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September 2012

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September, 2012

Abstract

There are considerable benefits from cooperating among member states on meeting the 2020 RES targets. Today countries are supporting investments in renewable energy by many different types of support schemes and with different levels of support. The EU has opened for cooperation mechanisms such as joint support schemes for promoting renewable energy to meet the 2020 targets. The potential coordination benefits, with more efficient localisation and composition of renewable investment, can be achieved by creating new areas/sub-segments of renewable technologies where support costs are shared and credits are transferred between countries.

Countries that are not coordinating support for renewable energy might induce inefficient investment in new capacity that would have been more beneficial elsewhere and still have provided the same contribution to meeting the 2020 RES targets. Furthermore, countries might find themselves competing for investment in a market with limited capital available. In both cases, the cost-efficiency of the renewable support policies is reduced compared to a coordinated solution.

Barriers for joint support such as network regulation regarding connection of new capacity to the electricity grid and cost sharing rules for electricity transmission expansion are examined and solutions are suggested. The influence of additional renewable capacity on domestic/regional power market prices can be a barrier. The market will be influenced by for example an expansion of the wind capacity resulting in lower prices, which will affect existing conventional producers. This development will be opposed by conventional producers whereas consumers will support such a strategy.

A major barrier is the timing of RES targets and the uncertainty regarding future targets. We illustrate the importance of different assumptions on future targets and the implied value of RES credits. The effect on the credit price for 2020 is presented in an exemplary case study of 200MW wind capacity.

Keywords: RES target, cooperation mechanisms, policy coordination, renewables, European energy policy

1. Introduction

The European Union (EU) has defined an overall target for renewable energy of 20% in 2020. The required total addition of renewable energy for the EU has been distributed among the Member States (MS) and translated into national targets for renewable energy taking into account selected parameters. The national targets are mainly based on an equal increase from the respective shares in 2005. The income level is one additional parameter: A slightly higher burden is put on wealthier countries. However, no consideration has been made to integrating cost efficient implementation into the allocation of national targets. Tolon-Becerra et. al. [1] examine alternative distribution weights among EU member state targets and illustrate that the targets chosen by the EU could be substantially different for some countries if more or less weight is put on initial energy consumption per capita or income levels/GDP. While the different weights in the analysis of Tolon-Becerra et. al. [1] do not intend to minimise costs of meeting the aggregate 20% EU target in 2020, it shows that the resulting target allocation can vary significantly, depending on the parameters chosen. The cost differences across Europe of implementing renewable investment have not been directly included in setting the targets. Since these cost differences can be significant for some technologies and regions, there exist potential benefits if some of the investment needed to comply with the overall European target could be re-allocated from countries with high cost renewable options to countries with lower cost options. This will lead to overall reduced compliance cost in Europe. These potential benefits could be realised if countries are allowed to implement their targets jointly. With the Directive 2009/28/EC [2], EU legislation has opened for such cooperation mechanisms. They comprise: joint support schemes, joint projects and statistical transfers as support for promoting renewable energy to meet the 2020 targets. The details for these mechanisms have not been laid out yet.

The purpose of this article is to analyse the barriers for cooperation mechanisms and possible policy solutions. Furthermore, the article investigates the importance of future RES targets for cooperation mechanisms. It takes thus a more general approach than [3], who illustrate the possible combination of support schemes and cooperation mechanisms specifically for offshore wind energy. The least complicated mechanism is the statistical transfer, an ex-post transfer of virtual RES certificates that can be used for target compliance. This mechanism depends directly on governmental involvement and can also be associated with the other mechanisms at the final stage of transferring the achieved RES certificates from one country to another. As Klessman et al. (2010) [4] argue, statistical transfers are not expected to induce significant amounts of additional RES development. They argue further that statistical transfers will most likely be used as an ex-post allocation mechanism for excess certificates rather than as a mechanism to strategically increase the efficiency in the distribution of RES development. Due to the incentive structure behind this mechanism, it is expected that only very limited ‘statistical transfer-volumes’ will be available to MS for complying with their target in 2020 [4]. The reason is that, if this mechanism should be used as strategic instrument rather than as an ad-hoc means of ‘filling the gaps’, MS would have to guarantee the delivery of RES certificates under a statistical transfer several years prior to 2020 so that the receiving MS can avoid the development of own

RES production. However, many MS (especially those using Feed-in tariffs or other non quantity-driven support systems) will not be able to guarantee delivery long before 2020, as they will be uncertain in regards to their own target compliance. Therefore, sharing of compliance risk would be a critical issue in agreements on statistical transfers ex ante.

The mechanism of joint projects gives MS that lack sufficient low-cost RES potential the option to develop projects in another MS, where the first MS would support private investors in undertaking the project. MS can either cooperate on a project-to-project basis or agree on a special support framework for a number of projects. These special support frameworks can be defined for a certain technology or a certain area, and will typically be implemented in parallel to the still existing national support schemes. In the medium to long-term, the cooperation on special support frameworks might lead to a further expansion of the cooperation (i.e. through standardisation) and therewith lead to the development of joint support schemes.

