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Challenges and appropriate policy portfolios for (almost) mature renewable electricity technologies

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Abstract

This paper assesses challenges arising for renewable energy technologies that have achieved a certain maturity level in terms of technology development, costs and market penetration. We identify these challenges, which diverge from challenges for less mature technologies and, based on three case studies, we analyse how some of the challenges have materialised and have been dealt with in practice. Case studies include experiences with the occurrence of negative prices in Germany, the question of how to deal with a market situation characterised by overcapacity in Spain and the problem of social opposition towards the construction of renewable power plants in the UK. Finally, we suggest solutions to deal with these issues in order to ensure the 2030 target is achieved, taking into account the changing framework conditions.

Keywords

Renewable electricity, renewable energy policy, policy design, mature renewable technologies

Introduction

The European Union has decided to transform the European energy system for reasons of sustainability, cost-competitiveness and security of supply. The large-scale deployment of renewable energy sources for electricity generation (RES-E) represents a major pillar of the strategy to decarbonise the power sector. There have been substantial cost reductions so far,

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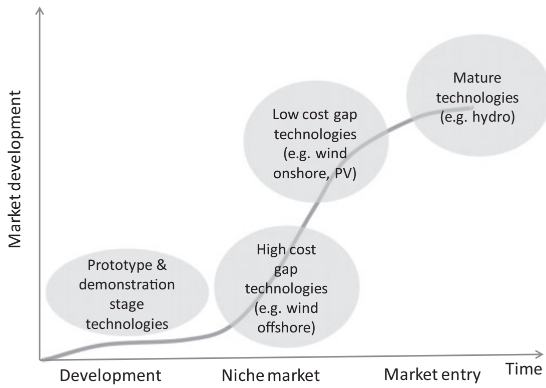

Figure 1. Categorisation scheme for RES-E technologies according to their market maturity.
Source: Based on International Energy Agency.[2]

particularly in solar photovoltaics (PV) and onshore wind, that have brought these technologies close to the levelised cost of electricity generation (LCOE) achieved by conventional generation technologies.[a] The challenge is to offer investors attractive framework conditions for these mature RES-E technologies in order to ensure target achievement by 2030 while ensuring minimal costs for society. This can, for example, be realised by keeping the risk premium for investments low. The aim of this article is to identify challenges arising for investments in (almost) mature renewable electricity technologies and, on the other hand, to suggest policy options to tackle these challenges.

Identifying what is meant by 'almost mature' is not a trivial issue. Following the economics of innovation, the level of maturity of a technology depends on its position in the S-curve and the stage of the innovation process (see Figure 1). Compared to other commercial products, it is more challenging to precisely locate the different RES-E technologies in the S-curve as they usually receive public support.[1] However, there are specific indicators that can be used to determine and compare the stage of technological innovation of individual RES-E technologies. They primarily include the LCOE and the globally installed capacity.

In terms of globally installed RES-E capacities, hydropower represents by far the most mature RES-E technology (1055 GW in 2014, according to REN21[3]). Substantial capacities of wind power (370 GW), solar PV (170 GW) and biomass (93 GW) have already been installed and can thus also be considered mature technologies.[b]

Looking at the LCOE of different RES-E technologies, data from IRENA[4] show that LCOE for hydro-based and some biomass-based electricity generation is in the range of conventional power generators (Figure 2).

There has been significant growth in installed capacity of solar PV and the substantial drop in costs involved already makes PV competitive with conventional power generators. A similar evolution can be observed for onshore wind, attaining even lower levels of LCOE.[c]

In this paper, therefore, CSP and offshore wind are considered as immature technologies and we do not consider geothermal for our analysis. Solar PV and onshore wind are considered as mature technologies at the stage of supported commercial use. Hydropower generation is regarded to be fully commercial. Biomass technologies are partially commercial,

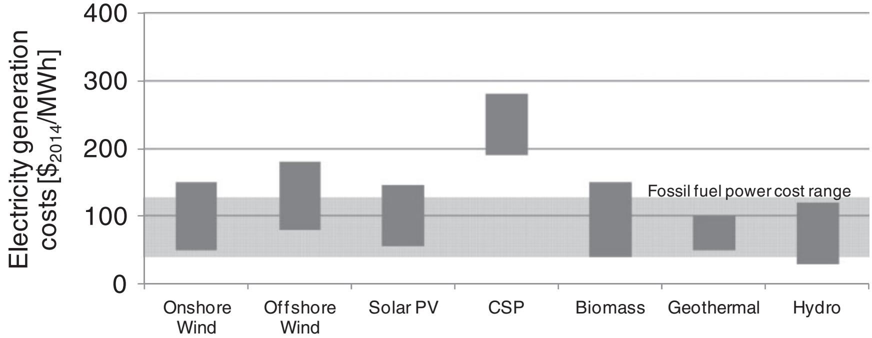

Figure 2. Electricity generation costs in 2014 (2015 Solar PV) of RES compared to costs of fossil fuel power cost.
Source: Own illustration based on IRENA[4] and AGORA for Solar PV (Solar PV in 2015, exchange rate of 2014: USD/EUR: 0.75354).[37]

but there are still non-mature technologies such as gasification plants. Since the range of biomass technologies covered is very broad, we do not consider it as a mature RES-E technology. Instead, we focus on solar PV and onshore wind.

The article is structured as follows. The next section discusses the approach and methodology to identify challenges arising for nearly mature technologies. These challenges and the policy options to address them are discussed before the article closes with a conclusion.

