Market Uptake of Solar Thermal Electricity through Cooperation

MUSTEC D6.2: Policies for CSP deployment by renewable energy cooperation in the EU

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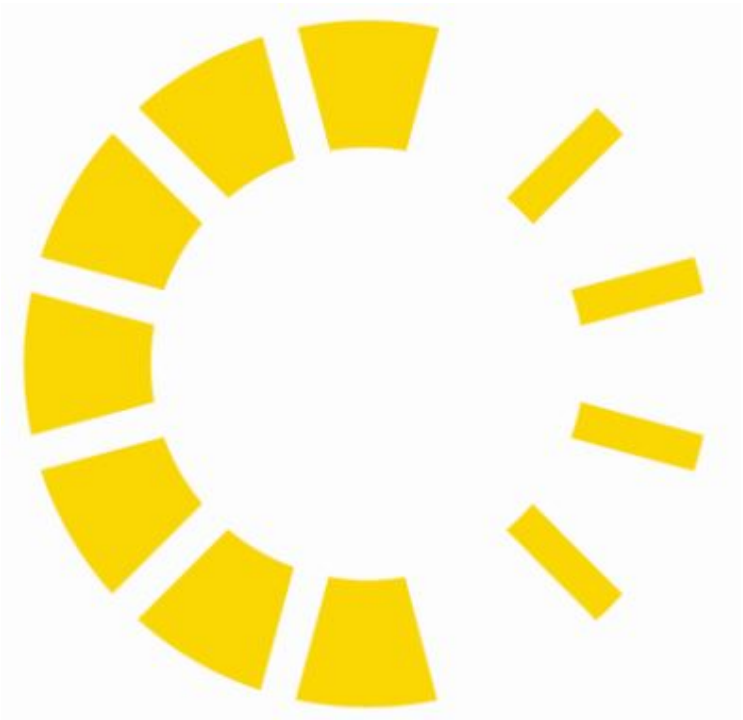
September 2019

The project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 764626

A report compiled within the H2020 project MUSTEC
(work package 6, D6.2.)



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This report should be cited as: Essig, S., Boie, I., Winkler, J., Ragwitz, M., Del Rio, P. (2019): Policies for CSP deployment by renewables energy cooperation in the EU. Deliverable 6.2, MUSTEC Project, Fraunhofer ISI, Karlsruhe

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CSIC, Consejo Superior de Investigaciones Científicas

ABOUT THE PROJECT

In the light of the EU 2030 Climate and Energy framework, ***MUSTEC- Market uptake of Solar Thermal Electricity through Cooperation*** aims to explore and propose concrete solutions to overcome the various factors that hinder the ***deployment*** of concentrated solar power ***(CSP)*** projects in Southern Europe capable of supplying renewable electricity on demand to Central and Northern European countries. To do so, the project will analyse the ***drivers and barriers*** to CSP deployment and renewable energy (RE) cooperation in Europe, identify future CSP ***cooperation opportunities*** and will propose a set of concrete ***measures*** to ***unlock the existing potential***. To achieve these objectives, MUSTEC will build on the experience and knowledge generated around the cooperation mechanisms and CSP industry developments building on concrete CSP ***case studies***. Thereby we will consider the present and future European energy market design and policies as well as the value of CSP at electricity markets and related economic and environmental benefits. In this respect, MUSTEC combines a dedicated, comprehensive and multi-disciplinary analysis of past, present and future CSP cooperation opportunities with a constant ***engagement*** and ***consultation*** with ***policy makers*** and ***market participants***. This will be achieved through an intense and continuous ***stakeholder dialogue*** and by establishing a tailor-made ***knowledge sharing network***.

Project information	
Project Number	764626
Project title	Market uptake of Solar Thermal Electricity through Cooperation - MUSTEC
Starting date	01/10/2017
Duration in months	36
Call identifier	H2020-LCE-2017-RES-CSA

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1 INTRODUCTION

This report gives an overview about the political framework for renewable energy deployment in the EU with a focus on potential future cooperation between Member States for CSP deployment. The content complements other deliverables of this project which have already analysed and identified, inter alia, reasons for the limited use of cooperation mechanisms in the past *(D4.1 [Caldés, N., Lechón, Y., Rodríguez,I., del Río, P. (2018)]*), drivers and barriers for the market uptake of CSP in the EU *(D4.3, [Del Rio, P. Kiefer, C.P. (2018),])* and potential obstacles to the use of cooperation mechanisms for CSP in the future *(D4.4, [Del Río, P., Caldés, N. and Kiefer, C. P. (2018).]).* While the market situation of CSP was described in Deliverable 6.1 *[Welisch, M. (2019)],* we concentrate on the political point of view and analyse mainly the role of energy policy changes occurring after 2020.

For this purpose, we first describe the present political framework (Directive 2009/28/EU) and briefly summarize the limited extent to which cooperation mechanisms have been used so far between Member States. Unfortunately, several EU countries are expected to miss their binding 2020 renewable energy targets, meaning a country-specific percentage number for the share of energy from renewable energy sources (RES) in the gross final energy consumption. These national 2020 targets are the basis for each country's contribution towards the new EU-wide 2030 renewable energy target. Therefore, an accelerated expansion and use of renewable energy technologies is needed in the coming years and in turn cooperation and cross-border actions will likely gain in importance. Changes of the EU renewable energy policies, in particular the definition of a new binding EU-wide target for the share of renewable energies by 2030, that become effective in 2020 and which are stipulated in EU Regulation 2018/1999 (Governance Regulation) and Directive 2018/2001, are thoroughly explained in section 2.2. The discussion focuses mainly on measures for the support of electricity generation from renewable energy sources and the possibilities for the use of cooperation mechanisms between EU Member States.

By 31st December 2018, all EU Member States had to submit drafts of their national energy and climate plans (NECPs) for the period 2020 to 2030. These specify the national renewable energy targets but also describe which technologies will be used in the countries to reach these targets. We analyzed the NECPs with respect to CSP expansion and prepared a list of Member States which intend to install new CSP capacities (see section 3.1). Further, the effectiveness of RES support schemes to incite CSP deployment is briefly discussed and since competitive auctions for feed-in premiums will be the major RES support mechanism in the EU, critical auction design elements are discussed regarding their relevance for CSP.

Finally, we assess the potential future use of cooperation mechanisms in the EU. For this we have identified those Member States which will likely need to engage in cooperation with other Member States in order to meet the 2030 target, but also those which might be interested to act as hosts for

RES projects. Those hosts need to approve the additional installation of a power plant on their territory and agree with a partial statistical or physical export of electricity generated from renewable energy sources. Correlating this estimation with the country's interest in CSP leads to conclusions about potential future CSP cooperation projects in the EU. In addition, we reflect upon the role that future EU policy instruments, like the new EU Financing Mechanism that will be established in 2021, might play for the support of cross-border CSP deployment.

2 STATUS QUO OF RES COOPERATION POLICIES IN EUROPE

In this section we first give a summary of the last RES Directive 2009/28/EU and explain to what extent cooperation mechanisms have been used so far by Member States to reach their renewable energy target till 2020. After a glimpse into the progress towards the 2020 goals, the new EU Governance Regulation 2018/1999 and RES Directive 2018/2001 are presented and discussed with an emphasis on cooperation mechanisms and support options for RES deployment. In addition an overview of the Member States' ambition for 2030 as stated in their national energy and climate plan drafts is given.

2.1 Legal framework for RES cooperation in the EU until 2020

2.1.1 *Cooperation mechanisms under the RES Directive (2009/28/EC)*

The EU Directive 2009/28/EC on the promotion of the use of energy from renewable sources set a **2020 EU target of 20%** for the overall share of energy from renewable sources in the gross final energy consumption. Binding national targets were set for each Member State which range from 10% for Malta to 49% for Sweden (see Figure 1a). These national targets were calculated based on the historical RES deployment of the Member States and their gross domestic product using a flat-rate approach. The individual potential for RES deployment in the Member States was not considered, which makes it harder for some countries to reach the target than for others. As the overall costs and LCOE of RES projects differ from country to country, Directive 2009/28/EC allows Member States to reach their targets by utilizing the following cooperation mechanisms:

- **Statistical transfers between Member States (Art. 6):** Cooperation in terms of statistical transfer does not require any physical transfer of energy and thus no interconnection between the involved countries is needed. Instead, a specific amount of electricity generated from RES is deducted in the host country from its total RES production and added to the amount of energy generated by RES in the off-taker country.
- **Joint projects between Member States (Art. 7):** Two or more Member States may conclude joint projects for the production of energy (electricity, heating, cooling) from RES. The energy generated on the territory of one Member State may be counted towards the national overall target of another Member State as jointly agreed but not beyond 2020.
- **Joint projects between Member States and third countries (Art. 9):** One or more Member States may implement joint projects for energy production from RES with third countries. However, in order to count the energy produced in a non-EU country towards the RES target

of an EU Member State the energy must be consumed in the EU, hence a physical interconnection is required. If this is not possible due to missing connection lines, the electricity may still be counted if the construction of an interconnection started before 2017 and will be operational by the end of 2022.

- **Joint support schemes (Art. 11):** Two or more Member States may decide to join or coordinate their RES support schemes and share the produced energy either by a statistical transfer or by using a distribution rule.

2.1.2 *Past use of cooperation mechanisms under the RES Directive (2009/28/EC)*

Even though cooperation mechanisms were suggested about a decade ago, they were only used by few countries and in a very limited manner. The few cases realized to date are briefly summarized in the following. A more detailed analysis of past cooperation initiatives is presented in Caldés N., Rodriguez I., Lechon Y., del Río P. (2018).

In 2017, both **Estonia and Lithuania** signed individual agreements with **Luxemburg** about the statistical transfer of RES electricity generated on their territory. Thereby, the two eastern European countries will help the small, 2586 square kilometers central European country to fulfill its 2020 RES target.

Germany and Denmark held their first cross-border auctions for renewable subsidies for solar photovoltaic (PV) installations as pilot projects in 2016. One open auction for sliding feed-in premiums was held in Germany and one for fixed feed-in premiums was in Denmark. An overview of the auction design is given in Table 1. Interestingly, in both cases the winning bids were projects located in Denmark and even the Danish auction attracted no bids from Germany. The latter was attributed to the very small installation size of 2.4 MW, a national auction in German with a volume of 160 MW that took place a few days later and the effort to familiarize with the Danish support scheme [von Blücher F., et al. (2019)]. The financing costs of the supportive premiums are born by the auction-holding country, and in turn also the corresponding solar electricity is counted towards the national target of that country. More details about the auction can be found in [von Blücher F., et al. (2019)].

In 2012**, Sweden** started a Joint Electricity Certificate scheme with its neighboring country **Norway** which is not an EU Member State. The scheme is technology-neutral and initially intended to support 28.4 TWh of power generation by 2020. RES producers receive one certificate per MWh of generated electricity for a period of 15 years but only for plants commissioned before the end of 2020 (§ 8 par. 4 Electricity Certificates Act [RES legal (2019)]). Norway and Sweden share the costs of their joined RES support and the RES electricity equally, regardless of the location of the RES power plant.

Table 1. Overview of design features and outcome of the first joint German-Danish cross-border auctions (content partly copied from [von Blücher F., et al.(2019)]).

Element of Auction	German cross-border auction	Danish cross-border auction
Volume	50 MW	20 MW (only 2.4 MW open to installations in Germany)
Maximum bid size	Projects in the range of 0.1–10 MW in size were eligible.	2.4 MW
Deadline for submitting bids	23 November 2016	8 December 2016
Remuneration method	Uniform pricing, No premiums are paid if negative prices persist for more than 6 consecutive hours.	Pay-as-bid, Premiums are paid only when (local) market prices are positive.
Ceiling price	The maximum accepted bid is 11.09 ct/kWh.	No ceiling price.
Premium design	sliding feed-in premium based on the local market prices	fixed feed-in premium paid on top of the local market prices
Material prequalification	Proof of land ownership or permission from the land owner of the site. No further material prequalification was required, which is less compared to the national auction.	No material prequalification criteria apply. Permits and licenses to be provided ahead of construction.
Financial prequalification	Bid bond of 70 €/kW. To balance lower material prequalification, the financial prequalification was raised compared to the national auction.	180 DKK per kW (approx. €24.12)
Realisation deadline and penalty	After 18 months the premium is reduced by 0.3 €ct/kWh. After 24 months the contract is revoked and a penalty of the size of the bid bond is levied.	If the project is not connected to the grid within 2 years, the contract is terminated, and the energy agency claims the amount guaranteed
Outcome	Auction attracted 43 bids, totalling 297 MW: ▪ 26 bids in total 143 MW for projects in Germany ▪ 17 bids in total 154 MW for projects in Denmark ➔ All 5 winning bids were projects located in Denmark, each 10MW, sliding premium of 5.38 ct/kWh	Auction attracted 36 bids, totalling 79.5 MW: ▪ no bids for projects in Germany ▪ all 36 bids for projects in Denmark ➔ 9 winning bids by 3 companies, fixed premium of 12.89 øre/kWh (approx. 1.73 ct/kWh)

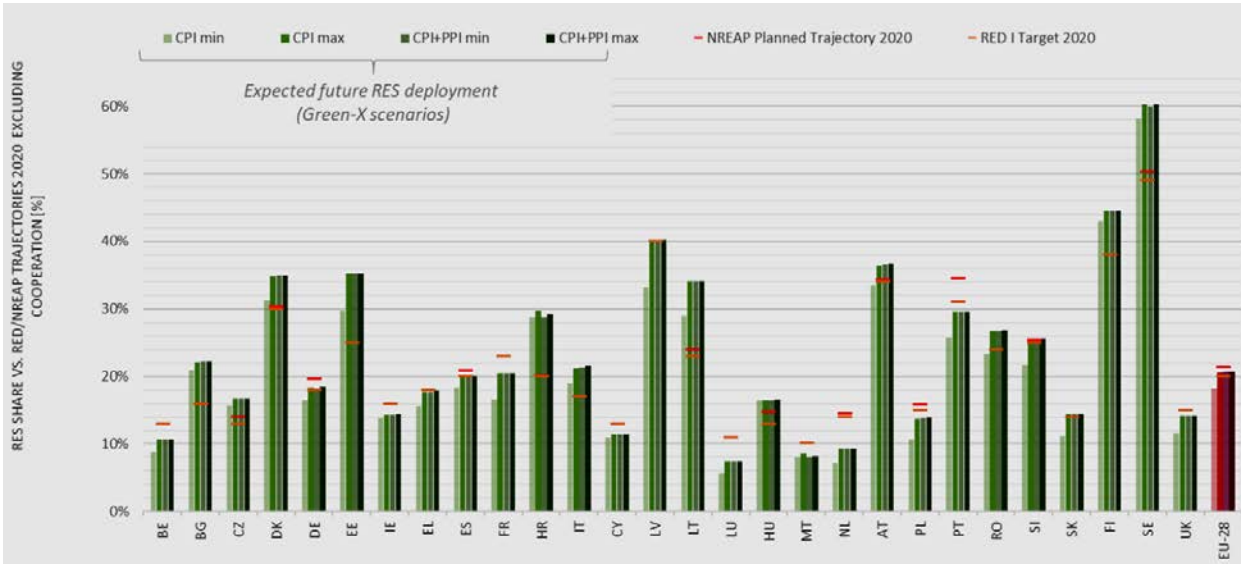
2.1.3 *Progress of Member States towards the 2020 targets*

An assessment of the Member States progress towards the 2020 RES target was included in the Renewable Energy Progress Report *[COM(2019) 225 final]* published by the European Commission in April 2019. It is based on an analysis performed in Ref. *[Navigant (2019)]* which used models considering the Current Policy Initiatives (CPI) and Planned Policy Initiatives (PPI) to estimate the expected RES share of each Member State in 2020. They concluded that on EU level a share of 18.1% to 20.7% of renewable energy of the final energy consumption can be expected, meaning that there is still a chance to hit or even exceed the EU wide 20% target. However, as shown in Figure 1a, 11 Member States (Belgium, Cyprus, France, Greece, Ireland, Luxembourg, Malta, the Netherlands, Poland, Portugal and the United Kingdom) will most likely not reach their national target in 2020, if there are no amendments of the national policies and without the use of cooperation mechanisms. Austria, Germany, Latvia, Romania, Slovenia, Slovakia and Spain, hence 7 Member States, have good chances to meet the 2020 target but this will depend on the reduction of their energy demand. All other countries are doing very well or have already reached their 2020 RES target.