The mechanism of joint support schemes is a broad cooperation of MS on a national level. It has the greatest potential to efficiently utilise RES potential in the involved MS, as the establishment of equal incentives will ensure the development of RES at the most beneficial sites in the cooperation area. It is also possible that the MS partially coordinate their national support schemes, so that it applies to certain technologies (such as PV) or it applies to specific areas, such as the North Sea.

For technologies with typically very few large projects in a limited area, such as offshore wind, the differentiation between joint support frameworks for projects and joint support schemes might practically have a limited significance.

This paper is structured as follows: We first provide an overview of the possible sources of benefits from cooperation on achieving renewable targets in section 2. In section 3 follows an investigation of the barriers for cooperation mechanisms. Finally section 4 examines some design options for joint support schemes and section 5 presents some preliminary conclusions.

2. Potential benefits of cooperation

Countries that are designing their support schemes for renewable energy independently from one another, without close coordination, might induce inefficient investment in new capacity that would have been more beneficial elsewhere and still provide the same contribution to meeting the European 2020 RES targets. Additionally, the countries might also find themselves competing for investment in a market with limited capital available. In both cases, the cost-efficiency of the renewable support policies will be reduced relative to a coordinated solution.

The fact that a country actually has difficulties meeting their own 2020 RES target, for example due to limited resources or adverse market conditions, is not the determining factor for whether a country will benefit from cooperation. Assuming that the costs of installing the marginal RES unit in one country is less than the costs of installing the marginal RES unit in another country, the country with the highest marginal costs of RES will benefit from installing its RES in the first country. Furthermore, as the countries will enter an agreement sharing the total savings, the country with the lowest marginal RES costs also benefit from cooperation.

In this paper, we look mainly on a situation where there are considerable benefits caused by large differences in RES costs and differences in other parameters such as power prices that can facilitate secondary benefits as well. The benefits of cooperation can be grouped into two categories:

1. Primary benefits: reduced target compliance costs
2. Secondary benefits: e.g. reduced cost in electricity supply and faster RE technological progress

2.1 Primary benefits

Cooperation and coordination across countries can contribute to a more efficient expansion of renewable generation in Europe and can therefore reduce the costs of compliance with the 2020 renewable targets. Often, the main potential for addition of renewable energy are located in border areas between markets with different support schemes and different rules for market access, market integration (incl. balancing responsibility) and development of transmission capacity. It can be expected that especially in these areas, major benefits can be easily harnessed. The main cost reduction can be expected from direct RES costs, but the value of the potential generation depends heavily on the power market structure and generating capacity mix in general.

For example, a country with low wind conditions and no biomass resources may achieve their RES target considerably cheaper by investing in generation capacity in other countries that possess an excess of these relatively cheaper renewable options.

The larger the difference between marginal costs of RES expansion between two countries, the larger the benefits of jointly meeting the targets will be since the country with the very high costs of RES expansion will face substantially lower costs exploiting the opportunity to install the RES in another country. The cost reduction will not be equally shared between the two countries in the first place. This stresses the need for the participating countries to develop a mechanism securing proper sharing of the cooperation benefits.

2.2 Secondary benefits

It is quite important that the primary benefits, given by reduced costs of compliance with 2020 renewable targets, are not achieved at the expense of some secondary objectives of the national RES policies. The secondary group of benefits of cooperation accounts for the less measurable benefits as well as other secondary policy objectives. Among these counts:

- Technological progress
- Power generation efficiency
- Employment effects
- Security of supply
- Investor risk
- Political risk

Technological progress

One of the most important secondary benefits expected is technological progress. An increase in the installed capacity of renewable energy sources is expected to lead to an increase in the level of research and development and learning effects and thus faster RE technological progress [5-7]. This argument is valid at the global level and there is not necessarily an effect in the country where the RES expansion takes place.

Higher level of research and development and thus faster RE technological progress is expected to have positive employment effects in MS. Furthermore, as installing more RES capacity is expected to increase the domestic demand for RES technologies, learning effects are expected to provide competitive advantages for producers of renewable technology.

Power generation efficiency

Increased cooperation could reduce power generation costs by allocating renewable investments to capacity where the existing marginal efficiency is relatively low. This is for example the case where additional power generation capacity is actually required, as compared to countries where additional renewable generation will replace relatively new, efficient conventional generation. As the short term marginal costs of electricity production from RES are expected to be less than the short term marginal cost of conventional (fossil) technologies, price reductions in electricity supply are expected. However, this is not an efficiency increase since it is the long term costs that exhibit the economic efficiency. Cooperation projects that involve expanding the interconnection capacities, for example to bring off-shore wind power a-shore in a high price area would certainly also improve the generation allocation efficiency. These efficiency benefits will not necessarily be evenly distributed and the price effects most likely will be different in cooperating countries. Nevertheless, the efficiency improvement could provide an important net benefit that could accrue to the country that only has limited direct benefits from the reduction of RES target compliance costs.

Employment effects

Investment in renewable deployment creates temporary employment in the construction phase, and permanent employment in operation and maintenance [7-10]. The short term employment benefit is often assumed to affect more remote areas with weak employment opportunities [11] to a higher degree than conventional power plant investments. Permanent jobs are also for some renewable technologies (biomass) seen as exceeding the number of jobs that they replace in the conventional generation [7].

