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The benefits of a European approach to green electricity

- Over the last two decades, the electricity sector has changed significantly. Its deregulation, aimed at boosting efficiency and competitiveness, has led to a reshaping of the incumbent monopolies and the opening up of certain activities, such as electricity supply, to competition. Electricity markets and interconnections between countries have been gradually introduced to exchange electricity.

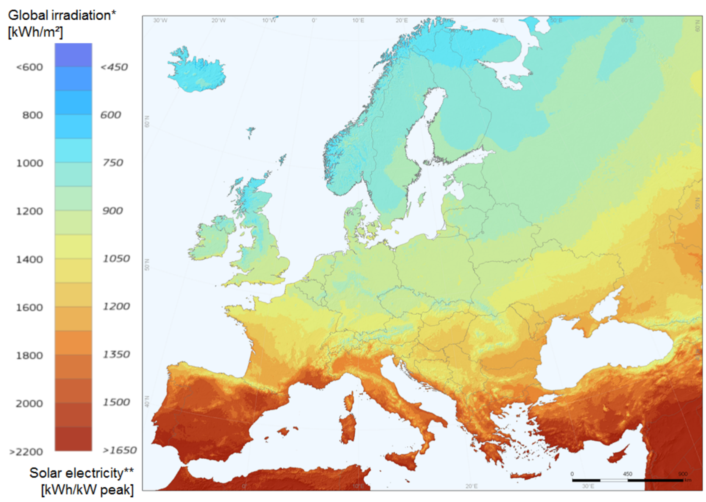
- In addition, the goal of reducing carbon emissions in the electricity mix spurred the development of renewable electricity in Europe, with its share in the mix rising from 14.4% in 2004 to 27.5% in 2014. As renewables are not yet competitive compared with carbon-intensive means of production, they receive considerable government aid. In Germany, the figure is around €24bn in 2017, representing 0.7% of GDP.

- The integration of the electricity market calls for heightened coordination of energy policies. For example, in an integrated market, the commissioning of solar panels in a European country increases the volume of electricity available to its interconnected neighbours, and contributes to reducing the cost of electricity in their markets. However, national renewable energy generation support policies are still highly fragmented both as regards the nature of the support provided and national development goals. This causes inefficiency and generates additional costs at European level.

- The introduction of a common European renewable energy policy would enable the most competitive resources to be tapped at European and not just at national level. Such policy would therefore lead to more solar panels being installed in Southern European countries (see chart) and more wind farms in the North, where there are more available resources. According to the Commission, the cost of the EU's renewable energy target of at least 27% of final energy consumption would be cut by around €10bn per year from 2021 through to 2030 compared to a situation in which renewable energies are deployed within a strictly national framework.

- Such a policy would imply that part of the sovereignty over management of national electricity mixes is transferred to the EU. This is one of the few sectors where the expected gains from bolstering European integration are so high. It would also involve a recasting of existing support mechanisms.

Photovoltaic Solar Electricity Potential in European Countries



Source: DG Trésor.

Note to the reader: The photovoltaic solar electricity potential can vary up to threefold between Southern and Northern Europe from less than 1000 kWh/m2 in Sweden to over 2000 kWh/m² in Southern Spain.
* Left-hand scale.
** Right-hand scale.

MINISTÈRE DE L'ÉCONOMIE
ET DES FINANCES

1. Since the 1990s, European energy policy has focused on three key goals: deregulating the electricity sector, limiting greenhouse gas emissions (decarbonation) and guaranteeing energy security

1.1 The EU initiated a largescale move to deregulate the electricity sector in order to provide access to competitively-priced energy

The electricity sector has four separate activities:

- Electricity generation either from renewable sources (hydropower plants, solar panels, wind farms), non-renewable carbon sources (gas or coal-fired power plants) or non-renewable non-carbon sources (nuclear).
- Electric power transmission along high or very high voltage lines which are spread over the country and regions from generation zones to consumption zones.
- Local electricity distribution via a network of medium and low voltage lines connected to the transmission network.
- Supply means selling electricity to end users (households, firms, etc.). Suppliers play a contractual intermediary role between electricity producers and consumers.

