Market4RES

Final project deliverable

Summary of D6.1, D6.2, D6.3 plus minutes and recommendations of the expert workshop and follow-up consultation process & stakeholder event allocated in WP6

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V2.0	2017-31-10	SINTEF	Final version

EXECUTIVE SUMMARY AND POLICY RECOMMENDATIONS

HARMONISATION AND INTEGRATION OF EUROPEAN ELECTRICITY MARKETS

In 2008, the European Electricity Regulatory Forum decided to develop a European Union-wide Target Model (TM) and a roadmap for the integration of electricity markets. The TM encompasses the harmonisation of market rules in order to facilitate cross-border trading across all time frames (day-ahead, intra-day, balancing and forward markets). It represents an attempt to make large penetration of renewable energy in the power system compatible with the satisfactory functioning of electricity markets in Europe.

INCREASING SHARE OF RES-GENERATION AND THE NEED FOR FURTHER MARKET REFORMS

Today, around 1/3 of the power generation in Europe comes from renewable energy sources. This is to a large degree a result of support to renewable power generation. Support mechanisms such as feed-in-tariffs (FIT) have provided a fixed income per MWh produced and priority dispatch has significantly reduced the risk for curtailment of RES-generation. Those instruments were designed to meet the intended policy objectives, especially reducing CO_2 emissions from fossil-fuel generation.

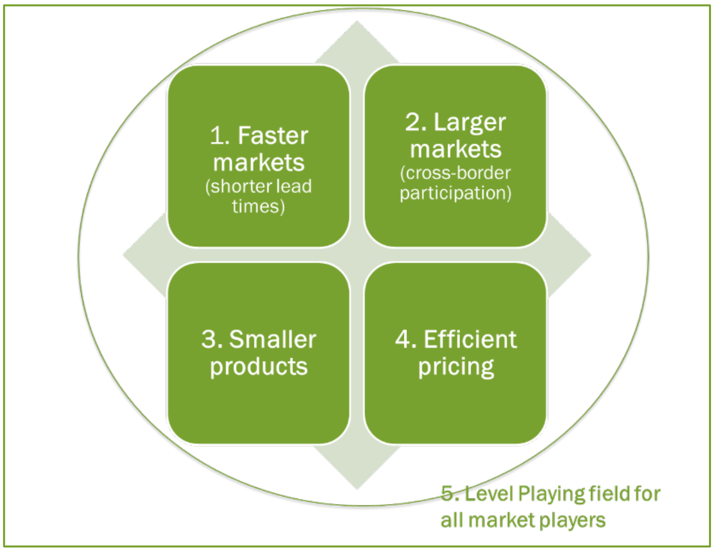
A present challenge is however that power producers are have found it increasingly difficult to recover investment costs due to lower electricity prices if they not supported with additional instrument. This have given concernes about the development of security of supply. The low prices are caused by several factors, also including large penetration of renewable generation with low marginal costs, and low CO_2 prices. Another challenge is that electricity prices have become more volatile, and that some existing support schemes incentivice generation even at times when electricity prices are negative.

Against the background of i.a. the above mentioned challenges a European discussion has emerged on how to further improve the electricity market design. A particular aspect in these discussions is how to reform support instrumens for renewables in order to reduce the interference with short term market signal and limit public support to new generation assess. Another aspect has been if there is a need for capacity markets.

KEY MARKET FEATURES FOR SUCCESSFUL INTEGRATION OF RES

The need for redesigning RES support schemes, is mirrored by the need for making markets more fit for RES. The MARKET4RES project has assessed which key design features that are critical for the successful participation and integration of renewable electricity producers in a fully liberalised and competitive European market across all timeframes (day-ahead, intraday and balancing).

The project arrived to the following conclusions:



Faster Markets: The timing of markets should evolve to refelct faster changes in system conditions, which are largely caused by weather patterns. The point in time when transmission system operators (TSOs) receive the generation schedule should be pushed as close as possible to real time giving market players with variable generation the option to self-balance their deviations via the market. This would increase the value of existing renewable generation, and reduce the need for capacity that is flexible on short notice (e.g. only a few minutes before real time).

Larger Markets: In order to couple cross-border markets at all timeframes (day-ahead, intraday, balancing), the available transmission capacity for trading should be clearly defined. TSOs should use more sophisticated methods (flow-based transmission capacity allocation) and make use of a Common European Grid Model, which takes into account the relationship between commercial flows and physical congestion on affected transmission network elements, maximizing the use of the existing infrastructure.

Smaller Products: Smaller timeframes for electricity trading products are positive for the participation of variable renewable generation units. However, they should be combined with other products to find a balance between the liquidity in the markets and the cost of implementation.

Efficient pricing: The prices should be transparent and should not be kept artificially off from revealing scarcity. This means that price volatility and spikes should be seen as positive outcomes of a market that signals when investments are needed, either in capacity and / or in flexibility.

Level-playing field: The design and rules have to establish a level-playing field for all market players. This include market access, increased transparency of operation procedures, and a polluter play principle.

The ongoing work on harmonisation of balancing responsibilities for all market parties should be accompanied by rules for trading closer to real time and a fair market access. Particularly, it is fundamental having an intraday market with a short gate closure time and a sufficient level of liquidity.

Also, in order to achieve a level playing field, priority dispatch to conventional generators must be eliminated. A reform of the EU emission trade scheme (ETS) is needed to restore a meaningful price of CO_2 and thus ensure polluters pay for the full costs of generating electricity with the technology and fuel of their choice. Last, the continued support to conventional technologies needs to be addressed in parallel to the reform of market design rules and the revision of state-aid guidelines for environment and energy.

Day-ahead Market

Locational pricing: MARKET4RES recommends a pricing scheme either zonal (one price per TSO control area) or hybrid zonal pricing (several/some price areas per TSO control area).

Administrative reliability pricing: With higher shares of varying renewable generation, MARKET4RES recommends having an administratively set price during capacity shortage conditions in addition to the reserve requirements needed for reliability. To the extent possible, this price should reflect the value that curtailed demand puts on electric energy,

Gate closure: The project recommends to establish a well-functioning intraday market rather than pushing the day-ahead market closer to real time.

Intraday market

Market timeframe: After comparative evaluation of different alternatives, the project concluded that combination of continuous trading with discrete auctions (hybrid solution) can be expected to be the best design variant.

Enlarging the geographic scope: When coupling cross-border intraday markets, regional auctions should be introduced at large scale. To do so, it would be required more regional coordination and some harmonisation on auction timmings and gate closure times.

Increasing liquidity: MARKET4RES recommends to increase liquidity in the market by introducing intraday auctions. Obligatory unit bidding also seem to play a significant role in increasing liquidity becuase encourage renewable generators to adjust their position to avoid significant balancing costs. The relatively low utilisation of cross-border capacity in the intraday suggests that the reassessments of network conditions after day-ahead gate closure time should be improved. The introduction of an intraday auction could also improve the liquidity by attracting markets players who would otherwise not have access to continuous trading.

Product design: MARKET4RES recommends the introduction of more granular (e.g. 15-minute) products as per in the German market. This would allow participants to refine their schedules more often, thereby limiting the deviation from their real production compared to an hourly basis.

Balancing Market

With respect to market designs for balancing markets, the Market4RES project recoments the following designs:

Procurement of balancing reserves

- Separated procurement of balancing capacity and balancing energy products is a preferable market design option.
- Separated procurement of upward and downward balancing capacity would contribute to increase the balancing market efficiency.
- There should be no technology–specific products on the market.
- Smaller minimum bid size should be required and the aggregation of several units should be facilitated.
- Compared to pay-as-bid pricing, marginal pricing should lead to more efficient balancing markets.

Imbalance settlement arrangements

- Imbalance settlement periods should be shorter in order to make the calculation of imbalance price more cost reflective. Single imbalance pricing typically leads to higher efficiency in electricity balancing

Global coherence among market designs implemented

- Only imbalances occurring after the closure of the intraday market should be balanced by TSOs within the balancing market timeframe.
- Bids activated for purposes other than balancing should not determine imbalance volumes and/or prices.

Demand participation

Demand response shall be one of the central topics to be addressed by the European Commission in its legislative proposals to redesign the electricity market, expected in the second half of 2016.

Design options for demand participation in short-term markets: The most important mechanism to promote demand-side response (DSR) is to expose consumers to electricity prices through their contract with their supplier, which requires real-time metering of actual consumption. This can be applied for day-ahead market prices but also for shorter time horizons. Independent demand response aggregators can be important for developing additional demand response resources. The qualitative assessment carried out in the project concludes that both implicit and explicit schemes should be allowed.

Quantitative analysis of the impacts of demand flexibility in short-term markets: The analysis show that demand flexibility considerably reduces the need for running expensive peak units. The studies also show results for the impacts on generation mix, costs and profits, market prices, CO_2 emissions, and cross-border market integration.

Participation in long-term markets: Three steps in building a DSR-capable market design are recommended:

- Explicit participation of demand in all markets
- Adapted governance framework to make it possible for DSR aggregators to fully compete with suppliers.

- Policy-makers may want to foster DSR through specific support schemes, and remove barriers for DSR participation.

An assessment of implicit vs. explicit participation in capacity markets for DSR have been carried out in the project. It is concluded that neither of the options should be strictly preferred, rather both of them should be allowed if capacity markets exist to make room for all types of demand response objects and of market arrangements.

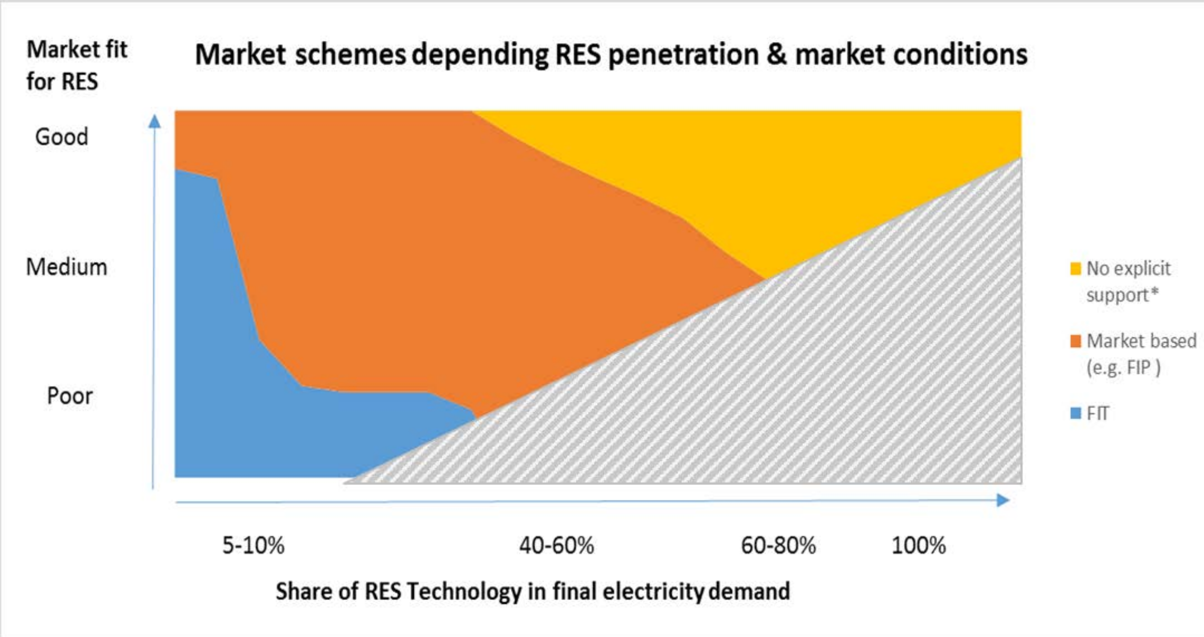
RES Support Schemes

Assessment: MARKET4RES project have assessed RES support schemes using the following criteria: efficiency, effectiveness, robustness, implementability and risks for investors. The assessment is carried out both for short-term impacts on markets, and for the long term impacts of schemes. MARKET4RES recommends that design options should be of a market nature (i.e. tenders/auctions) in order to increase their efficiency and reduce the possibility that authorities manipulate support payments. The following schemes performed overall well in the assessments: Feed-in premiums (set in auction), and long-term clean energy or capacity auctions. The following schemes did not perform well: Feed-in tariff, net metering of demand and generation, no support or provision of grid support services.

Discussion: Clean capacity auctions performed very well in the assessment, both with respect to not interfering with short term market signal and it's long term impacts. However, a floating version of feed-in premiums give reduce risk for invstors with respect to future income and it coincides better with the new environmental and Energy State Aid Guidelines.

Recommendations: The Market4RES project recommends a floating feed-in permium. The total price is set through a tender/auction. The premium to be provided on top of electricity prices for the next two years (for instance) is then calculated as the difference between the total price from the tender and forward prices for the next two years. To ensure an efficient short-term price signal for variable renewable generation, one of the following should be implemented: a) The supported volume is not reduced if renewable generation units cut back production e.g. because of a negative market price in any timeframe, or b) the volume produced at times when market prices are negative is not supported. Technology specific tenders should be permitted, tenders should not apply to all market parties (e.g. small players to be excluded).

Roadmap towards 2020 and beyond: An illustrative representation of a potential support schemes evolution has been developed. In this conceptual model, two dimensions are stipulated: technology maturity, represented by their market share, and the degree to which the market is adapted to account for the specific characteristics of the technology. In the early stage of market deployment, new technologies are generally expensive and not yet competitive. Still, if they represent a long-term cost reduction potential, they should be supported with instruments that reduce investment risk as much as possible to accelerate deployment at an appropriate cost for society. Producers should be exposed to prices only when the market is well adapted for this new technology. As the technology matures and increases its share in the energy mix, it is important to adjust the market instrument, reducing the overall support but also making it more dependent on market dynamics. The better the market situation, the faster this transition can be made. In well-functioning markets, and further technology development, RES production could eventually be financed without explicit support schemes.



Market4RES project recommends that the the European Commission Guidelines on State-aid Support for Environment and Energy should be continued after 2020, in line with the current framework, building on increasing experience from tender systems, and premium-based schemes.

Capacity Markets

A fully-functional energy market is undoubtedly the desired scenario when workable. Market4RES project do not take a position on whether capacity remuneration mechanisms are needed. However, we have assessed preferable design options for such mechanisms in case a robust and regional system adequeacy assessment concludes that a capacity remuration mechanism will be needed.

The product: A financial options with a high strike price is recommended. This gives provision of certainty to investors in firm capacity, and adequete incentives for agents to participate in short term markets.

Procurement: It is recommended that a price-quantity curve is used to set the producred amount, and that the procurement take place through a centralized auction.

Cross-border competition: The existing foreign capacities and interconnectors are already contributing to the security of supply in a country if it imports electricity during times of peak load. However, additional generation capacity in foreign countries would not give any further help if the transmission lines connecting these countries (direct and indirect routes) are congested.Several options for including interconnections in capacity markets are discussed in the project and it is concluded that an accurate mechanism corresponds to the simultaneous explicit participation of interconnections and foreign generators / demand response entities. However, legal limitations for the implementation of the explicit participation of both generation and transmission capacity within current EU regulations are identified. Considering those obstacles, a pragmatic approach consists in implementing the explicit participation of interconnections only, which is the solution selected in Great Britain and accepted by the Commission.

Market4RES

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ABBREVIATIONS

ACER	Agency for the Cooperation of Energy Regulators
ATC	Available Transmission Capacity
BRP	Balance Responsible Parties
CO_2	Cardon dioxide
CM	Capacity Market
CRM	Capacity Remuneration Mechanism
DSO	Distribution System Operator
DSR	Demand Side Response
ENTSO-E	European Network of Transmission System Operators for Electricity
EU	European Union
FIT	Feed-In Tariff
ID GCT	Intraday Gate Closure Time
LCOE	Levelised Cost of Energy
LSE	Load Serving Entity
KPI	Key Performance Indicator
NC	Network Code
NC CACM	Network Code on Capacity Allocation and Congestion Management
NC EB	Network Code on Electricity Balancing
NOx	NOx is a generic term for the mono-nitrogen oxides NO and NO2
PCR	Price Coupling of Regions
PV	Photovoltaic
RES	Renewable Energy Sources
RES-E	Electricity from Renewable Energy Sources
SO	System Operator
SO_2	Sulphur dioxide
TM	Target Model
TS	Transmission System
TSO	Transmission System Operator
VOC	Volatile Organic Compounds

1 INTRODUCTION

1.1 European Target Model

In 2008, the European Electricity Regulatory Forum (Florence Forum) decided to develop an EU-wide Target Model (TM) and a roadmap for the integration of electricity markets across regions, cf. description in *Market4RES report D2.2* [1]. Subsequently, a group of experts from the European Commission, regulators, and relevant stakeholders developed the TM. It represents an attempt to make the penetration of large amounts of renewable generation compatible with the satisfactory functioning of power systems in Europe from a techno-economic point of view. The TM encompasses the following areas for European harmonization:

- Cross-border integration of markets: day-ahead, intra-day, balancing and forwards
- Transmission capacity calculation and allocation
- Governance aspects

The implementation of the TM was enhanced by the EU Third Energy Package that came into force in 2009. Among other things, it created the Agency for the Cooperation of Energy Regulators (ACER) and the European Network of Transmission System Operators for Electricity (ENTSO-E). European energy regulators have been working together for many years to promote regional cooperation and the integration of energy markets, also before the development of a TM. This process has been important for the actual implementation of EU-legislation. In particular, large progress has been made in the implementation of day-ahead market coupling, which has allowed the coordinated dispatch of energy and interconnection capacity. By 2016, day-ahead markets in 19 countries constituting 85% of the total European market were connected by the price coupling algorithm EUPHEMIA, which largely complies with the requirements set in the Capacity Allocation and Congestion Management (CACM) Network Code. It was developed by the Price Coupling of Regions (PCR) project - an initiative of seven Power Exchanges. The share of Europe's day-ahead markets connected by this algorithm has grown after 2014.

An enormous effort has been made to promote the accelerated integration of RES-E generation technologies into the European power system. The commonly used system of feed-in tariff provided a fixed income per MWh produced for renewable generation, whereas priority dispatch has significantly reduced the risk for curtailment of RES-E generation. Those instruments were perfectly fitted to meet the intended policy objectives and expected market developments, especially reducing CO_2 emissions from fossil-fuel generation by providing renewable energy to the market. Now, about 1/3 of the power generation in Europe comes from renewable energy sources. However, the financial support (subsidies) for renewable generation is a market intervention apart from the forces of the electricity market itself. The effects of significant RES-E penetration in terms of low average wholesale electricity prices in general and extremely volatile, partly negative prices in particular have increased. See e.g. *Market4RES report D2.1* [2] for a further discussion. Subsequently, this has led to the situation that conventional electricity generation technologies have difficulties to cover their costs, while financial support instruments (subsidies) further stimulate investments into wind and PV generation. This has led to increasing profitability risks of many of these conventional generation technologies. Some of them already have been – or are expected to be – mothballed. Furthermore, although the importance to promote Demand Side Management implementation into the electricity market has been discussed for a long time, up to now there are no significant and promising best-practise cases qualified to be scaled up.

Against the background of the above-mentioned challenges, a European discussion emerged on how to further improve the electricity market design, especially with respect to:

- Cost recovery for RES generation: How should RES-support schemes evolve to meet future targets for renewable integration more cost-efficiently?
- Cost recovery for conventional generation: Is there a need for capacity remuneration mechanisms to ensure security of supply with increasing shares of renewable generation? If they are considered as necessary, how should they be designed?
- How to foster European electricity market integration with high shares of RES-E generation?

1.2 Market4RES project

Whereas the TM has significant strengths, crucial concerns remain about the suitability of existing instruments to trigger the new investments required to reach a progressive de-carbonization of the electricity sector in a cost-effective way, while ensuring system adequacy and security of supply.

The objective of the project Market4RES is to investigate, provide recommendations and contribute to the debate on the potential evolution of the EU Target Model enabling the integration of renewable electricity into the market by supporting the implementation of the 2020 targets and their follow up towards reaching de-carbonization goals of 2050.
The Market4RES project was launched on the 1st of April 2014 with a kick-off consultation that took place in Brussels, during which the project partners had the opportunity to meet relevant stakeholders, discuss the main steps to be taken and formulate the research priorities.

Market4RES is a project within the Intelligent Energy Europe Programme of the European Union. The project period is April 2014 – October 2016, with the budget 2.4 M €. The partners of the project are shown in Figure 1. SINTEF is co-ordinating the project.

Figure 1 *Partners in the Market4RES project*

The Market4RES project selected an approach based on a combination of complementing qualitative and quantitative analyses. The project started with making a **diagnosis of the Target Model (TM)** led by Energy Economics Group (EEG) of the TU Wien in Austria. This defined the status for the European power market, by mapping the challenges of RES-E deployment in a market driven by the TM.