Security of supply

Another benefit from cooperation across countries is increased security of supply. This is especially the case if cooperation involves increased interconnection capacity. Interconnection will also reduce the reserve capacity requirement and thereby costs of securing supply. Additionally, possible positive effects from harmonising connection, planning, and support administrative procedures will lead to faster implementation of best practices and thus improved security of supply.

Investor risk

One of the barriers for investors in terms of investing in renewable energy is the regulatory risk. Facing a new technology investors being uncertain of the future support policy will choose to invest their money in other markets. However, joint support schemes across countries targeting the 2020 RES targets will imply a larger degree of certainty as a change in the support scheme would be equal to a breach of international contracts and is therefore not expected.

Political risk

Finally, reduced political risk represents a secondary benefit of cooperation. The risk of not complying with the 2020 RES targets for the country initially being in lack of renewable capacity will be strongly reduced if not eliminated.

Since the secondary benefits as a point of departure is rather difficult to measure monetarily in contrast to the primary benefits (see above), the risk that the primary benefits are achieved at the expense of some secondary benefits must be eliminated.

The potential secondary coordination benefits with more efficient localisation and composition of renewable investment can be partly achieved by creating new areas and sub-segments of renewable technologies where support costs and credits are shared. Such a solution enables the parties to avoid loss of secondary benefits that are linked to their own national support policies for all the RES not included in the new cooperation.

An additional issue relates to the effect on investors' confidence in the support system. Depending on the specific design, an internationally coordinated support mechanism may not expose investors to political changes as much as a purely national scheme does. It is difficult for countries to change a support scheme if it is a common scheme and guaranteed by more countries.

3. Barriers for cooperation

The overall prerequisite is that MS will only agree on a cooperation mechanism if they both benefit from it. A mutually beneficial situation can be achieved if the overall benefits are greater than the overall cost and if the costs and benefits are allocated between the MS in an adequate way.

Klessmann (2009) [12] describes the different elements of costs and benefits for each MS under a cooperation mechanism: The primary costs are the support for the produced RES electricity (i.e. Feed-in premiums). The primary benefit is the contribution to RES target compliance. As described in the previous section, there are a number of secondary cost and benefits that require additional adjustments to allocation agreements. Difficulties in quantifying these secondary costs and benefits may lead to certain barriers for the implementation of cooperation mechanisms. In [13], an overview of all the possible barriers for cooperation is provided and the most severe identified. In some situations the secondary benefits will be entirely shifted between MS in cooperation and this could be effectively hindering the cooperation.

Especially local benefits (jobs, security of supply, innovation, export options) are often mentioned as a significant element by political decision makers and they therefore constitute a barrier if they will be negatively affected in one of the countries engaging in cooperation. Additionally the compensation for such losses are very hard to translate into a quantifiable price premium on the RES-certificate transfer price. However, the value of these effects is expected to be relatively limited compared to the primary effects, and is therefore not included in this paper.

Another relevant barrier is the one arising as a result of different policy objectives of the support schemes. Objectives may be to 1) maintain diversified support in order to achieve political accept or to 2) target the support in order to develop specific RES technologies and industries. Furthermore, different levels of support as well as the usage of different support mechanisms may appear to constitute barriers to cooperation. We therefore suggest that, for example, feed-in tariffs for the cooperation can be set at levels that diverge from the rest of the national renewable market without distorting the intended investment distribution between locations.

Barriers also include the influence on domestic/regional power market prices. One market will be influenced by for example wind expansion with lower prices that will affect existing conventional producers. Supporting that development will be opposed by existing producers whereas consumers, who will benefit from it, will support such a strategy. However, the investment will be influenced by decisions of producers as well as the possibility of securing connection to other markets with higher market prices could reduce the effect of the increased RES capacity on the market price.

Finally, there are a lot of other issues that can constitute possible barriers, such as how to structure the agreements legally, how to allocate cost of joint support into the PSO (Public Service Obligations) payments for consumers, etc. These issues are not perceived to constitute serious barriers and are expected to be fairly easy to overcome [13].

In the following we address the barriers related to different support schemes and power market effects in more detail.

3.1 Barriers as a consequence of different RES support systems and policy objectives

There are considerable barriers related to differences in support systems between countries, but just as important is the barrier from a difference in the level (cost) of support. Differences in support systems cover feed-in tariffs, feed-in premiums, green certificates or tendering auctions as well as differences in the coverage of technologies with technology banding or technology specific support level.

Cooperation between countries with different support systems can be initiated in two ways of which one is moving in the direction of harmonising the two support systems/schemes. The other option is to progress with different systems but initiate cooperation based on cooperation projects or just using the statistical transfer to exploit imbalances realised ex post in 2020. The first case will require very substantial changes to legislation and institutional arrangements where adjustments costs and time lags are considerable barriers. In the second case with project based cooperation, these costs and time lags are less, but the transaction costs and administrative burdens in order to have sufficient volume in projects can be substantial unless standardisation is widely possible. Statistical transfers have the lowest barriers, but there is no guaranty that they will generate any additional/relocation of actual RES development.