Historically, national electricity sectors were constituted of regulated public monopolies which were vertically integrated, meaning that they were in charge of all four activities. **A move to deregulate the sector was kick-started at EU level** to encourage operators to lower their costs, to increase productivity and to improve the quality and reliability of the service provided.

The liberalisation consisted first in separating the activities of generation, transmission, distribution and supply[1] and, second, in regulating activities covered by "natural monopolies" (transmission and distribution) while taking measures, which differed according to the country, to gradually open up the other activities (generation and supply) to competition.

In France, supply has therefore been gradually opened up to competition since 1999 with consumers being given the possibility to opt for so-called "market" offerings. Unlike regulated prices, decided on by the public authorities and offered only by the incumbent operator, these offerings are put forward by all suppliers with prices and terms being set freely.

Electricity generation has also been affected by deregulation. The gradual introduction of competition has gone hand-in-hand with the setting up of an electricity market that fosters exchanges between stakeholders (generators, suppliers, major consumers, etc.). There are also electricity interconnections between countries which allow for the importation and exportation of electricity. Demand is met on the electricity market by calling generating capacities by merit order of marginal costs; the last marginal cost determines the market price (see box 1).

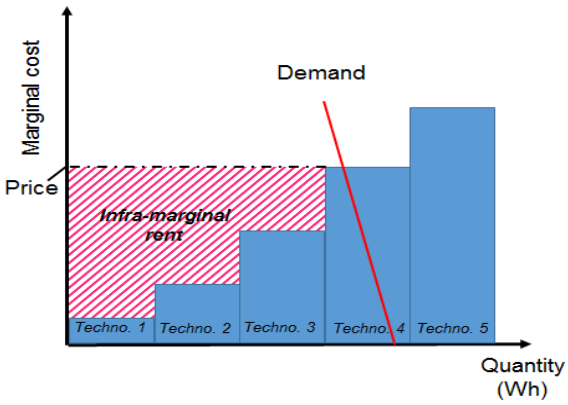
Box 1: **Functioning of the electricity market and price formation**

The price on the wholesale electricity market is based on the day-ahead[a] price which is calculated as follows. On the day before delivery of the electricity, generators bid at their marginal cost[b] on the day-ahead market. The bids are ranked by merit order and are then called until demand is met: the final bid determines the clearing price. Generators with a marginal cost which is lower than the market price make a profit called the "infra-marginal rent" (see chart 1).

The last units called are often gas or coal-fired power plants which have low fixed costs but higher marginal costs (related to the price of their fuel). Generators with a lower marginal cost use the rent received to fund certain facilities which have significant fixed costs (such as hydro or nuclear power plants).

The most competitive renewable electricity generation technologies (excluding hydroelectricity), such as ground-level solar panels and land-based wind farms, have almost zero marginal costs.

Chart 1: Price setting based on demand and merit order



Source: DG Trésor.

a. There are four key markets for electricity exchange: forward (up to several years before delivery), day-ahead (the day before delivery), infra-day (the delivery day) and balancing (close to real-time). The forward and infra-day markets take the day-ahead market as a reference whereas the balancing market, which aims to ensure constantly balanced supply and demand, is based on the actions of transmission grid managers.

b. Except generators able to exercise market power which can bid at a higher price.

(1) Directives 96/92/EC of December 1996 and 2009/72/EC of July 2009 make a distinction between the activities of generation, transmission, distribution and supply.

The transmission and distribution of electricity are considered as natural monopolies. Having a single grid, which represents a monopolistic position *de facto*, is indeed more efficient than having multiple competing grids. That said, both activities need to be strictly regulated so as to ensure fair access to all generators and suppliers.

The deregulation process for the electricity sector has encouraged stakeholders to become more efficient. This has been reflected, all other things being equal[2], by gains for the European final consumers. In France, consumers opting for a market offering can save up to 7% on their annual electricity bill compared to regulated prices[3].

1.2 Europe is making a major effort to reduce its carbon emissions

Since the Kyoto Protocol was executed in 1997, the EU has been taking action to fight greenhouse gas emissions and global warming. To this end, starting in 2009, the 2020 climate and energy package set three key targets: (i) 20% cut in greenhouse gas emissions (from 1990 levels); (ii) 20% of EU energy from renewables[4]; (iii) 20% improvement in energy efficiency by 2020[5]. For the period 2021-2030, the targets have been increased to 40% for greenhouse gas emissions and 27% for renewables.