Approach and method

We have identified key challenges for European renewable electricity policy assuming a 2030 perspective based mostly on literature review.[5] The RES-E policy challenges, addressed in this article, comply with two conditions. First, they are directly and indirectly related to factors affecting RES-E deployment in the time frame up to 2030 in the EU through increased market exposure and higher risk premiums for potential investors. Second, these challenges can be addressed through RES-E policy.

Assuming that the perspectives of policy-makers are reflected in policy documents, publicly available EU documents and information sources at member state level have been consulted to identify the challenges. In addition to the official documents, country case studies in scientific journals, relevant information in the ‘grey literature’ and work from other EU-funded projects have been taken into account (see del Río and Peñasco[5] for further details on the methodology).

Each type of challenge and potential policies to remove, or at least minimise these challenges, are addressed in more detail in the following sections. The method is based on qualitative comparisons between different alternatives for each challenge. In addition, we substantiate the analysis of the challenges and possible solutions with selected country case studies. Each section includes a short description of the challenge; we suggest appropriate policy options (instruments, design elements, combinations of instruments) to tackle the challenge and evaluate their strengths and weaknesses.

Challenges and policy options for nearly mature technologies

Each type of challenge and potential policies to remove, or at least mitigate these challenges, are addressed in this chapter. From the investor's perspective, mature RES-E technologies face a number of problems that potentially hinder the further deployment in a scenario of decreasing public financial support. These have been identified as follows:

- Market-based or grid-related curtailment of RES-E
- Retrospective/retroactive regulatory changes
- Additional risks arising from support scheme design
- Shrinking market values of RES-E
- The existence of non-economic barriers.

These challenges are drivers and address different dimensions of RES policy support, but they primarily relate to two issues with associated trade-offs: investor risk and market compatibility. The curtailment of RES-E, retrospective/retroactive regulatory changes and support scheme design risks pose additional risks to investors and thus may lead to an increase of support costs caused by additional risk premiums. One key problem regarding the challenges identified is that reducing the risk premiums typically counteracts the improved market compatibility of RES-E support which is required for increasingly competitive RES-E technologies.

Market-based curtailment

Description of the challenge. The current EU renewable energy Directive requires each member states to ensure priority dispatch for RES-E in so far a secure operation of the power system is guaranteed.[6] With increasing RES-E in the power system, special situations characterised by a highly inflexible 'must-run' electricity generation capacities[d] in combination with low demand have increasingly occurred in European electricity markets (see Figure 3).

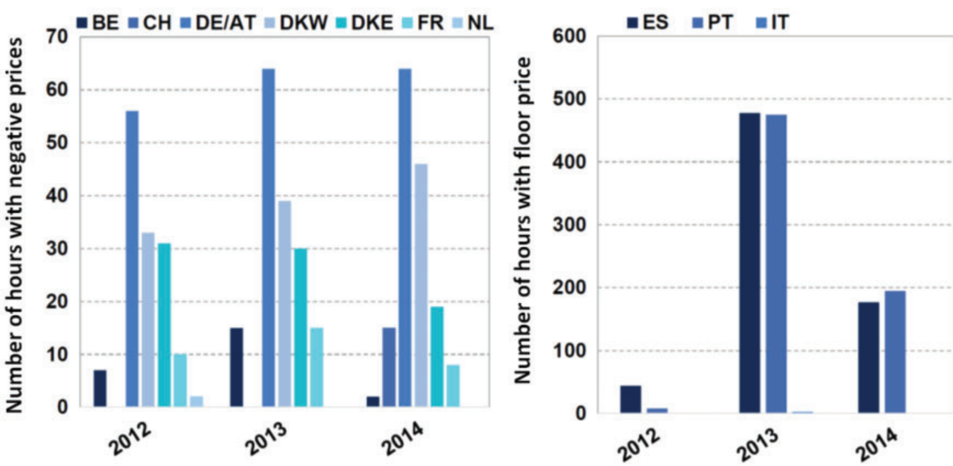

Figure 3. Number of hours with negative prices or with an effective floor price.
Source: Fraunhofer ISI, ZSW C, Burkhardt Beiten Rechtsanwaltsgesellschaft mbH.[7]

These situations may lead to negative prices if permitted by the market design. In recent years, negative prices have been observed during a limited number of hours on the different European day-ahead markets. Fraunhofer et al.[7] show that the number of hours with negative prices or effective price floor (when no negative prices are allowed) for different countries of the EU can be significant. In such situations, the RES-E operator or marketer has no incentive to sell electricity on the market if (1) the electricity is marketed directly under a market premium scheme and if (2) the market price drops below the negative value of the market premium (provided that the premium is paid during hours of negative prices). This behaviour of constrained bidding is also referred to as 'market-based curtailment'.[e]

Negative prices provide a signal for conventional and renewable power generators to stop generating electricity.

The impact of reducing the power output is more severe for technologies with a high share of capital costs, as such technologies need to maximise power output in order to ensure amortisation of the investment. In the case of variable RES, such as wind and solar PV, the electricity output is already limited by the availability of the respective natural resource, and curtailing its generation would further cut the revenue potential.

