Cost-Efficient and sustainable deployment of renewable energy sources towards the 20% target by 2020, and beyond

D3.5

CSP solar energy – Case study of cooperation mechanism design

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EXECUTIVE SUMMARY

Cooperation mechanisms, as described in articles 6-11 of the RES Directive (2009/28/EC), were introduced to provide European Member States (MS) with greater flexibility to achieve their national targets for energy consumption from renewable sources (RES) as well as to contribute to achieve the overall European 20% target in a cost effective way. The underlying rational of the cooperation mechanisms is to allow countries with high RES potentials and/or low production costs (in this report referred to as "host countries"), to sell their RES surplus to those countries that have either low RES endowments and/or have higher generation costs (referred to as "user countries").

Based on the cooperation opportunities identified by the previous modelling exercise documented in Dalla Longa *et al.* (2011), three case studies have been developed where Denmark, Romania and Spain could potentially sell part of their offshore wind, biomass and/or concentrated solar power (CSP) surplus potential, respectively, to the Netherlands, in order for the latter country to fulfil its RES national targets in a more cost efficient way.

The purpose of the analysis of these three case studies was twofold. Firstly, other factors, besides costs, potentials and national targets, have been identified which could play an important role in the implementation of the cooperation mechanisms. In addition to the above task, by conducting these three case studies, the particularities of the three different geographic locations and technologies could be explored in detail in order to identify associated opportunities and barriers, and to derive possible solutions for each context.

The results from the CSP case study, described in the present report, indicate that both countries (Spain and the Netherlands) could benefit from the implementation of a cooperation mechanism. In particular, the most suitable cooperation mechanism is a joint project, without physical transfer, where the Netherlands would acquire part of the RES electricity production it needs to fulfil its 2020 Res targets from Spain (approximately 5TWh).

When considering the support cost under the domestic and cooperative approach scenarios in 2020, clear savings under the cooperative scenario arise for the Netherlands. Similarly, Spain would also benefit, mostly in terms of environmental and socio-economic positive impact, from the possibility to further deploy its CSP industry without compromising Spanish public funds. The financial transfers from the Netherlands to Spain associated with the case study application of the cooperation mechanism would in fact encompass some additional primary expansionary impulses to the Spanish economy. If state-of-the-art Dutch suppliers are to be involved in delivery of specialty components, this may help to boost political and public support in the Netherlands. Moreover, granted that implementation of the case study application implies additional deployment of CSP, this would anyhow imply faster technical learning with the associated consequential cost reductions.

Besides the direct costs associated with the required support for CSP producers as well as the grid related costs, this study identifies some key direct and indirect effects associated to the "cooperative" scenario in comparison to the "domestic" scenario. Moreover, a first attempt to quantify and monetize to the extent possible such co-effects has been developed within this case study. This information, despite subject to great amount of uncertainty, should provide some guidance with respect to the magnitude and the sign of such co-effects.

In any case, even when considering the net co-effects, the cooperative approach between Spain and Netherlands seems to be mutually beneficial.

It is important to take into consideration that such benefits would only be materialized if the expected CSP generation cost reductions would be accomplished. The current generation cost is around 18 c€/kWh and it is expected that by 2020 the cost would have been reduced to 10 c€/kWh. This fact has implications with respect to the timing of the deployment of the plants. In particular a balance has to be found between starting as soon as possible in order to exploit the benefits of cooperation at an earlier stage, and delaying the implementation in order to take advantage of the projected cost reductions. Similarly, this fact has implications about the best CSP technology to be used for the plants. While the current situation is technology neutral (generation costs of the two main CSP technologies in the market, parabolic trough and central receiver, are very similar) it is possible that over the next few years, there will be one technology that achieves higher cost reduction, and thus would be the preferable one.

Various barriers have been identified that could potentially jeopardize the implementation of such agreement and possible solutions have been proposed. Some of the most important barriers are the lack of guidance with regards to the administrative and legal procedures (institutional set-up) to implement the cooperation mechanism, uncertainty about post-2020 targets and the coordination requirement with national authorities.

This case study has contributed to shed some light on the opportunities and challenges involved in the use of the cooperation mechanisms between two countries and has triggered the interest and discussion among Spanish relevant stakeholders (Protermosolar, I.D.A.E., REE) and the Dutch government.

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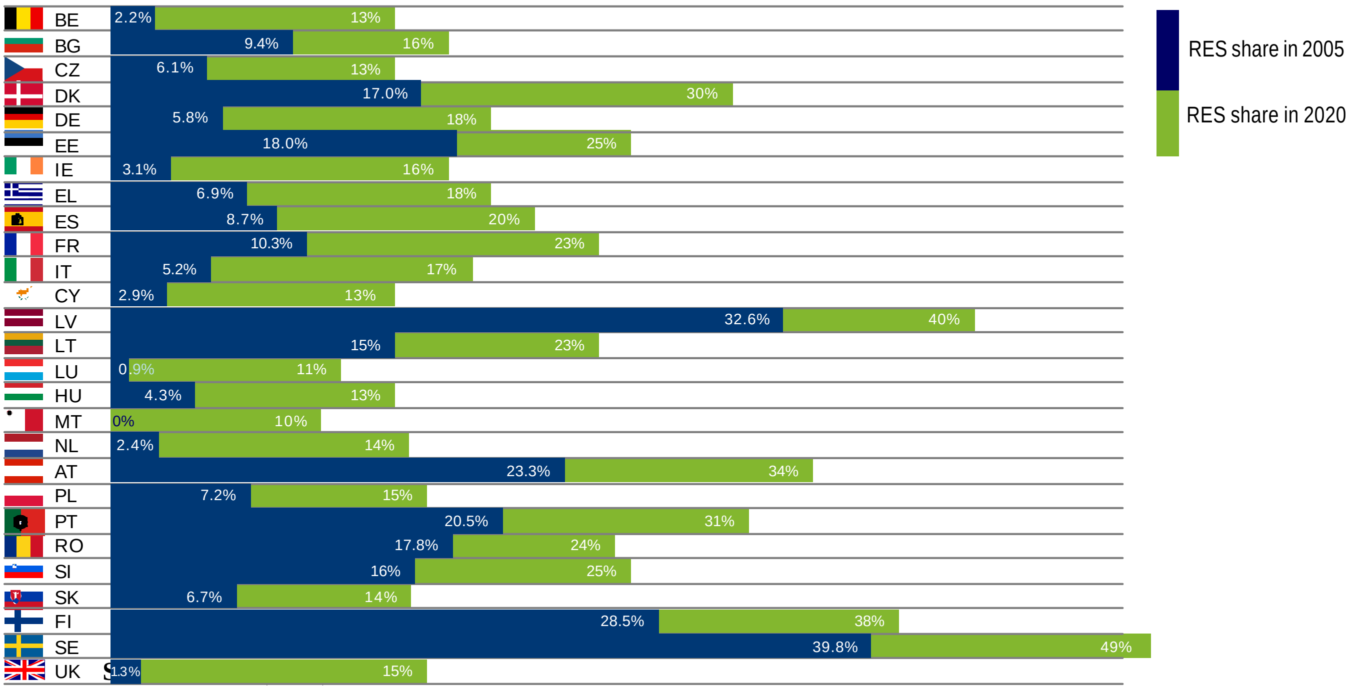
1 INTRODUCTION

The EU Directive on the promotion of the use of renewable energy sources (RES) was adopted in April 2009 (2009/28/EC) and sets binding targets for all EU Member States to reach the European target of 20% RES share in EU gross final energy consumption by 2020 (see Figure 1). Such targets are based on a flat rate approach (same additional share for each country), adjusted to the individual Member State´s GDP. This target allocation approach does not account for Member States´ RES potentials. Since the available resources of biomass, wind, hydro, tidal, wave and solar - power vary significantly across the different Member States (Klessmann *et al*. 2009), certain Member States may encounter disproportionate RES deployment challenges.

Figure 1. National RES targets according to the Directive 2009/28/EC [%]



Given such variability of renewable energy resource potentials and generation costs across Europe, articles 6-9 of the Directive introduce the possibility to use “cooperation”[1] mechanisms so that those countries with limited or expensive RES potential partially fulfil their RES target by purchasing or jointly developing RES projects in other countries with higher RES potential or lower production costs. Consequently, their objective is twofold: on the one side they aim at providing Member States greater flexibility and, on the other side, they aim at achieving the overall 20% target in a cost-effective way.

Three different types of intra-European[2] cooperation mechanisms have been proposed:

[1] They are not named “flexibility” mechanisms in order to diferenciate them from the Kyoto flexible mechanisms.
[2] Despite not being analysed in this project, there also exist the option to physically import RES electricity from third countries outside the EU (known as “joint projects between Member States and third countries”)

(i) Statistical transfers: Renewable energy that has been produced in one Member State is ex-post virtually transferred ex-post to the RES target accounting statistics of another Member State, counting towards the national RES target of the latter.

(ii) Joint projects: RES electricity or heating/cooling projects that are developed under framework conditions, jointly set by two or more Member States (for example: one Member State may provide financial support for a RES project in another Member State and count part of the project´s energy projection towards its own target).

(iii) Joint harmonization of support schemes: Member States combine part of their RES electricity or heating/cooling support schemes to achieve their national RES targets jointly. Under this mechanism, the produced RES energy can be allocated to the Member States via statistical transfer or a distribution rule agreed by the participating Member States.

In June 2010, in accordance with the RES Directive, all Member States had to submit a National Renewable Energy Action Plan (NREAP) that contained (i) estimation of gross energy consumption by 2020, (ii) sectorial targets by 2020, (iii) support actions in place as well as (iv) contribution of the energy efficiency and saving measures. According to a recent analysis of Member States´ National Renewable Energy Action Plans (NREAPs) conducted by Beurskens and Hekkenberg (2011) out of 27 Member States, 13 countries reported information on an anticipated excess or deficit of renewable energy by 2020. Two countries (Italy and Luxemburg) reported a deficit while eleven countries (Bulgaria, Denmark, Germany, Greece, Spain, Lithuania, Luxembourg, Hungary, Malta, Slovakia and Sweden) reported an excess. Overall, NREAPs reported an estimated European renewable energy production excess of about 0.7% over the 20% 2020 target.

The above mentioned summary indicates there might be some scope for utilization of the cooperation mechanisms. However, so far, only few countries (Italy, Luxembourg, UK) have expressed their intention to use them. One possible explanation is that the practical implementation of the cooperation mechanism is not straight forward and that further guidance of where the cooperation opportunities are and how to make use of them is needed. The Directive defines general accounting rules for using the mechanisms but does not give any specification of their design. It is up to the Member States to design and practically implement such mechanisms. Moreover, and as it will be discussed in a later section, there are various indirect costs that should be taken into account.

In this context, the EU funded research project RES4LESS (www.res4less.eu) aims at demonstrating that, in comparison to domestic energy strategies, the use of cooperation mechanisms will contribute to achieve the national and European renewable energy targets at a lower cost.

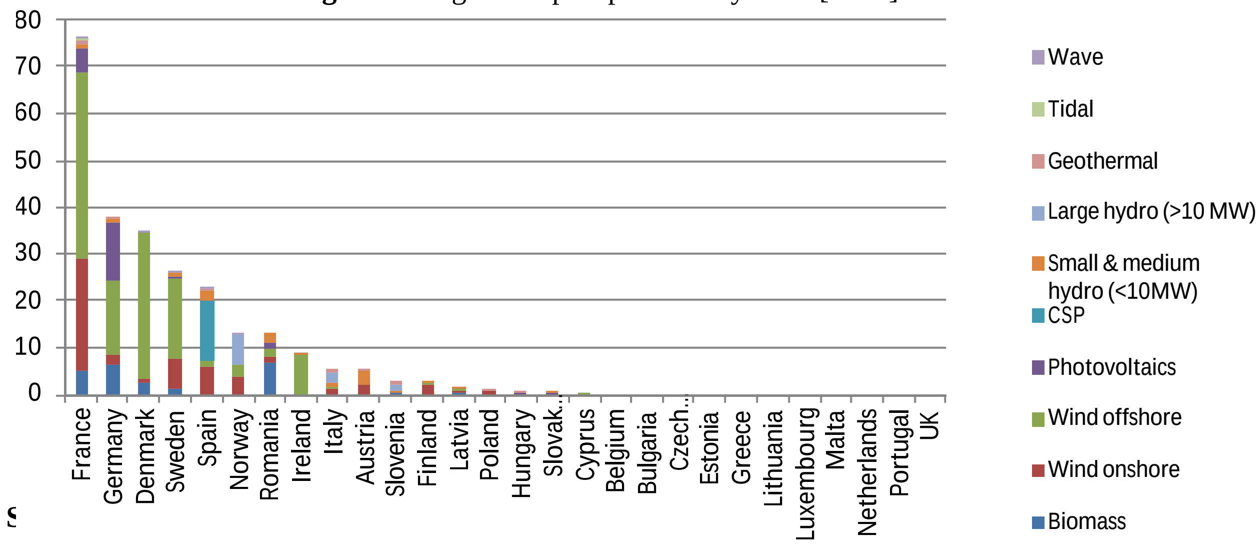
Based on the outcomes from previous work packages, the goal of this report (Deliverable 3.5: *CSP solar energy case study of cooperation mechanisms design*) is to present one of the three case studies selected to be analyzed within the frame of this project. The choice and content of the present case study is based on stakeholder consultation as well as on previous work within WP2. Within WP2 work, Task 2.2, developed a methodology to systematically analyze RES surpluses in EU. In the RES4LESS project, such Member State RES potential surpluses are referred to as Valleys of Opportunity (VoO). The VoO have been characterized with respect to costs and technology composition, to determine a preliminary set of candidate VoO that looks interesting from an economical perspective. Based on those results, Task 2.5 further elaborated on the model outcomes focusing on a specific technology and a specific region, the solar potential in South Europe. The next step was to conduct a "reality check" on the model outcomes against actual plans and expected outcomes and finally, narrowing down candidate VoO to more realistic VoO by considering practical barriers, that are not addressed by the model but are very likely to come into play. Based on such analysis, it has been possible to identify a concrete case study that has been analyzed in-depth, and which results will be presented in this document.

2 THE CASE STUDY

2.1 Background and scope

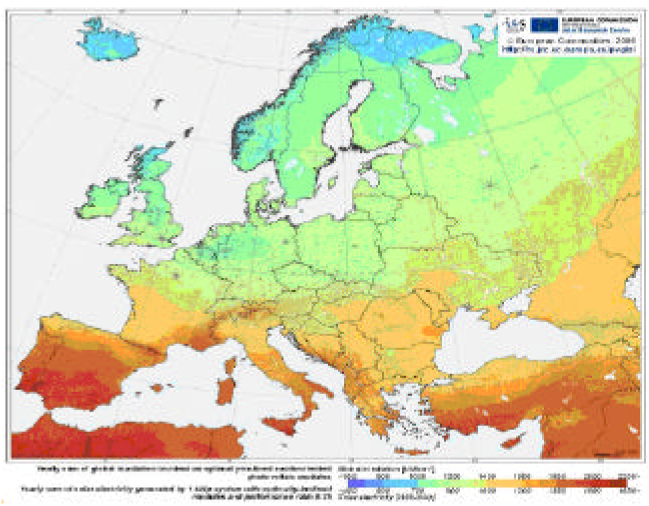
As mentioned previously, the choice of this case study is based on the analysis carried out in Task 2.2 and particularly Task 2.3 of the RES4Less project. Task 2.2 looked at identifying the possible cooperation opportunities within Europe. First step consist on identifying surplus potential that is the part of a cost supply curve beyond the RES national target derived from NREAP production forecasts as targets. Figure 2 show the results for the surplus potential by Member State and technology breakdown found within the context of Task 2.2.

Figure 2. Eligible surplus potential by 2020 [TWh]



The aim of Task 2.3 was to analyze specifically the VoO identified for the solar technologies. Based on the solar resource endowments present in the Southern part of Europe (Figure 3), Task 2.3 identified the possible surpluses of RES-E from solar technologies: Photovoltaics (PV) and Concentrated Solar Power (CSP).

Figure 3. Solar resource and electricity potential in Europe



Source: JRC (http://re.jrc.ec.europa.eu/pvgis/cmaps/eur.htm)

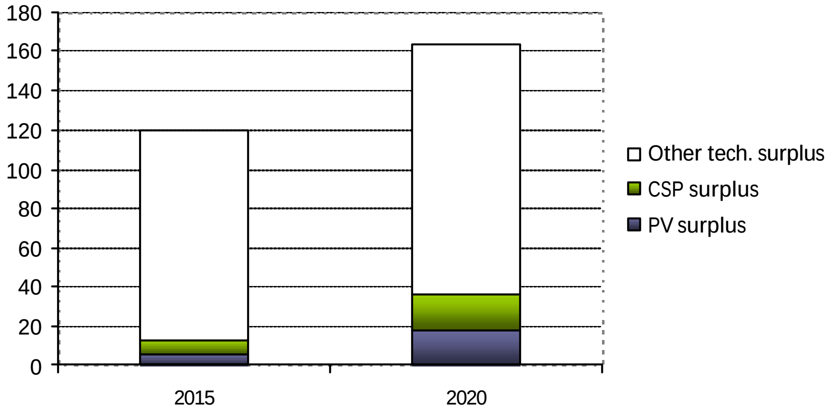
Based on those previous results, Table 1 and Figure 4 show the evolution of total solar surplus throughout the studied period and its share compared to the total renewable electricity surplus according to the NREAPS. By 2015 solar surplus will reach 13 GWh (5 GWh of PV and 8 GWh of CSP) and by 2020, 36 GWh (18 GWh of PV and 18 GWh of CSP).

Analyzing the results in relative terms (Table 2), it could be concluded that solar energy could represent 22% of EU total surplus by 2020, half of it from of CSP (11%) and half from PV (11%).

Table 1. Solar and total UE surplus [TWh]

	2015	2020
PV surplus	5	18
CSP surplus	8	18
Total solar	**13**	**36**
Total UE surplus	119	163

Figure 4. Solar and total UE surplus [TWh]

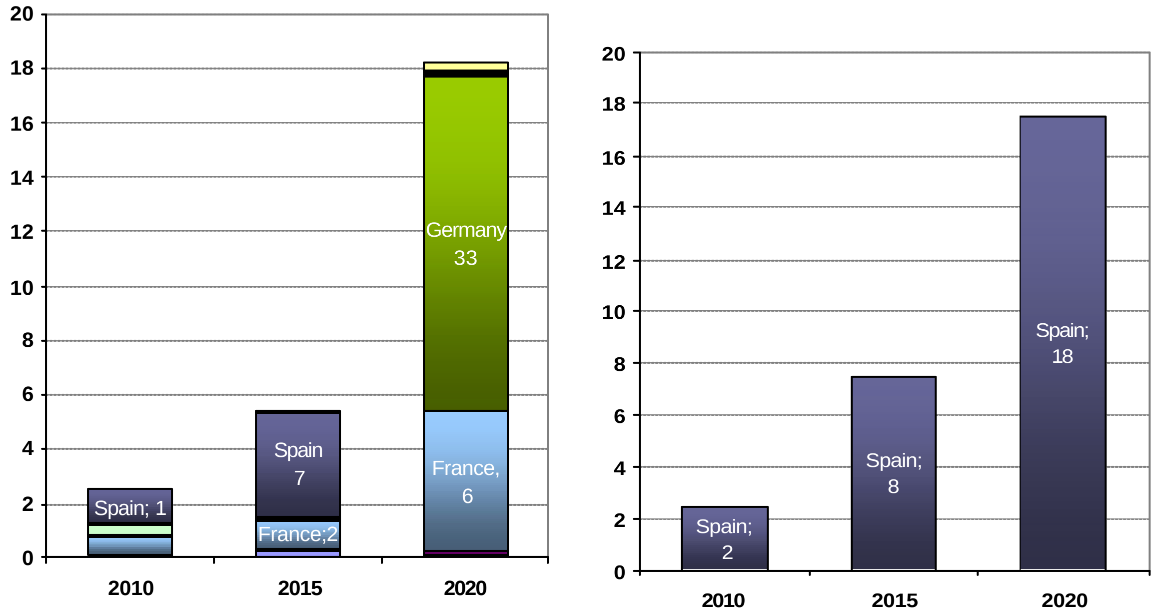


Source: RES4Less own estimates

As displayed in the Figure 5 and explained in detailed in D 2.3, the potential host countries that could have surplus solar potential are France, Germany and Spain.

Figure 5 / Contribution to solar surplus, country by country in 2015 and 2020 [TWh]

a) PV **b) CSP**



Source: RES4Less own estimates

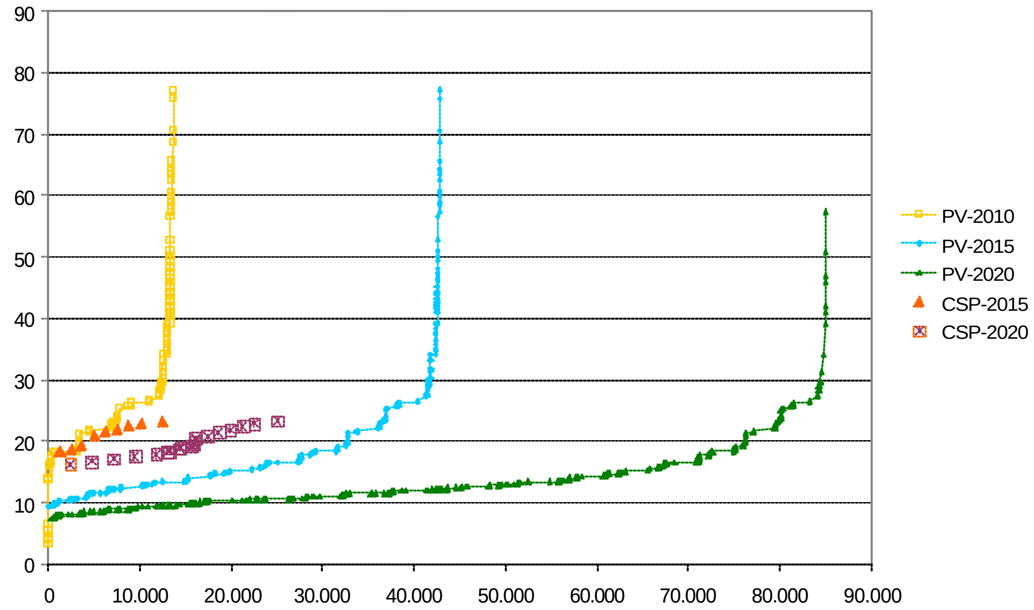
Summarizing, when taking into account total *RES surplus* in EU, the assessment shows that:

- By *2015*, 11% of total EU surplus will come from solar sources. In regional terms, most of PV solar surplus will be concentrated in Spain and France. In the case of CSP solar surplus, all of it will come from Spain.
- By 2020, 22% of total EU surplus will be originated from solar sources. In regional terms, most of PV solar surplus will be concentrated in Germany and France. In the case of CSP solar surplus, Spain continues to be the leading country.