This activity has essentially paved the road for the whole project and was followed by defining **the most promising modifications of the TM and design alternatives of new markets.** This set of activities, led by the Pontifical University of Comillas defined a few market design configurations deemed appropriate to address RES-E deployment challenges and selected the most promising options in a comparative assessment, based on a set of Key Performance Indicators (KPIs). The selected options for future markets were further quantitatively assessed in two parallel - but closely interconnected - work streams described in the following and illustrated in Figure 2.

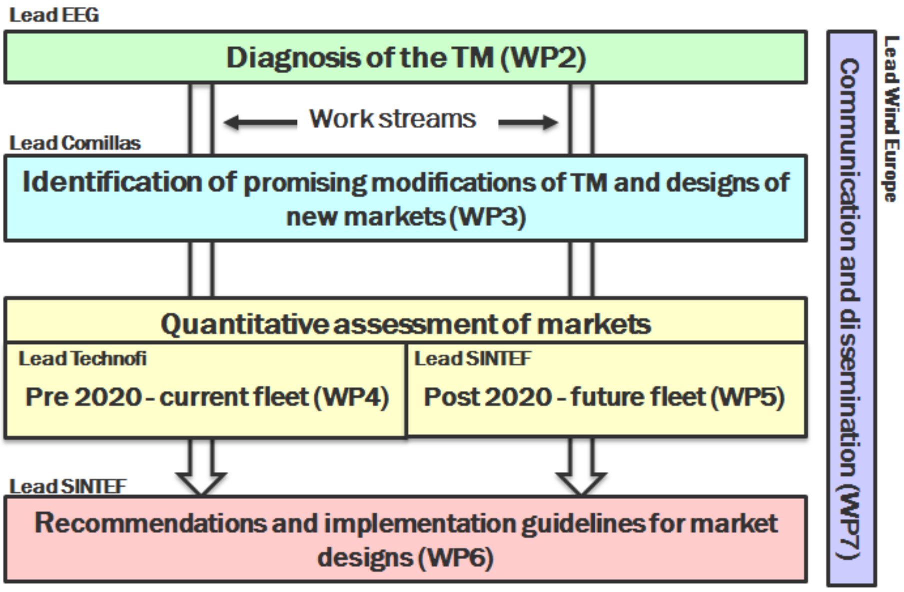

Figure 2 *Set of actions performed in Market4RES*

- **Quantitative assessment of markets (pre-2020)** - Assuming the current generation fleet as an input and current implementation status of the Target Model, the focus was on determining appropriate, yet novel, instruments (and their subsequent accompanying national energy policies) for increased renewable electricity generation in support of the 20/20/20 targets.

- All the analyses were based on a new simulation platform named OPTIMATE and were led by Technofi.

- **Quantitative assessment of markets (post-2020)** - Assuming the future generation fleet (beyond 2020) as a result of current market designs, and taking into account possible future changes in market design beyond the existing TM, the focus was on developing necessary additions or complementary instruments to the current design, which would induce investment incentives and phase out support schemes in the long term without

compromising system adequacy or security of supply. This assessment was led by SINTEF Energy Research. The analyses performed applied several simulation tools:
  - EMPS by SINTEF Energy Research
  - ROM by IIT-Comillas
  - EdisON by EEG
  - Micado by RTE

Results from previous work packages are analysed and gathered into a set of conclusions and recommendations. After a series of consultations with relevant stakeholders (please see the section below) these results were validated and converged into a set of **recommendations and guidelines for the implementation of market design options** (led by SINTEF Energy Research). Its major objective is therefore to recommend the steps towards a practical implementation of policy, legislation and regulations for the renewable electricity generation in order to secure a robust evolution of the EU Target Model (TM) beyond 2020.

As shown in Figure 2, the Work Package 6 (WP6) is the concluding part of the Market4RES project. Results from previous work packages are analysed and gathered into a set of conclusions and recommendations. Its major objective is therefore to recommend the steps towards a practical implementation of policy, legislation and regulations for the renewable electricity generation in order to secure a robust evolution of the EU Target Model (TM) beyond 2020. See Table 1 for an overview of how deliverables in WP6 are summarizing the work carried out in the other work packages in the project, and partly also adding new perspectives and assessments.

Table 1. WP6 deliverables and inputs from other WPs

Market design aspects	WP6 deliverable	Based on
Workstream 1: short-term objectives		
RES support schemes design up to 2020	D6.1.1 [3]	WP2, WP3, WP4
Participation of demand in short-term markets		
Other design features of short-term markets	D6.1.2 [4]	WP2, WP3, WP5
Workstream 2: long-term objectives		
New market designs for RES beyond 2020	D6.2 [5]	WP2, WP3, WP5
Design of capacity remuneration mechanisms	D6.3 [6]	WP2, WP3, WP5
Participation of demand in long-term markets		
Final project deliverable	D6.4	All WPs

1.3 Market4RES storyline

Considering the overall complexity of the discussions on electricity market design, Market4RES has maintained the initially established continuous dialogue with several stakeholder groups in order to enrich the project conclusions through receiving expert input, addressing concerns and considering different views. As illustrated in Figure 3, a series of interactive, open to all and freely accessible events have been organised since the beginning of the project, with the aim of discussing with stakeholders the ongoing research approaches and challenges as well as preliminary results, exposing Market4RES to constructive criticism and possible changes in the plans.

Specifically worth mentioning are two events that took place in May and June 2016 that discussed, respectively, RES penetration under the current Target Model and design options for the electricity market post 2020. A written consultation on the preliminary project findings was launched in May to gather feedback from several interest groups and served as a basis for further discussions in June. Thanks to this open approach, the final results and policy recommendations presented in this publication benefit not only from the contribution of project researchers, but also from the input of an audience that daily deals with the complexity of market design issues.

Among the stakeholders, the most significant contributions to the project have been made by members of the project's Advisory Board (AB), which has been a supportive and advisory body during the project period.

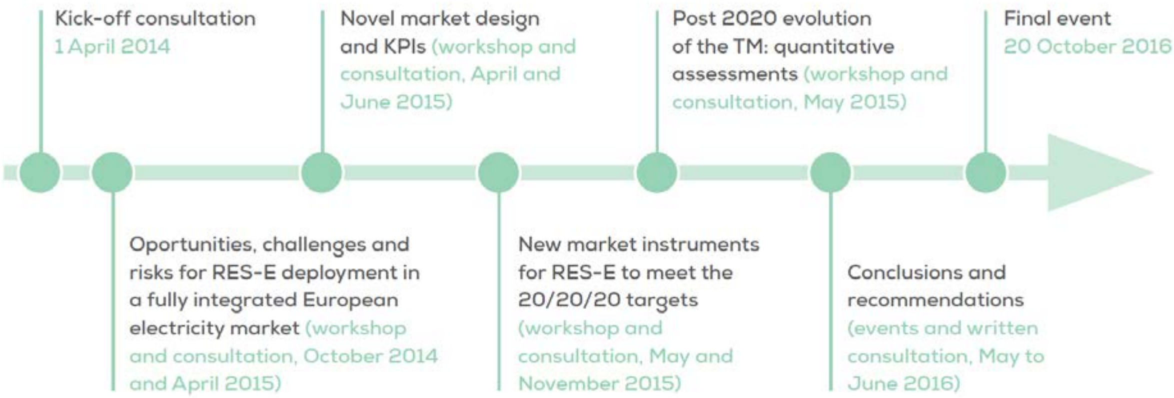

Figure 3 *Project timeline and milestones*

2 MAKING MARKETS FIT FOR RES

2.1 Challenges ahead

Traditionally, the foremost objective of market integration in Europe was to enable trading of electricity across borders, typically between national day-ahead markets. However, the integration of large amounts of renewable generation, with their unique characteristics, have created new challenges. Inflexibility of the market is a prominent issue, which is visible both through the impacts on market outcomes and through the real time operation of the power system.

2.1.1 Electricity prices: Lower, higher volatility, and sometimes negative

From a purely theoretical point of view, with low interconnection capacity, electricity prices will be

- Lower if additional renewable generation with zero marginal cost is added to existing supply.
- More volatile if the share of varying renewable generation (with no price-flexibility at positive prices) is increased.

Empirical analysis of day-ahead electricity market prices (see *Market4RES report D2.3* [7]) also concludes that renewable penetration is negatively correlated with the day-ahead electricity prices. As a result, renewable energy generation appears to be a driver of the differences in wholesale day-ahead prices. However, prices are influenced by supply relative to demand at specific points in time. Thus, the impacts on prices depends on the specific electricity mix and flexibility of the system.

A consequence of the downward pressure on power prices is that firm capacities (e.g. conventional fossil-fuel power generation) are having problems to recover their costs. This can lead to further reduction in flexibility through mothballing of controllable units.
In recent years, several European electricity markets have also seen their prices turn negative when high shares of inflexible generation hit a low demand period. The occurrence of negative prices on the wholesale markets signals the need for more flexible electricity supply and demand, and reinforces the need for better integration of renewable generation sources to the power grid.

2.1.2 Curtailment of wind and/or solar production

High RES-E generation coupled with low demand can create a need for curtailing renewable capacity. Firstly, in the day-ahead timeframe, RES-E suppliers will not offer electricity at negative prices. Thus, at times of excess supply, the price may drop to zero or even below to trigger a voluntary cutback of renewable generation. Secondly, in the real-time operation of the electricity system, system operators employ curtailment of generation to deal with constraints in distribution and transmission grids. Electricity producers can also be shut down for certain periods of time to balance the grid and secure stability of the system when there is, for example, network faults.

Spain in particular makes extensive use of curtailment due to its high wind production levels, lack of interconnection to neighbouring markets, must-run conditions of some non-RES units, and low demand levels at off-peak times. RES-E curtailment events have also happened several times in Germany, where wind power generation is important. With higher RES-E integration in the market, curtailment will likely (have to) happen more frequently in some markets unless other flexibility options such as interconnection capacity, flexibility of demand, and storage options are sufficiently included.

2.2 Possible options to increase flexibility on the short-term markets

Several perspectives can be taken on how to improve a power system's flexibility. On one hand, some regulatory changes will lead to higher flexibility. On the other hand, components of the power system are the providers of flexibility. Options can therefore be classified into two categories: **regulatory intervention** and **flexible technology investments.** Even though the Market4RES project is focusing on the former, both categories are discussed below.

Flexible technology investments.

Technology-based flexibility options include investments in:

- **More flexible conventional plants**, through retrofits of existing plants, or new plants.
- **Monitoring of demand,** which is a condition for exposing consumers to price-variation and including them in support schemes for flexibility.
- **Electricity storage.** Storage technologies will likely play a larger role in the energy mix in the future for their flexibility advantage. For example, it has been proven that the business case for storage is already positive in some cases in the US whereas different market actors are investing in large-scale storage in Germany. This option also include investments in electric vehicle (EV) and the corresponding infrastructure for the utilization of their batteries in providing flexibility for the power system.
- **Network capacity.** Power system transmission and distribution networks are key enablers of flexibility. Network strengthening is relevant for short-term, mid-term and long-term flexibility as it allows reducing congestion by allowing netting or offsetting changes in generation over larger geographic areas. Sharing existing flexibility resources among regions and countries, also including large existing hydropower reservoir capacity in Nordic area (about 85 TWh in Norway), can help to buffer variable renewable electricity generation in a cost-efficient manner.
- **Research on technology, software and markets:** By investing in research, new flexibility options can be invented and better market designs for the facilitation of flexibility in power systems and markets can be revealed.

Regulatory interventions

Regulatory interventions can be classified further into the following categories:

- **Making markets fit for RES.** This includes how markets should adapt to take into account the specific needs and characteristics for RES generation units, as well as needed adoptions on system level to better deal with high RES shares. This is discussed further in Section 2.3 - 2.6.
- **Demand response.** Some consumers or aggregators of them can be activated by exposing them to prices, or DSOs can to it on their behalf. This is discussed further in Section 2.7.
- **Capacity-remuneration mechanisms (CRM).** This includes a set of incentives to provide Security of Supply (SoS) also at times of unfavourable weather conditions. This is discussed further in Section 4.

Important regulatory interventions are recommended and elaborated in the above mentioned sections. However, no radical change in the European target model for short-term markets is recommended, cf. *Market4RES report D6.1.2* [4].The existing target model should be adopted and implemented as soon as possible. It is advised that one builds on the already existent features and market design, and gets inspired by the identified best practices to identify the market rules that are best adapted to the European local conditions. Most importantly, well-functioning intra-day markets must be promoted, with high liquidity, cross-border trades, and implicit pricing on transmission constraints.

2.3 Key market features for successful integration of RES

The following section summarize the key design features that are critical for the successful participation and integration of renewable electricity producers in a fully liberalized and competitive market place at all timeframes (day-ahead, intraday and balancing). These features are organized in five areas/aspects, as presented in Figure 4.

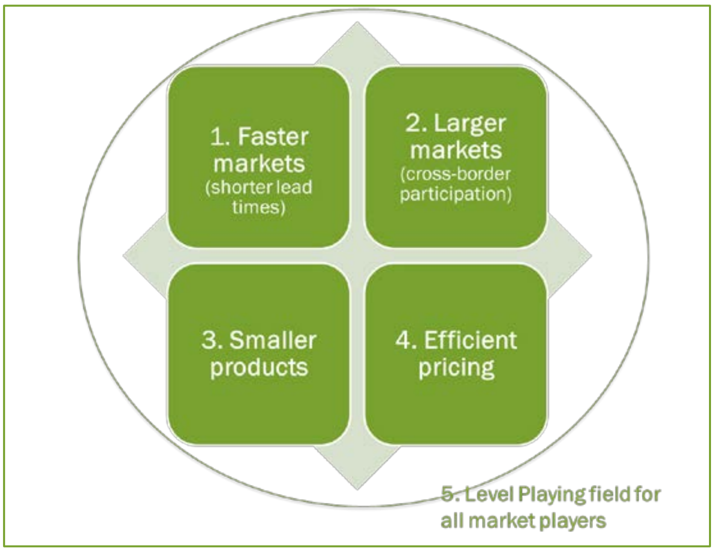

Figure 4 *Key market features for successful integration of RES in all market timeframes*

Afterwards, in subsequent sections, we address specifically each of the market timeframes. Much of the structure and content is based on *Market4RES report D6.2* [5]. However, the scope is widened slightly from how markets can be developed to fit better for RES producers, to also include other system needs facilitating high RES shares.

Faster markets

In a future power system dominated by wind, solar and other variable renewables, the timing of markets should evolve to allow faster changes in system conditions, which are largely caused by weather patterns (e.g. renewable generation, heating/cooling demand). Concretely, this means that the time point at which Transmission System Operators receive schedule generation and take control to ensure security (gate closure time) should be pushed as close as possible to real time giving market players with variable generation the option to self-balance their deviations via the market. This would increase the value of existing renewable generation, and reduce the need for capacity that is flexible on short notice (e.g. only a few minutes before real time). Figure 5 shows the sequence of various markets, from forward markets that can set energy bids in the long term, to close to real time like the balancing market. It can be observed that the procurement of balancing capacity can happened in the very long term. The figure tries to depict that the gate closure time for balancing energy should always be after the gate closure time for the intraday market (this is not the case in all European countries).

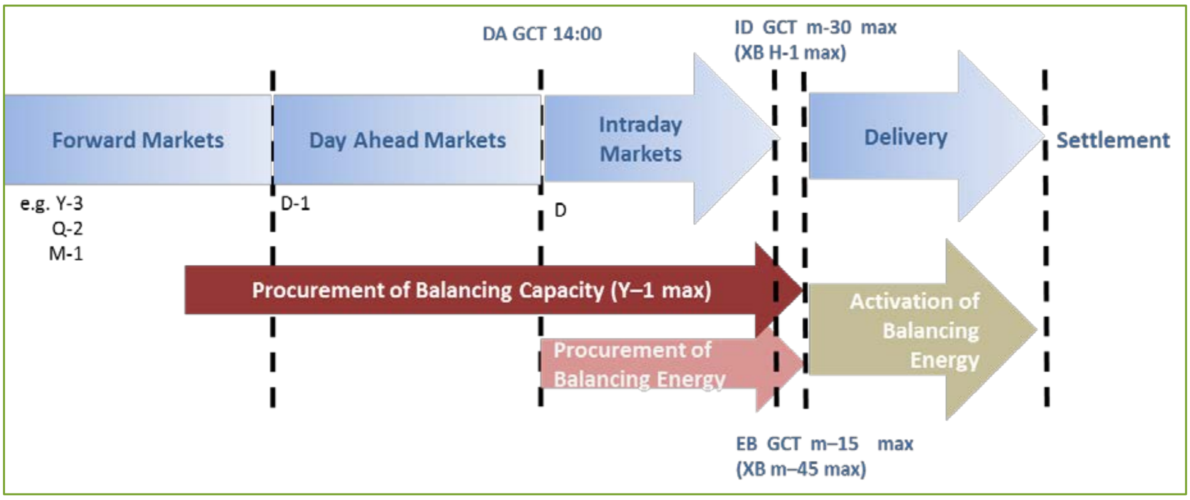

Figure 5 *Sequence of markets and interface between timeframes. Source: Wind Europe.*

Larger markets

Wind and solar power output is smoother when aggregated over several sites and across large geographical areas, many of which may or may not be located within the same grid, market, or control area. In order to couple cross border markets at all timeframes (day-ahead, intraday, balancing), the available transmission capacity for trading needs to be clearly defined. Traditionally, this is calculated before final flows are known, one border at a time and without considering bilateral trading impacts on neighbouring systems (*available transmission capacity* (ATC) method). This causes TSOs to frequently prioritise flows inside zones over flows across borders under different security standards, even when restrictions are not justified by the physical flows of power.TSOs thus would need to use more sophisticated methods (flow-based transmission capacity allocation) and make use of a Common European Grid Model. This approach takes into account the relationship between commercial flows and physical congestion on affected transmission network elements, maximizing the use of the existing infrastructure. Furthermore, markets are made larger by increasing the interconnection capacity between different areas and by allowing cross-border competition at different timeframes.

Smaller products

Smaller timeframes for the products are positive for the participation of variable renewables generation units. This is very much related to forecasting and predictability of renewable generation assets and their possibility to adjust to demand ramp up/down periods. The use of shorter products will need to be combined with larger ones to find a balance between liquidity in the markets and cost of implementation. Moreover, the procurement rules associated to specific products have a key impact on the participation of renewables, especially for balancing markets. The introduction of 15-min products in the German intraday market in 2011 has been hailed as a success for handling variability of renewable energy, compared to the traditional hourly based contracts. And although product volumes remains relatively low, they most likely will become higher as the share of renewables is increased.

Efficient pricing

Prices in the wholesale power market are the main reference for operational choices and investment decisions for all generators. Therefore, they must be transparent and should not be kept artificially from reveling scarcity. This means that price volatility and spikes should be seen as positive outcomes of a market that signals when investments are needed, either in capacity and, or in flexibility.

Prices in the wholesale market should also relate solely to the marginal costs of producing electricity. The entire rationale of a cost-efficient short-term dispatch of energy relies on ensuring that the most competitive generators are the first to serve demand. Marginal pricing (pay as cleared) therefore, should be considered as the common norm across all time frames, with the possible exception of bilateral intraday trading.

Restoring today's depressed low wholesale prices will therefore be a matter of ensuring that the right signals come out of the market itself, combined with reducing overcapacity though exit of non-competitive generators.

Level-playing field

Above all, for renewable energies to fully contribute to a functional energy market, the design and rules have to be adapted to a level-playing field for all generators. Market access, increased transparency of operational procedures, a polluter pay principle guiding dispatch and a complete phase-out of environmentally damaging subsidies are paramount for strengthening the market towards a more sustainable future.

- **Balancing responsibilities and the market.** The Electricity Balancing Guideline[1] aim to standardize and harmonize to a large extent the national terms and conditions for balancing services providers (BSPs) and balance responsible parties (BRPs). Balancing responsibilities is foreseen for all market players, as this is considered to be an important condition to achieve effective system balancing. Balancing responsibilities for all parties should however be accompanied by the existence of markets that allow trading close to real time (especially intraday market with short gate closure times and with a sufficient level of liquidity), to minimize forecast errors, and markets that have fair access rules to balancing markets for all market parties.

- **Priority dispatch.** Increased transparency on operational procedures leading to curtailment of wind and solar energy and remuneration of these events as system services are needed in order to progressively phase-out the priority dispatch provisions introduced in the 2009 renewable energy directive. In order to achieve a level playing field, occurrences of priority dispatch to conventional generators must also be eliminated.

- **Non-internalized environmental costs.** In today's power market, the cost of polluting air, water and soil while generating electricity is so low that conventional generation is artificially maintained as a competitive alternative against renewables. Among other things, a reform of the EU ETS is needed to restore a meaningful price of CO_2.

