSP and the cooperation mechanisms with an average of 8.3 and 6.5, respectively (in a 10-point scale).

11 experts finally filled out the questionnaire. The elicitations took place between April and May 2019 through e-mail. Experts were asked about the main features that a future CSP project should have in order to be attractive for importer and exporter countries under the cooperation mechanisms of the RED (articles 8 and 9).[4] Two policy-makers, two experts from industry, and seven

[4]For more details on the methodology, including the design of the questionnaire, see Del Río and Kiefer (2019).

academics were contacted, in line with the recommendation that different types of experts should be consulted (Verdolini et al. 2018).

4. Main results

Figures 1 and 2 show the results of our survey on the expected drivers and barriers to the future use of cooperation mechanisms for CSP in the EU. As mentioned above, respondents to the questionnaire could provide their answers on a − 3 to 3 scale, where −3 indicated "very important barrier" and 3 indicated "very important driver". The bars on the left denote that the respondents have regarded this factor as a barrier (on average), whereas the ones on the right mean that this is perceived as a driver. Further details are provided in del Río et al (2018).

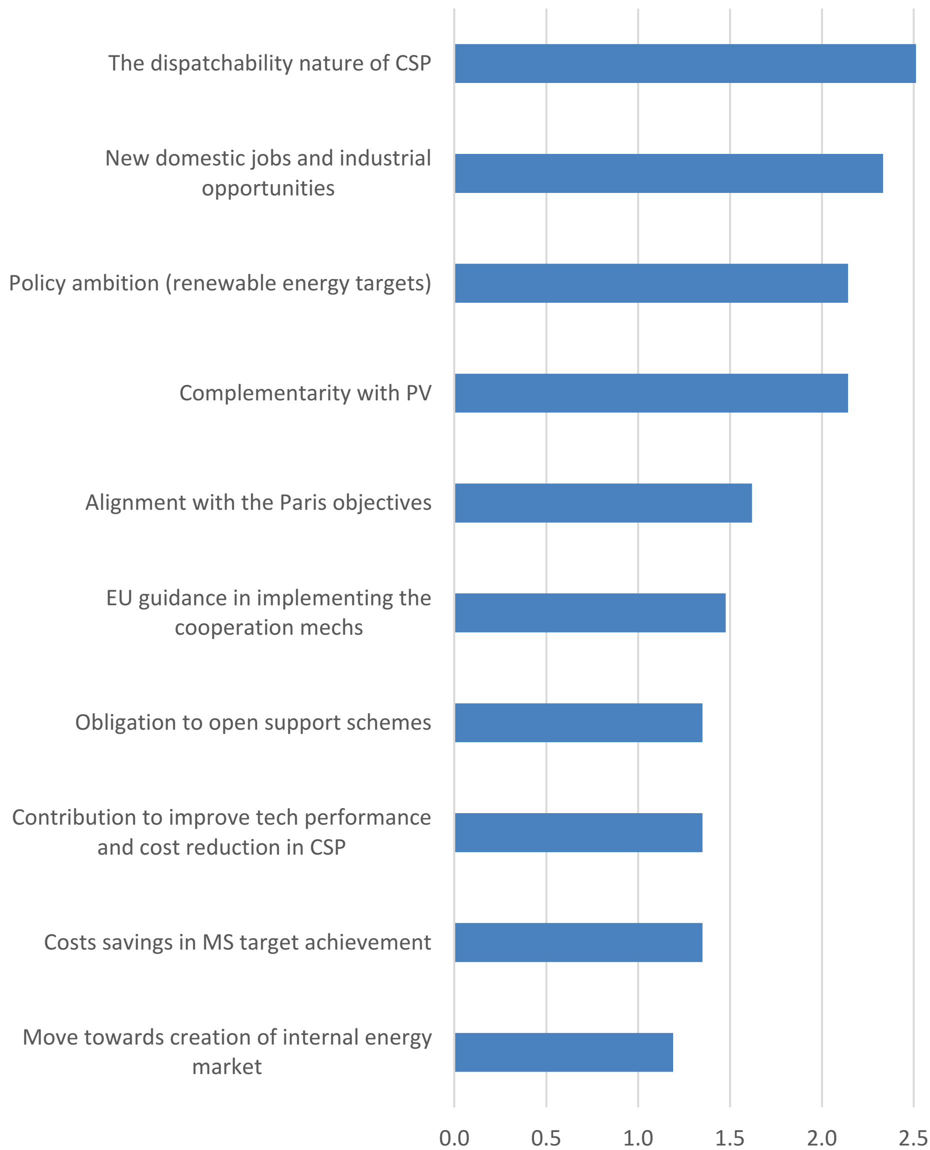

Figure 1. Will dispatchability be an important driver for the use of the cooperation mechanisms for CSP in the future? The relative importance of different factors as drivers. Source: Own elaboration. Note: Scale of 0 to 3, where 3 indicates very important driver.