Figure 1b additionally includes the agreed statistical transfer of RES energy from Estonia and Lithuania to Luxembourg. Thanks to this transfer, the expected 2020 RES share in Luxembourg increases from ~7% to the targeted 11%. In the Baltic countries, this transfer reduces the national RES share, however, due to their comparably higher total energy consumption, this reduction is minor and equals below one percent absolute.

Figure 1 also reveals that more countries could reach the 2020 target when using cooperation mechanisms, particularly statistical transfers, which is mainly an administrative process. Especially Bulgaria, Czech Republic, Denmark, Estonia, Croatia, Italy, Lithuania, Finland and Sweden might achieve significant numbers of surplus RES energy.

(a)



(b)

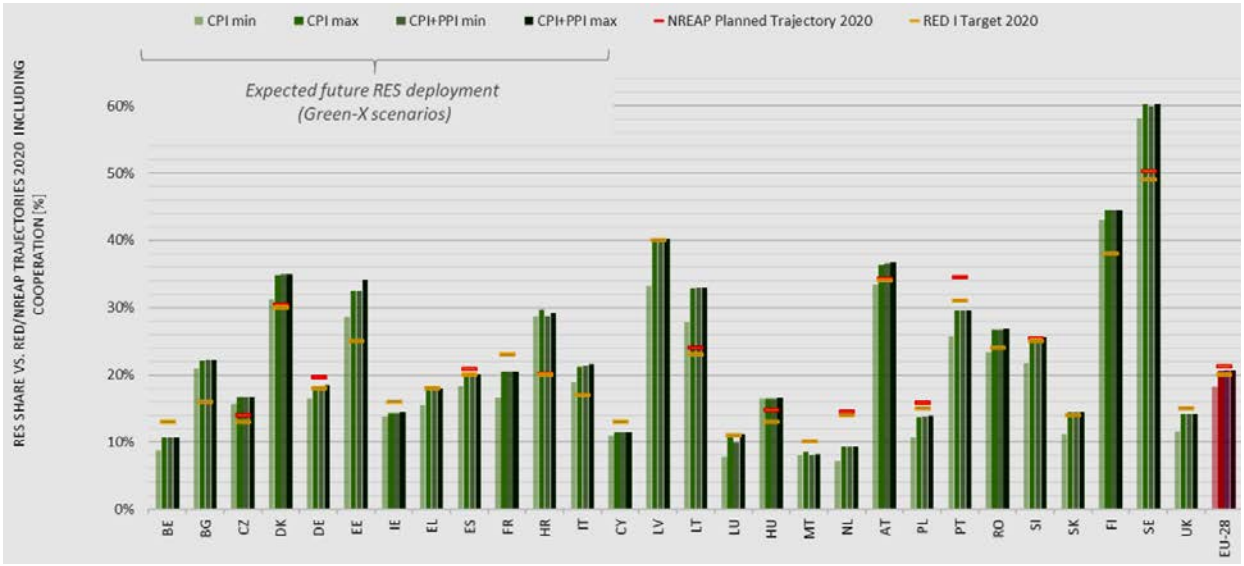


Figure 1: Comparison of expected renewable energy share [%] in 2020 and binding 2020 targets from Directive 2009/28/EC (RED I Target 2020) and 2020 planned (NREAP Planned Trajectory 2020) targets (a) excluding and (b) including the agreed cooperation of Luxembourg with Estonia and Lithuania. Figures copied from [Navigant (2019)].

2.2 Legal framework for RES support and cooperation in the EU from 2020-2030

2.2.1 *Introduction – the 'Clean Energy for all Europeans' CE4ALL legislative package*

The cornerstones of the EU climate and energy policy for the period 2021 to 2030 are defined by the latest legislative package 'Clean Energy for all Europeans – CE4ALL'. The legislative documents included in this package define the European strategy for the transition to a low carbon economy in accordance with the commitments of the Paris Agreement. The deployment of energy efficiency and renewable energy technologies as well as a stronger regional market integration and enhanced cooperation in the energy sector are central components of this strategy.

The CE4ALL package comprises eight documents[1] presented in Table 2, which were adopted in May 2019[2].

Table 2 Components of the Clean Energy for all Europeans (CE4ALL) package

Legal document	Full title
Energy Performance in Buildings Directive 2018/844	Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency[3]
Recast Renewable Energy Directive 2018/2001	Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources[4]
Revised Energy Efficiency Directive 2018/2002	Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 amending Directive 2012/27/EU on energy efficiency[5]
Governance Regulation 2018/1999	Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives

[1] Note on the different types of legal documents: A directive is a legislative document which establishes targets and general requirements which must be transposed into national laws by the individual Member States while regulations are directly binding for all Member States.

[2] https://ec.europa.eu/info/news/clean-energy-all-europeans-package-completed-good-consumers-good-growth-and-jobs-and-good-planet-2019-may-22_en.

[3] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&from=EN

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2002&from=EN

Legal document	Full title
	94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council[6]
Regulation on Risk-Preparedness in the electricity sector 2019/941	Regulation (EU) 2019/941 of the European Parliament and of the Council of 5 June 2019 on risk-preparedness in the electricity sector and repealing Directive 2005/89/EC[7]
Regulation for the Agency for the Cooperation of Energy Regulators (ACER) 2019/942	Regulation (EU) 2019/942 of the European Parliament and of the Council of 5 June 2019 establishing a European Union Agency for the Cooperation of Energy Regulators[8]
Regulation on the internal market for electricity 2019/943	Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity[9]
Directive on common rules for the internal market for electricity 2019/944	Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU[10]

Of particular relevance in the context of renewable energy cooperation are the Recast Renewable Energy Directive 2018/2001, which defines the binding target for the deployment of renewable energy on European level and sets guidelines for renewable energy support schemes (and cooperation), and the Governance Regulation 2018/1999, which establishes a governance system for the implementation of the energy and climate strategies on national level in the form of National Energy and Climate Plans (NECPs) and introduces mechanisms and instruments in case that a delivery gap regarding the collective EU RES target should occur. Further, the legislative documents dealing with the EU electricity market design (i.e. Electricity Regulation, Electricity Directive and Risk-Preparedness Regulation) include several aspects relevant for a stronger integration and coordination of the electricity markets of the EU Member States (e.g. better regional coordination of electricity supply and promotion of cross-border electricity exchange) which can be implicitly relevant for cooperation projects. The respective instruments and their potential relevance to CSP cooperation projects will be described in the following sections.

[6] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018R1999&from=EN

[7] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0941&from=EN

[8] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0942&from=EN

[9] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=EN

[10] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019L0944&from=EN

2.2.2 *Renewable energy targets for the period 2021-2030 (RES Directive 2018/2001 and Governance Regulation 2018/1999)*

In December 2018, the recast of Directive 2009/28/EC of the European Parliament and of the Council was adopted which aims to reinforce the Union's energy security, internal energy market, energy efficiency, decarbonisation, and research, innovation and competitiveness. The Recast RES Directive 2018/2001 and the Governance Regulation 2018/1999 define a new binding target for the share of renewable energies in the EU gross final energy consumption of at least 32 % in 2030. The indicative trajectory (Art.4, Reg 2018/1999) implies that EU-wide, at least 18 %, 43% and 65% of the total RES share increase will be reached in 2022, 2025 and 2027, respectively. In addition, a provision for the review and possible increase of this EU-wide binding target level by 2023 was included. As a major difference to the RES Directive 2009/28/EC, no break-down of the target for the individual Member States is included, but, in accordance with Article 9, the Member States are required to draft integrated national energy and climate plans (NECPs) by 31 December 2018 which specify their envisaged (non-binding) RES share in 2030. These NECP replace the former National Renewable Energy Action Plans (NREAPs) developed under the RES Directive 2009/28/EC. In case the sum of the Member State's RES contributions stays below the EU-wide regulated target, a so-called ambition gap exists and the commission will give recommendations to individual Member States with respect to their target level ambition and related policies and regulations.

Definition of RES contributions on national level

The gross final energy consumption in each Member State from renewable energy sources equals the sum of the gross final consumption in transport, heating and cooling sector and electricity. For this purpose, gas, electricity and hydrogen shall only be considered once and the contribution from wind and hydro power plants are accounted by using a normalization algorithm defined in Annex II of RES Directive 2018/2001 considering the production and capacity during the past 15 years. Notably, electricity generated by a hydropower plant with water that had previously been pumped uphill may not be counted – regardless of the electricity generation technology used for up-hill water pumping.

For the assessment of each Member States' contribution towards reaching the EU-wide 32% target, Annex II of the Governance Regulation 2018/1999 defines an equation to calculate the objective 2030 RES share target of each Member State *($Share_{2030}$), as:*

$$Share_{2030} = Share_{2020} + 0.3 \times C_{Flat} + 0.3 \times C_{GDP} + 0.3 \times C_{Potential} + 0.1 \times C_{Intercon} \qquad \textit{(equation 1)}$$

Here, the 2020 national RES target (*$Share_{2020}$)* plus a constant flat-rate contribution (C_{Flat}) is used as a base and country-specific contributions depending on the individual economic situation (C_{GDP}), the available potential ($C_{Potential}$) and level of interconnection ($C_{Intercon}$) are added. The individual

elements are considered in the equation with relative weights. Details about each criterion are summarized in Table 3.

Table 3: Criteria for the calculation of the 2030 RES contributions of each Member State [Winkler, J., Held, A., Ragwitz, M. (2019)]

$Share_{2020}$	The Member State's national binding target for 2020, RES share shall not fall below this number.
C_{Flat}	A flat rate contribution: Each Member State needs to increase its share of RES in terms of the same increase in percentage points. Assuming a required increase of 12%-points and 30% weight, this means that each Member State needs to increase by 3.6 %-points (= 0.3 × C_{Flat}).
C_{GDP}	A GDP-per-capita based contribution: The economic situation of each Member State is taken into account, by using a Eurostat's GDP per capita index (in purchasing power standards, referring to the average GDP between 2013 and 2017). The index for each Member State is individually capped at 150 % of the Union average. The sum of all Member States' CGDP together contributes to 30 % of the difference between 2030 and 2020 EU-wide RES target.
$C_{Potential}$	A potential-based contribution based on the difference between each country's 2030 PRIMES scenario[11] and its national binding target for 2020. Thereby, the national situation in terms of renewable energy resources is taken into account. The sum of all Member States C_{Pot} shall contribute 30 % of the difference between 2030 and 2020 EU-wide RES target.
$C_{Intercon}$	A contribution reflecting the interconnection level of the Member States. The electricity interconnection share index to Union average in 2017 is used as a base and measured by the net transfer capacity over total installed generation capacity. The interconnection share index is capped at 150 % of the Union average for each Member State individually. The sum of all Member States $C_{Intercon}$ shall contribute 10 % of the difference between 2030 and 2020 EU-wide RES target.

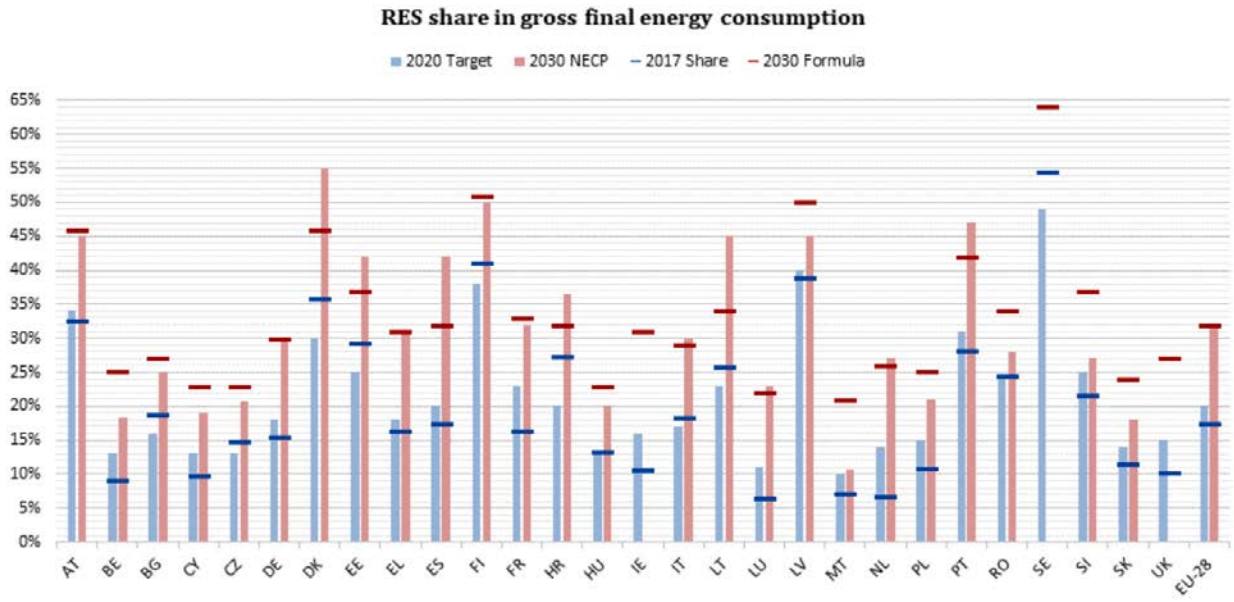
[11] The PRIMES scenario is a model based reference scenario for the EU which includes energy consumption and the energy supply system. It is regularly reviewed and updated. More information on PRIMES can be found under: https://ec.europa.eu/energy/en/data-analysis/energy-modelling (last accessed 15.9.2019)

Present ambition level of the Member States' RES contributions towards 2030

A first communication analyzing the NECPs drafts of the Member States was published by the European Commission in June 2019 (COM(2019)285 final). It was concluded that the envisaged contributions of only 11 Member States are in line or above the individual national share resulting from equation 1 (Annex II of the Governance Regulation). For example, Spain, which is a prime location for CSP deployment, targets a 42% RES share (NREP) in 2030, which is significantly higher than the 32% reference value resulting from equation 1. In contrast, and as shown in Figure ***2***, the submitted 2030 RES targets of 14 Member States (Belgium, Bulgaria, Cyprus, the Czech Republic, Finland, France, Hungary, Ireland, Latvia, Malta, Poland, Romania, Slovenia, Slovakia) were lower than the calculated objective value and the Member States were thus requested to reconsider their level of ambition in order to reach the overall EU target of 32%. According to the current NECPs, the aggregated EU-wide RES share in 2030 would only reach a value of 30.4% to 31.9% at Union level, which means that, based on the present NECPs, an EU-wide ambition gap exists.

