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# Do almost mature renewable energy technologies still need dedicated support towards 2030?


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# 1 Executive summary

The discussion on how to continue support for almost mature renewable electricity (RES-E) technologies, such as onshore wind and PV, has recently intensified. Magnus and Tennbakk (2016) and other analyses based on mainstream economics argue that

1. Current support for these technologies is the main reason for the currently low prices of electricity and $CO_2$ and
2. The costs of the energy transition would be lower if dedicated support were abandoned for almost mature RES technologies.

The suitability of different types of energy and climate policies, including RES-E policies, depends on the specific market circumstances. First, this report aims to present a general reasoning why a policy mix that includes both dedicated RES-E support and a cap-and-trade scheme for $CO_2$ emission allowances (such as the EU ETS) can make economic sense. Second, we apply this reasoning to the current market situation, where power and emission allowance markets are characterised by oversupply and low price levels.

Our key findings, which are generally applicable to market situations with and without oversupply, are the following**:**

**Does the current level of maturity of onshore wind and solar PV justify continuing dedicated RES-E support or should RES-E support be abolished?**

We understand technologies to be mature, if (1) generation costs are comparable to alternative investments (such as conventional generation technologies) and (2) there is no further cost reduction potential. Costs for onshore wind and solar PV diverge considerably depending on the location and additional factors such as financing conditions (see IRENA 2015, p. 12) and therefore still exceed the costs of alternative investments in many cases. With regard to the second criterion, (Wiser et al. 2016; IRENA 2016) have shown that wind and PV still have substantial future learning potentials. According to these analyses, onshore wind and solar PV are not yet completely mature and existing cost reduction potentials can best be exploited by dedicated RES-E support schemes. Therefore, we argue that it is too early to phase out RES-E support for almost mature technologies.

**Which reasons justify the use of combined policy targets and measures to support RES-E?**

A combination of targets and policies for greenhouse gas mitigation and RES-E deployment can be justified by multiple externalities including environmental effects as well as learning-by-doing and technology spill-over effects. While carbon pricing alone is not well suited to triggering long-term technology development, RES-E policies can stimulate innovation and long-term cost reductions of renewable energy technologies that lower the overall cost of the energy transition. Furthermore, regulatory RES policies can substantially reduce investment risk and financing costs, which have a strong impact on system costs. We argue that studies supporting a phase-out of renewables support such as (Magnus and Tennbakk 2016) overlook the beneficial effects resulting from the coordination between the European Trading Scheme (ETS) and renewables targets in EU energy and climate policy.

**Does the sole use of a cap-and-trade scheme lead to a cost-efficient transition of the energy sector?**

Due to the cost structure with a high share of fixed costs, RES-E technologies are more exposed to financing costs than less capital-intensive fossil fuel power plants. Well-designed RES-E support policies lower these financing costs (and the overall carbon mitigation costs) by reducing investment risks. (European Commission 2014b; Held et al. 2015) find that using RES-E policies and targets does not involve higher system costs if ETS and RES-E support are coordinated. A single $CO_2$ price for all mitigation options is therefore not the most cost-effective solution to achieving the transition to a low-carbon energy system.

In situations of oversupplied markets, we believe that the following aspects should be taken into account in addition to the general arguments listed above:

**Is increased feed-in of RES-E one main cause of overcapacity in power markets? Which measures can increase price levels?**

Although RES-E development certainly exerts downward pressure on power prices due to low marginal costs, the price-dampening effect of RES on power prices is often exaggerated. A recent analysis of the German power system, which has experienced strong RES-E growth, indicates only a limited impact of RES-E on power prices and identifies other factors, such as low demand (as a consequence of the economic crisis) and low emission allowance prices, as relevant drivers of the low price levels (Kallabis et al. 2016). Measures to help markets get back to higher price levels include policy incentives to increase the (flexible) demand for electricity in other sectors (heating and cooling, transport). Policies addressing the supply side include setting incentives for a progressive, regulatory-driven retirement of the oldest, most polluting fossil-fuelled power plants. This should be coordinated with adapting the number emission allowances.

**Is the increased feed-in of RES-E one main cause for the oversupplied emission allowance market? Which measures can increase price levels?**

(Koch et al. 2014) show that the price-dampening effect of RES-E on $CO_2$ prices has been very limited. No negative impact occurs if perfect ex-ante coordination between targets is assumed (del Río et al. 2013). Since RES development is currently in line with the 2020 trajectory, there are only minor unexpected effects of RES on ETS-budgets and consequently on related carbon price levels. With this in mind, other quantity-based measures to reduce the number of emission allowances, such as strengthening the Market Stability Reserve (MSR), should be applied in order to achieve the higher price levels that facilitate the transition to a low-carbon power system. Moreover, ETS measures need to be coordinated with RES targets and related policy measures in the 2030 context.

**Does the current specific oversupply situation in power and carbon markets change the decision for or against dedicated RES-E support for already mature RES-E technologies?**

As discussed above, there are strong arguments to continue RES-E support even for mature RES-E technologies. Furthermore, RES-E deployment is not the main reason for the current oversupply in power and carbon markets. Nevertheless, RES-E policy design can be adapted to the challenges of oversupply in these markets. A balance must be found between sufficient investment certainty / low financing costs on the one hand and the flexibility to react to different market situations on the other hand. Instead of completely abolishing support, auction-based RES-E support could offer the possibility to continuously control and adapt supported RES-E quantities without undermining the investment climate. However, sudden policy changes should be avoided to maintain investment certainty. Once sufficiently high price levels have been achieved, the auction volumes for RES-E support could be increased accordingly. Auctions have two major advantages: First, they provide stable investment conditions for RES-E investors because the actual support in most cases is provided through a feed-in premium system (for which the price is determined by the auction). Thus, such long-term (feed-in) contracts keep an investor’s risk at an acceptably low level. Second, the auction outcome also indicates when no more dedicated RES-E support is required, as the auction leads to a premium of 0 in this case.

