



sustainable energy for everyone



Design features of support schemes for renewable electricity



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Task 2 report

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Summary

The objective of this report is to supplement the European Commission's guidance document for support schemes (SWD(2013) 439) and numerous prior research projects by identifying best-practice design features of support schemes for renewable electricity. The analysis focuses on feed-in tariffs (FIT), feed-in premiums (FIP), tenders and quota obligations. Moreover, the report gives selected examples of Member States using these different options.

Design options common to all support schemes

Generally, we differentiate between price-based and volume-based support schemes. In **price-based** support schemes, the government sets the price and the corresponding volume evolves depending on the respective cost-potential curve. In contrast, **volume-driven** support schemes predetermine the volume and the price develops according to the existing resource conditions and technology costs. Several design options are similar in different support schemes. These include calculating the **levelised costs of electricity (LCOE)** which are then used to either administratively determine support levels (in a FIP or FIT) or to set ceiling prices in the case of auctions/tenders. According to the European Commission (2013), most countries calculate their support levels at some point, which can be based on the LCOE approach.

In price-based support schemes **controlling policy costs and revising and adapting support levels** are two crucial issues. In such schemes, cost control can be achieved by tendering the access to a FIT/FIP, or by defining a cap for the support budget. By adapting support levels, the learning effects of renewable technologies, changing fuel prices or changing raw material prices for power plants can be reflected in the tariff level in order to avoid overcompensation. Support levels can be adapted in different ways, e.g. according to predefined and fixed degeneration rates. However, such degeneration rates have sometimes proven to be inadequate when faced with unexpected cost developments, for instance, due to quick technology learning. Alternatively, tariffs can be adapted after a periodic review to enable reaction to unexpected developments. For this option to be functional, however, policy makers must have intimate knowledge of actual cost levels. A third possibility is to decrease tariffs in line with the additionally installed capacity during a certain time period. For instance, a growth corridor can be defined, according to which tariffs decrease.

In the context of increasing policy costs for RES-support, the fair **distribution of the resulting burden** without adversely affecting the competitiveness of energy-intensive industries is extremely important in order to maintain public acceptance of RES-support. Exemptions can affect the distribution of the burden: Reducing the **burden for energy-intensive industries** that are exposed to international competition may help the competitiveness of these industries. However, such exemptions should be carefully analysed, since the burden is then distributed over fewer consumers and the financial contribution of each consumer increases as a result. In addition, special regulations for **"own-consumption"** such as net metering may be used to incentivise consumption being adjusted to generation in order to reduce grid load. This can encourage the decentralisation of generation patterns.

However, the cost of exempting own-consumption from levies, charges and taxes also has to be distributed over the remaining consumers.

To provide adequate support, **support levels might be differentiated**, typically between technologies and even within technologies, as differentiation is able to better adapt to the individual requirements of each technology. However, an increasing level of detail regarding price or volume typically means higher complexity for parameterisation and transaction costs. In general, the issue of how much the support level design should be differentiated depends largely on the steepness of the cost-potential curve.

There is a fundamental tension in all support schemes: On the one hand, from an investor's point of view, support schemes as well as investment revenues need to be **predictable** and they need to be **stable**. On the other hand, from a policy maker's perspective, **support schemes need to provide flexibility** to adapt to changing circumstances. Thus, support schemes require some flexibility measures to be able to react to changing circumstances but in a predictable way without causing investors unnecessary insecurity.

As the share of RES in the electricity system increases, new challenges arise regarding its **integration into the electricity system**. In order to cope with these challenges, it is crucial to have good forecast systems for RES and to provide sufficient flexibility on the electricity markets, such as flexible intraday dispatch or the availability of balancing products. On the one hand, the increasing RES-share in European electricity markets requires adaptation and system responsibility from RES power plants, such as balancing responsibility. On the other hand, power market design has to adapt to the changing characteristics of the technology mix. This means, for instance, that gate closure at electricity exchanges should be as close as possible to real time in order to allow for changes in the feed-in of variable RES-E. Moreover, renewable power plants should be allowed to participate in balancing markets.

Support scheme-specific design options

Other design options and characteristics are specific to certain support schemes. In a **feed-in tariff** (FIT) system, power plant operators receive a fixed payment for each unit of electricity generated independent of the electricity market price. The main advantage of the fixed feed-in system as experienced in practice is its high effectiveness and low risk premiums. However, if tariffs are not adequately set (reflecting actual production costs), they are not sufficiently cost-effective. Moreover, they are less compatible with the principles of liberalised markets than other policy instruments. In a **feed-in premium**, plant operators have to market the electricity generated directly at the electricity market and receive an additional payment on top of the electricity market price- either as a fixed payment or adapted to changing market prices in order to limit both the price risks for plant operators and the risks of providing windfall profits at the same time.

Strictly speaking, **tender or auction schemes** do not represent a distinct support category, but they are used to allocate financial support to different renewables technologies and to determine the sup-

port level of other types of support schemes, such as feed-in systems, in a competitive bidding procedure. There are different ways to design an auction, but the static sealed-bid and the dynamic descending clock auction or a combination of the two have been used the most to support new RES-E installations. Different mitigation measures exist to ensure that winning bidders effectively implement their project. These include pre-qualification criteria required to participate in the bidding procedure, bid bond guarantees and penalties in case of non-delivery or delays. The aim of these measures is to reduce the number of bidders to those with serious intentions and the financial and technical ability to implement the project while maintaining market liquidity. Experiences with auction schemes have shown that auctions can be successfully applied to increase the cost-effectiveness of renewables support. However, finding a compromise between encouraging high implementation rates without reducing the number of market participants too much proved to be a difficult task. The outcome of auctions not only depends on the concrete design but also on the prevailing framework conditions. These include the attractiveness of the renewables market and resource conditions, economic growth perspectives, the number and characteristics of potential bidders and the existence of additional administrative and grid-related barriers.

Quota obligations constitute a fully distinct support scheme: Power plant operators receive certificates for their green final energy, which they may sell to the actors obliged to fulfil the quota obligation. Selling the certificate provides an additional income on top of the common market price of the final energy sold. The main advantages of the quota obligation with TGC markets are the high compatibility with market principles and the competitive price determination. However, high risk premiums resulting from the uncertain development of the prices of electricity and the certificates typically increase policy costs. Provided that quota obligations are designed in a technology-neutral way, only the most cost-effective technologies are supported, theoretically resulting in a high static efficiency. At the same time, dynamic cost efficiency tends to be low, since most of the cost-intensive technologies do not receive sufficient support. In case of a typically technology-neutral quota, windfall profits may occur for the lower cost technologies. Technology banding (i.e. distributing different amounts of certificates according to the technology) might partially address this issue. Moreover, floor prices can be introduced to reduce the risk premium. However, a quota obligation which features a cap and floor price and technology differentiation is hardly distinguishable from a FIP.

In addition to those support schemes, **investment support, low interest loans and tax exemptions** can be used to support renewables.

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1 Introduction

It is the objective of the European Union to increase the share of renewable energy sources (RES) in our energy system. More precisely, the RES Directive 2009/28/EC determined binding targets of 20% share of RES in final energy consumption and a 10% minimum target for renewable energy in the transport sector by 2020. At present most renewable energy sources (RES) still depend on financial support from different support schemes. In the past, EU Member States have implemented heterogeneous types of policy instruments to promote the use of RES. There is already considerable experience available with the use of support schemes, but changing framework conditions require the continuous adaptation and reform of the currently applied support schemes. For example, increasing support costs due to the strong growth of cost-intensive technologies such as solar PV development in Germany, Italy and the Czech Republic suggest a stronger focus needs to be placed on cost control mechanisms. In this context, tender or auction mechanisms have been increasingly applied inside and outside the EU to control the additional RES-capacity eligible for support and to determine support levels in a competitive bidding process.

With a view to guiding Member States in the reform and design of their RES policies, the EC has recently published a document with recommendations for future policy design (European Commission 2013)¹. It is the objective of this report to supplement the EC's guidance with an analysis of the different design features of different types of support schemes and common design options.

Therefore, we compare and assess design options that can be combined with different support schemes in a first step in chapter 2 including the following issues:

(1) Administrative determination of support level

We show how the costs of producing electricity can be calculated as a basis to determine the support level and assess the political and administrative processes in which the actual support level is defined.

(2) Policy cost control and adaptation of support level

Different ways of how to control policy costs including adaptation processes of support levels are presented and briefly assessed. This includes approaches to dynamically adjusting FIT, e.g. fixed versus deployment-dependent degression rates.

(3) Burden-sharing methodologies of RES-support

Here, we first compare different approaches to reduce the burden for energy-intensive industries resulting from RES-support. The second part deals with special regulations for onsite consumption which can also have an important impact on burden-sharing.

¹ http://ec.europa.eu/energy/gas_electricity/internal_market_en.htm

(4) Differentiation of support level design

The degree of technology differentiation of RES-support significantly determines the possibility of windfall profits, but also has important implications for the complexity of support scheme design and for parameterisation.

(5) Predictability, stability, and flexibility of support instruments

Predictability, stability, and flexibility are important but potentially conflicting characteristics of support schemes. Whilst predictability and stability aim to provide a secure investment environment, flexibility is required to adapt to changing circumstances, such as reducing support levels to reflect decreasing generation costs.

(6) Integration into electricity markets

The integration of increasing shares of weather-dependent RES into the electricity market poses additional challenges. Therefore, we analyse which design elements favour the smooth integration of RES into the electricity system.

In a second step, we evaluate support scheme-specific design features and focus on feed-in tariffs (FIT), feed-in premiums (FIP), tenders/auctions and quota obligations. The support scheme-specific analysis in chapter 3 starts with a theoretical evaluation based on criteria such as effectiveness, cost-effectiveness, market compatibility and ability to react to dynamic changes. Then, we present and briefly analyse practical experiences with these support schemes from within Europe and overseas. Instead of providing a comprehensive country comparison, we pursue an explorative approach and focus on the main lessons learned from each case.

Section 3.1 about fixed feed-in tariffs (FIT) focuses on implementation in the heating sector. When analysing feed-in premium (FIP) systems – see section 3.2 – we present different options of premium design, including a fixed premium, a floating premium and a premium with cap and floor. These premium design options can be differentiated according to the associated risk sharing and the market exposure for plant operators. In section 3.3 on tender or auction systems, we provide an introduction to different auction procedure design options and examples of combining auction or tender schemes with feed-in systems. The assessed examples have been chosen to show the broad variety of objectives and technology focuses that can be addressed in tenders or auctions. We analyse the suitability of existing auction procedures and rules depending on the objectives, the technology focus and other framework conditions. The assessment of quota obligations in section 3.4 focuses on the implementation of technology-neutral versus technology-specific quota obligations and presents an example where heating technologies have been integrated into a quota obligation for electricity. The final section 3.5 of the support scheme-specific design options presents a short overview of investment incentives, low interest loans and tax reductions.

2 Design options common for all support schemes

In this chapter we aim to analyse design options that may be used in different support schemes. Although some of the design elements may be better suited for a certain type of support scheme (mostly related to the criteria shown in Chapter 3) these common design options can be applied independently from the support scheme type. However, the suitability of these design options for different support schemes may vary. Therefore, we evaluate the suitability of the presented design options for the different support schemes.

2.1 Administrative determination of price and volume elements

Support schemes require either the determination of the prices in terms of support levels – price-based support schemes – or the quantity target – in case of volume-based support schemes. This determination may occur in an administrative procedure, which requires knowledge of the generation costs. This includes the calculation of levelised costs of electricity (LCOE) which in turn is used to either administratively determine support levels (in a FIP or FIT), to set ceiling prices in the case of auctions/tenders or to determine multiplier for a technology-specific quota.

The majority of Member States that uses FIT and FIP determine the support levels administratively. This is in contrast to an auction/tender that organises access to financial support and determines the level of a tariff. Most countries in Europe use a cost-based approach to calculate the required support level, but some Member States base the support level on the estimated “external” costs that renewables help to avoid, such as avoided CO₂ emissions or avoided health damage from avoided pollution. Other aspects that might be included in such an approach are avoided final energy or fossil fuel imports and increased energy security (Klein et al. forthcoming: 28-29). However, such calculations heavily rely on estimations and do not reflect the cost of producing energy. Therefore, and in accordance with the practise in most Member States and the European Commission (2013) advice to use a cost-based calculation approach, this chapter will focus on two aspects of the administrative determination of support level(s):

- first, the calculation of costs to produce electricity and,
- second, the political and administrative process in which the actual price and volume elements are defined.

2.1.1 Calculation approach of costs to produce electricity: levelised costs of electricity (LCOE)

The idea of an efficient support scheme implies that support levels should provide sufficient support in order to encourage investment without providing overcompensation. The most recommendable approach (and favoured by the EC) to achieve this goal is to determine price or volume elements via 'levelised costs of electricity' (LCOE). This approach allows a comparison between different energy technologies considering the overall lifetime of a plant (see, for instance, Kost et al. 2012; Prognos 2013). Based on the LCOE the financial gap between RES generation costs and energy market prices can be determined.

LCOE represents the present value of the total cost of building and operating a plant over its financial life (net present value – cash flow model), converted to equal annual payments (Klessmann et al. 2013). Thus, a support level calculated based on LCOE can be interpreted as the minimum required income over the economic life-time of a project. This remuneration may result from electricity sales (€/MWh) and a FIP or from a FIT (Klein et al. forthcoming). Tariff determination based on LCOE can be divided into three steps (Bauknecht et al. 2012):

- first, defining cost parameters;
- second, calculating a revenue projection;
- third, transferring LCOE into actual support levels.

Typically, the LCOE is calculated over 10 to 40 years lifetime of an installation and per unit of electricity generated (e.g. €/MWh). Depending on the planned duration of the support payments, the support level has to be adapted to the LCOE: the shorter the support period, the higher the support level in order to guarantee profitability. The LCOE is normally calculated by a cash flow model, which incorporates relevant technical, economic and fiscal variables. However, the level of sophistication and detail can vary significantly among models.

Defining and setting cost parameters

The first step is to define cost parameters: The RES generation costs from the RET project/investor's perspective consist of the following basic elements (based on Klessmann et al. 2013):

1. Investment-related costs:
The capital expenditure (CAPEX) for technology/equipment, land, construction and project development (costs for permits, grid connection contracts, and consultancy) leads to capital costs and the depreciation of the respective assets. Capital costs are determined by the interest rate for debt, the required return on equity, the debt-equity ratio, the period for which debt and equity need to be committed, and fees paid for acquiring the required capital (structuring finance) and depreciation.

Among others, the weighted average cost of capital (WACC) strongly depends on the investment risk, which is expressed as a risk premium on top of the risk-free reference rate (e.g. Euribor or the country-specific interest rate). The investment risk subsumes all kinds of project risks, i.e. technology, country, policy, bank- and investor-specific risks. Calculating the levelised cost of electricity under different policy regimes shows that the cost of capital can represent 20 to >50% of levelised cost of electricity in an average wind or PV project, i.e. in projects without fuel costs (Rathmann et al. 2011).

2. Operation & Maintenance (O&M) costs:

The operating expenditures, i.e. fuel and maintenance costs and cost for service contracts, guarantees and insurances, network-related costs (depending on network access regime), costs of market integration (e.g. balancing costs) once the RES plant is operational. The O&M costs are partially fixed and partially variable (see Schroder et al. 2013).

Compared to other energy technologies, the capital costs of RET projects are typically high, while the operating costs are very low, especially for supply driven RET that do not have any fuel costs, such as solar and wind energy. Only biomass plants imply a significant operational cost element that can vary considerably.

How these cost components are defined in detail can largely influence the outcome of the LCOE calculation (Bauknecht et al. 2012; Schröder et al. 2013), effectively more than the applied calculation method. Moreover, a particular difficulty in determining the LCOE is the dynamic development of most cost elements: The price for power plants and the installation costs tend to decrease as a technology is applied due to the so-called experience curve effect or due to technological learning. To reflect the decreasing costs in the support policy, a predefined degression of the tariff level by a certain percentage per year for new installations, based on an assumed learning/experience curve, can be applied (also see section 2.2).

The second step is to calculate a revenue projection, in order to calculate the required support level (Kost et al. 2012: 8). Revenue elements include for instance:

- Avoided costs for electricity purchase due to self-consumption (also see section 2.3.2)
- Revenues from selling electricity at the wholesale market in case of FIP/Quota
- Avoided costs from tax reductions, investment incentives and low interest loans
- Sales of guarantees of origin

The third and final step is to set the support level, which is supposed to provide an adequate profitability. As revenues often fluctuate, such as from selling electricity at the wholesale market, the support level effectively paid should be determined ex-post (and be adapted to actual revenues) (Bauknecht et al. 2012). However, this depends on the support scheme and is only applicable in case of a FIP or a Quota.

When setting the support level, it can be differentiated between technologies and site qualities in order to reflect heterogeneous generation costs. At the same time the principle of competition be-

tween producers, technologies and locations should be respected, regardless of the applied support scheme. This means that while technology and load factors can be included into a support scheme design, they would need to be restricted and should not fully compensate for revenue differences based on sites and/or technology.

2.1.2 Political and administrative process in which the actual support level is defined

While the LCOE approach to tariff calculation is the most commonly used in Europe, the procedure to finally set the tariffs differs strongly between Member States. The two main challenges in this respect are, first, gaining knowledge on actual production costs. Here, significant transaction costs can occur, for instance, for market studies on LCOE. Second, the potential lobbying that can occur in the process between calculating the LCOE and the final tariff setting, which can result in either significantly higher than required support levels or in too low support level, depending on the extent to which either lobbying group (conventional or renewable) are able to exert influence on this process.

The tariff setting process in Germany

We briefly present the process of tariff setting in Germany and setting ceiling prices in the Netherlands, which are both related to how LCOE calculations are applied in tariff setting. In Germany, tariffs are based on the calculation of the LCOE. The tariffs are reviewed regularly by the Ministry for Environment (BMU), in accordance with the Federal Ministry of Food, Agriculture and Consumer Protection, as well as the Federal Ministry of Economics and Technology. The LCOE calculation takes place within the general process of evaluating the experience gained with each amendment of the main German support scheme, the "EEG". In these evaluation reports ("Erfahrungsberichte"), which are due every four years, the Ministry of the Environment assigns external experts to review the rates and to conduct a cost analysis.²

The evaluation report is the basis for a draft of amendments to the support scheme (and to the tariffs more specifically). However, before being translated into tariff adaptations, the draft of amendments is discussed in and has to be approved by parliament. On the one hand, concerns have been raised that this procedure opens up opportunities for lobbying through the respective industries, thereby weakening the initial approach of setting tariffs on a purely objective or scientific basis. In this sense, tariffs in Germany are not purely defined administratively, but rather in a mix of an administrative and political process. On the other hand, this final step can mean that tariffs are adequately adapted to political preferences, for instance, to distribute wind onshore installations over different regions in Germany or to give preference to one technology over another.

² For the EEG 2011, evaluation reports for each technology can be found here: <http://www.erneuerbare-energien.de/die-themen/gesetz-verordnungen/erneuerbare-energien-gesetz/eeg-erfahrungsbericht-2011/> (in German).

Determination of ceiling prices in the Netherlands

A very different case to use the LCOE calculation approach is applied by the Netherlands. In the Dutch SDE+, the final tariffs are not determined administratively, but the LCOE calculation is used to set technology-specific ceiling prices in the auctioned tariffs (see section 3.3.3 on the Dutch system). However, the LCOE based process had also been applied in the former support scheme SDE, in which the tariffs were defined administratively. At the beginning of each year, the applied ceiling prices are reviewed and adjusted by the Ministry of Economy. The underlying LCOE are calculated yearly for each technology category by ECN, the largest energy research centre in the country and DNV KEMA, a private sector company active in energy-related consultancy activities. The respective report is extensive, applies a high level of transparency and contains detailed calculations and their parameters.³ Usually, the Ministry directly adopts the recommendations given by ECN without any additional parliamentary process, as in the German case.

In Task 6 of the project, concrete proposals with proposals for data sources will be developed that allow for concrete applications of best practices to determine LCOE.

2.1.3 Summary and short appraisal

Most countries in Europe use a cost-based approach to calculate the required support level, the so called "Levelised cost of Electricity". This approach allows us the costs of different technologies to be compared in order to provide just the right amount of support to trigger investment without over-compensating investors. First, cost parameters are defined, including investment-related expenditures and costs and Operation & Maintenance (O&M) costs. How these cost components are defined in detail can heavily influence the outcome of the LCOE calculation. Second, revenues are calculated in order to, third, determine the required support levels. Significant differences exist between countries concerning to what extent the tariff level is determined by the LCOE calculation or whether tariffs are determined politically. Defining tariffs in a political process might be prone to lobbying and expose policy makers to asymmetric information that distorts tariff levels.

2.2 Policy cost control and adaptation of support levels

The strong increase in deployment of some RES-E technologies experienced during the last five years, including in particular cost-intensive technologies such as PV in Germany, have led to a considerable increase in policy costs. This situation, together with the economic crisis, has made the **control of RES deployment** and the associated **policy costs** increasingly relevant in recent years in the public debate.

³ <https://www.ecn.nl/projecten/sde/>

On the one hand, limiting the RES expansion and thus related policy costs provides **higher predictability** of policy costs and allows for a better planning of the future electricity system. By restricting the growth of RES, investment uncertainties for conventional power plants and other flexibility options that contribute to integrating variable RES-E are reduced. On the other hand, caps for RES-development imply at least a partial transfer of market risks regarding the demand for RES-E from the public to renewable power plant operators, leading in turn to **higher risk premiums**. Particularly high risks arise in case of low political stability with maximum impacts if the government changes support conditions for existing RES power plants. When designing the implementation of a cap system, additional risk premiums should be kept low, whilst guaranteeing an effective cost and volume control.

2.2.1 Design options for limiting policy costs

To limit policy costs, the cap may be set either in terms of **volume** or directly in terms of policy **costs**. The volume can either be expressed in terms of **capacity/power** or **generation**. In principle, the different dimensions can be combined with assumptions on LCOE to convert cost into installed capacity and the expected full-load hours to convert capacity in generation terms or vice versa. The control effect of volume-based or cost-based caps may be less accurate in case of technology-neutral restrictions, since the future RES-technology mix is uncertain and costs of different technologies may vary considerably.

Control of policy costs can be applied for all support instruments, but the implementation design varies depending on whether instruments are based on principles of **price** or **volume control**. In **volume-based support instruments** such as quota obligations and auction/tender schemes, there is an implicit cap on policy costs through the target, usually defined in **volume terms**. Assuming that certificate prices decrease to 0 if the predetermined target is achieved, overall policy costs are restricted automatically. However, in a volume-based support scheme such as a quota obligation, uncertainty exists regarding the cost restriction resulting from the uncertainty about the certificate price. In a technology-specific quota with banding additional uncertainty exists because the resulting technology mix and the technology-dependent value of one unit of electricity is unknown. Potential risks of very high certificate prices can be mitigated through **penalty payments** for actors who do not meet their target. Besides contributing to the formation of a market price for the certificate, penalties are maximum limits for the certificate price⁴. All EU countries applying a quota system with tradable green certificates include penalty payments, although some countries define fixed values, whilst others (SE) define them as multiple of the current certificate price. However, penalties as multiple of the certificate price are less suited to function as cost-control mechanism than fixed penalties. The reason for this is that the penalty varies with the certificate price in case of multiple penalties and does therefore not provide a predetermined fixed maximum price.

⁴ The certificate price cannot exceed the penalty payment, since an actor who is subject to a renewables obligation would always prefer to pay the penalty instead of the theoretically higher quota price.

Apart from the type of support instrument, approaches to control policy costs may differ according to the following design options⁵:

- The time horizon for which the volume or cost limit is defined.
The cost limitation may be defined either with regards to the short-term horizon (e.g. on an annual basis) or refer to a longer time horizon. Determining the limit on a short-term horizon provides better predictability for policy makers and project developers and may restrict strong deployment of less mature (and thus more costly) technologies more effectively. Caps defined on a longer-term horizon provide more flexibility for plant construction and may lead to decreased risk premiums.
- Technology level.
The cap can either be determined technology-neutrally or technology-specifically.
- Budget monitoring and control as well as dynamic caps.
Regular reviews may be implemented in order to control and potentially adapt the cap to the changing developments in terms of exploited capacity and costs. However, allowing for a flexible adaptation of the caps results in lower predictability of the composition of the electricity system (i.e. the power production fleet).

In **price-based mechanisms** (i.e. feed-in systems) a revision and adaption of the initially set support levels is one important feature of policy cost control. To adapt tariff levels to real cost requirements, learning effects of renewable technologies, changing fuel prices or changing raw material prices for power plants may be considered. On the one hand, adapting tariffs is crucial in particular for technologies with a very dynamic cost development such as Solar PV. On the other hand, changes in support levels have to be foreseeable to avoid resulting in risks for investors, and subsequently increased risk premiums that could in turn also increase support costs.