While PV technology is present in many European countries (mainly Germany, France and Spain but also in other countries in Europe), CSP deployment has taken place almost uniquely in Spain (see table 3). As will be explained in detail later, this is due to the favourable climatic conditions, R&D as well as past favourable regulatory conditions.

Once the surplus for each Member States was estimated, next step consist on analyzing which would be the most efficient way to reach the EU RES target, on the base of having the possibility of using cooperation mechanisms. The results would be widely linked to the cost-competitiveness of reaching MS RES targets, so the cost of producing RES energy trough different technologies will play a crucial role. In terms of costs, figure 6 shows that while PV electricity generation is currently more cost competitive than CSP, uncertainty exists regarding what will be the actual cost evolution in the future for both technologies, in particular with regards to CSP.

Figure 6 / PV and CSP cost of electricity production along the UE in 2015 and 2020 [c€/kWh]

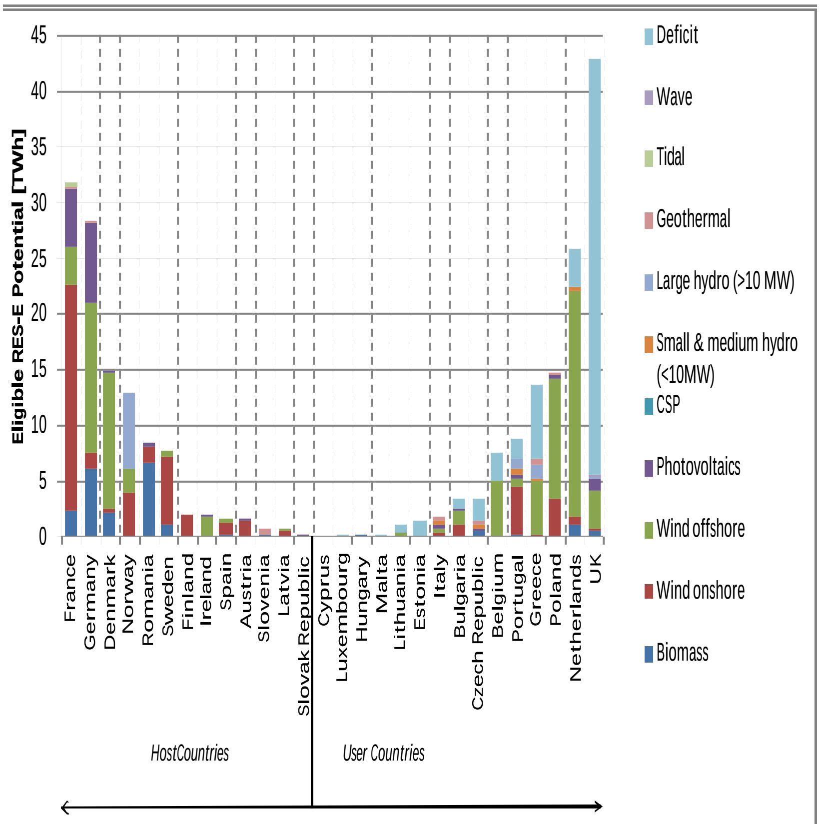


Source: RES4Less own estimates

In order to answer the research question how the cooperation mechanisms can be used in such a way as to reach the EU RES target at lowest cost, two complementary analyses have been conducted: a *pair-wise analysis*, targeting all possible pairs of MSs in EU, and a global *analysis*, targeting EU as a whole. The EU-level analysis yields an optimal allocation of RES-E surpluses in EU, but it assumes a EU-wide market for RES-E (or the corresponding RES credits) which is not realistically achievable within 2020. The pair-wise analysis is more realistic because it mimics the situation of two MSs wanting to establish a cooperation agreement; however it does not provide the most cost-efficient allocation of surpluses. As anticipated above, two complementary analyses have been conducted, a *pair-wise analysis*, targeting all possible pairs of MSs in EU, and an *EU-wide analysis*, targeting EU as a whole.

Figure 7 summarizes the results of the *global analysis* for the year 2020. For the set of Host Countries the bars represent the amount of Renewable Electricity that can be sold via cooperation mechanisms, broken down into the different technology components. For the set of User countries the bars represent the amount of Renewable Electricity that should be given up because too expensive, broken down into the different technology components. The category *"Deficit"* has been added to take into account the projected gaps between certain countries and their NREAP targets.

Figure 7. Global analysis results for 2020. Eligible RES-E Potential – Technologhy breakdown [TWh]

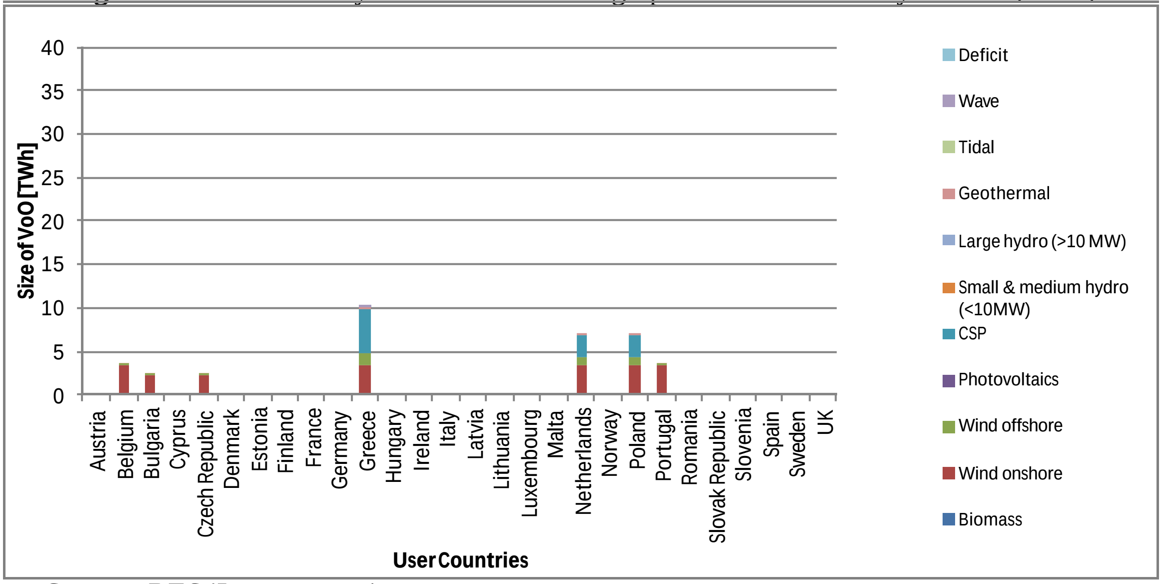


Source: Dalla Longa and Bole-Rentel (2012)

The results suggest that deficits and expensive wind offshore installations in Belgium, the Netherlands, Poland and the UK could be replaced by RES-E produced by wind offshore in Denmark, Germany and Ireland, by wind onshore in Sweden, Norway and France, by PV in France and Germany, and by Biomass in Romania and Germany. However, as already pointed out, not all the projected surpluses can be considered realistic (Tantareanu *et al.*, 2011; Santamaría *et al.*, 2011, Klinge *et al.* 2011).

The results of the *pair-wise analysis* are in general in agreement with Fig. 6, the main exception being that several VoOs based on Concentrated Solar Power (CSP) in Spain appear additionally as possible options, as indicated in Figure 8.

Figure 8: Pair-wise analysis results considering Spain as a Host country in 2020 [TWh]

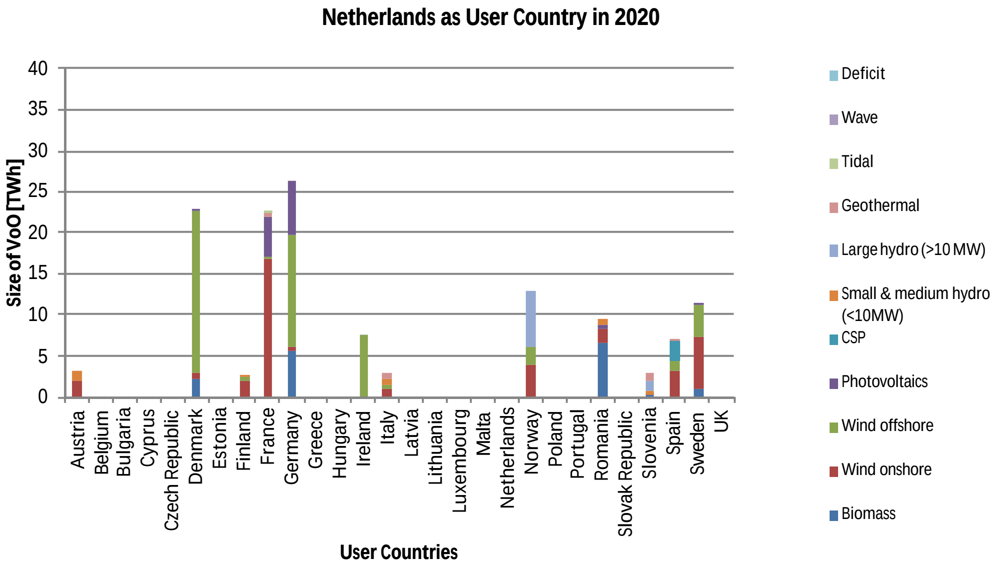


Source: RES4Less own estimates

It is important to remark that the VoOs identified by the pair-wise analysis are mutually exclusive, i.e. if one of the VoOs is realized, the corresponding surpluses are no longer available for the other VoOs.

The reason why VoOs based on Spanish CSP do not appear in the global analysis is that the costs of this technology are relatively high compared to other options available in the EU-wide market. However, since assuming a EU-level market for RES-E (credits) in the short term is not very realistic, and since our "reality check" identified Spanish CSP surplus under conditions of fast technical learning as a robust result, CSP-based bilateral cooperation agreements should still be regarded as economically attractive opportunities in 2020 for User Countries like the Netherlands, Greece and Poland. Despite Greece appears to be a potential user country for CSP solar surplus from Spain, its availability of solar resource as well as its current political situation and economic turmoil seem to indicate that is not the best country to be included in the case study. When looking for other countries, the Netherlands stands up as an attractive potential user country that could also be interested in purchasing energy produced from CSP plants in Spain. Moreover, the other case studies (Northern and Eastern European case studies) will be looking at the same user country.

Figure 9: Netherlands as a user country in 2020 (TWh)



Source: RES4Less own estimates

Besides taking into account the model outcomes, when considering practical barriers related to technological developments, administrative issues, policy and grid connection, etc., the following considerations have been identified.

- Germany can be ruled out as a major Host country of PV VoO´s because of the discontinuity of its role between 2015 and 2020 (it only shows as a strong PV host candidate in 2020 and not in 2015, when all the national production is used to meet 2015 Germany´s RES targets).
- Similarly, Spain does not seem to play a continuous "host country role" in PV solar technology (it only appears to have PV solar surplus in 2010 and 2015 but not in 2020).
- France appears as a potential PV host country both in 2015 and 2020.
- Given the current grid infrastructure limitations (existing interconnection capacity), physical transfer from Southern Europe (Spain, France and Italy) is cumbersome. The South-North transmission bottlenecks may improve upon implementation of the Infrastructure Package.
- Given the fact that PV and mostly CSP are not cost competitive, dedicated policy measures and support schemes need to be put in place or, alternatively, major costs reductions need to occur in order to compete with other more cost efficient RES technologies.

Besides the results from the model, there are additional issues that reinforce the selection of a case study focused in Spain and CSP:

a) Technological characteristics: mainly related to its comparative benefits with regards to its dispatchability; etc.
b) Economic aspects: CSP is a less mature technology with large potential for cost reduction as well as technological performance improvements. Nevertheless, the current RES support situation in Spain makes the cooperation mechanisms an even more interesting RES deployment tool to further deployment of the sector, contributing to reach a significant cost reductions due to learning curves. Beyond that, the potential future

deployment of this technology in other European countries (such as Portugal, Italy, Greece, etc) is very dependent on the continuity of the deployment of this technology in Spain.

c) Socio-economic benefits: as there are various indirect benefits that could arise in some EU countries (Spain and Germany) due to the further deployment of the technology (employment and economic activity in depressed rural areas, National industry stimuli, etc.)

d) Public acceptance and stakeholder involvement: Spanish Government and society support for this technology

Consequently, the case study that will be analyzed in depth in this report is as follows:

-User country: Netherlands
-Host country: Spain
-Electricity generated from: Concentrated Solar Power (CSP) technology in Spain
-Size of the coop. mechanism: 5 TWh
-Cooperation mechanism: joint project without physical transfer of the electricity

2.2 CSP technology in Spain

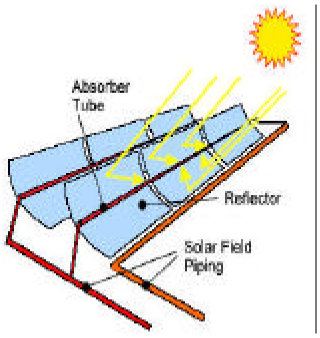
2.2.1 Introduction to the technology

Concentrating solar power plants produce electric power by converting the Sun's energy into high-temperature heat using various mirror configurations. The heat is then channelled through a conventional generator. The plants consist of two parts: one that collects solar energy and converts it to heat, and another that converts heat energy to electricity.

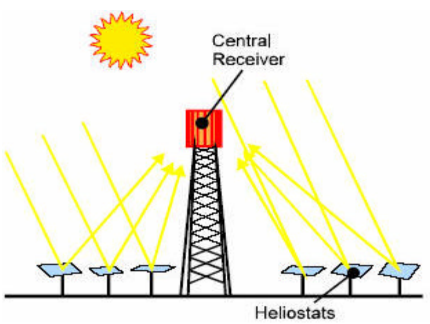
Some systems use thermal storage during cloudy periods or at night. Others can be combined with natural gas and the resulting hybrid power plants provide high-value, dispatchable power. These attributes, along with world record solar-to-electric conversion efficiencies, make concentrating solar power an attractive renewable energy option in the Southwest and other sunbelt regions worldwide.

At present, there are four solar thermal power technologies (parabolic trough, central tower, parabolic dish and linear Fresnel) being promoted internationally (Figure 10 and Figure 11). For each of these, there exist various design variations or different configurations. The amount of power generated by a concentrating solar power plant depends on the amount of direct sunlight. Like concentrating photovoltaic concentrators, these technologies use only direct-beam sunlight, rather than diffuse solar radiation.

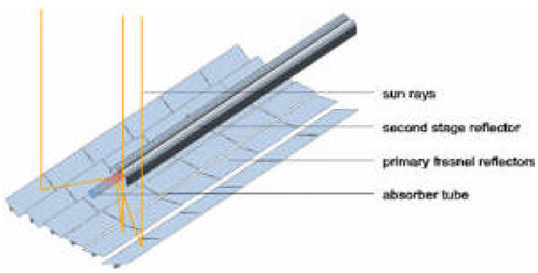
Figure 10. Types of CSP technologies



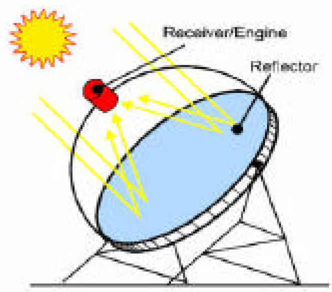
Parabolic trough



Central Receiver (tower)



Fresnel



Stirling Dish

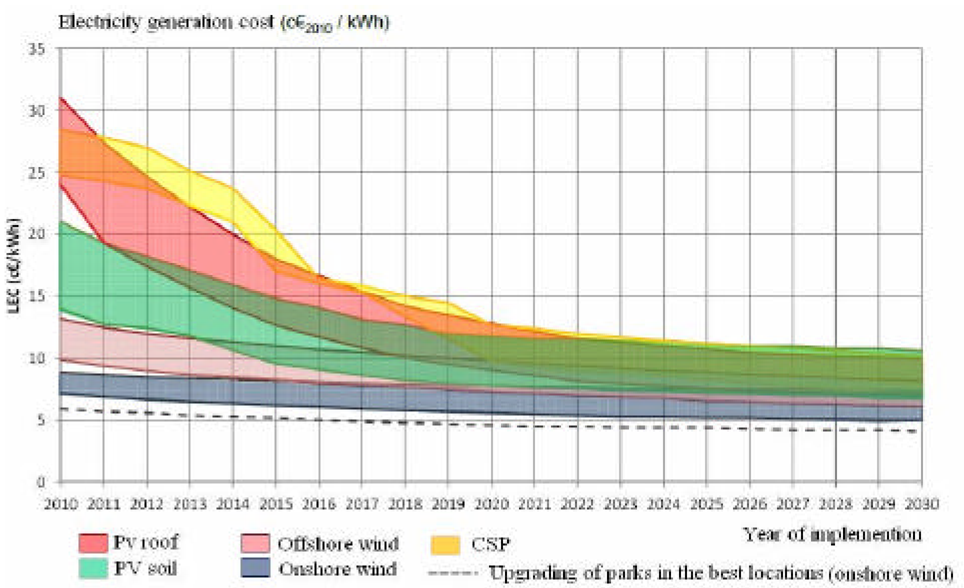
Source: www.S

Figure 11. Actual Solar Thermal Power Plants

Source: Courtesy pictures from Protermosolar (www.protermosolar.es)

Despite the fact that compared to other RES technologies, CSP technology has recently entered the commercial stage, the future potential decline in costs and technological advances are striking, as it has been highlighted in the International Energy Agency CSP roadmap (IEA, 2010). As it is shown in Figure 12 and as it will be explained in detail in Section 4, as of today, CSP private electricity generation cost is higher than both fossil fuel technologies as well as renewable technologies but a remarkable decline in costs is expected. (A. T. Kerney, 2010; IDAE, 2011; IEA, 2010),

Figure 12. Levelized electricity cost evolution of renewable technologies in Spain, 2010-2030 [c €$_{2010}$/kWh]



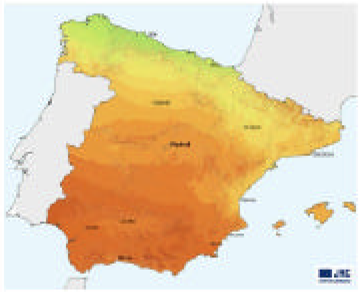
Source: IDAE (2011)

2.2.2. Solar potential and CSP deployment in Spain

During the next decades, solar energy is likely to be one of the most promising sources of clean energy. This fact is especially relevant for some countries like Spain, where solar radiation is high and solar electricity generation potential is remarkable.

Figure 13. Spanish RES potential for electricity generation.

Technologies	Potential (GW)
Solar PV & Solar Thermoelectric	>1,000
Wind on-shore + off-shore	340
Geothermal *(1)*	2.5
Geothermal *(2)*	20
Wave	20
Hydro	13
Pumping	13
Electricity Biomass	8
MSW	1,8
Biogas	1,2



Source*:* I.D.A.E. (2011)

According to the study undertook by the University of Zaragoza (Izquierdo *et al*, 2008), the theoretical potential in Spain is around 769,605 TWh/y and the geographical around 481,449 TWh/y. The same study estimates the theoretical potential of photovoltaic facilities in buildings in 10,552 TWh/y and the geographic limit in 988 TWh/y. Regarding the technical potentials, it is between 10857 y 21413 TWh/y for photovoltaic plants. The Institute of Technology Research (ITT) gives a technical potential of 1382TWh/y (Greenpeace, 2006).

The economic potential (Izquierdo *et al.*, 2008) for photovoltaic plants would be between 3293 and 6960 TWh/y (with a cost below 44.6-47.4 cEuro/kWh) and between 615 and 3089 TWh/y (with a cost below 20.5-21.5 cEuro/kWh) for thermosolar facilities. Finally, some studies give data on implementation potential by 2020: 8.5 TWh/y for thermosolar electricity (Izquierdo *et al.*, 2008; Greenpeace, 2006) and 2.85 TWh/y for photovoltaic electricity (Izquierdo *et al.*, 2008). Solar heating potential, according to the European Project RES2020, is between 4.0E-02 and 5.3E-02 TWh/y (RES2020, 2009).

Besides the common proven benefits associated to renewable energies –positive impacts on the environment and the economy, job creation as well as reduction in energy dependency, CSP technologies have additional benefits that have raised the Government's and society's interest, which have been taken into account when designing support mechanisms. For example, CSP technologies (i) facilitate the operation of the power system when it is reinforced with storage and backed up with other fuels (as natural gas and biomass); (ii) its production pattern match the summer demand peaks; (iii) compared to other RES technologies, they are able to retain a higher share of the total value added in Spain as most components are manufactured locally; and (iv) have placed Spain in a worldwide leadership position offering the possibility to become a potential exporter, of both technology and knowhow. Therefore, given the cost disadvantage of this technology compared the conventional fossil fuel technologies, the Spanish Government has put in place various support policies in order to promote RES.

Table 2 shows what have been the most relevant CSP support policies put in place over the last few years and which have been, among other factors, key to the deployment of the technology in Spain.