# 2 Introduction

Increasing the share of renewable energy sources (RES) forms part of the general European climate and energy policy strategy towards building a competitive, secure and low-carbon energy system. Various policies are currently being applied in the EU to achieve the low-carbon transition in the power sector including the EU emission trading scheme (ETS) and dedicated renewable electricity generation (RES-E) policies. Whilst the EU

ETS mainly intends to internalise environmental externalities by encouraging cross-sectoral competition between mitigation options, RES-E policies provide sector-specific support and are justified by their potential to induce cost reductions of RES-E technologies in the longer term. Depending on the choice of instrument, RES-E support may follow market-based approaches, e.g. in the case of auctions or quota obligations, or more price-driven approaches such as feed-in systems.

Strong market development of RES-E in recent years – triggered particularly by renewable support schemes – has been accompanied by considerable technology cost reductions, in particular of solar PV technologies. These cost developments have brought onshore wind and solar PV close to market maturity. Despite the fact that the additional learning potential of these technologies is widely acknowledged, there are uncertainties with regard to the future cost reductions that can still be expected. These developments raise the question whether it is still reasonable to continue RES-E support for almost mature technologies such as onshore wind and solar PV or whether electricity and carbon markets are already capable of triggering further investments in mature RES-E technologies.

In this context, the existing interactions between RES-E policies and carbon markets on the one hand and RES-E policies and power markets on the other hand remain a major issue and are currently the subject of controversial political debates. Some argue that RES-E policies exert a strong downward pressure on power and carbon prices and therefore distort these markets (e.g. Magnus and Tennbakk 2016; Böhringer and Rosendahl 2010). This paper discusses whether and how to continue sectoral RES-E support for almost mature technologies such as onshore wind and solar PV. We first elaborate on the general reasons why a policy mix including dedicated RES-E support in addition to a cap-and-trade scheme such as the EU ETS can make economic sense (sections 3 and 4). Our observations are backed by empirical findings and modelling results from literature. In section 5, we take a closer look at the current market situation, which is characterised by oversupply and low price levels. We provide a brief explanation for the current problems on the $CO_2$ and power markets, and suggest measures to return them to long-term equilibrium. We elaborate how to handle RES-E support in these situations, taking into account the expectations about potential price developments on the emission allowance market. As a further element. We also look ahead to carbon pricing once the markets have returned to a state of equilibrium. Finally, we present conclusions and recommendations for the way forward.

**Box 1: Markets in long-term equilibrium and out of long-term equilibrium**

A market can be described as being in 'economic equilibrium' when economic forces such as supply and demand are balanced. According to the standard textbook, equilibrium occurs at the point at which the quantities demanded and supplied are equal. As (Hirth and Ueckerdt 2013) state, "in a long-term equilibrium on perfect and complete markets with free entry, profits (rents, producer surplus) are zero. Positive long-term profits would attract new investments that drive down prices to the point where profits disappear. Vice versa, negative profits would lead to disinvestment, driving up prices until negative profits vanish."

In the power market case, low price levels due to excess capacity lead to negative long-term profits, incentivise disinvestments until prices rise again and lead to a situation of a long-term equilibrium, where power plants can operate on a cost-covering basis. Regarding the emission allowance market, there is no such "long-term equilibrium", but possible reasons for low price levels include the price not adequately reflecting long-term scarcity or lower mitigation costs than initially expected. A closer look at the specificities of electricity and carbon markets reveals some important peculiarities. Of key relevance is the degree of inertia within both markets – due to the long construction times as well as the long lifetimes of power plants and other infrastructure. In markets that feature inertia and where newly introduced policies are not fully anticipated, policy shocks shocks – i.e. sudden unanticipated policy changes can affect the long-term equilibrium on the power market and the emission allowance market.

# 3 Interactions between RES-E support and the ETS

When analysing the interactions between RES-E support and ETS, some see the conflicts between these two policy realms and instruments as unavoidable and argue against their combination (Braathen 2007; Frondel et al. 2010; Wittlich and Pethig 2009). They claim that adding a RES-E support instrument to an existing ETS does not make much sense, given that the ETS alone is supposed to achieve a cost-efficient transition to a low-carbon energy system. RES-E technologies are seen as an expensive way to tackle $CO_2$ emissions. Since $CO_2$ emissions are covered by a cap in an ETS, RES-E deployment triggered by RES-E policies does not lead to additional $CO_2$ emissions reductions (Frondel et al. 2010; Braathen 2007). They argue that RES-E technologies are generally more expensive than alternative low-carbon technologies (e.g. energy efficiency measures, $N_2O$ abatement measures in industry, fuel switching) and RES-E policies allow them to take part in the electricity generation mix. This leads to higher compliance costs with the $CO_2$ target than would be the case without RES-E policies.

Furthermore, it has been claimed by (Böhringer and Rosendahl 2010) that “green promotes the dirtiest”, e.g. that with a given $CO_2$ cap, additional RES-E in the system reduces the $CO_2$ price in the ETS, which in turn benefits conventional fossil-fuel generators. The consequence is increased production from the most $CO_2$-intensive power generation technologies (typically coal power) than would be the case under an ETS alone. Several authors share this view and question the need to adopt RES-E support policies[1].

However, the possibility to mitigate or even remove the conflicts listed above through appropriate coordination of instruments and/or targets has often been disregarded. $CO_2$ prices do not necessarily have to be lower if the RES-E and $CO_2$ targets are coordinated, e.g. the expected $CO_2$ emissions reductions due to RES-E deployment are considered when setting the ETS cap (del Río et al. 2013). If the $CO_2$ and RES targets were coordinated ex ante, then the alleged problem of diluting the $CO_2$ emission constraints as a result of RES deployment could be mitigated and a lower carbon price would not result. Only the development of RES diverging from the expected trajectory (i.e. over-compliance with the target) would have an impact on $CO_2$ prices. A higher (lower) than projected development would lead to a decrease (increase) in $CO_2$ prices, all other things being equal.