Since volume-based support instruments automatically include some kind of policy cost control, we focus on analysing practical experiences of how to implement cost or volume control in price-based instruments with a focus on feed-in systems. Whilst a separate section is devoted to competitive allocation mechanisms (see section 3.3), the adaptation of support levels and the setting of caps without combining it with a competitive allocation mechanisms are described subsequently.

2.2.2 Examples for limiting policy costs in feed-in systems

Fixed depression rates after a certain time horizon

The application of fixed depression rates corresponds to a reduction over time with predetermined depression rates. This mechanism provides a high level of predictability, but provides only a little range of cost control if actual cost development differs from anticipated cost reductions defined in the

⁵ In case of a quota system, these design options are usually predefined by and in line with the design of the quota obligation. More flexibility regarding the concrete design exists in case of price-based support instruments.

fixed degression rate. Experiences with fixed degression rates for Solar PV have shown difficulties to predict the cost development, in this case leading to an underestimation of cost reductions. Fixed degression rates may be well suited for technologies with predictable cost development and with low expected cost decreases. However, additional periodic reviews should be applied in order to control whether the degression formula is adequate.

Degression after periodic review

Alternatively, a degression mechanism may be introduced based on periodic reviews on current cost levels. However, this approach requires precise knowledge of cost levels and may involve high transaction costs by means of required studies. One example for such periodic reviews is the aforementioned process in Germany. In Greece, the revision of tariffs for PV power plants is undertaken more often than for other technologies, but PV power plant producers have 18 months to start plant operation at the initially agreed feed-in tariff. However, this comparatively long timeframe enables unnecessary windfall profits and may lead to inefficiencies in support for technologies with a very dynamic technology development.

Capacity-dependent degression

After the fixed degression of tariff levels proved to be insufficient to adequately reflect cost developments, several countries introduced more complex mechanisms, whereby tariff reductions depend on the actual exploitation of RES. In some cases this degression type is applied in combination with a periodic review of tariffs or a maximum cap.

In some cases support level reductions apply, **as soon as a certain target is achieved**. One example for this mechanism is the **California Solar Initiative** (CSI), a solar rebate program, which foresees that predetermined tariff level degressions are realized, if intermediate targets are reached (Kreycik et al. 2011). In order to avoid speculative queuing in the first-come first serve allocation of reservations for support, projects with a size over 10kW have to pass a three step procedure and provide a series of documentations including a "Proof of Project Milestone Package". Kreycik et al. (2011) judge the transparency on the remaining volume to be crucial for the smooth functioning of the system. It is probable that achieved cost reductions observed have been mainly due to global developments, rather than location-specific improvements of the installation procedure (Kreycik et al. 2011).

Other options of how to implement a capacity-dependent degression is to change tariffs according to the level of past capacity development. Currently, **Germany** has been adapting its feed-in tariffs for Solar PV according to the level of capacity growth by means of the so called "**breathing cap**" feature since 2009. Different growth corridors have been defined which in turn are related to a certain change in the degression rate. In a revision from 2010, tighter steps were introduced, in addition to cuts of PV tariffs ranging from 11 to 16% in order to reflect the strong cost reductions experienced. Since 2012, tariffs paid for solar PV are automatically reduced by 1% per month and every three months the "breathing degression" is applied in addition to the monthly reduction. However, in con-

trast to its original intention, initially the German breathing cap resulted in even stronger capacity growth by motivating investors to anticipate their investments with more favourable support conditions. This effect has also been encouraged by an overcapacity of PV manufacturers. As a result the adaptation of tariffs has been spread more evenly in order to avoid this unintended effect. This experience shows that the parameterisation of such a dynamic tariff degression mechanism is challenging in particular for dynamic technologies, such as Solar PV. Detailed periodic reviews may still be required to react to unexpected developments or potential technology breakthroughs. Beyond tariff reviews, caps on volume have their merit in controlling capacity development of fast evolving technologies.

In contrast to the German system, where beyond the overall 52GW cap no explicit maximum limits for PV capacity are being used⁶, **Spain** introduced technology-specific maximum capacity limits for Solar PV in 2009 to limit the previously strong PV development⁷. Thus, **quarterly calls** were organised to allocate predetermined feed-in tariffs to different projects. Besides the purpose of the capacity limit, the degree of target achievement was used to adapt feed-in tariffs for Solar PV. However, the introduction of this system was perceived as an abrupt change of the support scheme, leading to considerable uncertainty about the future of Solar PV support (Kreycik et al. 2011). Strongly restrictive quantities defined in the calls led to considerable bankruptcies and employment losses in the Spanish PV sector (Mir, 2012).

Another option of how to use capacity-dependent degression rates is used in the "**Oregon Volumetric Incentive Rate Program**", a pilot program for Solar feed-in tariffs introduced in 2009, where the degression depends on the speed of achieving a bi-annual capacity allocation (Kreycik et al. 2011).

Budget caps without competitive tariff determination

One example for using budget caps in feed-in systems is the British renewables support scheme. The **United Kingdom** controls levy-funded spending by means of the **Levy Control Framework (LCF)**. The control framework sets a cap on the cost for all levy-funded expenses such as the Renewables Obligation, Feed-in premiums and the Warm Home Discount (and in the future Contract for Difference - CfDs). The objective of the LCF is to make sure that the Department of Energy and Climate Change (DECC) achieves its energy and climate change goals in a way consistent with economic recovery and minimising the impact on consumer bills (HM Treasury, 2011). Cap limits are published until the year 2020/21. As of 2015, the LCF applies to all electricity policies in general. Non-electricity policies that are levy-funded, such as the Warm Home Discount, are not part of the LCF anymore (DECC, 2013). The cap to electricity policy levies is set to £ 4.3 billion for the year 2014/2015 and

⁶ Germany limited the total support of PV to an overall capacity of 52 GW.

⁷ Installed PV capacity in Spain already exceeded the national target set in the „Plan de Energías Renovables 2005-2010“ (PER) for 2010 by 85%. In September 2008 installed PV capacity amounted to more than 3 GW.

will rise to £ 7.6 billion by 2020/2021 (DECC, 2013). For each of the policies covered by the LCF a spending envelope is defined by DECC on an annual basis.

2.2.3 Summary and short appraisal

Dynamic cost developments for certain technologies require the adaptation of initially determined support levels. Thus, the support system should allow for some flexibility in order to react to cost reductions, in order to ensure the overall stability of the investment environment. **Fixed depression rates** seem to be a reasonable option where cost development is quite predictable. In the case of unanticipated cost developments, however, this design option is not able to adapt quickly to real cost reductions. **Capacity-dependent depression rates** are suitable for technologies with a significant cost reduction potential such as solar PV in order to control policy costs. Putting depression mechanisms in place provides incentives for early investment and therefore increases policy costs. Disruptive or unexpected cost reductions cannot be anticipated and could be dealt with by realising additional **adaptations** of the support level **after a certain time horizon**.

2.3 Burden Sharing of RES-support

In the context of increasing policy costs for RES-support, the fair distribution of the resulting burden without adversely affecting the competitiveness of energy-intensive industries is extremely important in order to maintain public acceptance of RES-support. Several crisis-hit Southern European countries have already announced suspension or have suspended RES-support for new power plants (e.g. Czech Republic, Portugal, Bulgaria) and Spain has retroactively replaced the existing feed-in support for plants in operation with payments, whose form and level are still unclear, but that should allow for a predefined compensation. The relevance of the applied burden-sharing approach depends in particular on the overall share of RES in the system and on the cost level of respective renewable energy technologies used in the system. Examples of how energy-intensive industries may receive special treatment with regard to bearing RES-support costs are briefly analysed in section 2.3.1.

Special regulations for onsite-consumption may also have an important impact on the burden-sharing, since auto-consumed electricity may be exempted from or profit from reduced certain levies, charges or taxes. Examples are described in section 2.3.2.

2.3.1 Burden-sharing methodologies and energy-intensive industries

In principle, funding may either come from a **public budget** (thus, paid for by tax payers) or from a **levy** linked to the consumption level and included into the final energy price (thus, financed by consumers). In the electricity sector most of the EU Member States distribute policy costs for RES-E support among all electricity consumers by imposing a levy per unit of electricity generated on top of the electricity price. In its recent proposal for guidelines on support schemes the EC clearly states a preference for financing RES-support via levy (European Commission 2013) in order to make RES-

support more compatible with European rules on state aid and the environmental polluter pays principle. According to European Commission (2013) almost all countries already finance their RES-support off-budget. Only Luxembourg and partly Belgium still use a state budget for bearing the main part of RES-support costs.

Many countries apply different types of **exemptions** for energy-intensive industries, since electricity costs represent a significant part of their total expenses. The preferred treatment of energy-intensive industries by granting exemptions or reductions of the required levy improves the international competitiveness of these industries, but increases the burden for the remaining consumers at the same time. Consequently, only companies who actually need an exemption or reduction to withstand international competition should be granted such privileges. Adequate **criteria** have to be defined to determine which companies should be exempted from or contribute less to finance renewables support. In addition, favouring a limited number of companies may also be critical from a legal perspective with regard to existing EU law and **state aid rules**⁸.

Netherlands

The former Dutch renewables support scheme SDE was financed through the state budget from 2007 until 2013. However, from January 2013, a levy on the energy bills of end consumers (households and businesses) was introduced to finance the follow-up programme SDE+. The distribution of the financial burden aims for 50% households and 50% businesses. It concerns a weighted average (estimated production and price for each kWh that is adjusted to meet the budgetary needs of that year and adjusted to meet the 50/50 distribution) established at the end of each year, for the next year. The levy is charged by the utilities and included in the monthly energy bills. Utilities are responsible for passing on the amount to the government. The levy is set until 2016 and increases every year to match the available SDE+ budget for the respective year. The following levies are set for 2013:

- Electricity: 0.13 €ct./kWh for 1 – 10.000 kWh, 0.17 €ct./kWh for 10.001 – 50.000 kWh and 0.05 €ct./kWh for 50.001 – 10 mln kWh;
- Gas: 0.23 €ct./m³ for 0 -170.000 m³ and 0.09 €ct./m³ 170.000 – 1 mln m³, 0.03 €ct./m³ 1 mln – 10 mln m³ and 0.02 €ct./m³ > 10 mln m³.

For households with an average electricity and gas consumption the levy was around 9 Euro per year in 2013.

Germany

In Germany, the burden for RES-E support is distributed to the electricity consumers via the EEG levy ("EEG-Umlage"). At the same time, the German system provides exemptions from the EEG levy and from other charges or fees to selected groups of stakeholder for different reasons:

⁸ The EC is currently discussing a draft for new guidelines on state aid.

- First, energy-intensive industries are granted reduced fees or even exemptions from levies in order to maintain their **competitiveness**.
- Second, the "green electricity privilege" ("Grünstromprivileg") reduces the EEG-levy for electricity suppliers that fulfil several conditions including a minimum share of renewables in their electricity mix to encourage participation of RES-E in the **market premium option**⁹.
- Third, **onsite electricity consumption** of small-scale technologies (Solar PV) is encouraged, by granting exemptions from the EEG levy.

The described privileges ultimately reduce the amount of electricity the burden is distributed over. This results in an increased burden for the remaining consumers. Subsequently, we describe the special regulation for energy-intensive industries and the "green electricity privilege", whilst onsite electricity consumption is dealt with in section 2.3.2.

Energy-intensive industries

Only companies with an annual electricity consumption of more than 1 GWh per year and a share of electricity costs exceeding 14 % of the gross value added are eligible for a reduction in the EEG-levy. Thus, eligible companies have to pay the full levy for the first GWh of electricity consumed, whilst a partial exemption applies for up to 100 GWh. Between the 2nd and the 10th GWh, 10 % of the normal levy is due, whilst 1% of the normal levy has to be paid for electricity consumption between 11 and 100 GWh. Electricity consumption over 100 GWh per year pay a fixed rate of 0.5 €/MWh. In case the share of electricity costs in gross added value exceeds 20%, companies are fully privileged consumers and pay 0.5 €/MWh for the total amount of electricity consumed. This regulation also applies for railway companies. shows that in addition to the EEG-levy, energy intensive industries count on additional reductions in other fees, charges and taxes, including VAT, grid charges.

⁹ According to the new German Government's coalition agreement, the "Grünstromprivileg" will be abolished.

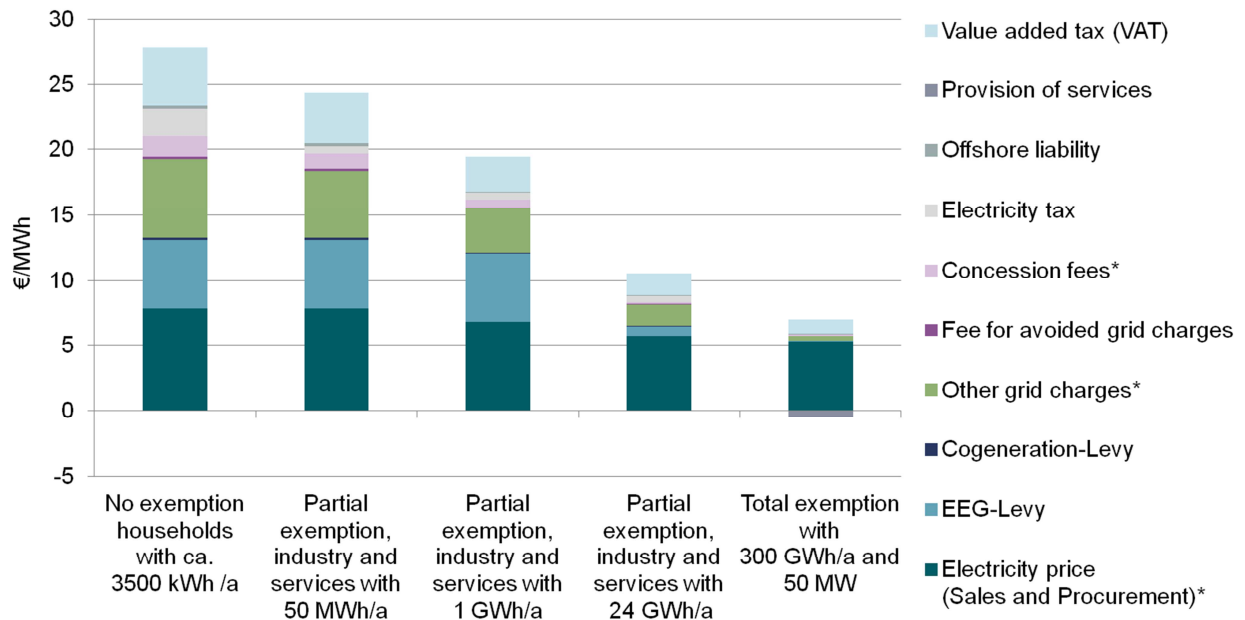


Figure 1 Components of electricity prices in Germany according to consumer type in 2013.
Source: Own illustration. * based on Bundesnetzagentur (2011)

Green electricity privilege for electricity suppliers (Grünstromprivileg)

In addition to the privileges for energy-intensive industries, the burden for some electricity suppliers is reduced to encourage participation of RES-E in the market premium option. In its initial version, introduced in 2009, the green electricity privilege offered all electricity producers with a share of at least 50 % EEG-eligible RES-E in their electricity mix an exemption from the EEG-levy for the overall electricity portfolio. Another precondition to receiving this exemption was that the RES-E was directly marketed and did not receive any additional support from the EEG. Thus, the green electricity privilege was attractive to electricity suppliers if the exemption compensated the missing feed-in tariff or feed-in premium payments for the RES-E part of the electricity mix. As a result the attractiveness of the exemption is related closely to the level of the EEG-levy. The increase of the EEG-levy in the last couple of years - amounting e.g. to 35.3 €/MWh in 2011 - made the use of the green electricity privilege even more attractive. However, as the participation in the green electricity privilege increased, fewer participants have to bear the burden and the EEG-levy increases. To avoid this self-reinforcing effect, the amendment of the EEG 2012 converts the previous full exemption from the levy to a partial reduction – up to a maximum of 20 €/MWh – and requires the following conditions:

- At least 50 % of the electricity portfolio must be from directly marketed RES eligible for EEG-support.
- At least 20 % of the electricity portfolio must be from directly marketed variable RES-E (Wind or Solar PV).
- These minimum shares of RES-E and fluctuating RES-E have to be fulfilled in one year and in at least 8 months of this year.

Figure 2 shows the increasing interest of electricity producers in the green electricity privilege. Most of the renewable electricity used to prove eligibility for the green electricity privilege is based on biomass, hydropower and wind. In total, roughly 5 % of the final electricity consumption was covered by the green electricity privilege and thus exempted from the EEG-levy in 2011, compared to values below 1 % in 2009 and 2010. After restricting the EEG-levy reduction to 20 €/MWh in 2012, the interest in the green electricity privilege has decreased again, as illustrated in Figure 2. The plans of the German Government's coalition agreement are to abolish the "Grünstromprivileg" in the future in order to cut policy costs for consumers and to be consistent with European law.

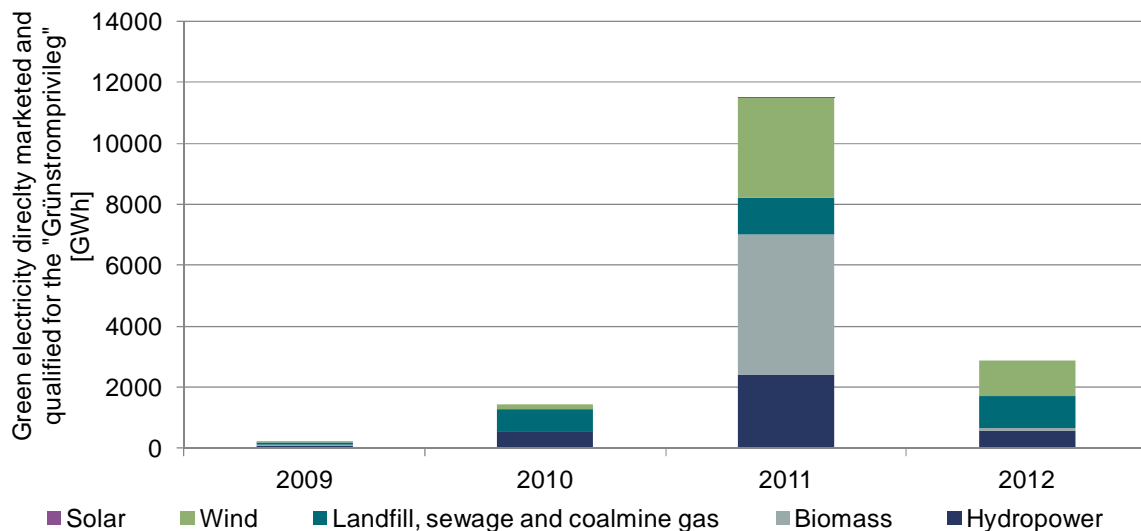


Figure 2 Green electricity directly marketed and used for the green electricity privilege.
Source: Own illustration based on data from Bundesnetzagentur (2013). Data for 2012 based on http://www.eeg-kwk.net/de/file/2012_EEG-Jahresabrechnung_.pdf

Both regulations described above may considerably increase the burden for non-privileged electricity consumers, since the RES-E support costs have to be covered by fewer actors, mainly households and non-energy intensive industries. The EEG levy in Germany amounts to 53 €/MWh in 2013 and a public debate revolves around the questions to which extent these exemptions are really necessary and whether they are target-oriented and fair. There are, for instance, indications that not all companies exempted from the levy are actually exposed to international competition.

Austria

Until the end of 2006, Austria used a levy per unit of electricity produced to finance the promotion of all RES with the exception of small-scale hydropower. The levy was defined according to the respective voltage level the electricity consumer was connected to. Thus, lower specific burdens were put on high voltage clients, typically energy-intensive industries.

In 2007, the “*Ökostromgesetz-Novelle*” modified the existing regulation by dividing the burden in two main components:

- Fixed annual charge according to the grid level (“Zählpunktpauschale” until 2007, “Ökostrompauschale” as of 2012)
- Variable levy paid and passed on to consumers by electricity traders

Electricity traders are obliged to procure a certain percentage of their electricity at a predetermined increased price (“*Verrechnungspreis*”). This “*Verrechnungspreis*” amounted to 105 €/MWh for all RES-E plants (excluding small-scale hydropower) in 2009, 124 €/MWh in 2010 and to 127 €/MWh in 2011. A more recent modification from summer 2012 changed the attribution of the levy – which was part of the electricity price until 2012 – and included the levy into the network charges in order to increase transparency. In addition the fixed component has been increased, as shown in Table 1. The share of the variable components increased from slightly above 60% to around 72% (E-Control 2012).

Table 1 Consumers’ contribution to financing RES-E support in Austria.

Source: Own illustration based on E-Control 2006, §22a Abs 1 Ökostromgesetz idf Novelle 2009, §45 Abs 2 Ökostromgesetz 2012.

Grid level	Annual costs for RES-E support		
	2006	2007 – 2012 Zählpunkt- pauschale	As of 2012 Ökostrom- pauschale
Grid level 1 – 3 (110 - 380 kV)	3.25 €/MWh	15,000 €/a	35,000 €/a
Grid level 4 (Transformation from 110 kV to 10-30 kV)	3.82 €/MWh	15,000 €/a	35,000 €/a
Grid level 5 (10 – 30 kV)	3.82 €/MWh	3,300 €/a	5,200 €/a
Grid level 6 (Transformation from 10-30 kV to 400 V)	3.98 €/MWh	300 €/a	320 €/a
Grid level 7 (400 V)	4.64 €/MWh	15 €/a	11 €/a

Denmark

Denmark passes additional costs resulting from the use of RES-E on to consumers through the *Public Service Obligation* (PSO) in terms of an additional levy on total electricity consumptions. This surcharge is determined on a trimestral basis by Energinet, the Danish TSO and varies with the consumers’ electricity consumption. Consumers with an annual electricity consumption exceeding 100 GWh only have to pay a decreased levy. The levy is reduced for all the electricity exceeding 100 GWh covering costs of grid companies and the system operator for the provided services. In contrast to Germany, only a small number of companies – seven – are covered by this regulation.

2.3.2 Special regulation for own-consumption of decentralised RES and net metering

Some countries favour renewable electricity produced geographically close – ideally without using the electricity network – to the consumption as an alternative to the remuneration for electricity fed into

the grid. In some cases the operator of the small-scale plant is allowed to consume electricity at a different time from generation. Provided that net electricity consumption has to be measured (total electricity consumption – onsite electricity generation) with a bi-directional meter or two uni-directional meters, these type of regulation is often referred to as **net metering**. In some cases the **excess electricity**, which is not consumed onsite, is remunerated. The objective of these measures is to reduce the load on the network by encouraging that electricity produced is consumed “onsite”. In practice, privileged onsite consumption mostly applies for the case of building-integrated solar PV power plants.

Electricity consumed onsite may be **exempted** from any type of **levies, charges** and **taxes**, which are usually part of the retail electricity price. If own electricity generation costs are lower than the retail price in case no alternative remuneration is available for feeding in the electricity into the grid, the onsite consumption option would be advantageous for the plant operator. In case other renewables support such as a feed-in tariff is available, opportunity costs of renouncing the available feed-in tariff have to be lower than the electricity retail price. Exemptions from levies, charges and taxes may involve considerable implications for burden-sharing, e.g. if the renewables levy has to be distributed over fewer consumers. These implications are described more in detail in section 2.3.1.

Potential **excess electricity generation** may be remunerated or offset with consumption in the next accounting period.

Whether the privileges for onsite consumption contribute significantly to alleviating network congestion is controversial, since the grid connection to the households is still required to guarantee secure electricity supply, when there is no own electricity generation available. There are also issues around the social distributional impacts of these measures. At present, countries such as the US, Italy and Germany use special regulations for own-consumption of decentralised RES.

Germany

In Germany, onsite consumption of small-scale solar PV electricity has been supported since 2009. In the beginning, electricity producers received a fixed FIT for feeding-in in electricity into the grid, whilst electricity for own use could be deducted and was incentivised at the same time. This regulation was first modified in 2010, offering a “split tariff” for building-integrated PV power plants smaller than 500 kW. Besides the FIT paid for the electricity fed into the grid, the onsite consumption received an additional incentive. Thus, the remuneration level of the onsite consumption is composed of the incentive and the avoided purchase price for electricity (retail price). The incentive was linked to the share of the onsite consumption and to the regular FIT. However, the additional incentive was abolished in January 2012 in order to reflect the changing economics of solar PV with FITs for PV being lower than retail prices. Net metering is still necessary to distinguish between the electricity consumed onsite and fed into the network.

Italy

According to the revision introduced in 2009, RES-E plants with a capacity below 20 kW, RES-E plants with a capacity below 200 kW (plant operation started operation from 2008 on) and high efficiency CHP-plants below 200 kW may claim for net metering privileges. Producers are then allowed to compensate the electricity consumed in different time periods with the electricity generated in different time periods. There is no additional remuneration for excess electricity consumed.

USA

In the United States net metering is rather wide-spread, being implemented with different design options in 47 states of the USA at the end of 2009. Excess generation after the deduction of own demand is remunerated with credits. The remuneration of the excess electricity generation is usually remunerated at retail prices, but some states pay wholesale prices for the excess electricity.