As countries often apply different support schemes targeting different technologies [14], barriers will arise when determining which support scheme to apply in the cooperation, independent on whether the two countries agree on going in the direction of harmonising their support systems or they agree on cooperation based on cooperation projects. In the following we list the barriers that may arise as a consequence of different support systems in the cooperating countries.

♦ **Barriers for combining feed-in and green certificate support schemes**

The two support schemes offer different properties with regard to the volumes realised and the support costs. Feed-in does not control the volume and could generate both excess and deficit results relative to 2020 RES targets. Green certificate schemes require a broader range of conditions fulfilled to work well of which the liquidity and transparency of the market is most difficult to satisfy. Combing the two is possible with feed-in for some technologies, where the countries prioritise their secondary objectives such as PV industry development and a common certificate system for other technologies. The main barrier is that the feed-in easily offer technology specific support level and the certificates would work best with competition between technologies. One option to combine the two schemes is to introduce technology banding in a common certificate scheme and another option is to combine a certificate scheme with feed-in tariffs or premiums for a few technologies or installation sizes. In either case, there is a trade-off between the efficiency of the scheme to promote the cheapest options and the degree to which the combined scheme is supporting diversified technologies. Barriers arise as a feed-in tariff support the purpose of developing infant domestic industries, conflicting with the idea of implementing RES development where it is cheapest, which certificates would support. If technology banding (technology specific support) motivated by concerns such as security of supply, diversification of power technologies etc. is desired, a feed in tariff would be introduced. Feed-in tariffs and premiums generally offer less risk in the support revenue to investors, whereas the certificate revenue is heavily dependent on if there is a commitment to increase the renewable obligations over time. Smaller investors would normally favor the feed-in to the certificate scheme if the intended level of support is in the same range.

♦ **Barriers for combining feed-in and tendering schemes**

Feed-in schemes work well with both smaller and larger projects, but are inflexible in providing the market incentive to increase or cut back on RES deployment speed. Tendering work well with larger projects that require interaction with governmental/TSO planning of infrastructure and localisation of investment etc. Feed-in and tendering is often combined with a fixed support at the time of settling with the tender winners, but new tenders are not bound with any level of feed-in tariff. The actual expansion of renewables can thus be controlled contrary to a feed-in. In cases where the tenders are for additional high-cost RES options and can be used for cooperation and RES certificate exchange, the combination of tenders and a general feed-in could work.

3.2 Barriers related to differences in support levels

Differences in support levels create barriers as they are expressing the willingness of the population/government to pay for renewable expansion. Secondarily the different support levels can only be harmonised by harming the renewable investment opportunities in the country of high support level (see Box 1). Renewable industry, green development supporters and renewable investors would all oppose the reduction of support levels even though it is the cooperation benefit that reduce costs and therefore enable more ambitious RES targets in the future. Likewise the country with low support would have important opposition against the increase in support cost for their RES development especially if the burden is directly levied over consumers.

Box 1 **Example: Barriers related to differences in support level.**

For example, Germany and Spain could decide to cooperate on a joint support scheme for new photovoltaic (PV) installations. The two support schemes are currently rather similar, featuring a differentiated feed-in tariff. Spain recently introduced a capacity cap, limiting the support of new PV installations, because they feared a too high increase of their overall RES support cost. At the same time, there is a significant build-out of PV in Germany to a much higher RES support cost. Assuming a joint support system, where Germany and Spain would have one common market for PV at an adequate common support level, the build-out of PV would move from Germany to Spain (due to the much better solar radiation levels). The overall support cost would be reduced by the difference of the required support cost in Germany to the required support cost in Spain. Germany and Spain would then share the RES certificates and the support cost. However, finding the right cost allocation would be a difficult negotiation. Germany would have a significant reduction in support cost (per generated unit of renewable energy), but would also lose local benefits. Spain would need to be compensated for bearing all physical and market integration issues, but would have all local benefits including the innovation and industry benefits, which currently seems to be a significant factor in Germany's PV support considerations.

3.3 Barriers associated with power market regulation, composition and price levels

This subsection addresses the following topics:

- Difference in network regulation (incentive regulation) approach
- Difference in power market design/functioning
- Difference in power market price and price volatility
- Difference in generation mix and mix of RES technologies

♦ **Barriers related to network regulation**

Network regulation varies a great deal between member states from rate of return to incentive based price and revenue caps. The details in incentive regulation include numerous differences and the enforcement of regulation is not always effective. Network regulation has impacts on the incentives to facilitate efficient connection of new technologies and network reinforcements [15]). If national regulation allow networks to include reinforcement investments caused by renewable generation in their capital base and thereby their revenue cap this cost will be borne by the network customers. In the case of cooperation the country providing the RES credits will require the receiving country to compensate also this cost, but the transfer to network customers in the receiving country seem very difficult to realise.

- **Barriers related to effects on the power market**

Power markets differ even though they are in many cases coupled and therefore prices to some extent are correlated. Differences in market concentration and technology composition create some barriers. The mix of technologies in power generation can be more or less flexible to adjust to short term changes in renewable generation. It can be an important barrier for increasing the renewable capacity in a country if the inflexibility of the existing generation capacity is combined with adding fluctuating renewable generation.