At European level, the EU Emissions Trading System (EU-ETS) for exchanging CO_2 emission allowances is a cross-border tool for cutting carbon emissions. The ETS caps the emissions of a number of sectors that account for around 45% of European emissions; electricity generators are subject to the ETS. The total amount of allowances in circulation is calibrated to achieve a reduction target and the allowances may then be freely traded between stakeholders on a market and generate a carbon price. The 2020 emission reduction target for sectors covered by the ETS is 21% (43% in 2030), compared to 2005 levels[6].

The targets for renewables are set out for each country and their achievement is left to the initiative of the Member States. These targets are nevertheless regulated by EU law in the Guidelines on State aid for environmental protection and energy 2014-2020. These Guidelines stipulate that aid is granted as a premium in addition to the market price[7] and lay down the principle of technological neutrality: the support systems must be non-discriminatory across technologies. There are however possible exceptions, for example to take into account the "need to achieve diversification" of the electricity mix or "the longer-term potential of a given new and innovative technology".

1.3 Issues linked to energy security are also at the centre of the European energy policy

The electricity consumed in Europe is entirely generated in Europe[8]. At EU level, the security of the electricity supply can therefore be evaluated by the standard and reliability of the delivery of the generated electricity to the consumers and the ability to absorb peak demand (for example, during a severe cold snap).

The EU has set a target for cross-border electricity interconnections in 2020. In each country, interconnections should be equivalent to at least 10% of installed generation capacity. The expansion of interconnections (see chart 2) has bolstered the system's robustness by fostering immediate access to foreign means of production in the event of disruptions on a domestic market.

(2) A study (European Commission, 2014, Energy Economic Developments) claims that Europe-wide, all other things being equal, the liberalisation of the electricity sector has led to lower retail prices for consumers. But, this does not necessarily mean an overall reduction in final prices over time. There are a number of reasons for this: prior to deregulation, regulated prices did not always cover related costs and taxes on electricity (to fund renewable energies for example) have risen significantly.

(3) Source: Energy Regulation Commission (CRE), "*Les marché de détail de l'électricité et du gaz*", Q4 2016.

(4) The target covers all energy consumption and is not broken down by major energy sectors (electricity, transport, heat).

(5) i.e. reduce primary energy consumption by 368 million tonnes of oil equivalent (Mtoe) compared to projected consumption trends (assuming no energy efficiency policy) of 1,842 Mtoe in 2020.

(6) See Boissinot J., Huber D., Camilier-Cortial I. and Lame G. (2016), "The financial sector facing the transition to a low-carbon climate-resilient economy", *Trésor-Economics* no. 185.

(7) Only for major installations (capacity of more than 500 kW or more than 3 MW for wind farms).

(8) Access to certain fuels such as gas or uranium may however be problematic.

Chart 2: Electricity transmission grids and interconnections in Europe

Source : ENTSO-E.

1.4 Energy policies must take into account the fact that the various objectives can complement each other but also be potentially divergent

The objectives of the European energy policy can reinforce each other mutually. A satisfactory functioning of the electricity market can help secure supply as electricity suppliers can be certain that they will always find a generator to meet consumer demand. Similarly, in countries which predominantly use gas power plants, electricity renewables reinforce the security of supply by mitigating the need to import gas.

That said, these objectives can sometimes diverge. As an example, renewable electricity generation using solar panels or wind farms is intermittent and difficult to forecast as it is contingent on weather conditions (sunshine and wind). This may have a negative impact on the security of supply if demand for electricity does not match generation. In the same vein, coal-fired power plants can help meet the objective of security of supply (the coal used is mainly produced in Europe) and competitiveness (electricity generation using coal is cheap), but they emit substantial amounts of CO_2 which is hardly consistent with the aim of reducing carbon intensity.

2. Despite a highly-integrated internal market, there is little coordination of national energy policies and the market price is set to remain too low to make investment profitable.