2.3.3 Summary and short appraisal

Reducing the **burden for energy-intensive industries** that are exposed to international competition contributes to maintaining the competitiveness of these industries. However, exemptions should be analysed carefully, since the burden then has to be distributed over fewer consumers and their individual financial contribution rises as a result. This is why criteria have to be defined to determine whether a company should be granted a reduction in the burden of RES-support. These criteria must reflect the share of energy costs in total costs and the degree of exposure to international competition. In this respect, it is also important to take into account potential lobbying from industries aiming to lower their energy-related costs. If too many companies profit from a reduced renewables support levy and the burden on the remaining consumers becomes too heavy, public acceptance of RES-support may dwindle.

Special regulations for **onsite consumption** such as net metering may be used to incentivise consumption being adjusted to generation in order to reduce grid load. This can encourage the decentralisation of generation patterns. Exempting self-consumption from the levy can be justified as long as the levy does not exceed the alternative support level minus market revenues. In general, it is not clear whether reducing grid load outweighs the resulting costs, since grid connection and provision are required to guarantee the security of supply. Similar to the regulation on burden-sharing for energy-intensive consumers, special regulations regarding self-consumption should be restricted to a small number of installations, e.g. small-scale residential installations.

For the two regulations presented that affect policy costs, it is important to dynamically monitor and control the evolution of policy costs and be able to adapt the scheme to avoid too sharp increases.

2.4 Differentiation of support level design

One relevant design option of renewable support schemes is the level of price or volume differentiation. Possible design options show a range from a technology-neutral determination of price or volume via a differentiation according to the technology to a very detailed distinction inside one technology category the suitability of the level of differentiation mainly depends on the cost range of technologies required to meet the predetermined target. If the cost range is broad – represented typically by steep cost-potential curves – a technology-uniform support may lead to undesired windfall profits for the cheapest technology, since these and more cost-intensive technologies receive the same remuneration (see e.g. Bofinger 2013). Thus, in most cases a stronger differentiation of price or volume better adapts to the individual requirements of each technology. However, an increasing level of detail regarding price or volume typically involves higher complexity for parameterisation and transaction costs. In general, the question how detailed the support level design should be differentiated depends largely on the steepness of the cost-potential curve.

2.4.1 Technology-neutral RES support design

Typically, technology-neutrality of RES support design has mainly been implemented in the context of volume-based support schemes in practice. Thus, either quota obligations or auctions have been partly implemented in a technology-neutral manner, whilst no case of technology-neutral renewables support in case of feed-in systems – if implemented in combination with the administrative determination of support levels – is known to the authors. However, even in case of volume-based support schemes, a trend of introducing technology-differentiation in quota systems could be observed during the last years (e.g. Italy, United Kingdom). Only the Netherlands converted their previously technology-specific feed-in premium into a virtually technology-neutral auction system for FIPs. Sweden, characterised by a flat cost-potential curve and abundant low-cost renewable potentials continues applying a technology-neutral quota system (see 3.4.1 for a more detailed description).

2.4.2 Technology-specific differentiation of remuneration or support scheme design

In concrete, the level of differentiation may affect the **parameterisation** of a volume- or price-based support scheme or even refer to the application of different support scheme types. In contrast to technology-neutral RES support design, a technology-specific differentiation of support levels is typical for price-based instruments, such as feed-in tariffs or feed-in premiums, in particular if the support levels are determined in an administrative procedure. In quota obligations, technology-differentiation can be introduced via assigning different number of certificates to one technology (technology banding) or via splitting up the target in sub-targets (carve-out). Examples for technology-specific implementation of quota systems are shown in section 3.4.1 in more detail.

Besides defining different support levels, another type of support scheme may be implemented for technologies with special needs. One typical example for a combination of different support schemes

observed in practice (e.g. United Kingdom and Italy) is the support of the more costly PV technology with dedicated feed-in tariffs in countries using a quota obligation as main support instrument.

2.4.3 Intra-technology differentiation of remuneration level

Regarding the intra-technology-differentiation, the most relevant criteria are the following:

- Location-specific differences, e.g. for wind onshore with strongly varying wind conditions
- Fuel-dependent, e.g. for biomass-based technologies
- Scale of the plant, e.g. for biomass-based technologies or PV power plants

Practical examples of how to design such an intra-technology differentiation will be with a focus on the potential design of location-specific differences for wind energy.

Location-specific determination of support level is one option applied to avoid windfall profits. Thus, the support level is fixed depending on the specific resource conditions of the respective renewable power plant. In particular, costs of electricity from wind energy vary considerably depending on the prevailing wind speeds.

In Europe, the **Netherlands** (until 2013), **Portugal**, **Denmark** and **France** restrict the payment of a high level tariff for a certain duration and reduce the payment after the threshold energy output of a plant is achieved. Thereby, limits may either be set on **annual level** or referring to larger time horizons up to the overall **support duration**. Annual limits are problematic because inter-annual fluctuations in the electricity output from wind power plants cannot be compensated.

In 2013, the **Dutch** SDE+ programme further refined the location-specific differentiation of the ceiling prices in its principally technology-neutral **auction scheme** by introducing a stronger diversification depending on the full-load hours that restrict the annual electricity eligible for financial support. Auctions for onshore wind are separated in six different phases with different base amounts or price limits (see Figure 3). In addition to the stronger tariff differentiation, a wind factor (1.25) has been introduced in order to avoid support losses resulting from the annual restriction of full-load hours due to inter-annual fluctuation in wind electricity production.

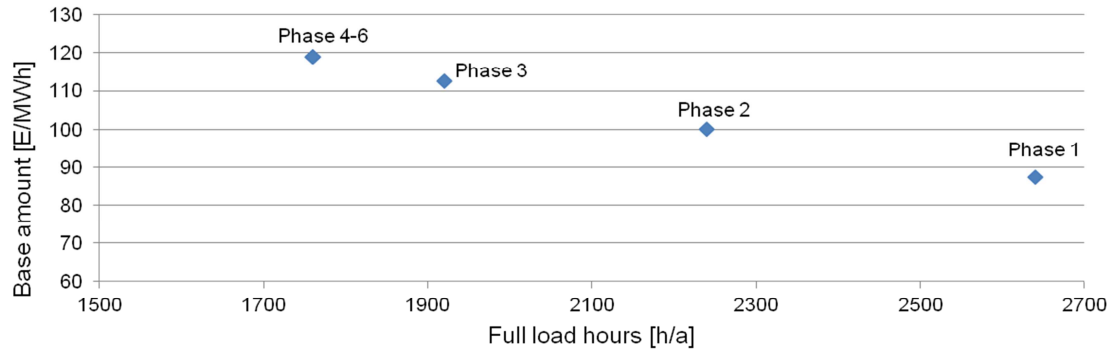


Figure 3 Ceiling price and maximum limit for supported full-load hours for onshore wind power turbines smaller 6 MW in the different auction phases.

In **Germany**, the support for wind energy depends on the performance of a wind turbine compared to a *reference yield*. The reference turbine, defined in the German Renewable Energy Act (Erneuerbare-Energien-Gesetz, EEG) assumes an average wind speed of 5.5 m/s and an altitude of 30 meters. All plant operators receive the same level of a FIT at least during the first 5 years of operation, but the duration of this initial high FIT depends on the real electricity output of the respective turbine. Then, power plants producing at least 150% of the reference yield, will receive a reduced tariff level for the remaining years of support. For each 0.75 % the electricity output stays below the 150% of the reference yield, the duration of the high initial support level is prolonged by 2 months. This means that wind power plants with average wind conditions (100%) receive the higher tariff during 20 years, whilst turbines located at favourable wind locations only receive a reduced tariff after a certain number of years. The use of wind energy is therefore not restricted to locations with favourable wind conditions and sites with less favourable conditions can also be exploited. In general, the current calculation methodology and its parameterisation still clearly favour well-located wind turbines, without completely preventing windfall profits for locations with good wind conditions. In addition, existing technical problems, leading to increased unscheduled down times are compensated for by a longer duration of the higher FIT. Finally, the German reference yield model is considered to be rather complex and opaque.

One potential simplified alternative to the reference yield model is to link the support directly to the **full-load hours**. However, the full-load hours do not only depend on the wind conditions, but also on the design of the wind power plant. Besides hub height, the relation between rotor area and rated power influences the full-load hours. Increasing either the rated power while maintaining the rotor area constant or reducing the rotor area while maintaining the rated power lead to lower full-load hours and to an increased tariff. Consequently, a non-intentioned over-dimensioning of the rated power is incentivised.

Misdirected incentives for over-dimensioning of the rated capacity can be avoided by linking the support level directly to **location-specific wind conditions** i.e. in terms of wind speeds. Since the power in the wind depends on the cube of the wind speed, average values are not precise enough

and the detailed distribution of the wind speeds or the average power density per area (W/m^2) should be taken as reference values. These data could either be provided for specific locations, as done in the new Danish auctions for offshore wind or cover a larger region within a wind atlas. In general location-specific assessments are more accurate, but a standardised approach is required in order to guarantee comparability at national or even EU-wide level. In contrast, broad geographic wind resource assessments typically are characterised by less accuracy and higher comparability. It should be taken into account that the required **wind resource assessments** may be time and cost-consuming.

2.4.4 Summary and short appraisal

When deciding about the level of technology differentiation in support schemes, the steepness of the cost-resource curve should be considered. There are the conflicting objectives of encouraging low-cost options by technology-neutral systems and of avoiding windfall profits by the application of differentiated support levels (short term cost minimisation versus medium to long term cost effective attainment of set policy goals). Differentiated support allows including less mature and more expensive technologies to come online and develop.

In case of a rather flat cost-resource curve, there might not be a need for differentiation, since deployment of the most cost-effective plants is encouraged, without providing too high windfall profits for the low cost technologies. However, if differences in technology costs are stronger, the technology-specific and possibly intra-technology differentiation of support may help reduce windfall profits. However, a stronger differentiation should still favour slightly lower cost technologies, e.g. provide a higher profit level for wind power plants build in locations with favourable wind conditions.

At present we consider the cumulated cost-potential curve in the EU28 to be too steep for technology-neutrality in particular regarding coordinated support schemes.

2.5 Predictability, stability and flexibility

This chapter focuses on a fundamental tension, which exist in all support schemes. On the one hand, from an investor's point of view, support schemes as well as investment revenues need to be predictable and they need to be stable. On the other hand, from a policy maker's perspective, support schemes need to provide flexibility to adapt to changing circumstances.

2.5.1 Predictability and stability

Predictability and stability are relevant on different albeit interrelated levels: first, regarding the policy perspective the overall support scheme has to be predictable and stable and, second, the revenues for investors need to have certain degree of predictability and stability in order to trigger investments and to keep risk premiums as low as possible.

Long-term commitment and stability of a support scheme

On the most general level, long-term legal commitments are crucial to provide a stable overall framework for RE investments. Such commitments include foremost credible renewables targets (including the required sanction mechanisms). On a more specific level, predictability regarding the future of a specific support scheme is crucial and revolves around basic questions such as whether a support scheme will stay in place, whether changes to a support scheme will occur and how such changes are defined and implemented. This is important because in a transparent and reliable support scheme, investors, firstly, can gain necessary knowledge on this specific investment context and can develop business strategies for specific national markets within Europe. Moreover, as we will explain further below, the **stability of a support scheme can be improved by including predictable flexibility features into support schemes.**

In contrast, numerous abrupt and unpredicted changes in several support schemes, as they have taken place lately, are counterproductive to an effective and efficient support scheme. First, they decrease the overall transparency of market conditions in Europe, thus generally raising transaction costs for investors. Sudden changes in policies are perceived by investors as “policy and regulatory risk” (Klessmann et al. 2013: 394). This results in higher capital costs, thus in higher required support and ultimately in decreased efficiency of the overall support scheme.

These effects are more severe, if existing investments are harmed by retroactive measures, that is, by changes in the support scheme that effect the revenue stream of existing installations (Rathmann et al 2011, p. 51). For instance, changes that have taken place in Spain have been hotly debated. First, with Royal Decree-Law 1/2012 (from 27 January 2012) the Spanish FIS had been abruptly stopped. After this, on 12 July, Spain passed an Energy Reform which included severe cuts in support for renewables in comparison to the former FIS. Moreover, this reform repealed all Royal Decrees that regulated RES retribution previously, thereby implementing a retroactive change. Details of the support granted for already existing installations have not been published and, thus, currently (as of 7 November 2013) RES producers have no certainty regarding remuneration through the support scheme for existing RES power plants. Another important, albeit less drastic, example has been the debate in Germany on the “electricity price brake” (“Strompreisbremse”) proposed by the German Minister for the Environment. In this proposal the Minister aimed at stabilising the cost of the German support scheme not only by reducing exemptions from the levy for energy intensive industries, but by putting a surcharge on remuneration of existing RES plants, which effectively would have resulted in a retroactive change. Although no retroactive change had actually been implemented the mere discussion around the topic has slightly raised risk premiums on investments in renewables in Germany.

Within the Re-shaping project, Rathmann et al. (2011) estimate that avoiding the above mentioned abrupt (or even retroactive) changes has significant “levelised” cost-savings potential in comparison to unstable schemes: The absence of retroactive changes implies overall cost savings potential of more than 20%, the absence of abrupt policy changes for upcoming projects more than 10% and renewables support which is financed off-budget via consumer surcharge saves approx. 3% of support costs, according to the authors. Such changes are considered as “one of the most important factors that affect renewable energy projects”, according to Falzon et al. (2013, p. 16). Moreover,

investors and project developers can barely mitigate investment risk resulting from such changes, meaning that such changes will most likely be translated into increased risk premiums (ibid.).

Revenue for investors

On a project level, the predictability and stability of the revenue stream are important factors, which influence the efficiency of a support scheme (Rathmann et al. 2011, p.66). The more unstable and less predictable the revenues from a support schemes are, the higher the risk premium. However, this is partially is a trade off with market integration, as predictability and stability are reduced by the extent the revenue depends on market mechanisms. In this respect, the different support schemes applied in Europe differ heavily. Figure 4 provides a simplified overview of the different types and the extent of revenue risks for investors.

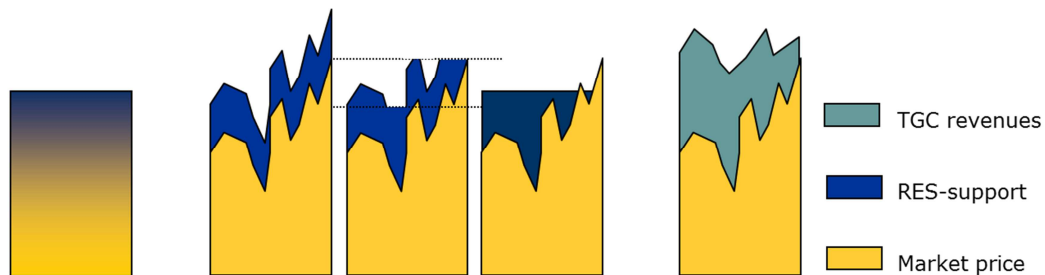


Figure 4 Overview of risk revenue in different support schemes
Source: Rathmann et al. 2011

A FIT provides the highest level of revenue stability, as the plant operator receives a fixed amount for each kWh produced. The only risk beyond the fundamental regulatory risk is that of the availability of, for instance, sun or wind (see chapter 3.1 on FITs). However, a FIT clearly performs least best with regards to applying market principles, since neither the investment decision nor operational decisions are influenced by market signals. The revenue risk is increased in a FIP, for instance, in a sliding FIP or a fixed FIP. In the latter case, the electricity producer receives a fixed premium on top of the value at the wholesale market, resulting in a significant revenue risk for the investor and a risk of over-subsidisation for the public. A sliding premium with cap & floor prices reduces this risk on both sides (see section 3.2 on FIPs). If access to a FIT or a FIP is organised via a tender or auction, competition and thus an additional risk is introduced at the stage of the investment decision. On the other end of the spectrum, quota schemes provide the least stable revenue stream. This is due to the fact that electricity producers carry both the risk of price developments at the wholesale electricity market as well as from the potential volatility of certificate prices (see chapter 3.4 on quota obligations).

2.5.2 Flexibility

While predictability and stability of support schemes and of revenues for investors decrease the overall costs of the support for renewables, support schemes have to constantly adapt to specific changes in market conditions. These include, for instance:

- decreased costs of technology and variable costs of material costs (e.g. steel);
- change in fuel costs (e.g. for biomass);
- the overall available economic resources to support renewables might change, for instance, due to an economic crisis.

As a result sometimes support levels have to be adapted (see section 0), sometimes there is a need to control overall support costs more effectively (see section 0) and sometimes even more fundamental reforms have to be implemented, such as a change from one support scheme to another. In the first place, the basic design of any support scheme should provide flexibility mechanisms, in order to enable a predictable reaction to specific changes in market conditions and in order not to be tempted to unexpectedly change the entire scheme.

The support schemes discussed in this report are compatible to necessary reforms to different extents. For FIP and FIT several instruments (and best practices) are available to organise flexibility while ensuring stability and predictability, such as the as the “breathing cap” to adjust tariffs (described in chapter 2.2). In contrast, quota schemes are comparably inflexible, since long-term targets are required to keep certificate prices stable. If for instance additional support schemes parallel to the quota obligation are introduced (such as a FIT for small-scale installations), certificate prices will be influenced, as the amount of available certificates in relation to the certificates required to meet the target changes. In order to stabilize prices in such cases, targets have to be adjusted.

The impact on stability and predictability is the strongest in the case of a phase-out of a support scheme or the transition of one scheme to another. Recently, several Member States have implemented such changes, such as the UK, which has changed from auctions to a quota obligation and which is now changing to a feed-in premium like “Contract for Difference”. Such changes create instability and potentially insecurity, for instance, regarding design details of the new system and of how the switch from one scheme to another will be organised in detail. In order to keep insecurity in such cases to a minimum, fundamental changes need to be announced timely and the public and stakeholders should be included through broad consultation processes. Moreover, interactions between (old and new) support schemes need to be assessed carefully.

Generally speaking, switching from a FIT to a FIP or including auctions into the process of organising access to support is not necessarily problematic – different schemes can even exist simultaneously without necessarily harming each other, such as FIT and FIP in Germany, FIT and auctions in France or FIT, FIP and a quota obligation in Italy.

Switching from a quota obligation to a feed-in premium is a more complex matter. For instance, for the certificate market to be maintained in parallel to the newly established scheme from the time of opening up the new scheme, the quota in the scheme is kept constant without adding new generation capacity under the scheme. Another option is to fully convert the quota obligation into the new scheme by buying the certificates at a fixed price (so called “grandfathering”).

In a public consultation in the UK from July 2013¹⁰, DECC proposed to include a transition phase from the RO scheme to the CfD, which is due to begin “when CfDs are available and ends when the RO closes to new capacity on 31 March 2017” (DECC 2013). During this time additional RE capacities are eligible for the RO and for the CfD. Presumably, the RO target will have to be increased more moderately than originally defined in the RO target trajectory and it has to be adapted to the newly installed capacities under either scheme to keep prices relatively stable. The consultation proposes to further manage the switch from one scheme to another through grand fathering: RO certificates will be bought for a fixed price from 2027 onwards until 2037, which is defined by the RO price in 2027 (+10%). Further details on how this complex switch is to be organised are currently being defined.

2.5.3 Summary and short appraisal

Support schemes and revenues for investors should be as predictable and stable as possible in order to keep support costs low. At the same time, support schemes need to adapt to changing circumstances and creating revenues through market mechanisms improves market integration and holds potential for efficiency gains. In general, support schemes should include flexibility measures to be able to react to changing circumstances predictably and without creating unnecessary insecurity. If a switch from one support scheme to another is envisaged, this change needs to be announced well in advance and need to include broad stakeholder consultation to make the change as well-designed and predictable as possible.

2.6 Integration into electricity markets

With an increasing share of RES in the electricity system, new challenges regarding the integration of RES into the electricity system arise. The fluctuating spatial and temporal generation patterns of some RES such as wind and solar lead to a dynamically varying demand for the remaining conventional technologies and an increased use of the existing grid infrastructure resulting in potentially increasing grid congestion. In order to cope with these challenges, it is crucial to have good forecast systems for RES and to provide sufficient flexibility on the electricity markets, such as flexible intra-day dispatch or the availability of balancing products. Caused by the close-to zero variable costs of most RES, the increased use of RES reduces hourly electricity prices through the so called “merit-order-effect” and therefore increased support payments required to finance RES-support. On the one hand, the increasing RES-share in European electricity markets requires adaptation to and system responsibility from RES power plants. On the other hand, power market design has to adapt to the changing characteristics of the technology mix, too. These two dimensions are described in the next two subsections.

¹⁰ See also: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/223489/ROtransitionconsultation17July2013.pdf

2.6.1 System responsibility for RES-E

Rising RES-E shares require higher market integration and system responsibility from RES plants. There are different measures of how renewable power plants can contribute to improving their integration into the electricity system:

- Demand-oriented generation features in support schemes
- Balancing responsibility for renewable power plants
- Remote control and dispatch
- Provision of system services

Demand-oriented generation

In support schemes with total support coverage, such as FIT, renewable power plants typically do not have an incentive to stop generating electricity during periods of low demand and high variable RES-E availability. Depending on the market design, market prices may turn negative in these periods. In contrast, in partial support schemes such as the FIP or a quota system, the incentives to generate electricity in these periods are lower, since the electricity price is part of the overall remuneration. The European Commission (2013) advocates that no support should be given to RES during periods of negative prices. However, a FIT can also be designed such that the FIT depends on the respective load situation in terms of a demand-dependent FIT. This could either be done by a predetermined classification of peak and base-load times or by linking it to the residual demand as control signal.

Thus, some Member States using FIT including Slovenia, Hungary and the previous Spanish system use multipliers in order to differentiate between peak and off-peak periods, mainly for dispatchable technologies such as biomass. Experiences from Germany, the Netherlands and Denmark show, that the use of the premium systems may have positive effect in avoiding negative prices.

Balancing responsibility

Another possibility for increasing system stability is to transfer balancing responsibilities to RES power plant operators, so that these may develop creative solutions in order to facilitate additional flexibility of the system. By shifting balancing responsibilities from the transmission system operator (TSO) to the plant operator, incentives for good forecasts may help reduce balancing needs of the overall system. The transfer of responsibilities may occur either in terms of

- informing the TSO about the status of the plant
- making the operator responsible for delivering the predicted electricity production at the day-ahead market
- making the operator responsible for delivering the predicted electricity production at the intra-day market

Thus, RES plants operators should be encouraged to provide good forecasts to make use of the full information on RES plant status. In countries using FIP or quota obligations balancing responsibilities are typically transferred to RES-plant operators. But also in case of FIT-systems, balancing responsibility may be transferred to the generators including penalty or bonus payments if a certain threshold error level is exceeded. In Spain, the operators had to pay a fee of 10% of the reference electricity price for each kWh of deviation, if the penetrated electricity differed from the provision by more than 20% in the case of solar and wind energy and by more than 5% in other cases until 2007. Currently, in Spain plant operator are penalised only in case the deviations from the forecast are contrary to the balancing need of the system in that particular hour. Slovenia and Estonia use forecast obligations for all plants larger than 1 MW, but they do not impose a penalty payment in case of non-fulfilment.

Remote control and dispatch

It is the objective to make renewable power plants contribute to maintaining or increasing system stability and to avoid extreme negative prices. Thus, real time monitoring of plant operation and their remote control can help avoid or mitigate problems in case of critical situations. Obligating the operator of plants with a certain minimum capacity to provide the TSO with access to plant data would be one option of improving system management. Compensation payments could be offered to the renewable power plant operator in order incentivise taking the plant off the grid when demand is low and thus to ensure system and grid stability. These measures are particularly important in case of comparatively high share of fluctuating RES in the system. Their implementation requires investments for infrastructure regarding the data transfer and the remote control. Another challenge is the clarification of the regulatory framework conditions, including the decision in which situations the TSO is entitled to reduce electricity generation of the plant. In general, costs and benefits of bottom-up online monitoring should still be analysed and compared to a top-down online prognosis. Furthermore it is important to notice that unbundled TSOs should only control RES plant for the purpose of grid and system stability. Market-based control to avoid negative prices etc. should be performed by RES generators or other market parties based on the signals of the electricity market.

Regarding the practical experiences, Spain obliges all plants with a size above 10 MW to realise online-monitoring of electricity generation with a temporal resolution of 12 seconds. All the data has to be transferred to the TSO. The TSO may request reduction of electricity generation, but does not dispose of the right for direct remote control. Experiences from Spain show that online plant control allows for an early identification of balancing needs, the timely activation of balancing power and for the identification of grid congestion situations. Thus, real time plant operation options have eventually led to reduction in grid congestion. In this way, security of supply could be maintained stable in times of high RES-E penetration in the system.