- **Barriers related to effects on the power price**

Power price level and volatility differs and creates additional barriers. Price levels in some countries will not be affected very much from increasing or decreasing the renewable expansion. However, countries where renewable expansion potentials are abundant and cheap could experience considerable changes in power prices and corresponding deterioration in profitability of existing conventional and renewable capacity. It is not necessarily ease to compensate the firms/producers that lose with the gains that consumers experience in terms of lower prices. At the same time the country facing the reduced prices will probably have to look for alternative ways to provide incentives for future investment in conventional capacity. Furthermore there is a risk of increasing curtailment of renewable generators both in the short run and permanently by expanding fluctuating renewable at a fast pace. If curtailment is necessary, the issue of compensation to generators has to be agreed upon. [16] suggest that this should be with respect to primary dispatch: if this has been granted historically, compensation needs to follow, whereas the curtailment risk may stay with generators in a more liberalised market environment.

- **Barriers related to generation mix**

Generation mix might be quite substantially influenced by intensively exploiting one cheap renewable resource. This is a result of expanding the technology itself but also the general power price effect (reduced for low marginal costs RES as referred above) which makes the least efficient base load plants less profitable or even loss making. The generation mix might then be affected in a direction that is providing less security of supply for power and makes the sector more vulnerable to changes in a few or just one single fuel price as natural gas.

3.4 Solutions to barriers

Above we presented the most important potential barriers to cooperation. In order to ensure cooperation the barriers have to be removed. The first step in this direction is to identify potential solutions. Solutions to the barriers fall in three categories:

1. Solutions that facilitate realisation of primary and secondary benefits
    a. Design of harmonised support instruments that reduce the transaction costs by increasing liquidity in certificate markets or increase competition among renewable investors.

   b. Coordinate investment timing in larger areas among more countries to utilise limited resources of manpower, technical facilities and equipment among potential investors (utilities) and in general increase transparency
   c. Ownership structure reorganisation

2. Solutions that improve and guarantee a fair allocation of costs and benefits
   a. Establish a fair and legally backed distribution of benefits and costs
   b. Sharing grid reinforcement costs
   c. How to overcome risk asymmetries
   d. Sharing connection costs

3. Solutions that solve regulatory or technical barriers
   a. Focus on regulatory changes that can be implemented easily
   b. Identify regulatory changes that are unnecessary = two regulatory sets of rules can coexist or does not provide unattractive incentives
   c. Reducing financing constraints caused by the non standard support case (simplify legal conditions regarding debt obligations in cross border investments etc)

4. Solutions that exploit resources that could not be accessed otherwise
   a. Focus on areas and resources that have not been included in the original RES deployment plans
   b. Sharing of technology and knowledge to exploit additional resources
   c. Infrastructure development that would otherwise not have taken place

Box 2 Example: Connection costs as a barrier and possible solutions

The sharing of connection costs seems to offer benefits from a practical point of view: if a joint support scheme refers to an offshore area and is connected to several countries, the involved TSOs need to agree on a division of investment costs. This may be done proportionally to expected national benefits and could also comprise further effects arising from a joint support scheme

Table 1 summarises the main characteristics of the three cooperation mechanisms, the barriers and possible solutions.

Table 1 Cooperation mechanism characteristics, barriers and solutions

Cooperation mechanism	Primary cost saving potential	Secondary benefits involved	Barriers for implementation	Solution for barriers	Possible time horizon for implementation
Harmonised joint support scheme	Large A full harmonised system without technology differentiation of support yields the highest efficiency gain	Larger markets, More competition, National secondary support objectives difficult to maintain Harmonisation in other market conditions and increased power market integration	Considerable time delays in legislation, Difficult to compensate directly the losers, National control of support policy reduced	Compensation mechanisms and cooperation on reaching secondary objectives (infant industries, employment and diversification of technologies), Allocation of net benefits to losers	Complicated and requires national legislation delays Long term option
Local/regional joint support scheme	Medium level Advantage for countries with shared/bordering resources	Maintained national support for not covered areas and technologies expand excess resources	Opposition to favoring investment in one area opposed to those areas covered by national scheme	Replicate one system from one of the cooperating countries – limited legislative delay	Medium term time scale
Joint projects cooperation	Small to medium advantage for few large projects	Maintain own support systems and secondary objectives	Transaction costs, Lack of transparency, Legal requirements because of lack of legislation	Target technologies with large project size	Short term time scale
Joint projects support framework	Medium	Maintain own support systems and secondary objectives	Transaction costs lower than for single project	Identify technologies/areas where standardisation easy and many small projects works better than a few large	Medium term time scale

Joint projects are the simplest in terms of need to change regulation and legislation and therefore can be implemented in a shorter time frame.