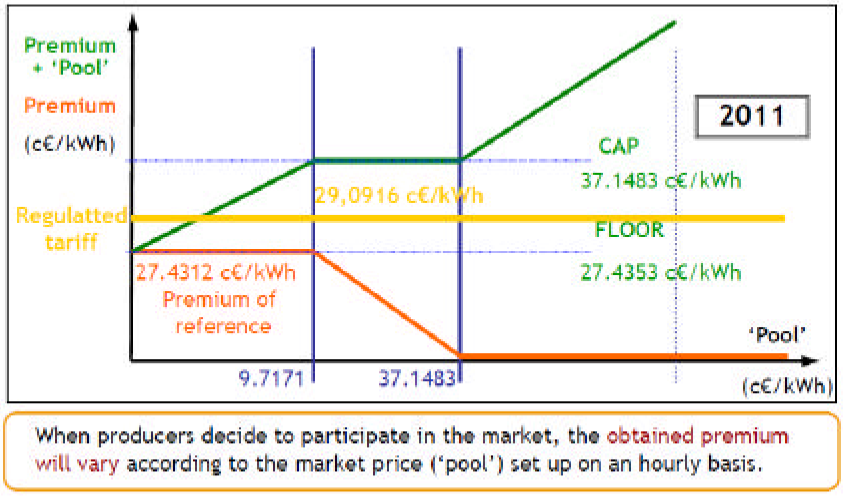
Table 2. Legal framework put in place by the Spanish government is as follows:

Support mechanisms	**Relevance for CSP deployment**
RD 2366/1994	None (no specific tariff for solar)
Feed-in Tariff	
RD 2818/1998	Revision of the tariffs and technologies
Feed-in Tariff	Establishment of specific groups. Only 1 group for all solar technologies (B.1)
RD 841/2002	Modification of RD 2818/1998
B.1.2 subgroup	Establishment of b.1.2. subgroup. Establishment of first specific feed in tariff for Solar Thermoelectric: 0,120202 c€/KWh (2002). No economic viability
RD 436/2004	Revision of the tariffs and technologies
Feed-in Tariff /Premium	Establishment of a profitable feed in tariff for solar thermal electricity. Objective: 200 MW. PPRE 1999-2010
RD 661/2007 Feed-In Tariff / Premium	Objective: 500 MW. Incrase Tariffs and Primes. Cap & Floor. Hybridization with Biomass and Biogas. REP 2005-2010
Royal Decree-Act 6/2009 (*)	Establishes a pre-assignment register of remuneration for special regime installation. It tries to plan electricity production installations for special regime
Royal Decree 1614/2010	Certain aspects related to the production of electricity from wind and solar technologies are regulated; it guarantees the benefits set by RD 661/2007 tl all projects included in the pre-assignment register and establishes a limitation in the equivalent functioning number of hours based on the technology and storage capacity
RD 1/2012	Stop of the support and incentive schemes for new plants for generation of electricity from Renewable sources, co-generation and wastes.

Source: Montoya (2011)

Regarding CSP remuneration and according to the RD 661/2007, Figure 14 shows the scheme that CSP producers can choose from - a fixed feed in tariff or a market price plus a premium which is capped by a cap and floor system. This system was later modified by establishing a pre-assignment register of remuneration in RD-Act 2009.

Figure 14: Remuneration of CSP plants in Spain, according to the RD 661/2007



Source: Montoya (2011)

As stated by the Royal Decree (RD 661/2007), a 0.29€/KWh fare[3] for the electricity generated by solar thermal technologies -parabolic trough, central tower and parabolic dish-, added to the possibility to construct mixed plants with gas (between 12% to 15% to compensate for any heat losses during the process), has generated a great interest for solar concentration technologies among investors and the Spanish industrial sector.

According to the Royal Decree, Act 6/2009: Retribution pre-assignment, applicants must to prove to the State Secretariat for Energy they fulfil important requirements. 104 applications were submitted to the Administrative Register of Pre-assignment, with a total capacity of 4,499 MW and 57 applications were approved, with 2,471 MW of capacity (Figure 15). Such projects obtained the feed in tariff of the RD 661/2007 with its updates. 4 phases were planned to connect the installations:

Connection phases according to the Pre-assignment (RD – Act 6/2009)

Phase 1: 880 MW. Connecting to the grid before 3 years after its registration
Phase 2: 567 MW. Connection to the grid between 2011 and 2012.
Phase 3: 500 MW. Connection to the grid in 2012.
Phase 4: 443 MW. Connection to the grid in 2013.

Source: Montoya (2011)

On December 7th 2010, RD 1615/2010 sets the following limitations in the functional equivalent number of hours for the different types of technologies and storage capacities:

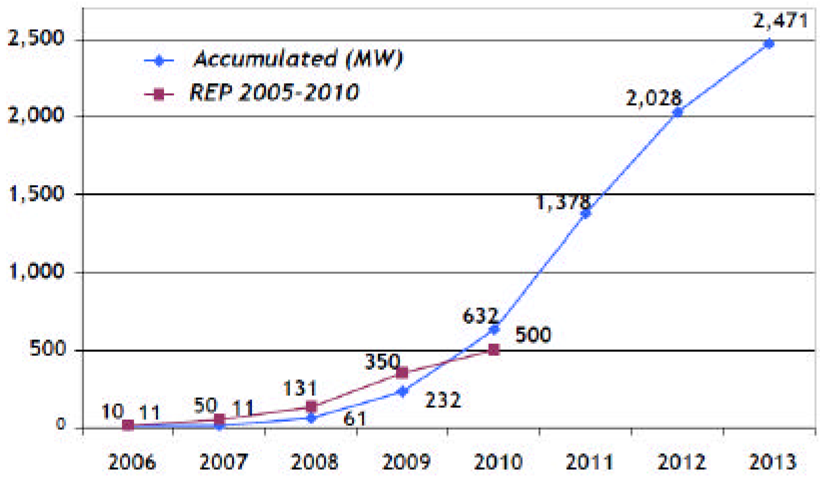
[3] The RD 661/2007 established that solar thermal producers can choose between: [i] obtaining a fix fare of 0.29€/KWh for the energy or [ii] selling it in the electricity market, taking in the price paid for the energy in the market plus a 0.27 €/kWh premium - with a minimum turnover (considering the price of the market and adding the premium) guaranteed of 0.27 €/kWh and a maximum limit of 0.37 €/kWh.

Table 3. Number of functional hours by type CSP plant that could benefit from the Feed-in premium system in Spain

Technology	Reference Equivalent number of hours / year
Parabolic trough without storage	2,855
Parabolic trough with 9 hours storage	4,000
Parabolic trough with 7 hours storage	3,950
Parabolic trough with 4 hours storage	3,450
Central receiver (Tower) with saturated steam	2,750
Tower with 15 hours molten salts storage system	6,450
Fresnel	2,450
Stirling	2,350

Source: Spanish Royal Decree 1614/2010

Figure 15. Annual capacity projects in Spain according to the pre-register data.



Source: I.D.A.E (2011)

Spanish Royal Decree 1/2012: Finally, since January 2012 there has been a moratorium on subsidies for new renewable energy projects.

According to the Spanish government this will help eliminate a €21.8 bn deficit that has built up in recent years. Moreover, the Spanish government believes that given the declining electricity demand and overcapacity in the Spanish generating system, “the introduction of new renewable capacity can be scaled back without jeopardising compliance with 2020 targets”.

As displayed in the tables below, this measure will imply, as it is the case for other RES technologies, an abrupt freeze in RES deployment in Spain. Besides whatever is included in the Pre-Registro up to 2013 (see Figure 16), no plans for new CSP plants are expected. If any other plant was to be constructed, it would not benefit from any Government support.

Figure 16: Estimated RES installed capacity prior and after RD 1/2012

Potencia Instalada (MW)	2012	2013	2014	2015
Cogeneración	6.285	6.432	6.582	6.731
Solar Fotovoltaica	4.172	4.560	4.948	5.333
Solar Termoeléctrica	1.501	2.281	2.521	2.771
Eólica	22.470	23.969	24.944	25.919
Hidráulica	2.082	2.119	2.158	2.198
Biomasa y Biogás	807	863	925	985
Residuos	510	515	520	525
Tratamiento de Residuos	658	658	658	658
Total	**38.485**	**41.398**	**43.256**	**45.120**

Fuente: CNE

Estimation of future RES installed capacity after to RD 1/2012

Potencia Instalada (MW)	2012	2013	2014	2015
Cogeneración	6.211	6.211	6.211	6.211
Solar Fotovoltaica	4.080	4.177	4.177	4.177
Solar Termoeléctrica	1.551	2.521	2.521	2.521
Eólica	22.470	23.944	23.944	23.944
Hidráulica	2.063	2.063	2.063	2.063
Biomasa y Biogás	775	775	775	775
Residuos	456	456	456	456
Tratamiento de Residuos	658	658	658	658
Total	**38.264**	**40.805**	**40.805**	**40.805**

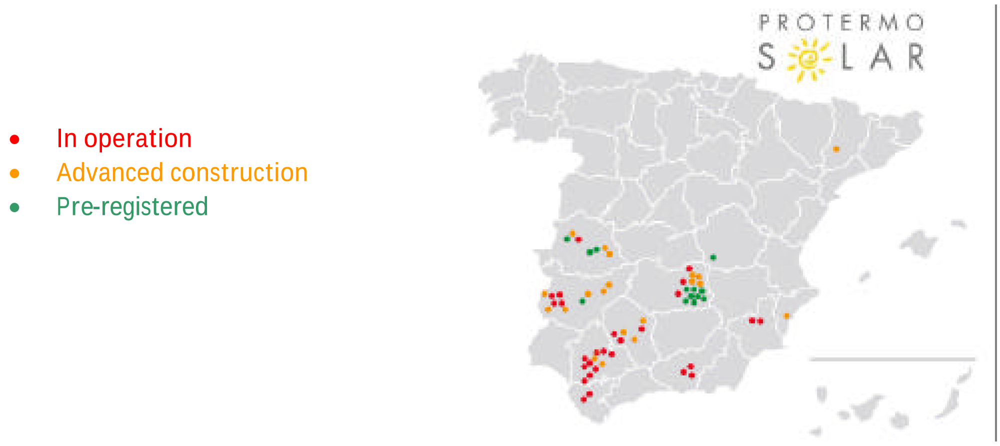
Previsiones de evolución de potencia del régimen especial en la Península por tecnologías
Fuente: CNE

So, despite the recent regulatory turmoil, with more than 600 MW of installed capacity by 2010, Spain could be considered a global leader in CSP technology deployment. However, besides the favourable regulatory framework up to 2012, there exist various key success factors for such remarkable promotion of the solar thermal industrial activity in Spain:

- Enough **solar resource**
- Suitable **planning** – The Spanish Government has identified the barriers and proposed measures to overcome them and achieve the deployment objectives.
- **Legal framework**: has allowed economic viability and grid access guarantee
- **R&D** activities have taken place in Spain since the 1980´s
- Mature **industrial sector** with capacity to develop the technology and invest great amounts (12 to 15 billion €)

Since the construction of the first CSP plant in 2006, a rapid increase of projects has taken place. As a result of it, by the end of 2010 total installed capacity reached 632MW, most of them parabolic trough (95%) but also some central receiver plants (Figure 17). Moreover, the recently approved Spanish Renewable Energy Plan 2011-2020 considers a solar thermal installed capacity of 4.800 MW by 2020. Its associated energy production amounts to 14.379GWh, which accounts for approximately 10% of the total RES (renewable energy sources) energy forecasted production by 2020.

Figure 17. Location of the existing CSP plants in Spain



Source: Protermosolar (2012)

With regards to the **expected CSP future evolution** in Spain until 2020, according to the Renewable Energy plan 2011-2020, 4,800 MW of CSP technology will be installed in Spain (Table 4, Figure 18 and Figure 19).

Table 4. Spanish Renewable Energy Plan 2011-2020

	2010			2015			2020		
	MW	GWh	GWh (normalizados)(*)	MW	GWh	GWh (normalizados)(*)	MW	GWh	GWh (normalizados)(*)
Hidroeléctrica (sin bombeo)	13.226	42.215	31.614	13.548	32.538	31.371	13.861	33.140	32.814
<1MW (sin bombeo)	242	802	601	253	772	744	268	843	835
1MW-10MW (sin bombeo)	1.680	5.432	4.068	1.764	4.982	4.803	1.917	5.749	5.692
>10MW(sin bombeo)	11.304	35.981	26.946	11.531	26.784	25.823	11.676	26.548	26.287
por bombeo	5.347	3.106	(**)	6.312	6.592	(**)	8.811	8.457	(**)
Geotérmica	0	0	(**)	0	0	(**)	50	300	(**)
Solar fotovoltáica	3.787	6.279	(**)	5.416	9.060	(**)	7.250	12.356	(**)
Solar termoeléctrica	632	691	(**)	3.001	8.287	(**)	4.800	14.379	(**)
Energía hidrocinética, del oleaje, mareomotriz	0	0	(**)	0	0	(**)	100	220	(**)
Eólica en tierra	20.744	43.708	42.337	27.847	55.703	55.538	35.000	71.640	70.734
Eólica marina	0	0	0	22	66	66	750	1.845	1.822
Biomasa, RSU, Biogás	825	4.228	(**)	1.162	7.142	(**)	1.950	12.200	(**)
Biomasa Sólida	533	2.820	(**)	817	4.903	(**)	1.350	8.100	(**)
RSU	115	663	(**)	125	938	(**)	200	1.500	(**)
Biogás	177	745	(**)	220	1.302	(**)	400	2.600	(**)
TOTALES (sin bombeo)	39.214	97.121	85.149	50.996	112.797	111.464	63.761	146.080	144.825

Source: IDAE (2011)

Figure 18. 2020 Spanish REP – RES share [GWh]

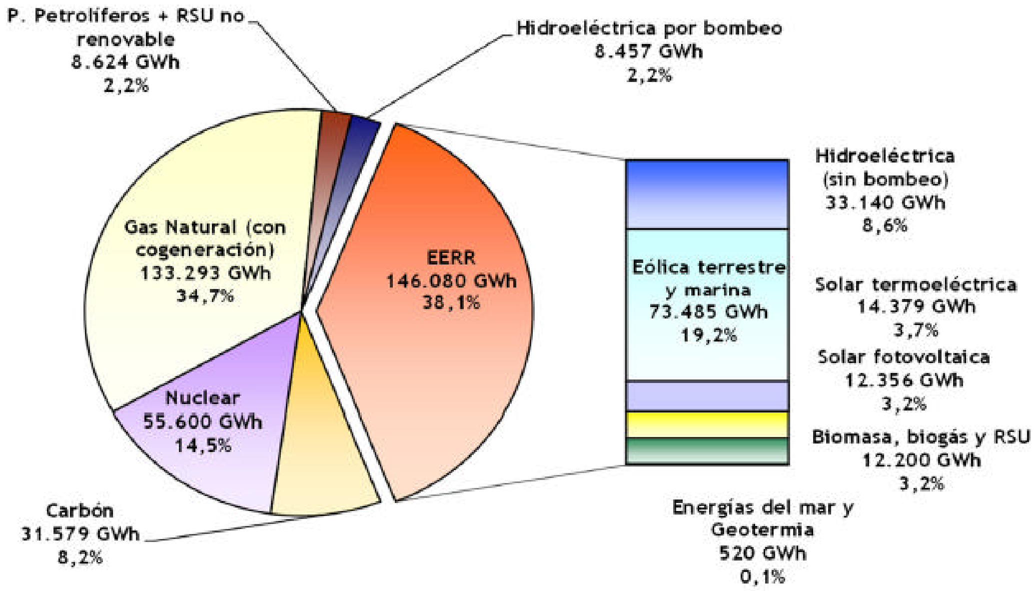
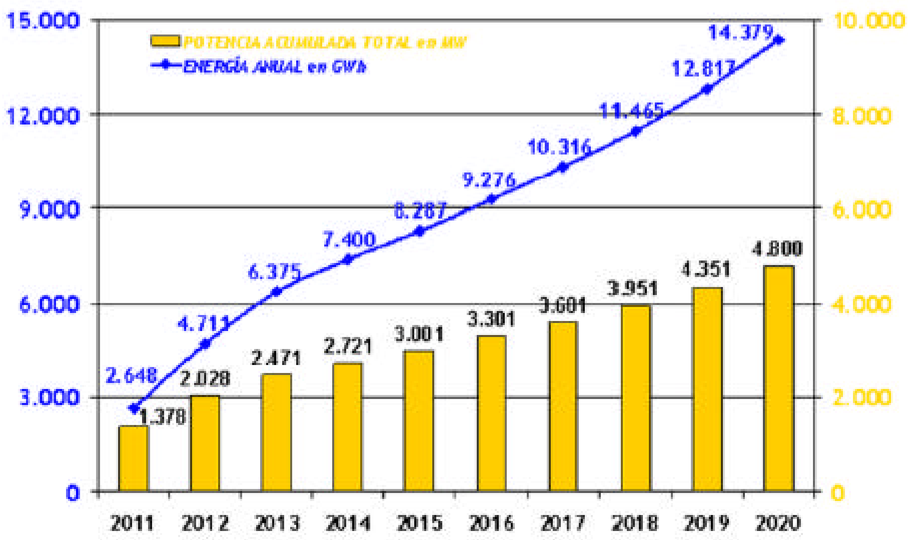


Figure 19. Concentrated Solar Power future deployment according to the Spanish REP 2011-2020



2.3 Proposed CSP joint project case study

The case study that will be presented in this section is the result from the following methodological approach:

Based on the results from the previous work packages, a size of 5 TWh was identified as a potential cooperation opportunity between Spain and the Netherlands using CSP technology. With this information, a consultative process took place. For this purpose, two main stakeholders were contacted in order to see if the results from the modelling exercise could be implemented in practice while taking into account – besdies costs, potentials and National targets- those other factors that had not been taken into consideration by the model.

The stakeholders that were most involved in this case study were: IDAE [4] (the Spanish Agency responsible for the design and implementation of renewable energy policies) and PROTERMOSOLAR (the Spanish Concentrated Solar Thermoelectric Association, who represents the CSP industrial sector in Spain). Moreover, we also received some feedback from the participants from the ESTELA Sumer workshop meeting[5]. As previously mentioned, the purpose of the involvement of the stakeholders was to utilize their knowledge of the existing challenges and opportunities that the RES sector is currently experiencing in Spain, to address the following issues :

1) Check if the identified potential was feasible (reality check of the modelling results)
2) If feasible, propose a deployment plan to produce such amount
3) Identify, based on the hypothetical deployment plan, what would be the most relevant challenges/bottlenecks that could possibly be encountered along the way as well as the most relevant opportunities.

From the various discussions held with them, the main outputs were:

Contributions from I.D.A.E:

- Spain would be very interested in broadening the CSP sector through the cooperation mechanisms. Given the existing moratoria, this would be a great opportunity to support the CSP industry without compromising public funds.
- Spain would be interested in establishing a cooperation mechanisms with the Netherlands.
- CSP sector is very important for Spanish RES industry with overall good acceptability due to the various environmental and socio-economic benefits that it has generated on the Spanish community.
- Given the existing interconnection limitations, it would be most convenient to develop a joint project without physical transfer.
- The implementation of a pilot project (such as 200 MW) without physical transfer would be a good option but for much larger amounts of energy, it would be required to have physical transfer (not necessary to the user country but to a neighbouring country). The reason for having the possibility to evacuate the electricity is that the current energy system has a bit of

[4] http://www.idae.es/index.php/lang.uk
[5] http://www.estelasolar.eu/index.php?id=95&tx_kbeventboard_pi1[evt]=26

overcapacity and that it would be desirable to have stronger interconnection capacity to let out the electricity that would be generated through the cooperation mechanisms. This idea of improving current interconnection capacities would be very valuable for the management of the grid and would be desirable for both cooperation mechanisms within MS as well as with third countries.

- Spain would be interested in pursuing this project in a gradual way (that is not to wait until the end of the period to start the construction of some of these plants).
- Developing cooperation mechanisms between Spain and the Netherlands would also provide benefits for Dutch companies from collaborating with Spanish firms in the development in CSP plants trough technological transfer and know-how.
- It was highlighted that the use of Cooperation Mechanism will not be expanded while the European Commission does not fix any punishment for no compliance of RES targets for 2020.

Contributions from PROTERMOSOLAR:

- The use of the cooperation mechanisms is perceived as a great opportunity for the CSP Spanish sector to further deploy in Spain (and more so in the current political turmoil when RES support policies have been drastically reduced).
- The additional production of 5 TWh (above the 4.800 MW that would be deployed according to the PER 2011-2020) seem technically feasible and no great barriers have been identified.
- PROTERMOSOLAR is aware of the key importance of reaching the expect cost reductions in CSP technology.
- Given the fact that at this point in time there is uncertainty about what technology (parabolic trough or central receiver) will achieve the lowest generation costs, they propose to use both technologies.
- PROTERMOSOLAR proposed the following technical parameters to produce 5 TWh

Contributions from the Dutch Ministry of Economic Affairs

- This case study presents some interesting possibility, especially considering the projected cost reductions of the technology, and the maximum achievable capacity.
- Spanish stakeholders have so far displayed a positive and proactive attitude towards the realization of this case study. This is seen as a very promising sign.
- The intention of the Dutch Ministry is, at a first step, to focus on the realization a pilot cooperation project that could be included for tenders for obtaining subsidy from the Dutch SDE+ regulation for RES stimulation.
- It seems reasonable to start the cooperation by conducting a first pilot project (200MW).
- However there are some barriers and uncertainties that need further clarification:
    - The Netherlands has a limited CSP industry[6], and CSP is not part of the Dutch strategic innovation program. Therefore, it could be easier to justify the election of other technologies to provide opportunities to Dutch enterprises to expand its activity abroad.

[6] Some Dutch firms within the CSP has been identifies and have expressed their business strategic interest in development of this case study.

- This point needs further discussion because the Dutch industry may be indirectly involved, for example in providing the chemicals used for storage and heat transportation in CSP plants, or in the heavy load machinery necessary in the building phase.
- The foreseen cost reduction of CSP makes this case study economically very attractive. Regarding this, it is necessary to clearly define the arrangements in order to remove any potential uncertainties about the possibility of allocating the corresponding RES-E credits to other MS.
- The joint project could in principle be scaled up to 1.2 GW. But in this case there are serious doubts that the grid could handle the extra RES-E locally, hence export of RES-E to neighbouring countries may be necessary. Uncertainties about the feasibility of increasing the interconnection capacity should be clarified.