This raises two important questions: Whether both targets have been coordinated in actual policy practice in the EU in the past; and whether there has been negative interaction between them (del Río 2017). According to the Impact Assessment of the EC, “the impact of the achievement of the renewables target was taken into account in the design of the climate and energy package, with 2020 carbon prices at that time being projected lower due to the achievement of an ambitious RES target” (European Commission 2014b, p. 23). Similarly, RES, energy efficiency and the GHG targets for 2020 were coordinated before determining the triple target for the 2020 package (European Commission 2008). Beyond that, the quality of coordination has been criticised: (Jalard et al. 2015) find that the ETS-cap for 2020 was determined in coordination with the respective RES objectives, whilst those for energy efficiency and international effects were not considered. (Höhne et al. 2008) believes the 2020 $CO_2$ cap is not stringent enough, and argues it should have taken the EU’s RES and energy efficiency targets into account. Finally, interactions depend not only on the type of instruments applied, but particularly on their detailed design, since coordinating different policy instruments such as the EU ETS and dedicated RES-E support schemes is easier using quantity-based schemes than price-based ones (del Río 2016). In fact, the recent move to auctions in the EU leads to more precise control of the monetary expenses related to RES-E support as well as of deployment volumes.

[1]See del Río 2014 for a detailed overview of the literature.

# 4 ETS and RES support in markets without oversupply: Reasons for using RES deployment policies in addition to the EU ETS

The following reasons exist for the combined use of RES-E policies and carbon pricing. First, there are several different market failures obstructing the achievement of the EU's climate and energy targets. These include both environmental externalities as well as deployment and innovation externalities. The former relates to GHG-emitters not having to pay for environmental damages; this negative environmental externality can be internalised by carbon pricing. Deployment externalities lead to lower generation costs because of learning-by doing effects. Positive innovation externalities occur if firms cannot benefit to the full extent from innovations because these can also be deployed by other firms (public good property of innovations). Therefore, a carbon price alone typically results in a lower than optimal level of learning investments. This relates to the **dynamic aspects** of energy and climate policy which are not adequately addressed by a cap-and trade scheme: dynamic efficiency (cost development in the long term) and dynamic innovation and technology development effects that help to achieve a long-term cost minimum and avoid technology lock-ins. Second, increasing the share of RES addresses **multiple objectives**. Besides greenhouse gas emission reductions, increased RES share can also lead to greater security of supply and local economic benefits (industrial policy, employment impacts). Applying solely a cap-and-trade scheme to cut $CO_2$ emissions is not necessarily the most efficient instrument to achieve multiple goals, because it mainly addresses static aspects of the environmental externality. Third, additional RES-targets and policies typically lead to **reduced financing costs** for RES deployment in the presence of RES targets and policy and can therefore increase the static efficiency compared to a pure cap-and-trade scheme. Fourth, the application of **RES-targets and policies do not lead to higher system costs** than a **$CO_2$ target only**. These arguments are elaborated in more detail in the following subsections.

## 4.1 Dynamics matter: positive long-term aspects of a combined energy and climate policy

Taking into account aspects related to developments over a longer term can justify the combination of targets and policies in the climate and energy policy realm. Two market failures have to be addressed in addition to the *environmental externality* (del Río 2011):

i. The increased deployment of a technology, which results in cost reductions and technological improvements due to learning effects and dynamic economies of scale, may result in a positive *deployment externality*. Even companies that did not initially invest in the new technology may benefit and produce or adopt it at lower costs. Thus, investments in the new technology will stay below socially optimal levels. Learning is certainly a source of innovation and cost reductions but it does not come freely. It is the result of previous investments, implying circularity: diffusion is endogenous to the level and evolution of costs, but costs are also affected by the degree of diffusion.
ii. The *innovation externality*, which is related to spillover effects enabling the copying of innovations, reduces the gains from innovative activity, meaning that the innovator will not receive full compensation, and private actors will carry out less R&D than the optimal level.

A $CO_2$ price, even one set at an "appropriate" level, would only internalise the environmental externality, but not the other two. The demand-pull for innovation stemming from a $CO_2$ price is simply too weak, as shown by previous research (Rogge et al. 2011; Schmidt et al. 2012; Calel and Dechezleprêtre 2014; Martin et al. 2011). Acemoglu et al. (2012) argue that, in the presence of an innovation externality, a carbon price alone will lead to higher $CO_2$ mitigation costs and thus be less efficient than combination with complementary instruments. A carbon price scheme addressing innovation externalities would require a much higher carbon price than in the case of combining carbon pricing with complementary instruments. Public support for RD&D is needed to address the innovation externality, and dedicated deployment support for renewable energy technologies can be justified to tackle both the innovation and the deployment externality. While RD&D support is a necessary supply-push influence for innovation, deployment support is more effective in creating a market (demand-pull). There is abundant literature from innovation economics and innovation studies showing that market creation is critical to triggering innovation in the energy sector (see del Río and Bleda 2012 for an overview). Therefore, RES-E deployment instruments are also innovation instruments since market creation feeds back into private R&D (del Río 2017). The deployment instrument helps create the market for a technology, which investors in R&D need in order to make returns on their technology investments (Spencer et al 2014).

The value of learning effects on innovation and cost reductions of RES-E technologies should not be underestimated. The improvements in RES-E technologies (particularly wind and solar) and their cost reductions over the last decade cannot be attributed solely to R&D support. Learning effects as a result of the diffusion triggered by RES-E support schemes have had a major impact in this context (see IRENA 2012 for solar PV for example). The cost reductions triggered in the past due to diffusion in countries with strong RES-E policies (Spain, Denmark, Germany) are likely to have had positive spillover effects in the rest of the world. Learning effects contribute to innovation and reducing the costs of new technologies, which in turn, reduces the costs of compliance with RES and $CO_2$ targets in the long term. This reduces $CO_2$ abatement costs in the future and the cost of achieving the GHG target in the longer term.

Therefore, due to the innovation externality and the deployment externality, lower than optimal learning investments would be made without RES deployment policies. This is true for all technologies with significant cost reduction potential. Wind onshore and large-scale PV can be considered almost mature in the sense that they have reached significant market penetration already and their generation costs are comparable to those of conventional technologies including $CO_2$ externalities (see Alberici et al. 2014). However, costs for solar PV and onshore wind diverge considerably depending on the location and financing costs (see e.g. IRENA 2015, p. 12). In addition, they still have substantial cost reduction potential. According to a recent study by Wiser et al. (2016), the following cost reductions are expected for onshore wind based on an extensive expert survey: 24% reductions by 2030, and 35% reductions by 2050. (IRENA 2016) expects 26% cost reductions for onshore wind by 2025 (compared to 2015). Offshore wind is expected to have a very similar cost reduction potential (see Figure 1). These further cost reduction potentials justify further policy support for onshore and offshore wind.