2.1 The electricity market is highly integrated, and significant cross-border exchange capacities have led to some price convergence

In recent years, Europe has witnessed a sharp upswing in interconnections between countries. In 2014, more than half of the Member States had achieved the interconnection target of 10%[9]. This is particularly true of France, where interconnections account for 10% of the country's installed production capacity. This indicator is somewhat questionable, however, since it does not factor in a country's geographic location or its size. Interconnection levels vary considerably depending on geographic location and generation fleet. Spain's interconnection level is 3%, but this figure is 245% for Luxembourg and 65% for Slovenia. Furthermore, in recent years the optimisation of commercial flows of electricity was considerably reinforced by the introduction of the so-called "market coupling"[10] mechanism between the markets of 19 European countries, ensuring that electricity flows from countries where it is the least expensive to produce to those where

(9) Source for data on interconnections: ENTSO-E, Scenario Outlook and Adequacy Forecast, 2014.

production is most expensive. Coupling significantly reduces the cost of supplying electricity.

The expansion of coupling and interconnections has led to greater integration of European markets and price convergence. Thus, for the years 2013-2015, the gap in wholesale prices between Germany and France was less than €0.01/MWh more than 50% of the time (the same is true for Belgium[11]).

2.2 At national levels, objectives and support mechanisms regarding renewable energy vary widely, and are costly to public finances

The EU's target of 20% gross final energy consumption from renewable sources by 2020 has been broken down into national objectives that vary greatly between countries, from 49% for Sweden (see Chart 3) to 11% for Luxembourg. The goal of 27% of energy from renewable sources by 2030 has not been broken down by country. The share of renewables in gross final consumption for all sectors (electricity, transport and heating) rose from 8.4% in 2004 to 16% in 2014.

For the EU as a whole, the share of renewables in electricity has increased from 14.4% in 2004 to 27.5% in 2014[12]. The share of renewables in electricity production[13] varies significantly between countries (70% in Austria compared with 7.3% in Hungary; see Chart 3).

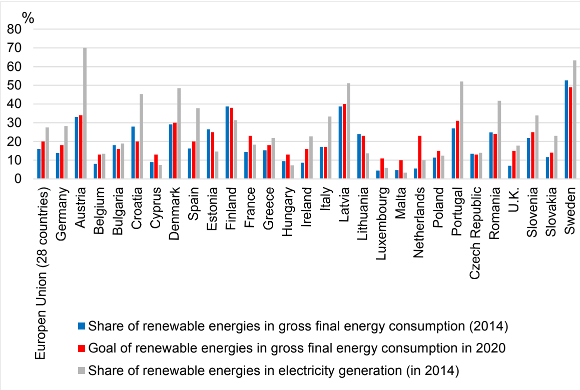
On the EU ETS market, which is the only cross-border tool for renewable energies, the price of an EU allowance (the right for a company to emit a tonne of carbon dioxide) is about €6/ton, which is not enough to make the least expensive renewable energies more competitive than carbon emitting capacities (gas- and coal-fired plants). A specific solution is needed to help expand the use of renewable energies.

Member States have adopted a variety of support mechanisms for renewable energies, which in most countries are not available to foreign renewable energies. These include:

- In both France and Germany, the public authorities pay a premium on top of the market price (in France, this is the so-called *complément de rémunération*[14]). European law authorises the smallest plants to benefit from a guaranteed feed-in tariff. In such cases, remuneration for generators is not dependent on the market price.
- Sweden and Belgium have "green certificate" systems. Each renewable energy plant is granted a certain quantity of certificates based on its output, and electricity suppliers are obliged to hold an amount of green certificates that is proportional to their market share. They can purchase such certificates from renewable energy generators or on the certificate market from other electricity suppliers that have a surplus of certificates. The costs associated with this obligation are passed on to electricity consumers.

Annual public subsidies in Europe are very high (€24bn in Germany[15], €5.6bn in France in 2017). According to the Commission[16], by retaining domestic markets, achieving the renewable energy goals for 2030 will require €1 trillion in public and private investments between 2015 and 2030, for the electricity sector alone.