Assumptions for the Case study:

Table 5. General characteristics of the cooperation mechanisms

Parameter	Value
Type of cooperation mechanism	Joint project
Host country	Spain
User country	Netherlands
Physical Transfer	No
Size of the VoO	5 TWh
Time frame	Negotiations: 2012-2014 1st phase: Construction: 2014-2016/7; Start operation: 2016/7 2nd phase: Construction: 2016-2018; Start operation:: 2018

Table 6. Key parameters for Host country (Spain)

Parameter	Value
Technology	CSP central receiver (Tower) or parabolic trough
Construction time	2 years
Capacity of the Plants	200 MW [7]
Generation costs	< 11 c€/kwh (expected to be around 10 c€/kwh by 2020)
Location	Southern Spain (to be further detailed based on an existing registered application)
Load factor	4.000h (45%)
Storage capacity	9 hours
Hybridization	Possibility to use Natural Gas or Biomass up to 15%[8]

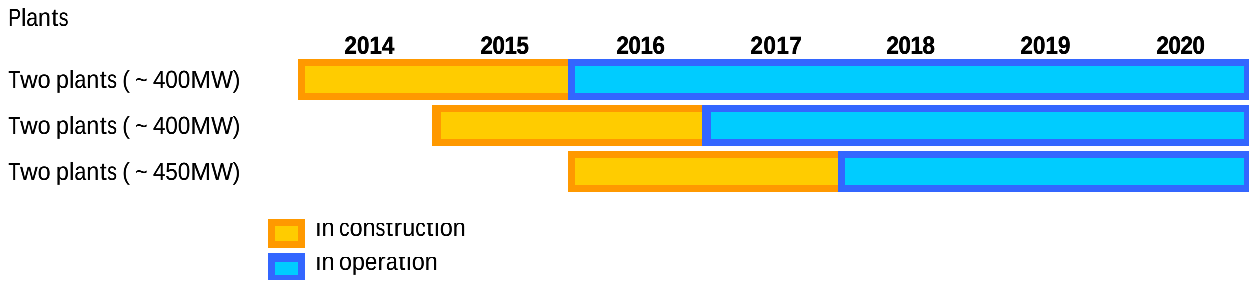
[7] Existing CSP plants in Spain and registered in the "pre-registro" have a size of 50MW as one of the requirements to receive FIT system is that the CSP plants should not exceed 50 MW. New CSP plant within a cooperation mechanism scheme would not benefit from any FIT system, so these plants are would not be subject to this size limitation. According to experts in the sector, the possibility of developing larger plants would be beneficial because of two reasons: (i) it would incentivize technological innovation and (ii) it would drive cost down.

[8] Total generation taking into account hybridization 5,75 TWh

Total installed capacity	**1250 MW installed capacity (5 TWh of production)**
Number of plants	**6 plants (4 plants of 200 MW plants and 2 plants 225 MW)**
Cooperation mechanism	**Joint project without physical transfer**
Displaced technology in the Spanish Energy mix	**Natural Gas Combined Cycle**

Figure 20 show a possible implementation scheme of CSP plants in Spain:

Figure 20. Proposed implementation schedule, by Protermosolar



Note: It is important to note that this scheme could very well be different depending on various factors such as the Dutch interests, administrative procedures timing, etc. More importantly, as will be discussed in detail in Chapter 4, costs will decline as time goes by. Consequently, when only considering costs, it would be most convenient to start the construction phase later than sooner. On the contrary, when considering other factors (such as the risk of non-compliance or post 2020 uncertainties), it would be best to start at an earlier stage.

3 COOPERATION MECHANISMS AND SPECIFIC TECHNOLOGY CASE

Of the two possible support arrangements considered in the RES4LESS case studies, joint projects (with/without physical transfer) and joint harmonization schemes, from the host and user country point of view and based on various discussions with Spanish Government representatives (I.D.A.E) and the Dutch Ministry of Economic Affairs, it seems that given the current situation in Spain and the Netherlands, the most appropriate type of support arrangement would be **Joint Project without physical transfer.** The main reason to dismiss the Joint support scheme is that it requires that both countries would coordinate their national support schemes. In that case, the level of coordination and agreement between both parties would be so deep that, nowadays, it seems far from being achieved. Rather, the implementation of cooperation agreements should be understood as a gradual process in which it seems appropriate to start with options that require a lower level of involvement (joint projects) and as the implementation goes progressing, the states will voluntarily go moving towards alternatives that require a greater level of coordination.

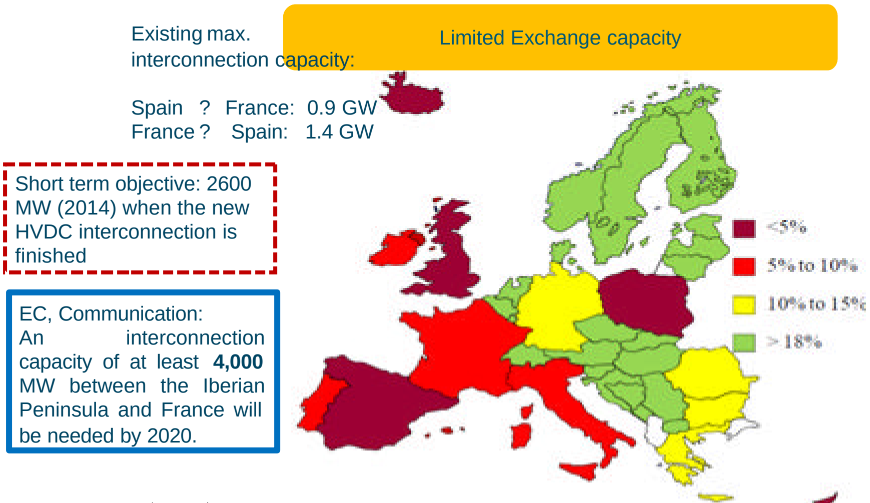
As stated by Klessman *et al.* (2009), when defining how the user country is going to provide the required financial support to RES private developers in the host country, there are different design options, from a project-by-project basis to a more general support framework for joint projects. As mentioned before (in Section 2.3), the intention of the Dutch Ministry is, as a first step, to implement the cooperation mechanisms through the use of tenders for pilot projects that would benefit from the Dutch SDE+ (RES support scheme). By this way, the Netherlands takes the initiative to set-up a joint project framework to reach its RES target, offering the possibility to RES project developers from other MS to have a direct involvement on it. It seems that this could be a progressive process that starts with a small scale cooperation framework by launching tenders for specific projects to a more general and extended framework.

In any case, governments from both countries should be involved, as the article 7 of the RES Directive establishes that the terms of the joint agreement and the design of the joint project should be defined by the involved member states.

Initially, the Spanish Government had only foreseen the utilization of the cooperation mechanisms through statistical transfers and joint projects with third countries, as was recognized within the Renewable Energy Plan 2011-2020 (IDAE, 2011). According to the National Government (I.D.A.E.), the reason for not having considered the possibility of hosting a joint projects with a user country within Europe was social perception. It was believed, that from a social acceptance point of view, it would not have been very well perceived the fact that another Member state would exploit National RES resources towards their own RES national targets. However, due to the latest developments in Spain (see RES support policies section), the development of a hypothetical *joint project within Europe* is now being regarded as a feasible option since this would imply a possibility to support the National CSP industry in Spain without compromising Spanish public funds.

Given the existing grid interconnection capacity between Spain and France (and the rest of Europe), the possibility of having a joint project with physical transfer is not considered as a current feasible option (see Figure 21).

Figure 21. Existing limited interconnection capacity between Spain and France



Source: REE (2012)

Once the type of cooperation mechanisms has been chosen and having also decided whether it is going to be a physical transfer of the energy or not, next step consist on entailing a complete price allocation process. This process aims, in the first place, to analyze the direct cost for the Host country in terms of RES energy production and its integration on the energy system. Besides the direct costs and benefits associated to the development of a joint project for both user and host country (that is the support needed to compensate the producer for the higher RES cost compared to the electricity price as well as the grid related costs), there are other possible co-effects that need to be taken into account which can affect the attractiveness of the agreement as well as affect the transaction price. Table 8, show a list of potential direct as well as indirect benefits and costs that would take place in Spain (as a host country) due to the implementation a joint project without physical transfer.

Table 8. Example of direct and indirect costs for a host country

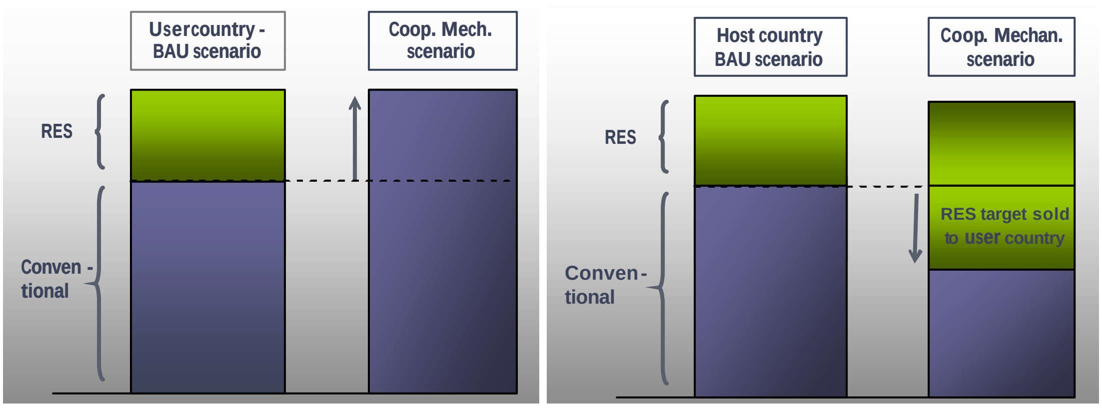
Direct benefits	Direct costs
- Revenues from the selling of the energy	- Cost of developing the project - Costs to the electricity network (grid reinforcement, balancing, system capacity costs, etc).
Indirect benefits	**Indirect costs**
- Increased security of supply - Increased economic activity - Local job creation - Innovation - Reduction in Air pollutants - Reduction in GHG emissions - Gradual transition to a low carbon energy system	- Costs of regulation (permits, political decision making, etc) - Societal and environmental costs (impact on land, water use and biodiversity) - Risk of having to pay higher RES energy costs if it failed to reach its national target and had sold out the low cost potentials.

Source: Adapted from Klessmann *et al*. 2010

Similarly, for a user country (in our case the Netherlands), Figure 22 shows a simplified situation in which two countries with the same projected 2020 energy consumption have to decide whether to cooperate or not using a joint project without physical transfer. When comparing the user country's energy mix under the two possible scenarios, we see that the resulting energy mix under the cooperative scenario has various implications that should be taken into account. Among others, one of the most relevant indirect costs is the negative environmental impact associated to a more carbon intensive energy mix (both regional and GHG emissions). Moreover, the country's energy security would be decreased as a result of the higher fossil fuel dependence and, finally, by not deploying a local RES industry, it would miss out on local job creation and economic stimulation.

Figure 22. Resulting energy mix in 2020 under two scenarios (with no physical transfer)

USER COUNTRY HOST COUNTRY



Source: Own elaboration

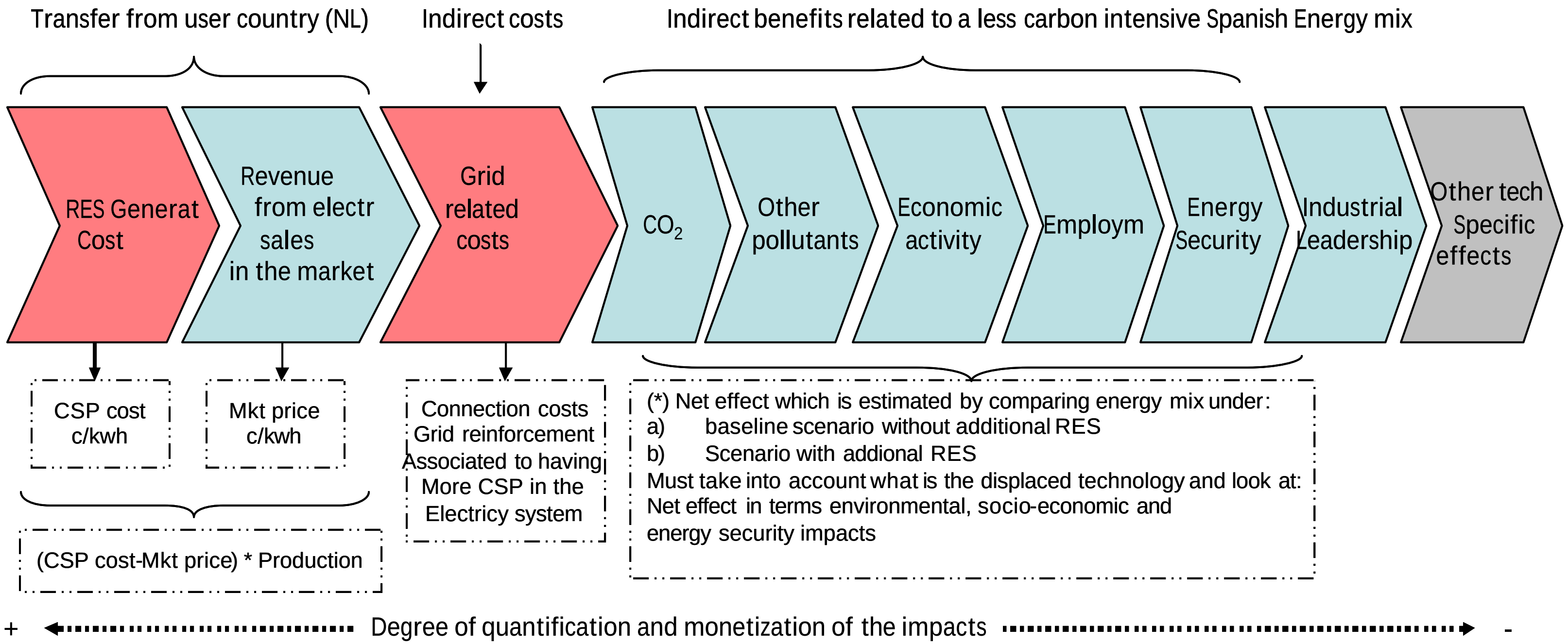
One additional challenge in all bilateral negotiations is the fact that most of those indirect costs and benefits are often hard to identify, quantify and monetize (see section 4). Since the required estimations are far from being straightforward, but tend to be time consuming and imply a high level of uncertainty, a new level of complexity is added to the negotiations which can be regarded as another obstacle or barrier to the utilization of the cooperation mechanisms.

Additionally, and specific to the CSP technology, besides the common proven benefits associated to renewable energies – positive impacts on the environment and the economy, job creation as well as reduction in energy dependency - CSP technologies have additional benefits, as for example, (i) facilitate the operation of the power system when it is reinforced with storage and backed up with other fuels (as natural gas and biomass); (ii) its production pattern match the summer demand peaks; and (iii) have placed Spain in a worldwide leadership position offering the possibility to become a potential exporter, of both technology and knowledge.

In an attempt to illustrate the analytical process that will be pursued in this case study, the two figures below show what is the conceptual approach that has been used in this case study to see: (i) if the use of the cooperation mechanism would be mutually beneficial for both Spain (as a host country) and the Netherlands (as a user country) and (ii) estimate, given the RES production eligible for this particular joint project, what would be the optimal size of the transfer between Netherlands and Spain.

It is important to note that, as a first approximation, the following analysis has attempted to estimate of the support size required. The financial gap that CSP project developers would require to operate takes into consideration the difference between the LCOE and the selling revenue in the market. This figure would provide a first indication about the amount of the tender conditions should have in order to attract CSP developers.

TRANSFER DETERMINATION PROCESS (FOR THE HOST COUNTRY: SPAIN)



CONSIDERATIONS/ASSUMPTIONS

Cooperation Mechanism: Joint project without physical transfer between Spain and The Netherlands;

RES Technology: CSP – need to provide details on technology, size, production, size of the plants, location, etc

Grid infrastructure by 2020: (a) Status by 2015-2020 and (b) technical and cost requirements in terms of connection & reinforcement

Spanish Energy mix: (a) Energy mix by 2020 –baseline- and (b) what is the technology that is being displaced

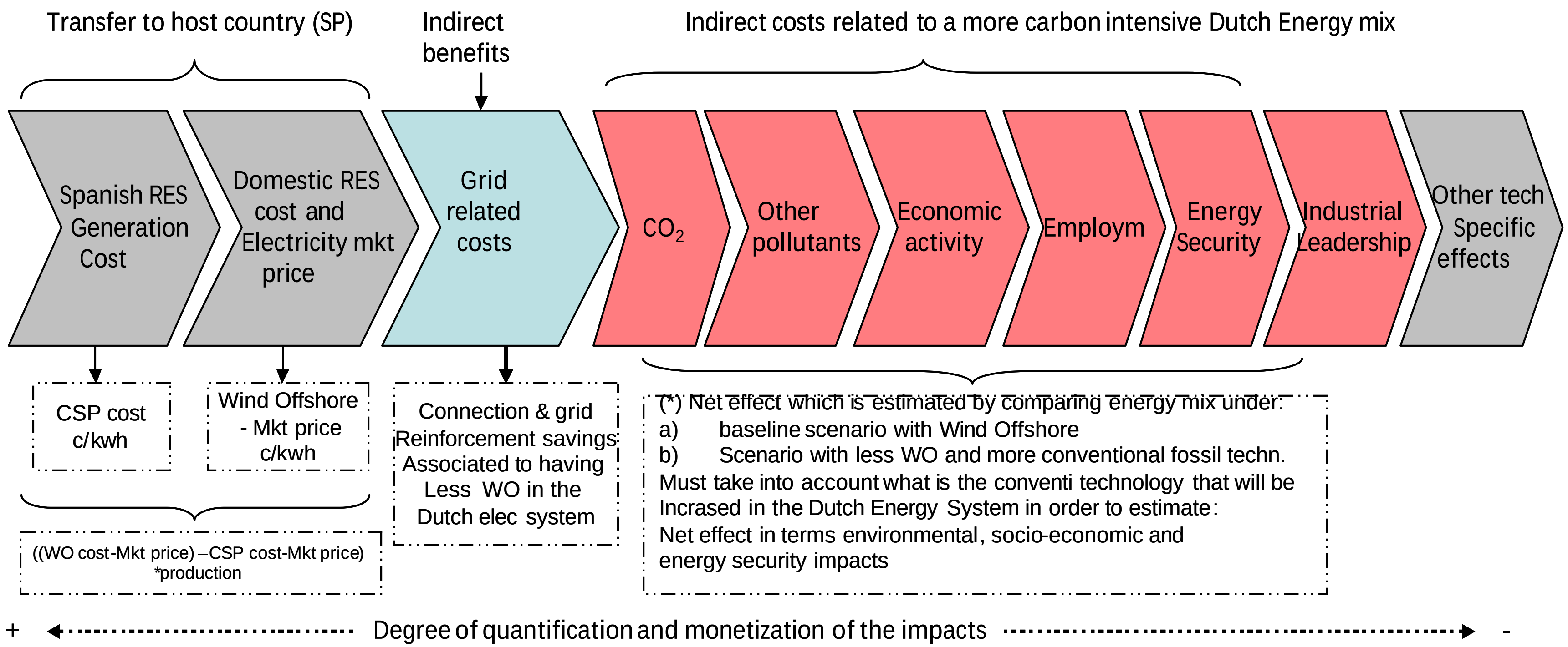
Electricity mkt price in the period 2015-2020 and the effect that the increse in RES will have in the consumers price.

Magnitude of the net indirect benefit (environm. and socio-economic effects) will depend on the technology that is being displaced

Industrial leadership: From what country are the firms participating in the Joint Project?

Other **technology specific indirect costs /benefits**: For example: for CSP, what is the potential effect in water and land use?

TRANSFER DETERMINATION PROCESS (FOR THE USER COUNTRY: NETHERLANDS)



CONSIDERATIONS/ASSUMPTIONS

Cooperation Mechanism: Joint project without physical transfer between Spain and The Netherlands

RES Technology: Characteristics of the Wind Offshore plants that would have been constructed in NL in absence of the Coop. Mech.

Grid infrastructure by 2020: (a) Status by 2015-2020 and (b) technical and cost requirements in terms of connection & reinforcement

Dutch Energy mix: (a) Energy mix by 2020 –baseline- and (b) what is the fossil fuel technology that would be replacing W-Offshore

Electricity mkt price in the period 2015-2020 and the effect that the decrease in RES will have in the consumers price.

Magnitude of the net indirect benefit (environmental and socio-economic effects) will depend on the conventional technology in NL

Industrial leadership: Who was going to develop the wind offshore plants in NL? What is the NL wind offshore mkt share?

Other **technology specific indirect costs/benefits**: For example: for W-O: what are the effects on marine ecosystems, fisheries, etc?

4 QUANTIFICATION OF EFFECTS/IMPACTS (RESULTS)

The aim of this section is to analyze and, to the extent possible, quantitatively estimate and provide a monetary value for all those aspects and variables that have to be taken into account in the present case study in which Spain (as host) and Netherlands (as a user) intend to cooperate under a joint project without physical transfer scheme.

The final decision should be taken on the basis of a sequential process integrated by the following steps:

1. **Identifying potential VoO** by comparing the cost of producing RES in both countries. The basic condition to consider a potential interest from a user country is that the cost of RES surplus production in the host country is lower than the cost of complying with RES targets in the user country. In that respect, the potential interest of the Netherlands in implementing the cooperation mechanism with Spain has been identified in previous Work Packages of the RES4LESS project (for more information, see Res4Less Deliverable 2.2.).
2. **Estimating the payment (or amount to be transferred)** from the User to the Host country,
   - 2.1. Estimating the amount of **public support** required by the RES operator in the Host country. This support is estimated as the difference between RES generation cost and revenues received by the operator from selling the energy in the electricity market. In case of non physical transfer, energy is sold in the Host country and in case of physical transfer, energy is sold in the User country. The following Section 4.1.1. and 4.1.2. are devoted to the analysis of both aspects (costs of RES and revenues) with the aim of estimating the size of the *support* that the user country would have to pay in this particular case study.
   - 2.2. Estimating **grid and system operation costs** derived from the implementation of the cooperation mechanism, which relate to grid connection and reinforcement to the Spanish Transmission System. The Section 4.1.3. will analyze this aspect.
3. **Estimating "external" effects (indirect costs and benefits)** for both countries in terms of environmental, socio-economic and energy dependency effects, mostly related to the change in the energy mix in each country. It is supposed that host country would mostly experience external benefits due to positive effects associated to a less carbon intensive energy mix while the user country would mostly experience external costs due to having a more carbon intensive energy mix, compared to a Bussines as Usual scenario of reaching RES targets in a domestic way. All these elements should be estimated and taken into account in order to reach and materialize an agreement. Section 4.2. will be focussed on the estimation of such external effects.

4.1 RES transfer determination from the user to the host country

As mentioned before, after identifying where are the potential opportunities to cooperate between Member Sates, the next step consists of estimating the transfer size from the user to the host country. This consists of determining, for the host country, the difference between the RES generation cost and revenues from the sale in the electricity market. In parallel, the user country must consider what are the domestic RES generation costs and the market revenues in case it did not use the cooperation mechanism, with the aim of analyzing the convenience of the agreement.