Provision of system services

Another issue of integrating variable RES-E into the electricity system is the guarantee of power system stability including frequency stability and voltage stability. Renewable power plants could contribute to guaranteeing system stability by participating in auctions for reserve or balancing products. Providing balancing power requires balancing and forecast responsibility. Typically high minimum

capacity requirements may hamper the participation of RES power plants in auctions of balancing power. This problem could be tackled by pooling various smaller plants and jointly offer balancing services (e.g. by an aggregator), but would require the installation of an adequate communication infrastructure at the same time.

2.6.2 Market design issues

In addition to requirements for RES power plants to improve RES-E integration, power markets need to accommodate the fact that wind and solar patterns vary across Europe. In particular changing electricity flows and congestion patterns require also an adaptation of electricity market design.

Markets should be designed such that the integration of variable RES-E is facilitated. Therefore, **gate closure** should be relatively close to real time in order to allow for changes in the feed-in of variable RES-E and renewable power plants should be enabled to participate in balancing markets.

In order to effectively integrate wind and solar electricity with its improving feed-in profiles into intra-day markets, **generation** of conventional capacities, **system services** and **transmission** has to be **optimised** in the same time frame. To do this short-term optimisation, market design needs to improve and integrate the allocation of generation, transmission and system services in a common platform. **Dispatching rules** should take into account renewable power plants' characteristics.

Market design should enable **efficient congestion management** in order to reduce requirements for investments in grid infrastructure and consider cross-border capacities. Systematic approaches instead of heuristics could be used to improve congestion management. Improved congestion management also provides transparent data useful for a potentially required grid reinforcement or expansion.

At the same time, market design should provide **long-term viability** to attract investment also in more innovative technologies and systems that guarantee efficient management of the electricity system on the longer term. In this context, the impact of RES-E on electricity prices should be considered for proper investment decisions.

When designing future electricity markets, the role of **smaller players** and their ability to participate in this market should be considered by either keeping rules simple or allowing for pooling of various small actors and their representation via an intermediate.

In general, responsibilities should be transferred to the party which is best able to manage the challenges, leading ideally to an **optimal share of responsibility between TSO and plant operators**. Thus, costs for connecting a renewable power plant to the grid may be borne either by TSO, plant operators or shared among both parties. For a detailed analysis of experiences with different grid connection approaches we refer to Klein et al. (forthcoming). Potential **curtailment** of excess supply of variable RES-E could partly be compensated in order to encourage their flexible dispatch.

2.6.3 Summary and short appraisal

Integrating RES into electricity markets requires responsibilities from renewable power plants and poses new challenges for market design. Table 2 summarises the suitability of support schemes for the analysed electricity market integration measures.

Table 2 Suitability of support schemes for electricity market integration measures

Measure	FIP / Quota system	FIT
Demand oriented generation	Fulfilled since RES plants are fully subject to price signal	Fulfilled if market price or residual demand is used as relevant signal
Balancing responsibility	Fulfilled because RES generators need to comply with schedule as all other plants	Depends on the detailed implementation.
Online-Monitoring and remote control	Can be fulfilled and is reasonable under both schemes	
Provision of balancing power	In principle provided, economic attractiveness depends on market details.	Can be implemented but transaction costs and opportunity costs higher than in case of FIP.

It can be seen that in particular support schemes where the electricity price is part of the remuneration are well suited for market integration measures. Regarding the share of responsibilities between renewable power plant operator and system operator only those risks, which can be reasonably mitigated by RES operator should be transferred to the plant operators. In particular the off-take risk in times of grid congestion should not completely be allocated to the RES plant operator. Priority dispatch in times of grid congestion is further needed.

3 Support scheme-specific design options

This chapter aims at analysing design options that are typical for certain support scheme types. Before analysing these support scheme specific design option we provide a short overview on the predominantly used support schemes. These include feed-in tariff and premium systems, quota obligations with or without tradable green certificates, investment grants or capacity payments, tax incentives, as well as auction schemes. We thereby do not consider auction schemes to be an own support scheme in the proper sense, since auctions rather represent a way of allocating financial support to RE-technologies and to determine the level of support. The support payment may thereby assume the form of a feed-in tariff, feed-in premium, a certificate price or an investment grant, meaning that the auction may be combined with each of the other support scheme types. Due to the high political relevance of auctions as elements of cost control and price determination in the current support scheme discussion, we include an own section on auctions in this chapter.

Support schemes can be differentiated according to the following criteria:

First, a support scheme may provide support either for supplied final energy or for the installed capacity. **Generation-based** support scheme typically encourage the best possible exploitation of a RES. However, in the electricity sector, generation-based support schemes may encourage the feed-in of non-dispatchable electricity in times when electricity demand is very low. Thus, a situation of oversupply characterized potentially by negative prices may emerge. A **capacity-based** payment would avoid this problem, but may lead to over-dimensioning of the installed capacity.

Second, the government sets the price in **price-driven** support schemes, and the corresponding volume evolves depending on the respective cost-potential curve in a country. In contrast, **volume-driven** support schemes predetermine the volume and the price develops according to the existing resource conditions and technology costs in the country. According to economic theory, the output of both systems would be the same in a hypothetical world with perfect information.

Third, a support scheme can be differentiated according to whether the financial support provides **overall remuneration** or whether its coverage is **partial**. In the latter case, the market price of the final energy represents the other part of the remuneration stream. Both options can mainly be distinguished regarding a different risk distribution between actors and compatibility with market principles. Whilst the plant operator is exposed to higher market risks in case of a partial support coverage, the market compatibility of the partial coverage option is higher than in case of the total support coverage.

Table 3 provides an overview of the main characteristics of the support schemes feed-in tariffs, feed-in premiums and quota obligations.

Table 3 Typical characteristics of the three dominant support schemes¹¹

Main characteristics of support schemes	Feed-in tariff	Feed-in premium	Quota obligations with TGCs
Generation-based	X	X	X
Capacity-based			
Price-driven	X	X	
Volume-driven			X
Total support coverage	X		
Partial support coverage		X	X

In general, recent developments have shown that support schemes are not always clearly distinguishable from each other anymore. Thus, price elements such as cap and floor prices have been introduced to the quantity-based quota obligation or volume caps have been added to feed-in systems. These stepwise changes have led to a smooth transition between the different support scheme types in order to combine advantages and to avoid the caveats of each type of support scheme.

Usually, the performance of support schemes can be evaluated based on different **criteria**. Trade-offs between the different criteria typically may arise when designing a support scheme. We base our analysis mainly on the following criteria:

1. Policy effectiveness

The effectiveness describes in principle the degree of target achievement a support instrument achieves. Thus, the extent to which a predetermined target is fulfilled can be used to measure the effectiveness of a support instrument. As used in this definition, the criterion “effectiveness” largely depends on the ambition level of the targets. To this end, several studies (e.g. Ragwitz et al. 2007, Steinhilber et al. 2011) evaluate the effectiveness of policy instruments independently from the degree of target achievement and take the achieved deployment of RES capacities in relation to the additionally available resource potential as indicator as reference for measuring policy effectiveness. In this analysis, we use policy effectiveness as the ability of support instruments to trigger new investments to qualitatively analyse the different support schemes.

2. Static efficiency or cost effectiveness

The static efficiency or the cost-effectiveness is achieved if a predetermined target can be fulfilled at the lowest possible overall costs. Thus, optimal resource allocation is required. We evaluate the static efficiency or cost-effectiveness based on the additional costs caused by the implemented support schemes. Transaction costs of designing and implementing a support scheme should also be consid-

¹¹ Changes in the design are possible and may affect these characteristics. Thus, feed-in tariffs may be paid as capacity payments or quota systems with cap and floor integrate price-based elements. This table shows the predominantly applied type of support scheme in practice.

ered. The static efficiency or cost effectiveness refers to total system costs and does not include distributional effects between different actor groups.

3. Dynamic efficiency

In contrast to the static efficiency, the dynamic efficiency evaluates the costs of target achievement over a long-term and considers whether a policy instruments helps drive down costs of less mature technologies.

4. Compatibility with market principles

We analyse qualitatively the different support schemes with respect to their compatibility with encouraging the integration of RES in the electricity markets. This issue has been becoming increasingly important, considering the rising share of RES in the electricity system and their impact on electricity prices and the use of conventional generation capacities.

5. Distributional effects

Besides the total system cost the distribution of the arising costs from policy support is one important evaluation criterion. Under distributional effects, we typically analyse whether financial support is suited to the actual generation costs of the technology or whether higher support payments for low-cost generation technologies may lead to windfall profits for renewable power plant operators.

Subsequently, we first give an introduction of the main support scheme categories including a brief qualitative assessment and describe the potential design variants. In the second part, experiences with the support schemes are analysed. Although we do not consider tender or auction schemes to be a distinct support scheme category, we dedicate an own section with various examples to this option in order to reflect the increasing relevance of this option in the current policy discussion.

3.1 Feed-in tariffs - FITs

In a feed-in tariff (FIT) system, power plant operators receive a fixed payment for each unit of electricity generated, independently from the electricity market price. This means that a RES-E power plant does not receive any remuneration directly from the energy-only market. Alternatively, the remuneration may be granted for capacity instead of electricity generation in order to encourage RES power plant operators to react to the real situation at the electricity market.

One main advantage of the fixed feed-in system is the **high effectiveness** of policy support that has been achieved in the past. An important reason for this is the certain investment environment, FITs provide for RES-E plant operators by providing stable income flows. Thus, feed-in tariffs typically lead to **low risk premiums**. The level of the feed-in tariff is typically determined by an administrative procedure, but it may also be estimated by using an auctioning mechanism. If determined by the administration, the basis for the calculation in practice has mostly been the overall cost of a technol-

ogy (levelised costs of electricity LCOE) but it may also be linked to the potential benefits of using RES. Since FITs tend to be applied in a technology-specific form, the market development of less mature technologies is promoted, leading to potential cost reductions and therefore allow a **high dynamic efficiency**. In this respect, the concrete design of adapting tariff levels in order to account for cost reductions is crucial for keeping policy costs low (see also section 2.2).

Fixed feed-in tariffs are often criticised for a low **cost-effectiveness** of target achievement related to the support of less mature technologies. However, it should be noted that the cost-effectiveness largely depends on the technologies supported and is not related to the character of the FIT itself. Another drawback is the decoupling of RES-E power plants from the requirements of the electricity market. Missing incentives to couple the feed-in of RES-E with the electricity demand at respective times and to encourage decentralised direct marketing of RES-E may hamper an optimal integration of RES into the electricity system. Therefore, fixed feed-in tariffs are **less compatible** with the principles of **liberalised markets** than other policy instruments.

Although FITs have proven to be an effective policy instrument in practice in the past, new challenges have appeared during the last five years. This includes in particular an overheated growth of Solar PV in some countries such as Germany, Italy and Spain, leading to strongly **increasing policy costs**. As a consequence mechanisms of **cost and volume control** are becoming increasingly important with growing shares of renewables. In principle, FIT-systems can be combined with cost or volume control. For general examples regarding cost and volume control we refer to section 2.2, 2.3 and 3.3). In addition, the increasing share of RES-E and the higher level of market maturity of technologies such as wind and Solar PV justify the application of more market-oriented support schemes compatible with the completing internal energy market. FITs may still be adequate to support less mature technologies or small-scale applications, which are have difficulties to bear the price risks or the transaction costs for participation in a market platform with professional traders. Equally, in non-functioning markets FITs can still be adequate as well.

3.1.1 Practical experiences

Long-lasting experiences with the performance of FITs in the electricity sector and considerable literature on the analysis of FIT's performance exist. Therefore, in this section we will focus the implementation of fixed tariffs for promoting renewable heat.

Renewable heat tariffs in the United Kingdom

Provided that the most relevant characteristics of FIT-systems are covered in the section on common design options and considerable experience and analyses are already available on best practices of FIT-systems, we show an example of using tariffs similar to an electricity-based FIT-system in the heating sector in the United Kingdom.

Before analysing the concrete design of the British support scheme for renewable heating, we will describe different characteristics of renewable heat compared to electricity which pose additional challenges to the design of a heating support scheme:

- First, it is difficult to **measure the heat output** of decentralized heating systems which are not fed into a grid, but generated and consumed on-site (Connor et al. 2013). Thus, the term “feed-in tariff” does not really fit, but the fixed tariffs paid for a unit of renewable heat strongly resemble the FIT-system applied in the electricity sector. The question how to measure or only estimate the heat generation is one of the crucial challenges of a RES-heat support scheme.
- Second, the size of installations in the heating sector tends to be much smaller in the heating sector, in particular regarding **decentralized technologies**, than in the electricity sector. This has to be considered in order to avoid an excess of transaction and administrative costs in total policy costs (Conner et al. 2013). Related to the first point, installing a heat meter for typically small-scale technologies in the heating sector usually suppose higher costs per unit of heat generated than for large-scale technologies.
- Third, considerable **less practical experiences** that help design support schemes in an appropriate way are available for supporting RES heating technologies than in the electricity sector. Thus, existing experiences are very useful for an adequate parameterisation of price or volume of the support scheme.

The UK has introduced its “Renewable Heat Incentive” (RHI) in 2011 in order to provide fixed tariffs for heat during 20 years. Its design is similar to a feed-in tariff for RES-E and it is the first FIT-like system for heat support. Initially, only non-residential heat has been addressed, but a new scheme for heating in households is planned to be introduced in spring 2014, after lengthy consultation processes have already led to some delays for the introduction of the scheme. The British RHI is financed by a public budget and the eligible technologies include

- Solar hot water
- Ground source heat pumps (GSHP)
- Water source heat pumps (WSHP)
- Biomass boiler
- Biomass methane

As shown in Table 4, payments depend on the heating technology and its scale. The rates for some technologies (GSHP, biomass boilers) are reduced after 15% of the total rated annual capacity has been used. Heating rates are adapted each year to consider inflation. Tariff reductions are also possible on a quarterly basis, if required not to exceed the predefined budget. A revision of tariffs undertaken after a public consultation in 2013 led to a strong increase of tariffs for GSHP, almost doubling the tariffs for small-scale installations and almost tripling the tariffs for large-scale installations. This increase was a reaction to lower than expected budget spending for heat pumps, assuming only 1% of the expected budget for heat pumps. This indicates difficulties of the policy design process regarding the detailed parameterisation of the support level.

Public consultations, as applied in the UK are one option to cope with missing experiences in the instrument design, but these may be time-consuming and costly, not forgetting that public consultations may be sensitive to lobbying attempts from stakeholders.

Table 4 Tariffs paid for non-domestic renewable heat in the United Kingdom
Source: http://www.icax.co.uk/Renewable_Heat_Incentive.html

Renewable Heat Incentive Commercial	Scale	RHI tariffs pence/kWh old rates	RHI tariffs pence/kWh revised rates	Tariff lifetime in years
Ground source heat pumps	< 100 kW	4.8 reduced rate: 2.3	8.9 - 10.2 reduced rate: 2.3	20
	> 100 kW	3.5 reduced rate: 2.3	8.9 - 10.2 reduced rate: 2.3	20
Solar thermal	< 200 kW	9.2	10 - 11.3	20
Solid biomass	< 200 kW	8.6, reduced rate: 2.2	8.6 reduced rate: 2.2	20
	200-1,000 kW	5.3 reduced rate: 2.2	5.0 reduced rate: 2.2	20
	> 1,000 kW	1.0	2.0	20
Biomethane	All scales	7.3	7.3	20
New technologies as of April 2014				
Air to water heat pumps	All scales	1.7	2.5	20
Biomass direct air heating	"Small"	2.1	2.5	20
	"Large"	1.0	2.0	20
CHP: Biomass	All scales	4.1	4.1	20
CHP: Bioliquids	All scales	4.1	4.1	20
Deep Geothermal	All scales	5.0	5.0	20

In general, the overall budget foreseen under the RHI has not fully been spent so far, also due to several delays regarding the introduction of the domestic RHI scheme.

In general, **metering** the heat eligible for support is required in to receive payments from the RHI. Metering the produced heat presents a major challenge in particular for smaller investors, given that only little practical experience with metering of small-scale heating systems is available in the UK. In its RHI, metering requirements are distinguished according to the complexity of the heating systems. These include simple systems where all the produced heat is eligible for support and complex systems where only a part of the produced heat is eligible (e.g. mix of renewable and fossil fuel heat sources) and multiple heat meter arrangements are required. Stakeholders have already raised concerns about the metering requirements, which led to a simplification of the heat metering requirements. For example, a heat loss calculation may be accepted instead of metering, in case the installation of the required meter supposes serious technical problems or financial burdens.

Regarding the heat metering issue, a good support scheme design should find a compromise between avoiding excessive burdens for owners with costly metering without facilitating potential fraud due to lose metering requirements.

Whilst there is still the transitory support available from the “Renewable Heat Premium Payment” (RHPP) in terms of upfront investment payments, the domestic scheme aims at supporting off-gas households and foresees tariffs shown in Table 5.

Table 5 Tariffs foreseen for domestic renewable heat in the United Kingdom starting from spring 2014.

Source: <https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi>

Technology	ASHP	GSHP	Biomass boilers	Solar thermal panels
Tariff	7.3p/kWh	18.8p/kWh	12.2p/kWh	At least 19.2 p/kWh

3.1.2 Summary and short appraisal

Fixed feed-in tariffs provide high investment security for project developers and lead to lower risk premiums than the premium option unless there is regulatory uncertainty. Thus, FITs are suitable to support technologies in an early stage of market development or technologies of small sizes which are operated by small and non-commercial players, such as house owners. Additional measure of cost control, such as an automatic degression of tariffs, the combination with an auction or tender system or the simple combination with volume or cost caps may be required in order to control costs. In contrast to FIPs, market compatibility of FIT for RES in the electricity sector is more difficult, since the overall cost coverage of the FIT does not integrate market price signals. Therefore, we recommend to introduce design elements that favour the integration of RES into electricity markets in a first step and to gradually convert existing FITs into FIP-systems in particular for mature technologies that are able to productively cope with the risks of market participation.

3.2 Feed-in premiums - FIPs

In general, FIPs can be evaluated similarly as FIT-systems (see 3.1), but there is one main difference regarding market compatibility and the risk allocation between the public and plant operators. In contrast to FITs, plant operators have to market the electricity generated directly at the electricity market and receive an additional payment on top of the electricity market price. Regarding the determination of the premium payment, different design options are possible, including a fixed premium, a floating premium 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. Feed-in premiums (FIP) are usually generation-based payments.

The main advantage of FIP-system compared with the fixed FITs is the market orientation, provided by the fact, that the electricity price is part of the overall remuneration for RES-E power plants. In

this way, decentralised direct marketing of RES-E is encouraged and for non-dispatchable renewable technologies incentives to feed-in electricity in times of negative prices is reduced¹². However, the stronger exposure to the market involves higher investment risks for power plant operators. Another negative impact of decentralised direct marketing could be a lower quality of forecasts for electricity generation from variable RES-E such as wind and solar energy from smaller actors, leading to higher system integration costs. An overview of the different design options for a feed-in premium are shown in Figure 5 and described subsequently.

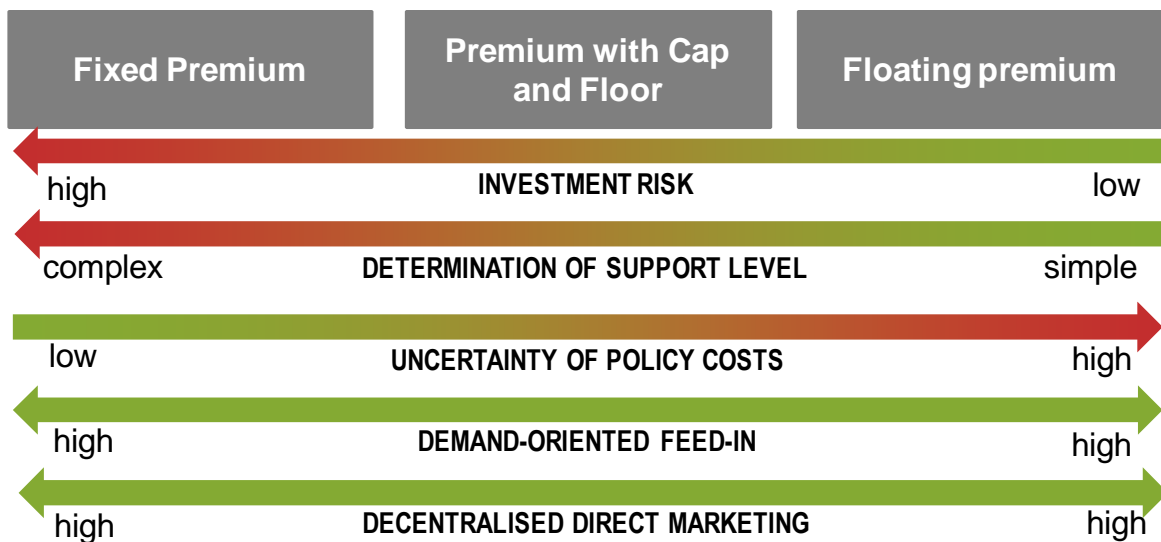


Figure 5 Premium design options and their characterisation

3.2.1 Fixed premium

In case of a fixed premium, the premium is usually calculated considering long-term average electricity prices, but does not take into account short-term variations on monthly, daily or hourly basis. Therefore, it leads to a good predictability of policy costs. However, rising electricity price may lead to an accelerated development of RES capacity and thereby cause an increase in policy costs. Regarding the risk distribution, RES power plant operators have to bear the overall risks arising from volatile electricity prices, leading to higher risk premiums.

Given that the level of the electricity price has to be considered, the determination of the premium level requires a good knowledge of future market development and is therefore rather complex. In this respect, the fact that increasing share of RES with low variable costs has led to decreasing electricity prices on the wholesale market should be taken into account.

¹² The remuneration becomes negative as soon as the absolute value of the electricity price exceeds the value of the premium payment.

3.2.2 Floating premium

Floating premiums are dynamic and depend on the level of the electricity price. In this way, plant operators of RES-E are not exposed to the overall risk of the electricity market price. Compared to FITs, investment risks are higher, since the renewable electricity has to be marketed. The determination of the premium level is similar to that of fixed FITs, and may be based on LCOE or determined in auction procedures. In case of a floating premium, the public has to bear higher risks regarding the policy costs, since they depend on the development of the electricity market price.

Tariff determination in the floating premium may take various forms, which makes the floating premium converge either towards a fixed feed-in tariff or towards a fixed premium. This depends mainly on the calculation of the reference value taken to determine the premium. Thus, if electricity prices are averaged over a long time horizon (for example on a monthly basis) and weighted by overall electricity generation are taken as a basis to calculate the premium payment, plant operators are well exposed to market price risks and therefore converge towards the fixed premium option. In contrast, if the premium is calculated based on hourly electricity prices and the weighting is restricted to wind electricity generation, market risks and market compatibility are lower and the floating premium is more similar to a fixed feed-in system. Thus, different feed-in premium and feed-in tariff options cannot exactly be differentiated, but rather merge into one another.

3.2.3 Premium with cap and floor

The premium with cap and floor is a fixed premium inside the limits predetermined by the cap and the floor, which is adapted as soon as the limitations are achieved. Concerning the risk distribution (investment risk, risk of policy costs) between public and plant operators, the FIP with cap and floor is compromise between the fixed premium and the floating premium. In contrast to both other options, it may be too complex to determine cap and floor premium in an auction procedure, suggesting the administrative determination of the support level.

3.2.4 Practical experiences

Floating premium in Germany

In Germany, a floating premium was introduced as an optional support instrument for renewables in 2012. Renewable plants can currently choose between support under the FIT and under the FIP. From 2014, biogas and biomass plants with a capacity > 750 kW will only be eligible for the premium option. Plants under the FIP scheme receive a market premium and a management premium on top of the market price (Klein et al. forthcoming; also: Klobasa et al. 2013).

The market premium is calculated ex post on a monthly basis. It is based on the difference between the fixed tariff and the average electricity market price in the respective month. The average market prices are adjusted by technology-specific factors for wind and PV as the prices that these technologies receive in the market are structurally different from the average price. Wind energy receives on

average lower prices because high wind penetrations lead to low electricity prices in the corresponding period due to the merit-order effect. Solar PV receives on average higher prices as PV plants generate electricity during day time only when typically electricity demand is high and prices therefore as well.

The management premium is an additional premium meant to cover additional costs (e.g. IT infrastructure, personnel, forecasts and balancing costs) due to the direct marketing of electricity sold under the premium model. This additional payment is technology-differentiated.

Furthermore, operators of biogas plants are entitled to a flexibility premium if they increase their installed capacity without producing more electricity and thus can react flexibly to market signals. Plant operators can choose between the options on a monthly basis. It is also possible to sell a percentage of the generated electricity under the premium option while the remaining share receives the fixed tariff. The plant operator needs to inform the grid operator in advance about these percentages.

Premiums with cap and floor in Spain

The Spanish system is currently suspended and no new plants are allowed to enter the scheme. Nevertheless, the Spanish case will be used to explain the feed in premium with a cap and floor as Spain was the first European country to introduce a feed in premium as a support option in the Royal Decree 2818 of 1998.