Chart 3: Share of renewable energies in the energy and electricity mixes (in 2014) and forecast for 2020



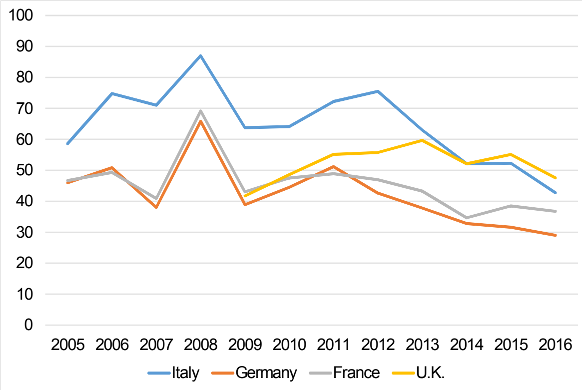
Source: SOeS for France, Eurostat for other countries.

Spot market prices have fallen sharply in recent years, and remain relatively low today. In France, the spot market price went from an average of €46.70/MWh in 2005 to €34.70/MWh in 2014 and to €36.80/MWh in 2016 (see Chart 4). Germany and Italy also witnessed significant fall-offs in spot prices.

Part of the fall-off in the market price is due to the economic context and is related to the drop in the price of combustibles such as gas (for which the spot market price dropped from €28.50/MWh in January 2014 to €13.10/MWh in October 2016[17]) and coal, which mechanically lowered the marginal generation cost at power plants. These plants are often used as a last resort and – since their marginal costs determine the market price – the market price that compensates all the means of production falls (see Box 1).

(10) Coupling matches all of a country's purchase offers with the full range of means of production in the coupled zone. It involves both electricity exchanges and transmission system operators through the use of a single platform for daily electricity transactions.
(11) Source: Energy Regulation Commission (CRE), "Les interconnexions électriques et gazières en France", 2016.
(12) Source: Eurostat.
(13) Since it is impossible to trace electrons and given the integrated electricity market, the level of renewable energy is expressed in terms of its share of production rather than of consumption. To this end, under the terms of Directive 2009/28/EC, gross final electricity consumption produced from renewable sources is defined as the quantity of electricity produced in a Member State from renewable sources.
(14) France has opted for a bonus known as the *complément de rémunération*. *Cf.* Grazi L. and Souletie A. (2016), "Renewable energies: public policy challenges", *Trésor-Economics* no. 162.
(15) Grid managers' estimate surcharge for electricity users as part of the Renewable Energy Sources Act.
(16) C0M(2016) 767.
(17) Source: Powernext, at the gas exchange point (PEG).

Chart 4: Spot prices in selected European countries between 2005 and 2016 (in €/MWh)

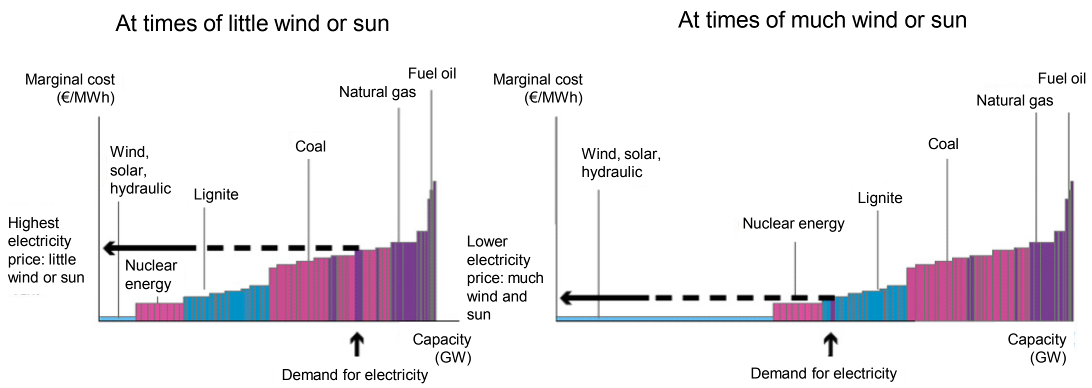


Source: Epex spot (France and Germany), GME sport market (Italy), APX Power UK.

There are also more structural causes. The widespread development of renewable energies has led certain countries to a situation of oversized generation capacities, which has a dampening effect on prices. In Germany, for example, onshore wind capacity rose from 12.0 GW in 2002 to 45.5 GW in 2016[18], while solar capacity increased from 0.3 GW to 40.9 GW[19]. During the same period, non-renewable capacity increased only slightly. Global capacity thus went from 114.8 GW to 197.2 GW, whereas demand for electricity remained relatively stable (509 TWh in 2002 and 514 TWh in 2015[20]). Even though renewable energies have a shorter lifespan than non-carbon means of production, this represents a significant increase in capacity.