[1] Also known as the Electricity Balancing Network Code

- **Subsidies to conventional technologies.** While today's discussion is centred on the support for renewable energy sources, conventional technologies continue to receive direct or indirect support at national and European level. Historically, technologies such as nuclear and coal have received direct support considerably higher than the support provided today to the various renewable energy sources. Indirectly, still today nuclear energy receives from European funds (Euratom- Horizon 2020) more support for research and development (focus on safety) than the support allocated to all other low-carbon technologies (including renewables, Carbon Capture and Storage, CCS, smart grids and energy efficiency). Therefore in order to guarantee a level-playing field, continued support to conventional technologies needs to be addressed in parallel to the reform of market design rules and the revision of state-aid guidelines for environment and energy.

2.4 Day-ahead market

Locational pricing

Differentiating electricity prices by local geographical area is important in order to reflect the differences in electricity generation costs due to the limitation of network capacity. Implementing locational prices implies that the prices are published and the associated financial settlement sufficiently reflects the reality of system operations. As wind and solar power increase the volatility of electricity flows and lead to congestion, efficient locational pricing will be needed. Still, decreasing too much the granularity of network representation (for example down to nodal pricing) also presents serious drawbacks, notably in terms of liquidity, implementation costs, transparency and fairness for small end-consumers, as explained in *Market4RES report D3.2* [8]. A right balance therefore needs to be found in terms of size of bidding zones. The recommended pricing scheme from the Market4RES assessment is either zonal pricing (one price per TSO control area) or hybrid zonal pricing (several/some price areas per TSO control area), depending on the topology of the grid in the system and the distribution and type of generation and demand.

As explained in the *Market4RES report D6.1.2* [4], a review process of existing bidding zones has been tackled by ENTSO-E with the support of ACER as part of the implementation of the CACM network code. ENTSO-E has developed alternative bidding zones configurations to be assessed, going from the status quo to a 'start from scratch' configuration. The work carried on by ENTSO-E in the bidding zone review process investigates the best delineation of bidding zones that fits the multicriterion of efficiency, price signals, liquidity and security of supply. The first results of the review are expected to be known by end 2016, but work will continue in 2017.

Administrative reliability pricing

With higher shares of varying renewable generation, there is a need for having an administratively set price during capacity shortage conditions, i.e. when there is insufficient flexible capacity to meet the residual load (expected consumption minus bids for renewable generation) in addition to the reserve requirements needed for reliability. To the extent possible, this price should reflect the value that curtailed demand puts on electric energy. If markets are well functioning, there will be correlation between prices in markets for procurement of reserves, day-ahead, intra-day, and finally in markets for balancing energy in real time.

Gate closure

Trading renewable energy mostly on day-ahead markets prevents the possibility of delivering more accurate bids, and leads to greater mismatches between scheduling and delivery of energy, which need to be corrected during the day of operation.

Today, most power exchanges in Europe "close" day-ahead trading at 12:00. Then, clearing is performed once per day for all the market coupled zones around 13:00, this way the orders can be matched between markets and the cross-border capacity is implicitly allocated.

In contrast to conventional power generation, which typically must be committed 6 to 8 hours ahead, RES generation is mainly supplied through the availability of its energy source in real time. This availability is more accurately forecasted at shorter time scales (around 10% error margin 24 hours ahead of delivery, for wind).

Delaying the day-ahead closure time could therefore result in a decrease in the errors made by RES operators when forecasting their available RES electricity production, as well as a reduction of the error on forecasting demand. More adequate forecasts should lead to less rescheduling (and corresponding transaction costs), and overall allow the system to decrease substantially the size of imbalances they must address in subsequent markets (especially important for RES generators).

To maximize efficiency and avoid distortion, all these tasks before market coupling calculation could therefore be pushed to take place as late as possible. However, for some power system there might be no significant added value to bring it too close to real time. The analyses carried out in *Market4RES report D5.2* [9] show that bringing closer the day-ahead market to real time only a few hours does not necessarily reduce the dispatch costs of the power system, because the reduction in the wind and solar forecast error is small. Moreover, if the day-ahead market is very close to the real-time, some generation units will not be able to start-up or shut-down in the required time and therefore, they will be automatically out of the market. Thus, to tackle various forecast errors and other events, it is probably better to establish a well-functioning intraday market rather than pushing the day-ahead market closer to real time.

2.5 Intra-day market

Market timeframe

The intra-day time frame is of significant importance to allow renewable generators to adjust their market position, but also to reduce the amount of balancing operations. An adequately functioning intraday market is a prerequisite to the full implementation of balancing responsibilities for all generators, notably because the correction of imbalance on this market in general is less costly than through the activation of balancing mechanism, which is generally financed by the market parties out of balance (imbalance charges)[2]. Two major alternatives exist for organizing this market:

- **Continuous trading**, i.e. bids can be submitted and matched by power exchange at any time before final gate closure time. For instance in Belgium, intraday platform becomes available for trading the day before delivery, at 14:00, and closes 5 minutes before is actual delivery.

[2] The Balancing process is generally financed through imbalance settlement. In some cases, its cost is also shared by all energy consumer through network charge.

- **Intraday discrete auctions**, i.e. one or several auctions are called at specific predefined time after the outcome from the day-ahead market has been published. For instance, EPEX SPOT launched on German intraday market[3] a complementary 15-min call auction at 15:00 allowing market participants to trade the 96 quarters for delivery the next day simultaneously. Then, continuous trading session starts at 16:00 until 30 min before delivery time.

Continuous markets (pay-as-bid) are simple to implement from a conceptual point of view. At least if only simple price-quantity orders are allowed. Including more complex types of orders may prove to be a challenge for the short-time period available to clear the market. There is a large international experience both at national and regional level with this type of markets (for instance in Northern and Central-West Europe).

Discrete intraday auctions are also relatively simple to implement, but require more regional coordination (at least some homogenization is needed on the decisions on when to schedule discrete sessions of the markets). There is international experience at a national level (e.g. Spain, Portugal and Italy). The experience in the regional context is limited in Europe to the simpler case of two interconnected systems (e.g. Spain and Portugal). However, the processes for intraday auctions are expected to mimic – or at least to be largely inspired by - the day-ahead process, which is already largely implemented in Europe. With intraday auctions, it will also be possible to apply implicit pricing of transmission capacity in the intraday timeframe – which should improve efficiency.

There is a possibility to combine both approaches into a hybrid design, combining the advantages of both (but also the disadvantages). **The hybrid approach can be expected to be the best design variant** as it achieves the most balanced and therewith best overall-outcomes with regard to the assessment done by the Market4RES consortium *Market4RES report D3.2* [8].

Enlarging the geographical scope

When coupling cross-border intraday markets, regional auctions need to be introduced at large scale, and this would require more regional coordination. Some homogenization is needed on the decisions on when to schedule discrete sessions of the markets and the gate closure times. The persistence of uncoordinated and heterogeneous intraday gate closure times (ID GCT), between but also within bidding zones, is an important barrier to the improvement of liquidity level in intraday markets according to ACER [10]. For example, in the Netherlands, the national ID GCT is five minutes ahead of delivery, while different GCTs are in place on their borders (which can be up to 8 hours ahead of real time). According to the CACM regulation, there should be one ID GCT established for each market time unit for a given bidding zone border and this to be at most one hour before the start of this market time unit[4].

Increasing liquidity

The main objective of improving intraday trading within and across border is to boost market parties' interest and thus liquidity (relatively low in the majority of national intraday markets). ACER has attempted to assess liquidity in EU markets by assessing various indicators that will

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[3] Note that "intraday" here is defined by all trades after the close of the day-ahead market and before the system operator takes control of the system close to real time.
[4] Regulation 2015/1222. See http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R1222&from=EN

unlock market parties' participation in this timeframe. As shown by their analysis there is an obvious relationship between intraday liquidity and the penetration of renewable-based generation. The presence of intraday auctions as well as obligatory unit bidding seem to play a significant role in increasing liquidity, notably because this latter incentivises renewable generators to adjust their position in this timeframe to avoid important balancing costs.

There is a close interdependency between the use of intraday cross-border capacity and the ability of close-to-real-time trading. It has been observed [10] at some borders that more than half of the intraday cross-border capacity was requested and allocated between one and three hours prior to delivery, proving that well-designed and interconnected intraday markets serve the balancing needs of renewable generators[5].

However, the relatively low utilisation of cross-border capacity in the intraday timeframe (as well as observed intraday price differentials) suggests that the reassessments of network conditions after day-ahead gate closure time could be improved.

Product design

As for day ahead timeframe, most intraday markets trade standard hourly products. However, the introduction of 15-min contracts on German intraday market in 2011 had fostered market participants' interest because it allows them to refine their schedules every 15 min thereby limiting the deviation from their real production compared to an hourly basis. In 2015, EPEX SPOT pointed out that *"since 2011, 15-minute contracts provide greater flexibility to handle intermittency and the daily ramping effects of renewable production, contributing to a more balanced market."* Although that liquidity remains relatively low it most likely becomes automatically higher as the share of renewables in the generation mix is to increase. Additionally, the introduction of an intraday call auction can improve the liquidity by attracting markets players who would otherwise not have access to continuous trading. A prerequisite to the introduction of more granular products seems to be consistency between the market time unit in the intraday market and the Imbalance Settlement Period (also 15 minutes in Germany).

2.6 Balancing market

Current status and work within Market4RES project

Balancing electricity systems is one of the core activities of TSOs, and has strong links with the security of the power system. The way balancing is done within each country is the result of a long history, taking into account national specificities such as the structure of the national generation fleets. Balancing markets have initially not been designed to be integrated at cross-border level, or to integrate high RES shares. As a consequence, very heterogeneous structures and patterns exist when drawing the different parameter settings characterising national balancing markets in Europe. The main differences include the different kinds of balancing services, the different balancing market architectures (central dispatch, self-dispatch portfolio based and self-dispatch unit based), different parameter settings (timeframe of products, gate closure times, minimum bid sizes, etc.). See *Market4RES report D2.1* [2].

Progress with respect to harmonization and cross-border trade of balancing productions is therefore rather slow, as illustrated by the date of the first scoping of ACER Framework Guidelines on Elecrticity Balancing in October 2011 to ACER recommendation for the adoption of ENTSO-E Network Code on Electricity Balancing in July 2015. Afterwards, the NC EB should be

[5] 56% for French borders with Germany and Switzerland in 2014. Source: ACER market Monitoring report

prepared by experts from the European Commission before it enters a comitology process, through which it should become European law: as far as the authors know, no date has been set yet for the comitology process regarding NC EB. In addition, once the NC EB entries into force, TSOs will have between 1 and 4 years to implement some of the NC EB requirements. Up to 10 years of negotiation, development and implementation will therefore have been needed. The degree of harmonization to be achieved after this decade is also not finally determined yet.

However, as concluded in *Market4RES report D6.1.2* [4], improving the functioning of electricity markets is urgently needed, and the NC EB does not provide detailed design for all kinds of balancing services. The debate on balancing market design, where the Market4RES project has contributed to (mostly from a perspective of RES integration), is far from being closed.

The Market4RES consortium has qualitatively analysed some of these design options (see *Market4RES report D3.2* [8]) and has carried out some simulations to quantify the effects of some design options (see *Market4RES reports D5.1* [11] and *D5.2* [9].

Qualitative assessment of balancing market design options

Within *Market4RES report D3.2* [8], different options have been assessed in terms of efficiency towards the achievement of a well-functioning cross-border European balancing market, cf. Figure 6. Those options are related to the procurement of balancing reserves, the imbalance settlement arrangements and the global coherence among market designs implemented. Regarding procurement of balancing reserves:

- **Separated procurement of balancing capacity and balancing energy products**[6] **is a preferable market design option** when compared to joint procurement of products. Joint procurement of capacity and energy products may limit or even prevent the participation of renewable producers and other small players since, in general, the gate-closure for capacity products have long lead-times.

- **Separated procurement of upward and downward balancing capacity would contribute to increase the balancing market efficiency.** Joint procurement of upward and downward balancing capacity may impose barriers to the participation of renewable generators since variable RES mostly is able to provide downward balancing capacity.

- If a competitive and efficient integrated balancing market is to be achieved, all potential providers should be allowed to participate in all balancing markets as long as they comply with the technical requirements for balancing

- To foster the participation of small units in balancing markets, **smaller minimum bid size should be required and the aggregation of several units should be facilitated.** It should be noted that aggregated forecasts are more accurate, which could lead to a more reliable participation of renewable producers in balancing markets.

- **Compared to pay-as-bid pricing, marginal pricing should lead to more efficient balancing markets.** Pay-as-bid pricing provides incentives to market parties to submit bids as close as possible below the resulting market price, whereas marginal pricing gives incentives to bid at marginal costs. Pay-as-bid pricing can lead to inefficiencies, among other things because small players do not have possibilities to forecast prices.

[6] I.e. not only the procured balancing capacity can be activated.

Competition among BSPs			
Procurement of balancing capacity and balancing energy products	Joint	Separated	
	Poor	Good	
Procurement of upward and downward balancing capacity products	Joint	Separated	
	Poor	Good	
Existence of technology-specific products	Yes	No	
	Poor	Good	
Minimum bid size	Large (> 5MW)	Medium (1MW-5MW)	Small (≤1 MW)
	Poor	Poor to fair	Good
Pricing of balancing products	Pay-as-bid	Marginal	
	Poor to fair	Good	
Adequate incentives on BRPs			
Imbalance pricing system	Dual	Single	Combined
	Poor to fair	Fair to good	Good
Settlement period	Long (1 hour)	Average (30 min.)	Short (15 min.)
	Poor	Fair	Good
Efficiency in balancing actions			
Balancing & intraday trading (ID)	Preventive balancing actions	All balancing actions after ID	
	Poor	Good	
Balancing & congestion management (CM)	CM affects imbalances	CM is treated separately	
	Poor	Good	

Figure 6 *Qualitative assessment of balancing market design options.*

Regarding imbalance settlement arrangements:

- In general, **the shorter imbalance settlement periods are, the more cost-reflective the calculation of imbalance prices will be.**

- **Under adequate balancing arrangements, single imbalance pricing leads to higher efficiency in electricity balancing.** While under single pricing BRPs that support the system balance are settled as balancing service providers, dual pricing is generally implemented to incentivize all BRPs to follow their schedules regardless the system imbalance direction - i.e. to not create a short position if they expect the system imbalance to be long and vice-versa. In principle, this goes against the concept of passive balancing according to which BRPs are incentivized to actively respond to the system balance state very close to real time operation. However, in the presence of market distortions, single pricing could provide incentives to BRPs to worsen the system imbalance. Therefore, the Market4RES project recommends that, **whenever the system imbalance cannot be anticipated (i.e. both upward and downward reserves are activated within a settlement period), a dual imbalance pricing system based on the price of activated reserves is implemented.**

Regarding global coherence among market designs implemented:

- Intraday and balancing markets are closely related since the more (or less) BRPs adjust their schedules through the former, the less (or more) balancing actions will be needed in real time. According to ACER [12], **only imbalances occurring after the closure of the intraday market should be balanced by TSOs within the balancing market timeframe.** This can be explained by the fact that preventive balancing actions may compromise liquidity in the intraday market (by moving bids from this market to balancing markets) and, at the same time, increase balancing costs (which could have been reduced through intraday trading).

- While the Network Code on Electricity Balancing [13] emphasizes the right of TSOs to activate balancing energy bids for ensuring operational security and, consequently, for congestion management purposes, it establishes that **bids activated for purposes other than balancing must not determine imbalance volumes and/or prices.**

Quantitative study validating possible future balancing market mechanisms

The study has been carried out with the model EDISON+Balancing developed by EEG (see *Market4RES report D5.1* [11] for a detailed description). The focus of the study is on the Netherlands, Belgium, Germany and Austria. The main findings of the study, as reported in *Market4RES report D5.2* [9], are:

- The **symmetric (joint)** procurement of upward and downward balancing capacity
  - increases total generation costs and total procurement costs,
  - increases procurement exchanges between German TSOs,
  - is a <u>poor design for RES integration</u>, due to the fact that e.g. wind farms cannot use their full electricity generation in order to be able to provide also upward balancing capacity.

- **Common procurement** of balancing capacity by all balancing areas
  - reduces total generation costs and total costs of procurement

- **Shorter time frame** of block products
  - reduces average implicit allocation of transmission capacity between balancing areas,
  - reduces total generation costs and total procurement costs,
  - is a <u>good design to integrate RES in balancing markets</u>, because the shorter the product length is, the more efficient RES can bid into the market.

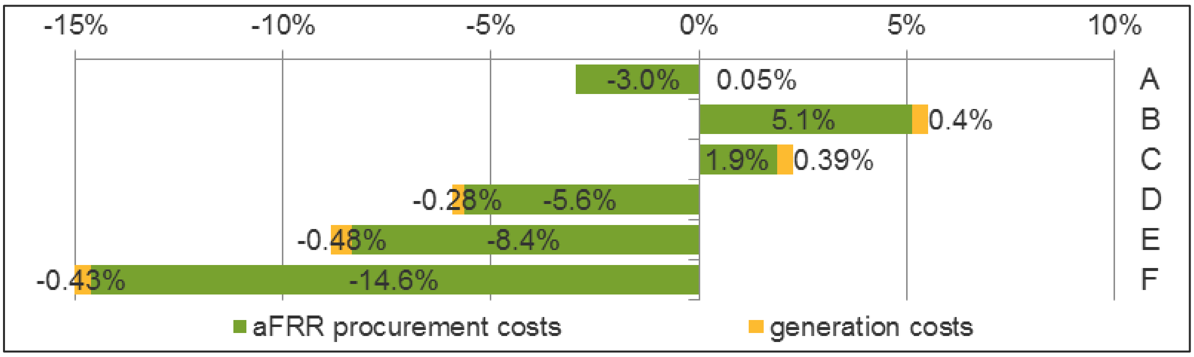


Figure 7 *Differences of aFRR procurement costs and generation costs compared to reference case.*

Furthermore, symmetric (joint) procurement of positive and negative balancing capacity tend to increase total generation costs and total procurement costs because, typically, the price of the single product is determined by the sub-product (in the case, either upward or downward balancing capacity) of highest cost (the costs of providing upward and downward balancing capacity can vary significantly). This has been demonstrated by the project consortium in *Market4RES reports D5.2* [9] by simulating balancing markets in 2030 (see Figure 7). In Case B (week-ahead) and C (day-ahead) the symmetric (joint) procurement of positive and negative balancing capacity has been applied in contrast to the reference case, where separated procurement is assumed. As it can be seen from the graph the procurement costs are around 5% (for week-ahead and 2% for day-ahead) higher than in the reference case.

2.7 Demand participation

Rationale for demand flexibility development

The need for demand response has not always been so urgent. Nowadays - and even more importantly within the future electricity system integrating higher shares of variable renewables, demand response (as well as other flexibility means) is increasingly needed, because the generation fleet will decreasingly be able to follow the load, unless mechanisms are put in place to ensure a considerable over-capacity. Rather, the load will perhaps more and more follow the non-dispatchable generation by being decreased or shed during low-production hours and possibly increased during high-production hours. Demand response shall therefore be one of the central topics to be addressed by the European Commission in its legislative proposals to redesign the electricity market, expected in the second half of 2016. As stated in *Market4RES reports D2.1* [2] and *D6.1.1* [3], demand participation in markets could result in a decrease in system operation costs, an increase in the level of integration for renewable generation, thus paving the way for higher RES-E penetration levels, and an increase in the level of competition, thus contributing to a reduction in the level of prices, among other benefits.

Game changer: Smart meters

As explained in *Market4RES report D6.1.1* [3], demand response from big, industrial consumers has been developed for long in most European countries. In France residential consumers have also been a source for demand response, and many research and demonstration projects have been or are being carried out in Europe to assess the potential and test the functioning of new types of residential demand response. Commercial development of residential demand response has started in a limited number of countries.

What is really new, is the development of explicit demand response thanks to the revolution in data technologies which implies a lower cost for smart meters. With the new affordable technologies in smart metering, DSR operators can now develop offers for small consumers or small industries and be able to value it explicitly on the markets. This opportunity creates competition between suppliers and DSR operators on the demand response market and can lead to new DSR designs.

Design options for demand participation in short-term markets

In *Market4RES report D3.2* [8] addressing the developments affecting the design of short-term markets, different approaches have been considered to make demand flexibility (or demand-side response – DSR) able to be valued efficiently in short term energy markets.

Consumers response to prices can be valued either *implicitly* through the contract with their supplier[7], or *explicitly* through their own participation in the market possibly through an aggregator that bids on their behalf.

The simplest but still important mechanism to promote DSR is to expose consumers to electricity prices through their contract with their supplier, which requires metering of actual consumption. This can be applied for day-ahead market prices but also for shorter time horizons.

If the supplier shall be able to utilize the demand side flexibility for bidding into real-time balancing markets, it must also be permitted to curtail the load. For this, more advanced control equipment must be in place. Consumers' flexibility may also be operated by so-called aggregators, which can control the possible curtailment of the load on their behalf. The corresponding flexibility can be sold to the consumer's supplier, which then can bid it into the market, or the aggregator can participate directly into balancing markets.