4. Cooperation design and future RES targets

After having elaborated on the qualitative details of the different barriers, we now turn the aspect of timing related to joint support schemes. First, we consider cooperation through establishing a joint support scheme and sharing support costs according to credits received. Next, we regard cooperation through cross border local or technology specific joint support schemes as an addition to existing national support instruments

In the following we present the general solution with just one support scheme for the participating countries. It will yield the largest potential benefits, but also faces barriers mainly as a result of removing/changing national support schemes and other regulation. Among other related considerations, [4] address this topic and refer to the Norwegian-Swedish plans for a common support scheme. Despite a large number of common characteristics, such as a common wholesale power market and a comparable geology for hydro reservoirs, it failed in 2006. Only after lengthy renegotiations an agreement was reached. The main reason for this first failure was that cost attribution could not be agreed upon between the two involved countries. Norway's hydropower share of total electricity generation is at almost 100% and thus, the political target was not the achievement of a certain RES share, as it is mandatory for EU countries in 2020. The setup for joint support schemes is therefore different between EU countries that all need to prioritise their investment. Standard benefits from trade can be incurred from the integration of support schemes, but if cheap resources are predominantly in one country (A), a common support scheme may 'sell' these resources to the neighbour B at a low price. At a later point in time, higher RES targets cannot be obtained by A alone because low-price locations are blocked. Thus, choosing an international support solution may impact the possible future choices negatively from a unilateral point of view.

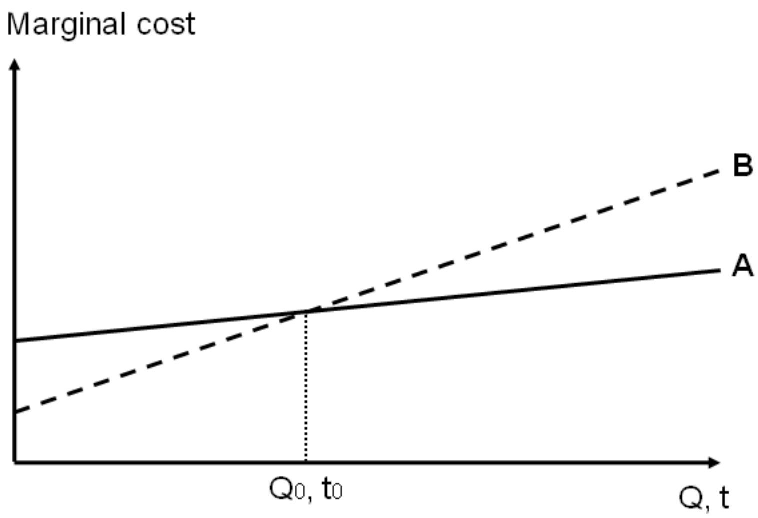

Figure 1: Marginal costs of RES extension in countries A and B over time

The picture could be different if the marginal costs of RES extension in the two countries intersect, as illustrated in Figure 1. The figure displays the marginal costs of RES extension of two countries A and B over time t and the RES amount Q. Until the intersection at Q_0/t_0, RES extension can be achieved at lower cost in B, and vice versa. In such a constellation, a cooperation could be politically more acceptable for both parties because A receives access to low-cost resources in the short run while B secures access to lower-cost resources in the long run (beyond Q_0). The joint support scheme could be a quota mechanism, a feed-in tariff scheme or a price premium scheme. As for all support schemes, basic features such as geographical and technological scope and a time horizon for its applicability need to be defined. A tendering scheme could also be suitable for a number of large-scale technologies such as offshore wind power. If support is granted over a certain time horizon, e.g. 15 years, this extends beyond the 2020 targets. Support to units in a neighbouring country may then have to be provided on an annual basis, although the support does only contribute to fulfilling RES for 2020.

We now consider local however cross border or technology specific cooperation where the cooperating countries maintain their existing support instruments. Implementing a special cross-border offshore zone where a joint support scheme could be implemented is a promising option that bypasses the barriers concerning harmonisation of the entire support schemes in the cooperating countries.

The combinations of electricity generation sold at one market (country) and the support provided partly by another country can be compensated by renewable credits. Such a scheme also has to cover the cost and benefits for the national power markets and include this in the compensation mechanism or the RES credits transfer price. Sharing the costs and benefits may involve swapping the receiver and provider of credits and support in time. One country may face a RES target deficit in 2020 but expect additional domestic RES development after 2020. Similarly a country already exceeding the 2020 targets might want to secure credits for a future period, still allowing another country to earn the credits up to 2020. This could for example be included in a joint tendering procedure.

We now turn to a situation with two countries that are characterised by differences in power prices, support schemes (feed-in tariffs vs. tendering) and connection costs attribution.

Figure 2 illustrates a possible design for a common technology-specific cross-border scheme: a neutral price zone has been established, tendering is the chosen support scheme and transmission/interconnection costs are borne by the TSO in the high price area. This allocation of costs illustrates that the high price area receives the major power price reducing impact. RES credits and subsidy costs are shared equally. The alternating price area could gain some practical relevance in offshore grids [17] and if interconnector capacity is identical to both countries, this implies that always the lower of the neighbouring prices applies [18].

Another aspect is that in case of an interconnector failure, power would still be provided to a country that is involved in the support of the generation units. Contrarily, locations that are remote from one country, but close to another shore could be accessed from this other shore. Connection costs could be reduced this way by sharing capacity among ‘foreign’ wind farms and adjacent national farms under a joint support scheme.