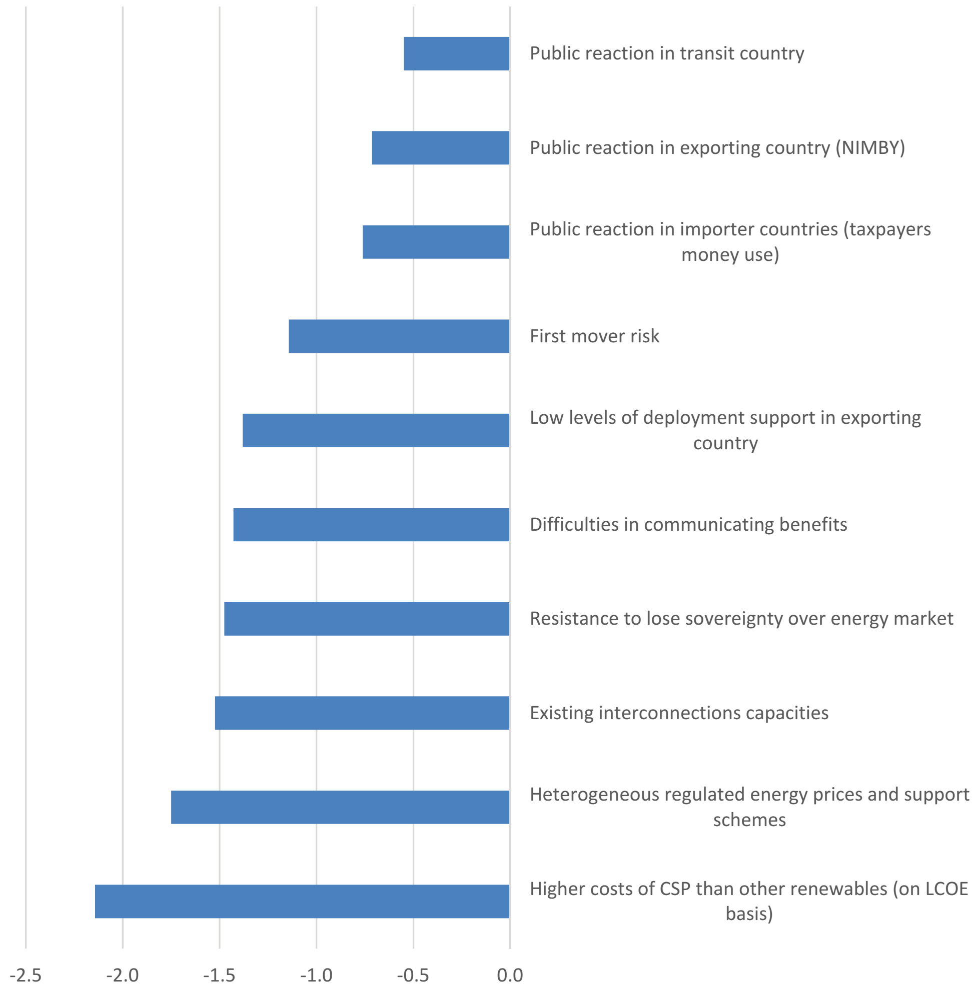

Figure 2. Will dispatchability be an important driver to the use of the cooperation mechanisms for CSP in the future? The relative importance of different factors as barriers. Source: Own elaboration. Note: Scale of 0 to −3, where −3 indicates very important barrier.

The results of our analysis confirm the future importance of dispatchability in driving the use of the cooperation mechanisms for CSP in the EU. This is deemed a more relevant driver than others, such as domestic employment creation and industrial opportunities, complementarity with PV and policy ambition. The expected future relevance of other factors is very limited and some are even perceived as barriers.