The final NECPs are expected for December 2019 and must be updated again by 2023 (draft version) and 2024 (final version). The progress on national level will be monitored in biannual progress reports starting in 2021 (Governance Regulation 2018/1999, Article 29).

(a)



(b)

MS	2017	2020 target	MS	RES Formula contribution	Draft NECP
BE	9.06%	13%	BE	25%	18.3%
BG	18.73%	16%	BG	27%	25%
CZ	14.76%	13%	CZ	23%	20.8%
DK	35.77%	30%	DK	46%	55%
DE	15.45%	18%	DE	30%	30.0%
EE	29.21%	25%	EE	37%	42%
IE	10.65%	16%	IE	31%	Between 15.8% and 27.7%
EL	16.32%	18%	EL	31%	Between 31% and 32%
ES	17.51%	20%	ES	32%	42%
FR	16.3%	23%	FR	33%	32%
HR	27.29%	20%	HR	32%	36.4%
IT	18.27%	17%	IT	29%	30%
CY	9.85%	13%	CY	23%	19%
LV	39.01%	40%	LV	50%	45%
LT	25.84%	23%	LT	34%	45%
LU	7.5%	11%	LU	22%	23%-25%
HU	13.33%	13%	HU	23%	20%
MT	7.17%	10%	MT	21%	Between 10.6% and 13.3%
NL	6.6%	14%	NL	26%	27-35%
AT	32.56%	34%	AT	46%	45-50%
PL	10.9%	15%	PL	25%	21%
PT	28.12%	31%	PT	42%	47%
RO	24.47%	24%	RO	34%	27.9%
SI	21.55%	25%	SI	37%	27%
SK	11.49%	14%	SK	24%	18%
FI	41.01%	38%	FI	51%	50%
SE	54.5%	49%	SE	64%	65%
UK	10.21%	15%	UK	27%	-

Figure 2: Graphical (a) and tabular (b) comparison of the member States' RES targets and intended national contributions for 2020 (NREAP) and 2030 (NECP) with the RES share in 2017 and 2030 formula of Annex II of the Governance Regulation of each country. Figures copied from [SWD(2019) 212/213 final] and [COM(2019) 285 final].

2.2.3 *The EU "gap-filler" mechanism*

In case the collective efforts of the Member States remain insufficient to reach the binding EU-wide 32% target (2030) or that the reference points of the indicative Union trajectory are missed, a so-called delivery gap exists. For this case, the Governance Regulation (2018/1999) has foreseen additional „gap-filler" measures. These imply that actions shall be implemented by those countries which fall below the reference points indicated in their NECPs (Article 32/3). The actions may include:

(a) the application of **national measures to increase the RES-share**,
(b) the increase of RES in the heating & cooling sector,
(c) the increase of RES in the transport sector,
(d) a **voluntary contribution to the Union financing mechanism** (see section 2.2.5), or
(e) the use of **cooperation mechanisms** (see section 2.2.6) as set out in Directive (EU) 2018/2001.

2.2.4 *RES support under Directive 2018/2001*

Regarding measures to increase the national RES share, Directive 2018/2001 (Art.4) defines **requirements referring to the design of support schemes for electricity from renewable sources**. These imply that support levels must be set based on a **competitive procedure (such as auctions)**; that support must be provided in the form of **market premiums (fixed or sliding**) on top of the market price and that support should be **technology neutral**. However, exemptions exist for the before mentioned requirements. The tendering process may be limited by the Member States to specific technologies if it can be shown that a technology neutral process would lead to a suboptimal result, in view of the need for technology diversification; the long-term potential for individual technologies; network constraints and grid stability; grid integration costs; the need to avoid distortions of raw material markets for biomass. Also small installations or demonstration projects can be exempt from the requirements. This is relevant with regard to CSP as, due to the comparatively high LCOE, a technology neutral auction would likely not allow for the successful participation of CSP projects.

A further requirement laid out in Directive 2018/2001 (Art. 5(1)) refers to the **opening of support schemes** for electricity generated from renewable energy sources to producers located in other Member States. The participation of foreign producers may have a yearly indicative share of minimum 5 % from 2023 to 2026 and minimum 10 % from 2027 to 2030, or (if lower) according to the Member State's level of interconnectivity in that year. Furthermore, pilot projects of such open support schemes may be organized. When opening its support scheme, the Member State may

require proof of physical import of the electricity which would limit the location of participating RES producers to the neighboring countries with existing interconnections.

In case of opened support schemes, the involved Member States shall find agreements regulating at least the allocation of the corresponding RES electricity. If desired by the Member States, the Commission will assist with the negotiations, provide guidance, technical expertise and information regarding financial aspects of this kind of cooperation.

However, the opening of support schemes as described by Art. 5 is purely optional, so far. **By 2023, the Commission will review the utilization of this option and will decide about the possibility of a mandatory opening of RES support schemes** (Art. 5/5). This would imply a significant push for cross-border cooperation in RES deployment and might also create new opportunities for cross-border CSP projects.

As energy storage is essential for the energy security and the flexibility of the energy system, the Governance Regulation 2018/1999 demands it to be part of the Member States' NECPs and their progress reports. However, there are no concrete targets or measures foreseen which might further increase the Member States' engagement in this field. Nevertheless this could potentially lead to a positive impact for the deployment of CSP in the future.

2.2.5 *The EU enabling framework*

Another new element in the recast RES Directive 2018/2001 is the **enabling framework** for renewable energy defined in Art. 3(5). It shall support the Member States' ambitions in renewable energy deployment and promote their decarbonisation process in order to ensure that the binding 2030 RES target on EU level is reached. To this end, it stipulates the use of Union funds and additional funds, for different activities:

- The reduction of the cost of capital for renewable energy projects;
- The implementation of projects and programs for the enhanced integration of renewable sources into the energy system and to increase system flexibility;
- The development of the electricity grid including storage facilities and other grid related actions to reach the 15 % electricity interconnection target by 2030;
- The promotion of cooperation between Member States or Member States and third countries through joint projects, joint support schemes and opening of support schemes for RES deployment.

The above mentioned elements of the enabling framework may be of direct relevance to CSP cooperation projects in particular as they explicitly address the support of projects that can contribute to increasing system flexibility as well as storage options. This implies that under the

enabling framework, additional support in form of low-interest loans or grants may be granted for CSP projects which help to increase electricity system flexibility in the EU Member States. Further, the enabling framework explicitly foresees the enhancement of regional cooperation and joint projects in renewable energy, which implies that in particular cooperation projects would be in the focus of the measures.

The reduction of capital costs for RES projects through the enabling framework could also support RES cooperation projects by making RES more competitive in the cross-border context. Costs of financing renewables differ substantially between the EU Member States. Usually measured as the weighted average costs of capital "WACC", they are partially influenced by the kind of support system for renewables, which is in place in a certain country or the political and economic framework conditions. For example, a fixed feed-in tariff over a long period (e.g. 20 years) implies a lower revenue risk for the plant operator, while a quota system with a market for green certificates or a fixed premium paid on top of the electricity wholesale price implies a higher revenue risk. However, another part of the investment risk also depends on the overall risk associated with the economic and political situation in the respective country. An indicative study by the DIA-CORE project[12] found that WACC for onshore wind power plants differ substantially between EU Member States with values between 3.5% and 4.5% in Germany on one end and up to 12% in Greece and Croatia on the other end of the spectrum. Here, the use of risk-reduction instruments could substantially decrease the investment needs for RES projects and help to reduce differences in the competitive market environment among Member States. This would help to create a more level playing field which would implicitly foster RES cooperation.

2.2.6 *The EU financing mechanism*

The EU renewable energy financing mechanism will be established by January 2021 and was introduced by the Governance Regulation 2018/1999 (Art. 33). It is the central element to fill a potential future delivery gap that might occur between the real and the envisioned pathway towards the EU-wide binding 32% RES target for 2030. Its main purpose is thus to increase the share of renewable energies in the gross final energy consumption of the EU Member States based on initiative on Union level. It includes the following strategies:

- Competitive tenders to support RES projects in the European Union shall take place.
- Support may be granted as feed-in premiums on top of the market prices to the bidder offering lowest costs or premium.

[12] http://diacore.eu/?option=com_content&view=article&id=11

- Member States have the right to decide about renewables installations in their territory. The Commission will also provide rules for the implementation, e.g. regarding the tender design, participation, the maximum premium and sufficient duration of the payments.
- The financing mechanism shall promote RES deployment irrespective of a delivery gap and support the aforementioned enabling framework (see section 2.2.4). Hence it may provide low-interest loans, grants, or a mix of both to joint projects between Member States as well as joint projects with third countries. For this, Union funds, contributions from private sector or Member States may complement the financing.

The generated energy from renewable energy sources will be attributed to contributing Member States according to their financial contribution. This financing mechanism will be managed by the Commission and necessary provisions will be set in the future as the details of its implementation have to be defined by secondary legislation (implementing acts).

The main contributions to the EU financing mechanism (possibly with the exemption of EU funds) will likely come from EU Member States that fail to reach their contributions and thus are required to implement measures. Among these Member States, there might be different reasons for choosing the option to contribute to the EU financing mechanism. One reason may be limited resource potential, which leads to high costs of fulfilling the national contribution domestically. Thus, it may be cheaper for such a Member State to make a contribution to a renewables project located in another Member State. Another example is that countries might have lower ambitions due to high costs of capital. In this case, they can decide to contribute to the EU financing mechanism and thus reduce the capital costs (and potentially overall costs) of reaching their target. Some countries might also use the contribution to the EU financing mechanism instead of more national support in order to limit the administrative burden or to avoid domestic acceptance problems related to RES projects.

Host countries for RES projects under the financing mechanism, on the other hand, could benefit from additional revenues and local employment effects. However, on the other hand there might also be negative aspects such as acceptance problems, lower availability of low cost resources to reach the own national RES targets or higher grid integration costs. Thus, especially countries with particularly favourable resource conditions and low capital costs could be suitable candidates as hosting countries

Possible design of the EU financing mechanism

Even though the exact implementation of the financing mechanism is not known yet, first insights into possible design options were given during a presentation held by NAVIGANT during an expert

meeting in Brussels in June 2019[13]. The main advantage of the contributing Member States will be savings in the support cost for the increase of RES share compared to costs of other (conventional) cooperation mechanisms. The host country will benefit from the reduction of greenhouse gas emissions, modernization of the energy system and the creation of local jobs.

NAVIGANT's draft for the practical implementation of the auctions by the financing mechanism suggests the following mechanism: Before any auction takes place, the host countries need to express their interest and give information on the available RES potential (capacities and technologies) plus the estimated required support levels of each quantity. In addition, the contributing countries indicate their demand, required quantities and maximum prices. Based on supply and demand the estimated support level will be determined and subsequently the involved Member States will be asked for binding commitments. Thereby, maximum transparency shall be guaranteed. A 90/10 (contributor/host) statistical distribution rule is suggested to account for system integration costs. In addition, the host country may also apply deep[14] charging for the grid connection and may reject certain technologies or locations that would cause higher costs.

After the adoption of the financing mechanism in early 2021, the tentative timeline assumes that binding commitments will be given by contributing Member States who failed to reach their 2020 RES target, in mid-2022. The financing mechanism tender would then be concluded in 2024 and first RES projects would be realized after 2025.

Assuming the above described setup, the financing mechanism could be of direct relevance to potential CSP cooperation projects, if technology-specific auctions on EU level would address CSP. Such cooperative CSP projects could then be supported through low-interest loans and/or grants provided by the financing mechanism.

[13] Expert Meeting in Brussels, 13 June 2019, Presentation by NAVIGANT: *The European Union Renewables financing mechanism, outcomes of a project for the European Commission.*

[14] Deep charging means that the generator needs to pay for the reinforcements to the existing electricity system in addition to the extension and immediate connection assets. Contrarily, shallow charging which is the more favourable option, means that the generator only pays for the immediate connection and sometimes for system extension [Inogate (2012)].

2.2.8 *Cooperation Mechanisms according to the new RES Directive (EU) 2018/2001*

Besides a voluntary payment into the financing mechanism, Member States can also employ cooperation mechanisms to reach their RES target. Similarly to the previous Directive 2009/28/EC, **joint support schemes** and **statistical transfer** with other Member States as well as **joint projects with EU Member States or third countries** are foreseen and will be explained in the following:

- **Statistical transfer** shall be facilitated in the future as according to the new Directive (EU) 2018/2001 (Art. 8), the Commission will establish a **Union Renewable Development Platform (URDP)**. On this platform, Member States can publish their expected excess or deficient amount of RES energy and a tentative price for the transfer. Subsequently, the URDP demand-and-supply matching mechanism will set the price for each transfer. Such statistical transfer arrangements are supposed to have a duration of one or more years.
- **Joint projects** (Art. 9) between two or more Member States are encouraged for the production of electricity, heating or cooling from renewable sources and the energy may be shared as agreed between the Member States. Yet, the energy will only be considered for the 2030 target and trajectory if the project was operational after June 25, 2009. The new element is that the Commission may help with the establishment of joint projects particularly through dedicated technical assistance and project development assistance.
- **Joint support schemes** will be promoted by the Commission through the **provision of guidelines and best practices recommendation.** According to Art. 13 (Directive 2018/2001), the energy produced on the territory of one Member State can count towards the renewable energy share of another country and this energy transfer may be purely statistical or as regulated by a distribution rule. Consequently, also for joint projects an interconnection between the countries is not required.
- **Joint projects with third countries,** in contrast to projects with Member States, require that the electricity generated from RES is consumed in the EU (Art. 11). Though, due to long lead times for interconnections, Member States may apply for accounting RES energy consumed in the third country if the interconnection construction started by the end of 2026 and can be operational by the end of 2032. The operation or refurbishment of the RES installation must have been concluded before June 25, 2009 and the project may only be supported by third countries through investment aid for the installation.