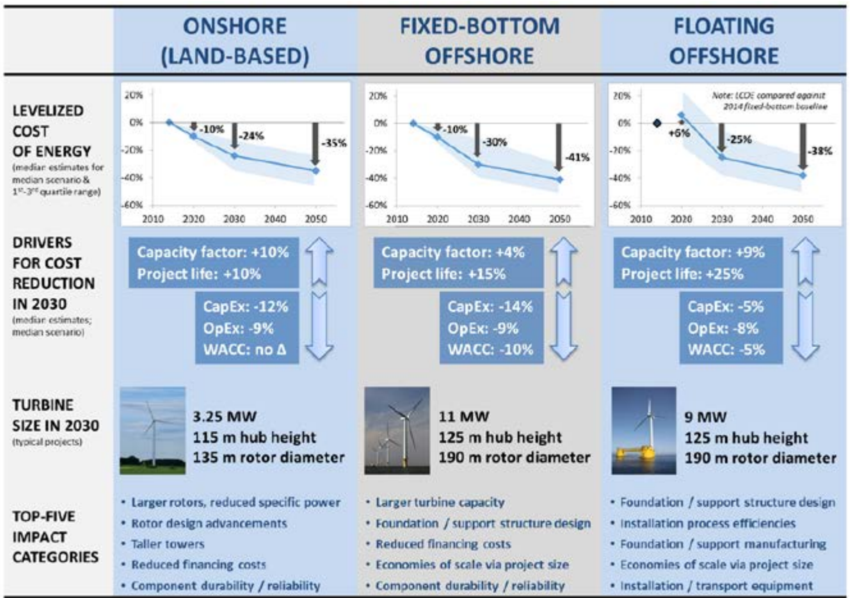


**Figure 1: Summary of Expert Survey Findings on cost reduction potential of onshore and offshore wind Source: (Wiser et al. 2016, use of figure permitted by authors).**

Regarding solar PV, the costs of power from large-scale photovoltaic installations in Germany fell from over 40 € ct/kWh in 2005 to 9 € ct/kWh in 2014 (Fraunhofer ISE 2015). Lower prices have been reported in sunnier regions of the world. Even in conservative scenarios and assuming no major technological breakthroughs, it is unlikely that cost reductions will cease at this point. Depending on annual solar irradiation conditions, (Fraunhofer ISE 2015) estimates power costs of 4-6 € ct/kWh for solar PV by 2025, falling to 2-4 € ct/kWh by 2050 (conservative estimate). An analysis by (IRENA 2016) also expects further cost reductions for solar PV leading to global weighted average costs for PV electricity of 6 $ ct/kWh by 2025 (-59% compared to 2015). Again, this cost reduction potential justifies further policy support for solar PV.

## 4.2 Multiple policy objectives for increasing the use of renewable energies: climate mitigation, supply security and increased local benefits (industrial policy, employment impacts)

Renewable energy targets and policies are motivated by additional policy objectives besides emission reduction. These include the increased security of supply (especially in terms of reducing fuel imports), as well as the improved competitiveness of European economies by fostering new innovative industries and services. These additional policy targets have been clearly articulated in EU policy[2].

The argument that ETS and RES-E support should not be combined fails to consider the non-$CO_2$ benefits of RES-E support. The Dutch economist and Nobel laureate (Tinbergen 1952, p. 27) outlined a major principle of economic theory: The number of independent targets (goals) must equal the number of independent instruments. Thus, following this Tinbergen rule, having an ETS to address several goals would be inefficient, since the number of independent goals would be greater than the number of independent instruments. Both RES-E deployment and an ETS share one common goal ($CO_2$ emissions reductions), but RES-E deployment contributes to other goals in addition to $CO_2$ reduction, the so-called secondary benefits. These include reduced dependency on fossil fuel imports, industrial innovation and other socioeconomic benefits, such as job creation (del Río et al. 2013).

The socioeconomic benefits of adding a RES target (and dedicated support policies) to an ETS can actually compensate the additional costs. The additional costs of $CO_2$ abatement resulting from the combination of ETS and RES-E support could be interpreted as the costs of achieving those non-$CO_2$ goals plus the dynamic efficiency benefits of RES-E deployment in terms of triggering innovation and cost reductions over time. Unfortunately, to our knowledge, so far there has been no integrated analysis of all the positive socioeconomic benefits at EU level. However, the findings of the European Commission's Impact Assessment of the 2030 energy and climate targets (EC 2014a) suggest that such compensation may actually occur. According to modelling simulations with PRIMES, the extra costs of the "other benefits" represent only between 0% and 0.05% of gross domestic product (GDP), whereas one of the benefits, the jobs created, increase by between 0.3% and 0.5% in 2030 (European Commission 2014b)[3].

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[2] The diversification of energy sources leading to lower fossil-fuel dependence is a goal which is mentioned seven times in the current RES Directive (The European Parliament and the Council of the European Union 2009). The Directive also mentions other goals: the promotion of innovation and the creation of opportunities for employment and rural and regional development (see also EC 2012).

[3] Comparison of the GHG40% +EE + RES30% scenario with respect to GHG40% +EE scenario (European Commission 2014b). Total system costs as % of GDP in 2030 in the GHG40EE scenario: 14.45% in 2030 and 14.90% in 2050. Total system costs as % of GDP in 2030 in the GHG40EERES30 scenario: 14.45% in 2030 and 14.95% in 2050.