The qualitative assessment carried out in *Market4RES report D3.2* [8] concludes that both implicit and explicit schemes should be allowed. Implicit schemes are the simplest ones and reasonably efficient. However, under these schemes, agents cannot compete to access DSR resources. Then, the implementation of independent load aggregators should also be considered an option. The transfer of funds between aggregators and suppliers should be set by an independent entity for the treatment to both of them to be fair and in order to promote efficiency in market.

Quantitative analysis of the impacts of demand flexibility in short-term markets

Here, we refer to a study carried out with the OPTIMATE prototype tool. The methodology implemented and the specifications of the study are described in the *Market4RES report D4.1* [14], and the detailed results are presented in the *Market4RES report D4.3* [16]. Results show that demand flexibility reduces the need for running expensive peak units. In our simulations, annual electricity generation costs are reduced by 458 to 1,143 million of euros in two different demand response scenarios for the current situation, whereas the values are about twice as high for 2020. The above mentioned studies also show results for the impacts on generation mix, costs and profits, market prices, CO_2 emissions, and cross-border market integration.

[7] Or retailer: these two terms are considered as synonymous in this report.

Participation in long-term markets

Demand response has a lot of value through the flexibility it brings and thus the need for other flexible resources; it essentially corresponds to a peaking technology. The summary-report for capacity markets, i.e. *Market4RES report D6.3* [6], do not discuss demand participation in dedicated sections. However, thorough the report it is a premise that the demand-side should be included in capacity markets. Moreover, capacity mechanisms are consistently described as an instrument to value generation or demand response activity. If one is successful in including demand-side flexibility in short-term markets, it should be cost-effective to include such options also when incentivizing flexibility through capacity markets.

The participation of demand in long-term markets is discussed in *Market4RES report D3.1* [**15**]. Three steps in building a DSR-capable market design are pointed out:

- Explicit participation of demand in all markets.
- Adapted governance framework to make it possible for DSR aggregators to fully compete with suppliers, including setting up specific market products.
- Policy-makers may want to foster DSR through specific support schemes.

An assessment of implicit vs. explicit participation in capacity markets for DSR is carried out. It is concluded that neither of the options should be strictly preferred, rather both of them should be allowed if capacity markets exist to make room for all types of demand response objects and of market arrangements.

Barriers

In order to realize the potential benefits of DSR, some barriers need to be overcome. A detailed discussion can be found in *Market4RES report D3.2* [8]. The barriers include:

- Technological aspects of service provision, related to the need to have the adequate equipment and communication protocols in place to provide such a service

- Economic aspects of service provision, related to the need to make DSR profitable for all the parties involved in the implementation of these solutions. This is also elaborated in *Market4RES report D6.1.1* [3]

- Operational aspects related to the deployment of DSR solutions, which are related to the difficulties for carrying out their function

- Control issues. Explicit DSR development implies that a neutral entity realizes the control of DSR to rule the competition relation between the supplier and the DSR operator from their client: the consumer. These control issues open huge technical challenges on metering the consumption and determining the DSR volumes

- Legal barriers. The contract between the supplier and the consumer could easily be used by suppliers to forbid other future contracts between consumers and DSR operators. The responsibilities have to be clearly defined in the law to allow to all parties a fair competition

Figure 8 illustrates the costs and benefits at system level of large-scale demand flexibility deployment. To make sure that demand response can kick-off at large scale as soon as the economic conditions are met (in particular, sufficient price spreads are needed), technical obstacles should be removed, concerning the design of the products traded on the wholesale electricity markets. Many design options are available and need to be followed to develop the potential benefits of DSR. DSR can be valued on the energy market, on the balancing market, on the capacity market, and for ancillary services. For DSR investors, it is important to touch most of these markets with the same IT system. The integration of DSR in the design of these markets is a heavy responsibility and challenge for DSOs and TSOs in the next decade.

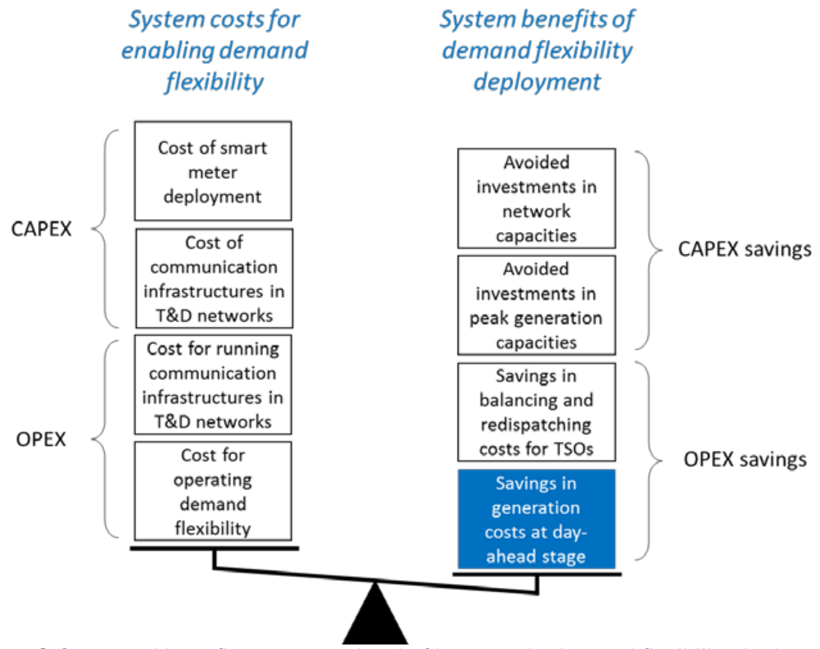


Figure 8 *Costs and benefits at system level of large-scale demand flexibility deployment*

Brief conclusions on making markets fit for higher shares of RES

- **Well-functioning intra-day markets** are needed so RES producers can adjust their day-ahead bid in accordance with updated forecasts. This will also reduce the need for real time balancing and over system costs. In the Intra-day time frame, one should consider combining continuous trading with discrete auctions, as the latter provides greater flexibility and the possibility for implicit pricing of transmission constraints.

- **Balancing responsibilities** for all parties should be closely linked to the existence of a well-functioning intraday market.

- **Intraday market liquidity** is heavily dependent on a number of factors, including: renewables participation, the existence of discreet auction in addition to continuous trading, short gate closure times, balancing responsibilities, possibility of aggregated bid, and implicit pricing of cross border transmission rights in the intra-day time frame.

- Options for the **procurement of balancing reserves** from the long to the very short term should be made available to **allow all types of resources** (including renewables and demand response) to contribute reserves to the extent of their possibilities. Lastly, the gate closure should be taken as close as possible to real time, providing, again, more flexibility. The gate closure time of the balancing market should always be after the gate closure time of the intraday market. System costs will be lower if day-ahead forecast errors can be corrected through trades in the intraday market rather than in the balancing market.

- **In balancing markets**, more competition would be achieved if both capacity and energy products and upward and downward reserve are separately procured, all technologies are allowed to participate, minimum size requirements for bids are removed (or aggregation is allowed to take place) and pricing of products is marginal.

- Regarding the **imbalance settlement rules**, if balancing arrangements applied are well suited to single pricing, this settlement scheme should allow prices to reflect the costs imposed on the system by any imbalance and should avoid creating a surplus for the system operator out of the application of the scheme. However, if balancing arrangements do not suit single pricing, this may produce worse results than dual pricing. The settlement period should be as short as possible for imbalances created by each agent to be reflected in payments to be made by it.

- Lastly, **imbalance actions should take place after intra-day markets** and the use of balancing resources for congestion management and balancing purposes should be kept separate regarding the price formation process.

3 RES SUPPORT SCHEMES

3.1 Rationale for RES support schemes

As explained in *Market4RES reports D2.1* [2] and *D6.1.1* [3], energy markets alone could not deliver the desired level of renewables in the EU, meaning that some support has been needed to stimulate investment in renewable energy. At least two types of measures have been necessary: priority dispatch and financial support.

Priority dispatch

Priority dispatch is the obligation on transmission system operators to schedule and dispatch energy from renewable generators ahead of other generators as far as a secure operation of the electricity system permits. Member States can either explicitly mention priority dispatch in national legislation or, alternatively, priority dispatch is considered to be implicitly given in support systems which include a purchase obligation, such as feed-in tariffs.

The rationale for the introduction of this regulatory tool was that the market structure and rules were not designed with variable energy generation technologies in mind. The response to price signals from these generators is different, based on availability of their fluctuating source, which they cannot control. If in addition, there is a lack of transparency in operation and curtailment rules, RES-E generators have an additional market risk (uncertainty on volumes sold). Wind and solar PV energy in particular, having variable output with very low marginal costs, risk being the first to be curtailed in power systems with low flexibility. As curtailing variable generators would be the easiest solution to solve grid issues in such systems, the RES-E Directive requires system operators to reduce curtailment of RES-E generation.

Overall, priority dispatch has been and still is an important tool to facilitate the integration of RES-E into the power system. The lack of transparency in curtailment rules of new variable RES-E generation in particular, makes priority dispatch in many Member States a policy-driven solution that ensures that its intrinsic characteristics are not a barrier to its exploitation. In this sense, well described and clear rules for curtailing RES-E generation would reduce risks for these generators as new market entrants, specifically by providing compensation rules for non-system security related curtailments.

Financial support schemes

Traditionally, fossil-fuel based technologies and nuclear power have enjoyed a wide range of public support, for example in fuel extraction and production. Moreover, external environmental costs were not fully internalized (global, regional or local). Considerable progress has been made for local and regional emissions with standards on technologies and abatement measures for e.g. SO_2, VOC, NOx and fine particles. Moreover, with the emission permit system in the EU, fossil fuel power generation gets an extra cost corresponding to the marginal cost of keeping total emission levels below a defined ceiling. On the other hand, renewable energy together with energy efficiency measures should be seen as enablers for making Europe less dependent on fossil fuels. Development and implementation of these technologies will make it simpler for policy makers to set more ambitions environmental targets in the future e.g. through reducing the ceiling within EU ETS. There are several reasons for providing financial support to renewable generation:

- The defined ceiling in EU ETS and the corresponding permit price do not represent the true environmental cost of emissions, because the ceiling is set too high.

- Renewable power generation still have a considerable potential for further technological development through learning-by-doing, which is a positive externality. Renewable energies need financial incentives to develop, to increase to significant market volumes and to foster technological innovation, until they become mature enough to compete with conventional generation fed into the grid.

- Renewable energy production in Europe gives reduced risks caused by dependency of imported energy.

- There are specific targets for RES shares in energy consumption in the EU for 2020 and 2030.

- RES support can stabilize revenues and reduce investor risk and therefore the overall cost of renewables.

In Europe, in most cases the financial support to renewable generation has initially been granted in the form of FiTs which guarantees a fixed price per unit of electricity generated (MWh) fed into the grid over a specific time period (see next section). This support has allowed triggering the development of RES-E generation capacities – mainly from wind and solar sources – and has led to significant generation capacities in Europe, up to almost 100 GW of PV capacities and 140 GW of wind capacities (see detailed figures in *Market4RES report D6.1.1* [3]).

Ultimately, the objective is to make RES-E competitive in a liberalised electricity market. However, RES support schemes are needed until the functioning of the electricity markets has been improved, and there is a meaningful carbon price.

3.2 Support schemes currently applied in Europe

Figure 9 provides an overview of the support schemes currently applied in Europe for solar generation (both for existing and for new capacities). Figure 10 below shows the support schemes applicable to new wind capacities and the experience in Europe with tendering procedures (categorized as auctions in the above list).

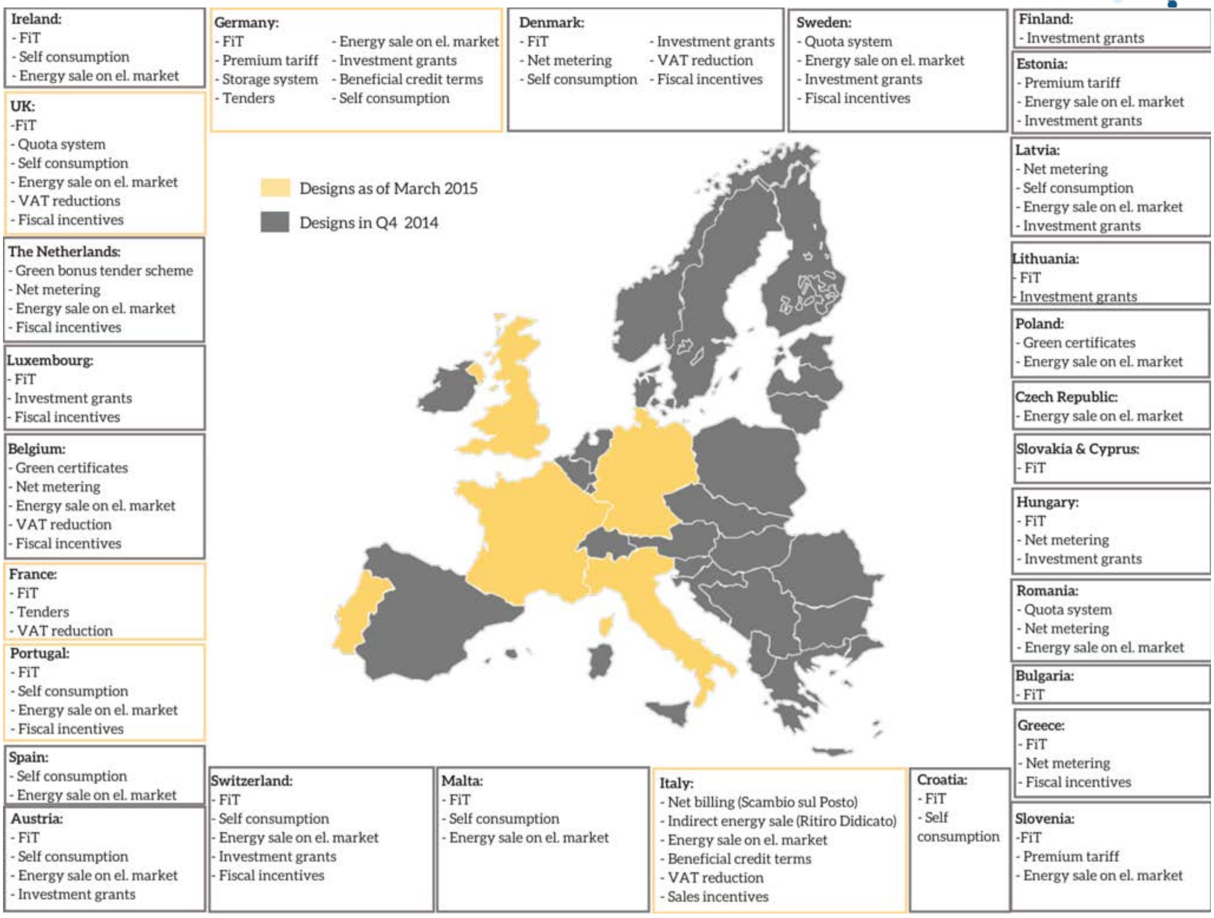


Figure 9 *Support schemes applied to solar capacities in the EU (update March 2015) Source: SolarPower Europe*

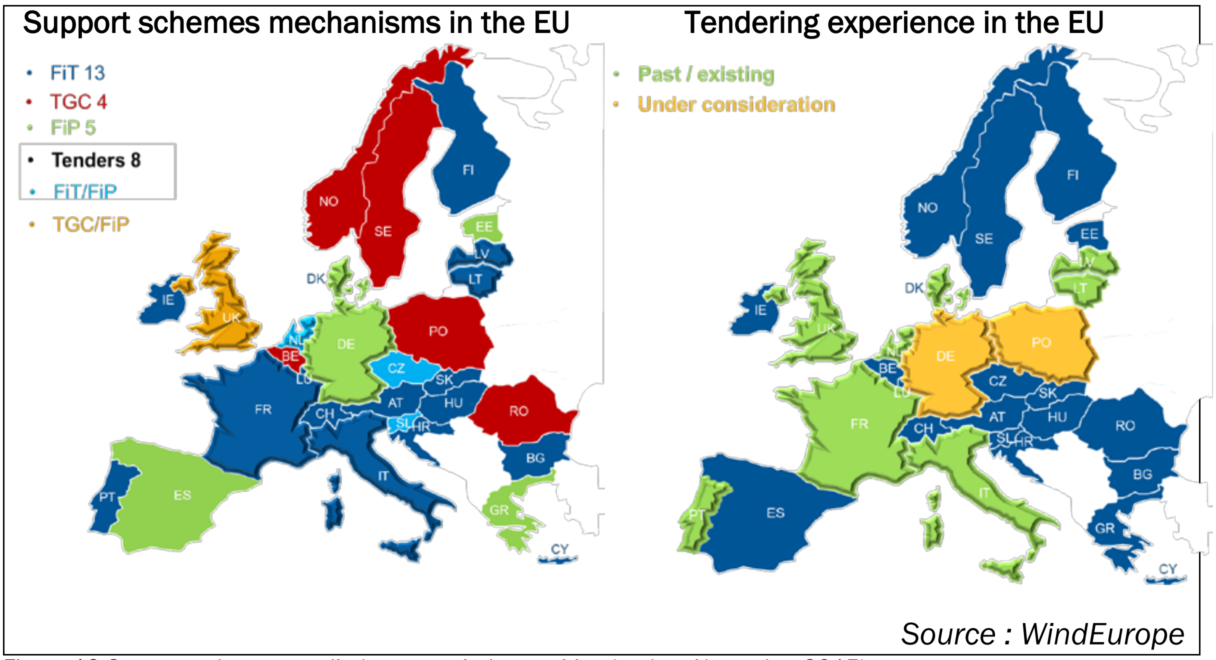


Figure 10 *Support schemes applied to new wind capacities (update November 2015)*

3.3 New environmental and Energy State aid guideline

The European Commission's new Environmental and Energy State Aid [17] guidelines have replaced the existing guidelines on aid for Environmental protection that entered into force in 2008. The new guidelines aim at defining criteria allowing EU Member States to design state aid measures that contribute to reaching their 2020 climate targets and provide sustainable and secure energy, while ensuring that those measures are cost-effective for society and do not cause distortions of competition or a fragmentation of the Single Market. These new guidelines will be in force until the end of 2020. As pointed out by the European Commission [18]:

"In recent years, renewable energy sources have been heavily supported with fixed tariffs. This has encouraged enormously the growth of renewables in the energy mix and has put Europe on track for meeting its 2020 renewables target. However, this type of support has also sheltered them from price signals and has led to market distortions. [...] As technologies mature and their production reaches a substantial share of the market, renewable energy production can and should react to market signals, and aid amounts should respond to falling production costs."

The market distortions mentioned in the Guidelines have been analysed in *Market4RES report D2.1* [2]. The new guidelines therefore aim to better integrate renewables into the internal electricity market in a gradual way, through the gradual introduction of market based mechanisms.

"In order to incentivise the market integration of electricity from renewable sources, it is important that beneficiaries sell their electricity directly in the market and are subject to market obligations. The following cumulative conditions apply from 1 January 2016 to all new aid schemes and measures:

a) *aid is granted as a premium in addition to the market price (premium) whereby the generators sell its electricity directly in the market;*
b) *beneficiaries are subject to standard balancing responsibilities, unless no liquid intra-day markets exist;*
c) *measures are put in place to ensure that generators have no incentive to generate electricity under negative prices."*

The new guidelines also foresee the gradual introduction of competitive bidding processes for allocating public support, while offering Member States flexibility to take account of national circumstances (p. 126).

"From 1 January 2017, the following requirements apply:
Aid is granted in a competitive bidding process on the basis of clear, transparent and non-discriminatory criteria[8], unless:

- *Member States demonstrate that only one or a very limited number of projects or sites could be eligible; or*
- *Member States demonstrate that a competitive bidding process would lead to higher support levels; or*
- *Member States demonstrate that a competitive bidding process would result in low project realisation rates (avoid underbidding).*

If such competitive bidding processes are open to all generators producing electricity from renewable energy sources on a non-discriminatory basis, the Commission will presume that the aid is proportionate and does not distort competition [...].

[8] So the support is no longer granted administratively but rather through a genuine competitive bidding process on the basis of clear, transparent and non-discriminatory criteria.

The bidding process can be limited to specific technologies where a process open to all generators would lead to a suboptimal result which cannot be addressed in the process design in view of, in particular:

- *the longer-term potential of a given new and innovative technology; or*
- *the need to achieve diversification; or*
- *network constraints and grid stability; or*
- *system (integration) costs; or*
- *the need to avoid distortions on the raw material markets from biomass support."*

With regards to small producers of renewable energy, small installations or technologies in an early stage of development can be exempted from participating in competitive bidding processes.

Therefore, this new legal framework will lead to profound changes in the support to renewable energy sources. Such changes are likely to have significant impacts on RES generation and possibly on the whole power system.