As an additional aspect relevant to RE cooperation, the recast RES Directive 2018/2001 suggests an **opening of RES support schemes** among Member States (Art. 5):

- Article 5 (Directive 2018/2001) suggests an **opening of the support scheme of one Member State to the participation of RES generators in another Member State**. As an indicative share (in the RES capacity to be supported or the budget to be allocated) at least 5% for the period 2023-2026 and at least 10% for the period 2027-2030 are mentioned. Shares could, however, be set lower depending on level of interconnectivity between the countries as a physical transfer of the electricity may be required.
- By 2023, an assessment of the usage of Art. 5 by the European Commission is foreseen with the possibility of an EU-wide **mandatory opening of MS support schemes of 5% by 2025 and 10% by 2030**.

Table 4 provides an overview and a comparison of the legal basis for RES cooperation under the RES Directive (2009/28/EC) and the recast RES Directive (2018/2001).

Table 4 Comparison of the cooperation mechanisms defined in RES Directive (2009/28/EC) and Recast RES Directive (2018/2001).

Cooperation mechanisms until 2020 under RES Directive (2009/28/EC):	Cooperation mechanisms until 2030 under RES Directive (2018/2001):
• **Joint Projects (Article 7):** Joint financing of individual RES projects and sharing the output (statistically) among EU Member States. • **Joint projects between Member States and 3rd countries (Article 9):** Transfer between EU and non-EU country, RES electricity must be consumed within the EU (physical transfer). If a respective transmission line is not yet in place but under construction before 2017 it must be operational by end of 2022. • **Joint Support Schemes (Article 11):** Merging or coordinating RES support schemes and sharing allocation to national targets of Member States based on statistical transfer or distribution rule. • **Statistical transfers (Article 6):** Virtual transfer between RES statistics of two EU Member States	• **Joint Projects (Article 9):** Joint financing of individual RES projects and sharing the output (statistically) among EU Member States. • **Joint projects between Member States and 3rd countries (Article 11)**: Agreement on transfer with non-EU country, electricity must be consumed within the EU (physical transfer). If a respective transmission line is not yet in place but under construction before 2027 it must be operational by end of 2032. • **Joint Support Schemes (Article 13)**: Merging or coordinating RES support schemes and sharing allocation to national targets of Member States based on a statistical transfer or distribution rule. • **Opening of support schemes (Article 5):** Opening of support schemes to participation of other Member States (optional), indicative shares of at least 5% (2023-2026) and 10% (2027-2030), respectively, or depending on level of interconnectivity. Physical transfer may be required. By 2023, assessment by EC and **possibly mandatory opening of support schemes** of 5% by 2025 and 10% by 2030. • **Union renewable development platform and statistical transfers (Article 8):** Virtual transfer to RES statistics of another Member State, counting towards the national RES target of that Member State, creation of Union renewable development platform ('URDP') to facilitate virtual transfer, i.e. to match demand and supply (participation voluntary).

In summary, the recast RES Directive (2018/2001) provides some additional elements to promote a stronger coordination (especially through the creation of the Union Renewable Development

Platform (URDP)) and cooperation among Member States (i.e. opening of support schemes). However, as the opening of support schemes is, so far, optional and the usage of the cooperation mechanisms as already established in the RES Directive 2009/28/EC has been very limited in the past, the impact of these instruments on potential CSP cooperation projects in the future will likely be limited. Notwithstanding, if the European Commission should decide in 2023 that the opening of support schemes should be mandatory in the future, this would create a strong driver for cross-border RES auctions, which could also target CSP projects.

2.3 The Connecting Europe Facility (CEF)

Since 2014, the Connecting Europe Facility (CEF) is an EU funding instrument for cross-border projects in the field of transport, energy and digital services. Currently, the CEF does not include direct support for RES project but this will change in 2021, when a budget of 42.3 billion Euro can be spent over seven years (2021-2027) of which 8.7 billion Euros are dedicated to the energy sector and shall promote the clean energy transition in accordance with the "Clean Energy for all Europeans package".

After the adoption of the final CEF regulation in mid-2020, the first work program is going to be published in September 2020. It shall include a new window for cross-border projects in the field of renewable energy (c-b projects in RES) which was presented in June 2019 during a stakeholder workshop organized by the European Commission. As defined in Article 7 of the Proposal COM(2018) 438 final *(see Box 2 below),* both projects between two Member States or Member States and third countries may receive support for technical, preoperational or feasibility studies and/or work. Eligibility for grants requires:

- Cooperation between countries as set out in Directive 2009/28/EC
- EU-added value
- Existence of a funding gap.

Hence, the project must lead to significant cost savings and/or offer benefits with respect to system integration, security of supply or innovation and it needs to be unprofitable without the CEF grant. Detailed economic and financial analysis must be included in the proposal and must stress the positive cost-benefit ratio and financial sustainability. The CEF grant cannot exceed 50 % of eligible costs and shall only be considered as the last gap-filler needed for project realization.

Based on the preliminary information presented at the stakeholder workshop, joint projects between Member States for CSP deployment, including the construction of a CSP plant, but also technical studies, can be supported under the CEF grant if the applicable eligibility and selection criteria are fulfilled. Consequently, the CEF can be a useful financial instrument for the future market uptake of solar thermal electricity in the EU through cooperation.

Support to c-b projects in RES under the CEF could also be complementary and synergetic to the mechanisms under the "gap-filler" and the "enabling framework" as it would complement actions taken at bi- or multinational level as well as at EU level on cross-border RES cooperation. The mechanisms under the "enabling framework" would generally help to ease the c-b project development and to distribute RES development more evenly across the Union while the EU-wide "gap-filler" would serve to complement c-b action, with the ultimate goal to fill the gap in RES deployment.

Regulation establishing the Connecting Europe Facility COM/2018/438 final
Article 7

Cross-border projects in the field of renewable energy

1. Cross-border projects in the field of renewable energy shall involve at least two Member States and shall be included in a cooperation agreement or any other kind of arrangement between Member States or arrangements between Member States and third countries as set out in Articles 6, 7, 9 or 11 of Directive 2009/28/EC. These projects shall be identified in accordance with the criteria and procedure laid down in Part IV of the Annex to this Regulation.
2. By 31 December 2019, the Commission shall adopt a delegated act in accordance with Article 23(d) of this Regulation to further specify the selection criteria and lay down details of the selection process of the projects and shall publish the methodologies for assessing the contribution of the projects to the general criteria and for assessing the overall costs and benefits specified in Part IV of the Annex.
3. Studies aiming at the development and identification of cross-border projects in the field of renewable energy shall be eligible for funding under this Regulation.
4. Cross-border projects in the field of renewable energy shall be eligible for Union funding for works if they meet the following additional criteria:
   (a) the project specific cost-benefit analysis pursuant to point 3 of Part IV of the Annex provides evidence concerning the existence of significant cost savings and/or benefits in terms of system integration, security of supply or innovation, and;
   (b) the applicant demonstrates, that the project would not materialise in the absence of the grant, or that the project cannot be commercially viable in the absence of the grant. This analysis shall take into account any revenues resulting from support schemes.
5. The amount of the grant for works shall be proportionate to the cost savings and/or benefits referred to in point 2 (b) of Part IV of the Annex and shall not exceed the amount required to ensure that the project materialises or becomes commercially viable.

Box 1: *Article 7 from COM(2018) 438 final, 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, published in Brussels on 6.6.2018.*[15]

[15] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018PC0438&from=EN

3 EXPANSION OF CSP ON NATIONAL LEVEL

The MUSTEC project focuses strongly on the market uptake of CSP by cooperation of EU Member States. However, the Member States' own ambition towards national CSP deployment does strongly influence their willingness to expand this technology on their territory in cooperation with other countries. Therefore, we searched for CSP expansion targets in the draft NECPs of EU Member States. In addition, a brief review of the effectiveness of RES support schemes, particularly auctions, is given with respect to the future growth of CSP as dispatchable RES technology.

3.1 CSP in draft NECPS of the Member States

In accordance with the new RES Directive 2018/2001, all EU Member States were required to submit their draft integrated national energy and climate plans (NECPs) by 31 December 2018. The deployment of solar CSP for electricity generation is included in the draft plans of Spain, Portugal, Italy, Greece and Cyprus. Quantitative targets for CSP installations are included in the NECPs of Spain, Italy and Greece and are summarized in Table 5 below.

Member State with quantitative CSP target	CSP in **2020**	CSP in **2025**	CSP in **2030**	*total RES-E **2030***
Spain, target scenario *Installed capacity*	2.303 GW	4.803 GW	7.303 GW	*116 GW*
Italy *Capacity growth target*	0.01 GW	0.25 GW	0.88 GW	*93.19 GW*
Greece *Installed capacity* *Production*	0.00 GW	0.07 GW (257 GWh)	0.07 GW (260 GWh)	*17.7 GW* *(34746 GWh)*

Table 5: Planned CSP deployment in Spain, Italy and Greece according to their draft NECPs16 submitted in December 2018.

[16] Draft NECPs of each Member State available at: https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union/national-energy-climate-plans. The drafts were submitted to the European Commission by 31 December 2018; the final NECPs are due on December 31, 2019.

In Spain, the target scenario aims to increase the share of RES (RES-E) in total electricity generation to 74% (compared to 55 % in baseline) and to reach a RES share of 42 % in the total final energy consumption (compared to 25 % in baseline). This plan includes the construction of new CSP power plants to reach a capacity of 7.3 GW in 2030. This means a factor 3 increase of the installed capacity in 2020 (2.3 GW). The solar thermal technology and hydraulic pumping shall be utilized for power dispatch and be complemented by the introduction of batteries into the electricity system. This shall minimize the wastage of energy and maximize the production capacity of non-dispatchable RES technologies (NECP draft Spain[17], page 166). Additional interconnections with Portugal and France will be built, thereby increasing the exchange capacities to 3000 MW and 8000 MW, respectively. Spain targets the export of electricity summing up to 31.7 TWh in 2030 and foresees the new installation of 57 GW additional RES-E capacity from 2021 to 2030. Multiple tenders for RES support shall take place which may also distinguish different energy generation technologies.

Compared to Spain, Italy plans smaller CSP expansions to reach 0.88 GW by 2030. Greece emphasizes in its NECP that solar thermal power plants and geothermal plants are beneficial for the operation of the energy system. Yet, Greece targets a minor share of these renewable technologies on the total electricity generation of only 0.5 % (CSP) and 1.1 %, respectively. While the final NECPs of the Member States are still under preparation, the draft versions already indicate that solar thermal electricity and CSP is recognized in Southern Europe and that a modest growth of this technology can be expected.

3.2 RES support for increased CSP deployment

From an economic point of view, RES support mechanisms aim at achieving the lowest possible system costs (including both direct (LCOE) and indirect costs [Breitschopf, B. and Held, A. (2014)]) while also minimizing support costs and achieving a high effectiveness. Simsek et al. *[Simsek, Y. (2018)]* investigated the effectiveness and sensitivity of different RES incentives for CSP projects in Chile where solar energy projects become more and more important. They concluded that the reduction of both the debt fraction and discount rate have a strong effect. Investment tax credits, production tax credits, depreciation as tax credit, and cash incentives in the form of production based incentives (like feed-in tariffs) *[Simsek, Y., et al. (2018)]* show high effectiveness; whereas investment based (cash) incentives and sales tax reductions were found to be less effective. Investment tax credits (ITC) have been widely used in the U.S. and equal 30% (20 %) of eligible costs for fuel cell, solar, and small wind property which was operational before 2017 (2020) *[KPMG (2017)]*. In 2010, the ITC in combination with a Department of Energy (DOE) loan guarantee program kick-started the expansion of CSP in the United States. In the following years and thanks to new

[17] https://ec.europa.eu/energy/sites/ener/files/documents/ec_courtesy_translation_es_necp.pdf

state-level renewable portfolio targets, they contributed to a significant reduction of the LCOE *[Chung, D. et al. (2016)].* In comparison, the largest growth in global CSP capacity in Spain occurred from 2008 to 2013 due to RES support in the form of administratively set feed-in tariffs (FIT) and subsequent FIT increases which are laid down in the Spanish Royal Decrees 436 and 661 (Climate Parliament 2009) *[Chung, D. et al. (2016)].* As a result, 2% of Spain's total electricity in 2014 was generated by CSP and almost 50 CSP plants were built *[Lilliestam, J., Barradi, T., et al. (2018*)]. However, the increase in support payments, in a context of reduction in electricity demand due to the economic crisis, overcapacity and a tariff deficit led first to a sine-die moratorium on the application of the FIT and then to a new support scheme which was not FIT-based. This halted CSP expansion in Spain in the following years.

This enormous CSP growth in Spain revealed the effectiveness of FIT for the uptake of a RES technology. However, it also illustrated the major drawback of this support mechanism, namely high costs - unless well regulated. Therefore, it was suggested to decrease the amount of FIT over time, thereby forcing the developers to further optimize the technology *[Lilliestam, J., Barradi, T., et al. (2018)].* Additional suggested improvements of FIT include the introduction of time-of-day bonuses or peak shaving *[Couture et al., (2010)] [Lilliestam, J., Barradi, T., et al. (2018)]* which can increase the efficiency of the electricity system. In case of CSP this would encourage producers to add a thermal storage unit and in general it can set an incentive for additional R&D activities in the field of dispatchable RES projects. Another advanced FIT support feature are bonus payments *[Couture et al., (2010)]* for innovation e.g. for the co-generation of heat and electricity which would also promote CSP projects.

Today and due to the learnings from the last decade, feed-in-premiums paid on top of the electricity market price and awarded through competitive auctions are the preferred support mechanism for RES deployment in the EU. They are also stipulated by the new RES Directive 2018/2001 and have previously been defined as a requirement for state aid in the EU Commission Guidelines on State Aid for environmental protection and energy 2014-2020 (2014/C 200/01)[18].