However, the relative importance of the driver "complementarity with PV" confirms the future relevance of dispatchability as a driver of CSP deployment in the future and, particularly, as a driver of CSP cooperation projects. The reason is that, as mentioned in section 1, high shares of variable RETs (such as PV) would require back-up with dispatchable electricity generation technologies. There are several alternatives in this regard, and CSP is certainly one of them. Although competition between solar technologies might have led to relatively low CSP deployment (del Río et al 2018), they will complement and even reinforce each other in the future. The value of CSP will increase further as PV is massively deployed, shaving peak loads or filling valleys (Gyalai et al. 2020; IEA 2014).

Unfortunately, a comparison of our results on the role of dispatchability as a driver of the EU cooperation mechanisms with past contributions cannot be undertaken, given the dearth of studies on this issue. These results suggest that there might be a synergy between both areas, with each

Table 2. Scores on the features that a CSP project should have in order to be appealing for an exporting country (such as Spain) and an importer country (such as Germany) to be used as part of the cooperation mechanisms.

Features of CSP projects	Exporting country	Importing country
Technical aspects of the project	3.45	2.82
Cost of the project	3.91	4.36
Dispatchability capacity of the project	4.55	3.09
High socioeconomic benefits in Spain (jobs and industry creation)	4.27	2.00
Low environmental impacts in Spain	3.45	2.18
High socioeconomic benefits in Germany (jobs and industry creation)	-	3.27

Source: Own elaboration. Note. Experts were asked which characteristics a future CSP project should have in order for it to be appealing for the cooperation mechanisms (articles 8 and 9), either for an exporting country (Spain) or an importer country (Germany) in a likert scale (5 = most relevant, 4 = somehow relevant; 3 = neither relevant nor irrelevant; 2 = somehow irrelevant; 1 = very irrelevant).

contributing to the other one. On the one hand, the cooperation mechanisms can be used by CSP and, thus, they can be an important driver for the deployment of this technology, which has been stagnant in Europe in the last decade. On the other hand, the dispatchability of CSP may increase the attractiveness of the cooperation mechanisms. This is much needed, given the limited use of these mechanisms in the past.

The answers of experts to the elicitation confirm the relevance of dispatchability, especially for the exporting country. Interviewees were asked about the features that a CSP project should have for an importer country (Germany) and an exporter country (Spain) in order to be deployed under the cooperation mechanisms. Given the absence of enough interconnection capacity between Spain and Germany, it was assumed that there would not be any transfer of electricity between these two countries. Only the virtual transfers of article 8 (statistical transfers) and article 9 (joint projects between MS) of the RED were deemed possible. The results are shown in Table 2.

The interviewees regarded dispatchability as the most appealing characteristic of a CSP project for the host country (Spain), either because "it is the distinguishing characteristic of CSP with respect to other RETs which are cheaper (from an LCOE point of view)", because "dispatchable plants would cause less disruption in the Spanish grid" or because they provide "stability/flexibility to the Spanish system" (in the context of a high penetration of variable renewables).

"High socio-economic benefits in Spain" is also perceived to have a high relevance for the host country. The least attractive features of CSP projects for the host country in this context would be "low environmental impacts in Spain" and "technical aspects of the project".

In contrast, the cost of the project would be the most appealing characteristic of a future CSP project for the off-taker country (Germany), since this cost is borne by this country (which would get the rights for virtual electricity imports in return). An important but expected result is that the off-taker country attaches a lower importance to dispatchability than the host country, given that electricity imports would only be virtual and, thus, they would not influence the management of the grid. "High socio-economic benefits in Germany" would be the third most appealing characteristic of CSP projects for the importing country. Finally, as it could be expected, "high socio-economic benefits in Spain" and "low environmental impacts in Spain" are perceived to be the least relevant project features for the importing country.

5. Conclusions

This article has investigated the relative importance of the dispatchability of CSP as a driver to the use of the cooperation mechanisms for this technology in the future. Our results show that, according to the survey to different types of stakeholders, dispatchability is perceived to be the most influential factor for the use of the cooperation mechanisms for CSP in the future. The expert elicitation on the features that, as part of the cooperation mechanisms, a CSP project should have in order to be attractive for an importer and an exporter country confirms the relevance of dispatchability. This is especially so for the exporting country.