The overall remuneration consists of the market electricity price (or the negotiated price in case of bilateral contracts) and the additional tariff components including a premium and an incentive for participation in the market. In 2007 cap and floor prices have been introduced in order to restrict the windfall profits enabled within former premium. Under this scheme there are four different situations leading to a different premium level and remuneration:

1. As long as the sum of the electricity market price and the reference premium amounts to less than the minimum limit (floor), the overall remuneration level is equal to the minimum. The resulting premium is calculated as the difference between the minimum level and the electricity market price. In this situation, the overall remuneration level is constant whereas the real premium adapts depending on the electricity market price.
2. If the sum of the electricity market price and the reference premium ranges between the minimum and the maximum limit (the cap and the floor), the reference premium is paid in addition to the electricity market price. Thus, the overall remuneration level increases, whilst the real premium is constant.
3. Until the electricity price exceeds the cap price, the overall remuneration level corresponds to the cap and the real premium is calculated as the difference between the cap and the electricity price. The overall remuneration remains constant and the real premium declines.

4. If the market electricity price exceeds the cap, no premium is paid and the overall remuneration is equal to the electricity market price.

The described calculation mechanism for the premium guarantees the RES-E producer a minimum income providing investment certainty for RES-projects on the one hand and cuts off windfall profits that have occurred due to rising electricity prices without a technology cost increase on the other hand.

Czech Republic

In August 2005 the Czech Republic introduced a premium option as an alternative to the already existing fixed feed-in tariff. Since January 2006 RES-E generators can decide to sell their electricity to the grid operator, receiving a fixed overall tariff, or alternatively offer their electricity directly on the market. In this case, a fixed premium called green bonus is paid on top of the market price. For power plants using co-firing of biomass and fossil fuels only the new premium option is applicable. The decision to use one of the alternatives is valid for one year. In order to encourage participation in the market, the level of the premium is chosen in a way that the overall remuneration of this option is slightly higher than in the case of a fixed tariff option. The fixed tariffs and the green bonus are adjusted annually by the Energy Regulatory Office, which takes into account the development of the different technologies and the market needs. However, in late 2013, the senate voted overwhelmingly in favour of a bill to eliminate subsidies for new photovoltaic power plants while quickly winding down support for other types of renewable power production.

Slovenia

Another country that applies a system with fixed tariffs as well as premium tariffs is Slovenia. The RES-E support scheme came into force 12 July 2009. RES-E plants with a capacity > 5MW and CHP plants with a capacity < 1 MW are supported via a FIP, smaller plants can choose between the fixed and premium options. Plants under the premium option as in the Czech Republic receive a fixed premium on top of the market price. The premium is calculated annually using a predefined reference market price (MP), technology-specific reference costs (RC) and a factor (called B-factor; B) which differentiates between different plant sizes according to the formula $\text{Premium} = \text{RC} - \text{MP} \cdot \text{B}$. From 2014 onwards, several changes will be applied to the scheme, such as a limitation in size of installations below (Wind 50 MW, CHP 20 MW).

United Kingdom – Feed-in Tariff with Contracts for Difference

The UK is about to introduce a sliding feed-in premium system with Contracts for Difference (CfD) to replace the current quota scheme Renewables Obligation (RO). CfDs will be available from 2014 onwards and between 2014 and 2017 project developers can choose between ROs and CfDs. After 2017, no certificates of the RO will be provided to new plants and CfDs will be the only option for new installation. The certificate market will probably be kept functioning for existing plants until 2037. The

scheme will support low carbon generation technologies including renewables, carbon capture and storage and nuclear.

The Levy Control Framework (LCF) puts a cap on the amount of money available for investment in low carbon technologies. It puts a maximum to the aggregate amount that can be levied from consumers by energy suppliers to implement Government Policy. The upper limit to electricity policy levies agreed on under the LCF has been set to £ 4.3 billion for the year 2014/2015 and will rise to £ 7.6 billion by 2020/2021 (DECC, 2013)¹³. See also section 2.2 on the control of policy costs.

The CfD scheme will act like a financial instrument that guarantees a fixed price for generators supplying energy. This fixed price is called the 'strike' price or 'reference' price. The generators will sell energy to energy suppliers at a price that can be above, below or the same as the strike price. If the selling price of energy to the suppliers is equal to the strike price, then there is no further action. If the selling price is below that price, it will trigger top up payments by the suppliers. If the sales by the generators are at a higher price, it will result in generators paying back the difference.

It is expected that contract length will be 15 years for renewable energy technologies and possibly longer for nuclear technologies.

3.2.5 Summary and short appraisal

The characteristics of FIP-systems are similar to those of fixed FIT-systems (see section 3.1) apart from the range of the support level coverage. While fixed FIT-systems provide overall support level coverage, the electricity price is part of the overall remuneration in a FIP-system. Consequently, FIPs provide better market compatibility, but also involve higher risks for plant operators. The degree of market orientation and the risk level of FIPs depend on their individual configuration. Thus, floating premiums, where the premium aims to balance electricity price variability, provide only slightly lower investment security than FITs, whilst fixed premiums mean plant operators are more susceptible to market risks. FIPs encourage decentralised direct marketing of RES-E and negative electricity prices reduce the incentive for renewable technologies to feed electricity into the grid during periods of low demand and high electricity supply. Decentralised direct marketing could lead to a higher quality of forecasts due to the incentive to improve forecasts on the one hand, but may also lead to a lower quality of forecasts from smaller actors, regional forecast errors may not be balanced with other regions, as is typical for more centralised forecasts.

¹³ DECC (2013) Annex D: Levy Control Framework Update, 13 July 2013, link: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/223654/emr_consultation_annex_d.pdf

3.3 Auction schemes

In the context of RES-support tender or auction schemes are often considered to be a distinct support scheme category, similar to quota obligations or feed-in systems. However, tender or auctions can be seen rather as a common design option that may be applied in combination with any other support scheme. Thus, the auction or tender is used to **allocate financial support cost-effectively** to the RE-technologies, taking into account selected criteria. Determining the level of granted support in a **competitive bidding procedure** is another key objective of auction or tender.

The difference between an **auction** and a **tender** is related to the award criterion. Typically, in the debate on public procurement processes for renewable energy, "auction" refers to a design in which the price is the only award criterion, whilst "tender" may include additional award criteria, such as domestic production requirements. However, auction theory does not clearly distinguish between the terms auction and tenders (see Kopp et al. 2013). In this report auction refers to a **competitive mechanism to select bids**. Thereby, we distinguish the following types:

- Pure price-based auctions, with the price as the only award criterion
- Multi-criteria auctions, where the price is the main criterion and additional prequalification requirements represent additional criteria (e.g. local content rules, impact on local R&D and industry, environmental impacts)

According to Maurer et al. (2011) an auction procedure includes the bidding, market clearing and pricing. The level of support is typically determined in a **competitive bidding procedure**. Support payments may be provided in terms of feed-in tariffs, feed-in premiums, a certificate price or a capacity payment. In the context of increasing policy costs for RES-support and the requirement for austerity in public spending, using elements of auctions offers a way of further developing and refining existing support schemes and of potentially increasing their economic efficiency. Although there are also examples of combining auctions with investment incentives, such as "Alternative Energy Requirement" (AER) in Ireland¹⁴, most of the auctions that have been applied for RES-support so far provide feed-in like support payments. According to Battle et al. (2012), auctions are one option to introduce **cost and volume control** to feed-in systems. Considering this issue together with the fact that most of the EU countries currently use have feed-in systems in place, that may be combined with auction elements, we will focus on analysing tender/auctions in combination with feed-in systems.

The **volume control** element and the determination of the support level in a **competitive price building mechanism** are the main advantages of an auction/tender scheme. In particular the competitive price building mechanism implies a **high cost-effectiveness** of the system. However, its cost-effectiveness depends on the individual design of the auction as well as on the degree of competition on the market. One necessary prerequisite to create competition is that the demand for support

¹⁴ The Irish AER has not been particularly successful.

has to be higher than the auctioned volume. Compared to feed-in systems, the auction introduces additional elements of uncertainty for project developers regarding revenues and the future realisation of committed projects. This in turn makes planning more difficult and can in some cases lead to higher **risk premiums**. The **dynamic efficiency** of an auction system largely depends on the design regarding technology differentiation, but the downward pressure on prices tends to limit development possibilities of less mature technologies, at least in a technology-uniform design.

The **effectiveness** of an auction depends on two key factors. While auctions aim for a specific amount of electricity to be produced or capacity to be installed, empirical experience has shown that a shortfall of the auctioned amount are a rather common phenomenon. This is mainly due to “underbidding”, which results in economically non-feasible projects. In addition, the effectiveness of auctions largely depends on the frequency, regularity and reliability of the auction dates, since commitment for support is only granted at a certain point in time. Moreover, the effectiveness (i.e. the realisation rate of selected projects) depends on the design of pre-qualification criteria and the effectiveness of penalties (see chapter 3.3.2).

Compatibility with integration to the **energy markets** mainly depends on whether payments include total support coverage as in a feed-in tariff or partial support coverage as in a feed-in premium and is not related to the auction scheme itself. However, the competitive price building mechanism better respects market principles than a predetermined determination of the support payment.

Subsequently, we will describe different options of how to design the auction procedure and then analyse practical experiences of using auctions for RES-support.

3.3.1 Auction procedure design

Most of the auctions realized in the electricity sector – with the exception of auctions where support for specific locations is determined – are **reverse multi-unit auctions** where multiple items of a homogeneous product (e.g. renewable electricity) are sold by multiple sellers to a sole buyer. A broad variety of auction formats and price determination rules exists. We will shortly introduce and review the auction formats most suitable for RES support, including an analysis of their performance in practice. This includes best practice examples and also problems that may occur during practical implementation.

Sealed bid

In a sealed bid auction, bids including price and volume are submitted by each bidder at once, without knowing the bids of the competitors. Given that no interaction or reaction to the competitors’ bids is possible, the sealed-bid auction is a **static auction**. Bids are then accepted according to ascending bid prices, until the predetermined energy demand can be satisfied or no more offers – in general or below a potential ceiling price – exist.

The price determination may take the form of **pay-as bid**, where each bid receives the individually offered price or a common price for all bidders. The common price may either be set by the most expensive successful bid, also known as **first price** auction or by the cheapest non-successful offer in the auction, the **Vickrey** Auction.

Evaluating the sealed-bid auction, one main advantage is its **simplicity** and the involved low level of transaction costs. In principle, the simplicity may attract more bidders, including smaller actors, who may be discouraged from participating in the auction.

The static character of the sealed bid auction and the missing possibility for bidders to exchange information may be a potential disadvantage, in case uncertainty about the price of a product exists. In case of renewable technologies this may be particularly important for less mature technologies such as CSP or Offshore Wind. The existing information asymmetry may lead to “the winners curse”, where bidders lower their prices in order to win the award, but the bid may result in non-profitable prices. Determining the price according to the Vickrey rule may reduce the winners’ curse by adding a small surplus to the price determined on the first price rule. However, the missing interaction between bidders in markets with **low levels of competition** is less vulnerable to collusive behaviour of market participants than dynamic auctions.

Descending clock

In contrast to the sealed bid auction, the descending clock auction is **dynamic**. After the auctioneer establishes a price ceiling, auction participants offer the volume they are willing to offer at the mentioned price. Subsequently, the auctioneer reduces the price in the **iterative bidding process**, until the planned volume is achieved. The **price** of a descending clock auction is **uniform** for all successful bidders. The volume tendered does not necessarily have to be published and the auctioneer may dynamically adapt to the volume based on the bids made by participants.

The main advantage of a descending clock auction is the potential learning effect for auction participants, if the auctioneer publishes price and volume after each round. In this way, the descending clock auction may reduce the winners’ curse. The downside of the descending clock auction is potential collusion in particular in situations of lacking competition. A dynamic auction is well suited for a situation where considerable uncertainties regarding the value of the product exist and allows for robust price discovery. Due to the iterative process, the descending clock auction tends to be more transparent than a sealed bid auction. It should also be noted, that the outcome of a descending clock auction largely depends on the auction parameter such as the determination of the volume and the starting price. Thus, information disclosure policy regarding the auctioned volume and the starting price plays an important role for auction performance. Although a descending clock auction appears to be more complex than a sealed bid auction, experiences have shown that transactions cost are only slightly higher than for sealed bid auctions.

Hybrid designs

Hybrid auction designs aim to combine the advantages of the described auction formats. One prominent example of combining different auction formats is a descending clock followed by a sealed bid auction, as e.g. applied by Brazil. The descending clock ends with a volume slightly above the target volume. The remaining reduction of the volume is realized with the resulting price of the first auction as price ceiling in a sealed bid auction, where the pay-as bid price determination rule may be applied.

It is also possible to combine both auction formats in different order. This combination is particularly suitable, if the value of the product is well known and if little difference exists between the best of-fers. In this way, the static auction design in the first round prevents collusive behaviour and the dynamic auction in the second phase encourages competition between products with similar prices. Brazil also has experience with this hybrid design, which has been applied for the project-specific auction for large-scale hydropower.

3.3.2 Measures to avoid low implementation rates

One main problem of auctions may be that after winning a bid, some participants decide not to realise the project due to different reasons. To avoid this, different mitigation measures can be applied. These include pre-qualification criteria, bid bond guarantees, and penalties for non-delivery or delays. The aim of these measures is to receive genuine bids, i.e. only those bids that really aim for and are capable of realising the respective RET-project.

First, **pre-qualification criteria** are requirements for participants that should be checked at an early stage of the bidding procedure. They can refer to specifications of the bid/offered project, such as technical requirements, documentation requirements, preliminary licences, etc. Or they can refer to the bidding party and require certifications, proving the technical or financial capability of the bidding party. Pre-qualification criteria can either be applied in a separate phase before the actual bidding takes places or bids can be evaluated according to qualification criteria after being submitted.

Second, **bid bond guarantees** are payments required from the bidding participants or only from the successful participants to prove their serious intentions to put the project into practice. Determining the level of the bid bond is a sensitive task, provided that excessive bid bonds may increase the risk premium for bidders and discourage actors from participating in an auction, whilst too low bid bond guarantees may imply low implementation rates.

A third option to increase the implementation rate in auctions is to apply **penalties**. Penalties may be required if a selected bid does not translate into a project timely, if the agreed amounts of electricity have not been delivered or if the whole project is not realised. Designing penalties is one of the most crucial and complex tasks when designing an auction. First, penalties put additional risk on bidders. Whoever is subject to penalties is exposed to a financial risk. However, to function efficiently, risks should be distributed to those who can best mitigate them. For penalties in auctions this means that the project developer should only be sanctioned for those delays he is responsible for and that he can

effectively address – which has not always happened in existing auction design. For instance, if a project delay occurs because of complications in the supply chain, this is a regular part of project development. However, if a delay is caused by problems in public licensing procedures, the project developer might rather be compensated for unexpected revenue gaps, than being exposed to an additional economic burden.

Penalties can take different forms: their design might include the termination of contracts, lowering support levels, shortening support periods by the time of the delay (or multiplied by x), confiscation of bid bonds or even additional penalty payments, for instance, in case that a delay would harm security of supply.

3.3.3 Practical experiences

Auctions have been broadly applied in electricity markets, including dispatch of electricity in spot markets, balancing markets and for triggering investment in new capacities. In this section we show and analyse practical experiences with auctions for RES support in combination with feed-in systems (e.g. China, Brazil, The Netherlands, and California).

Since only very limited experiences are available with capacity-based payments in auction system we will shortly describe existing ideas and concepts for such systems at the end of this section. The first capacity-based auctions for RES-support in Russia have only been carried out very recently in September 2013, meaning that it is still too early to draw conclusions from the Russian example.¹⁵

Applied auction schemes in the different countries can be characterized by very heterogeneous objectives, framework conditions and implementation design of auction schemes. Thus, Brazil uses auctions as their predominant RES-support scheme, whilst China has been using auctions for the support of specific projects. In addition, China used tariffs determined in renewable auctions as a benchmark for setting a fixed feed-in tariff. We present and analyse the specific characteristics of these heterogeneous examples and show the main lessons learnt from each case rather than providing a cross-country comparison. This explains why no uniform structure of evaluation is followed during the presentation of the case studies.

Provided that considerable experiences with the use of auctions outside Europe are available, we also integrate non-European countries into our analysis. For example, Latin America counts on considerable experience with the use of auctions, mainly for reliability and system adequacy reasons (Maurer 2011). Table 6 shows the main characteristics of the auction schemes applied in the countries selected for this analysis.

¹⁵ For more information on the Russian RES-support scheme we refer to Boute (2012).

Table 6 Main design options of analysed auctions/tenders

	Brazil	California	Netherlands	Denmark	France	China
Main feature	Hybrid auction design	Auction for distributed technologies	Floating premium determination	Location-specific tender for Offshore/Near-shore	Online tender for small-scale PV	Location-specific multi-criteria auction
Auction procedure	Hybrid: descending clock followed by sealed pay-as-bid	Sealed pay-as bid	Sequential bidding rounds with pre-determined prices	Negotiated procedure	Pay-as bid	First-price sealed bid (single price for single object), changed to average bid price.
Technology-focus	Technology-specific and technology-neutral	Technology-specific for Solar PV	Technology-specific and technology-neutral	Technology-specific for wind offshore	Technology-specific for Solar PV	Technology-specific for Wind onshore >50MW, Wind offshore, Solar PV and CSP
Price ceiling	✓	✓	✓	✓ Offshore planned for near-shore	✗	✗
Qualification requirements						
<i>Prequalification</i>	Environmental permits, grid access approval, resource measurements by an independent authority, fuel supply agreement.	Developer experience, proof of site control, use of a commercial technology, grid connection study	Environmental licence; water permit (geothermal/heat and cold storage projects); written permission of the owner of the land (if relevant).	Final criteria published as a part of the contract notice	Bidder has to be owner of the building; plus CO2 assessment and statement on recycling of the installation	Local content rules, financial and project experience requirements
<i>Bid bonds</i>	1% in 1 st phase, 5% in 2 nd phase.	Required from successful bidders		The winner has to put in bank guarantees for the potential penalties.	-	
<i>Penalties for non-realisation or non-delivery</i>	Delay by more than 1 year: contract can be terminated without justification. Complex penalty regulation for non-delivery of electricity.		Penalties are in place for non-realisation of projects within the required period. Penalties only apply to projects that claim over EUR 400 mln.	Penalty rules are clearly stated in tender material	In case of construction delays: duration of support can be reduced by the delay, multiplied by two	Unclear non-compliance rules
Duration of support	15 (biomass), 20 (wind) and 30 (hydro) years.	10,15 or 20 years	5, 12 or 15 years depending on the technology	50,000 full-load hours or 12 – 14 years	20 years (1580 h/a in France, mainland and 1800 h/a per year in Corsica and overseas)	
Frequency of auctions	>1/year, but no fixed schedule	Bi-annual between 2011 and 2013	Annual auction with new budgets each year	Frequency according to schedule.	Regular schedule foreseen (5-6x per year)	Mainly irregular, annual for wind onshore between 2003 and 2007

A hybrid auction design as the predominant RES-support scheme in Brazil

Brazil has been applying auctions in the electricity sector since 2005, broadly differentiated into two types of auctions: “new energy auctions” and “reserve auctions” (Cunha et al. 2012). New energy auctions are conducted once a year by the government-owned company EPE, based on demand forecasts of the regional distribution network operators (discos). They can either be technology-neutral or technology-specific. In these auctions, EPE procures electricity representing the discos one year, three years, and/or five years ahead of time. Moreover, the MME (Ministério de Minas e Energia) conducts reserve energy auctions on an ad-hoc basis to complement a potential lack of electricity supply. Since 2008, Brazil has been conducting technology-specific auctions as part of both new energy auctions and reserve auctions for RES, replacing the former FIT-like support scheme “Proinfa”.

The EPE applies a **hybrid auction design**, combining a (“Dutch”) descending-clock auction with a (“English”) sealed-bid pay-as-bid auction, preceded by a qualification phase. The first phase is a descending price clock auction (as described in section 3.3.1). This phase serves for price discovery and is used as the **ceiling price** for the second round. All bids selected in the first round enter into the second round, which is a pay-as-bid sealed-bid auction. Competition between bidders in this round is created by reducing the targeted amount of electricity usually by 7-10% from the first round, depending on the estimated level of competition.

The entire auction is executed via an **easy-to-use online platform**. Prior to auctions, there are “**auction trainings**” available to increase the number of bidders and thus the level of competition created by the auction (Cunha et al. 2012).

There is a **short-term backup procedure** in place: If a bidder cannot deliver all necessary documents within 48 hours after the auction is closed, his project is excluded and the next lowest bid is included into the selection of projects (Kopp et al. 2013). There is no long-term back-up procedure; potential gaps in electricity production due to the exclusion of further projects are addressed via reserve auctions, as described above.

Auctioning awards are tradable in Brazil, resulting in a “secondary market”. Some experts estimate that around 30 % of earlier auctions are dealt with in a secondary market (Interview with Luiz Barroso). While some interpret this as a sign of failed auctions, others hope that the secondary market will improve the realisation rate of projects in the mid-term. Since the secondary market is entirely made up of “over-the counter” deals, there are neither numbers on the actual amount of contracts already concluded, nor on the resulting rate of realised projects or the prices.

The **qualification phase** is applied to improve the quality of the bids and to ultimately increase the rate of project realisation. Bidders have to provide several documents to qualify for participating in the auction. Depending on the technology, the required documentation includes environmental permits, grid access approval, resource measurements by an independent authority (Cozzi 2012, p. 26) or a fuel supply agreement in the case of biomass (Cunha et al. 2012). In addition, bidders have to provide a bid bond equalling 1% of the estimated investment to enter into phase 1 of the auction.

Subsequently, bidders are required to increase the bid bond to 5% of the estimated investment in order to be entitled to participate in the second round. Preparation for bidders to pass the qualification phase usually takes between three and six months.

Time frames to construct the installations are not technology-specific, but depend on the type of auction (A-1, A-3, and A-5 = 1, 3, or 5 years). Resulting PPAs are valid for 15 (biomass), 20 (wind) and 30 (hydro) years.

The auction design aims to increase the rate of project realisation (and thus the effectiveness of the auction in terms of renewables deployment) by requiring the above-mentioned bid bonds and additionally by applying **penalties**. If **project realisation** is delayed by more than one year, the contract can be terminated without proper justification (and without reimbursement of the bid bonds). However, in practice such penalties have not been applied because in cases of delays project developers have credibly argued that public entities were responsible for delays occurred (e.g. in licensing procedures). Regarding **electricity production**, a complex system of penalties applies (Porrua 2010): In short, any deviations between 90 % and 130 % from the contracted electricity amount are bankable up to four years. If electricity production falls short of 90 % of the contracted amount, a penalty of 115 % of the support level has to be paid for the shortage below 90 %. Moreover, in this case the missing amount is transferred to the balance of the next year. If electricity production exceeds 130 % of the contracted amount, 70 % of the tariff is paid for the extra amount of electricity and the amount is again transferred to the following year. After four years, producers are required to clear their balance and to compensate for deficient or over-production by buying or selling electricity from other producers.

Regarding the **results of the auctions** we will concentrate on wind onshore, since most effective price reductions have been achieved for this technology (as shown in Table 7). In a first auction for wind realised in 2009, reductions of 44 % compared to the Proinfa-tariff resulting in a FIT of 57.87 €/MWh have been achieved. In the 2nd wind auction from August 2010 prices have dropped to only 45 €/MWh. Between 2009 and 2011 3 GW of wind power have been contracted for the next five years (Silva et al., 2013). Results of a more recent auction in August 2013 resulted in even lower prices with 35.25 €/MWh (for projects to be up-and-running by 2015) (Spatuzza 2013b). Table 7 provides an overview of auction results from 2009 until August 2013. It is still difficult to evaluate viability of projects, since final clearing of deviations in electricity delivery is only required after four years. Thus, 2008 auction results will only become visible from 2014 onwards and some experts state that there is high uncertainty as to the amount of required balancing.

Table 7 Auction results for auctions in Brazil

Source: <http://www.epe.gov.br/leiloes/Paginas/default.aspx>

	2009	2010	2011			2012	2013	
	Wind (reserve)	Wind, biomass, small hydro (A-3 and reserve)	Wind, biomass, hydro, natural gas (A-3)	Wind, biomass (reserve)	Wind, biomass, hydro (A-5)	Hydro, wind (A-5)	Wind (A-3)	Hydro, biomass, natural gas (A-5)
Average Price in €/MWh (across technologies)	n.a.	~59.83	~44.27	~43.21	~42.26	~33.69	n.a.	~39.87
Equivalent of contracted capacity (MW) (all technologies)	n.a.	2,892	2,744	1,218	1,211	574	n.a.	1,265
Average Price in €/MWh (wind only)	~57.87	~58.63	~43.20	~43.18	~43.48	~32.16	~35.25	n.a.
Equivalent of contracted capacity (MW) (wind only)	1,806	2,047	1,068	861	976	282	1,505	n.a.

Assessment

Auctions in Brazil are characterised by three main issues, which we would like to highlight:

- first, significant price reductions;
- second, the exclusion of smaller players;
- third, a low and/or uncertain rate of project realisation.