Compared to administratively-set FIT, auctions offer superior cost control, typically lead to lower support levels and a higher degree of efficiency *[Kreiss, J., et al. (2017)].* Auction designs differ strongly between countries and can be more or less beneficial for certain RES technologies [Winkler, J., et al. (2018)], particularly for CSP projects as further discussed in section 3.2.2 and ref. *[del Rio, P. and Mir-Artigues, P. (2019)].* Though, the cost pressure in auctions can be very strong and sometimes even too strong as speculated by Lilliestam et al. in *[Lilliestam, J., Barradi, T. (2018)]*: within only two years the price level of purchase power agreements in South Africa decreased by over 40% which led to doubts regarding the financial viability of the supported projects and about their realization. High penalties or prequalification criteria can prevent such effects but, generally

[18] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014XC0628(01)&from=EN

speaking, the effectiveness and efficiency of auctions as support schemes must be carefully monitored and adjusted in order to serve best the countries' RES targets *[Winkler, J., et al. (2018)].*

3.2.1 *CSP projects and dispatchability*

From 2020 onwards and in accordance with Directive 2018/2001 and the Guidelines on State Aid for environmental protection and energy 2014-2020, the main RES support scheme provided in the EU will be feed-in premiums (sliding or fixed) paid on top of the electricity market price granted through competitive tenders. Hence CSP installations will need to participate in auctions and eventually compete with other RES technologies offering much lower LCOE (see figure 3). Naturally, due to similar Direct Normal Irradiance (DNI) requirements, solar PV projects are the main competitor for CSP which can be built on the same sites (and additional sites with lower fraction of direct sunlight but diffuse light) but at about half of the LCOE which is a major obstacle for the market uptake of CSP.

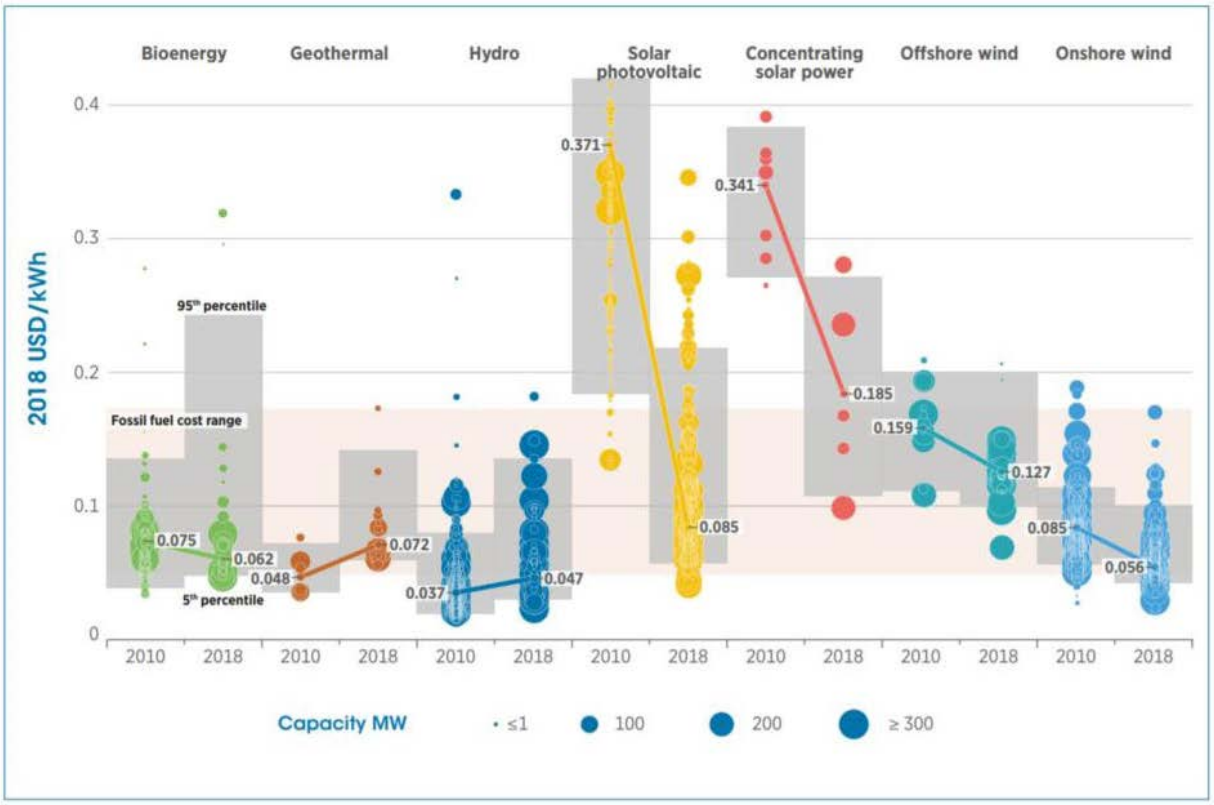


Figure 3: Global LCOE of utility-scale renewable power generation technologies in 2010 and 2018 (© IRENA 2019) [IRENA (2019)].

Therefore, it has been concluded in other deliverables of this project (D4.2 *[Lilliestam, J. (2018)],* D4.4 *[Del Río, P., Caldés, N. and Kiefer, C. P. (2018)],* D5.2 *[Del Río, P. and Kiefer, Christoph P. (2019)])* that the main selling point of CSP power plants, respectively driver for CSP deployment, is its ability of energy storage and thus a certain level of dispatchability. In CSP power plants, solar energy is focused on a transfer medium which is heated up and hence gains thermal energy. This thermal energy can be stored/conserved before it is converted into electrical energy (electricity). The ability to store energy will gain on importance in the future: Thanks to continuous RES support, the share or renewables on the energy production and in the electricity mix will increase, leading to higher fluctuations in the electricity generation [Welisch, M. (2019), Perez-Linkenheil, C., (2017)]. Hence, there will be more occurrences of excess wind and solar electricity production especially on very sunny and/or windy days. Ideally, this temporarily overproduced electricity will be stored and subsequently used during the night (without sunshine). Nowadays, the main energy storage technologies are pumped-hydro, thermal, electrochemical (including batteries), and mechanical *[Gür, T. M. (2018)].* Pumped-hydro is globally the most widely used storage technology and is also employed in combination with solar PV in hybrid projects in Australia. However, suitable locations for pumped-hydro power plants are limited due to the need of higher altitude water reservoir or insufficient integration in spatial planning. In addition, the levelized costs per unit of stored energy are about a factor 2 higher for pumping than for thermal storage *[De Vita, A., et al. (2018)].* CSP plants with a thermal storage allow to store the heat for some hours during the day before the thermal energy is transformed and consumed as electricity during the night or when demand is higher. In contrast to the solar-hydro hybrid approach currently followed in Australia, no special location near mountains is required for CSP. However, locations that are suitable for CSP with thermal storage are also suitable for photovoltaics power plants combined with non-hydro storage technologies (typically batteries).

The cost-competitiveness of utility-scale PV installations plus batteries in comparison to CSP with thermal storage was analyzed in a report published by NREL *[Feldmann, D., et al. (2016)]*. They concluded that CSP installations have generally higher LCOE and cannot compete with PV combined with battery systems if a relatively short storage use of up to 4 hours is needed. However, batteries do not experience the same scaling benefits as CSP storage and therefore CSP with storage might be the preferred choice for long storage times of 8-10 hours and offer lower LCOE in such a case.

In summary, CSP plants with thermal storage have the potential to increase the flexibility of the energy system in the EU which is one objective of the new RES Directive but its prospects will depend on various factors (especially the future development of battery prices) and requirements.

3.2.2 *Auction design beneficial for CSP*

Auctions for RES support have become an important support instrument for the expansion of renewable energy technologies. In the end of 2017, already 13 EU Member States (Belgium, Denmark, France, Germany, Greece, Italy, Malta, Netherlands, Lithuania, Portugal, Poland, Spain and United Kingdom) had successfully implemented schemes for RES auctions [CEER (2018)] and more countries have been following since. On the one hand the use of tenders for RES support is stipulated by the RES Directive 2018/2001 and had been included as a requirement for state aid in the EU Commission Guidelines on State Aid for environmental protection and energy 2014-2020 (2014/C 200/01), on the other hand there are strong economic arguments for their increased usage in Europe and throughout the world [Mora, D., et al. (2017)]. The main advantage of auctions for RES support is that, if they are well designed, support levels are determined in a competitive way leading to market-based and up-to-date prices [Winkler, J., Magosch, M., Ragwitz, M. (2018).]. In addition, since a certain volume or capacity is defined prior to the auction, the country has– compared to other support schemes- a better control of the RES growth pace and total costs [Winkler,J., Magosch, M., Ragwitz, M. (2018)].

Auctions for renewable energy support can be designed in various different ways. Important characteristics of renewable energy auctions are, among others, whether they are technology-specific or technology-neutral, whether one or several projects are awarded in one auction, how penalties and prequalification requirements are defined or which realization periods (i.e. the time between the auction and the start of plant operation) are defined. The design of these elements defines which technologies and project types can actually be realized under an auction scheme.

On a global level and according to a recent IRENA report *[IRENA (2019a)]*, CSP projects equaled below 1% of the globally auctioned renewable energy volume in 2017-2018, which was mainly awarded in Central and Western Asia, specifically in the United Arab Emirates. The largest auction share had solar PV (55%) and onshore wind (32%) followed by offshore wind (10%) and biomass (1%). As an example, the main features of two auctions held in 2017 in which CSP projects had winning bids are summarized in Table 6.

The auction in Dubai from Table 6, was technology-specific for CSP, however, the auction in Southern Australia was open to all technologies, partly also plants using fossil fuels. However, due to the dispatchability requirement specified in the tender and the high direct normal irradiance (DNI) values in that region, CSP projects were competitive and won the auction. Notwithstanding, due to comparably high LCOE for CSP (see Figure 3 and e.g. [IRENA (2019)]), not every auction design is beneficial for CSP deployment.

Table 6. Examples of CSP auctions held in 2017 [del Rio, P., Mir-Artigues, P., 2019].

Dubai: *700 MW, 4th phase of Mammoth Mohammed Bin Rashid Al Maktoum Solar Park*

- One-off, technology-specific auction in June 2017 for 200 MW project minimum
- Dispatchability required: Plants should be able to generate power from 4 pm to 10 am
- Capacity based, site-specific (land provided at nominal costs), price-only static auction, no ceiling price, pay-as-bid
- Deadline for completion: 2021
- 35 years power purchase agreement

Outcome:

- Very low price of 7.3 cents $/KWh. Highest bid: 17.3 $/MWh, 30 expressions of interest
- Awarded project combination of a solar tower (100 MW, 15 hours storage) and three parabolic troughs (PTs) (200 MW each, 11 hours storage)
- Penalties details of contract not public

Southern Australia: *150 MW Aurora Solar Energy Project , Port Augusta*

- One-off, technology-neutral but site-specific auction in 2017 for 150 MW project
- Dispatchability requirements: peak government load of 125 MW must be covered. Tenders for two power supply contracts in order to meet long term power needs: 75% is open to any dispatchable technology (also fossil fuels), 25% is constrained to dispatchable renewable energy technologies.
- 20-year power purchase agreement
- Ceiling price at 78 $/MWh
- Deadline for construction: end June 2021
- Preapproval of project by the South Australian government required
- Renewable Energy Certificates as additional source of revenue
- The full energy output of the Aurora facility is contracted to the South Australian government under a Generation Project Agreement

Outcome:

- The awarded bidder, *Solar Reserve*, receives 0.61$/KWh (for power generated by 125 MW of 150 MW plant). Government expects to pay 75$/MWh for 20 years but not more than 78$/MWh. Solar Reserve will provide electricity from other sources in the market at times of low demand and low prices. Excess energy not needed by government can be sold in the market
- 75% of Renewable Energy Certificates are owned by Solar Reserve (to expire in 2030)
- Penalty details of the contract not public
- 8 hours full load storage, 1100 MWh stored energy according to https://www.solarreserve.com/en/global-projects/csp/aurora.html

The pros and cons of different auction designs were thoroughly analyzed and discussed in a recent publication of Del Rio and Mir-Artigues *[del Rio, P. and Mir-Artigues,P. (2019)]*. While the full details can be found in their paper, we will give in the following a summary of the main findings.

Effective and relevant auction design elements are:

- **Putting a high value on the dispatchability of CSP**: The ability to store the thermal energy for several hours before it is converted into electricity is the main advantage of the CSP technology. However, this feature is oftentimes not taken into account in auction design but could be included by specifying a time-diverse generation profile (base-load, non-peaking and peaking, like e.g. in California) or by offering higher remuneration at times of higher demand (e.g. in Mexico, Abu Dhabi, South Africa) or by requiring a minimum number of hours of storage as a pre-qualification (like e.g. done in Dubai).
- **Technology-specific auction:** Typically, technologies with higher LCOE do not succeed in technology-neutral auctions which lead to higher competition. Therefore, auctions should target specifically CSP.
- **Site-specific auction: A**uctions with pre-defined sites may facilitate the realization of large projects as investors do not need to secure land, organize the environmental permits and apply for grid access which significantly reduces project risks.
- **Single-item auction:** The auctioned amount is allocated to a single bidder and not split between several bidders.
- **Capacity-based support:** As a highly capital-intensive technology, the up-front support of a CSP project would facilitate its financing as the total support costs are known from the beginning on. However, this bears the risk that plants are not run efficiently which might be the reason why the EU governance currently does not include such a type of support.
- **Long lead times and realization periods:** As CSP plants are usually large and capital-intensive projects the financial closure might take longer and consequently long lead times between the auction announcement and the bid submission deadline are favorable. Sufficiently long realization periods further promote large-scale projects and lower the risks for investors as financing can be organized and negotiated over a longer period of time.
- **Information provisions (DNI measurements):** An up-front assessment of the site-specific irradiance levels lowers the risk for bidders.
- **Pay-as-bid (PAB) pricing rules and penalties:** With the PAB pricing rule each winner receives the actual support level of his/her bid which gives more certainty to the bidders and prevents under-bidding and subsequent under-building. Sufficient penalties levels guarantee the bidder's seriousness.

In contrast, **maximum size limitation and seller concentration can hinder CSP deployment** in auctions. CSP power plants typically have a size of a few hundred MW to be fully cost-efficient and therefore, e.g. a limit of 50 MW would be problematic. Due to the large-scale of the projects also the participation of small actors or a large number of actors is rather unlikely.