4.1.1. RES cost

Based on the database of RESolve model, used to identify the VoO, as well as other relevant techno-economic reports and personal communications, this section presents the current and estimated future generation costs for those technologies relevant for this case study (that is CSP and Wind Offshore).

a) RES cost in the Host country (Spain):

Providing detailed financial analysis of project economics of CSP is not an easy task as the Levelized Electricity Cost of Energy (LCOE) is closely dependent to various technical and side specific parameters. These parameters may significantly vary from one project to another. Furthermore, CSP technology is in its early stages of technological development so it is expected to experience a substantial reduction on LCOE due to large-scale deployment and technology improvement, as have been highlighted by numerous studies (Pitz-Paal, 2005, IEA, 2010; AT Kerney, 2011).

This section seeks to analyze what are the most likely values for those parameters that better fit with the case study currently been analyzed (the implemention of a joint project of CSP plant in Spain). Based on these parameters, the aim of this section consists on estimating what would be the cost of the electricity produced in these plants. It would be crucial to take into account the expected reductions along the medium term as it is foreseen that these plants would be constructed in the future. One of the most comprehensive and recent study on CSP cost is the one conducted by IRENA (2012), that has been used as the main reference for revising those key parameters involved in CSP cost estimation.

Key parameters to estimate CSP cost

1. Type of technology. As can be seen in Table 9 there are four types of CSP plants (parabolic trough; solar tower; linear Fresnel and dish-stirling), that significantly differ on technical and economic aspects, but also reliability, maturity and operational experience. As stated by IRENA (2012), parabolic trough and solar tower are the ones that, combined with energy storage, can meet the requirements of utility-scale plant. On one hand, parabolic trough stands as the most widespread and mature CSP technology nowadays, resulting to lowest development risk. On the otherhand, although solar tower is in a previous developed stage it appears to be the most promising CSP technology for the future for the following reasons. It is expected to experience a significant reduction in capital costs and improved performance. Moreover, it offers a higher flexibility (compared to parabolic trough), lower energy storage costs, higher capacity factor, greater efficiency of the steam factor and firmness in output production (*ibid*).

Table 9. Comparison of different CSP technologies

	Parabolic trough	Solar Tower	Linear Fresnel	Dish-Stirling
Typical capacity (MW)	10-300	10-200	10-200	0.01-0.025
Maturity of thechnology	Commercially proven	Pilot commercial projects	Pilot projects	Demonstration projects
Technology development risk	Low	Medium	Medium	Medium
Operating temperature (ºC)	350-550	250-565	390	550-750
Annual solar to electricity efficiency (net) (%)	11-16	7-20	13	12-25
Annual capacity factor (%)	25-28 (no TES) 29-43 (7h TES)	55 (10h TES)	22-24	25-28
Storage system	Indirect two-tank molten salt at 380ºC (dT=100K) or Direct two-tank molten salt at 550ºC (dT=300K)	Direct two-tank molten salt at 550ºC (dT=300K)	Short-term pressurised steam storage (<10 min)	No storage for Stirling dish, chemical storage under development
Hybridisation	Yes and direct	Yes	Yes, direct (steam boiler)	Not planned
Grid stability	Medium to high (TES or hybridisation)	High (large TES)	Medium (back-up firing possible)	Low
Cycle	Superheated Rankine steam cycle	Superheated Rankine steam cycle	Superheated Rankine steam cycle	Stirling
Steam conditions (ºC/bar)	380 to 540/100	540/100 to 160	260/50	n.a
Maximun sloap of solar field (%)	<1-2	<2-4	<4	10% or more
Water requirements	3 (wet cooling) 0.3 (dry cooling)	2-3 (wet cooling) 0.25 (dry cooling)	3 (wet cooling) 0.2 (dry cooling)	0.05-0.1 (mirror washing)
Application type	On-grid	On-grid	On-grid	On-grid/Off-grid
Suitability for air cooling	Low to good	Good	Low	Best
Storage with molten salt	Commercially available	Commercially available	Possible, but not proven	Possible, but not proven

Source Fichtner (2010), on IRENA (2012)

2. Inclusion of storage systems. Including thermal storage within the design options of a CSP plant will increase the capacity factor of the plant and its dispatchability. Nevertheless, the introduction of storage system substantially increases the investment cost of CSP plants. Table 10, based on IRENA (2012), collects data about the influence of installing storage system in different types of plants. In case of parabolic trough, installing an energy storage system of 6 hours would double its capacity factor and would increase the investment cost in the range of 54%-113%. In the case of tower plants, installing a storage system that doubles the number of storage hours (from 6-7.5 hours to 12-15 hours), would increase the capacity factor from a level of 40%-45% to a level of 65%-80% and would increase the investment cost of the plants by approximately i40%.

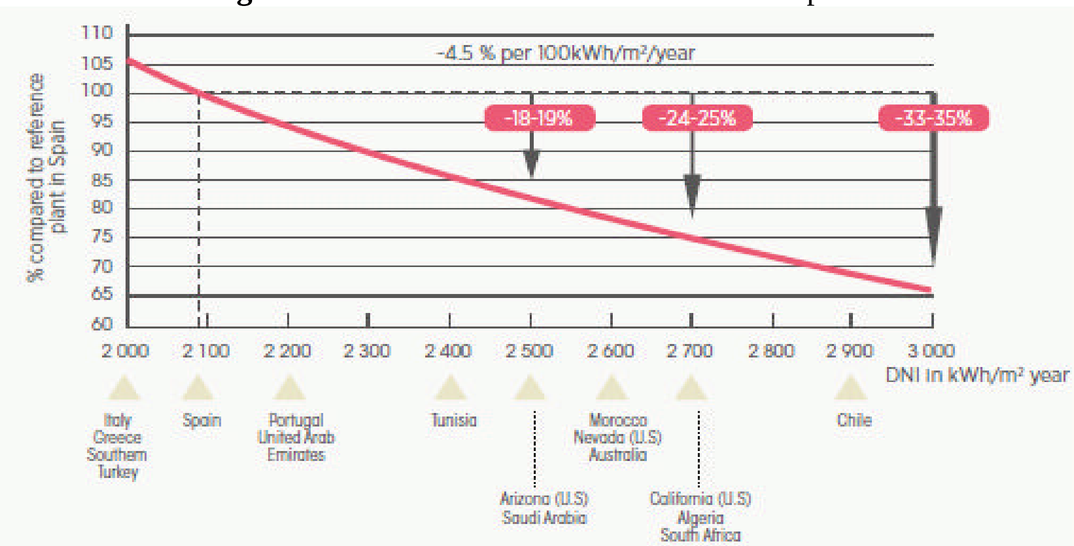
Table 10. Impact of storage system on investment cost and capacity factor of parabolic trough and solar towers

	2011	
	2010 USD/kW	Capacity factor (%)
Parabolic trough		
No storage	4 600	20 to 25
6 hours storage	7 100 to 9 800	40 to 53
Solar tower		
6 to 7.5 hours storage	6 300 to 7 500	40 to 45
12 to 15 hours storage	9 000 to 10 500	65 to 80

Source IRENA (2012)

3. Solar resource: The LCOE of CSP plants is highly correlated to the irradiation level, measured though the DNI index (kWh/m²/year). Standard values of DNI to produce energy from CSP plants have a range from 2,000 to 3,000 kWh/m²/year. The higher DNI on a specific location, the higher production of a CSP located there and, so, the lower LCOE of that energy. Figure 23 show the impact of DNI level on LCOE of CSP, and the standard values for potential producer countries of CSP. As it can be seen, Spain has a typical DNI of 2,100 kWh/m²/year.

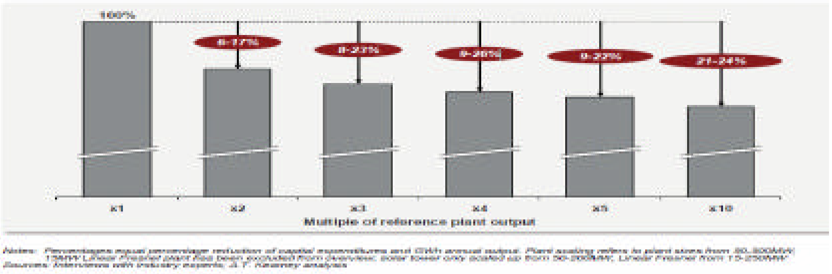
Figure 23. Influence of DNI in LCOE of CSP plants



Source: A.T.Kerney and Stela (2010), on IRENA (2012)

4. Size of the plants. As in most productive processes, increasing the size of a plant would result in a decrease in marginal cost of production. The same occurs with CSP plants and this parameter (the size) stands as one of the main sources of cost reduction in the near future, mainly because CSP technology is in its first stages of development and it is expected that size plant will continue to grow, as it is happening in the United States. Figure 24 shows the potential impact of increasing the scale of plants on LCOE, as forecasted by ATKerney report (2011).

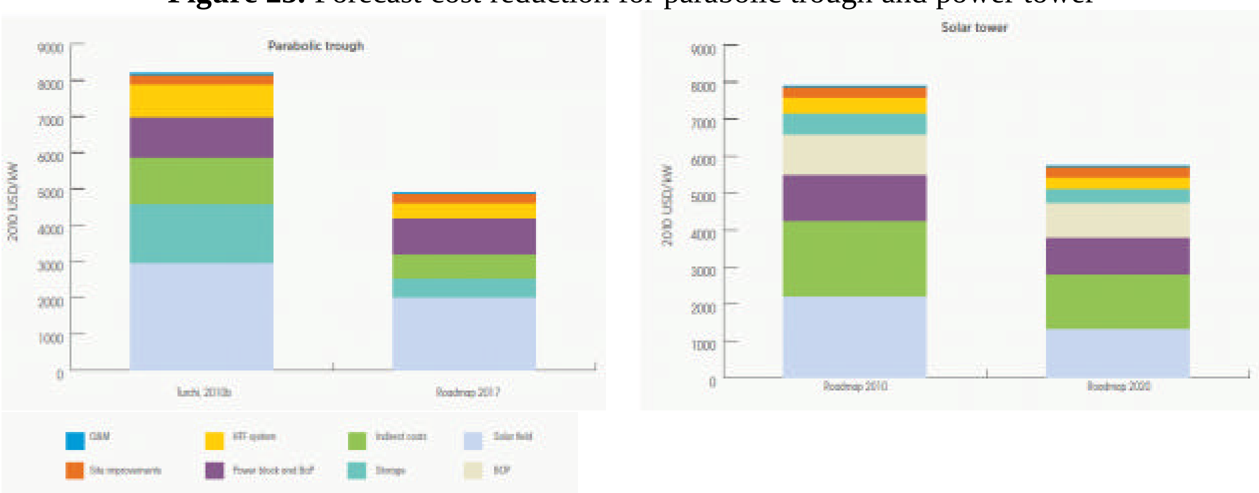
Figure 24. Impact of economies of scale in CSP cost [%]



Source: ATKerney (2011)

5. Cost reduction potential. A significant cost reduction of CSP LCOE is expected, both the investment cost and O&M costs of CSP plants. Many studies have attempted to tackle this issue by analyzing each of the main costs items and their potential future cost reduction (Turchi, 2010; Kutscher *et al.*, 2010; Kolb, 2011). Based on data from Hinley (2010), figure 25 shows the expected reduction in both parabolic trough by 2017 and tower plants by 2020, considering 100 MW plants with 6 hours of storage located in Queensland. The main sources of cost reduction in parabolic trough would be the thermal energy storage and HTF system. In the case of tower, the cost of solar field is expected to experience a reduction of 40%. Based on the existing studies to the date, IRENA (2012) concludes that overall reduction in investment cost for parabolic trough by 2020 is estimated to be in the range of 17%-40% (Hinley *et al.*, 2010 and Kutscher *et al.*, 2010). In the case of solar towers, the expected reduction would be 28% (considering a plant with similar technical parameters). Other methodological approach to tackle the question of potential cost reductions is the analysis of "learning curves". Based on existing data, this indicator estimates the percentage cost reduction for each doubling of the installed capacity (IEA, 2010; Trieb *et al.*, 2009). Even there is some variation in the estimates in the literature, IRENA (2012) considers a conservative rate of 8% to 10%. This could result in a reduction in investment cost by 2020 in the range of 30% to 40% under an aggressive deployment scenario (IEA, 2010) which is considered as a realistic assumption based on the current and forecasted pace of CSP deployment. With regards to O&M cost, IRENA (2012) considers that overall cost reduction could be 35% by 2020 for parabolic trough and 23% for solar tower.

Figure 25. Forecast cost reduction for parabolic trough and power tower



Source: Hinkely (2011), in IRENA (2012)

Based on this data, Table 11 aggregates results from the main studies that offer estimates of expected declines of LCOE for parabolic and tower projects from 2011 to 2020. Potential reduction vary from different studies, but most of them coincide that it is expected a significant reduction (of approximately 50%) in LCOE of CSP plants.

Table 11. Estimated LCOE for parabolic trough and solar tower projects in 2011 and 2020 [€[9] $_{2010}$/kWh]

	2011		2020		
CSP type and source	**Low estimate**	**High estimate**	**Low estimate**	**High estimate**	**Notes**
Parabolic trough					
IEA, 2010	0.15	0.22	0.08	0.11	Low estimates, DNI: 2600. High estimates, DNI: 2000
Kutscher *et al*. 2010	0.17		0.08	0.09	Plants in USA[10], DNI: 2500-2700. In 2010, 100 MW and 0-6 hours of storage. In 2020, 250 MW and 12 hours of storage.
Solar Tower					
Kolb *et al*., 2010	0.12	0.13	0.06	0.07	Plants located in USA (DNI: 2500-2700). In 2010, 100 MW and 9 hours of storage. In 2020, 150 MW and 14 hours of storage.
Parabolic trough and Solar Tower					
AT Kerney	0.17	0.24	0.10	0.12	

Source: Based on IRENA (2012)

CSP cost in Spain

As mentioned before, the aim of this section is to analyze what are the most likely values for those parameters that fit best with the current case study conditions (implementing a joint project of CSP plant in Spain). Based on the previous description, CSP cost estimates used in this case study consider:

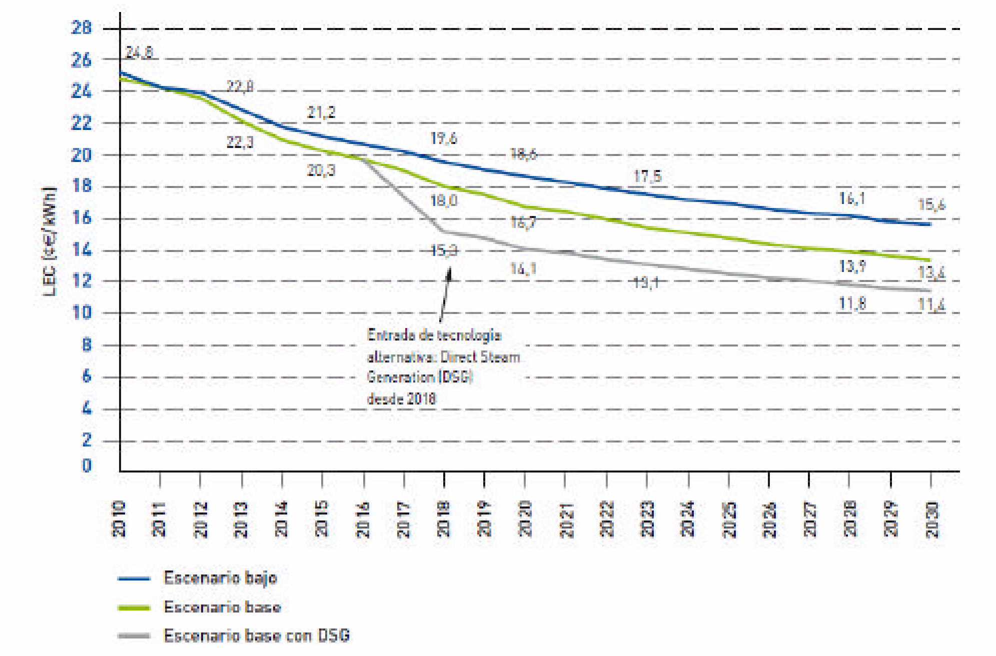
- Firstly, the type of technology is going to be an open question (being parabolic trough and central receiver the most cost efficient alternatives to be exploited at a large scale). As mentioned before, it seems that central receiver or solar tower would be more competitive in the long term while parabolic trough is the current most cost competietive alternative. So, depending on the timing of the agreement between Spain and the Netherlands, the most appropriate technological option will be chosen.
- Secondly, plants are going to have storage system as it increase the capacity factor of the plants.
- Thirdly, related to plant size, even current CSP plants has a limit of 50 MW which is the maximum capacity required to benefit from the feed in tariff system in Spain, CSP plants constructed within the context of cooperation mechanisms will not have such size restrictions (as they will not benefit from the Spanish FIT regime). According to the Spanish CSP Association, if such restriction is removed, it would be possible to construct more cost-efficient plants with 200-225MW capacity. Based on the ATKerney report (2011), such an

[9] Original figures from IRENA (2012) are expressed in 2010 USD. In order to provide comparable data, it has been used the average exchange rate of 2010 (1.33 USD/€).
[10] Adjusted to exclude impact of tax credits

increase in the size of the plants could imply a significant marginal cost reduction of about 9 to 26% when considering parabolic trough technology and 21-24% when considering central receiver plants.

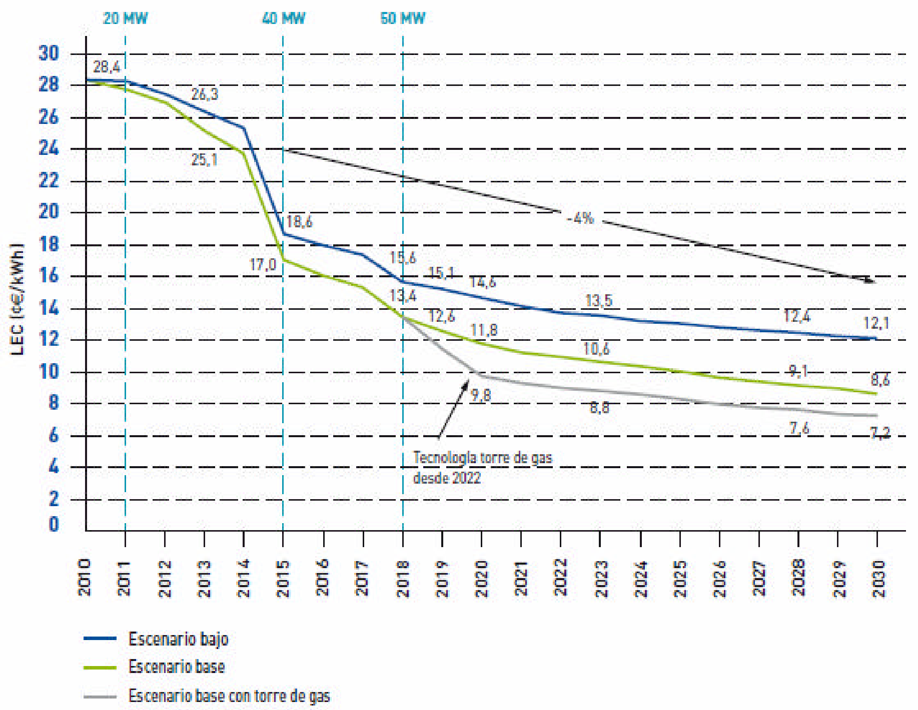
- Related to cost reduction potential, CSP current and future forecasted cost data used by the RESolvE model are based on the Prospective Technology Study in Spain, conducted by Boston Consulting Group (BCG, 2011) on behalf of Spanish Institute of Diversification and Saving of Energy as a technical input for the preparation of Renewable Energy Plan 2011-2020 (IDAE, 2011). Figure 26 displays the expected cost evolution data for a 50 MW parabolic trough with storgage and Figure 27 displays the expected cost evolution for central receiver plant in Spain.

Figure 26. Expected cost evolution of 50 MW CSP parabolic trough plants in Spain, 2010-2020 [c€/Kwh]



Source: BCG (2011)

Figure 27. Expected cost evolution of CSP central receiver in Spain [c€/Kwh]

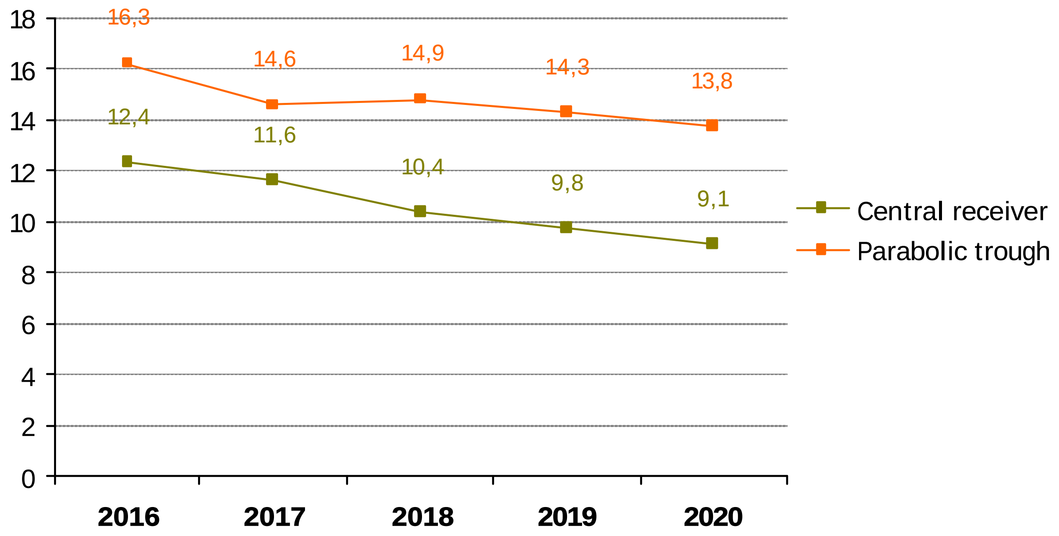


Source: BCG (2011)

It is important to note that the figures from the BCG study by 2020 are based on a 50 MW capacity plant which is the maximum capacity required to benefit from the feed in tariff system in Spain. Nevertheless, as mentioned before, the forecasted size of CSP plants constructed in the context of cooperation mechanisms will have 200-225MW capacity. Based on the ATKerney report (2011), such an increase in the size of the plants could imply a significant marginal cost reduction of about 9 to 26% when considering parabolic trough technology and 21-24% when considering central receiver plants.

Consequently, when taking into account the following data and assumptions: [i] BCG (2011) cost estimates and [ii] the expected reduction cost due to an increase in plant capacity, the estimated levelized electricity cost (LCOE) for both types of technologies are displayed in Figure 28.