3.4 Assessment of support schemes

Considered schemes

In the *Market4RES reports D3.1* [15] and *D3.2* [8] addressing the developments affecting the design of long- and short-term markets, options for RES support have been described and assessed. An overview of considered schemes is provided in Table 2,[9] whereas the corresponding assessment is described in the following. The mentioned assessment in *D3.1*and *D3.2* was extended in *Market4RES reports D6.2* [5] and *D6.3* [6] by discussing an extra support scheme & design of tenders, and another assessment criterion respectively. This is described in Sections 3.5 –3.7, whereas the following discussions within the project and the final recommendations about RES support schemes are in Section 3.8.

Time-frames and criteria

Regarding impacts on short- and long-term:
The assessment of RES support schemes have been carried out with respect to short- and long-term impacts. The distinction between short- and long-term is not calendar time, but rather impacts on the operation and on the development of the power system respectively. When studying short-term impacts, the installed capacities are (by definition) taken as given. The short-term impacts of RES support schemes have been studied qualitatively in *Market4RES report D3.2* [8], whereas the quantitative impacts in short-term markets are studied in *Market4RES reports D5.2* [9] and *D4.2* [16]. On the other hand, when studying long-term impacts, the development of capacities e.g. through new investments are in focus. The long-term impacts of RES support schemes have been studied in several Market4RES reports, including *D3.1* [*15*] and *D6.3* [6].

RES support schemes have been historically introduced to drive the deployment of RES generation in large quantities in order to accelerate the development of specific technologies (by technology development and economies of scale). Therefore, these incentives have been designed to trigger long-term investment decisions. These incentives however did not pay much attention on how they did impact the operation of short term markets, as the share of

[9] See CEER [16] for case studies about several of these support options.

renewables was still relatively small. However, with higher shares of renewables, their impacts on the operation of the power system must also be considered.

Ideally, short-term markets should not be affected by long-term investment instruments, apart from impact on electricity prices due to supply from RES generation. However, a balance needs to be found between impacts on the short- and long term.

Table 2. Overview of assessed support-schemes

Scheme	Short description
Feed-in-Tariffs (FIT)	Administratively set tariff for every MWh produced over a given period. Assessment is done for systems where the price is set administratively or as a result of an auction respectively.
Feed-in-Premium (FIP)	Administratively set premium on top of market price for every MWh produced over the given period. Also called Price Premium. Assessed with our without price caps and floors (maximum / minimum level for the overall price resulting from adding up market price and premium), and for where the price is set administratively or as a result of an auction respectively.
Long term clean capacity auctions	This is a system of long term generation capacity auctions, whereby support to a predefined amount of RES generation capacity of a certain technology to be installed (being the amount decided by authorities and the technology that, or those, that need to be supported to get mature) results from bids accepted in the auction. The marginal capacity bid accepted would be setting the price paid for each unit of generation capacity installed.
Long term clean energy auctions	Remuneration conditions affecting the compulsory supply of a certain block of clean energy (predefined amount of it) are set through an auction process taking place in the long term.
Tradable green certificates (TGCs)	Introduction of a quota for several years per renewable technology. Electricity suppliers would be either obliged to produce a certain volume of green energy, or to buy an equivalent volume of “green” certificates corresponding to electricity produced by RES producers.
Net metering of demand and generation	Net power production and demand over certain periods of time are netted out in order to compute the level of regulated charges paid by the corresponding network user. Thus, a sort of subsidy can be deemed to be applied to the latter.
Support conditioned to the provision of grid support services	In this case, support to RES generation, which tend to be of a FIP or FIT type, is largely contingent on the provision of voltage support service by this RES generation. RES generation not providing voltage support earns some basic support which is much lower than that earned by RES generation providing voltage support. As far as authors are aware of, this scheme has only been implemented in Germany.
No support	No support mechanism. RES producers would sell at the best price offere.

Regarding criteria:
For the short- and long-term impacts, the set of criteria applied in this assessment included:

- Efficiency: Ability to minimize the overall system cost of provision of the product transacted in them. Aspects are related to this criterion includes: marginal cost reflectivity, liquidity, diversity of products and market transparency.

- Effectiveness (achievement of policy goals- RES targets)

- Robustness (resilience to changes in fundamentals such as fuel prices and demand)

- Implementability (simplicity, experience with the implementation and applicability to other contexts).

Result of assessment

Short term impacts:
The following schemes have some serious drawbacks regarding their short-term impacts, or do not perform well on average terms, and should be discarded as sound options to implement:

- Feed-in tariffs (all types)
- Feed-in Premium (regulated price)
- Net metering of demand and generation
- Support conditioned to the provision of grid support services

The following options perform well:

- Feed-in Premium resulting from an auction
- Long term clean energy auctions
- Certificate schemes

Whereas the these options perform very well with respect to their short term-impacts:

- Long term clean capacity auctions
- No-support

One of the important factors for this assessment is the degree different support mechanisms are distorting the short-term price signal provided from the day-ahead market to RES generators. With feed-in tariffs, there is a total de-coupling between producer price and electricity market price. As a consequence, RES producers will supply electricity to the market even at times when the electricity price is below zero. For e.g. feed-in premium and certificate schemes, changes in electricity prices give a corresponding change in producer's prices. However, the producer's price for RES is on a higher level, which creates a distortion. If only investment support through a capacity auction is provided, the electricity price is the short-term price signal for RES producers.

Long-term impacts:
For the assessment of long-term efficiency, the focus has been how different schemes are able to bring about new capacity (MW). The assessment of long-term impacts (i.e. impact on investment decision for new RES capacity) concluded that the design options should be of a market nature (i.e. tenders/auctions) in order to increase their efficiency and reduce the possibility that authorities manipulate support payments. Specifically, the most promising RES support mechanisms are those with a market nature, namely

- Long term clean capacity auctions

- Feed-in tariff (with tariff set through auction)
- Feed-in premium (with premium set through auction)

These mechanisms result in the most cost-competitive RES generation that is compatible with the achievement of RES deployment objectives being installed in the system and could be accepted by authorities and stakeholders. The reasoning for focusing on installed capacity (MW) rather than e.g. (MWh/year) is that the manufacturing of the corresponding equipment are leading to long-term cost-reductions, which are motivating the support for it.

Most promising options:
Taking into account the assessment and ranking made of RES support schemes according to both their short and long term effects, Figure 11 classifies them into most promising options (Green) and those to be discarded (Red). From the qualitative analysis done in the project, the most promising options are feed-in premium resulting from auctions, long term clean capacity auctions, long term clean energy auctions, and certificate schemes.

Although the option "no support scheme" has overall strong grades, it would however perform very poorly under the effectiveness criterion and, therefore, cannot comply with policy objectives set for RES targets in the long-term.

Design Options	Weak points (-)	Strong points (+)
✓ Long-term clean capacity auction ✓ Long-term clean energy auction ✓ Certificates ✓ FIP (auction)	• FIP (auction) and Certificates imply some project risk • FIP, Certificates, and energy auction distort short term prices to some extent, and this distortion depends on system conditions • LT clean auction difficult to extend to other markets (involves central buyer) • Relevant amount of support provided • Create some barriers to RES participation in markets	• Tend to reveal the marginal cost of RES capacity in LT procurement schemes for new projects • Effective to meet LT RES targets • Limited distortion of efficient short term signals • Tend to foster both LT and ST liquidity • Certificates promote Cost Causality • Resilient to political intervention
✓ FIP regulated ✓ Net metering ✓ FIT ✓ Support conditioned to the provision of grid support	• May not reflect marginal cost of RES capacity for new projects • Fail to meet LT RES targets • All create relevant distortions of short term prices (FIT-largest, FIP regulated-relevant, Net Metering-localized) • FITs, Net Metering and , and Voltage condition reduce liquidity in short term markets • Prone to political intervention • Regulated FIP and FIT: Large support	• FIP regulated promotes liquidity in short term markets • Low overall support involved in Net Metering • Grid support condition reduces the amount of support mobilized • Experience within the EU • Can be extended to other systems

Most promising design options (overall strong grades) Discarded design options (overall weak grades)

Figure 11 *Overall assessment of RES support schemes considering their short and long term effects, and reasons supporting this.*

3.5 Floating feed-in premium

General idea of the mechanism

In the following we describe the support scheme "Floating feed-in premium", which are further elaborated in *Market4RES reports D6.2* [5]. In this system, a feed-in premium is provided on top of electricity prices to ensure that the *average total price* received by renewable generation (i.e. electricity price plus feed-in premium) is at a targeted level. The target level for the total price (Euro/MWh) could be set either administratively or through a competitive procedure / tender. Since the average electricity price varies from year to year, the feed-in premium will vary too – thus it is *floating*The floating premium can either be set ex-ante on basis of forward electricity prices, or ex-post on basis of realized electricity prices. The resulting annual electricity price used for setting the floating feed-in premium is called the *reference electricity price*.

Even though the floating premium aims to achieve that the price for renewable generation (electricity price plus price premium) is at the targeted level on average (a characteristic similar to feed-in tariffs), the premium will be the same for all hours within any given year (a characteristic similar to standard feed-in premium). Thus, the floating feed-in premium combines two good characteristics for support schemes: it reduces the risk with respect to cost-recovery, and it provides incentives in short-term markets due to varying hourly prices.

If the horizontal axis in Figure 12 is interpreted as different years, then the left and right panel respectively show the average price for renewable generation within the standard and floating price premium scheme.

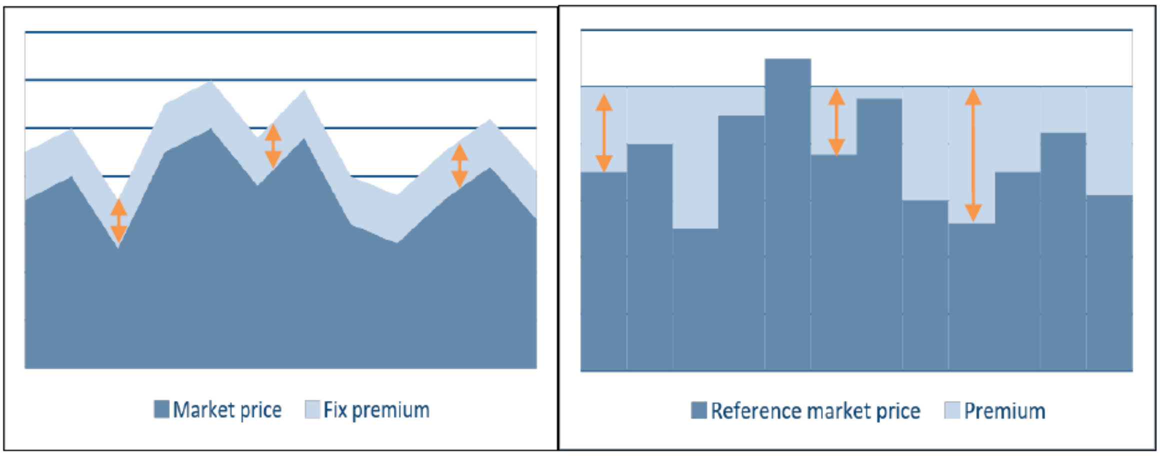


Figure 12 *Functionalities of a fix premium and floating premium scheme. Source: CEER, 2016*

Design options of the floating premium

Specific design option parameters to be considered include:

- The reference price can be calculated on basis of forward or realized electricity prices.

- A new reference electricity price could be calculated for each year, or with either shorter or longer time-intervals. A new reference electricity price will automatically give a new price premium in this scheme.
- The target level for the total price can be set administratively or a result of a tender. In the latter case the quantity is set administratively rather than the price.
- Uniform or technology specific target levels for the target price can be implemented.
- The reference electricity price can be an unweighted or weighted average of hourly prices. If they are weighted, the corresponding weight could e.g. be based on the renewable power generation profile (average, not for each individual producer). If prices on average are low at times of high renewable generation, this will then lead to a higher price premium, to make sure that the total average price is sufficient for cost-recovery.

3.6 Additional assessment criteria: Investor risk

Cost of capital for investors in the total cost structure

The cost structure of different electricity generation technologies are analyzed in *Market4RES report D6.3*, and shown in Figure 13. Wind- and solar-power run fuel-free, but have high investment costs, Their cost structure is therefore very different from e.g. hard coal and gas-power (CCGT) plants. As a consequence, the cost of capital (financing cost) is an important parameter when calculating whether a project is bankable or not, cf. Figure 14. Thus, studies in the Market4RES project have considered how different support schemes affects risks, the corresponding cost of capital for renewables, and thus impact of costs of support schemes.

Risk's impact on societal costs for CO_2-mitigation

Market4RES report D6.3 [6] includes a quantitative study of the cost of reducing CO_2 emissions from the power system. The study utilizes a long-term electricity market model that includes both the operation of existing units and investments in new generation. Two instruments for reducing CO_2 emissions were studied: a CO_2-price (tax or permit price) and a feed-in tariff for renewable generation. Different CO_2 prices are selected, and then the feed in tariff is tuned in such a way that the same level of emissions is obtained for each case. In the reference case there is no feed-in tariff, and the CO_2-price is set to 250 €/tonne. In the other cases, where a feed-in tariff scheme is applied to support renewables, there is no price risk for investors in renewable generation. Therefore the applied interest rate for renewable generation investments was set lower for those cases. Figure 15 shows the resulting total discounted system cost for different combinations of CO_2-prices and feed-in tariffs. Notably, due to reduced risk for investors in renewable generation, the total system costs are lower if an emission permit system is combined with support for renewable generation. The part of total costs originating from risk in the case where only emission permits are applied (on the right), is shown by orange colour.

Risk profiles in different support schemes

The quantitative study discussed in the previous section only considered one support mechanism for renewables; feed-in tariffs. In this system, there is no price-risk for investors. However, there is still a volume risk due to the variability of the renewable generation. A qualitative assessment of the risk profile for different support schemes is described in *Market4RES report D6.3*, and illustrated in Figure 16. Three types of risks are considered: price risk (indicated by vertical arrow), volume risk (indicated by horizontal arrow), and profile risk (curvature arrow). The colors are determined by the corresponding combination of volume- and price-risk, cf. label in figure. When applicable, the boxes for each support scheme are divided into different parts corresponding to income from sale of electricity (upper part), and income from RES-support scheme (lower part).

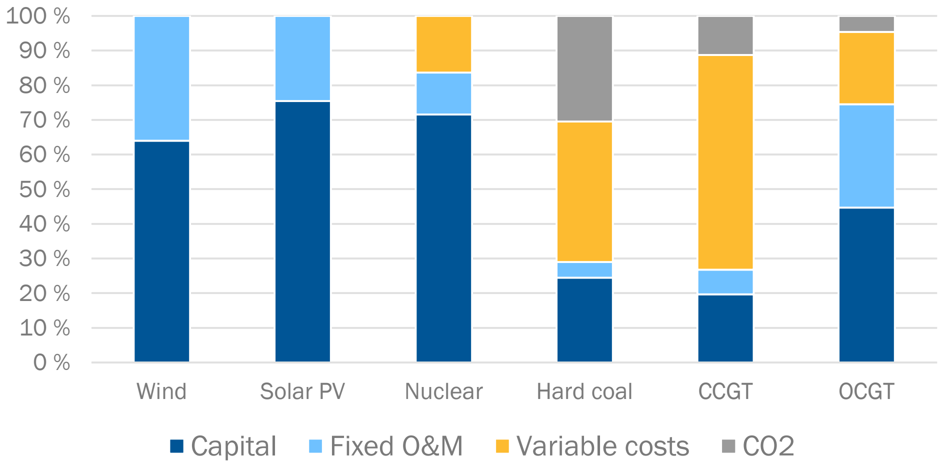


Figure 13 *Split cost of the energy generated for different technologies. Result from market simulation in Market4RES project.*

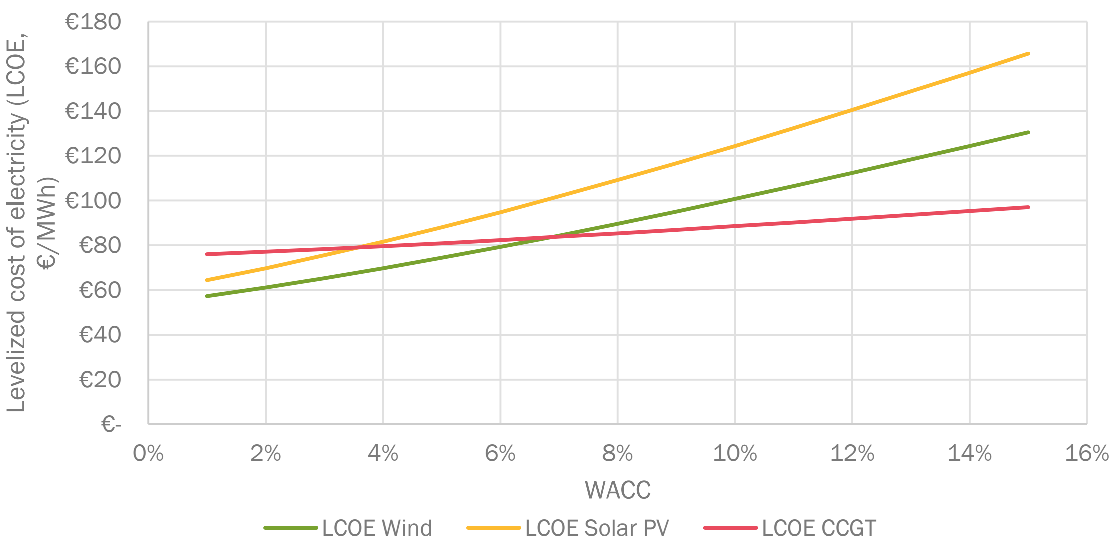


Figure 14 *Levelized Cost Of electricity (LCOE) in function of the Weighted Average Cost of Capital (WACC)*

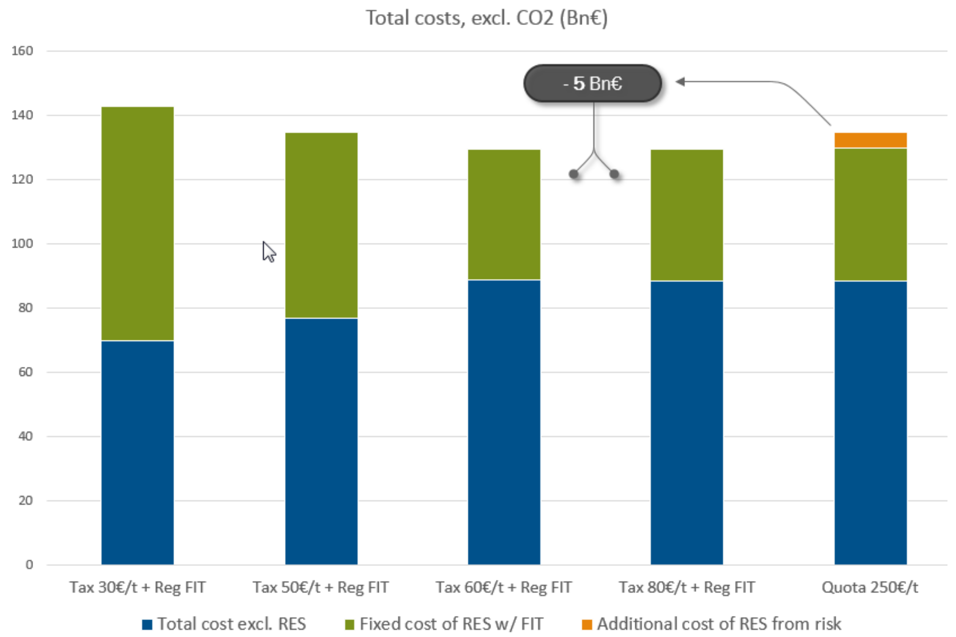


Figure 15 *Total Costs as a function of the support mechanism's designs at a regional perimeter*

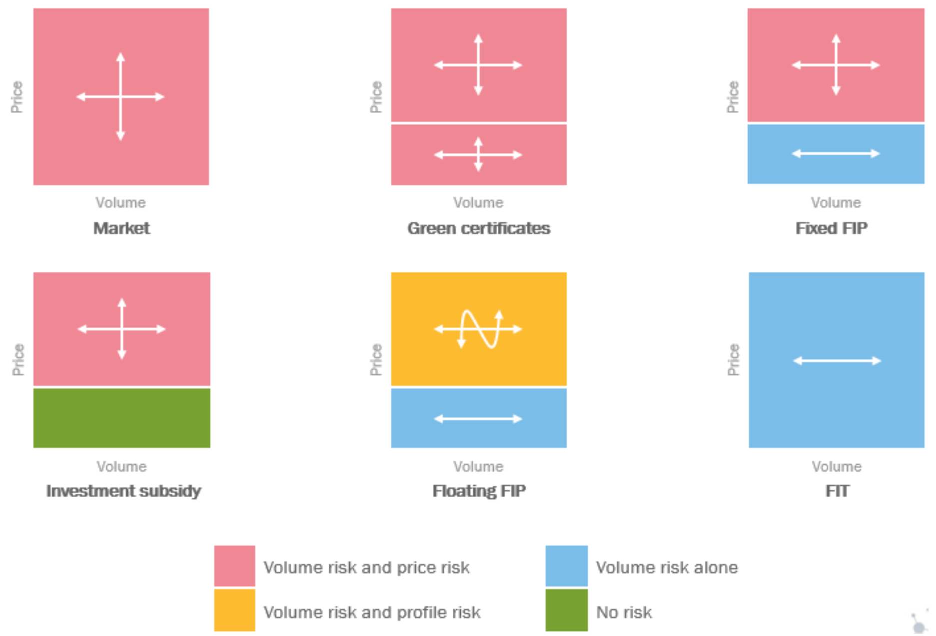


Figure 16 *Support schemes and risks for renewable projects*

Below, some comments are provided to explain the assessment for each support scheme. See *Market4RES report D6.3* [6] for further details.