A detailed analysis of the socioeconomic impacts of RES expansion at EU level today and in future as conducted in the EmployRES II study confirms its positive impact on the labour market: Net employment change compared to a business-as-usual scenario amounts to 90–720 thousand (160–1500 thousand) jobs by 2030 if a 2030 RES target of 30% (35%) is implemented (Duscha et al. 2016; Duscha et al. 2014). The impact on GDP would also be positive, amounting to 0.1–0.4% (0.1–0.8%) of EU GDP by 2030 in the case of ambitious RES targets for 2030. Thus, it has been concluded that: "Despite the moderately higher generation costs of renewable energies the overall impact of ambitious renewable energy targets is positive due to the shift from a fossil fuel-based energy system [where, consequently, extra-EU fossil fuel imports are large] to an investment-focused one." [4]

## 4.3 Proactive risk mitigation and reduced financing costs through dedicated RES-E support

The question whether prices resulting from power markets and $CO_2$ emission markets may or may not be sufficient to invest in mature RES technologies depends on several factors such as the available technology mix, fuel prices, the demand for electricity and $CO_2$ allowances and the costs of RES technologies (see Janeiro et al. 2016). In general, surplus supply reduces prices and the possibility for both conventional and renewable power plants to operate on a cost-covering basis. At the same time, there are differences between conventional and renewable power plants related to their cost structure. The electricity generation costs of RES technologies – characterised by a high share of upfront costs – are more exposed to financing costs than less-capital-intensive fossil fuel power plants. Financing costs typically reflect the investor-specific risk assessment of investment projects. For this reason, we take a closer look at the key risk factor responsible for the capital costs of RES investments. According to results from the project DIA-CORE, stakeholders from all EU Member States deemed risks related to policy design more important for RES-development than other risk factors such as grid access or social acceptance (Boie et al. 2016, p. 46). The stakeholder survey also reveals that EU Member States show strongly diverging Weighted Average Costs of Capital (WACC) for onshore wind ranging from 3.5% in Germany to 12% in Greece and Croatia assuming sectoral RES-E policies to be in place (Boie et al. 2016, p. 46; Janeiro et al. 2016).

The risk premiums required by investors and therefore the capital costs of RES-E can be lowered by providing a secure and predictable investment framework for RES-E. Dedicated RES-E support can provide such a framework. However, it remains questionable whether a cross-sectoral cap-and-trade scheme alone can deliver electricity prices able to cover the generation costs of RES-E and in particular whether it is capable of restoring investors' confidence. An effective way to keep risk premiums at a low level is to provide remuneration for new RES-E plants based on long term contracts such as a contract-for-difference or sliding premium systems. Sectoral RES-E policies can reduce costs of the energy transition by reducing risk premiums.

If RES-E support for almost mature technologies is awarded in a competitive bidding procedure, this ensures minimum generation costs of RES-E development and therefore maximum economic efficiency in this sector. In addition, tendering RES-E support allows flexible adaptations of the RES-E volume supported, if necessary (see section 5.2). However, with regard to $CO_2$ mitigation costs, the cost-dampening effect is counterbalanced by potential efficiency losses occurring because more cost-effective decarbonisation options are not deployed

[4] This subsection is a summary of del Río (2017). See del Río (2017) for a broader coverage.

outside the renewables sector. Regarding the relevance of capital costs, (Hirth and Steckel 2016) show that they play a significant role for the costs of the transition to a low-carbon power sector[5].

## 4.4 Coordinated approach of dedicated RES-E support together with an ETS: Its impact on total system costs

This section addresses the question of how the existence of RES-targets and policies affects overall system costs compared to a scenario where $CO_2$ reduction targets are achieved by the ETS alone. To do so we refer to several modelling studies analysing the costs of different future energy scenarios.

In its Impact Assessment of the 2030 energy and climate targets, the European Commission finds similar total system costs for the period 2011-2030 for a scenario without dedicated RES-E support (assuming an energy efficiency target of 30%) and for a scenario including an ETS and a 30% RES target with RES-E support schemes (European Commission 2014b)[6]. For the longer-term period 2031-2050, the EC expects slightly higher total system costs of an additional 0.05% points of GDP for the RES-target scenario when compared to the scenario focusing on ETS and energy efficiency policies.

A study assessing the impact of specific RES-E policies on the power sector, which was based on several bottom-up modelling tools with a high level of detail regarding the costs and potentials of RES, concludes that the combined implementation of targets for energy efficiency and renewable energies in addition to a pure greenhouse gas emission target can considerably reduce the total energy system costs (Held et al. 2015). The authors of the study explain that these potential cost reductions stem from lower investment risks and financing costs due to sectoral targets and the implementation of sectoral policies (Held et al. 2015). Furthermore, the modelling results indicate that a RES-target of 30% leads to only slightly higher total system costs than a scenario with just a cap-and-trade system (Held et al. 2015). The additional costs resulting from implementing RES-targets and policies remain moderate and are estimated to be € 1 to 4 billion per year. As regards the power sector, a RES-target of 30% may even slightly reduce the total system costs of electricity generation.

In addition to the estimated costs from a system perspective, the study by (Held et al. 2015) shows how costs and savings can impact selected economic agents. These effects are not overall cost effects, but they reflect distributional effects and determine how the system-related additional costs are distributed among consumers and producers. This comprises an analysis of the annual support expenditures borne by electricity consumers under specific RES development pathways. Expenditures for dedicated RES support under a 30% RES target for 2030 range from € 20 to 22 billion per year, whilst the reference scenario where the ETS acts as the core driver leads to considerably higher support payments of € 41 billion per year on average. The higher support expenditures in the ETS-only scenario can be explained by the mechanism of the ETS, where the marginal technology required to fulfil the emission reduction target sets the price for all mitigation options. All other technologies with lower abatement costs are paid the uniform $CO_2$ price. As a consequence, producer profits arise depending on the steepness of the $CO_2$ abatement curve. In contrast, lower $CO_2$ prices resulting from dedicated RES-E support reduce these profits. It should, however, be noted that support expenditures do not reveal any information on the overall generation cost of the system, but represent a price or distributional effect. (Hirth and Ueckerdt 2013) argue that the undesired distributional impacts of carbon pricing may limit the effectiveness of carbon pricing policies. When looking at the impacts for different actors, (Hirth and

[5] Hirth and Steckel (2016) analyse the role of capital costs in decarbonising the power sector and find that the change of the WACC from 3% to 15% involves a decrease of the RES-E share from 40% to almost 0 in the cost-optimal electricity mix assuming a carbon price of USD 50 per ton.

[6] Modelling results indicate total system costs of 14.45% of GDP in both scenarios compared to system costs amounting to 14.3% of GDP in the Reference Scenario.

Ueckerdt 2013) expect large conventional power generators to support carbon pricing, whilst consumers probably tend to support the use of RES-E policies in addition to carbon pricing.