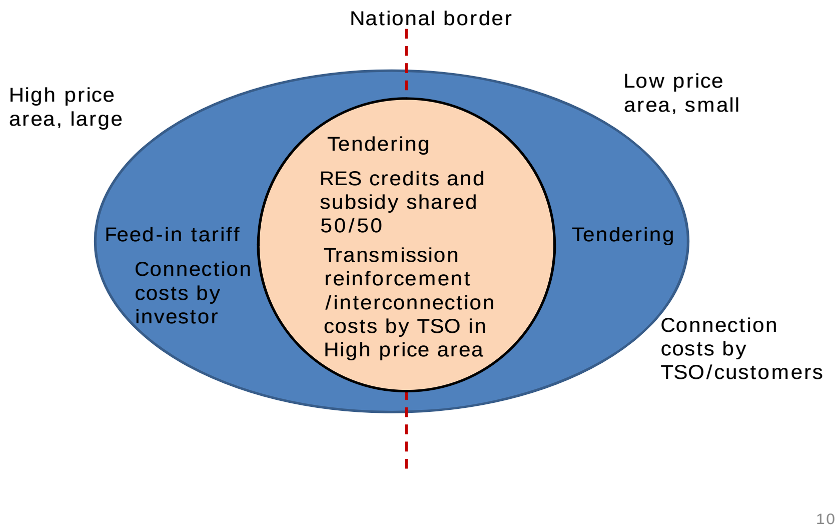

Figure 2 Joint support schemes as a subset of support instruments in two or more countries

Tendering is practical for large-scale projects (or bundles of projects) and also mainly applied for offshore wind energy, e.g. in Denmark. The tendering design can be such that the investor asking for the lowest feed-in tariff over a predefined time period wins, and it can either be site-specific or general but still within the central cooperation area ("x MW have to be built within the region"). This cooperation allows national support mechanisms of both countries outside the cooperation area to be maintained and could therefore be acceptable for all involved parties. Connection costs borne by investors induce that these require a higher feed-in tariff, which implies that costs are shared equally between consumers in both countries. For investors, it is a crucial question whether both countries reserve the right for changes during a predefined time span or whether the support scheme is frozen during this period. In the first case, risk premium increases because another government can interfere. In the latter case, the international contract between governments ensures that stable environment that investors perceive as superior to being exposed to one country's support scheme. A necessary prerequisite for a cross-border joint support scheme is the harmonisation of permission procedures. If administrative requirements deviate between countries, a level playing field between all possible locations cannot be achieved. Hence, the goal of a least-cost RES extension is out of reach unless interstate agreements or a superior coordination body, as discussed in [19], remedy this issue.

4.1 Future RES targets and the use of cooperation instruments

One of the important barriers for cooperation lies in the uncertainty regarding the post 2020 targets for RES shares. The uncertainty influences the value of the possible RES credits from generation after 2020. Expecting tighter (higher) targets after 2020 will make excess countries reluctant to sell their relatively cheap RES options off. Countries in deficit considering buying credits will be reluctant to support foreign long term investments in RES without certainty that the generation credits after 2020 have any value. Table 2 illustrates exemplary calculations of the necessary support costs on top of the expected power prices in each country. The example demonstrate that the issue of uncertain future RES targets has important implications for the cooperation attractiveness where one country is partly or fully financing the necessary support for renewable projects in another country.

The examples shows the effect on the transfer price for credits based on the value per generated unit in 2020, of different values of RES technology costs, power price, and the value of the credits to the country in which the development takes place (country A). The assumptions underlying the calculations in Table 2 are: a technology lifetime of 15 years, annual generation 4100 full load hours, no discounting, constant real prices and support levels. The most crucial assumptions are the RES technology costs in columns 2 and the expected value of future credits in column 7. For all levels of expected credit value the calculations are carried out with and without a physical transfer of the generated electricity to the other market. The cost of interconnection capacity is not included in calculations.

Table 2 Examples of RES credits prices with permanent or single year transfer, 200 MW offshore wind

Assumptions\ Country	RES Technology costs	Wholesale power price (generation lifetime)	Necessary support to investment in country A[a]	Total support cost for 15 years in country A	Value to A of credits post 2020	Support costs covered by country B	Transfer price credits per generated unit in 2020[b]
	c€/kWh	€/MWh	c€/kWh	Mill. €	c€/kWh	Mill. €	c€/kWh
Country A	12	40	*8.0*	*984*	*0*	*984*	*120*
Country B	15	63	5.7	701	0	701	85
Country A	12	40	*8.0*	*984*	*2*	*754*	*92*
Country B	15	63	5.7	701	2	472	58
Country A	12	40	*8.0*	*984*	*4*	*525*	*64*
Country B	15	63	5.7	701	4	242	30
Country A	12	40	*8.0*	*984*	*6*	*295*	*36*
Country B	15	63	5.7	701	6	12	2
Country A	14	40	*10.0*	*1230*	*4*	*771*	*94*
Country B	15	63	7.7	947	4	488	60

[a]: for the entire lifetime of the technology. With and without physical transfer (*in italic*)

[b]: assuming the support for the entire lifetime of the technology is paid in one single year, 2020

The last column is expressing the total lifetime support payments financed by country B per generated unit in one single year, namely 2020. These are in most cases much higher than the necessary support costs per generation unit for the entire lifetime as illustrated in column 4. If the support financed by country B is covering the entire necessary support because country A assign no value to future credits this corresponds to country B buying all the credits at the price of 5.7c€/kWh as in row 3. Such a situation can be expected for many bilateral cooperation possibilities in the EU. For most countries, the value of future RES credits will be rather low, but some countries might expect much higher RES targets for the future or they might have national targets that exceed the 2020 target set by the EU directive. This is for example the case for Denmark that has set higher targets for renewable shares post 2020.