In order to design appropriate policies that reduce the risk of market-based curtailment, it is crucial to understand the reasons for negative prices. One explanation is that negative prices typically occur at hours with high shares of RES-based electricity generation and low levels of demand. However, the share of RES-E did not exceed 65% of electricity consumption during hours with negative prices on the EEX/EPEX day-ahead market in 2012 and 2013.[8] That is to say that negative prices do not only occur when demand is fully covered by renewable electricity generation. The two major reasons for this phenomenon are: 1) certain conventional power plants (in particular base load capacities) are characterised by technical restrictions that prevent them from shutting down and starting up very quickly or for a short number of hours, and (2) that operators of conventional capacities can also be required to sell electricity at the market at low prices if they have to fulfil additional contractual obligations.[8]

Case Study Germany: No RES-E support in hours with negative prices. The state aid guidelines for environmental protection and energy (124a) of the European Commission[9] require member states, from 1 January 2016, to put measures in place that 'ensure that generators have no incentive to generate electricity under negative prices'. In the framework of the last update of the German Renewable Energy Act (EEG), the government added the new article §24 to comply with these requirements.[10] No feed-in premium is paid in periods of negative prices that last for at least 6 h. Thus, security of investment in wind and solar capacities is not only endangered by negative prices but, in the German case, also forced to shut down at times of maximum RES-E production (given the high correlation between RES-E generation and negative wholesale prices at the spot market).

In the past, the frequency of situations with negative prices that lasted for at least 6 hours has been minimal in the electricity wholesale market.[7] Thus, the regulation of § 24 EEG would have had a marginal effect on the earnings of operators of RES-E installations. However, with further expansion of RES-E capacities, such §24 situations are expected to occur more frequently in the future.

If marketers expected a §24 EEG situation, they would probably adjust their bids in order to counteract a loss of revenue. It is most probable that they would not submit their bids at a price incorporating a negative market premium,[f] but would opt for 0 €/MWh on the day-ahead market. The electricity that was not sold on the day-ahead market would then be put on the intra-day market (if this is within the regulation for managing regional balancing zones). Alternatively, §24 could incentivise marketers to behave in a questionable way with respect to anti-trust and competition law; they might aim to prevent §24 situations by avoiding a negative market price in the sixth hour through a coordinated strategy.

Both strategies are questionable with respect to the efficiency of the wholesale price signal and could, thus, ultimately jeopardise the operation of the market as a whole. In addition, a reduced level of energy sold and a reduced market premium cause losses of revenue for plant operators and marketers.

Policies. The conceivable policy options to address the previously outlined risks for investors comprise (1) continuing to pay the feed-in premium during hours of negative prices, (2) offering compensation payments for marketers or plant operators for revenues lost due to the cessation of the premium payment in hours of negative prices, or (3) coupling of the day-ahead and intra-day markets to cushion the risk-conducive impacts of not paying the premium payment in hours of negative prices. These measures are particularly relevant for countries with a sufficiently high share of non-dispatchable RES-E and other 'must-run' technologies in the power system, and where market design allows for negative prices.

However, situations of negative prices should primarily be avoided as far as possible, for example by adopting the following measures:

- The reduction of the 'must-run' capacity block would diminish the capacity of power plants that potentially place negative bids on the market in order to fulfill additional contractual obligations. Reducing the amount of spinning reserve could be realised by providing better access to the ancillary services market for RES-E generators (e.g. through shortened auctioning periods that are compatible with the RES-E forecast horizon and adapted prequalification requirements) and incentivising more flexibility in the heat sector (power-to-heat measures and heat storage).
- An expansion of transmission capacities between EU countries can facilitate the convergence of spot market electricity prices and thus reduce the frequency of hours with negative prices.[11]
- To increase the flexibility of electricity demand, adequate policies should pave the way for the introduction of time-variable tariffs and possibly provide the regulatory framework for the rollout of the corresponding infrastructure (smart meters). A dynamic design of charges and taxes can provide additional incentives to consume electricity in hours of high RES-E generation.

A reactive policy measure to alleviate risks related to market-based curtailment is to treat it the same as the provision of ancillary services, in terms of downward reserve capacity, and therefore (partially) compensate for any losses in revenue.[12]

Grid-related curtailment

Description of the challenge. In addition to market-based curtailment due to negative prices, RES-E generators may face losses of income through congestion management and grid-related curtailment. The severity of this challenge depends on the frequency of grid congestion. Uncertainty about the frequency of such situations in the future thus represents an additional driver for the risk premium.

There are at least two major reasons for grid-related curtailment: network constraints and network security and inertia (see for instance Klinge Jacobsen and Schröder[13]). These reasons do not necessarily generate a risk for investors, as curtailment may happen on a voluntary basis. However, if it happens involuntarily, it can be understood to be a major driver for the risk premium due to the uncertainty in estimating the potential future loss of income through grid-based curtailment.

Policies. To avoid or reduce grid-related curtailment, a wide range of measures is conceivable. These include the expansion and upgrade of the transmission and distribution grid (including interconnectors and transformer stations between grids of different voltage levels). With the optimised operation of grids, the improved utilisation of the existing grid infrastructure can be ensured with RES-E capacities and reserves. The transmission system operator (TSO) and the distribution system operator (DSO) can make better use of their grids, for instance, through dynamic line rating.[g] RES-E generation can be shortened through automated curtailment. Improved forecasting methods reduce the need for precautionary curtailment. Partial compensation payments for RES-E operators can also trigger the installation of new RES-E sites in regions where grid reinforcement costs are low and curtailment is poor. When curtailment occurs, compensation payments can (partly or completely) cover profits lost by RES-E investors.