The studies analysed above indicate that the use of RES-E policies and targets in addition to a cross-sectoral emission reduction target with a cap-and-trade scheme does not automatically involve higher system costs, due to the consideration of dynamic aspects as well as risk perception and impacts on financing costs. A single CO2 price for all mitigation options is therefore not necessarily the most cost-effective solution to achieving the transition to a low-carbon energy system. Other analyses, such as (Böhringer et al. 2016), indicate higher costs of combined energy and climate policies compared to the sole application of an EU-wide emission cap-and-trade scheme, but these neglect risk factors and their strong impact on capital costs.

# 5 ETS and RES-E support in $CO_2$ and power markets characterised by oversupply

For **markets (power and $CO_2$) out of long-term equilibrium** (Magnus and Tennbakk 2016) argue that removing support for mature RES technologies is an efficient way to allow markets to return to equilibrium, leads to higher prices and brings RES technologies closer to competitiveness. The question to be asked is whether phasing out support for mature renewables is the most suitable and beneficial measure to raise the prices of power and $CO_2$. This section therefore addresses the question “What are the most efficient measures that allow markets to return to equilibrium?”

In order to answer this question, we first explore why European power and emission allowance markets are currently out of equilibrium by drawing on empirical evidence for the relative importance of the driving factors identified. Then we suggest potential measures to restore market equilibrium, taking into account the objective of achieving a cost-efficient transition to a low-carbon energy system, and expectations concerning future $CO_2$ price development.

## 5.1 Reasons for current oversupply situation

Several power markets in the EU are currently characterised by low prices. These low prices are in many cases insufficient to cover the generation costs of existing plants (both RES and conventional). Moreover, they do not provide a sufficient price signal to drive investment in the clean and flexible capacity needed for the energy transition. In this sense, the electricity market can be seen as “out of equilibrium” (see **Box 1**, page 5). There are multiple underlying reasons for this situation, including demand falling below projections as a result of the economic crisis, the lack of coordination between investments in conventional generation capacity and policy-driven renewable deployment objectives, and the “merit-order effect” of renewables. These multiple factors make it challenging to define how much each factor contributes to the price drop currently being experienced on European power markets.

**The impact of RES-E policies and other factors on electricity markets**

When looking at the impact of RES-E policies on power markets, we observe downward pressure on power prices caused by low-marginal cost renewables known as the “merit-order” effect (e.g. Sensfuß et al. 2008). Due to their low variable costs, an increased use of RES-E technologies typically leads to lower electricity prices on the wholesale market. This applies to RES-E participating in the market and RES-E benefitting from priority feed-in under fixed feed-in tariff schemes. In the first case, RES-E technologies (with the exception of biomass technologies) bid with close-to-zero variable costs and displace technologies with higher variable costs from the market. In the case of priority feed-in, the residual demand for non-renewable electricity generation is reduced and the power plants with the highest variable costs are also driven off the market. It is therefore logical that the relevance of the price-reducing impact of low-marginal cost renewables on power prices increases with their level of market penetration (Hirth 2013). In order to define measures able to bring markets back to long-term equilibrium, it is necessary to quantify the impact of RES-E development on power prices in the current market situation. In an empirical study analysing the reasons for reductions in the base futures price on the German power market between 2007 and 2013, (Kallabis et al. 2016) find that RES-E feed-in is only responsible for roughly 10% of the reduction in power prices (-6.28€/MWh out of 65,69€/MWh). They calculate that the low $CO_2$ prices are responsible for roughly 22 % of the reduction in base futures prices and therefore suggest intervention to increase $CO_2$ prices and also power prices.

RES-E policies are not the only reason for low price levels on power and carbon markets. Lower demand due to economic developments has also resulted in oversupply on power markets. According to (Kallabis et al. 2016), the impact of a low carbon price on electricity prices appears to be more relevant than increased RES-E feed-in. Another reason for low electricity prices may be a low level of interconnectivity, which is particularly relevant for the Iberian Peninsula, which was strongly affected by the economic crisis.

**The impact of RES-E policies and other factors on emission allowance markets**

Ex post analyses assessing the impact of RES-E policies on emission allowance markets find that RES have had a limited impact on ETS prices (Ellerman 2013; European Commission 2014a). While RES-E policies did reduce $CO_2$ prices, this effect was very small. (Ellerman 2013; European Commission 2014a) conclude that the economic crisis, fuel switching from coal, lenient targets and other factors had a much greater influence on the low allowance prices. However, (Koch et al. 2014) question whether the responsible drivers can be clearly identified. They estimate that about 90 % of the allowance price reduction cannot be explained. With regard to the 10 % that can be explained, the authors find that 40 % is caused by changes in economic activity, whilst RES capacity additions in Germany are found to be responsible for only 8 % of the decrease in $CO_2$ prices. Another interesting finding is that these ex post assessments identify less interaction between RES-policies and ETS-prices than simulation-based analysis (Kallabis et al. 2016; Koch et al. 2014). This indicates potential exaggerations of carbon pricing schemes and RES-E policies in simulation-based analyses.

Assuming an ex ante coordination of emission reduction and renewable targets, only RES development above the predicted trajectory should have a price-dampening effect on carbon prices. When looking at RES deployment compared to the targets of the combined energy and climate package for 2020 (20% GHG mitigation / 20% RES / 20% efficiency), RES development is in line with the planned trajectory and not higher than expected. Therefore, unexpected RES development cannot be a main reason for the markets being oversupplied (Kallabis et al. 2016; Koch et al. 2014; European Commission 2015b). According to the European Commission's progress report on renewables, the majority of Member States are on track to reach the 2020 target of 20 %, but slight underachievement is expected in 2020 for the EU as a whole (European Commission 2015b)[7]. Other factors such as low demand as a consequence of the economic crisis appear more relevant for the currently low price levels; this is also stated by (Magnus and Tennbakk 2016).