First, the **significant price reductions** in comparison to the former Proinfa support scheme indicate a high level of competition in the auction, indicating **high static economic efficiency** of auctions in Brazil. The low prices, e.g. for wind energy, have been enabled by several internal and external factors: On the one hand, the two-phased auction design has proven to be effective in lowering prices. On the other hand, additional measures such as tax reductions (about 30 % of investment) and favourable financing conditions from BNDES National Bank of Economic and Social Development for domestically manufactured plants have allowed for low capital costs. There are several reasons that have significantly contributed to the results of auctions in Brazil that are not directly related to the auction design itself. For instance, Brazil has been still a relatively new market with abundant sites of excellent resource quality. In addition, the economic crisis in other important markets (e.g. Europe)

has provided a strong incentive for international investors to look for new opportunities, partially leading the way to auctions in Brazil. Several experts assume that in this context some international investors have offered prices below production costs (underbidding), in order to facilitate their market entry, effectively cross-subsidising their low bids (Pereira et al. 2012).

Second, **smaller players have apparently been excluded** from auctions in Brazil. Despite the initial transaction costs for the qualification phase not being excessive, they have excluded smaller actors. This can partly be attributed to the fact that the required bid bonds have posed significant barriers for smaller (and for local) potential bidders. And local bidders participating in the auctions have largely not been able to compete with the underbidding strategies of international investors.

Third, a large share of the selected **projects are heavily delayed**, thereby negatively affecting the **effectiveness** of the auctions: for instance, in 2012, 1,077 MW of wind power have been installed, indicating that between 40% and 65% of the contracted projects are delayed. Realisation rates for projects of auctions in 2011, 2012 and 2013 cannot be estimated since their allowed time frame for construction has not yet ended. Given that prices in the more recent auctions have dropped even more significantly, there is a chance of the project realisation rate equally decreasing.

Numerous additional issues regarding the auctions in Brazil have been discussed controversially, such as the **postponement and final cancellation** of an A3 auction in 2012, when the auctioneer reacted to wind power farms that had previously been built, but had not been connected to the grid (Spatuzza 2013a). This aspect is relevant insofar that even in the context of a very stable and reliable time table and execution of auctions, such as in Brazil, such irregularities can occur. This in turn directly influences investors' confidence in a market and is going to be reflected in the applied risk premiums. As a result, such irregularities are likely to exert influence on the final costs of electricity and, thus, on the efficiency of auctions in Brazil.

Another crucial issue is the difficulty to **adequately (administrative) parameterise ceiling prices** (see Rego 2013b for a detailed discussion). The initial ceiling price significantly influences the level of competition and thus the number of bids that will be received in an auction: if it is set too high, auction results might be inefficient, since bidders might collectively be tempted to bid well above their lowest possible profit margin. If it is set too low, only few bidders will enter into the auction, leading to undersupply and a lack of competition. In the case of Brazil, in some technology-specific auctions (for instance, December 2005 and October 2006), thermoelectric and hydro power have been auctioned separately. However, the price cap for thermoelectric power was set higher than for hydro power, resulting in a higher average price for thermoelectric power. As a result, the final price for the overall procured electricity was higher than it would have been, if more (cheaper) hydro power had been auctioned than the more expensive thermoelectric power.

Box 1: Main lessons learnt from auctions in Brazil

Core issues identified

- Auctions in Brazil have been capable of significantly reducing support levels in comparison with former FIT (efficiency). However, reductions have been partially due to an effective auction design, but equally due to factors external to the auction design (e.g. excellent sites, international competition, economic crisis in other parts of the world, etc.).
- Rates of project realisation have partially been low and/or are still uncertain (effectiveness). This might result in problems in the mid-term regarding the availability of adequate capacities, if the number of outstanding projects increases. Thus, some of the auction results are partially “fictional” rather than reflecting the actual price for produced electricity.
- Penalties have not distributed project risks precisely and adequately between project developer and public entities and have therefore not been sufficiently applicable and effective.
- The technology choices in auctions in Brazil have focused on onshore wind biomass and hydro, thereby not encouraging a broad technology mix and decreasing dynamic efficiency.

Recommendations derived

- When selectively applying auctions in Europe factors besides the auction procedure have to be taken into account. Assessing the adequacy and feasibility of specific auctions, the scope, the chosen technology, the project size, have to reflect a wide variety of context factors that will influence the success of auctions.
- The actually targeted amount of RE-production capacity should exceed the actually required/envisaged RE generation capacity – potentially reflecting the estimated rate of project realisation.
- Penalties need to distribute risks in the most effective way, addressing different involved actors and their suitable responsibility in the entire process (e.g. differentiating between delays caused directly by project developers and public entities).
- Technology-specific auctions have to reflect the envisaged technology mix; a more diversified mix increases dynamic efficiency.

Floating premium determination in sequential auction rounds in The Netherlands

In July 2011, the Dutch government replaced its existing feed-in premium scheme SDE (Subsidiering duurzame energieproductie) introduced in 2008 with SDE+, a sliding premium determined based on auctions. The SDE+ scheme aims to incentivise the deployment of renewable energy at the lowest possible cost. The main changes of the SDE+ compared to the SDE are:

- The introduction of renewable heat: whereas the SDE incentivised only renewable electricity and renewable gas, all three categories have to compete for support in the SDE+;
- One overall annual budget: whereas the SDE had different budgets per technology category, the SDE+ knows one overall budget ceiling, decided on each year;
- Financed through a levy on the energy bill of consumers: the SDE was funded by means of direct government budget or taxpayers, while the SDE+ budget is financed by a surcharge for sustainable energy as of 2013. A household with average energy consumption will pay a surcharge of € 9 in 2013 (Rijksoverheid 2013).

The SDE+ opens in a number of **sequential auction rounds** with increasing prices. The government defines base amounts for each round and the bidders offer the respective volume. This is called a volume tender. Developers that wait until round 6 could benefit from a higher subsidy, but they will run the risk that the SDE+ will be closed before round 6 if the annual budget ceiling has been reached. The scheme works on a **first come, first serve** basis. Although the design of the instrument differentiates between technology categories or bidding rounds, the scheme in practice resembles rather a technology-neutral scheme.

The scheme knows a **“free category”** in each round that is open for projects that are able to produce at lower costs than the (maximum) base amount that has been calculated for the specific technology (NL Agency 2012). This way, the free category gives entrepreneurs the opportunity to access the SDE+ sooner. All projects, independent of the technology, can apply for subsidy in this free category. A number of technologies come into consideration in this free category only. In 2013, these technologies were free flowing energy (low head hydro power), osmosis and biomass gasification (NL Agency 2013).

The **budget** for the SDE+ is determined annually. The height of the budget depends on several developments such as whether the entire budget is consumed in previous year(s), the actual realisation rate of projects and changes in energy price scenarios. The total budget available under the 2011 SDE+ was EUR 1.5 bln. and increased to EUR 1.7 bln in 2012 and EUR 3 bln. in 2013.

The Dutch government published expected SDE+ expenditures up to 2020. These expenditures include all expenditures to projects that receive MEP, SDE and SDE+. The total expenditures will increase from € 900 mln in 2013 to € 3.820 mln in 2020 (Ministry of Economic Affairs, 2013)¹⁶.

The SDE+ does not incentivise **less mature** and **innovative** technologies. These can benefit from incentives outside the SDE+ such as subsidies and various tax benefits. The 2013 budget from the Ministry of Economic Affairs presents subsidies of € 23,8 mln available for the Topsector Energy and € 31,7 mln available for innovation in energy (Ministry of Economic Affairs, 2013)¹⁷. A new regulation on energy innovation that will start in 2014 will make additional budget available: € 25 mln in 2014, € 35 mln in 2015, € 45 mln in 2016 and from 2017 onwards € 50 mln per year (SER, 2013). The SDE+ is organised in such way that only established, low-cost technologies will receive support. The Netherlands argue that it will be too expensive to reach the 2020 renewable energy target with innovative projects and technologies. It is however questionable if the target will be reached with only low-cost technologies.

Since 2012, **penalties** are in place for the non-realisation of projects within the required period of usually 4 years. This is only relevant for projects claiming over EUR 400 mln of the budget (over their lifetime) (Kopp et al. 2013).

When making the bid, the project developer needs to present an **environmental licence** and a **water permit** (relevant for geothermal and heating and cooling storage projects). Furthermore, the applicant needs to prove the viability of the project by means of 1) a completed application form, 2) a general description of the project and expected annual production and a realisation and financial plan.

A number of changes have been included in the 2013 scheme compared to the 2012 scheme:

- The government introduced an **additional auction round** in the allocation process between round 1 (EUR 0.07 €/kWh) and round 2 (0.09 €/kWh) to encourage participation of more projects. The extra stage has been added as second round for projects able to produce sustainable energy for a basic sum of (less than) EUR 0.08 per kWh.
- A number of new technologies eligible for support were added to the scheme, such as:
 - Geothermal with depth over 2700m;
 - Renovation of existing hydro-electric power stations with at least one new turbine;
 - Renewable gas production with waste water;
 - Sewage treatment with thermal pressure hydrolysis, and;
 - Manure mono-fermenters for gas and CHP.
- Another change is that SDE+ differentiates the remuneration for wind projects according to the location-specific wind conditions in terms of annual full-load hours. The fewer the amount

¹⁶ Ministry of Economic Affairs (2013) Letter to Parliament, available at: <http://www.rijksoverheid.nl/ministeries/ez/documenten-en-publicaties/kamerstukken/2013/01/14/kamerbrief-over-kasuitgaven-en-verplichtingenbudgetten-sde.html>

¹⁷ Ministry of Economic Affairs (2013) Departmental budget 2013. Available at: http://www.rijksbegroting.nl/2013/voorbereiding/begroting,kst173862_10.html

of full load hours, the higher the basic sum, the later the auction round, the less probable that there is still budget left.

- The government introduced a number of measures to limit the budget claim of projects that are not realised. These measures include:
 - I. Project developers that do not realise their project within the predefined 4-year realisation period are excluded from SDE+ for five years for the same project;
 - II. Stricter check on feasibility of projects and their economic viability on the basis of an assessment of the realisation plan and a financial plan that are submitted by applicants;
 - III. Check of progress after one year by the Dutch authorities, and;
 - IV. For projects with a budget claim >400 mln EUR, a bank statement and a realisation contract is required. The contract states that the project has to be realised within the given timeframe.

Results

In 2012 the annual budget ceiling was already reached in the first tender round, in 2013 the allocated budget was EUR 2.2 bln. and reached on 3 October 2013. The competitive character and the given budget restrictions of the scheme resulted in a high share of the budget requested in the free category (85% in 2011, 20% in 2012 and > 50% in 2013). The realisation rate of projects so far amounts to roughly 40% of the projects that were committed in 2011, 26% of the projects that were committed in 2012 and 0.5% of the projects that were committed in 2013. However, it is still too early to evaluate the implementation rate of SDE+ projects.

In the old SDE (without the competitive bidding procedure) 80% more budget was needed for the same amount of renewable energy (2011-2012). One explanation for the significant difference in support costs between the old SDE and SDE+ is that the former SDE only supported renewable electricity and renewable gas and that the SDE+ also supports renewable heat projects, which are comparatively cheap. The average weighted guarantee price under the SDE scheme was 0.13 €/kWh, while in 2011 and 2012 almost the full budget was committed at respectively 0.07 €/kWh and 0.09 €/kWh (Ministry of Economic Affairs 2013).

Table 8 Overview of key results of the SDE+ scheme in the years 2011, 2012 and 2013¹⁸.
Sources: Agentschap NL, 2012, Agentschap NL, 2013, Ministry of Economic Affairs, 2013.

	2011	2012	2013
Available budget	EUR 1.5 bln.	EUR 1.7 bln.	EUR 3.0 bln.
Number of committed projects	740 projects , of which: Renewable electricity: 710 (196 MW, 6,408 GWh) Renewable gas: 30 (22,612 Nm ³ /h)	234 projects , of which: Renewable electricity: 112 (20 MW, 398 GWh) Renewable heat and CHP: 118 (1,110 MW, 247 PJ) Renewable gas: 4 (1,470 Nm ³ /h)	456 projects , of which: Renewable electricity: 353 (12,232 GWh) Renewable heat and CHP: 98 (153 PJ) Renewable gas: 5 (210 Nm ³ /h)
Budget claims	Biogas claimed EUR 1.2 bln.	Geothermal claimed EUR 0.8 bln.	N/A
Average guaranteed tariff	Almost complete budget committed at 0.09 € /kWh	Full budget committed at 0.07 €/kWh	N/A
Projects in free category	85% of the claimed budget	21% of the claimed budget	>50% of the claimed budget

Regarding the deployment of less mature technologies, **offshore wind** has been identified as a technology that should have a significant contribution to achieving the 2020 renewable energy target in the Netherlands. Because of its high costs and long lead times this technology will not get any subsidy under the current SDE+ scheme. The recent Energy Agreement between government and industry (September 2013) acknowledges that the current SDE+ needs to be opened to offshore wind. Discussions start on placing a partition in the SDE+ budget to assure a certain budget for offshore wind.

Assessment

This assessment concentrates on a number of aspects very typical for the Dutch SDE+ scheme, being: 1) the focus on low-cost technologies (static efficiency) and the focus on short-term implementation objectives and 2) the competition between electricity, heat and gas.

The SDE+ is structured in a way that low-cost and proven technologies are favoured compared to innovative, high-cost technologies. Under the SDE+ scheme technologies that need less support than 0.15 €/kWh are in principle eligible and might receive support. Still, this limit is often not within reach for technologies that currently face high production costs, such as offshore wind, but offer potentials for significant cost reductions in the future. This way one can argue that technological change is not fostered by the scheme. The Dutch government decided that electricity, heat and CHP and gas should all compete under the SDE+ scheme and for the same budget. The Dutch government argues that renewable heat options and CHP can significantly contribute to achieving the 2020 target for renewable energy (14% in 2020). Renewable heat options often are low-cost options that make it possible to realise the target at lowest possible costs. In addition, the different value of heat and electricity – in energetic terms – does not allow for just price comparison of heat and electricity in one system.

¹⁸ 2013 results figures present the status quo on 17 October 2013



Since January 31st 2012, four of the six renewable heat technologies fall into the lowest first-phase cost band, which makes them belong to the most competitive options. However, it is questionable, whether the Netherlands are able to achieve their comparatively ambitious 2020 target by focussing only on low-cost technologies.

Recently, the Dutch government announced that it will investigate how projects developed in other EU Member States can be financed under the SDE+ scheme, by making use of the cooperation mechanisms of the RES Directive (Ministry of Economic Affairs 2013)¹⁹. The government plans to open up the SDE+ scheme for projects under the cooperation mechanisms of the RES Directive. No preference for one of the types of cooperation mechanisms has been made explicit in a letter to Parliament. On 18 November 2013 the parliament took a vote, stating that the Ministry may proceed with including the flexible mechanisms in the SDE+. The next step will be to define whether the scheme is opened for (joint) projects in other Member States, for statistical transfer, or both. Subsequently the Dutch legislation will have to be adapted and the revised law will have to be submitted to the European Commission for proper state aid approval. The Ministry plans to inform the parliament in 2014 about further details.

¹⁹ Ministry of Economic Affairs (2013) Letter to Parliament, available at: <http://www.rijksoverheid.nl/documenten-en-publicaties/kamerstukken/2013/10/31/kamerbrief-over-sde-regeling-voor-duurzame-energie.html>.

Box 1: Main lessons learnt from auctions in the Netherlands

Core issues identified

- Compared to the SDE (until 2012), the SDE+ showed significant reduction of support costs on the short term. A significant part of the available budget (over 60%) is consumed by low cost renewable heat technologies in recent years.
- Monitoring and control mechanisms need to be firm to assure that projects come to development and to avoid unnecessary budget claims.
- Not all technologies that are deemed necessary to achieve 2020 renewables targets will get support under the scheme, because of current high costs (for example offshore wind).
- Compared to the SDE (until 2012), the SDE+ showed significant reduction of support costs on the short term. A significant part of the available budget (over 60%) is consumed by low cost renewable heat technologies in recent years.

Recommendations derived

- The definition of the technologies eligible for support is crucial in order to avoid unnecessary windfall profits. Competition between electricity and heat under one budget should be avoided, since low cost heat technologies will consume most of the budget available, while offering no perspectives for innovation and cost reductions.
- An adequate monitoring and control mechanism should be implemented. Amongst others, at the submission stage, project feasibility should be subject to strict checks without deterring potential bidders from participation in the bidding procedure.
- When designing a volume tender with the objective of a high static efficiency, additional measures for less mature and innovative technologies should be implemented.
- The definition of the technologies eligible for support is crucial in order to avoid unnecessary windfall profits. Competition between electricity and heat under one budget should be avoided, since low cost heat technologies will consume most of the budget available, while offering no perspectives for innovation and cost reductions.

Participatory elements in a location-specific tender for large-scale technologies in Denmark

Denmark is a pioneer in wind offshore technology; with its first plant being installed already back in 1991. In 2004, the Danish government achieved a broad political agreement to support 2 x 200 MW of wind offshore energy and to determine a guaranteed price paid in an international tender with a negotiation procedure. The guaranteed price is paid as a sliding premium payment, which is calculated based on the electricity price weighted by the real electricity generation of the respective wind park. Therefore, only low price risks resulting from forecast deviations have to be borne by plant operators.

Two projects, namely Horns Rev 2 and Rødsand 2, have been tendered in a negotiated, multi-criteria tender process starting in 2004. Whilst the Horns Rev 2 tender was successful at a resulting guaranteed overall remuneration of 51.8 øre/kWh (~69.5 EUR/MWh) in the first round, the Rødsand 2 tender had to be re-tendered in 2008, after the winning consortium had withdrawn from the contract. The major concern was that the project was no longer realisable at the rather low contracted support level, mostly due to a delay in project and increase in turbine prices. The negotiated multi-criteria procedure used for the first round was changed into a single-bid, single-criteria tender procedure in the second round of Rødsand 2 and the guaranteed price contracted in the 2nd round amounted to 62.9 øre/kWh (ca. 84.4 €/MWh) compared to 49.9 øre/kWh (ca. 66.9 €/MWh) of the first round. After this, the 400 MW Anholt tender was initiated also as a single-bid, single-criteria tender in April 2009. Due to several circumstances and tender conditions, there was only little interest from investors in the Anholt tender. The winning price was at 105.1 øre/kWh (ca. 136.2 EUR/MWh). All three wind farms have been constructed and connected to the grid (Horns Rev 2 in 2009, Rødsand 2 in 2010 and Anholt in September 2013), while Anholt was (probably thanks to the introduced delay penalties) the only project commissioned within the time frame specified in the tender material.

Reasons for the low interest in the Anholt tender – effectively resulting in only one offer – were amongst others the difficult market situation with the economic crisis at that time, ongoing offshore wind site allocations in the UK and ambitious time planning with high penalties for delays. In addition, the auction included a requirement for the second bidder to take over the tender with unchanged time planning. This meant a considerable risk to investors and foreign investors felt apparently as outsiders compared to national actors.

In the meantime, the Danish Energy Agency announced new tenders for a total capacity of wind offshore and near shore amounting to 1,540 MW by 2020 (Danish Energy Agency 2013). Tenders for Horns Rev 3 (400 MW), Kriegers Flak (600 MW), for several near shore locations (450 MW) and test turbines for R&D purposes (50MW) are carried out between 2013 and 2015 and realisation of projects is planned from 2017 until 2020.

The procedure of the new tenders follows a **participatory approach**, including an open dialogue with stakeholders on tender specifications and framework conditions. Thus, interested tenderers have been involved in designing the tender procedure in a dialogue with the Danish Energy Agency for the

Horns Rev 3 and the Kriegers Flak tenders. This dialogue is currently continuing with a public consultation on the prequalification criteria in autumn 2013.

The **tender procedure** itself will – like in the first tenders for Horns Rev 2 and Rødsand 2 – include two phases, a preliminary phase where bids are not binding and a second final phase, where the final price is determined. The price is the most relevant bidding criterion and other bidding criteria are to be determined in cooperation with prequalified bidders. Financial support is provided in terms of a **sliding feed-in premium**, providing in fact a guaranteed price level, for up to 50,000 equivalent full-load hours of operation (the tenders are more precisely for 20 TWh of production for the 400 MW project, and for 30 TWh of production for the 600 MW project etc.).

The final form of the tender for **near shore locations** is not yet completely established, but there will be one tender for six areas. One main difference to the offshore tenders is that concession owners are obliged to offer 20% to local residents or companies in order to guarantee local acceptance of the turbines, typically visible from the shore. If concession owners achieve to sell 30% to locals, a bonus of 1.3 €/MWh may be obtained. At present, a cap on the bidding price amounting to roughly 70 øre/kWh (ca. 94 €/MWh) is currently under discussion.

The organisation of the new offshore tenders in Denmark includes several elements with the aim to provide a **secure investment framework** and to **simplify administrative processes** for bidders. Thus, the Danish Energy Agency streamlines the administrative procedures in terms of a **one-stop-shop for permits**, providing the draft permits as part of the tender material. Certain permits are then required to be included into the bid. In addition, the required environmental impact assessment (EIA) has to be realised by Danish authorities before tender submission starts. The agreement with the required Danish authorities on the use of the respective offshore location is thus guaranteed for tenderers. With regard to **grid connection**, costs are borne by electricity consumers and the Danish TSO guarantees the grid connection to the offshore plants for the large projects only. The near-shore projects have to finance their own offshore substation and connection to land. In case of connection problems, clear compensation rules have been defined. Priority access to the grid is granted for successful projects. **No local content rules** apply for offshore tenders.

Another important design criterion is related to the **transparency and information provision** of the tender procedures. Thus, the Danish Energy Agency realises pre-investigation studies about meteorological and geological conditions at the respective wind offshore site before submission of tenders. Provided data include wind speed, waves, currents and information about the seabed conditions. This allows all bidders more equal conditions to sharply calculate foreseen electricity generation costs.

In the new large offshore tenders, the Danish Energy Agency also conducts a very **pro-active communication strategy** especially also for potential foreign investors by participating in several EWEA conferences and regularly publishing news on their homepage.

The integration of the tender procedures in **long-term policy commitments** and the existence of a **clear time line** provide stability for investments. Thereby, the future development of wind offshore

in Denmark is part of a **broad political agreement** and **backed by a large part of the population**. The long-lasting experience with wind on- and offshore energy in Denmark provides good framework conditions, including well-trained employees and good R&D conditions.

Provided that the new tenders for wind offshore are still in its initial phase, we cannot evaluate the outcome of these tenders yet and therefore restrict our characterisation to the design of the scheme. In general, the current Danish offshore tender design shows an excellent potential for realising successful location-specific tenders for large-scale technologies.

Box 1: Main lessons learnt from auctions in Denmark

Core issues identified

- Possible shortcomings of earlier tenders have been identified, e.g. too strict penalties in combination with tight time plans can hamper competition.
- Early clarification and finalisation of administrative and permitting issues for both the project itself and also for the grid connection infrastructure has improved investment security for bidders and will reduce problems regarding non-realisation. Integrating the permitting process into the tender procedure reduces transaction costs for bidders.

Recommendations derived

- Penalties have to be parameterised sensibly and have to be balanced with the need for adequate levels of competition.
- Other developments, such as ongoing tenders in other countries or the general economic situation, should be considered for the timing and design of the tender procedures.
- The participatory and flexible approach together with a very pro-active and long-term communication strategy appears to be suitable to avoid typical implementation shortcomings of tender schemes. However, the open dialogue may be sensitive to lobbying attempts and involve certain transaction costs.
- Bringing forward administrative and permitting issues and the organisation in a one-stop shop should be part of a well-designed auction or tender procedure. Generally, being in good time to start the entire tender process is crucial to avoid too strict time plans for bidder.

- The timely provision of information on local resource conditions and EIA appears to be very useful and reduces costs for bidders.
- Guaranteed grid connection and clear compensation rules provide investment certainty.
- Local content rules are only used to increase public acceptance in sensitive areas (near shore offshore plants).
- Realising pre-examinations of the site should be implemented in any project-specific auction of resource-dependent RES. This reduces uncertainty regarding the real costs of a project and contributes to preventing under-bidding.
- Guarantee of grid connection and clear compensation rules should be part of a well-designed support scheme for offshore wind in particular if large capital requirements and risk issues endanger interest of investors.
- Local content rules should generally be avoided and only be implemented if required for reasons of social acceptance.

Site-specific multi-criteria auction of partial volumes used to determine support level in China

China has been applying **technology-** and **site-specific auctions** since 2003 including auctions for wind onshore (2003 – 2007), wind offshore (since 2010/2011), solar CSP (since 2011) and for solar PV (2009 – 2010). Another typical design feature of the auction applied in China is that exemplary auctions for wind onshore and solar PV have been used to determine a country-wide FIT. This can be characterised as the auction of a **partial volume**, given that the result of auctioning a small quantity of final energy provides the bases for determining country-wide FITs. The implementation frequency of Chinese auctions is not embedded in a longer-term strategy and auction scheduling rather follows **an irregular ad-hoc auctioning interval** (with the exception of wind onshore auctions, where annual auctions were realized between 2003 and 2007). With regard to the auction design, **multiple criteria** in addition to the price have been decisive for selecting the auctions' winners. The auction procedure follows the **first-price sealed bid** principle.