Retrospective and retroactive regulatory changes

Description of the challenge. Political uncertainty and instability risk the predictable funding schemes required for a continuous and stable extension of RES-E capacities. Concerns of governments about increasing total policy support costs of mature technologies due to increasing penetration (in spite of lower unitary costs) may lead to retrospective or retroactive reductions or repeal of support.[h] This severely affects the stability and viability of existing RES-E installations and seriously damages the investment climate for new plant. This is a relatively widespread issue across Europe, according to EPIA[14] and Fouquet and Nysten,[15] particularly for solar PV, and include a grid injection fee (e.g. Belgium in 2013, Bulgaria in 2012 and Slovakia in 2014), limitations in generation (Bulgaria in 2013, Spain in 2010), taxes on production (Bulgaria in 2014, the Czech Republic in 2011, Greece in 2013, Italy in 2013 and Spain in 2013) and FIT reduction a posteriori (France in 2011, Greece in 2013, Italy 2014 and Spain in 2010).

Policies. Retroactivity should be avoided in order not to destroy investors' confidence. Problems of rising policy costs have particularly occurred in feed-in systems and need to be tackled before they increase too much. Thus, issues related to exorbitant policy costs should preferably be handled by means of preventive policies, such as using volume restrictions (caps for feed-in systems or tender procedures). Other design elements suited to avoiding excessive policy costs for highly dynamic technologies are different types of degression mechanisms. In future, tender schemes will be a key policy element in combining quantity control and competitive measures for price determination.

Risks arising from support scheme design

Description of the challenge. The landscape of RES-E support schemes applied in the different member states is quite diverse. In addition, the EC requires member states to support RES-E predominantly by applying a competitive auction process from 2017 onwards (see the guidelines, sec. 3.2.2.1, (126), in European Commission[9]). This raises the question of how the different support schemes, and in particular auctions, affect the different market actors and which of the actors concerned is best able to cope with the respective risks. In general, the support scheme cannot reduce existing risks related to the development of RES-E, but it can influence the allocation of risks to the actors. Dealing with these risks involves certain costs and a support scheme should ideally allocate risks to the actor who is best able to cope with them. There is also the question of whether a risk should be borne by the public or private investors. Whilst productive risks can be influenced actively by an actor, unproductive risks are outside the actors' control.

There are several remuneration options for RES-E, including fixed feed-in tariffs (FIT), different options of feed-in premium (FIP) systems or capacity-based payments. Whilst financial support for a feed-in tariff and a feed-in premium is reimbursed by unit of electricity generated, capacity premiums provide financial aid by installed capacity. The fixed feed-in tariff provides full cost coverage, while reimbursement of a premium feed-in scheme to RES-E operators takes the form of a partial premium payment and revenues from selling RES-E on the electricity market. The main advantages of FITs are stable revenue with low investment risk and therefore low risk premiums with respect to RES financing. However, they do not generate incentives for market integration. In contrast, feed-in premiums involve higher market risks for investors, but incentivise market integration of RES-E. Different design options can be used to determine the premium payment, including a fixed premium, a floating premium or contract for difference, where the premium depends on the level of the market price and a premium with cap and floor. The different premium design options can be differentiated according to the associated risk sharing between the RES power plant operators and the public. A fixed premium is usually calculated based on long-term average electricity prices; variations on monthly, daily or hourly basis are not considered. Such variations, however, are taken into account when determining the floating premium, for which reference electricity prices may be calculated on an hourly, daily, monthly or even an annual basis.

When evaluating the different support schemes, fixed market premiums or capacity payments tend to increase the risks of long-term price development for RES-E investors, which reduces the cost-efficiency of market integration of RES-E generators (so-called unproductive risks). Quota obligations particularly affect the risks due to the uncertainty resulting from price variations on two separate markets (electricity and certificates). Thus, sliding market premiums should be given priority as the related risks are productive in the sense that they trigger market-based behaviour (electricity sales at hours of high prices) and improved integration (e.g. enhanced forecasts and thus reduced need for reserve capacity).

Policies. From a government perspective, auctions represent a powerful tool to determine the required level of support while controlling the total costs of support. They are particularly applicable for large-scale projects (such as offshore wind or solar thermal power). However, an auction transfers some risks to the RES-E investor, as costs for planning occur prior to the actual auction process and might end up as sunk costs. Although applying auctions to determine the support level can potentially increase risks for RES-E investors, they may provide a strong impetus for investors to better assess and control their cost structures ('productive' risk) and reduce overall costs for funding. An appropriate risk-minimising design of auctions could include elements such as pre-approved RES-E sites for large-scale technologies, a frequent and predefined auction schedule, efficient seller concentration rules which cap the number and size of bids or the revenue per bidder, deadlines for construction and penalties for non-compliance.[16]

The remuneration should be based on a feed-in premium in order to facilitate market integration. A sliding premium would be the preferred alternative since non-productive risks for investors are avoided, whilst market participation encourages learning by RES-E developers. In contrast, determining the remuneration level based on an administrative procedure, instead of using auctions, is likely to be more appropriate to promote smaller bidders (such as cooperatives) and their respective technologies (e.g. decentralised small-scale wind and PV) due to lower risk exposure for investors.

Shrinking market values

Description of the challenge. Incentivising operators of mature RES-E technologies to sell major shares of their electricity directly on the market represents a recent trend in the design of support schemes. By doing so, RES-E providers would become more market-oriented, react to price signals from the market and relieve public support schemes that need to be publicly financed.