Some policy implications derive from our analysis. Our results suggest that activating the drivers or mitigating the barriers to the use of the cooperation mechanisms for CSP requires a combination of policy interventions (e.g., a policy mix). Two types of measures are recommendable: some of them should be directed at the technology, whereas others should target the cooperation mechanisms themselves.

Regarding the former, two main drivers to CSP need to be activated. One is cost reductions which, given its cost-gap with respect to other RETs (solar PV and wind on-shore) would justify that dedicated deployment support is provided for this technology in order to allow it to advance along its learning curve. In turn, this would lead to cost reductions.

However, even a more relevant driver which needs to be activated in order to encourage the participation of CSP projects in the cooperation mechanisms is the dispatchable feature of this technology. With an increasing penetration of variable renewable electricity generation, the dispatchability of this renewable energy technology is certainly an attractive feature of CSP for policymakers. Therefore, public policy interventions should take into account the services which CSP provides to the electricity systems and its contribution to their stability and reliability. In general, this can be done with particular instruments or with design elements within these instruments (Kiefer and del Río 2020).

A main alternative is to adopt a support scheme that takes into account the value of electricity generation, which is higher at specific times (i.e., when demand is higher). In the EU, article 3 of the REDII states that support should be granted through a feed-in premium (FIP) only and not through a feed-in tariff (FIT). The reason is that the latter provides a total price for the electricity sold and does not encourage its integration in the electricity market. Under a FIP (whether fixed or sliding), the electricity generator needs to sell the electricity in the market and, in addition, receives a premium on top of the electricity price. In contrast to a FIT, the renewable generator has an incentive to sell the electricity where and when its price is higher in order to increase his revenues, and this price is higher when the electricity has a higher value, i.e., at times of high demand.

Furthermore, in general, the dispatchability of CSP could be rewarded through design elements in FITs and FIPs, whether set administratively or in auctions. These may include a requirement that the project produces electricity at specific times (i.e., to cover peak load, as in Dubai), the adoption of hourly adjustments in renewable energy auctions which encourage electricity generation in the hours when the electricity has a higher value (as in the peak-load hours in South Africa), auctioning electricity volumes in hourly blocks (as in Chile) or according to the demand profile (as in California), or organizing technology-specific auctions for dispatchable technologies (as in South Australia)(see Del Río and Mir-Artigues 2019 for further details).

Concerning policy measures that should target the cooperation mechanisms themselves and which would have a positive impact on the use of cooperation mechanisms for CSP, it should be taken into account that market and policy fragmentation across the EU are regarded as the main barriers to the use of those mechanisms in our stakeholder survey. A greater coordination or harmonization of support schemes and the improvement of interconnection capabilities across the EU are, thus, obvious measures that could be promoted at the EU level. Other government levels (national and regional) may also play a role in this context.

In addition to other, more general policy interventions with an indirect positive influence on the use of the cooperation mechanisms (such as ambitious renewable energy targets or progress toward an internal energy market),[5] some specific instruments could encourage the use of those mechanisms. These include information provision, legislative initiatives, access to finance, public awareness campaigns and international cooperation (Caldés et al. 2019). Particularly relevant is information provision about the importance of dispatchability in energy systems and, more specifically, about the role

[5]See Caldés et al. (2019) in this regard.

that CSP can play in this regard. There is considerable lack of knowledge about CSP among policymakers in Europe and the population in general (Dütschke et al 2018a). In addition, increasing the interconnections between countries would support the implementation of the cooperation mechanisms, although the findings of our research do not indicate that this is a very relevant barrier or driver and progress in this area is slow. Finally, further support to CSP projects under the aforementioned Connecting Europe Facility (CEF) could be justified 2018b. However, in order to qualify for cross-border renewable energy cooperation projects under the CEF, dispatchability should be included as a main EU value-added criterion 2018a.

Some limitations of the study should be mentioned. First, the number of our respondents can be deemed relatively low, although the number of people with expertise on, both, the EU cooperation mechanisms and CSP is also very low. Second, the survey and expert elicitation focused only on two countries (Spain and Germany), which affects the generalizability of our findings. Therefore, the research sample could be enlarged to include other potential producer and off-taker countries (e.g., Italy and Luxemburg, respectively).

Funding

This work was supported by the European Commission [764626].