Regarding **Wind onshore** annual auctions were realized between 2003 and 2007. The concession period covers 25 years including 3 years until the project is operative and the feed-in tariff is paid up full-load hours of 30,000 h/a. Due to serious problems with underbidding resulting in non-realised projects, the price determination rule was changed in 2007. Instead of setting the price at the lowest price bid, bids closest to the average price bid scored highest with respect to the price criterion. Auction winners would receive the average price bid of all bids excluding the lowest and highest bid (IRENA 2013, p. 26). Additional award criteria included the following local content rules: Half of the produced equipment was required to be of domestic origin until 2005 and the share of local content

was set to 70% thereafter (Liu and Kokko, 2010). The initial weight of the price criterion of 40% was reduced in 2006 to only 25% in order to avoid underbidding and to promote the local economy. However, the introduced measures could not avoid the existing problem of underbidding in China. The lack of clear compliance rules or penalties for non-compliance has certainly contributed to the underbidding problem. Despite the existing problems, auction results have been used as basis for the Feed-in Tariff introduced in 2009 (Cozzi 2012). Feed-in tariffs resulted in values ranging from a minimum of 37 €/MWh for a project awarded in 2004 to maximum of 59 €/MWh for a project awarded in 2005²⁰. Auction results of 2006 and 2007 showed prices in the range of 41 to 51€/MWh.

The first auction for **Wind offshore** was opened in September 2010. Following the lessons learnt with wind onshore auctions before changing the pricing rule in 2007, the price setting is based on average prices of all bidders, meaning that bids closest to the average price are best rated. The multiple criteria for awarding the feed-in tariffs and their relevance are the following:

- Price with a weight of 55%
- Technical design with a weight of 25%
- Bidder experience with a weight of 15%
- Financial project data with a weight of 5%

In addition to the mentioned criteria strict prequalification rules concerning financing abilities and technical experiences apply (IRENA 2013). Thus, bidders must be a legal entity with net assets exceeding the capital value of the project. With regard to technical experiences, only bidders owning already a wind farm of at least the size of the project are admitted. According to IRENA (2013) bidders are obliged to show a supply contract with a turbine manufacturer, who again needs cumulated experience of at least 100 wind turbines equal or above 1 MW. In contrast to Wind onshore auctions, no local content rules are applied in these auctions. The concession period of the Wind offshore support covers 30 years, with 4 years reserved for construction of the plant.

Available experiences with the Wind offshore auctions show – similar to the case of Wind onshore – a lack of clear compliance rules. Underbidding has been observed and very little international bids have been made with only 2 out of 26 bidders being from abroad. In addition, private investment could not be encouraged in this auction, provided that auction winners were mainly public companies. According to IRENA (2013) resulting prices apparently have not been sufficient to guarantee profitable projects and have only been possible, since winning state-owned companies cross-subsidise these projects with profits from the fossil fuel business. There have been also serious planning and coordination inefficiencies, leading to a modification of all four project locations after having awarded the financial support. These changes included moving one area 15 km offshore, relocating another project and reducing the predefined sea area for the two other projects.

²⁰ Converted based on annual average conversion rates taken from www.oanda.com. Contract prices in Yuan/MWh were taken from IRENA (2013).

Two auctions for **solar PV** projects at pre-identified locations were conducted in 2009 and 2010. Similar to the auctions for wind, underbidding has been a problem in the Chinese PV auctions. In addition, realised projects have been characterized by a low quality of power plants. The auction outcomes led to tariffs between 81 and 121 €/MWh (Becker & Fischer 2012) and were taken as a basis for the determination of the country-wide FIT that has been introduced in 2011. The FIT for installations until July 2011 of 121 €/MWh and the 111 €/MWh for installations thereafter are judged to be too low to support roof- and building-integrated PV power plants, as well as PV power plants in East China, where most of the electricity demand is located. According to Becker & Fischer (2012) the duration of support has not been determined, involving thereby a considerable investment uncertainty.

The first auction for a 50 MW **concentrated solar power** (CSP) plant in Erdos, Inner Mongolia, has been opened in January 2011. With only three bids from state-owned companies, there was only little interest from the private industry in this auction (IRENA 2013). The winner Datang Energy will receive a feed-in tariff of 117 €/MWh²¹ for a duration of 25 years, which is considered to be insufficient for other CSP-projects (Wiesenberg et al. 2012). Another 92 MW project for the Yulin alternative energy park has been awarded in 2012²².

²¹ Conversion from January 2011: 0,1242€/RMB. Source www.oanda.com.

²² www.renewablesinternational.net/esolars-chinese-partner-makes-a-successful-bid-for-solar-thermal-project-in-fuxin-city/150/510/30493/

Box 2: Main lessons learnt from auctions in China

Core issues identified

- Many problems in the practical implementation exist, mainly due to missing compliance rules and additional administrative deficiencies such as ex-post change of location.
- Underbidding in the Chinese auctions could not be avoided, despite several modifications including a change in pricing rules introduced.
- The Chinese example shows, that auctions of exemplary projects can be used to determine country-wide feed-in tariffs. However, experiences in China indicate important difficulties with this auction type. This applies in particular to resource-dependant technologies, since conditions and requirements between different regions may diverge considerably. Besides the problem of under-bidding, price bids for location-specific auctions typically reflect lower-cost potentials.
- Only little interest of private investors in state-company dominated market has been observed in particular in case of the less mature technology CSP.

Recommendations derived for Europe

- Clear compliance rules are a prerequisite to encourage participation and their coherent implementation improves the rate of project realisation.
- The price setting rule and auction procedure must be carefully designed and adapted to the individual policy and market context.
- Additional rules are required to successfully use auctions for determining country-wide support level. This may include the link to resource conditions (e.g. reference yield model or link to wind/solar atlas) in order to partially offset different cost requirements.
- Another more general option is to increase bid prices by a certain percentage to determine more general tariff levels, but this increase is difficult to quantify.
- Due to market liberalisation competition from state-companies should not be a major issue for the European case. However, these lessons could apply for incumbent players in liberalised markets with high market concentration. Participation of smaller actors should be facilitated.
- For immature technologies such as CSP a stronger weight of technical and project experience in a multi-criteria auction could improve the rate of project realisation.

Online tender for small-scale PV in France

Since 2011, France has conducted standardised pay-as-bid online-auctions for rooftop PV installations between 100-250 kW. The auction time-table aimed for regularly held auctions (for instance, five auctions in 2012), but in 2013 the first three scheduled auctions have been cancelled to improve auction design.

Apart from the standardised online-process, no financial guarantees are required and there is no pre-qualification stage to achieve eligibility for the auction. However, the bidder needs to be the owner of the building on which the PV installation is constructed in order to be able to make a valid bid. Moreover, a CO₂ assessment has to be included into the documentation (according to a provided template, including distances for shipping the equipment etc.) and a statement regarding recycling of the installation after dismantling. The CO₂ assessment influences the evaluation of the bid by 33% (thus, it is not a pure price-based auction).

Support is paid for 20 years. While the support level is mainly based on the outcome of the auction (80%), 20% of the tariff is indexed annually with income levels in the energy industry and an industry-specific price index. Moreover, support is limited to 1580 hours per year in France (mainland) and to 1800 hour per year in Corsica and overseas.

The installation has to be up and connected 18 months after publication of the auction results (extendable by 2 months, if the delay is caused by the DSO). In case of delays, the duration of support can be reduced by the delay, multiplied by two. Table 9 provides an overview of auction results in 2012, ranging from 194 €/MWh to 231.5 €/MWh.

Table 9 Auction results in France, 2012.

Round	Auctioned amount	Results
2012 / 1	120 MW	<ul style="list-style-type: none"> • Bids: 345 (68 MW) • Eligible bids: 218 (45 MW) • Average Price: 229 € / MWh
2012 / 2	30 MW	<ul style="list-style-type: none"> • Bids: 227 (47 MW) • Eligible bids: 138 (27 MW) • Average Price: 231.5 € / MWh
2012 / 3	30 MW	<ul style="list-style-type: none"> • Bids: 262 (53 MW) • Eligible bids: 148 (30,2 MW) • Average Price: 231 € / MWh
2012 / 4	30 MW	<ul style="list-style-type: none"> • Bids: 388 (81 MW) • Eligible bids: 143 (30,9 MW) • Average Price: 194 € / MWh

Several main issues are remarkable regarding these auctions in France. The easy-to-use online platform for auctions has attracted a high number of bids. However, of those bids at most 60% were eligible. This is seemingly due to unclear and/or inadequate documentation requirements (for instance, regarding the CO₂ assessment). This in turn resulted in a lack of demand, reduced competition and relatively high prices (**low efficiency**) – the opposite an auction aims for. In this context, it should be considered, that technological requirements – PV installation have to be building-integrated – is another factor leading to higher prices.

Moreover, some bidders submitted several bids and as a result, in the fourth auction in 2012 the 143 bids were submitted by only 35 bidders. Due to this fact, auctions for 2013 have been cancelled to improve the auction rules. Nonetheless, this example illustrates that auctions do not per se exclude smaller players. Notwithstanding, the design has to reflect the reduced capacity and capability of smaller players of bearing transaction costs.

Box 3: Main lessons learnt from auctions in France

Core issues identified	Recommendations derived
<ul style="list-style-type: none"> Auctions for small-scale technologies are possible, but have to be designed adequately to ensure a high share of eligible bids. 	<ul style="list-style-type: none"> Keep documentation (requirements) clear, simple and straight forward. Avoid any requirements (e.g. CO₂ assessment) that cannot be realised by smaller, inexperienced bidders/project developers.

Auction for distributed generation technologies in California

California realised **technology-neutral auctions** for distributed generation technologies with a size ranging from 3 MW to 20 MW. In its Renewable Auction Mechanism (RAM) four bi-annual auctions have been realised between 2011 and 2013 in order to support 1.3 GW of RES-capacity (Douglas 2012). Three product types have been auctioned in the RAM:

- base-load technologies
- peaking-as-available (PV)
- non-peaking-as-available (wind and hydro).

The auctions followed a **sealed-bid procedure** with **product-specific initial price limits**. Prices – in terms of a fixed feed-in tariff – were determined pay-as bid supplemented with additional support for transmission upgrade costs. Resulting prices of the auction will be the basis for determining a FIT for small-scale plants smaller than 3 MW, whilst larger plants are supported by the RPS-system.

In order to increase the rate of **project realisation**, several prequalification criteria (such as documented developer experience, proof of site control, the use of a commercially available technology, finalised grid connection study) are defined. Successful winners must provide a deposit and they have 18 months (up to two years in case of regulatory delays) to start plant operation.

The outcome of the first two auctions shows a strong interest among potential bidders and **low prices** - below US \$ 90/MWh (Douglas 2012). Successful bids in both auctions were clearly dominated by solar PV power plants, with an increased share of other technologies in the second auction. Provided that the first plants are expected to go online in the third quarter of 2013, the effectiveness of the scheme cannot yet be evaluated. According to Douglas (2012) the RAM procurement was welcomed by auction participants, also, because it was judged to be considerably faster than the process to solicit support – including bid solicitation until approval – under the RPS system.

Box 4: Main lessons learnt from auctions in California

Core issues identified

- The Californian RAM represents a simplified procurement mechanism compared to the state RPS, targeting small- to medium scale technologies.
- The RAM includes a clear and reliable time-table.
- The differentiation according to dispatching characteristics instead of technology may contribute to better adapt the technology mix to market integration requirements.

Recommendations derived for Europe

- The Californian example shows that auctions can successfully be applied to support small- to medium scale technologies.
- An auction should be embedded in clear and reliable time-tables with regular auction frequencies. The bi-annual implementation of auctions appears to be adequate for small- to medium scale technologies, where strategic behaviour is less likely than for larger-scale technologies.
- Similar differentiation might be included into an auction design in Europe as well, if feasible in a specific context.

Combining generation-based and capacity-based tariff determination in auctions – The volume-market model by Groscurth & Bode (2011)

The concept for an auction-based tariff determination proposed by Groscurth & Bode (2011) differentiates between dispatchable and non-dispatchable RE-technologies. Non-dispatchable RE-technologies should receive auction-based determined tariffs for a determined maximum of total electricity generation during the whole lifetime of the plant. The maximum electricity generation suitable for remuneration is determined by the auction-based tariff.

neration is thereby calculated by the installed capacity, the lifetime and a predetermined amount of full-load hours. In contrast, auctions for dispatchable RE-technology are used to determine the price of a capacity payment in order to encourage market and system integration of dispatchable technologies. Potential problems regarding capacity payments are related to a possible over-dimensioning of the installed capacity.

3.3.4 Summary and short appraisal

Tender or auction schemes do not represent a distinct support category, but are often used in combination with other support schemes. They are usually applied to **allocate financial support** to different renewable technologies and to **determine the support level** of other types of support schemes, such as feed-in systems, in a **competitive bidding procedure**.

Auction design options

Regarding the auction procedure, the **static sealed-bid** and the **dynamic descending clock** auction or a combination of the two have been predominantly used to support new RES-E installations, typically combined with **pay-as bid** prices or a **uniform clearing price**. In general, dynamic auctions are well suited for less concentrated markets where there is uncertainty about the detailed costs of a RES-project. Static sealed-bid auctions, on the other hand, are better at preventing collusive behaviour that may occur in markets with low levels of competition. The auction procedure selected should reflect the bidders' strategies and behaviour and be suited to the individual market conditions (Kopp et al. 2013). There are different measures to avoid winning bidders not following through with actual implementation. These include **pre-qualification criteria** for participation in the bidding procedure, **bid bond guarantees** and **penalties** in case of non-delivery or delays. The aim of these measures is to reduce the number of bidders to those with serious intentions and the financial and technical ability to implement the project without reducing market liquidity too much.

Heterogeneous objectives and implementation design in practice

Auction schemes used for RES-support can be characterized by very heterogeneous objectives, framework conditions and widely varying design. For example **Brazil** uses auctions as their predominant RES-support scheme for various renewable technologies and applies a hybrid auction design combining sealed bids with a descending clock auction procedure.

The Netherlands use sequential auction rounds to determine a floating premium with a focus on increasing the static efficiency of policy support. Although, in principle, the auction is open to most renewable technologies, less mature and more cost-intensive ones such as wind offshore have only a very small chance of receiving a premium under the Dutch auction scheme. **Denmark** applies location-specific tender schemes for wind offshore and takes stakeholder feedback into account when stipulating the tendering rules. **China** has been using auctions for specific projects and to use the results of the auctions as a benchmark for setting a fixed feed-in tariff. That smaller players may also be included in an auction, is demonstrated in the **French** online-based tender procedure for medium-

size PV installations. **California** relies on auctions to determine feed-in tariffs for distributed generation technologies. Although designed to be technology-neutral, the winners of the Californian auctions have mostly been Solar PV technologies.

Lessons learnt from international experiences

Experiences with auction schemes have shown that they can be successfully applied to increase the cost-effectiveness of renewables support. However, the analysis of the practical experiences also reveals that important critical issues and challenges related to auction procedures still have to be addressed.

Empirical evidence indicates that **low implementation rates** caused, e.g. by underbidding or the existence of non-cost barriers, are one of the main drawbacks of auctions used for RES-support. However, it should be remarked that it is still too early to draw any final conclusion about this issue, since the permitted time frame for construction and delivery has not yet ended in most of the analysed schemes. Thus, it remains to be seen whether auction schemes can eventually achieve the desired effectiveness.

Lessons drawn from applying measures to mitigate the “non-realisation” problem, such as **prequalification criteria**, **penalty payments** for non-fulfilment or **bid bond guarantees**, show that the definition and application of these measures is challenging. Their practical implementation has been partially successful, but finding a compromise between encouraging high realisation rates without over-restricting the number of market participants, proved to be a difficult task. When determining the target volume for the auction, the potential share of non-realised projects should be taken into account. In addition, too harsh measures to avoid underbidding may increase the risks for plant operators and therefore lead to higher risk premiums and policy costs.

Shifting **risks** to the project developer may lead to higher support costs. Risks should therefore be distributed to the actor best able to deal with them. For example, licensing could be done by public entities, whilst issues related to project development are probably better dealt with by the project developer.

Another challenge of auction schemes is to guarantee the **continuity of support**. There is a possible risk of stop-and-go cycles due to the one-off approval of support, which may again increase the risk premiums required by bidders. Regular and predictable auction timetables can avoid this problem, but too regular schedules might increase the possibility of strategic behaviour by larger market players at the same time. Lower frequencies tend to be more difficult to cope with for smaller market players, whilst larger players are usually more flexible as to when RES-support is made available. In addition, transaction costs rise with increasing auction frequency. However, these challenges should be able to be addressed in the auction design, which needs to find a compromise between high frequency in order to guarantee continuity and avoiding strategic behaviour at the same time.

Finally, the **outcome** of the auction depends heavily on the combination of its **concrete design** and the prevailing **framework conditions**. These include the attractiveness of the renewables market and resource conditions, economic growth perspectives, the number and characteristics of potential bidders and the existence of additional administrative and grid-related barriers. Experiences have shown that technology-neutral auctions in particular cause lower technology diversification by predominantly encouraging technologies characterised by low generation costs, and neglecting support for more innovative technologies with the potential for future cost reductions. Thus, technology-neutral auction design tends to provide only very limited development possibilities for less mature technologies (low dynamic efficiency) and can **limit the variety of market participants**, since smaller actors may not be able or willing to bear the transaction costs of participating in an auction.

3.3.5 The way forward

Auctions should therefore be carefully designed and individually designed to match the respective objective and framework conditions. At present, RES-support with auctions is still undergoing a learning phase and may require adaptation to avoid potential caveats. Based on suggestions from based Kopp et al. (2013) and Klessmann (2013) we suggest following several steps for auction design (see Figure 6).



Figure 6 Four-step process to implement auctions
Source: based on Klessmann 2013, Kopp et al. 2013

First, before implementing an auction, fundamental decisions have to be made, e.g. which technologies are targeted. If a technology-neutral design is selected, implementing additional measures to stimulate less mature technologies and smaller-scale technologies should be considered. Moreover, the targeted volume in the medium and short-term should be agreed. This is crucial to further break down the overall targeted volume into smaller parts to be auctioned during one year and, on a more specific level, during each auction round. In addition, it is important to decide whether the auction should be location-specific or not.

Second, the market environment should then be analysed. This includes information on market, number and characteristics of market participants and details on the typical project cycle of the targeted technologies. A careful examination of the market is crucial because competition stimulated through the auction depends on the market structure – the bigger the market and the more potential bidders, the higher the expected level of competition. Several design aspects of the auction depend significantly on these factors. For instance, if a technology is typically characterised by short project cycles, a more ambitious time table can be adapted than for technologies with longer project development cycles. Typical risks in a project cycle of specific technologies have to be examined in order to be able to address them in design details (such as penalties).

Third, the actual auction design should be addressed. These features include the type of auction, pricing rule, qualification criteria, penalties, etc. All the information gathered in the second step needs to be taken into account for the design. For instance, penalty rules will influence the level of competition and the project cycles are relevant for the defined time table.

Finally, one possibility to learn from concrete auction design is to implement a pilot phase for auctions at a lower scale. Additional experience can be gained before potentially, gradually scaling up the scope of the auctions. Another possibility is to implement a participatory approach, as used in the Danish tender for offshore wind, and to include the knowledge and experiences of stakeholders in the concrete design. In this case, lobbying influences should be avoided. Experiences which feed back into the adapted auction design include answers to the questions: What were the actual levels of competition and first result in terms of prices? Which are the implementation rates for specific technologies? How can the practical implementation of the auction procedure be improved? These and other issues can then be addressed and the auction design for a specific context can be improved.

3.4 Quota obligations

The first step of implementing a quota obligation in combination with tradable green certificates (TGC) is to set the target, usually in terms of RES-share in final consumption. Power plant operators receive certificates for their green final energy, which they may sell to the actors, obliged to fulfil the quota obligation. Selling the certificate provides an additional income to the common market price of the final energy sold.

The main advantages of the quota obligation with TGC markets are the **high compatibility with market principles** and the **competitive price determination**. However, **high risk premiums** resulting from the uncertain development of the electricity and the certificate price typically increase policy costs. Existing price risks in both markets can be mitigated by concluding long-term contracts.

Regarding the **effectiveness**, a quota obligation is theoretically well suited to exactly meet the target, but empirical evidence indicates shows, that in practice over-fulfilment (Texas) and short-fall of targets as in the United Kingdom and Italy may occur (Wood & Dow 2011). In addition, there is some type of auto-regulation of certificate prices if the target is reached, leading to considerable drops in prices. These price drops strongly affect the income stream of already existing plants and contribute to increasing risk premiums. One potential remedy to avoid these price drops and to improve investment security is a continuous adaptation of the quota target through a "headroom", as applied in the United Kingdom. However, the use of a headroom involves a reduction of the target achievement accuracy.

Provided that quota obligations are designed in a **technology-neutral** way, only the most cost-effective technologies are supported, leading theoretically to a **high static efficiency**. At the same time, **dynamic cost efficiency** tends to be **low**, since most of the cost-intensive technologies do not

receive sufficient support. In case of a typically technology-neutral quota, **windfall profits** may occur for the lower cost technologies.

Regarding **it implementation options**, the quota obligation has originally been applied in a **technology-neutral** form, meaning that one overall quota obligation is determined for all the different renewable technologies. Consequently, all technologies required to fulfil the quota receive the same level of support. If the costs of the supported technologies diverge strongly – characterised by a steep cost-potential curve – windfall profits for the most cost-effective technologies occur. Thus, technology-neutral quota obligations are better suited for renewables support in case of flat cost-potential curves. One option to avoid excessive windfall profits is the introduction of **technology-specific** elements into the quota system. These technology-specific elements may take the following forms:

- **Technology banding**, where a different number of certificates is assigned to the technologies. For example one unit of electricity generated in wind onshore power plants may receive 1 certificate, whilst offshore wind could receive two certificates for each unit of electricity.
- **Technology-specific targets or carve-outs**, where individual markets are created for each technology group.

Both options contribute to avoiding windfall profits, but have also other implications. Technology banding adds complexity to the market and does hamper the accuracy and control of target achievement compared to technology-neutral quota. In addition, parameterising the multipliers for the different technologies is very sensitive for the performance of the quota and requires good knowledge of technology costs. The additional complexity of banded quotas makes the prediction of the certificate prices more difficult, which may imply higher risk premiums from investors. In contrast, technology-specific targets maintain the advantages of predictable and controllable targets, but lead to smaller and less liquid markets, reducing thereby competition.

One measure to reduce the risk premium is to introduce **floor prices**. Maximum prices or penalties are implemented in practically all quota systems in order to ensure target fulfilment. These penalties have to exceed the costs of the marginal technology required to meet the target.

Subsequently, we present experiences with implemented quota obligation systems, mainly focussing on the comparison of technology-neutral and technology-specific quota systems.

3.4.1 Practical experiences

At present, six EU Member States, the US at federal level in many states, three Canadian Provinces, Chile, Thailand and Australia apply quota obligations to support renewables (Buckman 2011, Battle & Barroso 2011). Based on the experiences made with quota obligations, three of the European Member States (UK, Italy and Poland) have announced the replacement of the quota obligation with another support scheme. In the United Kingdom and in Italy, high certificate prices and low policy effectiveness certainly influenced the decision to abolish the quota system. Thus, the sum of certificate price and electricity price in the United Kingdom led to an overall remuneration of roughly 125 €/MWh

for onshore wind, enabling considerable windfall profits. At the same time, the British quota system was not as effective in stimulating investment in additional RES-E capacity as other countries applying FIT or FIP systems regarding onshore wind support (Steinhilber et al. 2011). Similarly, the Australian quota obligation only triggered a very moderate growth of wind power plants, whilst mainly more cost-effective renewable heating technologies have been deployed. In general, it should be taken into account that the concrete implementation design of the quota system determines its success or failure in practice, similar to other support schemes.

Technology-neutral quota obligation in Sweden

The technology-neutral Swedish quota obligation system was implemented in 2003 and since 2012 there is a joint certificate market between Sweden and Norway²³. Most of the renewable technologies, including existing RES power plants, hydropower plants with a capacity of at least 1.5 MW and plants using peat, are entitled to receive green certificates. Existing plants have been included in order to guarantee a minimum liquidity, but in 2013/2014 the support for existing RES power plants will be phased out (Bergek & Jacobsson 2010).

In the first two accounting periods, the penalty level was below (2003) or very closed to the certificate prices (2004), leading to a quota fulfilment of only 77% in 2003. As a consequence the penalty payment in Sweden was fixed at 150 % of the certificate as of 2004/2005, guaranteeing a penalty level always above the certificate price or the generation costs of the marginal technology. Another change introduced in 2006 was the extension of the validity period from 2010 to 2030 in order to improve investment security on a longer term horizon (KOPP ET AL. 2013).