The potential revenue that RES-E providers can generate on the market is expressed by the market value. This equates to the average hourly wholesale electricity price weighted by the respective RES-E generation. If RES-E generation primarily occurs during peak hours, the market value exceeds the average wholesale price (and thus the relative market value is greater than 1). That means the market value depends on the temporal coincidence of RES-E generation with high or low market prices. It is thus affected by the actual electricity generation profile as well as the temporal variation of the electricity price which, in turn, depends on the shape of the residual load and the merit order curve.

Following Pudlik et al.,[17] there are a number of factors that influence the market value (see Figure 4), either through the residual load[i] or the merit order. Thus, an increasing RES-E share reduces the residual load and replaces conventional power plants with higher variable costs in the merit order. Changes in the carbon and fuel price development may affect the merit order of conventional power plants and indicate a fuel switch. In contrast, the direct, short-term impact on the market structure, the conventional power mix and the RES-E support is limited to the merit order; longer-term changes typically affect the share of RES-E technologies and thus also the residual load.

Policy suggestions, to increase the market value of mature RES-E, are designed to consider these factors.

Policies. Rising RES-E shares imply a reduction of market values through the merit-order effect. In addition, there are a number of additional drivers for low market values:

- Lack of flexibility in demand, insufficient storage or grid capacities
- Lack of market coupling and grid infrastructure
- Inflexible power plants and 'must run' capacities.

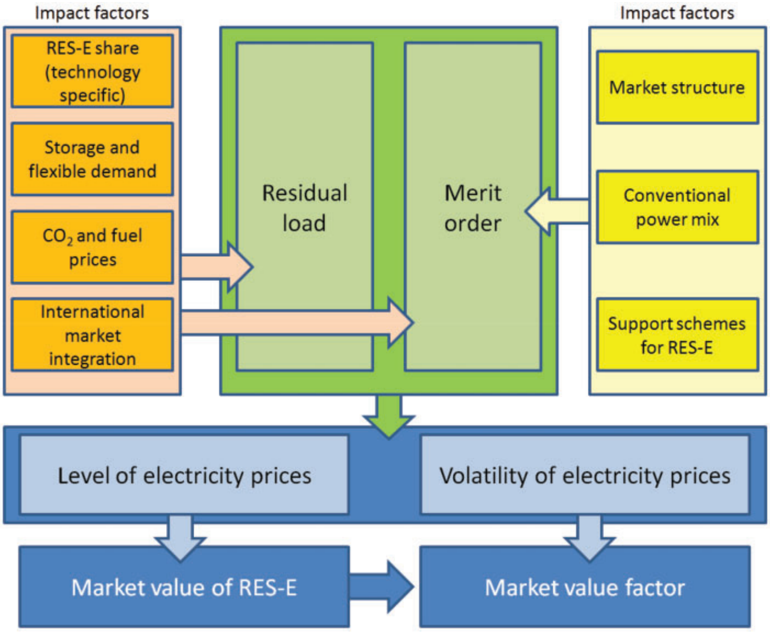

Figure 4. Overview of the factors influencing the market value.
Source: Pudlik et al.[17]

All these factors represent barriers to electricity markets with a high degree of flexibility, required to integrate the increasing share of RES-E.

Several policy measures can contribute to achieve higher market values for variable RES-E:

- The price elasticity of electricity demand can be increased through policies facilitating the introduction of time-variable tariffs. A dynamic design of charges and taxes can provide additional incentives for load management. Coupling of the electricity sector with other sectors can lift demand and thus market values. Sector coupling can, in particular, be envisaged through electrification of the heat and transport sector and a greater use of electricity to generate industrial products and synthetic matters.
- Extending large-scale storage facilities can further stabilise the market values of RES-E.
- The expansion of international net transfer capacities and the further coupling of the European electricity markets allow countries to make use of flexibility options from foreign countries. The simultaneous generation of RES-E can be reduced given the larger geographical distribution of sites. Thus, at a European level, member states should work more on the setting up of an internal European energy market, following the idea of a European Energy Union (see for instance Held et al.[18]).
- In the short term, higher fuel and CO_2 prices increase the market value. Thus, policies inducing stable CO_2 prices should be implemented.
- To avoid the reduction of market values through 'must-run' capacities, policies should facilitate the access to ancillary service markets for RES-E generators.
- The policy framework should not exclusively incentivise projects with the lowest LCOE, but also take into account market values.

Non-economic barriers

Description of the challenge. Non-economic and other regulatory factors pose an important challenge for RES-E diffusion. Their relevance has been highlighted in various research projects, scientific literature and by the European Commission (e.g. European Commission[6,19–22]). According to Ecorys,[23] the most severe types of non-economic barriers are:

- Administrative barriers including problems regarding the planning and authorisation procedure of RES-E projects (delays, great efforts for project developers to obtain the needed permissions or problems related to spatial planning)
- Problems with regard to grid connections (inconvenient grid access conditions, long lead times and low transparency)
- Social acceptance problems and public opposition from locals against RES-E projects (Not-in-my-backyard NIMBY).