Moreover, since the marginal production cost for most newly-deployed renewable energies is practically zero, they are the first to be used, which means that other generation technologies with a higher marginal cost are pushed off . Chart 5 presents the situation in Germany, which has a high number of intermittent renewable energy sources. If there is no wind or sun, the final units called upon will be carbon emitting power plants (such as coal or gas fired plants), which have relatively high marginal costs, which means a high price on the electricity market. In the presence of wind and/or sun, renewable energies are dispatched first, which means that some power plants are not (for a level of demand that remains constant). The final units called on are nuclear or lignite power stations, which have a lower marginal cost, which keeps the price for the whole of the electricity market down. Deploying renewable energies thus leads to a drop in the price of the electricity market.

Chart 5: Price formation on the wholesale market in the presence of renewable electrical energies



Source: E. Beeker « La sécurité d'approvisionnement électrique », after Agora Energiewende in France Stratégie, 2015, L'Union de l'énergie.

Due to the low market price of electricity and the relatively high fixed costs of generation units, a number of capacities are not spontaneously profitable today, and some have been forced to close. **It is important to make sure that all electricity production capacities have sources of financing.** There are a variety of solutions, to which a strict cost/benefit analysis should be applied. This is not the subject of the current paper. These include an "energy only" approach, which allows the energy market to allow prices to increase fully during peaks of demand. This would allow generators to earn enough to cover their fixed costs, for example by raising price caps. Introducing "capacity mechanisms" to supplement the electrical energy markets would allow remuneration for available capacities over and above effective production The use of long-term agreements between generators and suppliers would take account of average production costs and not only the marginal cost.

3. A greater coordination of national energy policies would bring about efficiency gains and allow for a significant reduction in public subsidies at European level

The highly integrated European electricity market *de facto* calls for increased consideration of the European dimension when planning energy policies. The presence of interconnections implies that a variation in the price of electricity in one country affects the countries with which it has interconnections. Thus the deployment of renewable energy at a near-zero marginal cost puts downward pressure on the price of electricity in the country in question (see above), but also on the interconnected countries. Such repercussions suggest that closer cooperation of national energy policies would result in the following gains in efficiency:

(18) Source: AGEE, BMWi, Bundesnetzagentur.
(19) Source: AIE, Trends 2015 in Photovoltaic Applications (for 2002) and EurObserv'ER, Baromètre photovoltaïque 2015 (for 2015).
(20) Source: Eurostat.

- *Geographic optimisation in the implementation of renewable energies.* The best renewable energy resources would be used at European level, not only within each country. This would encourage the use of solar power in Europe's sunniest zones (such as Spain and Portugal). Thus, solar power would not only be deployed in the southern part of each country, but indeed in southern Europe (see cover chart). In the same way, production from wind farms would be concentrated in the most windy countries (such as Denmark).
- *Stimulating competition at European level that would likely lead to a drop in the overall costs of the electrical system and thus, in the amount of public subsidies.*
- A reduction in issues caused by intermittent renewable energy, particularly as regards the stability of the electrical grids. Deploying renewable energies destabilises the electricity grids: given their intermittent nature and, to a lesser extent, the non-dispatchable aspect of their production, renewable energies can give rise to large imbalances between supply and demand for electricity. Because of the interconnections, these externalities concern not only countries deploying renewable energies, but also their neighbours. For example, when wind farms in northern Germany suddenly begin to operate due to windy conditions, the surplus of energy generated is transferred to interconnected countries that do not necessarily need it, creating an imbalance between supply and demand in those countries. A European energy policy would attenuate this negative effect by reducing the problems of intermittency due to the use of more cost-effective (and thus longer-running) sources and to a more adequate use of renewables (for example, since decorrelated wind schemes exist in Europe, optimised allocation of wind capacities would lower the variability of total wind farm production).