4 CSP DEPLOYMENT IN THE EU THROUGH COOPERATION

Cooperation between EU Member States shall enable countries with low RES potential or high LCOE for RES technologies to reach their renewable energy targets. Under the EU RES framework up to 2020 there was very limited use of cooperation mechanisms and no collaborative CSP projects were realized at all. In this section we summarize the cooperation options that are encouraged within the new "Clean Energy 4 all Package" and evaluate their potential to support collaborative CSP deployment in the EU. Potential host and off-taker countries for CSP cooperation projects are discussed and finally two possible future cases for CSP cooperation projects are described.

4.1 Evaluation of measures for CSP cooperation under the 2020-2030 policy framework

In accordance with the above mentioned EU legislation and regulation, the following section discusses 6 options for cooperation between EU Member States and evaluates the role they could play for the market uptake of CSP.

1) Statistical transfer between Member States

In the past, statistical transfer has only been used by Luxembourg which statistically exchanged energy with Lithuania and Estonia. Soon, the Commission will implement the Union Renewable Development Platform which shall enhance the use of statistical transfer between the Member States. Match-making support through the Renewable Development Platform (URDP) is foreseen and thus administrative hurdles for cooperation shall be reduced. This might also reduce the costs of the statistical transfers and the process may become more transparent and competitive. Even though administrative barriers affect CSP deployment [Caldés, N. et al. (2018)], it appears unlikely that the match-making service will boost the number of CSP projects as statistical transfer does not value the dispatchability of CSP and makes it less competitive compared to technologies with lower LCOE. Realizing CSP projects under this instrument would require that Southern European countries would decide to increase their RES share beyond their own 2030 target by the installation of additional CSP power plants. Due to the comparably high LCOE of CSP (see Figure 3), the occurrence of such a scenario will depend on the national strategy of the selling/host country and particularly on its decision to foster dispatchable technologies.

2) Joint projects and joint support schemes

From 2020 onwards, RES support shall generally be awarded as premiums through competitive tenders (RES Directive 2018/2001), hence joint RES projects and joint support schemes would both imply cross-border auctions for RES support. To date, joint support schemes were successfully realized by Sweden and Norway. In the future, the European Commission plans to support the establishment of joint projects particularly through dedicated technical assistance and project development assistance, and will disseminate guidelines and best practices for the use of joint support schemes. Depending on the future implementation, both measures will lower administrative barriers and might contribute to a faster realization of joint projects.

In contrast to a purely statistical transfer, this support may also include the physical import of electricity and involved Member States would need to find agreements e.g. regarding the auction designs, ceiling prices, realization periods and (statistical or physical) distribution of the generated electricity as well as the grid connection of the projects. Unless the involved countries have a strong interest in energy storage and physical transfer of electricity, the high LCOE of CSP significantly lowers its chances of success under this instrument. Yet, in a scenario in which neighboring countries hold joint auctions and share the benefit of the dispatchable energy, CSP projects could gain support. An overview of design options and best practices for cross-border auctions are given in the report *[von Blücher,F., (2019)]* of the EU-funded AURES 2 project.

3) Open RES support (cross-border auctions)

In 2016, Germany and Denmark agreed on a pilot project to open each one PV auction for bidders from both countries. Such cross-border auctions for RE support are explicitly mentioned in the Governance Regulation 2018/1999, Art. 5, and a mandatory (partly) opening of RES support schemes after 2023 is considered. It is not defined, however, whether the opening would have to be mutually or which design elements would apply to opened support schemes. Such open auctions would lead to similar results as joint support schemes based on auctions, thus the realization of CSP projects would strongly depend on the details of the auction design and the Member States' national strategies regarding CSP.

4) "Enabling framework"

The enabling framework described in the RES Directive 2018/2001 foresees the use of Union funds and additional funds, for different activities to foster RE deployment and explicitly addresses the promotion of cooperation between Member States through joint projects, joint support schemes and opening of support schemes for RES deployment. Possible activities which could be of direct relevance to CSP include the reduction of capital costs for RE projects and the implementation of programs for enhanced integration of RES into the energy system. As CSP projects with storage could help to enhance system flexibility, they could qualify for support (in form of low-interest loans

or grants) under the enabling framework. As the enabling framework also foresees the support of cooperation, this would make an even stronger point for CSP cooperation projects.

5) Funding under the CEF

The new CEF program to become operational in 2021 will give grants covering up to 50% of the cost for joint projects in the field of renewable energy. Preoperational or feasibility studies as well as construction of the plant are eligible for funding but the project needs to be a cross-border cooperation, add value to the EU (be innovative) and a funding-gap must exist without the requested CEF support (cf. section 2.3).
It is well conceivable that CSP cooperation projects would qualify for funding under the new CEF, as a joint CSP project could add flexibility to the EU energy system (EU added value) and would depend on additional support due to the high LCOE (funding gap).
For example, Spain, as a country with an active CSP industry, might apply together with a partner (e.g. Germany) for funding to realize an innovative CSP project aiming at cost reduction or feasibility studies based on the latest R&D results. In turn, such a pre-study project will lead to more learning and will bring down costs of CSP in the long term. However, because of high installation costs for CSP (~5 Mio US$/MW investment costs [IRENA (2019)]) and other technologies applying for funding, the limited CEF fund will probably only be able to support very few cross-border CSP projects.

6) EU Financing Mechanism ("gap filler")

If Member States do not meet their contributions to the 2030 EU RES target, they can make a contribution to the EU financing mechanism (cf. section 2.2.5). The collected funds are used by the EU Commission to promote new RES projects through feed-in premiums awarded through tenders, and might provide support by offering low-interest loans and/or grants for cross-border projects in accordance with Article 9 of Directive (EU) 2018/2001 (i.e. joint RES projects between Member States). While the contributing countries will have no direct impact on the supported RES technology (only by requesting certain levels of costs or energy sectors), the potential host countries need to express their interest and indicate the energy quantities, suggest projects and estimate support levels for the intended RES projects that could be newly built on their territory. This could lead to situations in which CSP projects with high LCOE from Southern Europe compete with wind projects in the Baltic Sea or hydro power plants with storage. CSP would likely only be successful in technology specific auctions targeted specifically on CSP and its benefits (i.e. dispatchability / storage options). However, with today's limited knowledge about the actual design and implementation of the financing mechanism, further conclusions would be highly speculative.

Table 7 summarizes the evaluation of the potential relevance of the individual instruments for CSP cooperation among EU Member States.

Table 7 Assessment of policy instruments for CSP cooperation projects in Europe

Legal document	Instruments potentially relevant for EU CSP cooperation	Assessment of potential implications and level of relevance for CSP cooperation
Renewable Energy Directive (2009/28/EC)	• **Cooperation mechanisms:** o Joint Projects (Article 7) o Joint Support Schemes (Article 11) o Statistical transfers (Article 6)	**No impact on CSP cooperation** - Hardly any use of cooperation mechanisms in general and no application to CSP in the past.
Recast Renewable Energy Directive 2018/2001	• **Cooperation mechanisms:** o Statistical transfer and establishment of Union Renewable Development Platform (URDP) for facilitated matchmaking (Article 8): Member States can publish their expected excess or deficient amount of RES energy and a tentative price for a statistical transfer.	**Impact on CSP cooperation unlikely** - Additional elements to promote coordination and cooperation among Member States have been introduced, especially through the establishment of the URDP. - However, the impact of statistical transfer on potential CSP cooperation projects in the future will likely be very limited as statistical RE transfer does not value the dispatchability of CSP and thus makes it less competitive compared to RE technologies with lower LCOE.
	o Joint Projects between MS (Article 9) o Joint Support Schemes (Article 13)	**Impact on CSP cooperation highly unclear** - The relevance of joint projects and joint support schemes, likely realized in the form of cross-border auctions, strongly depends on the auction design (in particular the technology specification) and the level to which the dispatchability of CSP is valued in the detailed auction design.
	• **Opening of RES support schemes:** • Suggested indicative share of minimum 5 % from 2023 to 2026 and minimum 10 % from 2027 to 2030. • By 2023, review of utilization and decision about the possibility of a mandatory opening (Art. 5/5).	**Potentially relevant for CSP cooperation** - A mandatory opening of support schemes after 2023 would imply a significant push for cross-border cooperation in RES deployment. - The opportunities for cross-border CSP projects, however, depend on the interests, i.e. the technology focus of the individual countries.

Legal document	Instruments potentially relevant for EU CSP cooperation	Assessment of potential implications and level of relevance for CSP cooperation
	• "**Enabling framework**": Use of Union funds and additional funds, for different activities to foster RE deployment: o Reduction of the cost of capital for RE projects; o Implementation of projects and programs for enhanced integration of RES into the energy system and to increase system flexibility; o Development of the electricity grid including storage facilities and other grid related actions to reach the 15 % electricity interconnection target by 2030. • Promotion of cooperation between Member States [...] through joint projects, joint support schemes and opening of support schemes for RES deployment.	**Potentially high relevance for CSP cooperation** - Actvities under the enabling framework could be of direct relevance to CSP cooperation projects as they explicitly address the support of projects that can contribute to increasing system flexibility as well as storage options. - Support may be granted in form of low-interest loans or grants for CSP projects which help to increase the EU electricity system flexibility. - Reduction of capital costs for RES projects could support RES cooperation projects by making RES more competitive in the cross-border context as costs of financing renewables differ substantially between the EU Member States. The use of risk-reduction instruments could substantially decrease the investment needs for CSP projects and help to reduce differences in the competitive market environment among Member States. This would help to create a more level playing field which would implicitly foster RES cooperation. - The enabling framework explicitly foresees the enhancement of regional cooperation and joint projects in RE, which implies that in particular cooperation projects (including CSP) would be in the focus of the measures.

Legal document	Instruments potentially relevant for EU CSP cooperation	Assessment of potential implications and level of relevance for CSP cooperation
Governance Regulation 2018/1999	• **Union financing mechanism** („gap-filler" instrument if EU target is missed) to be established by January 2021, no detailed design yet, main characteristics: o Competitive tenders o Support granted as feed-in premiums on top of the market prices. o Member States have the right to decide about RE installations in their territory. o Commission will provide rules for the implementation (e.g. regarding tender design, participation, maximum premium and duration of the payments). o Financing mechanism shall promote RES deployment irrespective of a delivery gap and support the enabling framework. Hence it may also provide low-interest loans, grants, or a mix of both to joint projects between Member States […]. For this, Union funds, contributions from private sector or Member States may complement the financing.	**Potentially high relevance for CSP cooperation** - The financing mechanism could be relevant for CSP cooperation projects if auctions on EU level would be technology-specific and would be targeted specifically on the benefits of CSP (i.e. dispatchability / storage options). - If auctions would be technology-neutral CSP would likely not be competitive. - Collaborative CSP projects could also be supported through low-interest loans and/or grants for feasibility studies or for the actual project implementation.
Connecting Europe Facility (CEF)	• 2021-2027budget of 42.3 billion Euro of which 8.7 billion € are dedicated to the promotion of the clean energy transition in accordance with the "CE4All" package.	**Potentially high relevance for CSP cooperation** - Based on the preliminary information it is well conceivable that CSP cooperation projects would qualify for funding under the new CEF, as a joint CSP project could add flexibility to the EU energy system (EU added value) and would depend on additional support due to the high LCOE (funding gap).

Legal document	Instruments potentially relevant for EU CSP cooperation	Assessment of potential implications and level of relevance for CSP cooperation
	• Support to cross-border projects in the field of RE (c-b projects in RES) between two Member States [...] for technical, preoperational or feasibility studies and/or work. • Eligibility for grants requires: o Cooperation between countries as set out in Directive 2009/28/EC o EU-added value o Existence of a funding gap.	- CSP coopertaion projects could receive grants covering up to 50% of the costs and/or funding for feasibility studies. - Support could be complementary and synergetic to the mechanisms under the "gap-filler" and the "enabling framework" as it would complement actions taken at bi- or multinational level as well as at EU level on cross-border RES cooperation. - Due to the high installation costs for CSP and competition with other technologies/projects the limited CEF fund will likely only be able to support very few cross-border CSP projects.

4.2 Potential Host and Off-taker countries for CSP project cooperation

In this section we discuss which Member States might be interested in cooperation mechanism or the usage of the financing mechanism and we will focus on CSP projects. Member States which increase their RES share thanks to an installation in a different country are called “off-takers” and those who approve additional RES plants on their territory are called “host” countries.

Off-taker Member States are most likely those countries which will either miss their 2020 or 2030 RES targets due to a lack of RES generated energy on their own territory or which want to benefit from cheaper RES support costs or the higher RES potential in other Member States. As described in section 2.1.3 and shown in Figure 1a, Belgium, Cyprus, France, Greece, Ireland, Luxembourg, Malta, the Netherlands, Poland, Portugal and the United Kingdom are expected to miss their national RES target in 2020 without cooperation. Consequently, most of these Member States will need to start cooperation or make a contribution to the EU financing mechanism. Notably, Luxembourg already signed statistical transfer agreements with Estonia and Lithuania to reach the 2020 targets. According to the NECP draft published in December 2018, Luxembourg will also make use of cooperation mechanisms to reach the national 2030 RES target. In the electricity and heating sectors major changes are planned in the country which will lead to sectoral RES shares of 33.6% (RES-E) and 30.3%, respectively, contributing to a total RES share of 19.8% on the final energy consumption. The use of cooperation mechanisms shall boost the overall RES share to the targeted 25% (in 2030). For this, cooperation similar to those used for the 2020 targets shall be employed and statistical transfers with other Member States shall be developed involving specific projects.

The fact that several countries have a RES share shortfall raises the question whether a high demand of RES energy is sufficient to trigger the expansion of CSP in the EU, a technology with comparably high LCOE. In case of RES projects excluding physical transfer of electricity, any engagement in cooperation – from the off-taker’s point of view - will be purely cost-driven. In this case, solely the host country does benefit from the storage and there is no mutual interest in supporting a dispatchable but costly technology. Therefore, we hypothesize that a CSP project with higher LCOE will only be realized though cooperation if either

(1) physical import of electricity is possible and will improve the off-taker’s electricity mix, or
(2) the host country limits the offered cooperation RES projects to this technology, or
(3) the Commission decides that the financing mechanisms shall support RES technologies with storage to ensure the Union’s energy security and flexibility of the energy system.

Potential **host countries** for RES projects are those Member States which have already reached their 2020 targets with significant numbers of surplus RES energy, thus Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Italy, Lithuania, Finland and Sweden (see Figure 2b). In general, host countries of RES projects benefit from the creation of jobs, reduction of greenhouse gases, modernization of their energy system, and in longer term - once the agreement with the off-taker expired- the further increase of their own national RES share. In addition, a CSP plant with storage increases the stability and flexibility of the electricity system in the host country and could also serve the co-generation of electricity and heat and increase the RES share in the heating sector [Del Río, P. and Kiefer, Christoph P. (2019)].