Case Study UK: Lack of social acceptance for new wind parks. Despite the fact that the deployment of wind energy, particularly, onshore wind, is slower than in other European countries with less favourable wind resources, the UK government decided to halt subsidies to new onshore wind power plants in June 2015. Although on a national scale, views towards wind power tend to be favourable (see Boßmann et al.[24]), opposition remains strong at a local level.[25]

Despite the advantages that wind power can offer, articles in the media repeating misstatements, the emotive language of journalists as well as each individual's attachment to the landscape and personal concepts of how the countryside should look are entwined with public opposition.[26] The opposition is often triggered by the concern that landscapes are being destroyed and the idea that property prices will drop where wind turbines are in view.[26] This was aggravated by the fact that under the Renewables Obligation, no allowance for different wind speeds was made, which often favoured sites in remote and scenic areas.[27]

Residents living in close proximity are also worried about the noise caused by the movement of blades. Local opposition is often the result of a poorly undertaken public consultation process and a limited perception of fairness and the economic benefits for residents.[25] At the national level, along with the destruction of landscapes, major concerns driving opposition are the unreliability of electricity supply and increasing electricity costs.[28] General beliefs are that onshore wind is both expensive and heavily subsidised by the taxpayer. Variability of electricity supply is another argument that is frequently made against onshore wind.

Policies. Compared with other European countries, NIMBYISM seems to be strongest in the UK. However, the further development of RES-E may also lead to decreasing social acceptance in other European countries. In the UK, a lack of community involvement is seen as a dominant factor in the opposition to wind farm development. As siting decisions are predominantly driven by the private and commercial sectors, residents do not feel involved in the planning process nor do they receive a share of economic benefits. Measures to promote greater citizen involvement and the generation of local economic benefits may increase acceptance of onshore wind, as shown in Germany[29] and Denmark.[30] The Danish Renewable Energy Act contains four instruments to promote such acceptance: (i) a fund to support the financing of preliminary investigations by local wind turbine owners' associations or groups; (ii) a mandatory auctioning of a minimum 20% of the shares in a wind turbine to neighbours living within a 4.5 km limit of the wind farm project; (iii) a right of property owners to full compensation for loss of value to real property due to the siting of wind turbines in their vicinity; and (iv) a fund to enhance local scenic and recreational values, such as nature restoration projects or the installation of renewable energy sources in public buildings.[30]

These measures could be used to inform policy making in the UK. The creation of a fund, under which local added value is increased, as well as encouragement of active participation of the public, can help to overcome local opposition.

Besides increasing local added value, fact-based information campaigns could help to mitigate the effect on the public opinion of common misconceptions about wind power and highlight the wide range of public benefits of this technology. As the concern for climate change has been decreasing in recent times in the UK, renewables and especially onshore wind could be re-framed as a way of tackling, for example, energy security, reducing air pollution from fossil-fuelled plants, driving the development of domestic, high value-added industries and creating jobs.[31] Given that information alone cannot change ideological opposition, a combination of measures, including active public participation and financial incentives is necessary.

Generally, views towards wind farms tend to be more favourable in Scotland.[27] In 2013, Scottish Renewables launched the Onshore Wind Community Benefit Protocol, detailing a consistent approach to community benefits across Scotland. This also includes the sharing of best practices for community involvement and provides more support for local administration.[32]

While there are opposition groups for onshore wind in the UK, France has strong support groups for nuclear power and for this reason also faces non-economic barriers.[33,34] On a more general level, we suggest countries should mitigate non-economic barriers to reduce risks and ensure fair competition between all bidders in the following ways:[35]

- Create a stable and reliable policy framework for administrative processes and spatial planning
- Enhance the diffusion of best practices, e.g. through guidelines
- Harmonise spatial planning regulations and provide uniform national standards
- Introduce time limits for permit approval
- Support local administration
- Provide the public with the possibility of participating in and profiting from RES-E investments.

Overcapacity and low wholesale prices

Description of the challenge. Excessive electricity generation capacity, in short, overcapacity, is a widespread phenomenon across the EU member states. This has been mostly related to unexpected reductions in electricity demand due to the economic crisis. The underlying problem is the inherent difficulty in forward planning of investments when there is uncertainty in forecasting future electricity demand. There is a delay between taking the decision to invest in new capacity and meeting the demand for future electricity generation. Overcapacity has likely been detrimental for RES investments. An obvious reason is that, with excessive electricity generation capacity, additional investments in RES-E are unlikely to capture any market quota. Therefore, further RES-E investments, particularly in mature renewable energy technologies, are discouraged. Related to this is the fact that, with overcapacity, there is an incentive for the government to reduce support for new RES, but also to retroactively change the remuneration for existing RES. An excess of supply tends to reduce electricity prices, which renders RES support more expensive, providing incentives for those cuts.

Case Study Spain: overcapacity as a barrier to the uptake of new RES-E installations. Electricity generation capacity installed has increased significantly in Spain over the last 15 years from 55 GW in 2001 to 108 GW in 2015. This increase has been above the rise in electricity demand over the same period. Most of this new generation capacity came from investments in renewable energy technologies (onshore wind and solar PV) and natural gas-fuelled combined cycle gas turbines (CCGTs).[j] Investment in new conventional generation was mostly driven by expectations of a substantial future increase in power demand as a result of high economic growth rates.