Figure 28. Forecasted CSP costs (by type of technology) for plants that start operating along 2016-2020 in Spain for different technologies [c€/kWh] - Data used to conduct the current case study



Source: Own elaboration, on the base of BCG (2011) and ATKerney (2011)

As discussed in Section 2.3, the consulted Spanish stakeholders suggested the convenience to start-up the joint projects as soon as possible (as proposed in Figure 20). The main reason for that is that the construction of the required CSP capacity (1250 MW) needs to be dealt in a progressive way, mainly because of the long construction lead time of CSP plants (minimum two years) but also due to the high volume of investment required for it. Despite these factors suggest the desirability of implementing joint projects as soon as possible, the economic analysis has shown that a remarkable cost reduction in CSP cost is expected to take place within the next few years leading to higher the profits for the User country the longer it waits. The solution to this dilemma is to find a balance between the requirement of conducting the construction of plants progressively and the convenience of waiting in order to obtain lower cost of production. In this sense, one possible solution would be to delay the start-up of plants until 2017 and even 2018. Furthermore, instead of planning a homogeneous construction of two plants each year, try to look for an incremental process, for example, by start-up one plant in 2017-2018 continue with more than two plants the following years. Secondly, results show that in the medium to long term, central receiver technology could become the most cost-competitive alternative but this is very much dependent on the rate of deployment of each technology worldwide.

Finally, it should be said that the numbers showed in Figure 28 should be considered as conservative estimates of the actual CSP cost evolution because of: [i] firstly, during the long construction phase, some technical improvement could bring costs down (compared to those initially foreseen during the pre-construction phase) and [ii] secondly, because of very competitive CSP electricity prices recently reached in North Africa (Ouarzazate) (which seem to indicate a higher speed in the cost reduction path than initially expected getting closer to 14 c€/kwh).

b) RES cost in the User country (The Netherlands):

This case study considers that marginal technology that would be displaced due to the implementation of cooperation mechanism in The Netherlands would be Wind Off-shore. Based on data used in the RESolve Model, the marginal cost of this technology would be over 15c€/KWh.

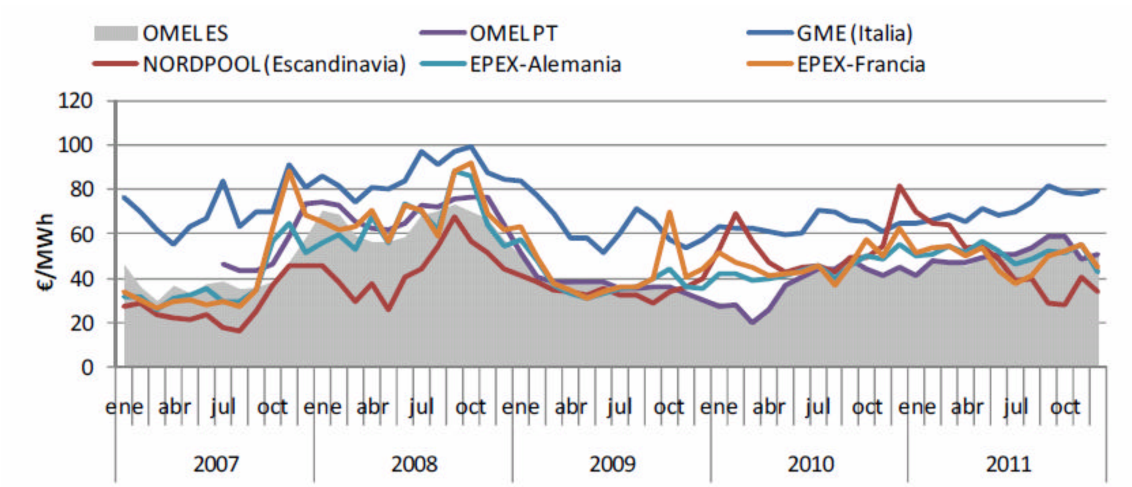
4.1.2. Power market prices

The amount of RES transfer between the two countries will be determined, firstly, on the basis of the RES generation cost difference, and secondly, by taking into consideration the revenues from selling the electricity in the market on both countries (given the fact that there will be no physical transfer, all the electricity that would be produced by the new CSP plants in Spain would have to be sold in the Spanish Electricity market).

In order to estimate the market revenue in 2020 and before, it is necessary to estimate the electricity market prices in the future.

a) Power market prices in the Host country (Spain): For the Spanish case and based on 2011 figures, approximately 70% of electricity is negotiated in daily market so it could be considered as a good representative of the revenues from the market. The current average daily market price in 2011 is 4.993 c€/KWh, which represents an increase of 34.9% respect to 2010 (CNE, 2012). In order to estimate the 2020 prices, it has been assumed that the price evolution will follow the same pattern as in the previous year. Figure 29, shows the evolution of electricity daily market price in Spain from 2007 to 2011, and compares it with several EU countries. Based on this information, it seems reasonable to assume a future electricity price in the medium term of 6-7 c€/KWh[11].

Figure 29. Electricity price in daily market evolution in Spain and several EU countries, 2007-2011 [€/MWh]

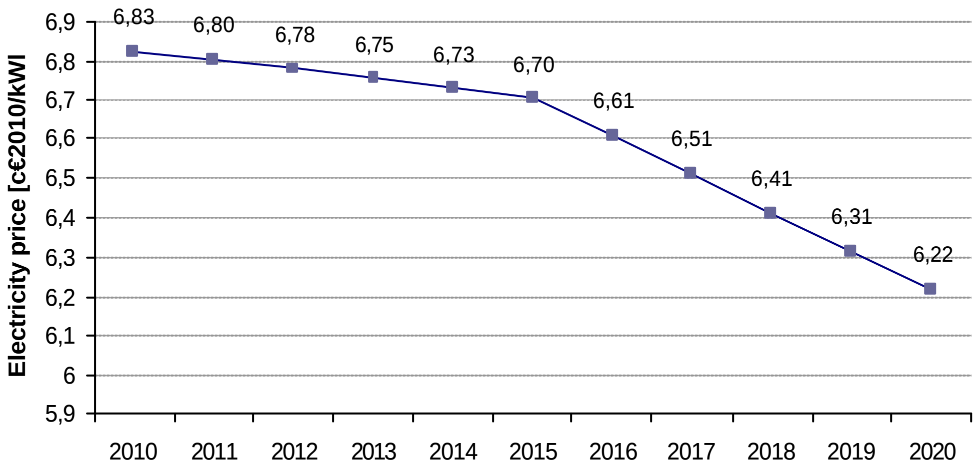


[11] In order to do the estimates, it has been considered an average reference price of 6.5 c€/kWh for 2020 and for the previous years it has been considered a lineal progression from current prices to 6.5 c€/kWh in 2020.

Source: CNE (2012)

Besides this, Figure 30 shows the price electricity for Spain forecasted by the RESolve-E model. These figures are in agreement with the range previously mentioned.

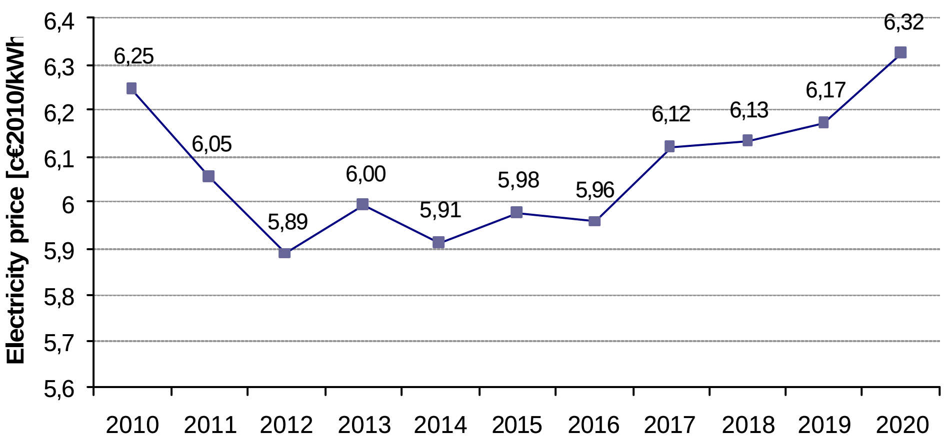
Figure 30. Electricity prices for Spain, forecasted by RESolve model [c€$_{2010}$/kWh]



Source: RES4Less, own estimates

b) Power market prices in the User country (The Netherlands): The future power prices are very difficult to forecast. The dominant factors in The Netherlands are the evolution of the gas price and the evolution of intermittent RES-E penetration. Even this challenge, the current case study has considered the Dutch prices of electricity forecasted by the RESol-E model, as shown in Figure 31.

Figure 31. Electricity prices for the Netherlands, forecasted by RESolve model [c€$_{2010}$/kWh]



Source: RES4Less, own estimates

For both countries, an additional issue that should be taken into account is the potential effect on the consumers´ electricity price associated to an increase/decrease of RES production in the electricity system in Spain/Netherlands due to the implementation of the cooperation mechanism[12]. As an example, and based on Nieuwenhout and Brandt (forthcoming), in the case of the Netherlands, some preliminary estimates show that increasing the share of wind off-shore in the Dutch electricity market in 2GW would have a price effect -0.025 c€/kWh. Consequently, as the impact on electricity market prices of RES is mostly negligible in the Netherlands and given the fact that this information is not yet available for Spain, this effect is not going to be taken into consideration in this case study.

4.1.3. Grid and system operation costs

a) Grid and system operation cost in the Host country (Spain)

Based on the report on "Integration of electricity from renewables to the electricity grid and to the electricity market. Spain, National report" (Sonvilla *et al.*, 2011) the cost of integrating RES production in the electricity system includes the following issues:

- **Connection cost**: Connection charges in Spain are based on the "deep" approach, that means that developers incur with the connection costs to the grid (Sonvilla *et al*. 2011). As the developer assumes this amount, the connection cost is currently included in the costs estimates presented in Figure 27. Therefore, this cost item is not going to be considered in the current section.
- **Grid reinforcement:** Spain publishes every four years its electricity and gas infrastructure Plan for a ten years period. The current plan was approved in 2008 for the period 2008-2016 and a new revision for the period 2012-2020 is currently being prepared but it has not been yet approved. The former plan was built on the basis of the RES Plan 2011-2020[13]. After revising various grid planning documents in Spain (MITYC, 2008 and 2011), it could be concluded that, even though a reinforcement of the grid in two critical points in the South of Spain[14] is planned, there are no significant grid congestion problems in those regions where CSP plants will be located. Based on this evidence, this case study will consider the hypothesis that there will be no need of grid reinforcement due to cooperation mechanisms. Nevertheless, if cooperation agreement finally takes place, the expected increase of RES installed capacity derived from it should be communicated to the Spanish Ministry of Industry in order to be taken into account in the future planning. In case that grid reinforcement would be needed, the associated costs should be paid by the host country. The way to proceed in order to demonstrate the additional requirement of reinforcement is to use the standard tools applied

12 This effect has not yet been estimated nor considered in the analysis. However, it seems that it will be negligible.

13 Due to recent changes in the promotion policies framework, it is expected a depth revision of it in order to consider a new RES deployment scenario in Spain.

14 The Plan forecasts two specific actions in order to evacuate local production from new generation plants within southern half of Spain: [i] in Seville, there is necessary to reinforce the Seville ring of 400 kV, on the West side and [ii] in Castilla La Mancha, it is necessary to reinforce the mesh system in Ciudad Real and Albacete in order to evacuate generation from RES plants.

for the infrastructure planning process. The evaluation process should be done by comparing the requirements in two different scenarios: [i] a baseline scenario, without increasing the capacity of RES due to cooperation mechanism and [ii] an alternative, in which there is an agreement that involves an increase of RES installed capacity. In case grid reinforcement were necessary, costs will be estimated through the standard values of grid costs infrastructures (currently collected in the Ministerial Order ITC/368/2011).

- **Grid (transport and distribution) usage cost:** These costs will not be transferred to The Netherlands as energy will be consumed in Spain.
- **Operation costs:** Due to the small size of renewable plants in Spain (up to 50 MW), there exits a large number of renewable plants throughout the Spanish territory (about 800). In order to safely operate the electric system, Red Eléctrica de España (REE, the Spanish System Operator) needs to collect information accurately and in real time from such producers. In order to have an agile system, RES producers are required to report to a Generation Control Center (GCC). The role of these GCC (currently 43) is to act as intermediaries between REE and RES operators: REE establishes direct communication with GCC and CCG contact with their associated renewable operators. The fees of these GCC should be considered as an additional cost of integrating RES in the system. Accurate data about these fees is not available at this moment but, based on personal communication with experts, as a first approach it could be considered that it would be around 0.3 c€/KWh.

b) Grid costs in the User country (The Netherlands)

In order to analyze the profitability for Netherlands of using cooperation mechanism, the associated cost of grid expansion associated to an increase in wind off-shore needs to be taken into account (as a potential indirect benefit –savings- associated to the implementation of the cooperation mechanism for the Netherlands). The Dutch TSO TenneT is currently implementing the Randstad 380 project intended to evacuate the production from, among others, an expected 6000 MW of wind offshore. *A priori*, this case study is going to assume that the investment on the Ranstad 380 project is going to be taken independently of reaching an agreement between Spain and the Netherlands (in the context of the cooperation mechanisms). In that case, the extra costs of grid infrastructure of wind offshore production in the Netherlands would be cero.

On the other side, additional cost of operating RES should be taken into account in order to analyze the benefits of implementing a "cooperative approach" instead an "domestic approach". Nevertheless, this information is not available at this moment. Taking into account the uncertainty on the estimates of this parameter in the case of the Host country (Spain), this case study is not going to take into consideration this aspect within the preliminary estimates aimed at analyzing the convenience of conducting a cooperative approach. Nevertheless, this parameter should be further refined (especially in the case of the Host country) in order to be taken into account within the price allocation process if the two countries finally reach an agreement.

4.1.4. Results of RES transfer determination from the user to the host country

As described at the beginning of Section 4, once the potential cooperation opportunities between Member States have been identified (in order to reach national RES targets in a cost-effective way), the first step of the "price allocation" process consists on estimating the amount that the User country should give to private operators of renewable plants in the User country. This support could be estimated as the difference between the cost of the RES technology and the revenues expected from selling the energy in the market, as indicated by:

$$\text{Support} = \text{Cost}_{RES} - \text{Revenues}$$

Table 11 shows the required information to conduct these estimates in the current case: firstly, the unitary cost of energy from CSP plants that start-up in different years during the period 2017-2020; secondly, the expected revenues that private operator of CSP plants would received from selling the energy in the Spanish electricity market; and finally, the amount of support needed to cover the RES costs. In order to compare both scenarios, Table 11 also collects the information to estimate what the support that the Netherlands would have to assume in the case of fulfilling its RES target trough a domestic approach (producing internally RES energy from wind offshore plants).

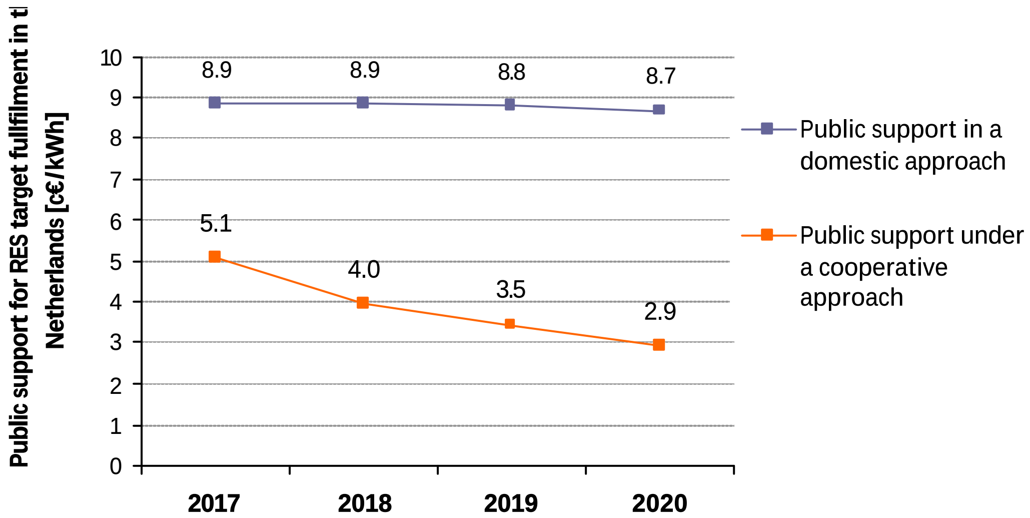
Table11. Data required to estimate the support, both in a cooperative and a domestic scenario [c€/kWh]

Cooperative scenario: Spain as producer of CSP energy for the fulfilment of Dutch RES target				
	2017	**2018**	**2019**	**2020**
RES Cost in the Host country [c€/KWh]	11.6	10.4	9.8	9.1
Revenues from selling energy in the Host country [c€/KWh]	6.5	6.4	6.3	6.2
Public support from the User country [c€/KWh]	5.1	4.0	3.5	2.9

Domestic scenario: Wind offshore produced in the Netherlands for the fulfilment of Dutch RES target				
	2017	**2018**	**2019**	**2020**
RES Cost in the User country [c€/KWh]	15,0	15,0	15,0	15,0
Revenues from selling energy in the User country [c€/KWh]	6,1	6,1	6,2	**6,3**
Public support from the User country [c€/KWh]	**8.9**	**8.9**	**8.8**	**8.7**

Figure 32 shows the total support that the Netherlands would have to provide to RES energy produced for plants that would start-up in different years along the 2017-2020 timeframe under both scenarios: [i] an domestic scenario, in which the Netherlands produce RES internally and, [ii] a cooperative scenario, in which CSP energy is produced in plants located in Spain to fulfil Dutch RES target. These results show that public support that will be required to produce RES energy in Spain to be transferred to The Netherlands (orange line) would be lower than public support that would be required to produce RES energy in the Netherlands to reach its own target (blue line).

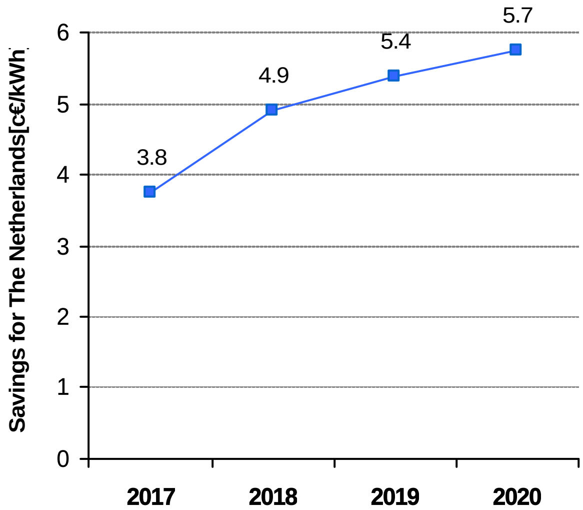
Figure 32. Public support under both scenarios, a cooperative approach and domestic approach [c€/kWh]



Source: RES4Less own estimates

It can be concluded that implementation joint projects to "transfer" RES energy from CSP plants located in Spain that would start-up along the period 2017-2020 will result in net positive savings for The Netherlands. This savings are estimated as the difference of support that the Dutch Government would have to assume under both scenarios: with and without implementing cooperation mechanisms. Figure 33 shows the preliminary estimates of these savings (expressed in unitary terms), for the plants that start-up in different year within the period 2017-2020.

Figure 33. Savings for The Netherlands (expressed in unitary terms[15]) of joint projects of CSP plants located in Spain that start-up in different years along 2017-2020 [c€/kWh]



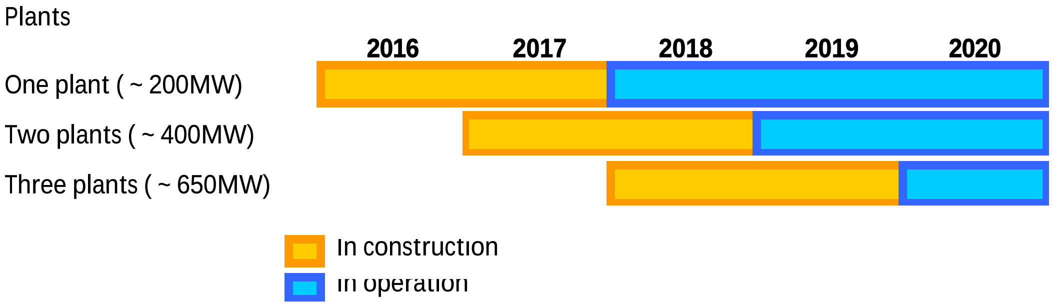
Source: RES4Less own estimates

It has to be mentioned that once a plant stat-up in a specific year, for example 2017, The Netherlands would have to maintain the public support to private operators of that plant for a long period (at least 15 years). Taking into account that the potential savings represented in Figure 31 are going to be extended over a long period of time, it seems convenient to suggest that the later

[15] ,Per unit of energy produced.

the CSP plants located in Spain start its operation, the higher the savings would be for the Netherlands. Nevertheless, as was argued before, the long constructing phase of CSP, the risk of National target uncompliance as well as the large investment requirement and acquisition process, seem to indicate that it would be best not to wait until the end of the period. As mentioned before, it is necessary to find a balance between all these objectives. In this sense, one possible solution would be to delay the start-up of plants until year 2017 and even 2018. Furthermore, instead of planning a homogeneous construction of two plants each year, it is possible to follow an incremental process. That is, for example, to start-up a 200 MW pilot plant in 2017-2018 and more than two plants the following years. Based on this new approach, a new investment timeline is presented in Figure 34.

Figure 34. Investment timeline following a gradual development pathway



Finally, it has to be mentioned that along the process of estimating the amount of public support from the User to the Host country it is necessary to make forecasts about some variables that are subject to uncertainty (as the future revenues from the market). The estimates done within this case study should be interpreted as a preliminary exercise.

4.2 External effects determination:

As mentioned before, the last step of the decision making process consists on integrating into the analysis the “external” effects for both countries in terms of: [i] environmental, [ii] socio-economic and [ii] energy dependency resulting from a change in the energy mix in each country[16]. If no physical transfer took place, it is assumed that host country would experience some social benefits associated to a less carbon intensive energy mix and, contrary, the user country would experience a cost due to an increase in conventional sources in its energy mix.