CSP installations are economically most viable in those EU Member States with areas of high annual DNI values. Based on resource availability (see DNI map in Figure 4), Spain, Portugal, France, Italy, Greece, Malta, Cyprus and Croatia offer the most suitable locations. This means that currently only Italy and Croatia have both a high CSP potential and had a RES share in 2017 that exceeds their national 2020 target (see Figure 2b). Therefore, using the 2020 target achievement as a proxy for the likelihood of the countries' ability to supply additional RES capacities through cooperation, both countries appear as good candidates to serve as host countries for CSP cooperation projects. Yet, Croatia did not include CSP in its draft NECP[19] and the country enjoys also a high potential for hydro and wind power which decreases the likelihood of being a CSP project host country. In contrast, Italy's NECP draft included an increase of CSP capacities from 0.01 GW in 2020 to 0.88 GW in 2030 and might thus be interested in the realization of additional CSP projects by cooperation. But noteably, Italy's ambition regarding CSP is small when compared to Spain's quantitative CSP target of 7.3 GW in 2030 (compare Table 5).

Portugal, Malta, Cyprus, Greece and France are special cases since on the one hand high DNI values qualify them for CSP projects, on the other hand they will most likely miss their 2020 targets (see Figure 5). Therefore, they might be more interested in reaching their own targets before helping other Member States in terms of engaging in cooperation as a host country which would give them only a fraction of the generated energy. Notably, the draft NECPs[19] of Portugal, Greece and Cyprus already included the deployment of solar CSP for electricity generation, partly even with quantitative targets (see Table 54). However, the 2020 target achievement is only used as an indication to what extent the countries might be able to supply additional RES capacities through cooperation in the timeframe up to 2030. Also countries that might miss their 2020 target could nevertheless be interested in RES cooperation in the timeframe after 2020.

[19] The Draft National Energy and Climate Plans (NECPs) submitted by the member states in December 2018 are available under: https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union/national-energy-climate-plans

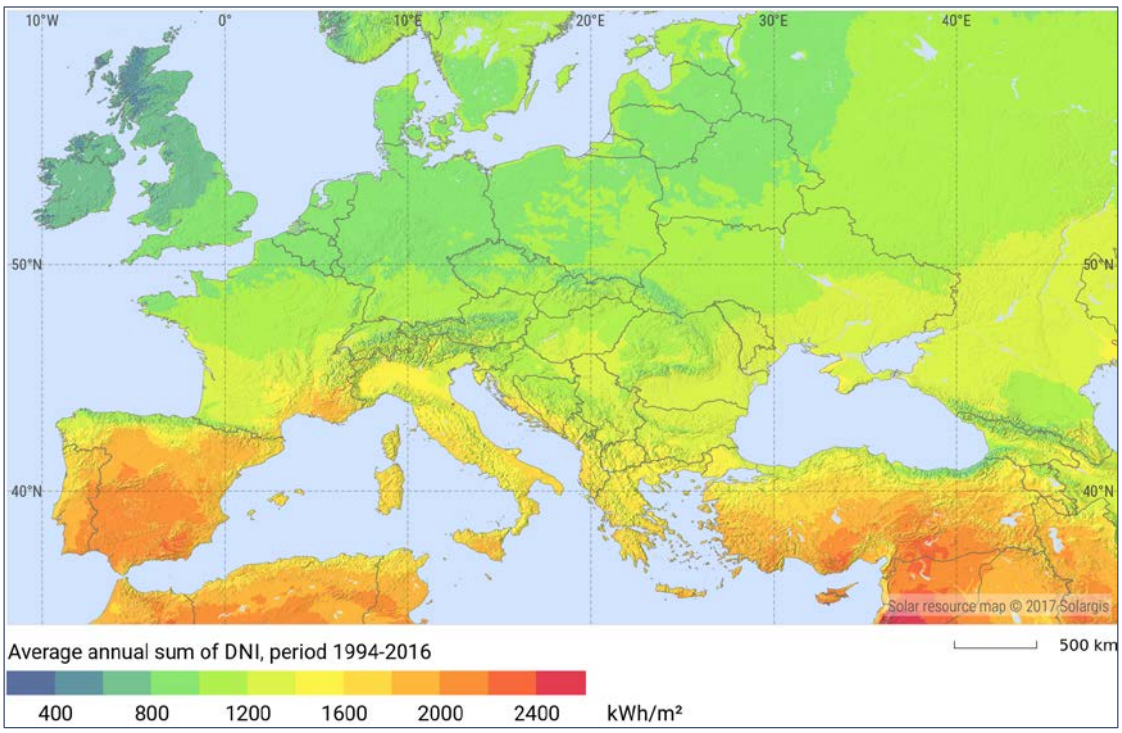


Figure 4: Map showing average annual DNI value, (Source: https://solargis.com) © 2019 Solargis.

Malta, as a small country consisting of 3 islands and with an area of 316 km^2, has so far no plans for a CSP project and according to their draft NECP[19], they will mainly expand solar PV which shall contribute 42% to the total RES share in 2030. For system stability, battery storage shall be installed and the county will use flexible balancing services through the 200 MW Malta-Sicily electricity interconnector. Unfortunately, the analysis of Malta's draft NECP revealed an ambition gap since the RES contribution formula results in an objective RES share target of 21% and the national plan equaled only 10.6-13.3% (Figure ***2***). Therefore, we could well imagine that Malta (like other potential off-taker countries) will utilize cooperation mechanisms or the financing mechanism. There are also fair chances that they start a joint project with Italy targeting RES electricity import during the night possibly promoting a CSP cooperation project.

Spain is expected to reach its binding 2020 target of 20% RES share. For 2030, the draft NECP included a RES share target of 42% revealing large ambition in comparison with the objective target of 32% resulting from equation 1 in section 2.2.2. Spain also plans to increase the installed CSP capacity from 2.3 GW in 2020 to 7.3 GW in 2030 which will contribute to strengthening the regional economy. It was reported in deliverable 4.2 [Lilliestam, J. (2018)] of this project that the engineering, procurement and construction of CSP in Europe is strongly dominated by Spanish companies and that Spain is home of most remaining CSP companies. Therefore Spain will have multiple benefits of

a market uptake of CSP and will likely be interested to serve as a host country for CSP cooperation projects.
Both France and Portugal might opt for joint or open auctions with Spain as this could lower their RES support costs. The possibility of physical import through enhanced interconnection could trigger a dispatchability requirement in the auction design (beneficial for CSP). Yet if a location close to the Spanish-French border is desired, the Pyrenees mountain range might as well stimulate a joint hydro power project with pumped storage or wind farm.

In summary, we identified Spain and Italy as the countries with the highest potential as host countries for future CSP cooperation projects, however Spain's ambition to deploy CSP is higher due to the existing CSP industry thus economic reasons. Multiple off-taker countries for statistical transfer exist yet CSP projects will more likely gain support if also the off-taker benefits from the higher costs of the dispatchable technology, e.g. Malta as off-taker for CSP in Italy, Portugal and France for CSP in Spain.

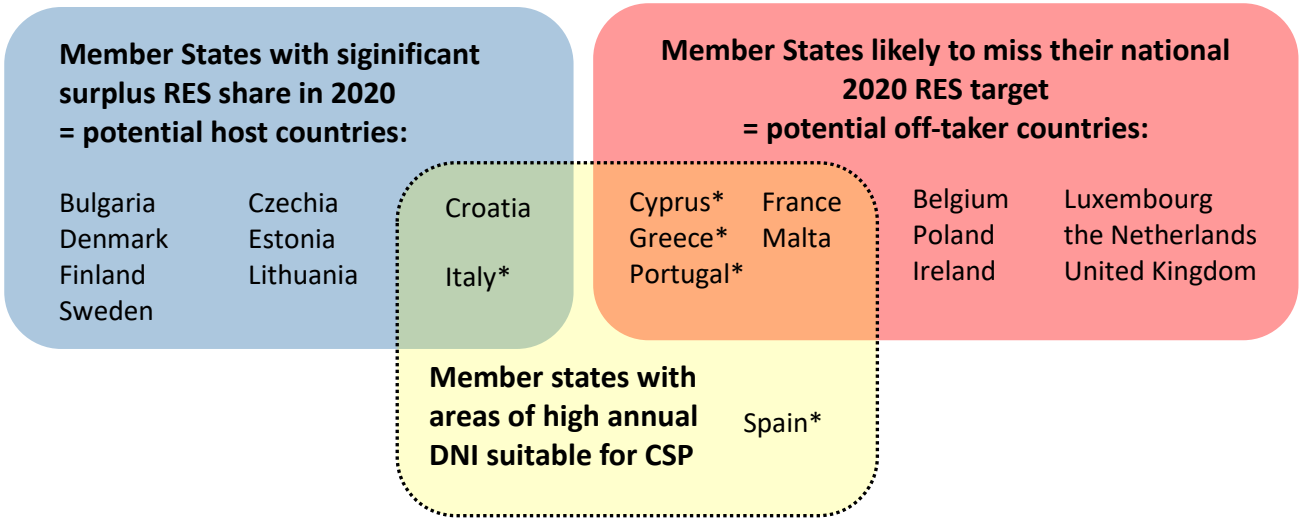


Figure 5: Overview of the potential host countries (blue box) and contributors (red box) for cooperation in the EU, and Member States with areas of high DNI values beneficial for CSP projects.

*The * indicates countries which included CSP in their draft NECPs from December 2018. Spain is expected to just meet the 2020 target.*

4.4 Potential scenarios for European CSP cooperation projects

The future use of cooperation mechanisms in the EU is uncertain and it is hard to predict if they will be able to enhance CSP deployment. However, to analyze the way different framework conditions and policy instruments may impact the cooperative deployment of CSP in the EU, we want to outline a selection of possible future scenarios:

- A "bottom-up scenario" in which CSP cooperation takes place mainly on the basis of individual Member States' political initiative. Here, we look at a potential cooperation between France in the role of an off-taker country and Spain as a possible host country of a CSP project.
- A "top-down scenario" in which CSP cooperation projects are driven primarily by instruments on the level of the European Commission as a response to a realization gap i.e. to prevent missing the European 2030 RES target. This case implies the implementation of an EU-wide, technology-specific (CSP) auction organized by the EU Commission and financed through the EU financing mechanism.

In both cases also the potential role of other support instruments on EU level, like the new Connecting Europe Facility (CEF) or the EU enabling framework, are considered.

A variety of other cooperation scenarios (e.g. including statistical transfers or technology neutral cross-border auctions) is conceivable, however, as the role of CSP would be limited in such scenarios, we will focus on the above options.

4.4.1 *Scenario 1: Joint CSP project between Spain and France*

Based on present prognoses, France will likely miss its binding 2020 RES target [Navigant (2019)] and may subsequently have trouble ensuring to stay on track of its NECP trajectory towards 2030. This would create a strong driving force for the participation in RES cooperation mechanisms to ensure target achievement.

One option would be a joint RES project with a neighboring country. Currently, the electricity mix in France is strongly dominated by nuclear power and the fraction of RES energy varies strongly depending on the season. A maximum of ~30 % share of renewable energy sources in the electricity consumption per quarter occurs in late spring of 2018 due to the high fraction of hydropower related to snowmelt. Hydroelectric power generation had the largest share (see Figure 6) in 2018 with an installed capacity of 25.5GW [RTE (2019)].

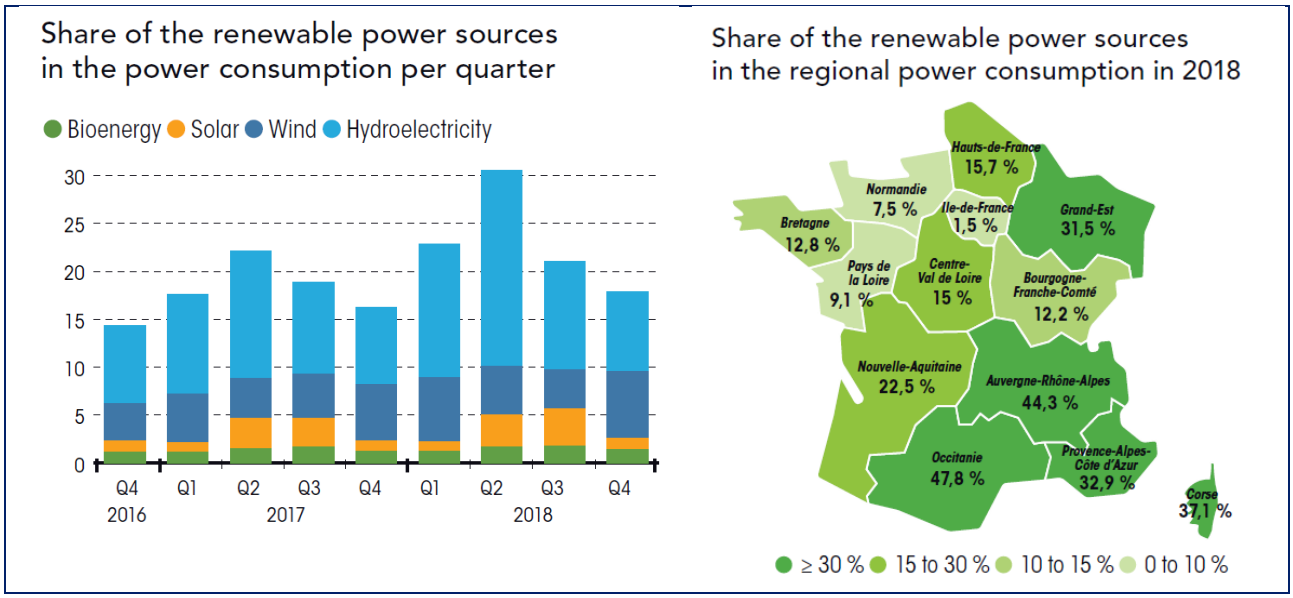
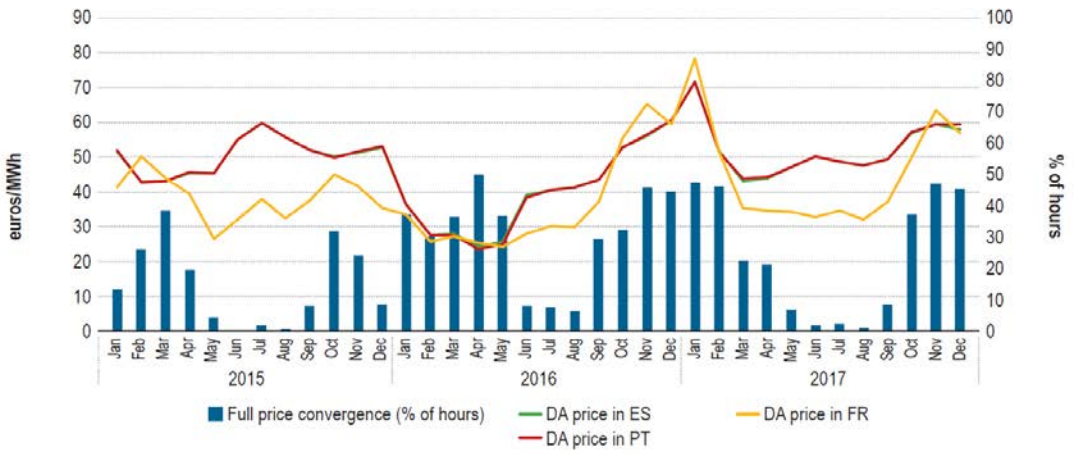


Figure 6: Share of RES in electricity consumption of France. Copied from [RTE (2019)].