References

Bergmann, J., Bitsch, C., Behlau, V., Jensen, S., Held, A., Pfluger, B., Ragwitz, M., & Resch, G. (2008). Harmonisation of support schemes. A European harmonised policy to promote RES electricity– sharing costs & benefits. A report compiled within the European research project futures-e (work package 3; Deliverable D17)

BMWi. 2017b. Ergebnispapier Langfristige Trends – Aufgaben fur die kommenden Jahre Strom 2030.

Boie, I., and K. Franke 2020: Synthesis of key issues affecting CSP development in Europe. Deliverable 10.1, MUSTEC Project, Fraunhofer ISI, Karlsruhe.

Bosetti, V., M. Catenacci, G. Fiorese, and E. Verdolini. 2012. The future prospect of PV and CSP solar technologies: An expert elicitation survey. *Energy Policy* 49:308–17. doi:10.1016/j.enpol.2012.06.024.

Caldés, N., P. Del Río, A. Gerbetti, and Y. Lechon. 2019. Renewable energy cooperation in Europe: What next? Drivers and barriers to the use of cooperation mechanisms. *Energies* 12:70.

Caldés, N., Y. Lechón, I. Rodríguez, and P. Del Río 2018. Market uptake of solar thermal electricity through cooperation. Analysis of the barriers to the use of the cooperation mechanisms for renewable energy in the EU.

Caldés-Gómez, N., and A. Díaz-Vázquez 2018. Promoting solar electricity exports from southern to central and northern European countries Extremadura case study. doi:10.2760/673989

del Río, P., & Bleda, M. (2012). Comparing the innovation effects of support schemes for renewable electricity technologies: A function of innovation approach. Energy Policy, 50, 272-282. https://doi.org/10.1016/j.enpol.2012.07.014

Del Río, P., C. Peñasco, and P. Mir-Artigues. 2018. An overview of drivers and barriers to concentrated solar power in the European Union. *Renewable and Sustainable Energy Reviews* 81 (November2016):1019–29. doi:10.1016/j.rser.2017.06.038.

Del Río, P., and C. P. Kiefer 2018. Analysis of the drivers and barriers to the market uptake of CSP in the EU. Report for task 4.3 of the MUSTEC project, funded by the European Commission under the H2020 programme. Madrid. http://mustec.eu/sites/default/files/reports/4.3Analysis_of_the_drivers_and_barriers.pdf

Del Río, P., and C. P. Kiefer 2019. Evaluation of the pros and cons of different alternative CSP projects and policy implications. Deliverable 5.2 of the EU-funded MUSTEC project.

Del Río, P., N. Caldés, and C. P. Kiefer 2018. Potential Obstacles to the Use of Cooperation Mechanisms for CSP in the Future. Report for task 4.4 of the MUSTEC project, funded by the European Commision under the H2020 programme. Madrid. https://ec.europa.eu/research/participants/documents/downloadPublic?documentIds=080166e5c03d74ee&appId=PPGMS

Del Río, P., and P. Mir-Artigues. 2019. Designing auctions for concentrating solar power. *Energy for Sustainable Development* 48:67–81. doi:10.1016/j.esd.2018.10.005.

Deutsche, E. 2014. *DENA-Studie Systemdienstleistungen 2030*

Dütschke, E., S. Min, R. Sala, and C. Oltra 2018b. Stakeholder mapping report. Report of the EU-funded MUSTEC project. https://www.mustec.eu/node/72

Dütschke, E., U. Burhard, R. Sala, C. Oltra, and S. López 2018a. Socio-political acceptance findings. ReportoftheEU-fundedMUSTECproject.2020.Electricitybalancing.https://www.entsoe.eu/network_codes/eb/. https://www.mustec.eu/node/98ENTSOE

ENTSOE (2020). Electricity balancing. https://www.entsoe.eu/network_codes/eb/

European Commission. 2016. Innovative financial Instruments for first-of-a-kind, commercial-scale demonstration projects in the field of energy. http://ec.europa.eu/research/energy/pdf/innovative_financial_instruments_for_FOAK_in_the_field_of_Energy.pdf

European Commission. 2018a. Cross-border renewables projects in the new connecting Europe facility. https://ec.europa.eu/energy/sites/ener/files/documents/4-holl_presentation_on_cross-_border_res_in_cesec_clean.pdf

European Commission. 2018b. Proposal for a regulation of the European Parliament and of the Council establishing the Connecting Europe Facility and repealing Regulations (EU) No 1316/2013 and (EU) No 283/2014. Brussels. https://ec.europa.eu/commission/sites/beta-political/files/budget-may2018-cef-regulation_en.pdf

European Commission DG-ENER. 2018. Towards a more Europeanised approach to renewables policy–A possible instrument to support cross-border cooperation on renewables in the multiannual financial framework post-2020. *Background Document for the Expert Consultation Meeting* (Brussels).