Most of those external costs and benefits are often hard to identify, quantify and monetize. Previous research shows that there are various methodological approaches that can help policy makers in this endeavour. With regards to the environmental impact, depending on the pollutant: [i] GHG emissions can be valued through carbon markets and [ii] other environmental externalities, through the "*impact pathway approach*" (EC, 2005). Finally, socio-economic impacts can be estimated trough input-output analysis or similar approaches (Ragwitz *et al.*, 2009, Wei *et al*, 2011).

[16] The external effects, especially environmental and energy dependency effects, would be significantly lower in case of existing a physical transfer as the host energy mix would not have to be modified.

4.2.1. Energy mix variation variation (displacement / increase of conventional technologies)

In order to estimate external cost of the cooperation mechanism implementation, it is necessary to identify which are the conventional fossil fuel technologies that would be displaced in the host country and, contrary, increased in the user country. The technology choice assumption is based on expert information and technical reports and in the present case study the following assumptions have been made (Table 12):

- **Spain:** In the case of Spain, and based on CNE (2011), the technology that most probably would be displaced is the natural gas combined cycles.
- **Netherlands:** In the case of The Netherlands, the technology that most probably would be increased is the natural gas combined cycles or an increase of imports. For the purpose of this case study, the first case has been assumed.

Table 12/ Expected consequences for the energy mix in both countries

Country	RES	Conventional sources
Host country (Spain)	↑ CSP	↓ Natural Gas Combined Cycles
User country (The Netherlands)	↓ Wind Off-shore	↑ Natural Gas Combined Cycles

4.2.2. Environmental impact

The largest environmental benefit associated to renewable energies arises from GHG reduction but also, reduction on other kinds of pollutants (regional and local pollutants). Consequently, a change in the energy mix derived from the implementation of cooperation mechanism (in case of not existing a physical transfer of energy) would result in an improvement on environmental quality on the host country and a deterioration of the environmental quality in the user country. In order to analyze the magnitude of this issue and integrate this impact within the frame of a decision taking process, this section is devoted to estimate the value of the environmental impact (that means, expressing it in monetary units) in order to provide decision makers with useful information about the relevance of this issue.

It has to be mentioned that there are other kinds of environmental impacts such as visual, land occupation or water consumption, that should be taken into account but its economic valuation depends on site-specific characteristics. Consequently, in the present case study, the assessment of such impacts has not been considered.

Methodological approach

The methodology for valuing environmental impacts is based on the well known “Impact pathway approach”, designed within the context of the ExternE project. This project has been the most relevant project dealing with the determination of the externalities of energy in the European context. It was launched in 1991 by the European Commission and the US Department of Energy. Since then, the European Commission has continuously supported this research field through several projects. The last of these projects is the NEEDS Project (New Energy Externalities Development for Sustainability, www.needs-project.org/) and other related projects like the EU CASES project (www.feem-project.net/cases).

The ExternE methodology is widely accepted and considered as the world reference in the field by the scientific community. The quantification of the external costs in based on the "impact pathway approach" (IPA). The impact pathway methodology aims at modelling the causal relationships from the emission of a pollutant to the impacts produced on various receptors through the transport and chemical conversion of this pollutant in the atmosphere. The main steps of an IPA can be grouped as follows (EC, 2005):

- Emission: specification of the relevant technologies and pollutants (e.g. kg of particulate matter (PM) per GWh emitted by a power plant at a specific site;
- Dispersion: calculation of increased pollutant concentrations in all affected regions (e.g. incremental concentration of PM), using models of atmospheric dispersion and chemistry.
- Impact: calculation of impacts (expressed in physical units) using a dose-response functions (e.g. cases of respiratory hospital admission due to this increase in PM);
- Damage: that is the loss of welfare derived form the impacts caused by pollutants (e.g. the cost of treating patients with respiratory deficiencies).

In practice, ExternE uses Life Cycle Analysis in combination with Impact Pathway Approach to get a complete assessment of external costs due to energy production. Main receptors of the impacts are human health, crops, ecosystems and materials. Welfare losses produced by these impacts are assessed using economic valuation methods (such as contingent valuation, health care cost, etc). Impacts categories, pollutants and effects considered in the ExternE methodology are summarized in Table 13.

Table 13. Impacts categories, pollutants and effects considered in the ExternE methodology

Impact category	Pollutant	Effects
Human health-Mortality	PM10, SO2, NOx, O3	Reduction in life expectancy
	As, Cd, Cr, Ni	Cancer
	Accident risk	Fatality risk from traffic and workplace accidents
Human health-Morbidity	PM10, O3, SO2	Respiratory hospital admissions
	PM10, O3	Restricted activity days
	PM10, CO	Congestive heart failure
	PM10	Cerebro-vascular hospital admissions Cases of chronic bronchitis Cases of chronic cough in children Cough in asthmatics Lower respiratory symptoms
	Pb	Neurotoxicidad
	O3	Asthma attacks Symptom days
	Benzene, Benzo-[a]-pyrene 1,3-butadiene Diesel particles	Cancer risk (non-fatal)

	Noise	Myocardial infarction Angina pectoris Hypertension Sleep disturbance
	Accident risk	Risk of injuries from traffic and workplace accidents
Building materials	SO2 Acidic Acid deposition	Ageing of galvanised steel, limestone, mortar, sand-stone, paint, rendering, and zinc for utilitarian buildingso
	Combustion particles	Soiling of buildings
Crops	NOx, SO2	Yield change for wheat, barley, rye, oats, potato, sugar beet
	O3	Yield change for wheat, barley, rye, oats, potato, rice, tobacco, sunflower seed
	Acid deposition	Acid deposition Increased need for liming
Global warming	CO2, CH4, N2O, N, S	World-wide effects on mortality, morbidity, coastal impacts, agriculture, energy demand, and economic impacts due to temperature change and sea level rise
Ecosystems	Acid deposition Nitrogen deposition	Acidity and eutrophication (avoidance costs for reducing areas where critical loads are exceeded)

Source: EC (2005)

Five major types of damages have been considered in ExternE. The main categories are human health (mortality and morbidity effects), effects on crops and materials as well as damage on ecosystem and global warming. Global warming impacts assessment is subject to a very high degree of uncertainty. Within NEEDS, the model FUND 3.0 was used to estimate the marginal external costs of GHG emissions (Anthoff, 2007). Results greatly differ depending on the assumptions regarding some very influencing parameters like discounting and equity weighting. As an alternative option, the current case study is going to estimate the value of the change in GHG emission, trough the use of forecasted prices in permit emissions market.

The tool used for conducting the whole process is Ecosense, which is suited for fixed emission sources. The development of the complete methodological process is time and data consuming. Nevertheless, within the context of the CASES project (one of the followers on the frame of the ExternE project) the whole impact pathway approach was implemented, offering results of total damages produced by an increase in one tonne of pollutant (expressed in €/t of pollutant). The “damage factors” resulting from the CASES project are disaggregated at the country level. At the same time, the CASES project database offers information about “emission factors”, that means the increase in emissions associated to the production of an additional unit of energy from different technologies (expressed in t/kWh). Knowing both parameters (the change in emissions by technology and the damages associated to those emissions), finally it could be estimated the marginal environmental damage per unit of energy produced trough different technologies, trough a simply multiplying both factors:

$$\text{Damage}\left(\frac{€}{kWh}\right) = \text{Emissions}\left(\frac{t}{kWh}\right) * \text{Damage factor}\left(\frac{€}{t}\right)$$

This will be the approach used to estimate which will be the value of environmental change due to a change in the energy mix derived from the implementation of cooperation mechanisms.

Data and hypothesis within the estimation process

As described before, in order to estimate the value of the change in environmental quality due to changes in the energy mix in both countries (the Host and the User country), the first step consists on estimating the emissions associated to the different technologies involved in the current case study. As was mentioned in Section 4.2.1., the energy mix in the Netherlands is going to experience an increase in natural gas combined cycle. Emissions associated to the production of energy from natural gas combined cycle are shown in Table 14. Taking into account that the emission factor (during the production stage) of wind off-shore is cero, the total increase in emissions in The Netherlands would be equivalent to the figures displayed in Table 14 for natural gas combined cycle. On the other side, Spain is going to experience a decrease in the presence of natural combined cycle in its energy mix. Following the same argument, as CSP emission factor (during the production stage) is cero, Spain would experience a decrease in emissions equivalent to the figures in Table 14 for natural gas combined cycle. Emission factors have been taken from the "Cost Assessment of Sustainable Energy Systems" (CASES) Project, by considering exclusively the operation phase (instead of Life cycle Inventory). The main reason to select the emissions produced only during the operation phase is that some emission within the lyfe cycle of the technologies (mainly the extraction of fuel, in the case of natural gas combined cycle) could take place out of the consumer countries borders. In order to be conservative and have comparable results, is has been considered convenient to use the emissions produced only during the operation phase.

Table 14. Emissions factors for different technologies [Kg/KWh]

Pollutant	Natural gas combined cycle	Wind Off-shore	Solar thermal
CO2 equiv.	3.30E-01	0	0
NOx	2.54E-04	0	0
PM 2.5	2.84E-06	0	0
PM coarse	8.68E-08	0	0
SO2	6.48E-06	0	0

Source: CASES (2008a)

Secondly, as described before, by the whole implementation of the "impact pathway approach", the CASES project offered results of total damages produced by an increase in one tonne of pollutant (expressed in €/t of pollutant). These have been collected in Table 15 for those countries directly involved in the current case study, and they can be considered as a kind of "damage factor" (CASES, 2008b). In the case of GHG, instead of "damage factors", the forecasted prices of CO_2 permits in the market have been used. There is a great uncertainty about the future evolution of CO_2 permit prices. Consequently, there is a large variety of estimates in the literature (Russ *et al*., 2009, Capros *et al*., 2010, PC, 2012), ranging from 12 €/t CO_2 to more than 40 €/t CO_2. The International Energy Agency (IEA) offer estimates about the marginal cost, by 2020, of reducing CO_2 to limit the increase of temperature to 2ºC. This could also be an alternative approximation to this value. Estimates provided by the IEA (2012) ranges between 23 €/t CO_2 and 39 €/t CO_2[17]. So finally, and in order to be conservatives, current work has considered an intermediate value of 23 €/t CO_2, based on Russ *et al*. (2009)[3] that analyzes the consequences of limiting the increase of the temperature to 2ºC.

Table 15. Damage factors [$€_{2010}$/t]

Pollutant	Damage factor for the Host country	Damage factor for the User country
CO2 equiv.	23	23
NOx	4,253	9,385
PM 2.5	18,377	3,417
PM coarse	1,040	57,536
SO2	5,947	13,721

Consequently, once the change in pollutant emissions per unit of energy produced in each country ("emission factors") is known, "damage factors" can be used to estimate the loss of welfare derived form a change in environmental quality/performance that will result from a change in the energy mix. As explained before, this has been estimated by simply multiplying both factors. Based on these assumptions, Table 16 shows the environmental effects for both countries:

- Spain would experience a benefit derived from an improvement in its environmental performance of approximately 0.69 c€/kWh. Most of the environmental benefit (86%) would become from a reduction in GHG emission.
- The Netherlands would experience a deterioration in its environmental quality/performance of approximately 0.80c€/Kwh. Most of the environmental cost (74%) would originate from an increase in GHG emissions.

Table 16. Value of environmental changes due to cooperation mechanisms [c$€_{2010}$/kWh]

Pollutant	Avoided environmental damage in the Host country (Spain)		Induced environmental damage in User country (The Netherlands)	
	Damage avoided	Distribution of damages[%]	Induced damage	Distribution of damages[%]
CO2 equiv.	0.75829	87%	0.75829	75%
NOx	0.10799	12%	0.23831	24%
PM 2,5	0.00522	1%	0.00097	0%
PM coarse	0.00001	0%	0.00050	0%
SO_2	0.00386	0%	0.00890	1%
TOTAL	0.87537		1.00697	

Source: Own estimates

[17] The figures provided by the IEA (2012) are expressed in dollars: 30-50 USD/t CO_2. It has been used an exchange rate of 1.28 $/€ to expressed in euros.

4.2.3. Socio-economic impact

Methodological approach

Compared to conventional fossil fuels, a new RES project generates a higher effect in both economic activity as well as job creation. This is due to the fact that investment costs are usually higher but also because most of the activities involved take place in the country (in the case of conventional technologies, a large percentage of the energy cost is due to the fuel provision that normally takes place abroad) (Ernst and Young, 2012).

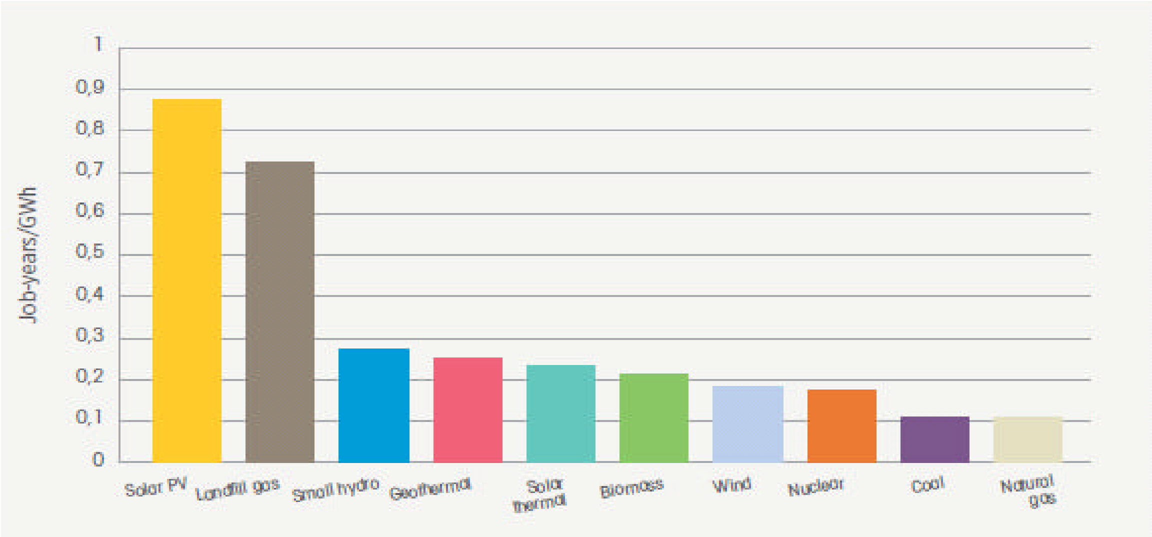
That is why renewable energies have a positive socio-economic effect in terms of employment and income creation compared to conventional fuels. Consequently, and similarly to the environmental impact, a change in the energy mix derived from the implementation of cooperation mechanism would result in a positive socio-economic effect in the host country (due to an increase in renewable technologies in its territory), while a decrease in potential socio-economic effects in the user country. In order to analyze the relevance of this question and integrate this impact within the frame of a decision making process, this section is devoted to estimate the value of the socio-economic impact (expressed in monetary units) in order to provide decision makers with useful information about the relevance of this issue.

As stated by Capros *et al.* (1992), the socio-economic impact of renewable technologies should be measured taking into account the *direct impact* in those sectors directly involved in the production of that energy, as well as *indirect* impact in those sectors that supply goods and services to the previous ones. Besides this, the impact should be measured in *net terms*, that means considering the socio-economic impact that it would have taken place in case of having produced that energy with a conventional source.

The input-output analysis provides the most appropriate methodological framework to analyze this issue. The application of this methodology is very time and data consuming. Nevertheless, there are various studies that has tackled this question in various contexts (Whitely, 2004; Hillebrand, 2006; Ragtwitz, 2009).

One of the most comprehensive studies that collect data on the socio-economic impact of different technologies is the one conducted by Wei *et al.* (2011). Its only limitation is that it only covers the employment effect, not including GDP effects. On the other hand, this study has the advantage of providing data on employment impact (direct and indirect) by unit of energy produced, as can be seen in Figure 35. This way of expressing results facilitates the comparability between different technologies. Consequently the current case study is going to analyze the socio-ecomic impact only in terms of job creation.

Figure 35 Comparison of job-years across technologies (Job-years/GWh)



Source: Wei *et al*. (2011), in IRENA (2011)

Proceeding in a similar way as in the environmental impacts section, once the information about the change in employment is available, next step consist in trying to estimate its value (in economic terms). The aim of this work is to provide results expressed in monetary terms to be integrated a common balance in order to extract conclusion about the magnitude of consequences derived from the implementation of cooperation mechanisms. The way to estimate the economic value of this impact will be trough the estimation of total saving for the public authorities in terms of avoided unemployment subsidy, as indicated in the following expression:

$$\text{Socio-economic benefit}\left(\frac{€}{kWh}\right) = \text{Job creation}\left(\frac{job}{kWh}\right) * \text{Unemployment subsidy}\left(\frac{€}{kWh}\right)$$

Data and hypothesis within the estimation process

Based on the resulting change in energy mix in both countries (as described in Section 4.2.1.), the first step consists on estimating the net change in employment in both countries: [i] in the case of Spain, the increase in employment would be the difference between the employment impact of solar thermal minus the employment impact of natural combined cycle; and [ii] in the case of the Netherlands, the potential loss on employment would be the difference between the employment impact of wind-offshore minus the employment impact of natural combined cycle. In order to estimate the socio-economic impact within the current case study, data of employment impact for different technologies have been taken from Wei *et al.* (2011). Nevertheless, data has been adapted in several senses. Firstly, figures have been adapted to obtain information about employment creation (instead of employment rate). This is related to the fact that the employment rate does not provide data about employment creation, as mentioned before, as it is expressed in terms of jobs of one year of duration. Taking into account the lifetime and construction phase of the plants, data from Wei *et al*. (2011) has been converted into figures of job creation (expressed as new jobs/kWh). Secondly, it has to be taken into account the fact that, in the case of natural gas combined cycle, a significant source of employment creation comes from fuel extraction and processing. These processed, normally, takes place out of the consumer countries (at least in the case of Spain and the Netherlands). Thus, this amount of employment has been discounted in order to do the estimates of net impact on employment. Finally, Wei *et al.* (2011) offer data for wind on-shore but not for wind off-shore. On the other hand, EWEA (2012) concludes that wind off-shore energy is between 2.5 and 3 times more labour intensive than wind on-shore. This incremental factor is going to be used to conduct the estimates. After conducting these corrections, Table 17 show the employment creation rates that are expected for both countries due to the implementation of current case study.

Table 17. Net impact on employment of cooperation mechanism between The Netherlands-Spain [jobs/GWh]

	Spain	Netherlands
Net impact on employment creation [jobs/GWh]	**0,04**	**-0,23**

In order to be able to consider the socio-economic impact in the transfer price negotiation process, further efforts should be done in order to monetize such impacts taking into consideration the net savings/expenditure due to unemployment subsidy. As a first approach as considered the following assumptions: [i] for Spain, the unemployment subsidy lasts 2 years and the forecasted average unemployment compensation could be approximately 900€/month[18] and [ii] for The Netherlands, as a first approximation while waiting for more accurate data on that topic, a similar figure as in Spain has been considered. Table 18 shows the final results potential savings or costs for Public Administration due to changes in employment derived from the implementation of cooperation mechanisms.

Table 18. Socio-economic impact of cooperation mechanism between The Netherlands-Spain [c€/kWh]

	Spain	**Netherlands**
Savings for Public Administration due to employment changes related to cooperation mechanisms [c€/kWh]	0,09	-0,49

Source: Own elaboration

As mentioned before, the impact on employment is only a part of the socio-economic impact. A more complete estimate would require the estimation of the net impact on national income for both countries (that is taking into account the impact on National GDP associated to CSP, Wind-offshore as well as NG Combined Cycle). This economic net effect estimation will be conducted in future revisions of this study once we get more accurate data, especially with regards to the economic implication of NGCC in both countries.

Other aspects related to socio-economic impact are difficult to estimate in economic terms. For example, in Spain, given the temporary moratoria of RES support policies (FIT system), the RES national industry and, CSP industry is not the exception, is suffering from a temporary stop.

[18] Based on official data, in January 2012 the amount of unemployment compensation has been 866€/month.

Besides those plants already registered up to 2014, no new plants with FIT are foreseen to be constructed in the near future in Spain until RD 1/2012 is modified. Consequently, the cooperation mechanisms are regarded as an exceptional opportunity for the future CSP industry deployment in Spain.

4.2.4. Energy dependency

As the cooperation mechanisms induce a change in the natural gas imports pattern, this has positive consequences for the Host country and negative consequences for the User country in terms of energy dependency. This issue could be valued though the economic consequences of being exposed to volatile prices of natural gas. This economic effect will be analyzed in future revisions of this study.

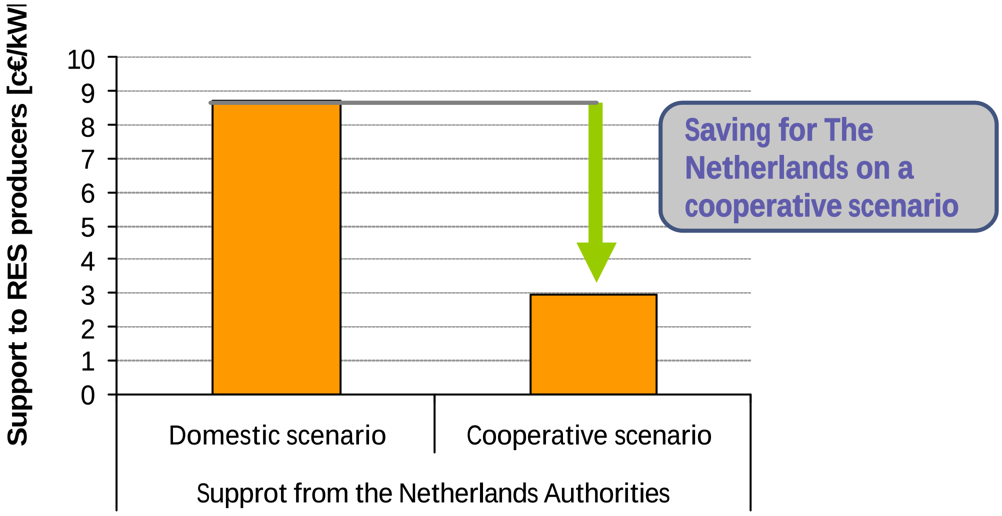
4.3 Summary of costs and benefits

This section summarizes the information presented in the previous sections in order to derive some preliminary conclusions regarding the economic consequences of implementing the proposed case study. Despite the difficulty to value some intangible categories, results seems to be quite robust and send a clear message about the costs and benefits associated to implementing the cooperation mechanism for both countries.