The accumulated installed capacity of RES-E in 2015 is much higher than the historical peak demand, which occurred in 2007 (45.5 GW). In the Spanish system, installed power capacity is currently twice the maximum peak demand in the day (4 February 2015, 8 p.m., 40 GW). The causes of overcapacity are related to the factors affecting both the supply and the demand. Several demand-side factors include the deep economic crisis (reducing electricity demand levels) and very optimistic power demand forecasts in the early 2000s. Supply-side factors included risks related to security of supply (black-outs) in the late 1990s, government investment signals (favouring deployment of CCGTs and RES) and easy granting of administrative authorisations. A fast reduction of the difference between the 'firm' generation capacity and peak hourly demand occurred in the late 1990s, leading to several cuts in electricity supply in Spain in the early 2000s. This led the government to 'urgently' approve a considerable number of CCGT projects.[36] Probably the main driver of overcapacity from the supply-side was the investment signals provided by the government regarding CCGTs and RES-E. Regarding the former, the Plan for Electricity and Gas Infrastructures 2002–2011 envisaged the construction of 14.8 GW of CCGTs. This indicative target was increased to 30 GW in 2005. This government backing, together with relatively low investment costs, shorter construction periods and lower carbon risk compared to coal plants, made investments in CCGTs attractive for utility companies. This was in the context of increasing wholesale prices due to a growing electricity demand. Regarding RES, the Renewable Energy Plans in 1999 envisaged a doubling of electricity generation from RES-E by 2010 (from 39526 GWh in 1998 to 76555). A FIT implemented in 1998 provided guaranteed support in the context of regulatory stability. In fact, support increased after the 2004 and 2007 amendments. For example, the total average remuneration for solar PV and onshore wind, the two technologies that experienced the greatest increase over the period, increased from 37 c€/kWh in 2004 to 45 c€/kWh in 2010 and from 6 to 8 €cents, respectively. The predicted electricity demand and, particularly, the peak demand expectations turned out to be much higher than the actual figures, due to the economic crisis. For example, it was expected that the peak demand would be around 53 GW in 2011 (revision of the Plan for Power and Gas Infrastructure 2002–2011), whereas the actual demand was only 44 GW.

The Spanish example has shown that overcapacity has palpable economic consequences at the system level and for power market actors. At the system level, overcapacity results in under utilisation of assets which, in turn, results in a sub-optimal allocation of economic resources. For renewable generators, overcapacity has two main negative effects. First, the downward pressure on wholesale power prices results in an increased competitiveness gap (the difference between the RES-E generation costs and the revenues obtained from the market), increasing the need for support per unit of energy generated. Second, overcapacity hinders further penetration of renewables in the system, since in such conditions it is difficult to politically justify the provision of economic support for new RES-E plants.

Policies. In order to avoid situations as occurred in Spain, developments of conventional generation need to be carefully coordinated with national renewable energy deployment objectives. Actual levels of deployment, both of conventional and renewable energy, need to be frequently monitored. National authorities – in charge of long-term energy planning – and local and regional authorities – usually in charge of permitting procedures – should coordinate very closely.

The possible solutions to this problem may also open up opportunities to accelerate a broader long-term transition to a low-carbon energy system. The excess generation capacity can be corrected by adopting measures both on the demand and supply side. On the demand side, overcapacity in the electricity system may be an opportunity to accelerate the electrification of the heat and transport sectors. On the supply side, overcapacity could serve as a reason to realise a gradual coal phase-out in the medium term. This could be done by de-incentivising the continuation of the most polluting plants by establishing stricter environmental standards for combustion plants and removing existing subsidies for the consumption of domestic coal. The possibility of removing or adapting existing capacity payments for dispatchable generation plants should be reconsidered.

Conclusions

Our analysis has shown that policy design addressed to support mature RES-technologies needs to react to changing challenges resulting from technology development, reduced electricity generation costs and higher market penetration levels. Less mature technologies still require early support with a high level of investment security. Market integration issues of variable RES-E have become more important and require additional policy features. Thus, market integration should be facilitated when designing support schemes for more mature technologies assuming that these are better positioned to cope with higher risk levels. It requires policy-makers to understand and adjust to market conditions and policies to be designed to find the right compromise between the counteracting factors of market compatibility and investment security.

This paper has assessed the challenges arising for mature RES-E technologies that may impede their further deployment in the run-up to the year 2030. The challenges identified may occur across all EU member states. The general assessment of these challenges is complemented by three specific case studies that describe how they manifested in specific countries (Germany, Spain and the UK). Possible policy options to address these challenges have been suggested.

Three key challenges for continuous deployment of mature RES-E technologies were identified:

- Uncertainty for potential RES-E investors as a consequence of increasing occurrence of (grid and market-based) curtailment, retroactive policy changes and unfavourably designed support schemes. This uncertainty translates into an increase of the revenue risk premium.

- The risk of dropping market values of RES-E technologies, caused for example by the merit-order effect and a lack of system flexibility, resulting in lower profit margins.
- Non-economic barriers, such as administrative barriers, problems with grid connection or missing social acceptance, that discourage RES-E investments despite their economic profitability.

The competitiveness of mature RES-E technologies is strongly affected by the level of revenue risk. Smart policies can reduce these risks for RES-E developers while reducing policy support costs. The decreasing market value of variable RES-E generation is a fundamental problem, which pushes the need for continued subsidy of mature technologies further into the future. At the same time, policies to incentivise the flexibility of power markets (both from the demand and the supply side) will be required in order to accommodate increasing RES-E shares, while keeping system (and support) costs at acceptable levels. Reducing non-economic barriers represents no-regret options that will gain further importance in the period up to 2030 in the context of a better-integrated energy market.

Distinct measures to be integrated into policies are identified in this study. The most effective measures are summarised in the following. They can be differentiated between those to be implemented at a national or European level.