According to Eurostat comparison[20] the electricity prices (EUR per kWh) for non-household consumers in France were below the EU average In 2018. The comparison of day-ahead electricity market prices in Spain, Portugal and France in Figure 7 shows that mostly, and with the excemption of only a few winter months, the day-ahead prices in from 2015-2017 were lower in France than in its southern neighbor [ACER /CEER (2018)]. Further, according to the RTE-Electricity Report 2018[21], France exported 86.3 TWh electricity to its neighbor markets and imported only 26.1 TWh . Thereof, 4.4 TWh of imported electricity were provided by Spain while 16.4 TWh were exported from France to Spain. However, interestingly the Spanish NECP foresees to invert the trade balance: The Spanish target scenario of 2025 foresees an increased exchange of electricity leading to an export of 18.9 TWh and import of 10.7 TWh to and from France. From an economic point of view, this can only be accomplished when also electricity prices similar or lower than the ones in France will be achieved. The high ambition of Spain and Spanish efforts towards higher electricity exports might promote their willingness to realize joint projects with France. Benefits for Spain as a CSP off-taker country include the creation of jobs, a higher RES share and increased flexibility of their electricity grid (see also section 5.2).

[20] https://ec.europa.eu/eurostat/statistics-explained/images/9/94/Electricity_prices_for_non-household_consumers%2C_second_half_2018_%28EUR_per_kWh%29.png

[21] https://bilan-electrique-2018.rte-france.com/?lang=en#



Source: ENTSO-E and ACER calculations (2018).

Figure 7: Comparison of day-ahead electricity market prices in Spain, Portugal and France from 2015-2017, Soure [ACER /CEER (2018)].

In summary, we postulate that both France and Spain will be interested in a joint project which includes the physical transport of electricity generated by RES at times of high demand. Thus it is well imaginable that France and Spain will prepare a joint auction for RES support in the form of feed-in premiums for some 100 MW CSP project with storage that might be located in either Spain or France. The two countries will need to decide about a distribution rule for the generated electricity and the duration of support through feed-in-premium (typically 20 years) and the exact auction design including ideally Pay-as-bid (PAB) pricing rules and penalties for non-realization of the project. Further, both countries should then provide suitable sites offering high DNI values. The auction design should lead to a high degree of competition and since projects in both countries could have the winning bid a higher social acceptance can be expected. The outcome of such a fictive future auction is hard to predict but projects in Spain will likely have lower LCOE hence there are high chances that mainly CSP projects in Spain will be awarded. Notably, Spain would also benefit from projects in France since those would also support the CSP engineering and construction industry which is mainly located in Spain [Lilliestam, J. (2018)].

4.4.3 *Scenario 2: EU-wide CSP auction under the EU Financing Mechanism*

The financing mechanism will be established in 2021 and aims to help Member States in reaching the RES targets. Since several countries will have missed their national RES target in 2020 the financing mechanism will be utilized for RES support auctions. Thus in 2021, all Member States will be asked to express their interest to participate as host and contributor country in such auctions.

The host countries will suggest different locations and technologies. Probably, the more northern countries e.g. Finland, Estonia, Lithuania and Sweden will suggest on-shore and off-shore wind projects, CSP projects with storage might be suggested by Italy and Spain, and biomass power plants and solar parks by various countries. All host country candidates need to provide information about the suggested locations, quantities of RES energy and estimate the support costs. The contributing countries indicate their demand and required quantities and the maximum price they are willing to pay. The supply and demand data will be used to determine the estimated support level and the involved Member States will be asked for binding commitments. Then the EU decides about the auction and whether technology-neutral or technology-specific auctions will take place. As the flexibility of the electricity grid is of major interest, the EU will likely hold at least one auction for electricity generation by RES including non-battery storage. Hence most likely a technology-specific auction for a CSP project will be held. The auction will only include statistical transfer of the electricity and a distribution rule (90:10, contributor:host) for the electricity will be included. The invitation for bids will probably be published before 2024 and the project will need to be realized before 2030.

5 SUMMARY AND CONCLUSIONS

Cooperation mechanisms were introduced by the European Commission in 2009 to support the EU Member States in reaching their binding 2020 RES target share. The basic idea is to generate energy from renewable sources at locations which require low support costs by offering high potential and/or minimum direct and indirect system costs. Therefore, four cooperation mechanisms were included in Directive 2009/28/EC: Joint RES projects between Member States or Member States and third countries, Joint support schemes for RES projects, and statistical transfers of RES energy between Member States. Till today (October 2019), and even though several Member States will more than likely miss their 2020 target, only few countries have engaged in cooperation mechanisms so far: Estonia and Lithuania agreed to statistically transfer RES energy to Luxembourg, Germany and Denmark held joint auctions for photovoltaic installations, and Sweden and Norway introduced a Joint Electricity Certificate system. None of these cases involved CSP projects.

For the time horizon 2020-2030, the 'Clean Energy for all Europeans – CE4ALL' package adopted in May 2019 includes a new EU-wide 2030 target of 32% for the share of renewable energies in the gross final energy consumption, sets guidelines for renewable energy support schemes (and cooperation), and introduces mechanisms and instruments that will be used in case Member States miss their envisaged national RES share leading to a collective delivery gap. If a delivery gap for RES energy occurs, Member States may implement national measures to increase the RES-share or increase RES in other sectors or use cooperation mechanisms or pay into the Union financing mechanism.

RES support in the EU shall be granted by competitive procedures and provided in the form of fixed or sliding market premiums. Importantly, if a technology-neutral process would lead to suboptimal results, Member States may limit the support auction to specific technologies. This is particularly relevant for CSP projects since their deployment and competiveness is limited by higher LCOE compared to other RES technologies, such as solar PV or onshore wind. The selling point of CSP installations is dispatchability meaning that the thermal energy generated by sunlight can be stored for several hours before it is converted into electricity. Consequently, the success of CSP projects in tendering processes depends critically on the auction design (section 3.2.2 and [del Rio, P., Mir-Artigues, P., 2019] and if the energy storage option is valued.

The foreseen EU enabling framework stipulates the use of Union and other funds to enhanced the integration of RES technology and storage facilities in the electricity system, to reduce cost of capital for RES, to increase system flexibility and interconnection and to promote cooperation between Member States. Depending on the implementation of these measures, the enabling framework might strongly promote the expansion of CSP as a dispatchable RES technology.

Regarding cooperation, the new Recast RES Directive (2018/2001) foresees more support for Member States with the practical implementation and includes additional new instruments. Firstly,

statistical transfer of RES electricity shall be facilitated in the future by a Union renewable development platform which basically acts as a match-maker and shall reduce administrative hurdles for RES cooperation. Secondly, the Commission encourages the opening of RES support schemes to other Member States and will assess the mandatory opening of support schemes by 2023. In the post 2020 framework, CSP projects might benefit from cooperation mechanisms, however, this requires a strong interest of Member States in fostering dispatchable RES technologies. In case of statistical transfer, the off-taker country aims at low costs and has no benefit from the dispatchability. If the cooperation is based on a purely economical optimization, CSP projects will most likely not have the winning bid. This is different when electricity is physically transferred between the cooperating parties and when enabled by either joint projects or joint support schemes or open RES support auctions. In those cases, CSP with storage could contribute to an increased flexibility in the host and off-taker countries' electricity system contributing to energy security.

We also conclude that CSP expansion in Europe will likely benefit from the "Connecting Europe Facility" (CEF) program and the EU financing mechanism. From 2021-2027, an amount of 8.7 billion Euros of the CEF budget is dedicated to support technical, preoperational or feasibility studies and/or work towards the clean energy transition and which include cooperation between Member States (section 2.3). We speculated that a RD&D CSP project with thermal storage, most likely will be proposed by Spain and one other Member State, will have high chances to be eligible for funding under the CEF.

The EU financing mechanism is a new instrument that will be established by January 2021 and will likely become a powerful instrument to close a potential RES delivery gap in the EU. In addition, it will supplement the enabling framework. Once a delivery gap is determined, Member States with RES deficiency can make a financial contribution and support a RES project in a host Member State which will be awarded by auctions organized by the Commission (see section 2.2.6 for details). Prior to such an auction, host countries of potential RES projects need to specify the possible capacities and technologies and contributors/off-takers share their demand and maximum price. Main drivers for a host country to participate would be a modernization of the electricity system, reduction of greenhouse gas emissions and economic benefits through job creation. Drivers for the off-taker countries are most likely high support costs on their territory and/or limited resource potential which in turn increase costs.

On national level, CSP deployment has been included in the draft national energy and climate plans (NECPs) of Spain, Portugal, Italy, Greece and Cyprus. The future role of CSP in cooperation projects between Member States is discussed and estimated in section 4.2 of this report based on a comparison of the Member States progress towards the RES share targets and their national interest in CSP as well as the resource potential for the technology in each country. We identified Spain and Italy as Member States with the highest probability to engage in future CSP cooperation projects,

yet Spain's existing CSP industry and lobby might stronger push the country's ambition. Several Member States could serve as off-taker countries for statistical transfer but we conclude that CSP projects will more likely gain support if physical transfer of electricity can take place, e.g. from Italy to Malta, or from Spain to France. Only in such cases the off-taker will benefit from the dispatchability through the storage option and might be willing to accept higher costs of the electricity generated by CSP.

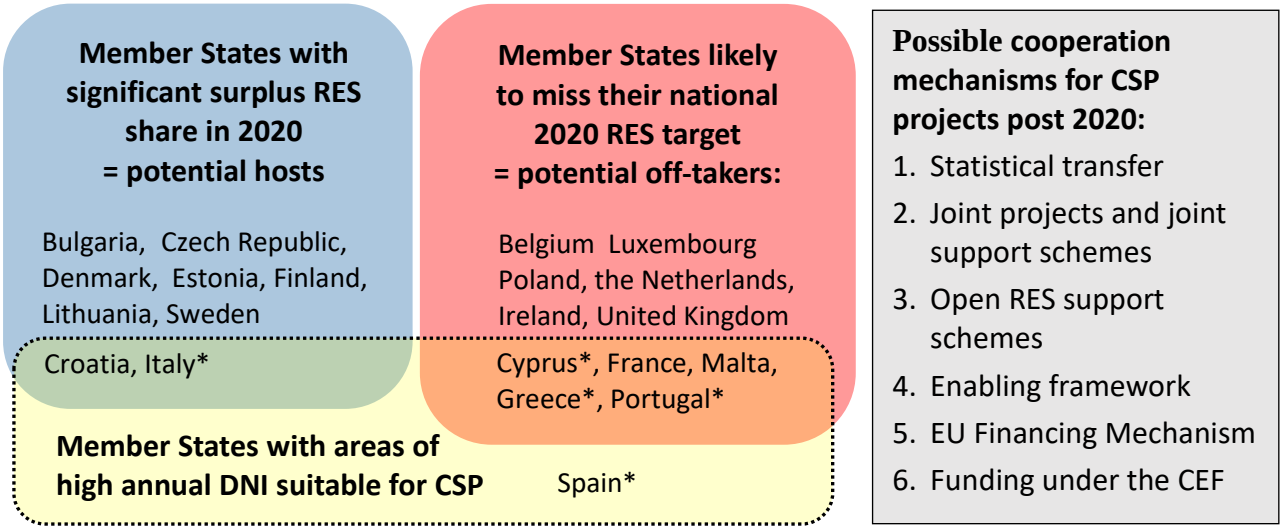


Figure 8: Summary of potential host countries, offtaker countries and policy instruments potentially relevant for CSP cooperation 2020-2030

*Overview of potential host countries (blue box) and off-taker countries (red box) for cooperation, and Member States with areas of high DNI values beneficial for CSP projects (yellow box). The * indicates countries which included CSP in their draft NECPs from December 2018. Spain is expected to just meet the 2020 target. The grey box summarizes possible instruments that might promote CSP cooperation projects in the 2020-2030 timeframe.*

In Summary, the increasing ambition and target to increase the share of RES energy in the EU will lead to the expanded growth and deployment of RES technologies and thus most likely increase the use of cooperation, especially through the EU financing mechanism. The extent to which CSP will benefit from the new measures and instruments will mainly depend on the Member States' interest to expand the flexibility of their electricity systems, hence promote a dispatchable technology and if costs for CSP can be substantially reduced in the future.

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7 APPENDIX: LIST OF ABBREVIATIONS

CEF	Connecting Europe Facility
CSP	Concentrated Solar Power
DNI	Direct Normal Irradiance
DOI	Department of Energy
EU	European Union
FIT	Feed-in tariff
FIP	Feed-in Premium
LCOE	Levelized Cost of Electricty
NECP	National energy and climate plans
NREAP	National Renewable Energy Action Plans
PPA	Power purchase agreement
PV	Photovoltaics
RE	renewable Energy
RES	Renewable Energy Source
RES-E	Electricity generated from renewable energy sources
WACC	Weighted Average Cost of Capital

MUSTEC
Market Uptake of Solar Thermal Electricity

WHO WE ARE

The MUSTEC consortium consists of nine renowned institutions from six European countries and includes many of the most prolific researchers in the European energy policy community, with very long track records of research in European and nationally funded energy policy research projects. The project is coordinated by Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas-CIEMAT.

Name	Country	Logo
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University of Piraeus Research Center – UPRC	GR	
Eidgenössische Technische Hochschule Zürich - ETH Zürich	CH	
Technische Universität Wien - TU WIEN	AT	
European Solar Thermal Electricity Association – ESTELA	BE	
COBRA Instalaciones y Servicios S.A – COBRA	ES	
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The project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 764626

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