**Expectations about the future role of carbon pricing**

It remains an important question whether the implemented and proposed revisions of the ETS (see section 5.2) will enable the emission allowance price to stabilise at a sufficiently high level. For example, a 2016 survey by the International Emissions Trading Association expects an average price of about 18€/$tCO_2$ between 2020 and 2030 (IETA/PwC 2016). The European Commission expects a price development of about 14 to 33 €/$tCO_2$ in the same period in its most recent modelling exercise which takes into account the planned and implemented ETS reforms ("backloading" and the Market Stability Reserve) (European Commission 2016). However, the

[7] COM(2015) 293 final "With a projected share of 15.3% in 2014 in the gross final energy consumption, the EU and an overwhelming majority of Member States are advancing well towards 2020 targets. However, as the trajectory becomes steeper over the coming years some Member States may need to intensify their efforts to keep on track, and where necessary by making use of the cooperation mechanisms with other Member States."

uncertainty concerning the actual future carbon price development is considerable, since this depends on multiple factors including the impacts of existing and future reforms of the ETS.

In order to evaluate the future impact of the carbon price, the price level needed to induce a switch from coal-fired generation to gas-fired and renewable generation is as important as the expected carbon price itself. According to (Hecking 2016), the carbon price range enabling a switch in the merit order from coal to gas lies between 12 and 63 €/t$CO_2$. This range indicates a high sensitivity to coal and gas prices, which have shown a significant degree of volatility in recent years[8]. The lower end of the given range reflects a lower natural gas price and a higher coal price than is currently the case[9]. It corresponds to a substitution of the oldest, most inefficient coal plants with the most efficient natural gas plants. The same study estimates, as an EU average, the carbon price range needed to make onshore wind power competitive with coal-fired generation at about 60-90 €/t$CO_2$ in the absence of support schemes.

Hence, the current carbon price level (4-6 €/t$CO_2$ throughout most of 2016) is too low to substantially influence technology switch decisions of market actors. Moreover, it is far below the scientific estimates of the external cost of emitting carbon, given as €$50_{2012}$/t $CO_2$ for the lower end of the range (Alberici et al. 2014).

While political momentum for restoring an upward price trend has already precipitated in the "backloading" reform and the adoption of the Market Stability Reserve, some MEPs as well as national governments have indicated their willingness to support further reinforcement of measures as part of the "phase 4" revision process. The European Commission supports these measures as long as they are predictable, gradual and volume-based. These conditions are supported by multiple Member States. Meanwhile, concerns about the detrimental effects of high carbon prices on the competitiveness of the EU's energy-intensive industry act as a counterforce in the political debate. While a significant short-term increase in the emission allowance price seems unlikely, the longer term development depends on the concrete measures applied to reduce oversupply (see section 5.2). A strengthened Market Stability Reserve and a higher linear reduction factor may find favour with EU legislators. The prior option could start to have an effect before 2020. The latter option would speed up the reduction of the system-wide annual carbon allowance budget, potentially causing a stronger upward pressure on carbon prices throughout the 2020s.

## 5.2 Measures to move the markets back to situations without oversupply

There are different general possibilities to address the current challenges in power and $CO_2$ markets. There are measures addressing the oversupply of $CO_2$ allowances on the one hand and measures suited to reducing overcapacity in the power sector. When defining these measures, the interactions between both areas must be considered. Higher allowance prices contribute to increasing the electricity price and strengthening the (currently) low price signal for investment in low-carbon generation technologies in the power sector. A higher (long-term) carbon price would also strengthen the market signal for divestment in carbon-intensive generation, helping to reduce overcapacity. Measures suitable to move the $CO_2$ market and power market towards higher price levels are elaborated below.

**Measures affecting the carbon market**

The carbon market has been oversupplied by an accumulation of at least 2 bn emission allowances (equivalent to 2bn tonnes of $CO_2$) since 2013, which is roughly equal to the current consumption of the entire ETS sector in one year (European Commission 2015a). This large oversupply has led to very low prices that fluctuated

[8] In the last months, both markets have been experiencing downward price trends

[9] Assumption for lower end value (and price level in November 2016); coal 70 USD/t (57); gas 6 USD/Mbtu (6.5)

between 4 and 6 €/tonne during most of 2016[10]. A number of measures could move the carbon price upward. These can be price-based or volumetric, i.e. decreasing the quantity of allowances.

Two main measures are being proposed in the current debate on the directive amending the ETS: a higher linear reduction factor and the so-called "Market Stability Reserve" (MSR). Both measures would address the volume of auctioned allowances. The linear reduction factor defines by how much the total stock of allowances is reduced annually. It therefore sets the speed at which electricity production (and industry) covered by the ETS are decarbonised. Raising the factor as proposed from the current 1.74% to 2.2% could be expected to slowly create scarcity and thus raise the carbon price in the long term. It would, however, do little to decrease oversupply in the short term. The MSR has already been adopted as a measure to decrease oversupply in the short term. This mechanism withholds allowances scheduled to be auctioned if the market is oversupplied according to pre-defined rules. The MSR addresses the surplus of allowances from 2019 onward.

More stringent intervention is necessary to increase the carbon price earlier, or to a higher price level. A carbon price floor has been discussed as an option to this end in some Member States[11]. As a price-based instrument, it could set a minimum price at which allowances would have to be auctioned. In order to be more coherent with the quantitative allocation of auctioning volumes, the price floor could also be used as a threshold that needs to be exceeded before new emission allowances are released on the primary market.

With regard to its impact on the power market, it needs to be calculated whether the reforms will have a meaningful effect on price levels in order to change the merit-order of gas and coal plants and lead to an early retirement of coal power plants. It is questionable whether the planned reforms are likely to achieve the carbon price of roughly 35 – 40 €/t $CO_2$, which is required to induce a switch from coal to gas, and are even less likely to induce a switch from coal to renewables that would require a price level of 60 – 90 €/t $CO_2$ (see section 5.1 on the expectations of $CO_2$ price development).

**Measures affecting the electricity market**

As discussed above, one of the reasons for the current low electricity prices is the existence of excess generation capacity in several EU power markets. Markets could return to a state without oversupply in the long run as a result of the progressive retirement of existing plants, and increasing demand driven by recovery from the financial and economic crisis. However, there are a number of possible policy options that could accelerate this process and are in line with long-term EU decarbonisation goals. The issue of excess power generation capacity could be corrected by adopting measures on both the demand side and the supply side:

On the demand side, electrification of the heat and transport sectors has been identified as a key lever for decarbonising the whole economy (IEA, 2014). Setting up policy incentives to increase (flexible) demand for electricity in the transport and heating & cooling sectors could be justified as this additional power demand could offset primary energy consumption and result in significant emission reductions in these sectors. Policies to achieve this goal could include regulations or incentives for electric vehicles as well as "power-to-fuel" and "power-to-heat" solutions.