This requires harmonisation, particularly of the various regulations that exist in each country (for example, rules governing wind-turbine installation). But the potential gains linked to increased cooperation in terms of renewable energy support policies are very high. According to the European Commission, the shift towards a European policy of subsidies for renewable energies would lower the cost of deploying such energies by some €10bn [21]each year (see Box 2). The order of magnitude of the anticipated gains is similar to estimates in most academic studies.

Box 2: **Gains in pooling support for renewable energies**

The Commission[a]estimates that the changeover from a scenario in which renewable energy policies are determined strictly at national level and achieve the goal of 27% renewable energies by 2030[b] to one in which renewable energy policies are determined at European level in such a way as to minimise costs[c]would lead to a reduction in the cost of the electrical system of some €10bn each year between 2021 and 2030[d], most of it due to the reduced cost of deploying renewable energies. Less aggressive cooperation (opening 10% of support mechanisms to foreign renewable energies, and then 15% starting in 2025) would result in €1bn in savings each year.

Several studies confirm that coordination would result in significant savings. Aune et *al.* (2012)[e] demonstrate that the introduction of a European green certificate market (instead of national markets) would lower deployment costs by some 70%. Capros et *al.* (2011)[f] estimate that the introduction of a European market (in which Member States could buy and sell the renewable energy production of other States to meet their goal) would lower the cost of electricity by between 16 and 25%. Saguan and Meeus (2014)[g], applying a theoretical model to two countries, emphasise that cooperation could result in significant gains if countries do not have the same production profile (for example when a country generates renewable energies during peak demand and the other country when demand is lowest). In this theoretical model, cooperation lowers the cost of the electrical system by between 50 and 90%, depending on the production profiles.

a. SWD (2016) 418 final, impact assessment accompanying the document "Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources", part 3/4.
b. The so-called CRA (Current Renewables Arrangement) scenario.
c. The EUCO27 scenario.
d. Both scenarios are identical in other aspects.
e. Aune F.R., Dalen H.M. and C. Hagem (2012), "Implementing the EU renewable target through green certificate markets", *Energy Economics*, 34, pp 992-1000.
f. Capro P., Mantzos L., Parousos L., Tasios N., Klaasen G. and T. Van Ierland (2011), "Analysis of the EU policy package on climate change and renewables", *Energy Policy*, 39, pp 1476-1485.
g. Saguan M. and Meeus L. (2014), "Impact of the regulatory framework for transmission investments on the cost of renewable energy in the EU", *Energy Economics*, 43, p 185-194.

Most estimates of gains connected to coordination of renewable energies subsidies consider that the size of the transport grid and the current interconnections are sufficient to capture most of the gains. Coordination thus represents significant gains, even in the absence of new transport and interconnection infrastructures. Any expansion of new interconnections should be carried out on a case by case basis and after a cost/benefit analysis to ensure that they would lead to new gains.

Over and beyond the shift from national to European level (see below), it would also be necessary to review the design of support mechanisms in order to harmonise them and develop a genuine European policy. Several solutions are possible:

- *Increase the price of EU carbon allowances at European level.* A sufficiently high carbon price (for example between €30 and €40/ton of CO_2) would encourage actions that incur the lowest carbon emissions. Private investments would naturally be directed to the least expensive renewables at European level, which would become more competitive than new gas or coal plants. Public subsidies for renewable energy generation would diminish and could be redirected towards R&D.

(21) The €10bn in savings would be shared between consumers and the public finances (the distribution would vary depending on the mechanisms chosen).

- *Introduce a single renewable energy support mechanism to encourage exploitation of the most profitable resources at European level.* These subsidies could take the form of a flat-rate premium paid at European level, or a European market of green certificates that suppliers would be obliged to purchase from renewable energy generators and whose price would depend on future changes in electricity prices.
- *Expand the current national subsidy mechanisms to include foreign capacities.* This would be a first step towards greater cooperation.

4. Implementing of a common energy policy to support renewables would represent a major integration step for the EU

Tighter coordination of policies in support of renewable energies – and more generally of national energy policies – means that the Member States must agree to renounce part of their sovereignty regarding the national electricity mixes, and specifically the composition of the share of renewable energies. Anyway this integration is already underway due to the interconnection policy: the fact of being able to import and export energy within a market itself represents a certain loss of control over the source of the energy generated. There are however few sectors in which the potential gains from bolstering European integration are so high.

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