As such the basic cost savings from cooperation is found as the difference between RES generation costs in country A and country B. This is the cost differential in column 2 which is 3c€/kWh except the alternative in the last two rows with only a 1c€/kWh cost difference. Adding the benefits of physical transfer between the two markets is not a result of the cooperation project, but might be achieved with just adding interconnection capacity assuming that the market price differential is not dependent on the RES project. If there is much larger RES expansion than in the present 200MW example, there might be a downward effect on market prices in country A if there is no available interconnection capacity. This would increase the price differential and make the addition of interconnection capacity more economically attractive.

In reality the transfer price will be a result of a negotiation process and the example of 29.5 c€/kWh (see Box 3) is a minimum price as the price have to be higher if country A should have a net benefit from the cooperation.

Box 3 Transfer price for 2020 credits with physical transfer, row 7

Calculation of the transfer price for 2020 credits with physical transfer as in row 7 can be exemplified by first calculating the necessary support (column 4):

(Technology cost in A (12c€/kWh) – market price in B (6.3c€/kWh)) * 4100 hour annually * 200MW *1000 * 15 years = 701.1 mill €.

Of this support A will be willing to contribute up to the expected value of 4c€/kWh for the remaining 14 years of generation: 200MW * 1000 * 14 years * 4c€/kWh = 459.2 mill €.

Then B will have to pay 701.1 mill € - 459.2 mill € = 242 mill € for the RES generation credits in 2020. This corresponds to 242 mill €/(200MW * 1000 * 4100h) = 29.5 c€/kWh.

The last two rows illustrate a situation where there is only a minor difference between the technology costs in countries A and B. The result is that transfer price for 2020 will be high and if there is no physical transfer option the domestic expansion of RES in country B will be more efficient than expanding RES in country A even though the technology costs are lower here. The value of the generated electricity is simply higher in country B than in country A. This could reflect that there is excess generation capacity in A and a need for more electricity capacity in country B.

One consequence of the uncertainty regarding the future target is that renewable technologies with the shortest lifetime will be favoured as the total costs per generated unit in 2020 will be the least.

An EU policy for the future RES targets, which not necessarily have to be a specific target, just an indication that the future target will be at least at the level agreed for 2020, would reduce the uncertainty regarding the value of post 2020 RES credits considerably. Such an announcement may facilitate cooperation just by reducing the uncertainty and contribute to reaching the 2020 RES targets at a lower aggregate cost.

5. Concluding remarks

Renewable electricity potentials and costs vary considerably among EU countries. These variations in combination with differences in power market structure and price levels must be included when examining the benefit of cooperating on meeting the 2020 EU RES targets.

The potential benefits of cooperation on reaching the 2020 RES targets are of considerable size, but the barriers for realising these potential savings are of similar size. Table 1 summed up the characteristics and issues specifically involved for each type of cooperation mechanism. The conclusion is that the joint projects are the simplest in terms of need to change regulation and legislation and therefore can be implemented in a shorter time frame. This type of cooperation has its advantage for larger projects such as tendered off-shore wind farms, whereas the smaller projects would involve relatively more administrative costs in negotiating and designing individual contracts. In case of smaller projects this could be possible if standardisation of contracts and conditions is possible.

The most important barriers are associated with the different objectives of renewable policy priorities of the countries. The large differences in existing support schemes, power markets and power sector regulation also form considerable barriers. One specific important barrier is the large uncertainty regarding the future RES targets. Financing RES expansion in another country just to meet the RES targets for one single year in 2020 can be very costly as demonstrated in Table 2.

The simplest solutions in terms of maintaining existing legislation and domestic support schemes, but adding new dimensions for support will be the easiest and fastest to implement. Here we suggest to look into larger projects for project based cooperation and the joint support schemes added on top of national support schemes for specific technologies or areas/regions.

Cooperation mechanisms involving countries which have similar priorities and at the same time exhibit large differences in compliance costs seems the easiest to implement. In this case even the harmonised single joint support scheme could be a solution to start moving towards, by defining compensation principles and methods and preparing the national markets for the change.

Joint project cooperation where there are both benefits from difference in RES technology costs and benefits from expected difference in power market prices and physical market transfer will have the best chances for being implemented. However negotiating the transfer price for credits in 2020 is difficult especially since the country binding targets post 2020 are unknown and the value of future generated RES credits therefore very uncertain. This may lead to a sub-optimal preference for projects with a short lifetime. Announcing some direction for the future binding targets of EU would improve on this situation and reduce this barrier for cooperation.

6. Acknowledgements

This paper is partly based on research carried out as part of the RES4LESS project under the Intelligent Energy Europe program, Grant IEE/09/999/SI2.558312. A previous version was presented at the 12th Global Conference on Environmental Taxation, Madrid, in October 2011.

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