Based on the analytical approach described in Section 3, the decision making process for the user country (the Netherlands) has been illustrated below. Figure 36 represents the support that the Netherlands should provide to RES operators by 2020 under two alternative scenarios. The left part of the figure, which represents the base case scenario, reproduces the "domestic approach" where the Netherlands would generate RES by using wind-offshore technology. Taking into consideration the data and assumptions made in this case study (without considering the indirect effects), the support that the Netherlands should give wind offshore producers by 2020 would amount 8.7 c€/kWh. Alternatively, in the right part of the figure, if the Netherlands chose to acquire the equivalent CSP production from Spain, when considering the values presented before, the required support that the Dutch government should give the Spanish Government to compensate CSP producers that star-up plants in 2020 would amount 2.9 c€/kWh. The additional cost to compensate grid reinforcement and RES integration in the system seems to be negligible but a deeper analysis of this question should be done in the case of the Netherlands and Spain finally reaching an agreement. These results revealed that the required support under the cooperative scenario is significantly lower than producing RES domestically in the Netherlands. The potential savings for the Dutch government of conducting a cooperative approach with Spain could approximately reach 5.7 c€/kWh by 2020[19].

[19] It is important to highlight that this is a static view of what the transfer per Kwh would look like in 2020. However, and as was shown before, the size of the transfer and thus the savings for the Netherlands are time dependent because of the gradual decline of CSP generation costs.

Figure 36. Support required to the Netherlands under a domestic and cooperative scnerario [c€$_{2010}$/kWh]



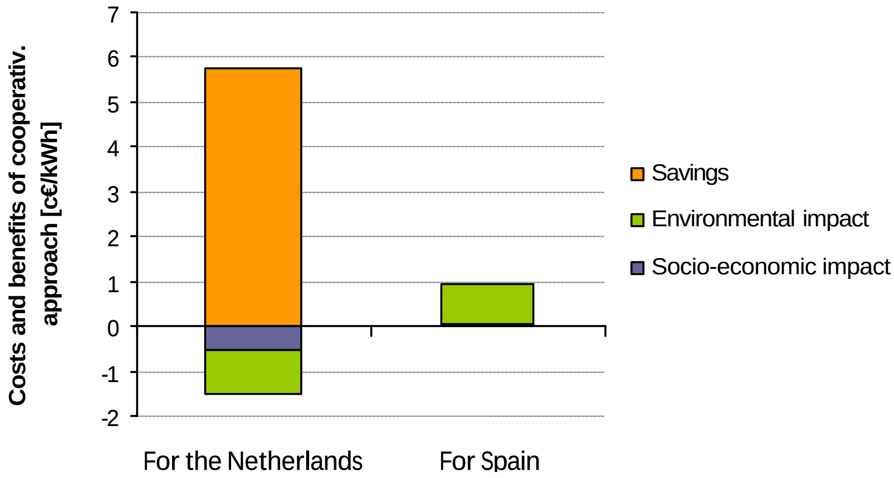
Source: RES4Less, own estimates

Besides these estimates, when sitting at the negotiation table, both governments should take into consideration the associated indirect benefits and costs of the cooperative scenario. In the current case study, as a result of not having physical transfer of electricity, compared to baseline scenario (domestic approach), the resulting Dutch energy mix would be more carbon intensive. Since we assume that the energy demand would remain unchanged under the two scenarios, the wind offshore production would be probably replaced by the cheapest alternative, which in this case, we have assumed to be natural gas combined cycle. As a result of that, there would be some environmental and socio-economic net effects. As a summary of all the net effects described before, the resulting environmental and socio-economic negative impacts would approximately amount 1.50 c€/kWh.

On the other side, the resulting energy mix for Spain would generate some net benefits in terms of both environmental and socio-economic impacts associated to a less carbon intensive energy mix compared to the base case scenario. Since the demand is assumed to remain the same in both scenarios, as a result of having more CSP production the Spanish energy mix would have to adapt by reducing the production of another energy technology (which, in this case, has been assumed to be NG combined cycle). By having a less carbon intensive energy mix, when considering the sum of all indirect socio-economic and environmental benefits, it is estimated that the net effect would be 0,97 c€/kWh.

Finally Figure 37 shows the balance between cost and benefits for both countries under a cooperative approach. The savings for the Netherlands in terms of RES support are large enough to compensate the potential external costs in terms of environmental and socio-economic impact, leading to a net benefit of 4,25 c€/kWh. On the other side, Spain would experience a net benefit because of external positive consequences of 0.97 c€/kWh. In aggregated terms, the cooperative scenario would provide a benefit for both countries that can be valued in 5.21 c€/kWh by 2020.

Figure 37. Net benefits for both countries under the cooperative scenario [c€$_{2010}$/kWh]



The authors of this report would like to stress the fact that, as will be described in detail later, the estimation and monetization of the associated indirect effects for both countries are based on a large number of assumptions and are subject to uncertainty. Therefore, we recommend that the consideration of these figures is taken as a first approximation. This goes *a fortiori* for the valuation of the indirect costs and benefits.

5 BARRIERS AND POSSIBLE SOLUTIONS

Based on various conversations with relevant stakeholders, the Table 19 indicates what are the most relevant barriers that Spain faces for the implementation of the proposed cooperation mechanism. Consulted stakeholders recognize the various additional aspects, besides the parameters included in the modelling work, that are likely to affect MSs' interest and feasibility of the cooperation mechanisms.

The table below summarizes what are the main barriers as well as possible solutions that could be put in place to overcome such difficulties.

Table 19. Barriers and possible solutions to implement the cooperation mechanisms

Type of barrier	Description	Possible solution
Institutional set-up	Complexity of the administrative and institutional arrangement needed to implement the cooperation mechanism in both countries	Higher involvement of National Authorities from both countries and start working on the required administration procedures since early stages of the negotiation.
Uncertainty about post 2020	RES private developers cannot get on board of a project, committing a large amount of financial resources, having a compromise from the Host country of providing support for only one year (2020) or a few years. Consequently, it is crucial to look beyond 2020 in order to define a compensation scheme.	The issue of RES goals for 2030 still needs to be resolved in the coming few years (c.f. 2020 targets were agreed on in March 2007, i.e. less than 3 years before the start of this period). An important way-out would be presented by opening of the Dutch support scheme to Spanish CSP developers. When applying successfully, they could get support certainty over a period of typically 15 years. New Dutch regulation for CSP should be introduced to that extent, which does not seem to present a major hurdle. In any case the transaction schemes between the Netherlands and Spain should go beyond 2020. The agreement should ensure a support system of 15 years.
Opposition from those sectors that will be negatively affected	In the case that interconnection capacity does not experience a significant increase, no physical transfer of the electricity will take place. Thus, other conventional technologies (mostly natural gas combined cycle) will be displaced from the energy mix. Currently, there is an overcapacity of the electricity system in Spain and, more over, natural gas combined cycle sector offers some impediments to increase the production from RES. The production of RES energy in a large scale within the context of cooperation mechanism and without physical transfer would enhance the conflict	The Spanish Government should be aware of this fact when taking part of the negotiation process within the context of cooperation mechanisms. Pending intervening developments, it seems prudent to focus initially on one project only. Furthermore, all stakeholder involved in the development of interconnection capacity with France (REE, ENTSO-e, etc) should work hard in order to reach agreements that assure a significant improvement in solving the bottleneck of the Iberian electric system, making good use of the Projects of Common Interest facility to solicit EU support and simplifying approval procedures.
Coordination with the existing National Regulatory scheme	Despite the project will not benefit from a National Support Scheme (for example: FIT scheme), some coordination with the Spanish Regulatory scheme is needed in terms of ensuring market access priority over conventional fossil fuel technologies	Conversations with relevant Spanish Institutions (CNE, REE and I.D.A.E.) are needed to reach an agreement in that respect.
Payment scheme	A clear definition of the support scheme for the project is needed to attract project developers and reduce the risk perception	Various possibilities exist: - A Dutch support scheme exists providing eligibility for the long time (typically 15 years) - The payment scheme is articulated through an off-taker (international body that manages and facilitates the transactions between user and host countries)
Risk of non-compliance	Given the actual regulatory turmoil, the RES sector has entered into a temporary stop. If the situation is not reversed, there may exist	-If the agreement is well defined, the risk can be greatly reduced or eliminated by committing a certain amount of production only for the use of the Cooperation

	doubts regarding the Spanish capacity to fulfil its own 20% RES target by 2020. Nevertheless, as total consumption of electricity in Spain is declining as a consequence of the economic break, public authorities considered that it is feasible to achieve National target	Mechanisms and not for National RES targets fulfilments. Moreover, application of the cooperation mechanism Joint projects between Member States as analysed in the present case study would create additional installed CSP capacity in Spain and would thus not (negatively) affect Spain's target compliance.
	Less relevant barriers	
Difficulty in Identification, quantification and monetization of those indirect costs and benefits	In order to determine the transfer price, both countries must look at the associated indirect costs and benefits. In order to estimate their value and incorporate it in the calculation of the transfer price, various assumptions need to be undertaken (for example: electricity market price and demand in 2020, etc) which are subject to great uncertainty	It is necessary to set an analytical framework to take into consideration such indirect costs and benefits (see previous graphs). Despite great uncertainty exist, it is possible to undertake sensibility analysis on those variables subject to great variation and also identify what is their magnitude. In any case, it seems that the indirect costs and benefits already identified are not expected to greatly influence the results.
Social acceptability	Spanish population living near the plants may be affected by the associated environmental impact (visual as well as land and water use)	The affected population needs to be informed and involved in the decission making process regarding the possible consequences and compensation schemes. In any case, such impacts seem not to be as relevant as for other RES and fossil fuel technologies.
Grid interconnection capacity limitation	The existing interconnection with France and NA is quite limited and represents a bottle neck to develop joint projects with third countries in the N.A. region as well as to develop joint projects within Europe that require physical transfer	It would be necessary to improve/enlarge the interconnection capacity of Spain in order to have the possibility to develop joint projects with physical transfer and therefore overcome many of the barriers previously identified (for example, the need to reinfoce the existing National Grid)
Spanish Economic Situation	The Spanish Government is facing budgetary cuts and does not want to incur in additional costs related the implementation of the cooperation mechanisms (for example: grid reinforcement costs)	The plants developed under the cooperation mechanisms would not benefit from any Spanish Support mechanism (FIT or whatever) so no additional financing support will be required. Moreover, the transaction could generate additional revenues for Spain and indirect benefits through the promotion of economic activity and job creation. The potential additional costs associated to grid reinforcement should be considered in the transfer price determination. The Dutch financial transfers to Spain in the framework of implementing the case study would constitute a welcome primary impulse to the Spanish economy. Especially the Spanish CSP sector and associated sectors performing backward linkage activities would benefit. To the extent that it would lower on aggregate Dutch support cost, also the Dutch economy would profit from *gains from trade*, permitting the Dutch economy to specialise more in activities were it has comparative advantages. Especially Dutch electricity consumers would benefit. The Dutch offshore wind sector would lose out.

The importance of the barriers identified in Table 20 do not have the same relevance as possible bottlenecks that could jeopardize the implementation of a joint project without physical transfer between Spain and the Netherlands. The table below attempts to rank by order of importance the different identified barriers in this case study.

Table 20. Ranking of the barriers

Ranking	Type of barrier
1	Institutional set-up

2	Uncertainty about post 2020
4	Payment scheme
5	Coordination with the existing National Regulatory scheme
6	Risk of non-compliance
7	Identification, quantification and monetization of those indirect costs and benefits
8	Opposition from those sectors that will be negatively affected
9	Social acceptability
10	Grid interconnection capacity limitation
11	Spanish Economic Situation

6 CONCLUSIONS, PERSPECTIVES AND GENERALIZATIONS

The utilization of the cooperation mechanisms, as described in articles 6-11 of the RES Directive (2009/28/EC), were designed to provide MS with greater flexibility to achieve their national targets as well as to contribute to achieve the overall European 20% target in a cost effective way. The underlying rational of the cooperation mechanisms is to allow countries with high RES potentials and/or low production costs (in this report referred to as "host countries"), to sell their RES surplus to those countries that have either low RES endowments and/or have higher generation costs (referred to as "user countries").

Based on the cooperation opportunities identified by the previous modelling exercises within the project RES4Less, three case studies have been identified where Denmark, Romania and Spain could potentially sell part of their offshore wind, biomass and/or concentrated solar power surplus potential to the Netherlands, in order for the latter country to fulfil its RES national targets in a more cost effective way.

The purpose of the analysis of these three case studies was twofold. Firstly, other factors, besides costs, potentials and national targets, have been identified which could play an important role in the implementation of the cooperation mechanisms. In addition to the above task, by conducting these three case studies, the particularities of the three different geographic locations and technologies could be explored in detail in order to identify associated opportunities and barriers, and to derive possible solutions for each context.

The results from the CSP case study indicate that both countries (Spain and the Netherlands) could significantly benefit from the implementation of a cooperation mechanism. In particular, the most suitable cooperation mechanism is a joint project, without physical transfer, where the Netherlands would acquire part of the RES electricity production it needs to fulfil its 2020 Res targets from Spain (approximately (5TWh).

When considering the support cost under the domestic and cooperative approach scenarios in 2020, clear savings under the cooperative scenario arise for the Netherlands. Similarly, Spain would also benefit from the possibility to further deploy its CSP industry without compromising Spanish public funds.

Besides the direct costs associated with the required support for CSP producers as well as the grid related costs, this study has identified some key direct and indirect effects associated to the "cooperative" scenario in comparison to the "domestic" scenario. Moreover, a first attempt to quantify and monetize to the extent possible such co-effects has been developed within this case study. This information, despite subject to great amount of uncertainty, should provide some guidance with respect to the magnitude and the sign of such co-effects.

In any case, also when considering the net co-effects, the cooperative approach between Spain and Netherlands seems to be mutually beneficial.

It is important to take into consideration that such benefits would only be materialized if the expected CSP generation cost reductions would be accomplished. The current generation cost is around 18 c€/kWh and it is expected that by 2020 the cost would have been reduced to 10 c€/kWh. This fact has implications with respect to the timing of the deployment of the plants, under the assumption that the longer we wait the lower the generation cost will be, given technological improvements. Similarly, this fact has implications about the best CSP technology to be used for the plants. While the current situation is technology neutral (generation costs between parabolic trough and central receiver are very similar) it is possible that over the next few years, there will be one technology that achieves higher cost reduction, and thus would be the preferable one. Still it is advised to start the further investigations and negotiations soonest to enable the implementation start well before 2020, enabling transfer of renewable target accounting units as stipulated by the RES Directive.

Various barriers have been identified that could potentially jeopardize the implementation of such agreement and possible solutions have been proposed. Some of the most important barriers are the lack of guidance with regards to the administrative and legal procedures (institutional set-up) to implement the cooperation mechanism, uncertainty about post-2020 targets, the strategic requirement of increasing the interconnection capacity with France and the coordination requirement with national authorities.

This case study has contributed to shed some light on the opportunities and challenges involved in the use of the cooperation mechanisms between two countries and has triggered the interest and discussion among Spanish relevant stakeholders (Protermosolar, I.D.A.E., REE) and the Dutch stakeholders (Dutch Ministry of Economic Affairs and private firms involved in CSP sector).

7 REFERENCES

- Anthoff, D. (2007) Report on marginal external damage costs inventory of greenhouse gas emissions. NEEDS project (New Energy Externalities Developments for Sustainability. Deliverable 5.4
- AT Kearney (2010) *Solar thermal Electricity 2025. Clean electricity on demand: attractive STE cost stabilize energy production*
- BCG (Boston Consulting Group) (2011) *Evolución tecnológica y prospectiva de costes de las energías renovables*. Estudio técnico PER 2011-2020.
- Beurskens, L.W.M. and Hekkenberg, M. (2011) *Renewable Energy Projections as published in the National Renewable Energy Action Plans of the European Member States*. ECN-E--10-069. .
- Capros, P., Karadeloglou, P. Y Mentzas, G. (1992) Employment Impacts of Energy: a survey and framework for analysis. *Socio-economic Planning Sciences*, 26 (4): 257-274.
- Capros, P., Mantzos, L., Parousos, L., Tasios, N., Klaassen, G., Van Ierland, T. (2010) Analysis of the EU policy package on climate change and renewables. *Energy Policy*, 39 (3): 1476-1485
- CASES (2008a) *Database on life cycle emissions for electricity and heat generation technologies 2005/2010, 2020 and 2030*. Deliverable D.2.1
- CASES (2008b) *External costs, Euro/ton values*. CASES Project (Cost Assessment of Sustainable Energy Systems). Deliverable D.2.2.
- CNE (Spanish National Commission of Energy) (2012) Informe anual de supervision del mercado eléctrico, Año 2011 (*Annual report of electric market supervision, 2011*).
- Dalla-Longa, F. and Bole-Rentel, T. (2011) *Methodology to identify possible Valleys Of Opportunity for cooperation among EU countries.* Res4Less project: Cost-Efficient and Sustainable Deployment of Renewable Energy Sources towards the 20% Target by 2020, and beyond. Deliverable 2.2.
- EC (European Commission) (2005) ExternE, Externalities of Energy. Methodology 2005 Update. EUR 21951
- EWEA (European Wind Energy Association) (2012) *Green growth, the impact of wind energy on jobs and the economy.*
- Ernst and Young (2012) *Analysis of the value creation potential of wind energy policies. A comparative of the macroeconomic benefits of wind and CCGT power generation.* ACCIONA and EDP
- Fichtner (2010) *Technology Assessment of CSP Technologies for a Site Specific Project in South Africa Final Report*. The World Bank and ESMAP, Washington D.C.
- Greenpeace (2006) Renovables 100%. Un sistema eléctrico renovable para la España peninsular y su viabilidad económica
- Hillebrand, H., Buttermann, G., Behringera, J.M., Bleuel, M. (2006) The expansion of renewable energies and employment effects in Germany Bernhard. *Energy Policy* 34: 3484-3494.
- Hinkley, J. Hinkley, J., Curtin, B., Hayward, J., Wonhas, A. Boyd, R., Grima, C., Tadros, A., Hall, R., Naicker, K., Mikhail, A. (2011) Concentrating Solar Power-Drivers and Opportunities for Cost-competitive Electricity, CSIRO, Victoria.
- IDAE (Institute for Energy Diversification and Saving of Energy) (2011) *Plan de Energías Renovables 2011-2020*.
- IEA (International Energy Agency) (2010) *Technology Roadmap. Concentrating Solar Power*.
- IEA (International Energy Agency) (2012) *Energy Technology Perspectives 2012. Pathways to a Clean Energy System.*

- IRENA (International Renewable Energy Agency) (2011) *Renewable Energy Jobs: Status, Prospects & Policies. Biofuels and grid-connected electricity generation.*
- IRENA (International Renewable Energy Agency) (2012) *Concentrating Solar Power. Renewable Energy Technologies: Cost Analysis Series*. Working paper. Volume 1: Power Sector. Issue 2/5
- Izquierdo S, Rodrigues M, Montañés C, Dopazo C, Fueyo N. Assessment of potential of solar energy in Spain [in Spanish] tech. report. University of Zaragoza: Fluid Mechanics Group, 2008.
- Klessmann,C., Lamers, P., Ragwitz, M., Resch, G. (2010) Design options for cooperation mechanisms under the new European renewable energy directive. *Energy Policy*, 38: 4679-4691.
- Kolb, G.J., C.K. Ho, T.R. Mancini, J.A. Gary (2011) *Power Tower Technology Roadmap and Cost Reduction Plan*, Sandia National Laboratories, Alburqurque, NM.
- Kutscher C., M. Mehos, C. Turchi, G. Glatzmaier, and T. Moss (2010) Line-Focus Solar Power Plant Cost Reduction Plan, NREL, Boulder, CO.
- MITYC (Ministry of Industry, Tourism and Trade) (2008) *Planificación de los sectores de electricidad y gas 2008-2016 Desarrollo de las redes de transporte*. July 2008
- MIITYC (Ministry of Industry, Tourism and Trade) (2011) *Planificación de los sectores de electricidad y gas 2012-2020 Desarrollo de las redes de transporte*. First Draft (July 2011)
- Montoya C (2011) – Personal communication that took place at the SolarPaces 2011 in Granada
- Nieuwenhout, F. and Brandt, A. (forthcoming) The impact of wind power on APX day-ahead electricity prices in the Netherlands. VVM-Intermittency project
- PC (Point Carbon) (2012) *Carbon 2012*. Coordinated by E. Tvinnereim
- Pitz-Paal, R., Dersch, J. and Milow, B. (2005). *European Concentrated Solar Thermal Road-Mapping (ECOSTAR): roadmap document.* SES6-CT-2003-502578
- Ragwitz, M., Schade, W, Breitschopft, B. Walz, R, Helfrich, N y Fraunfofer ISI (2009) *EmployRES, The impact of renewable energy policy on economic growth and employment in the EU.*
- REE (2012). Personal communication during the Article 9 intergubernamental workshop held in Barcelona (March 2012).
- RES2020 (2009) Monitoring and Evaluation of the RES directives implementation in EU27 and policy recommendations for 2020 Reference. Document on Renewable Energy Sources Policy and Potential Deliverables D.2.2 and D.2.3
- Russ, P., J. Ciscar, B. Saveyn, A. Soria, L. Szabo, T. van Ierland, D. van Regemorter y Virdis, R. (2009) *Economic assessment of post 2012 global climate policies*. Joint Research Centre of the European Communities.
- Sonvilla, P.M., Piria, R., Bracker, J.F., Bauknecht, D. (2011) *Integration of electricity from renewables to the electricity grid and to the electricity market* – RES-INTEGRATION. National report: Spain. Eclareon and Öko-Institut e.V. for the DG Energy.
- Steen, H.v. (2009) Implementing the EU's renewable energy targets for 2020. DG TREN, European Commission. Presentation in the "Implementing the EU's renewable energy targets for 2020" CEPS event. 4th November 2009
- Trieb, F., Schillings, C., O'Sullivan, M., Pregger, T., Hoyer-Klick, C. (2009) *Global Potential of Concentrating Solar Power*, DLR, Stuttgart
- Turchi, C., M. Mehos, C.K. Ho, G.J. Kolb (2010) *Current and future costs for Parabolic trough and power tower systems in the US market*, National Renewable Energy Laboratory (NREL), CO.
- Wei, M., Patadia, S., Kammen, D.M. (2010) Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US? *Energy Policy, Volume* 38 (2): 919-931

- Whitely, M., Zervos, A., Timmer, M., Butera, F., (2004) *Meeting the targets and putting renewables to work*. Overview Report for MITRE Project, ALTENER Programme. Directorate General for Energy and Transport. 2004