Analysing the experiences with the Swedish quota system, it becomes clear that **certificate prices** are comparatively low, but show a certain volatility (see Figure 7). Prices ranged between 15 and 40 €/MWh during the last five years.



Figure 7 Certificate prices in Sweden.
Own illustration with data from <http://www.skm.se/priceinfo/history/>²⁴.

²³ Although Norway is not a Member of the European Union, it has voluntarily adopted renewables targets by 2020.

²⁴ Swedish Crowns have been converted to Euro using weekly exchange rates based on www.oanda.com/currency/historical-rates/.

According to Bergek & Jacobsson (2010) the low certificate price level in Sweden still provides high producer rents for operators of cost-effective biomass power plants using waste from the pulp and paper industry. To understand the low price level in Sweden, it is important to mention, that the Swedish cost-resource curve is comparatively flat and Sweden disposes of large low-cost renewables potentials. In addition, the ambition level of the Swedish target is comparatively low. The 2020 target of 49 % has already been achieved in 2012 and the Swedish Renewable Energies Association assumes a target of around 70 % to be feasible for Sweden (EREC 2013). Thus, the Swedish quota system mainly supports the "lower-hanging-fruits". Another reason for the low price level is the current over-fulfilment of quota targets, leading to an erosion of prices. Bahr et al. (2012) suggests to continuously adapting the quota target in order to avoid price erosion as a result of getting closed to the target.

Swedish quota obligations have mainly been fulfilled by industrial and CHP biomass power plants and peat-fuelled power plants so far. The majority of the renewable electricity used for the quota obligation has been generated in existing power plants and only low investment in new power plants have been encouraged. Thus, new power plants produced only 2.5 TWh of renewable electricity in 2008, whilst the remaining increase in RES-E generation is attributed to existing biomass power plants. Another low-cost option used to fulfil the quota are former fossil-fuel power plants converted to "reverse" co-firing plants, where mainly biomass is combusted together with a small amount of coal. Low prices, the existing volatility and the missing long-term horizon have not stimulated investments in additional wind onshore power plants or biomass CHP plants in the earlier years of the quota obligation, but since the expansion of the support horizon to 2030, investments in new capacities have increased.

Experiences with the technology-neutral Swedish system have to be seen in the country-specific context with its very specific framework conditions. These experiences are only transferable to other countries to a very limited extent. The reasons for this are the high potential of low-cost resources, a low ambition of RES-targets and a high share of dispatchable RES such as biomass power plants in the system. The system still has to prove whether it may stimulate investments in new capacity after existing plants will be excluded from the quota in 2013/2014. In countries with more ambitious targets and less favourable RES-potentials the Swedish quota system may lead to completely different outputs.

Technology-banding in the United Kingdom

After having supported renewables with auction or tender schemes (Non-Fossil-Fuel-Obligation - NFFO), the United Kingdom changed its main support scheme for RES-E to a renewables obligation (RO) with a tradable green certificate market in 2002. In its initial form, the British RO was technology-neutral, but technology-banding was introduced in April 2009 after a public consultation in order to reduce potential windfall profits for cheaper technologies and to encourage stronger growth of less mature and more cost-intensive technologies. In addition, the British government launched a FIT scheme for small-scale technologies with a size below 5 MW in spring 2010. The validity horizon of the quota obligation was extended from 2027 to 2037 in 2010 to increase investment certainty and

trigger more long-term investments (KOPP ET AL., 2013). However, the plans of the British government to replace the RO by a feed-in premium scheme (Contract for Difference – CFD) as of 2014 indicate that the realised modifications of the quota obligation could still not fulfil expectations of the British government. New plants may still apply for support under the RO until March 2017 and the quota obligation will run in parallel to the CfD system until 2037, allowing for revenues from certificate prices during 20 years after the last new plant enters into the certificate system. More analysis on the path dependency of quota systems are realised in section 2.5.2.

Experiences with technology-banding in the UK showed that the design of the banding and the determination of the multipliers are crucial for the success of the banded quota. In principle, technology banding comes closer to price-based approaches, provided that the setting of the banding multipliers requires knowledge of RES-generation costs similar as in a price-based support instruments. Introducing banding in the British quota system has been partly perceived as abandonment of market-principles (Buckman 2011).

Accordingly, these were calculated based on RES-E generation costs at present and their outlook until 2020. A revision of the initial wind multiplier for offshore wind from 1.5 to 2 after a public consultation indicated some difficulties to adequately determine banding multipliers. Buckman (2011) states that revenues from banded certificates were still more generous for certain technologies such as wind onshore and landfill gas than for less mature technologies. Another issue concerns potential higher risk premiums in banded quota systems due to more difficulties in estimating the future certificate price (Johnston et al. 2008). The price depends on the degree of target achievement which is much more difficult to predict in a banded quota system. Accordingly, stronger fluctuation of certificate prices could be observed since the introduction of banding.

One option to reduce price risk and to guarantee a minimum price level is the use of the “headroom”, where quota targets are increased a certain level above the desired target in order to avoid that price crashes if RES-E deployment is close to target achievement (Buckman 2011). The headroom assumes the role of an implicit floor price.

Observing the target achievement under the RO (see Table 10) shows a low level of target achievement in all accounting periods between 2002 and 2011. Buckman (2011) attributes the low level of target achievement to intentions of market participants to increase the recycling payment. The concentrated market in the United Kingdom and the fact that a low degree of target fulfilment increases the recycling payment may have encouraged this strategic behaviour (Buckmann 2011).

Table 10 Target achievement in the British RO.
Source: Own illustration based on DECC (2012)

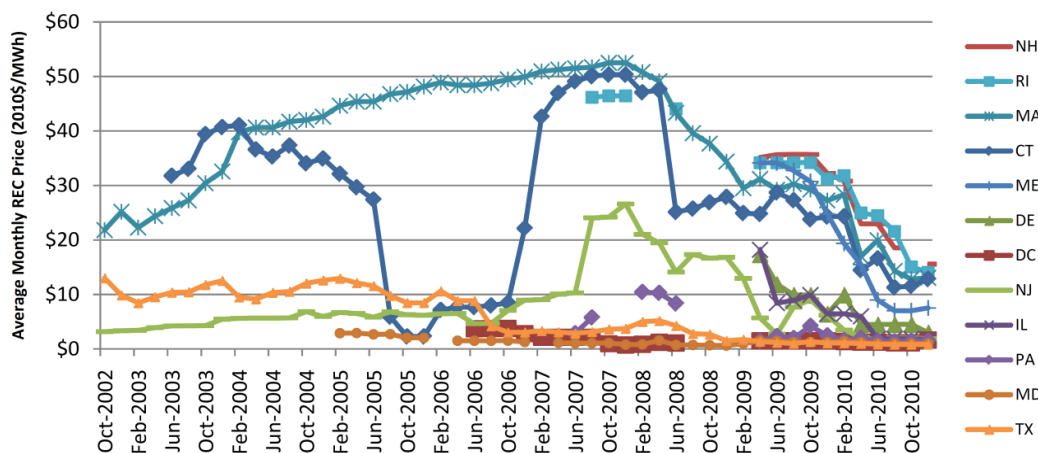
Year	Target	Target achieved	Degree of target achievement
2002/03	3.0%	1.8%	59%
2003/04	4.3%	2.4%	56%
2004/05	4.9%	3.4%	70%
2005/06	5.5%	4.2%	76%
2006/07	6.7%	4.4%	66%
2007/08	7.9%	5.1%	64%
2008/09	9.1%	5.9%	65%
2009/10	9.7%	6.9%	71%
2010/11	11.1%	8.0%	72%

Technology-banding in Italy

The Italian quota system (introduced in 2001) was replaced by a tender scheme for large-scale power plants as of 2013, whilst smaller-scale applications receive feed-in tariffs. Initially, some first elements of technology-banding in Italy were introduced by differentiating the validity horizon of certificates for different technologies in 2006. Most of the technologies could issue certificates during 12 years, whilst biomass power plants certificates were granted certificates for 100% of their electricity generation during 8 years. For the next 4 years, certificates could only be issued for 60% of electricity generation in biomass plants. Before the introduction of this system, certificate validity was 8 years for all technologies. Tradable green certificates were then differentiated according to technology categories based on multipliers since 2008 until the end of the Italian quota system. However, only little technology differentiation through banding with multipliers ranging from 0.8 for biogas to 1.8 for ocean technologies was used. In general, the performance of the Italian quota obligation was characterised by high certificate prices - with average values ranging from 74 to 85 €/MWh between 2009 and 2012 - and low effectiveness for most of the technologies in particular in the earlier phases of the quota obligation (Steinhilber et al. 2011). Despite the less favourable banding factor the development of onshore wind has been stronger than in case of biomass in particular in the last two years of the obligation. Another problem observed in the Italian system was the non-existence of clear and explicit non-compliance penalties. Although sanctions in case of non-fulfilment exist in theory, there were only vague rules for monitoring compliance.

Pioneer in using quota obligations for RES-support in Texas

The US applies renewable portfolio standards (RPS) in half of the 50 states. Out of these, 11 states apply technology-specific targets or carve-outs, where the overall quota is split into technology-specific targets (Buckman 2011). Figure 8 shows a broad range of corresponding certificate prices in some US states. Provided that Texas was one of the first states in the US that implemented a RPS, we will shortly describe the long-lasting experience with the Texan quota obligation.



Note: Plotted values are the last trade (if available) or the mid-point of bid and offer prices for the current or nearest compliance year.
Source: Evolution Markets (2007) and Spectron Group (2011).

Figure 8 Certificate prices in the USA (Holt et al. 2011, p. 11)

The initial target of the RPS was set to 2 GW of renewable capacity by 2009. With the exception of solar PV, which receives 2 certificate per MWh of electricity generated, the Texan RPS can be regarded as technology-neutral. Certificates are valid during 3 years. The low ambition level of this target – 2 GW correspond to only 3.6 % of peak load demand – lead to very low certificate prices assuming values of 2-5 USD/MWh from 2008 to 2010 (see Figure 8). Provided that the targets set for 2009 were already achieved in 2005, future targets have been determined in 2005, amounting to 5.88 GW by 2015 and 10 GW by 2025. This shows that over-fulfilment of quota occurs in practice and that accurate target achievement is not always guaranteed by quota systems in practice. In case, the quota obligation is not met, 50 USD/MWh have to be paid as penalty.

The effectiveness of the Texan quota is difficult to evaluate, since additional factors probably influenced the strong and very successful development of wind power. Very low prices of the RPS certificates indicate that the RPS was not the only driver for the strong wind development. Favourable wind resource conditions and long-term contracts between wind plant operators and electricity suppliers have been identified as important driving factors of the effective wind development (Kieldegaard 2008). Finally, there is additional support from the federal production tax credit.

Integration of heat in quota system in Australia

We briefly analyse the Australian quota due to the integration of heat in the quota system. Solar water heaters and heat pumps are entitled to participate in the Australian certificate market. Thereby, the electricity displaced by the solar water heater or the heat pump during 10 years determines is the reference level for the number of certificates eligible for heat generation. Uniform renewable energy certificates (REC) used since 2001 have been split into "large-scale generation certificates" (LGCs) "small-scale technology certificates" (STCs) in 2010. Certificates for heating technologies are covered by the STCs. Observed prices have been fluctuating depending on the demand and generally as-

sumed values between 20 and 40 AUD/MWh for STCs. Target for the STC obligation are shown in Table 11.

Table 11 Current targets for small-scale technologies under the quota system in Australia.

Source: <http://www.energyaction.com.au/australian-energy-market/energy-state/sres-targets.html>

Year	STCs Target (# of certificates)	Old ST P	New STP	STC Price	Old Cost for Con- sumer (c/kWh)	New cost for consumer (c/kWh)	Cost In- crease
2013	34,460,000 (thereof 15,990,000 carryover from 2012)	7.87%	18.76%	\$40.00	0.315	0.750	0.435 (1 38%)
2014	14,486,000	6.10%	7.69%	\$40.00	0.244	0.308	0.064 (26%)

In general, experiences show that the Australian system favours low cost technologies (Byrnes et. al 2013).

3.4.2 Summary and short appraisal

Quota obligations with tradable green certificate market are very compatible with market principles. Due to the competitive price determination of the support levels in terms of the certificate price, both support level components – the electricity price and the certificate price – are subject to market mechanisms. Thus, a quota obligation is characterised by greater market compatibility than a FiP-system. However, the uncertain development of the electricity and the certificate price mean strongly increasing price risks for plant operators. The high risks in the quota obligation system tend to favour incumbent players, since large companies are usually better able to hedge the prevailing price risks.

Empirical evidence concerning quota systems shows that the theoretical advantages of quota systems could not be realised in practice. The recent substitution of quota obligations with other support mechanisms in three large countries – the UK, Italy, and Poland – suggests a trend moving away from using quota obligations for RES-support in Europe.

One major problem is the occurrence of windfall profits for lower cost technologies with the technology-neutral design option. Design elements to implement the quota obligation in a technology-specific manner, such as banding factors or carve-outs introduce additional challenges, such as the correct parameterisation of banding factors or sub-targets and lead to additional complexity. Banding implies a less accurate volume control, whilst sub-targets decrease market liquidity.

Technology-neutral quota obligations may be useful in countries with low differences in the generation costs of potential RES-projects – reflected by a flat cost-resource curve – as implemented in Sweden or in Texas. However, windfall profits cannot be totally avoided.

Similar to other support schemes, the concrete design and its alignment to framework conditions such as market size, shape of the cost-resource curve or ambition level of target are crucial for suc-

successful and well-functioning quota obligations. Experiences have shown that the long-term perspective of support from the quota obligation is crucial to encourage investments in renewable energy.

3.5 Investment support, low interest loans and tax exemptions

3.5.1 Investment support

On a national level, **investments grants** for RES-E are available in several Member States and are often devised to stimulate the take-up of less mature technologies such as PV. Often, investment support is not the main instrument to support renewable energy and exists beside other measures such as feed-in tariffs or premiums. Also, investment support is more often available for renewable heating & cooling projects compared to renewable electricity projects. In 2011, only Finland, Malta (for wind), the Netherlands and Poland had investment support in place for renewable electricity (Reshaping 2011). For deployment of renewable heating & cooling projects, most of the EU Member States have investment grants available.

3.5.2 Tax incentives or exemptions

Tax exemptions are, besides investment grants, the main support instrument for RES heating and cooling (De Jager et al. 2011).

Tax incentives or exemptions for renewable electricity are often complementary to other types of renewable energy incentive programmes. They are powerful and highly flexible policy tools that can be targeted to encourage specific renewable energy technologies and to impact selected renewable energy market participants, especially when used in combination with other policy instruments.

Investment and production tax exemptions are most prominently present in the EU. Some countries, including Spain, the Netherlands, Finland, Greece and Belgium provide **tax incentives related to investments** (including income tax deductions or credits for some fraction of the capital investment made in renewable energy projects, or accelerated depreciation). Other Member States, such as Latvia, Poland, Slovakia and Sweden, have devised **production tax incentives** that provide income tax deduction or credits at a set rate per unit of produced renewable electricity, thereby reducing operational costs (De Jager et al. 2011).

3.5.3 Low interest loans

Low-interest loans are loans available at an interest rate below the market rate. Soft loans may also provide other concessions to borrowers, including longer repayment periods or interest holidays. Thus, they reduce investment-related costs, which account for the bulk of electricity generation costs of most RE-technologies. By reducing capital costs of projects, the profitability increases. A major benefit for investors is the transfer of part of the financing risk to the creditor. This means that the risk is transferred to the public, since usually the creditor of low interest loans is a public institution.



In practice low interest loans have mostly been used to support RE-technologies in the electricity and in the heating sector. Whilst soft loans in combination with investment incentives have been used as key policy instrument to support RE-heating, soft-loans in the electricity sector have mainly been used as a supportive instrument in conjunction with other policy measures such as feed-in systems or quota obligations. Low interest loans and investment incentives often address the use of renewable energy or energy efficiency in buildings under the same programme or measure.

On a national level, soft-loans have been used e.g. in Bulgaria, Croatia, Czech Republic, Denmark, Germany, Lithuania, Netherlands, Bulgaria, Estonia, Malta and Poland (De Jager et al. 2011, RES-Legal 2013). Table 12 provides an example of soft loan programmes that have been applied in several EU countries. One example for a conjoint support programme addressing both, residential renewable heating technologies and energy efficiency, are the German low interest loans and investment incentives available under the "Marktanreizprogramm" (MAP). Denmark provides local initiatives investing in wind energy with guarantees for loans used to finance feasibility studies conducted before building a wind power plant (RES-Legal 2013). Another important feature to stress is the verification of eligibility criteria for projects with capital requirements exceeding € 5 million in order to be allowed to apply for a low interest loan granted by the Croatian bank of reconstruction and development (HBOR) scheme. These criteria are mainly of financial character and include liquidity, creditworthiness and the securities offered.

Table 12 Illustration of soft loan measures available in the EU.

Source: Own illustration based on RES-Legal 2013

Country	Measure	Target group	Maximum loan per project	Financing conditions	Comment
Bulgaria	Bulgarian Energy Efficiency and RES Credit Line (BEERECL)	Small-scale RES and industrial energy efficiency	Max € 2.5 Million		
Croatia	HBOR (Croatian bank for reconstruction and development) scheme		Max 75% of capital needs	Variable, currently 3-months Euribor avg +2%	Eligibility criteria for applications > € 5 Million
	Environmental fund loan				Loans are tendered.
Czech Republic	Eco Energy loan		~ € 2 Million and 75% of capital needs	1% per year	
Denmark		Local initiatives investing in wind energy	67,000€		
Germany	KfW Renewable Energy Programme	RES-E and CHP-power plants	100 % (excl. VAT) up to € 25 Million per project	Duration 5 to 20 years	
	KfW Loan for Offshore Energy	Wind offshore power plants	50-70% of external capital needs and € 400-700 Million per project	20 years with 3 year repayment-free period.	
	KfW financing initiative energy transition	Large-scale residential RES and energy efficiency	€ 25-100 Million for each project and 50 % of capital needs	Interest rates set by local bank	
	Marktanzreizprogramm (MAP) ²⁵	RES-heat, biogas processing			
Lithuania	Fund of the Special Programme for Climate Change Mitigation		No maximum limit established		Partly financed by programme and banks
Netherlands	Loans			Interest rates reduced by 1%	
Slovenia		Municipalities / companies / households (hh)	Max € 2 Million for legal entities and € 5 Million for hh	3-months Euribor avg +1.5%	

²⁵ Whilst support under the MAP consists mainly in low interest loans for large-scale applications and is managed by KfW, small-scale applications are promoted mainly by investment incentives managed by the Federal Office of Economics and Export Control BAFA.

4 Conclusions

In the context of the guidance published by the European Commission (SWD(2013) 439), which supports Member States in reforming and adequately designing their renewable energy support schemes, this report has discussed potential design options of various support schemes. Moreover, we included numerous practical implementation examples of these design features. Experience has shown that the design has to be individually adapted to the prevailing framework conditions in the different regions, including the shape of the cost-resource curve, the electricity mix and the existing national and cross-border grid infrastructure.

Based on the results of this analysis we highlight the following aspects regarding **common design options**:

1. Detailed knowledge of generation costs is required when designing support schemes

Knowledge of generation costs is not only useful to administratively determine feed-in tariffs or premiums, but also to set ceiling prices in auction-/tender systems or identify banding factors in technology-specific quota systems. The approach used to determine costs should be based on levelised costs of electricity (LCOE) calculations. A transparent communication of the calculated costs should be pursued.

2. Cost control is increasingly important for price-driven support schemes

Price-driven support schemes such as feed-in premiums and feed-in tariffs require enhanced mechanisms to control policy costs. Thus, the volume may be restricted by combining feed-in systems with tender/auction schemes or by implementing flexible quantity caps without a competitive bidding procedure. Regarding the adaptation of the tariff level to decreasing generation costs, capacity-dependent degression rates may be implemented for technologies with an important cost reduction potential, such as solar PV. However, the concrete implementation design should take into account the potential negative impacts on investment security.

3. Implement clear and fair burden-sharing rules

Exemptions for energy-intensive industries contribute to their competitiveness, but policy costs for non-exempted consumers increase as a result. Thus, adequate criteria have to be defined to determine whether a company needs to be granted an exemption from the burden of renewables support. These criteria should reflect the share of energy costs in total costs and the degree of exposure to international competition. It is crucial to adequately monitor and control the evolution of policy costs and to adapt the scheme when necessary in order to avoid too steep increases for non-exempted consumers.

4. Implement a stronger technology-differentiation in case of steep cost-resource curves and less pronounced technology-differentiation in case of flat cost-resource curves

The extent to which the support level design should be differentiated largely depends on the steepness of the cost-potential curve. Stronger differentiation helps to avoid windfall profits for more cost-effective technologies and is more closely adapted to the individual requirements of each technology. However, increasing detail with regard to price or volume typically involves higher complexity for parameterisation and transaction costs, suggesting that less detailed differentiation should be the norm for rather flat cost-resource curves.

5. Long-term commitment is crucial while still permitting built-in flexible adaptations to changing framework conditions

There is a fundamental tension in all support schemes: between their need to be predictable and stable from an investor's point of view and their need to provide flexibility to adapt to changing circumstances from a policy maker's perspective. Thus, support schemes should feature flexibility measures which allow them to react to changing circumstances predictably and without causing investors unnecessary insecurity. Too abrupt changes and changes that effect already realised investments should be avoided, but gradual changes that do not adversely affect investment security may be realised and, ideally, should be communicated to and discussed with the parties affected in advance.

6. Early communication of changes and including the public in the support scheme design are necessary

If a switch from one support scheme to another is envisaged, this change needs to be announced well in advance and should include broad stakeholder consultation to make the change as well-designed and as predictable as possible.

7. Integration of renewables into electricity markets is necessary and possible

The increasing RES-share in European electricity markets requires system responsibility from RES power plants, such as balancing responsibility. However, at the same time power market design has to be adapted to the characteristics of the changing technology mix, for instance, by making gate closure as close to real time production as possible.

With regard to **support-specific design options**, several distinguishing criteria appear to be more important than the type of support instrument applied. These include:

- generation-based versus capacity-based support
- price-driven versus volume-driven support
- overall remuneration versus partial remuneration where the electricity price is part of the remuneration for renewables

Recent policy developments have shown that support schemes are not always clearly distinguishable from each other. For instance, price and volume control may be combined in an intelligent manner by price elements such as cap and floor prices into quantity-based quota obligations or flexible volume caps into feed-in systems. The advantages of each type of support scheme may be combined and disadvantages mitigated.

Support scheme-specific recommendations:

1. Feed-in tariffs and feed-in premiums

When comparing overall remuneration (as provided by feed-in tariffs) with partial remuneration (as provided by a feed-in premium) – support should increasingly be based on partial remuneration in order to encourage the market integration of renewables. However, this change should be orchestrated gradually and only those market participants and technologies able to manage market participation and bear the involved risks should be exposed to the related risks. For instance, sliding premiums can help to reduce price risks for plant operators. However, a fixed feed-in tariff may still be the better choice for less mature and small-scale technologies. Both types of feed-in systems can be combined with measures of quantity control, such as flexible caps or auctions/tenders.

2. Tenders and auctions

Combining tenders or auctions with feed-in systems may help control policy costs. However, tender or auctions require careful design and adaptation to the objective and to framework conditions. Practical experiences have shown that there are still several critical issues and challenges; low implementation rates have been identified as one of the main caveats of tender and auction schemes in practice. Thus, when designing tender or auction schemes, it is important to find the right balance between avoiding low implementation rates on the one hand and reducing competition too much on the other hand. Typically, it is more difficult for smaller participants to be successful in an auction or tender procedure. Thus, additional measures for small-scale technologies may be required in order to ensure actor variety.

3. Quota obligations

Due to the competitive price determination of the support levels in terms of the certificate price, both support level components – the electricity price and the certificate price – are subject to market mechanisms, leading to a strong market orientation. However, the uncertain development of both price components implies increasing price risks for plant operators and therefore favours the participation of incumbent players. Technology-neutral quota obligations may result in wind-fall profits for lower cost technologies, whilst a technology-specific quota design may lead to higher complexity, decreased market liquidity and less accurate volume control. The concrete design and alignment to framework conditions such as market size, shape of the cost-resource curve or ambition level of target are crucial for well-functioning quota obligations. Thus, technol-

ogy-neutral quota obligations may be useful in countries with small differences in the generation costs of potential RES-projects – reflected in a flat cost-resource curve.

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Ministry of Economic Affairs, xxxx. BIJLAGE 7 BEHORENDE BIJ ARTIKEL 39 VAN DE REGELING AANWIJZING CATEGORIEËN DUURZAME ENERGIEPRODUCTIE 2011 Uitvoeringsovereenkomst tot zekerheid van het aanvangen van de activiteiten ter zake waarvan subsidie is verstrekt op basis van artikel 35, eerste lid, van de Regeling aanwijzing categorieën duurzame energieproductie 2011. <https://zoek.officielebekendmakingen.nl/stcrt-2011-9424.html>.

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