Market. This is the assessment for the case when no support scheme exists. In this case, there is price risk for all income, and volume risk for the amount produced.

Green certificates. In this case the income is the sum of income from sale of electricity and green certificates, represented by the upper and lower part respectively. Both of them are subject to both price- and volume risk.

Fixed feed-in premium. The risk for income from sale of electricity is the same as for green certificates. However, the income from the RES support scheme is subject only to volume risk as the feed-in premium is fixed. This gives a lower total risk.

Investment subsidy. The risk for income from sale of electricity is the same as for green certificates and fixed feed-in premium. However, the income/transfer from the RES support scheme is subject neither to volume- nor price-risk. Thus, the total risk is lower than for green certificates and fixed feed-in premium. The investment subsidy corresponds closely to the long-term capacity auction scheme. However, compared to a fixed investment subsidy, there is an additional risk of auctions / tenders through the transaction costs of participating in them. On the other hand, the application of auctions or tenders can/will be a part of most relevant support schemes.

Floating feed-in premium. In this case, the average price over time is in principle fixed since the support per MWh produced will be calculated as the amount needed to reach a given total income level per MWh on average for all RES electricity generated. However, the average price obtained for any given producer will still be different since the production profile, and therefore the average electricity price, will deviate from the average profile. It can be better or worse, but since it is an uncertainty it is by definition a "risk". The income from the RES support scheme is however only subject to volume risk.

Compared the investment subsidy, the floating feed-in tariff has a lower risk for the electricity sale income, but a higher risk for the transfer from the RES support scheme. Thus, this qualitative inquiry of risk gives no clear ranking between those two alternatives. However, the total risk is lower than for green certificates and fixed feed-in premium.

Feed-in tariff. Since the income per MWh produced is pre-defined, there is only volume risk. This gives an even lower total risk compared to the floating feed-in premium.

3.7 Tenders

If the principles of the current EU State Aid regulation are to remain, all new support schemes will be based on a competitive tendering process (for systems abpve 1 MW). However, the continuation of this part of the regulation will have to depend on the experience gathered by the implementation of these complex mechanisms in the following years.

As far as the recent experiences can tell, design parameters play a crucial role and practices currently vary substantially across the different EU countries. The use of tenders can lead to market efficiency *Market4RES report D3.1* [15], but for this to happen the tender design options needs to be carefully defined.

Due to the limited European and international experience with tendering, public authorities will seek the appropriate tender format on a learning-by-doing basis thus challenging the industry (including developers and financing institution) to adapt to frequent changes in tender arrangements. Tenders present participants with higher risks (costs of applications under uncertainty of the outcome with respect to project selection and support level). Those risks are internalised in bids and could temporally result in higher support costs[10].

There is no tender design system that is a complete success story, because tenders are subject to continuous adaptation of both design elements and participants' behaviour. For a tender to be effective, it has to achieve competitive prices (cost-competitiveness criterion) and high realisation rates (efficiency criterion). It is very important that the tenders are not applied to all market participants (e.g. small players to be excluded), given the transaction costs associated with a tendering process.

Market4RES report D6.2 presents lessons learnt from current experience, and a set of detail design parameters necessary for a successful scheme. The fact that tendering designs vary significantly across Europe limits the opportunities of project developers to reduce their overall cost for participating in multiple tenders. Consequently, a single European-wide tender would in principle ensure uniformity in the treatment of bidders and promote the most attractive projects on a European scale. Such a design however seems unlikely to be implementable within short to medium timeframes due to the fact that aspects such as compatibility with national energy policy and system integration requirements call for a direct control by Member States. With respect to this, a progressive harmonization of tendering design parameters can be expected to increase the overall efficiency of tenders. Furthermore, the provision of a roadmap and or long-term perspective regarding the volumes to be auctioned would increase investors' confidence and would help the industry to sustainly plannify manufacturing capacity and optimize the supply chain. Finally, the creation of a database providing insights on globally tendered and successful connected capacities is recommended.

3.8 Conclusions on RES support schemes

The supported volume

From the project background and the initial assessment of RES support schemes, there was a focus on avoiding distortions in short term markets. For instance, it was concluded that the incentive provided to renewable power generation in feed-in tariff systems at times of negative electricity prices should be avoided. The best assessment was given to schemes providing investment-aid (Euro/MW), without providing any distortion of the short term-price signal (Euro/MWh). However, additional assessments and discussions carried out in the project extended the assessment with additional perspectives:

- Risk aspects. The involved risks for investors affects the cost of capital and thus the support they need. This cost should also be taken into account when considering the efficiency of a support scheme.

[10] Recent pilot experiences for a PV tender in Germany, based on pay-as-bid rules resulted in higher premiums than the premium administratively set (FiT). www.rechargenews.com/wind/1419928/ones-to-watch-german-tenders-monitored-across-europe

- Furthermore, with respect to implementability, feed-in premium type systems coincides better with the new environmental and Energy State aid guideline.

An important question then was how to combine the assessments, and develop a synthesis of proposed schemes that would be considered good from each perspective. The key to reaching this consensus was to focus on the supported *volume*. A main argument against e.g. fixed and floating tariff system is that it provides incentives to produce also at times of negative electricity prices (because of the price premium, the total price for renewables can be positive even when electricity prices are negative). This distorts the price-signals for renewable generation in all short-term markets. However, if the support received by renewable generation (e.g. fixed or floating feed-in premium) is not affected by how much they produce when electricity prices are negative, or when supported RES production is curtailed by any other reason, then this distortion will not exist, as mentioned in the discussion about floating feed-in premium in *Market4RES report D5.2* [9]. In principle, this can be obtained by two different means:

- There is full support to renewable generation even if they voluntary cut back their supply (due to negative prices). The supported volume is therefore based on what we can call "gross or potential" generation, and not the amount actually fed into the grid.

- There is no support to renewable generation if electricity prices are negative. If a price premium is applied, it is set to zero for such hours. If the electricity price is positive, the actual produced volume will be supported.

There are some practical challenges for each of them. In the former approach, there is a need to monitor what the generation would have been, if it was not cut voluntary. In the latter approach, it is a challenge that there exist several prices for any given hour in the different time-frames (day-ahead, intra-day hours and balancing energy). The simplest would be to condition the support on positive day-ahead market prices. However, even though there will be a correlation between prices in different time-frames if markets are well-functioning, it would not be fully efficient to condition support only on the day-ahead market price. The challenges and corresponding solutions of the two above mentioned approaches should be investigated further.

Recommendations

Based on the previous discussion, the following general recommendations for future support mechanisms can be made:

- A careful balance needs to be found between impact on short-term market signal, and long-term efficiency accounting also for effects on investment risks.

- A system of floating feed-in tariff could provide this balance under the following set-up:
    - The supported volume is not reduced if renewable generation units cut back production because of negative market prices (in day-ahead, intra-day or during activation of downward regulation). Thus, the short term efficiency of the system would be good. Alternatively, volume produced at times when market prices are negative is not supported.
    - The price premium on top of electricity prices is regularly adjusted (e.g. every 2-3 years) if it is calculated ex-ante on basis of forward electricity prices. This shields RES producers from long term price uncertainty. At the same time, incentives are provided to optimize generation profiles (could be important e.g. for site selection, technology development, and some short term flexibility).

- The level of support should be the outcome of a competitive market process (tender).
- Technology specific tenders should be permitted.
- Tenders should not apply to all market parties (e.g. small players to be excluded), given the transaction costs associated with a tendering process. However, the pre-qualification criteria should be project-related (provision of building consent, grid-access connection, land acquisition) rather than bidder-specific (experience, project portfolio).
- Tendering design parameters should be progressively harmonize across EU member states. A roadmap and or long-term perspective regarding the volumes to be auctioned should be put forward to increase coordination among countries, leading to an increase of investors' confidence and helping industry to plannify accordingly.

3.9 Roadmap towards 2020 and beyond

Based on the assessment of markets design aspects and on the penetration rates of a certain renewable technology (which is an indicator of technology and market maturity), we provide an illustrative representation of a potential support schemes evolution (see Figure 17). In this conceptual model, two dimensions that are central for which support scheme that is appropriate: technology maturity, represented by their market share, and the degree the market is adopted to account for the specific characteristics of the technology.

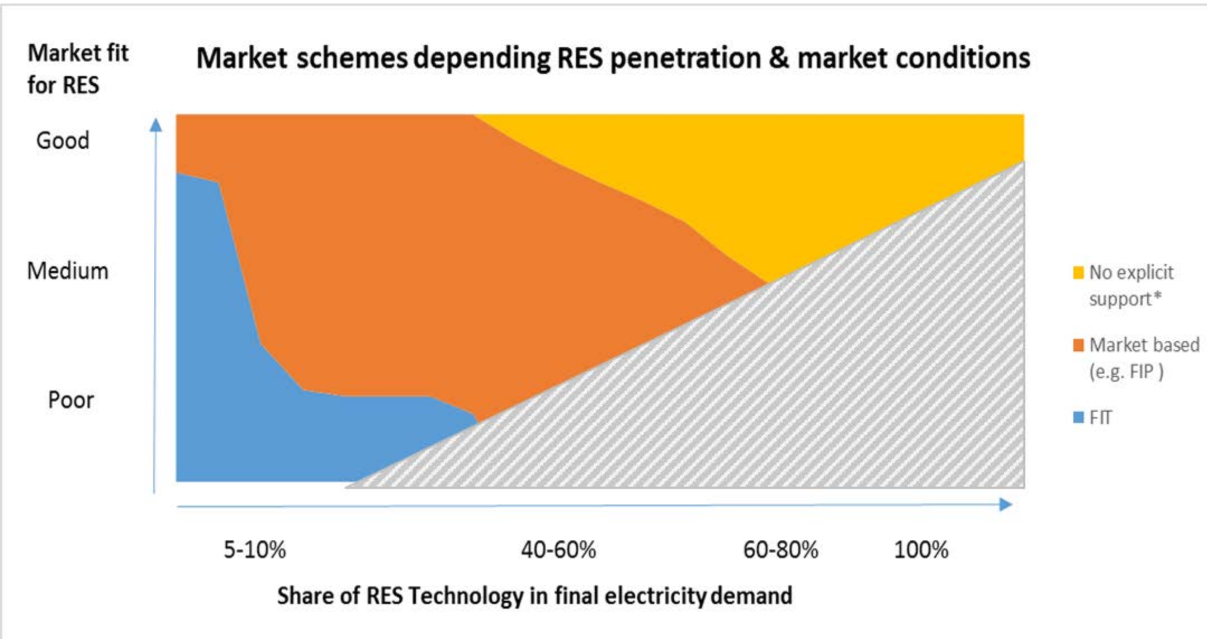


Figure 17 *Conceptual illustration of the potential evolution of support schemes based on market design and penetration of a specific RES technology.*

In the early stage of market deployment, new technologies are generally expensive and not yet competitive. Still, if they represent a long-term cost reduction potential, they should be supported with instruments that reduce investment risk as much as possible to accelerate deployment at an appropriate cost for society. Producers should be exposed to prices only when the market is well adapted for this new technology.
As the technology matures and increases its share in the energy mix, it is important to adjust the market instrument, reducing the overall support, but also making it more dependent on market dynamics. The better the market situation, the faster this transition can be made.

In well-functioning markets, and further technology development, RES production could eventually be financed without explicit support schemes. If electricity prices at some point in time become a sufficient incentive for the market to provide an amount of renewable generation that exceeds possible targets for this technology, then this should be visible from the outcome of the tendering process (needed price premium is zero).

Finally, it is worth explaining that we do not contemplate the possibility to achieve a significant market penetration (e.g. above 10-15%) in a system where the market conditions are somehow not adapted to these new technologies (this is represented in by the grey area).

With this background in mind, the European Commission guidelines on state-aid support for environment and energy should be continued after 2020, in line with the current framework, building on increasing experience from tender systems, and premium-based schemes.

4 CAPACITY MARKETS

4.1 Energy-only and capacity markets in Europe

"Energy-only" markets have been established in Europe with the start of the implementation of wholesale electricity markets in 1999 (a few forerunners like UK and Norway have done so already at the beginning of the 1990s). In Europe, the late 1990s were characterised by quite convenient excess electricity generation capacities. Therefore, the implementation of textbook theory on wholesale market places to trade electricity (for different periods in time) based on short-run marginal cost has been the favourable and most efficient approach.

Since then, Europe's electricity sector is experiencing a phase of great transition with increasing shares of renewable generation thanks to effective support schemes. In the meanwhile, demand is stagnating due to relatively low economic growth and energy efficiency measures. As a consequence electricity prices have been falling, leading to less investments in conventional generation and even to decommissioning of some existing capacities. See *Market4RES report D2.1* [2] for a further elaboration.

Higher shares of varying renewable generation combined with low investment in firm capacity have led to concerns about the security of supply of many member States of the European Union. Some governments have expressed doubts on the maturity of energy markets and, more specifically, their appropriateness to produce the investment signals needed to ensure an adequate generation mix able to meet the demand at all times. Several European countries (cf. *Market4RES report D6.3* [6]) have already implemented capacity markets, some countries are in the process of implementing them, while others are debating introducing them.

4.2 Guidance to ensure generation adequacy

In its staff working document [20], the European Commission presented a guidance to properly ensure generation adequacy in the Internal Energy Market (IEM). This guidance establishes that the energy only market should be given an opportunity to encourage appropriate investments.

To ensure security of supply in the long-term, the EU compels public authorities to undertake periodic assessments of the generation adequacy situation in their Member State. Key issues for this assessment include (i) developments at regional and Union level, (ii) the effect of European policy objectives, and (iii) the potential of demand response.

Where as a result of the previous assessment, a concern about generation adequacy emerges, its causes should be first properly identified. Once identified, to the extent possible, they should be removed to allow the energy only market work and give proper long-term incentives.

Only when all the previous steps have been taken and the long-term investment problem remains, Member States may opt to intervene by implementing a CRM mechanism to ensure generation adequacy (also including State aid, cf. *Market4RES report D3.1* [15]).

4.3 Concerns about implementation of national schemes

The national initiatives to establish capacity markets have taken place in an uncoordinated manner, resulting in impacting the progress of achieving the objectives of European regulation. This situation has raised the EU Commission and ACER alarms, who precisely perceive these national movements, if not properly designed and coordinated, as a potential threat to the proper development of the Internal Energy Market. This concern has been recently expressed by the EU Commission in the launched sector inquiry on CRMs [21]:

“As these capacity mechanisms are mostly being planned or introduced in an uncoordinated manner they risk being inefficient and materially distorting cross-border trade and competition between the various capacity providers. Generally, they risk distorting price formation in the internal electricity market. Moreover, they may include only certain generation technologies or exclude non-generation activities such as demand side response. They may also disregard the contribution that capacity providers outside national borders and improved interconnection with neighbouring markets can make to ensure security of electricity supply.”

4.4 Qualitative analysis of capacity remuneration mechanisms

An overview of different types of capacity mechanisms is provided in Table 3. See *Market4RES report D6.3* [6] for further details. The classical way to structure discussions of capacity mechanisms is to follow the categories mentioned in this table. The second alternative, which is more complex, but which also allows more details in the characterization, is to identify all relevant design decisions that need to be specified by the regulator.

The assessment carried out in the *Market4RES report D3.1* [15] was based on the latter approach. Even though a fully-functioning energy market is undoubtedly the desired scenario when workable, the analysis took it as a premise that after following the EU recommendations, a capacity remuneration mechanism is still deemed as necessary in a Member State. Therefore, energy-only markets were not compared with different CRM approaches. The considered decisions – or design elements – are shown in Table 4. For each design element, a set of relevant assessment criteria was developed, typically including aspects of efficiency, effectiveness, and some others (different for the different design elements).

The assessment led to the following recommended design for Capacity Remuneration Mechanisms:

1. Financial options with a high strike price[11] seem to achieve the right balance between the provision of certainty to investors in firm capacity and the provision of incentives for agents to participate in short term markets.
2. Regarding the price vs. quantity nature of the mechanism to contract firm capacity, expressing the system needs in terms of a price-quantity curve seems preferable. This avoids that the amount of firm capacity contracted is too high or too low, as well as the possibility that its price is too high. Setting a price-quantity curve partially curb market power and would be implementable in the EU.

3. The procurement should probably take place through a centralized auction, which would be effective and efficient, and would be accepted widely, even when not allowing a large variety of products to be traded.

4. Lastly, cross-border provision of firm capacity should be allowed to increase the efficiency in the provision of this product. The amount of transmission capacity available for this should be computed through statistical means, since this is most reliable.

[11] The provider is responsible to bring a given amount of energy (MWh/h) to the market when this is called for, at a price specified by the strike price.

Table 3. **Overview of assessed capacity remuneration mechanisms**

Type	Country	Brief description
Strategic reserve	Poland, Sweden, (Norway, Belgium, Germany)	System contract capacity to be dispatched when all other available capacity in the market is operating.
Capacity Auction	GB, PJM	A Central Authority determines the volume of physical capacity required and centrally procures this volume from the market.
Ex-Ante Capacity Obligation model1)	Previously in USA, PJM	Load Serving Entities have an obligation to procure capacity based on the peak load that each LSE has served before.
Ex-Post Capacity Obligation model2)	France	Load Serving Entities have an obligation to procure capacity certificates, reducing their actual load or thermo-sensitivity. The final obligation will only be known ex-post.
Reiability options	Colombia	Delivery of a physical volume when the security of supply is at risk. The product is structured as a financial instrument. Central Authority set the volume to be procured, and the strike price.
Fixed payment per MW installed capacity	Spain, Ireland, and Chile	Negotiated when a capacity provider enters the market, and provided by the system operator to that provider for the term of that agreement.

1) Also also known as Central Obligation model, 2) Also known as De-Central Obligation model

Table 4. **Considered design elements of capacity remuneration mechanisms**

Design element	Considered features
The product	Firmness of supply, financial energy contract (incl. strike-price levels), physical energy delivery obligation, lead time, and contract duration
Price-based or quantity-based	Does the procurer set the price, the amount, or a combination?
Who defines the quantity?	Centralized (one central entity is in charge of defining the quantity to be procured), or decentralized / bilateral.
Who defines and purchase the product?	Centralized (defines product, organize auction), decentralized procurement of standard products, and decentralized procurement without standard products.
Cross-border participation	A single scheme for whole Europe, national mechanisms implicitly considering the contribution of neighbors, explicit participation of foreign capacities, and different isolated CRMs.

1) Similar productions, 2) Also also known as Central Obligation model, 3) Also known as De-Central Obligation model

4.5 Procurement of interconnection capacity

The *Market4RES report D6.3* [6] elaborates further on the possible need to procure capacity on interconnectors in case of participation of foreign capacities in capacity markets. In some cases, generation capacity in a foreign country may not contribute to meet the domestic load for another country if interconnectors are congested. Figure 18 shows the constraints on cross border interconnections during the French load peak periods.

Of course, existing foreign capacities and interconnectors are already contributing to the security of supply in a country if it imports at maximum (i.e. congestion) during a peak load. However, additional generation capacity in the foreign country would not give any further help if the transmission lines (direct and indirect routes) are congested.

Several options for including interconnections in capacity markets are discussed in the *Market4RES report D6.3* [6], and it is concluded that an accurate mechanism corresponds to the simultaneous explicit participation of interconnections and generators/demand responses entities. However, legal for the implementation of explicit participation of both generation and transmission capacity within current EU regulations, are identified. Considering those obstacles, a pragmatic approach consists in developing an explicit participation from interconnections only, which is the solution selected in Great Britain and accepted by the Commission.