National measures

The relevance of potential RES-E curtailment and the occurrence of negative prices are already a challenge in some member states and are expected to increase further with rising shares of non-dispatchable RES-E. The reduction of 'must-run' capacities can substantially contribute to the prevention of curtailment, and mitigate problems related to negative prices in the short term. Policies should provide access for RES-E generators to ancillary service markets and incentivise enhanced flexibility in the heat sector. In particular, the occurrence of negative prices in times of oversupply can be reduced. Another co-benefit would be a positive effect on the market value of RES-E.

In a mid-term perspective, the introduction of time variable levies, grid fees and other tariff components increases the price elasticity of demand and thus the market value of RES-E. Shrinking market values will become increasingly important with a higher share of variable RES-E in the power system.

The inclusion of cost-containment elements in the design of RES-E support schemes can render political retroactivity unnecessary. Thus, the policy scheme should be flexible enough to correct support conditions for new installations and thus control support costs. Using, for example, auction systems as required by the EC's state aid guidelines as of 2017, which systematically imply a volume control, allows for an early adaptation of the supported RES-E quantity (in the future) while there is no need to perform retroactive regulatory changes. In general, auctions can be well suited to control policy costs for mature technologies, but properly designing and implementing the auction can be challenging. Thus, technology characteristics and the specific market situation need to be considered. Furthermore, auction design should reflect a compromise between exposure to competition and keeping risks at an acceptable level.

A well-shaped, sliding market premium (including frequent auctions as well as transparent deadlines and penalties) can further pave the way for market entry of RES-E generation while reducing the resulting risks and uncertainties for RES-E investors to a minimum. It represents a good compromise between incentivising market integration of RES-E whilst avoiding exposure of RES-E operators to risks they cannot control (unproductive risks).

In the long term, the electrification of additional demand sectors (heat, electricity) and the phase-out or hibernation of fossil fuel plants can contribute substantially to an improved economic viability of RES-E investments.

Involvement of local communities in RES-E projects and the creation of local added value are effective measures to overcome problems of social acceptance. Non-economic barriers need to be mitigated by creating a level-playing field for RES-E in all EU member states in terms of providing stable and reliable policy frameworks for administrative processes and spatial planning. This includes a stronger harmonisation of this framework with other EU member states.

European measures

On the European level, concerted action is required with respect to a creation of a fully functioning internal energy market. These actions should make the electricity market more flexible. Thus, the EU could require the capacity of inflexible 'must-run' power plants to be reduced in the framework for electricity market design. In this way, the frequency of negative prices, where they are allowed, and the associated risks arising for RES-E can be restricted. In addition, the EU could require national regulations to allow RES better access to ancillary markets (e.g. through shortened auctioning periods that are compatible with the RES-E forecast horizon and adapted prequalification requirements). Other examples include providing incentives for more flexibility in the heat sector (power-to-heat measures and heat storage) or increasing the flexibility of electricity demand by providing a regulatory framework for the roll-out of the corresponding infrastructure (smart meters).

Borderless electricity exchange throughout the EU ensures access to cross-border flexibility and reduces simultaneous generation of RES-E. The expansion and upgrade of the existing grid infrastructure (at EU and member states level) can contribute to reducing grid-related curtailment and mitigate the problem of shrinking market values. Setting up an effective ETS with significant carbon prices would make the lower external costs of RES-E generation visible, driving its market value and therefore reducing the need for financial support from sector-specific RES-E policies.

Finally, we suggest setting up a regulatory framework that explicitly excludes the possibility for member states to retroactively or retrospectively revise support conditions for supported projects and therefore provide a minimum level of stability for investors.

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Notes

a. LCOE reflects the total average cost per unit of electricity generated over the lifetime of a power plant and makes it possible to compare costs of different technologies.
b. In contrast, there are only small numbers of installed capacities of geothermal and concentrated solar power (CSP) (12.8 GW and 4.4. GW, respectively). Whilst CSPs could thus be assigned to the phase of pre-commercial or supported commercial maturity, we do not include geothermal for analysis due to low available resource potentials and a low relevance for the European power system.
c. Comparatively high levels of LCOE and a substantially low number of large-scale installations are characteristic for geothermal and offshore wind, indicating a lower degree of maturity. Electricity generation from CSP features a reduction in LCOE but is still far from being competitive.
d. Under the term 'must-run', we understand electric capacities which are typically not disconnected from the grid at very low or even negative prices.
e. Market-based curtailment should not be confused with grid-related curtailment, where congested grids require the curtailment of electricity.
f. The usual behaviour of bidding at the price of the negative market premium is explained by the fact that this is the lowest price at which income can be generated, as the income consists of the market price and the actual market premium.
g. Dynamic line rating relates to a real-time monitoring of physical parameters of transmission system lines to assess the actual transmission capacity, which can substantially exceed the nominal capacity determined under static line rating and worst case conditions.
h. Fouquet and Nysten[14] distinguish between retrospective and retroactive changes, although in some jurisdictions these terms have been used interchangeably. With retrospective changes, newly introduced laws apply from their date of entry into force onwards and also apply to actions or events that have started in the past. Retroactive changes apply to changes made before their publication and to facts that have occurred entirely in the past and change the legal consequences of the completed transactions (Fouquet and Nysten,[14] p. 3–4).
i. The residual load describes system load after deducting feed-in of variable RES-E.
j. Between 2003 and 2010, Spain installed 25.3 GW of natural gas-fuelled generation plants. From 2010 to 2015, the CCGT capacity has remained roughly constant. Installed onshore wind power increased from 6.2 GW to 23 GW over the period 2003–2014.

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