Guebebia, I., and M. S. Jomâa. 2017. Methodology of technico-economical performances evaluation of concentrating solar power (CSP) plants for trigeneration. *Energy Sources, Part B: Economics, Planning, and Policy* 12 (2):147–57. doi:10.1080/15567249.2014.919042.

Gyalai, M., L. Zentkó, C. Hegyfalvi, G. Detzky, P. Tildy, and N. H. Baranyai. 2020. Gábor Pintér and Henrik Zsiborács 2020. The role of electricity balancing and storage: developing input parameters for the European calculator for concept modeling. *Sustainability* 12 (811):1–26.

Holl, M. 2019. Supporting cross-border cooperation on renewables in the baltics and beyond – The new Connecting Europe facility (CEF). EUFORES IPM, Helsinki, http://www.eufores.org/fileadmin/eufores/Events/IPMs/IPM_19_Helsinki/Presentations/Michaela_Holl-EC.pdf

IEA. 2014b. *Energy technology perspectives*, Vol. 2014. París, France: IEA publications. http://www.iea.org/etp/etp2014/.

Karacosta, C., Marinakis, V., Flamos, A., Tuerk, A., Frieden, D. (2016). Expanding RES cooperation with West Balkans: from importing electricity to exporting RES. International Journal of Energy Sector Management, 10(4), 363–380

Kiefer, C. P., & del Río, P. (2020). Analysing the barriers and drivers to concentrating solar power in the European Union. Policy implications. Journal of Cleaner Production, 251. https://doi.org/10.1016/j.jclepro.2019.119400

Lilliestam, J., L. Ollier, M. Labordena, S. Pfenninger, and R. Thonig. 2020. The near- to mid-term outlook for concentrating solar power: Mostly cloudy, chance of sun. *Energy Sources, Part B: Economics, Planning, and Policy*. doi:10.1080/15567249.2020.1773580.

Lilliestam, J., R. Thonig, G. Resch, G. Totschnig, J. Geipel, M. Ragwitz, . . . N. Caldés Gómez 2018. Mapping the policy variables affecting the role of concentrating solar power in the European Union. Report of the EU-funded MUSTEC project.

Lilliestam, J., S. Ellenbeck, C. Karakosta, and N. Caldés. 2016. Understanding the absence of renewable electricity imports to the European Union. *International Journal of Energy Sector Management* 10 (3):291–311.

Mehos, M., J. Jorgenson, P. Denholm, and C. Turchi. 2015. An assessment of the net value of CSP systems integrated with thermal energy storage. *Energy Procedia* 69:2060–71. doi:10.1016/j.egypro.2015.03.219.

Mir-Artigues, P., P. Del Río, and N. Caldés Gómez. 2019.Cham (Switzerland). *The economics and policy of concentrating solar power generation*. Springer.

Otner, A., and G. Thosti. 2019. The future relevance of electricity balancing markets in Europe - A 2030 case study. *Energy Strategy Reviews* 24:111–20.

Papapostolou, A., Karacosta, C., Marinakis, V., Flamos, A. 2016. Assessment of RES cooperation framework between the EU and North Africa: A multicriteria approach based on UTASTAR. International Journal of Energy Sector Management 10(3), 402–426

Reinier, A. C., and R. A. H. van der Veen. 2016. The electricity balancing market: Exploring the design challenge. *Utilities Policy* 43:186–94.

Verdolini, E., L. D. Anadón, E. Baker, V. Bosetti, and L. Aleluia Reis. 2018. Future prospects for energy technologies: insights from expert elicitations. *Review of Environmental Economics and Policy* 12 (1):133–53. doi:10.1093/reep/rex028.

Welisch, M. 2019. The market environment for CSP projects in Europe. Report 6.1 of the EU-funded project MUSTEC.