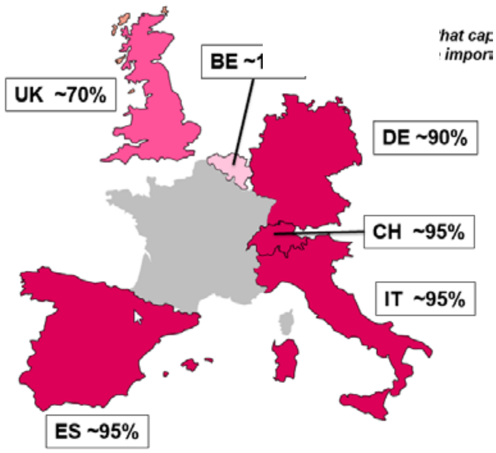


Figure 18 *Frequency of congestion between France and neighbouring countries during French peak load periods.*

4.6 Analysis of energy only vs. capacity markets

Missing money

The *Market4RES report D2.1* [2] discusses the so-called "Missing money" problem in energy-only markets. This concept is used for describing two different situations, both leading to difficulties for conventional power generation and especially peak load units to recover investment costs.

The first situation is the development that has occurred in Europe, in general because of overcapacity. Renewable generation enters the market and produce at zero marginal cost. The corresponding positive shift in the supply curve give lower equilibrium prices, which are below levelized investment costs for conventional power generation. Over time the market will respond to this by adjusting the overcapacity.

The second situation occurs in situations where administratively implemented price caps prevents wholesale electricity prices from reaching high levels during times of scarcity. In this case, it is impossible to recover investment costs for any flexible option having marginal costs equal to or above the price cap. This can then lead to shortage of supply from time to time, with corresponding curtailment of consumption / load shedding.
A price cap set below the value of lost load can therefore be considered as an imperfection, leading to a less then optimal system. On the other and, it could be hard to get public support for occurrences of extreme electricity prices. Thus, this is a challenge for energy-only electricity markets. Capacity markets can provide the capacity through different price-mechanisms, but in principle, it will come at some economic cost for society: The total capacity is higher than optimal and, and the shares installed for different production types may not be optimal.

Quantitative simulation

The *Market4RES report D5.2* [9] describes a long-term electricity market study. Here, long-term means that investment and decommissioning decisions are considered in addition to the day-to-day decisions for demand and supply. In this study, it is presumed that all agents are *risk natural*. Three different cases are analyzed:

- EOM20: Energy-only market with high a price cap corresponding to value of lost load (VLL), i.e. 20000 €/MWh.
- EOM3: Energy-only market with a lower price cap; 3000 €/MWh.
- CM: A system with combined energy- and capacity market. The price-cap is set to 3000 €/MWh.

One could expect that the first case will be more efficient than the second case, whereas the third case at best (depending on which capacities are procured) can have the same efficiency as the first case. The resulting total system costs are shown in Figure 19. There are results for three different scenarios: Ref, Low and High, which are explained in *Market4RES report D5.1* [11].

For each scenario, total system costs are highest for energy-only market with low price cap. As expected, an energy-only market with a price cap corresponding to the value of lost-load give lower costs (this system should lead to a cost-efficient outcome). However, the scenario that includes a capacity market gives a very similar cost. Actually, the difference is due to the granularity of investment decisions. Thus, in this model and for the considered scenarios, the procured capacity was indeed the optimal one. Therefore, this analysis shows how capacity markets in principle can lead to efficient market outcomes. That result could be sensitive e.g. with respect to how large share of the cost-efficient flexibility is provided in the energy-only market at marginal costs above the low price cap.

As explained in *Market4RES report D5.2* [9] no risk aversion was included in the above described study. An important motivation for having a capacity market is however to avoid occurrences of very high prices that are needed to yield the same capacity in energy-only markets. Figure 20 shows the variability of revenues of a peaking generating unit for each system and case. As seen from the figure, the price variability is lower in the case where a capacity market is included. If risk aversion and corresponding impacts on cost of capital had been included, the lower price variability in a system with a capacity market would possibly contribute to reducing the relative system cost of for this alternative, cf. discussion of risk in Section 3.2.

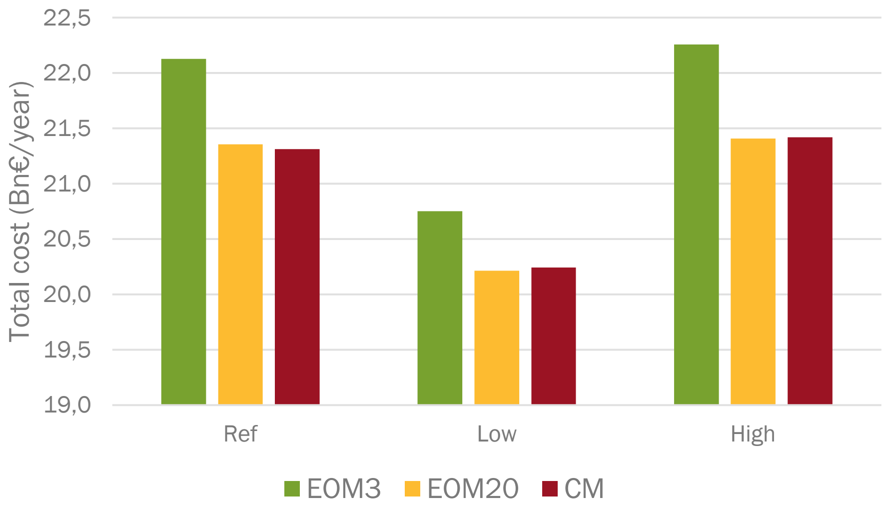


Figure 19 *Total cost (Bn€/year) by scenario and market design*

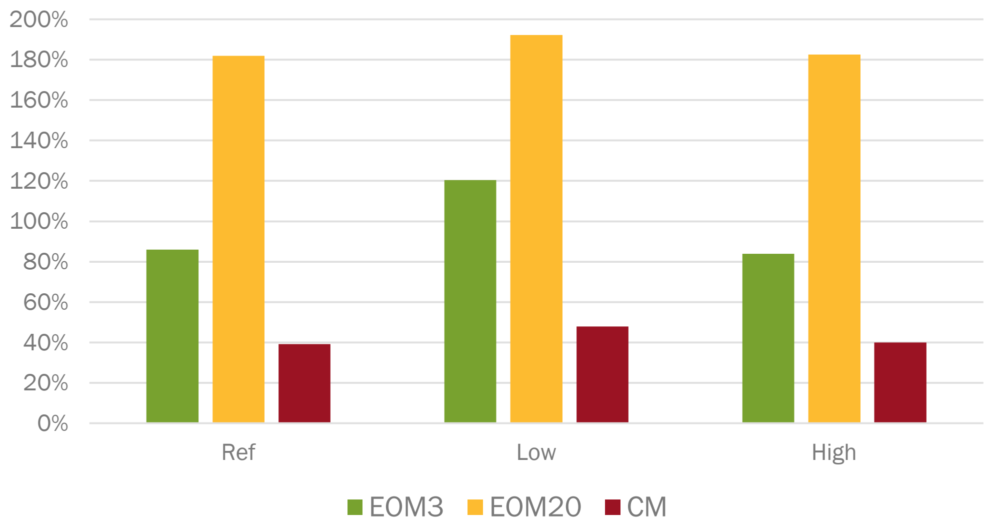


Figure 20 *Variability of revenues of a peaking generating unit*

4.7 Conclusions about capacity markets

- A fully-functional energy market is undoubtedly the desired scenario when workable. For CRMs, the Market4RES project do not take a position on whether we think they are needed or not, as this should be revealed by proper system adequacy assessments.

- **Several countries have already implemented capacity markets**; some are in the process of implementing them, while others are debating introducing them.

- **Capacity markets can improve the security of supply** by providing incentives to build new generation units, maintain existing units, and develop demand side flexibility.

- However, over-investment in firm capacity in separate national markets should be avoided, and it should be **mandatory to allow the use of cross-border interconnection capacity** to contract firm capacity in third systems.

- In addition, if capacity markets are implemented, we recommend that they have the following specific characteristics:
  - The product should be a **financial option with a high strike price** to avoid interference with short term markets; it should have a firmness requirement associated with it.
  - A **penalty for non-delivery** should be applied.
  - Demand for this product should be in the form of a **price-quantity curve**, i.e. the final price paid for it should affect the quantity contracted (to reduce strategic bidding).

5 MESSAGES TO POLICY MAKERS

Overall, the Market4RES project considers that the process initiated by the Target Model should be pursued to harmonize European electricity markets further. It also identifies areas were concrete improvement should be made for better integration of renewable electricity. The goals for the development of markets are to a large degree considerate toward the need for renewable generation. The planned integration of markets for all time periods should be implemented as soon as possible.

This is not the time to stop supporting renewable power generation, as it would give a setback for the transition to a low carbon society. There is a need to reform EU ETS to get a meaningful price on CO_2 emissions, and RES-friendly market structures are not implemented yet. The project supports the adopted State Aid guidelines for RES support, which specifies a transition from the traditional feed-in tariffs to systems based on price premiums set through tenders.

The implementation of well-functioning intraday markets is a clear pre-requisite for the progressive phase-out of priority dispatch and the exposing of all producers to balancing responsibilities to ensure renewable power generation has the opportunity to adjust their position.Furthermore, all types of electricity markets (including balancing and capacity markets) should be adapted to make sure RES generation and demand can contribute to the greatest extent of their potential.

The project suggests a floating version of the feed-in premiums to reduce risks for investors and increasingly expose producers to market dynamics, reducing their interference with short-term market signals. Against this context, the scheme should not incentivise production when the electricity price is negative. The specific design of this scheme, particularly the implementation for different market periods, should be investigated further.

The fact that tendering designs vary significantly across Europe limits the opportunities for project developers to reduce their overall cost for participating in multiple tenders. A progressive cross-border convergence of tenders requires first aligning design parameters at the national level in order to ensure uniformity in the treatment of bidders. The provision of a roadmap and/or long-term perspective regarding the volumes to be auctioned would also increase investor confidence.

Over-investment in firm capacity in separate national markets should be avoided. If capacity markets are implemented, it should be mandatory to allow the use of cross-border interconnection capacity to contract firm capacity in third systems. Regarding specific designs, a financial option with a high strike price is recommended. Furthermore, the final price paid for it should affect the quantity contracted. The use of capacity markets should follow the result of undergoing a robust regional generation adequacy assessment, including the potential contribution of demand-response and renewable generation.

Exposing consumers to prices should activate some of them and improve the efficiency of markets. To achieve this, the automatic metering of electricity consumption needs to be implemented. In order to utilize demand flexibility for real-time balancing, more advanced control of this demand is needed. We recommend further focusing on metering of electricity consumption and exposing consumers to prices.

6 MINUTES OF MEETINGS IN WP6

6.1 Stakeholder event:

Venue, date and agenda

This event was a part of European Sustainable Energy Week (EUSEW). It was organized 17th June 2016 in Brussels. The full tile of the event was: "An electricity market fit for renewables. Considering design options for the electricity market post 2020". The agenda for the event is shown in Figure 21.

9:00-9:30	Welcome coffee
9:30 – 9:40	Introduction by the project coordinator *Andrei Morch - Research Scientist, SINTEF Energy Research, Norway*
9:40-10:20	Implementation of new market design options in Europe with large shares of Renewables *Daniel Fraile – Senior Grids Analyst, WindEurope, Belgium*
10:20 – 10:50	Market design in the long term: high shares of renewables penetration and security of supply *Aurèle Fontaine – Chargé d'Etudes, Market models & economic studies and Frédéric Galmiche - Market Design Engineer, RTE, France*
10:50 - 11:00	*Q&A first part*
11:00 – 11:30	Coffee break
11:30 – 11:50	Presentation of the results of the stakeholder consultation on market design launched in May *Ove Wolfgang, Research Scientist, SINTEF Energy Research*
11:50 – 13:00	Panel debate "Guidelines for new market design options" *Session moderated by James Watson , CEO of SolarPower Europe* *Q&A session included*
13:00 – 14:00	Networking lunch

Figure 21. *Agenda for stakeholder event*

Comments and questions to presentations

Presentations are available here: http://market4res.eu/events/past-events/. Below we mention some comments given and questions asked after each of the presentations.

<u>Comments/questions to Daniel Fraile</u>

- Question: Have your discussed network design in the project? Answer: Yes, there has been some work on this too.
- Comment: For RES support schemes, contracts for differences (Cfd's) gives protection both for producers and consumers, cf. system in GB.
- Question: Are feed-in tariffs getting less popular? Answer: This depends on the market situation, especially if the considered technology is new/immature or already having a large market share. With high shares, it make sense to go for a market-based system.
- Question: Have feed-in tariff schemes been poorly designed? Answer: It varies between countries. The German system has been effective, whereas tariffs have not been adjusted in the Spanish system.

<u>Comments/questions to Daniel Fraile and co-presenter Frederic Galmiche</u>

- Question: Your analysis showed an emission permit price of 250 €/tonne in case the share of renewables is incentivised only the emission permit system. Which scenario did you base your calculations upon – was it e.g. a 2 degree scenario? Answer: Scenarios based on ENTSO-E scenarios we have been utilizing within the project.

<u>Comments/questions to Ove Wolfgang</u>

- Question: In the project you are suggesting different market design elements. Have you carried out numerical simulations that includes all the design elements you are suggestion? Answer: We have studied several of them in dedicated studies. However, we have not carried out a study where all suggestions have been included in one single simulation. This would be hard because of limitations of quantitative simulation tools.

Panellist debate

The members of the panel are shown in Table 5 and Figure 22. Panellists (except from project partners) were given a set of questions each prior to the stakeholder event. They started by addressing those topics. Then the panellists from project partners responded to this, before the open discussion.

Figure 22. *Panelists, cf.* Table 5.

Table 5. Panelists. Mentioned from left towards left in picture below.

No	Name	Institution and position
1	Benedikt Günter	Policy Advisor at the German Federal Ministry for Economic Affairs and Energy
2	Iván Pineda	Director of Public Affairs of Wind Europe
3	Suzanne Nies	ENSO-E. Head of the Distribution System Operators Unit
4	Jan Papsch	European Commission – DG Energy. Policy and Legal Officer at European Commission.
5	Marion Labatut	EURELECTRIC. Coordinator wholesale and retail market issues.
6	Luis Olmos	University of Comillas. Professor. Representing Market4RES project.

Summary of initial comments from Marion Labatut

- In our view it is a high time to look at the market design.
- PV costs will go further down (a lot)
- Today's price in EU-ETS is 5 €/tonne. RES support will be needed in coming years.
- However, the support schemes should be market-based.
- Exemptions for balancing responsibilities should be removed. Removing priority dispatch is important.
- RES should be allowed to participate in all electricity market types including ancillary services. Believes that capacity markets should value and remunerate capacity firmness and not include extra requirements linked to the flexibility of the assets as suggested by the Market4RES project.
- Negative prices caused by priority dispatch should be avoided.
- It is important to further reduce time between gate closure and the operating hour.
- Efficient congestion management is important.

Summary of initial comments from Jan Papsch

- Interesting results of/in the project.
- Day-ahead markets have improved a lot in recent years.
- Still, there are many things to do. Priority list of actions now is:
    - Remove distortions and interventions in electricity markets
    - Enhance flexibility of markets
    - Support schemes should have as little impact on markets as possible
- There will be capacity markets in Europe in coming years

- However, a detailed assessment of them is needed. They could go away eventually because their need is based on imperfections.

Summary of initial comments from Benedikt Günter

- Many points have already been mentioned by Marion and Jan.
- Regarding capacity remuneration mechanisms vs. energy only market: In the future we will need more flexibility. This flexibility should be provided by markets' prices rather than specific market designs / new incentives.
- The need for more flexibility is not very apparent in markets now.
- Focus should be on removing barriers for the provision of different types of flexibility, rather than new market designs. We do not need capacity markets.
- Intraday markets will be central market place for trading flexibility, together with Day-ahead.
- Feed-in premium is a better support scheme for RES than feed-in tariff.

Summary of initial comments from Suzanne Nies

- Market4RES is an important project.
- RES should be allowed to participate in all markets.
- Agree with the importance of gate closure. The gate close of intra-day markets are already regulated in the CACM Network Code. Markets should not close more than 1 hour before the actual operation.
- New market designs should be tested and evaluated before full implementation. It is important not to over-push implementation of new designs.
- The balancing network code NC EB will be adopted before the end of this year. However, "the devil is in the implementation".
- Improving forecasts is important
- Getting distributed generation into the market is an important issue. A new active customer paradigm is evolving, with DSO-involvement.
- The term "renewables" will be old jargon in some years, as the diversification of RES technologies will become even more apparent, and that PV in particular will be seen as something else, being closer to an app than to a power plant.

Summary of initial comments from Iván Pineda

- Market exposure for RES must be conditional on level playing field.
- In principle, the use of tenders can give cost-efficiency.
- However, the use of them should be tested before full implementation. It is also important not to rush the use of tenders for immature technologies. Let's use the same approach as Network Codes.
- In many markets there is a balancing responsibility for RES even without well-functioning intra-day markets.
- Do not forget the background for implementation of priority dispatch.
- Priority dispatch should be kept where congestions exist. We can look at this as a security mechanism.
- The focus on occurrences of negative prices is irrelevant. This happens in less than 1% of a year.

Summary of initial comments from Luis Olmos

- It is a need to fit markets for the needs in the future. There are no perfect solutions. Technologies will not come automatically. Some market-mechanisms are needed for the provision of RES and flexibility.
- Those market-mechanisms should not be considered as subsidies, but rather a way to make sure that markets provide the services we need from them.
- Capacity markets are needed to avoid too much price variation in the future with higher RES shares.

Open discussion

- Wind Europe: Over time, the German approach will lead to a very efficient electricity market. The question is what is the cost of doing this now.
- Suzanne Nies: There will be no RES-support during hours, when there is no need for it's generation – no way!
- Jan Papsch: There have been discussions about whether capacity markets are legal under current regulation or not. The answer to this is that they can be legal. However, as a start, markets should solve this.
- Marion Labatut: Demand side flexibility will be needed, and it will be incentivized by higher price variation in the future. We need to be able to offer dynamic prices- We will see more Smart Meters etc in the system. The need for this will be particularly high if there is no capacity markets.
- Question from audience: Are negative prices bad?
    - Answer by Jan Papsch: The goal of the system is reducing CO_2 emissions and security of supply, and RES support contributes at least to the former. The rest is instrumental: systems should be set up to ensure cost-efficiency. Negative prices are not necessarily bad, but incentivizing generation at times of negative prices is bad.
- Jan Papsch: Regarding high prices, they may not be realized in the end. The important issue is to remove barriers to allow flexible technologies to enter the market.
- Marion Labatut: Yes, let those high prices happened without accusing players for misuse of market power. Let's do this in a proper way.
- Ivan Pineda: If you have inflexible generation it will be always opportunity costs for up- and down regulation. Negative prices are going to be a part of the future.
- Comment from the audience (Daniel Fraile, Wind Europe): Well functioning balancing markets with RES participation should be a precondition for cutting priority dispatch.
- Jan Papsch: This must be worked on. Agree that one have to meet goals for RES participation.
- Benedikt Günter: One have to keep in mind that balancing markets are small. One should not exaggerate their importance for income.
- Suzanne Nies: It is time to be impatient with regard to changing the RES support schemes. Forget priority dispatch.
- Luis Olmos: Negative prices is not a problem in itself. It is the incentives to produce at times of negative prices that are problematic.
- Luis Olmos: Markets for flexibility should be closer to real time to allow RES participation. However, to procurement should be some time before real time because of the need for planning for some technologies.
- Jan Papsch: RES producers do not get rich by bidding in balancing markets. The important issue is high distortion costs because of RES incentives.

- Iván Pineda: The importance of RES being able to participate in balancing markets is more about risks for RES. If risks are reduced, then capital costs are reduced too.

6.2 Expert workshop

Venue, date and agenda

This event was organized 19th May 2016 in Brussels. The full tile of the event was: "How to pave the road into the renewable future: Electricity market analyses and policy implications for 2020-2030". It was a combined event for WP5 and WP6 in the Market4RES project. The agenda for the event is shown in Figure 23.

08:30 – 09:00	Welcome coffee and registration
9:00 – 09:10	Introduction *Ove Wolfgang, Research Scientist, SINTEF Energy Research, Norway*
Post 2020 evolution of the Target Model: Quantitative assessments	
9:10 – 09:55	Power system evolution in light of investor risk considerations, renewables support, CO2 taxation and demand response incentives *Aurèle Fontaine, RTE, France*
09:55 – 10:40	Short term (operational) impacts of the timing of markets and RES support schemes *Fernando Báñez, Research Fellow, University of Comillas, Spain*
10:40 – 11:10	Coffee break
11:10 – 11:35	Market performance: Energy only, capacity remuneration and RES support schemes *Peter Ahcin, Research Scientist, SINTEF Energy Research, Norway*
11:35 – 12:15	Assessment of future balancing market mechanisms *Bettina Burgholzer, University of Vienna, Energy Economics Group, Austria*
12:15 – 12:45	*Q&A session – open discussion*

12:45 – 14:00	Lunch
RES Penetration under the current Target Model	
14:00 – 14:45	Impacts of demand flexibility with different RES shares *Sophie Dourlens-Quaranta, Director – Sustainable Electricity, Technofi, France*
14:45 – 15:15	RES penetration: Roadmap for the transition from Feed-in-Tariffs to market-based schemes *Daniel Fraile, Senior Grids Analyst, WindEurope*
15:15 – 15:45	Market4RES project in concluding stages. Preliminary findings and policy recommendations in view of upcoming public consultation *Ove Wolfgang, Research Scientist, SINTEF Energy Research, Norway*
15:45 – 16:15	*Q&A session – open discussion*
16:15	Wrap-up and end of the event

Figure 23. *Agenda for combined event for WP5 (stakeholder event, before lunch) and WP6 (expert workshop, after lunch).*

Comments and questions to presentations

Presentations are available here: http://market4res.eu/events/past-events/. Below we mention some comments given and questions asked after each of the presentations (for stakeholder event WP6 after lunch).