Policies addressing the supply side could also accelerate the return of power markets to higher price levels. A recent study by the European Environment Agency EEA (Tomescu et al. 2016) shows that a large part of the EU's coal-based power capacity is nearing the end of its lifetime. While the current trend is that operators tend to extend the operation of these generating assets, the above mentioned study concludes that the prolonged operation of inflexible, carbon-intensive power plants, along with the planned construction of new fossil fuel capacity, could result in higher costs for the decarbonisation of Europe's power sector. This would have a lock-

[10] Spot market data from the European Energy Exchange (EEX); available at (https://www.eex.com/en/market-data/environmental-markets/spot-market/european-emission-allowances#!/2016/11/14)

[11] Whilst the United Kingdom applies a price floor of £18 per tonne/$CO_2$ from 2016 to 2020, France recently abolished its plans of introducing a floor price for emission allowances.

in effect and increase the dependence on carbon-intensive power plant capacity. The progressive, regulatory-driven retirement of the oldest, most polluting fossil-fuelled plants could speed up the return of power markets to equilibrium while aligning the EU's power mix with its long-term decarbonisation goals.

During the transitional period of oversupply in power markets, limiting the volume of new supported RES-E capacity could help restore price levels in the medium term. Instead of completely abolishing RES-E support, gradually limiting the annual auction volumes for supporting mature RES-E (in cases where there is large overcapacity in the overall power system) could avoid undermining investors' confidence. These volumes could be guided by long-term RES deployment 'corridor' objectives. This option could accelerate the process of restoring price levels in power markets without undermining the credibility of the renewable energy support scheme, provided that a sufficient planning horizon is used and the other measures are already in place. Once sufficiently high price levels are achieved, the auction volumes for RES-support may be increased accordingly.

The measures described above are aimed at mitigating the effect of existing generation overcapacities in EU power markets; however, there is another contributing factor at play that could undermine long-term investment signals for renewables. This is the downward pressure that low-marginal cost renewables exert on power prices, which was previously referred to as the "merit-order" effect (see section 5.1). The existence of this phenomenon is an indication of the current inability of power markets to swiftly respond to the increased generation of low-marginal-cost wind and solar with additional demand. A long-term solution to this issue requires greater flexibility in the power markets and systems. Overall system and/or market flexibility can be improved by increasing the flexibility of generators and consumers, e.g. through demand-side response programmes, but also by implementing energy storage solutions, increasing interconnection capacity with other systems, adapting power market rules and/or expanding the size of the market.

# 6 Conclusions

In this paper we analysed the multiple arguments in recent literature pro and contra the phase-out of renewables support. We conclude that there are good reasons to continue dedicated RES-E support beyond 2020.

We showed there is no conflict between ETS and RES-E support, assuming that ETS and RES targets are properly coordinated. Furthermore, dedicated RES-E support still holds multiple benefits, even when almost mature renewables like onshore wind and solar PV are increasingly cost-competitive. A review of recent literature reveals there are still significant cost reduction potentials for these technologies. The increased use of renewables has multiple socio-economic benefits in addition to climate change mitigation, including industrial innovation, job creation and the avoidance of fossil fuel imports. Dedicated RES-E support can provide a predictable, secure investment framework that lowers the risk premiums required by investors and therefore reduces the capital costs of RES-E. Due to these effects, the use of RES-E policies and targets in addition to the ETS makes economic sense.

These arguments are still valid when looking at the current market situation characterised by oversupply and low prices on both the power and $CO_2$ markets. There is evidence that RES-E are not the main reason for the current oversupply. It would therefore not be effective to take actions towards restoring market equilibrium in the form of radical or overall phase-out of RES-E support. It would be almost impossible to achieve a cost-effective energy transition driven solely by the carbon and electricity markets. Instead, we identified several measures addressing the main causes of the current problems in power and $CO_2$ markets with the aims of returning to a market equilibrium and an exclusively market-driven energy transition in the medium term: Quantity-based measures to reduce the number of emission allowances, such as strengthening the Market Stability Reserve (MSR), should be applied in order to achieve higher price levels that facilitate the transition to a low-carbon power system. Moreover, ETS measures must be coordinated with RES targets and related policy measures. In a transitional period with high oversupply, RES-E volumes can be controlled and limited through auction-based support schemes that control RES-E deployment and support volumes.

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| *Web:* | www.towards2030.eu |
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# *About the project*

The aim of **towards2030-*dialogue*** is to facilitate and guide the RES policy dialogue for the period towards 2030. This strategic initiative aims for an intense stakeholder dialogue that establishes a European vision of a joint future RES policy framework.

The dialogue process will be coupled with in-depth and continuous analysis of relevant topics that include RES in all energy sectors but with more detailed analyses for renewable electricity. The work will be based on results from the IEE project beyond 2020 (www.res-policy-beyond2020.eu), where policy pathways with different degrees of harmonisation have been analysed for the post 2020 period. **towards2030-*dialogue*** will directly build on these outcomes: complement, adapt and extend the assessment to the evolving policy process in Europe. The added value of **towards2030-*dialogue*** includes the analysis of alternative policy pathways for 2030, such as the (partial) opening of national support schemes, the clustering of regional support schemes as well as options to coordinate and align national schemes. Additionally, this project offers also an impact assessment of different target setting options for 2030, discussing advanced concepts for related effort sharing.

# *Who we are?*

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| Energy Research Centre of the Netherlands (ECN), Netherlands |
| Centre for European Policy Studies (CEPS), Belgium |
| National Technical University of Athens (NTUA), Greece |
| Consejo Superior de Investigaciones Cientificas (CSIC), Spain |
| Ecofys Netherlands and affiliates (Ecofys), Netherlands |
| REKK Energiapiaci Tanacsado Ltd (REKK ET), Hungary |
| European University Institute, Florence School of Regulation (EUI), Italy |