Comments/questions to Daniel Fraile

- Question: Why do a floating price premium contribute to risk for an investor compared to a feed-in tariff. Answer: If the premium had been calculated hour-by-hour, cf. the system in UK, then floating premium is similar to feed-in tariff. However, when the floating premium is set in beforehand for some years on basis of expected market developments, there is a risk compared to a feed-in tariff.
- Question: For the proposals in Market4RES, do we need a 4th Energy Package in the EU, or can it be implemented as network codes within the 3rd Energy Package. Answer: I think proposals can be implemented within the 3rd Energy Package.
- Question: Why do an auction / tender on basis of €/MWh support give more risk for an investor than a regulated price? The project must be realized only if the support is higher than the needed amount. Answer: Because investors do not know the price in beforehand,

and there is an entry-cost of participation in auctions. This is avoided with a regulated price.

- Question: Is there a volume risk for RES mentioned in case of congestion? Answer: Yes, because of possible curtailment of RES in case of excess supply due to the congestion.

<u>Comments/questions to Ove Wolfgang</u>

- Question: The project is suggesting a gradual move from feed-in premium to something more market-based, before RES support eventually may be unnecessary sometime in the future. Would it not be better to keep the existing effective schemes until support is not needed anymore instead of changing schemes too often? Answer: Even though we point out that gradual changes in market development and the share of renewables affects which schemes is the most suited one, we are not suggestion changing the schemes from year to year. With very large shares of RES it is natural to expose it for variation in market prices. This is how market-economies are organized. Exemptions can be OK when market are not well-functioning or technologies are immature. But not when the technologies are dominating the supply side in the market.
- Question: What would you say is the strongest part of the work in the Market4RES project? Answer: We are not discussing and analysing only one factor, but the totality of the market design. This is possibly the strongest side of our work. We also have a good analysis of RES support schemes.

7 WRITTEN CONSULTATION PROCESS

The invitation to contribute to the written consultation process were sent to Market4RES contact list plus targeted additional stakeholders, and promoted through newsletters and web-site for project.

7.1 Invitation letter

Market4RES project

The "Market4RES - Post 2020 framework in a liberalised electricity market with large share of Renewable Energy Sources" project focuses on electricity market design to support a more efficient integration of renewable electricity (RES-E) into the pan-European electricity system, in line with the 2020 objectives and their follow-up towards the forthcoming 2030 targets. The project is co-funded by the Intelligent Energy Europe (IEE) programme of the European Union and coordinated by SINTEF Energy Research (Norway). The main objective of the project is to study the potential evolution of the EU Target Model (TM) necessary to secure the European power system decarbonisation with large amounts of renewables. The project started on the 1st of April 2014 and is planned to be finalised by the end of October 2016.

Main Findings in Market4RES

The 'Main Findings' document is a result of joint efforts of all the partners in Market4RES as well as feedback received from two Market4RES Advisory Board meetings, several Expert Workshops and Stakeholder events organised in the course of the project.

Market4RES Written Consultation

The written consultation represents a fundamental step of the project and is intended as an interaction with stakeholders in order to enrich the project conclusions through receiving skilled and relevant input, addressing concerns and considering different views. Parties participating in this written consultation will therefore have an opportunity to contribute to and influence the main conclusions and final recommendations from the project.

The consultation is accessible here. Before filling the form in and in order to ensure an efficient process, we kindly ask the responding parties to:

- Indicate which specific section the comment relates to
- Include a clear rationale for the comment
- Propose an alternative to the commented item, which can be considered by Market4RES project

Privacy

The Market4RES project will consolidate and publish in the form of a summary the comments received, including names or affiliation of the respondents unless the project is specifically asked for not having the identity (-ies) disclosed. Thus, all respondents are asked to clearly indicate in their feedback if their response –or part of it- should be considered as confidential.

Deadline for submission of comments

The comments can be submitted electronically to market4res@sintef.no before **10.06.2016**.

The results of this consultation will be presented and discussed at the next Market4RES event, that will take place in Brussels on the 17th of June 2016. The final project results and policy recommendations will then be presented at the Market4RES Final Event in Brussels in October 2016 (place and time to be confirmed).

The presentations and outcomes of the past events are available at http://market4res.eu/events/past-events/.
Next events and registrations are accessible here: http://market4res.eu/events/future-events/

With my best regards,

Andrei Z. Morch
Coordinator of the Market4RES project

7.2 Consulted document of main findings

Market4RES project: main findings and recommendations

Part I: Introduction

(1) The purpose of this document
Market4RES is a European project (IEE, 2.4 M €, 2014-2016, http://market4res.eu/) dealing with the further development of European electricity markets and RES support schemes pre and post 2020. During the project we have:

- carried out a diagnosis of the roadmap for pan-European market integration (the so-called Target Model), and its implementation status
- identified and characterized the most promising modifications to the design of markets
- quantified impacts of a set of policies and fundamental market developments
- facilitated the dialogue among the relevant stakeholders

With this document we present our main findings and conclusions. It is a draft version since **we intend to improve the final recommendations with your feedback.** Your comments will be discussed during the next project events (http://market4res.eu/events/future-events/).

Part II: Background

(2) Initially, markets were not fit for RES
Traditionally, the RES shares in electricity generation were low in many countries. Thus, the markets were not designed with RES-specific characteristics in mind. Because of their variable output and flexibility to reduce it on short notice, combined with a lack of transparency in operation and curtailment rules, renewables were often the first to be curtailed at times of excess supply in real time operation.

(3) Europe's policy for promoting integration of RES-E technologies has been a success story
Replacing fossil fuel consumption with renewable energy is important for combating global warming, and for reducing dependency of imported energy. With the RES-E directives in 2001 and 2009 targets were set for increasing the share of renewables in energy consumption. Also, renewable generation was given priority dispatch so that the energy produced was guaranteed to reach the market, and not being curtailed. Many countries provided a guaranteed income per MWh produced through feed-in tariffs. As a result of increased income and reduced risk, there has been considerable investments

Part III: Support mechanisms for RES

(4) This is not the time to stop supporting RES

A more ambitious environmental policy is needed to limit global warming and avoid considerable future mitigation costs. Such a policy will involve reducing the number of emission permits or similar measures to increase the cost of emitting greenhouse gases. This will then lead to higher costs for fossil-fuel power generation, and higher electricity prices. Then the share of renewable power generation will increase even without any support mechanisms. However, at today's prices for emission permits, support for RES is still needed not to jeopardize the ongoing transition towards a future sustainable energy system in Europe.

(5) However, it is time to reconsider the design of support schemes

In the early phases of liberalisation, implemented policy instruments for supporting RES were fit for the promotion of RES-technologies. However, due to the large penetration levels that have been achieved, the volatility of electricity prices has increased, firm capacities having large difficulties to recover its investment costs, and considerable financial support is being provided to RES generation. Hence, the design of RES support schemes must be considered carefully again.

(6) RES support schemes designs

The best-suited support scheme for RES generation depends on market penetration/maturity, and on whether electricity markets are set up to fit for RES generation characteristics. It is also important to take into account risks for investors. A higher risk lead to higher costs and need for higher support levels for capital-intensive technologies such as wind and solar power. To reduce the total costs for the system, support schemes should be designed to not interfere with short-term price signals to RES generation.

Supported volume

The supported volume for a given RES producer is determined by the amount that can be produced, account taken for availability of capacity as well as weather conditions. Thus, it should not be based on the actual generation. For wind and solar power this means that a voluntary reduction in output because of negative prices or provision of negative balancing energy in real time, will not have any impact on the volume supported. In this way interference with short-term price signals is avoided.

Floating price premium

We recommend a floating price premium. In this system, a price premium (€/MWh) is provided on the top of electricity prices for the supported volume. The level of the premium is adjusted e.g. every 1-3 years so that the total price for RES generation (i.e. electricity price plus price premium) is in accordance with the result of a preceding tender process. This system gives lower risk for investors than a fixed price premium on top of electricity prices.

Tenders

The level of support should be the outcome of a competitive market process (tender). In the tender, investors bid the total price (electricity price plus support per MWh) they need. Technology-specific tenders should be allowed, and small players should be exempted because of the transaction costs associated with a tendering process (they could get an administratively set support instead, or in accordance with the outcome of the tendering process). However, pre-qualification criteria should be project-related rather than bidder-specific to allow small players' participation.

Part IV: Making markets fit for RES

(7) Keep up the momentum in the harmonization of markets for electric energy

Considerable achievements have been made in recent years in integrating day-ahead markets in Europe. This has been part of a process led by the Commission with important roles for European associations for regulators (ACER) and system operators (ENTSO-E) in developing regulations to be adopted by the EU. To facilitate further integration of renewables and reduce costs for society, the focus should be put on implementing integrated and well-functioning intra-day markets with gate-closure times that are close to real time, and with access to cross-border transmission capacity. A combination of continuous trading and some organized intra-day auctions to increase liquidity is recommended, also by considering reservation of cross-border transmission capacity in several market timeframes.

(8) RES-friendly environment for electricity balancing is needed

The network code for electricity balancing has good intentions with respect to RES. However, the concrete regulations to implement are, to a large extent, left open to be specified later. Netting of imbalances is a central element in making markets fit for RES integration. Markets for ancillary services should be open to RES generation and demand resources. Balancing products should be specified with this in mind to allow utilization of RES-based resources when they can provide such services cost-efficiently.

Part V: Other design elements of electricity markets

(9) A careful approach regarding capacity markets

Several countries have already implemented capacity markets; some are in the process of implementing them, while others are debating introducing them. Such markets can improve security of supply by providing incentives to build new generation units, maintain existing units, and develop demand side flexibility. However, over-investment in firm capacity in separate national markets should be avoided, and it should be mandatory to allow the use of cross-border interconnection capacity to contract firm capacity in third systems. In addition, if capacity markets are implemented, we recommend that they have the following specific characteristics:

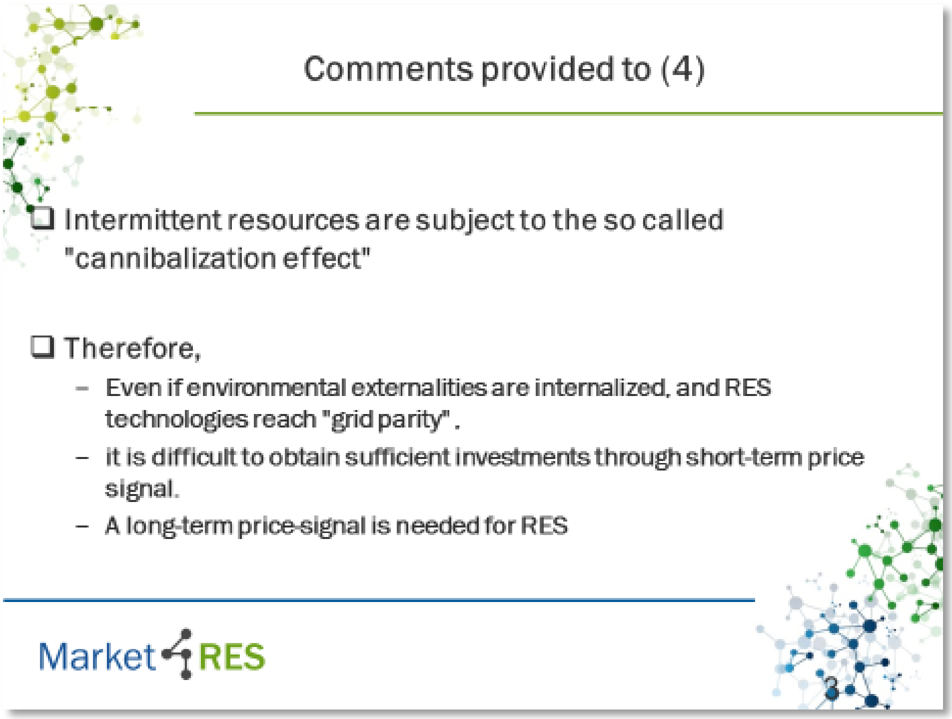
- the product should be a financial option with a high strike price to avoid interference with short term markets; it should have a firmness requirement associated
- a penalty for non-delivery should be applied
- demand for this product should be in the form of a price-quantity curve, i.e. the final price paid for it should affect the quantity contracted (to reduce strategic bidding).

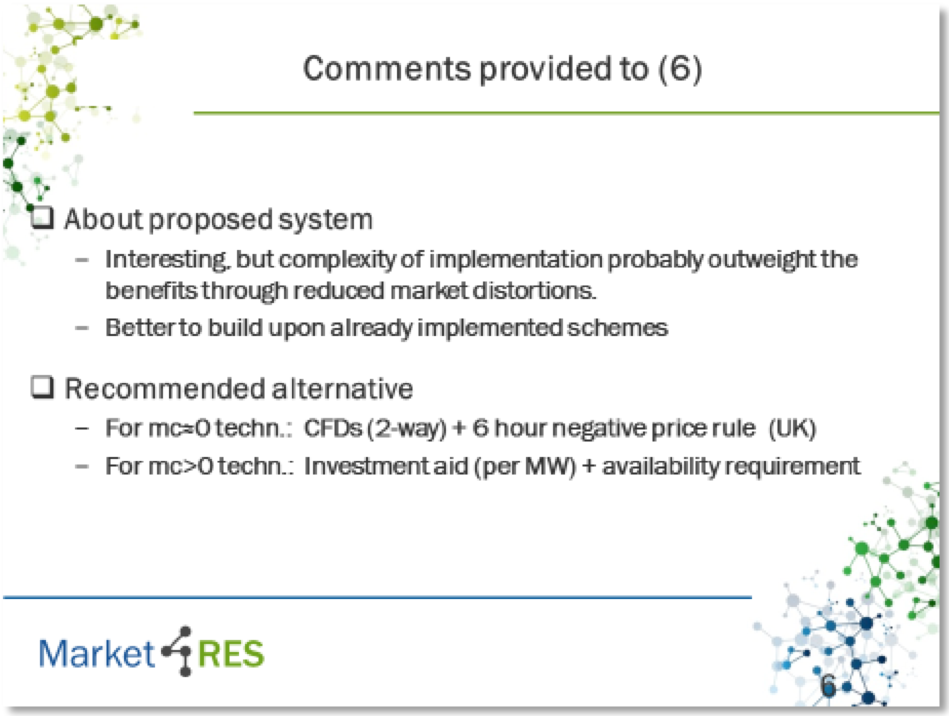
(10) Consumers need to be exposed to prices

Variations in the output from renewable generation can at least partly be balanced by adapting electricity consumption. Higher shares of RES generation result in an increase in the value of demand response, both in day-ahead energy markets and in providing real-time flexibility. Exposing consumers to prices should activate some of them, and improve the efficiency of markets. To achieve this, the automatic metering of electricity consumption needs to be implemented. In order to utilize demand flexibility for real-time balancing, more advanced control of this demand is needed. We recommend further focusing on metering of electricity consumption, and exposing consumers to prices. Cost-benefit assessments of demand-side management schemes need to take into account the long-term learning effects in markets, for technology, and for the utilization of price variability.

7.3 Response from written consultation

We got three responses in the written consultation. However, each of them consisted of several comments. Main comments are summarized in the Power Point slides shown below. Numbers refer to numbering in Section 5.2.





Comments provided to (6)

- Unclear about participation of small players in tenders (extempted vs. pre-qualification)
- Have the project addressed the following?
  - The need for harmonization of RES support schemes in the EU
  - The need to continue policy of giving priority dispatch for renewables
  - If maybe some RES technologies do not need support in the future

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Comments provided to (7)

- Continuous trading close to real time is the most efficient solution
- Intraday auctions could be difficult to implement because it would require to assign a value to cross border capacity
- Reserve capacity for intraday with use-it-or-sell-it would be difficult to implement near real time (and reduce utilization)

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(Market4RES, Deliverable 6.4, Final project deliverable.)

Comments provided to (9)

- We are suggesting a system with cost recovery through
  - Short term price signal / wholesale market prices
  - Capacity payment (only for) firm capacity to solve security of supply
  - Support scheme for RES
- This gives an unfair perception of higher prices for renewables compared to fossil fuel generation
- RES
  - Is not firm
  - But with high shares, it contributes to security of supply and firmness

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Other comments

- Document is lacking a discussion
  - On grid tariffs
  - How to avoid inefficient indirect incentives
- We should be clear about which topics are addressed / not addressed in the project (gaps)
- Conclusions should be limited to addressed topics
- It would be helpful if we could relate conclusions to corresponding deliverables that provide the basis for them

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(Market4RES, Deliverable 6.4, Final project deliverable.)

8 REFERENCES

[1] Olmos L et al. (2015), "Implementation Status and Market Focused Diagnosis of the Target Model", report D2.2 in Market4RES project.

[2] Auer H, and Burgholzer B (2015), "Opportunities, Challenges and Risks for RES-E Deployment in a fully Integrated European Electricity Market", report D2.1 in Market4RES project.

[3] Dourlens-Quaranta S *et al.* (2016), "Roadmap for RES penetration under the current Target Model high-level principles (2014-2020). Part 1: recommendations about RES support schemes and demand flexibility", report D6.1.1 in Market4RES project.

[4] Dourlens-Quaranta S *et al.* (2016), "Roadmap for RES penetration under the current Target Model high-level principles (2014-2020). Part 2: recommendations about other short term market topics ", report D6.1.2 in Market4RES project.

[5] Fraile D *et al.* (2016), "Guidelines for implementation of new market designs in Europe with high shares of RES-E penetration (post-2020)", report D6.2 in Market4RES project.

[6] Fontaine A *et al.* (2016), "Recommendations for implementation of long term markets (energy and capacity) 2020 - 2050", report D6.3 in Market4RES project.

[7] Flament A et al. (2015), "Report on the empirical case study analyses emphasising the challenges in the very short-term, short-term and long-term electricity markets in Europe with high shares of RES-E penetration", report D2.3 in Market4RES project.

[8] Olmos L *et al.* (2015), "Developments affecting the design of short-term markets", report D3.2 in Market4RES project.

[9] Burgholzer *et al.* (2016), "Report on the quantitative evaluation of policies for post 2020 RES-E targets", report D5.2 in Market4RES project.

[10] ACER (2015). Market monitoring report 2014

[11] Burgholzer *et al.* (2016), "Description of planned analyses, scenarios and models for the post 2020 time horizon", report D5.1 in Market4RES project.

[12] ACER (2014), Opinion of the Agency for the Cooperation of Energy Regulators no 07/2014 on ENTSO-E Network Code on Electricity Balancing. Available from: http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Recommendations/ACER%20Recommendation%2003-2015.pdf.

[13] ENTSO-E (2014), Final draft of the Network Code on Electricity Balancing. Available from: https://www.entsoe.eu/Documents/Network%20codes%20documents/NC%20EB/140806_NCEB_Resubmission_to_ACER_v.03.PDF

[14] Dourlens-Quaranta S and Pagano T (2015), "Specifications of the most adequate options for flexibility markets and RES support schemes to be studied in a cross-border context, report D4.1 in Market4RES project.

[15] Fontaine A *et al.* (2015), "Developments affecting the design of long-term markets", report D3.1 in Market4RES project.

[16] Dourlens-Quaranta S *et al.* (2016), "Quantification of the expected impacts coming from evolutions of RES support schemes and demand flexibility ", report D4.3 in Market4RES project.

[17] European Commission (2014), "Communication from the Commission - Guidelines on State aid for environmental protection and energy 2014-2020", 2014/C 200/01.

[18] European Commission (2014), "Energy and Environmental State aid Guidelines – Frequently asked questions", European Commission, April 2014.

[19] CEER (2016), "Key support elements of RES in Europe: moving towards market integration", report January 2016.

[20] European Commission (2013), "Generation adequacy in the internal electricity market - guidance on public interventions. Commission staff working document, accompanying the Communication from the Commission on Delivering the internal electricity market and making the most of public intervention", Energy and Environmental State aid Guidelines – Frequently asked questions", European Commission, Released on November 2013.

[21] European Commission (2015), "Commission decision of 29.4.2015 initiating an inquiry on capacity mechanisms in the electricity sector pursuant to Article 20a of Council Regulation (EC) No 659/1999 of 22 March 1999", April 29, 2015.