Post-2020 framework for a liberalised electricity market with a large share of renewable energy sources

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Market4RES

Post-2020 framework for a liberalised electricity market with a large share of renewable energy sources

A study on the potential evolution of the Target Model for the integration of EU markets that will enable a sustainable, functioning and secure power system with large amounts of renewables

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Market4RES

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SYMBOLS AND ABBREVIATIONS

ACER	Agency for the Cooperation of Energy Regulators
aFRR	Automatic Frequency Restoration Reserve
ATC	Available Transmission Capacity
BRP	Balance Responsible Parties
BSP	Balancing Services Provider
CAPEX	Capital Expenditure
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
DSM	Demand Side Management
DSO	Distribution System Operator
DSR	Demand Side Response
ENTSO-E	European Network of Transmission System Operators for Electricity
ETS	Emission Trading Scheme
EU	European Union
FIT	Feed-In Tariff
ID GCT	Intraday Gate Closure Time
LCOE	Levelised Cost of Energy
KPI	Key Performance Indicator
NC	Network Code
NC CACM	Network Code on Capacity Allocation and Congestion Management
NC EB	Network Code on Electricity Balancing
OCGT	Open Cycle Gas Turbine
OPEX	Operational Expenditure
PV	Photovoltaic
RES	Renewable Energy Sources
RES-E	Electricity from Renewable Energy Sources
SO	System Operator
TS	Transmission System
TSO	Transmission System Operator
VAR-RES	Variable renewable energy generation

FOREWORD FROM THE COORDINATOR

Setting the 2020 climate and energy targets in 2007 was an important milestone, indicating a paradigm shift for the European power industry, which used to be one of the most conservative sectors. Massive efforts were made to promote an accelerated integration of Renewable Energy Sources (RES) in Europe. The support schemes for RES technologies have been a success story, resulting in considerable volumes of RES added to the generation mix.

The market interventions on this scale have however led to some adverse effects of the financial subsidies and significant penetration of electricity from renewable energy sources (RES-E). This highlights the need to modify the existing European electricity market design in order to guarantee sustainable framework conditions in the long-term, both for the market-compatible integration of further RES-E technologies and for the maintenance of adequate levels of firm electricity generation capacity.

Finalising Market4RES today, we conclude that our expectations and hypothesis made some years ago during the preparation phase of the project proved to be correct and the selected research approach was adequate to the challenge.

An effective market design should provide sufficient investment signals to accommodate a high share of renewables while achieving the required level of security of supply. Which market design can be effective in achieving these two European Union energy policy goals? More specifically, should renewable sources continue to be supported, and if so, which mechanisms should be applied? Will capacity remuneration mechanisms be a necessity in the future? How should balancing markets be adjusted for higher shares of renewables? These are some of the questions we tried to answer. The research, which was conducted by the partners throughout the course of the project, has truly demonstrated the complexity of the issue and again showed that there are no easy solutions to this challenge.

After two and a half challenging years, we are happy to be able to share our results and conclusions. We hope that the Market4RES recommendations will contribute to the understanding of these complex issues and inspire European stakeholders and policymakers in shaping the future European power industry.

Andrei Morch
SINTEF Energy Research

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1. 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 periods (day-ahead, intra-day, balancing and forward markets). This harmonization brings opportunities and challenges to make high 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, roughly a third of 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. These instruments were designed to meet the intended policy objectives, in particular reducing CO_2 emissions from fossil-fuel generation.

However, a current challenge is that power producers are finding it increasingly difficult to recover their investment costs without additional support instruments due to low wholesale electricity prices. This has raised concerns about the development of security of supply. Low prices are caused by several factors, including an increasing penetration rate of renewable generation with low marginal costs, and low CO_2 prices. Another challenge is that electricity prices have become more volatile, and some existing support schemes incentivise generation even at times when electricity prices are negative.

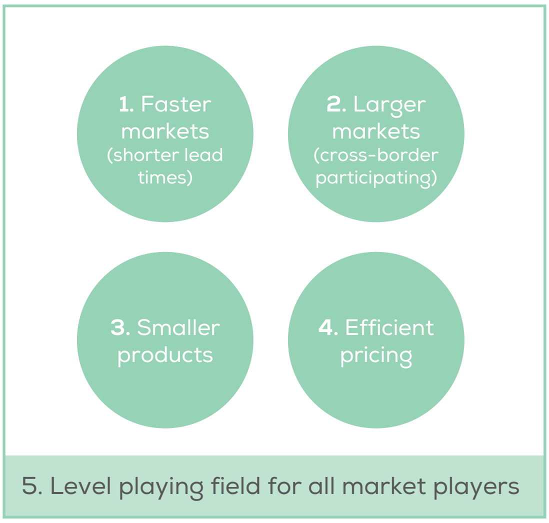
A European discussion has emerged on how to improve electricity market design further. A key point in these discussions is how to reform support instruments for renewables in order to reduce interference with short-term market signals and limit public support to new generation assets.

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 the key design features which are critical for the successful participation and integration of renewable electricity producers in a fully liberalised and competitive European market across all periods (day-ahead, intraday and balancing). The project arrived to the following conclusions (which also are summarized in Figure 1).

Faster markets: the timing of markets should evolve to reflect 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).

FIGURE 1
Key market features for successful integration of RES in all market timeframes



Source: WindEurope

Larger markets: in order to couple cross-border markets at all periods (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 existing infrastructure.

Smaller products: smaller periods 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 liquidity in the markets and the cost of implementation.

Efficient pricing: the prices should be transparent and should not be artificially kept 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 or in flexibility.

Level playing field: the design and rules should establish a level playing field for all market players. This includes market access, increased transparency of operation procedures, and a polluter pays 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 fair market access. Having an intraday market with a short gate closure time and a sufficient level of liquidity is fundamental.

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 for CO_2 and thus ensure polluters pay for the full costs of generating electricity with the technology and fuel of their choice. Lastly, continued support to conventional technologies needs to be addressed in parallel with reform of market design rules and the revision of State Aid Guidelines for Environment and Energy.

DAY-AHEAD MARKET

Locational pricing: Market4RES recommends either a zonal (one price per TSO control area) or a hybrid zonal (several/some price areas per TSO control area) pricing scheme.

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 establishing a well-functioning intraday market rather than pushing the day-ahead market closer to real time.

INTRADAY MARKET

Market period: after a comparative evaluation of different alternatives, the project concluded that a combination of continuous trading with discrete auctions (a hybrid solution) could be the best design variant.

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

Increasing liquidity: Market4RES recommends increasing liquidity in the market by introducing intraday auctions. Obligatory unit bidding also seems to play a significant role in increasing liquidity by encouraging 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 liquidity by attracting market 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 in the German market. This would allow participants to refine their schedules more often, thereby limiting deviation from their real production compared to an hourly basis.

BALANCING MARKET

With respect to market designs for balancing markets, the Market4RES project recommends 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 increased 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 period;
- Bids activated for purposes other than balancing should not determine imbalance volumes and/or prices.

DEMAND PARTICIPATION

Demand-response should be one of the central topics 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 shows 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 has been carried out in the project. It is concluded that neither of the options should be strictly preferred.Both should be allowed if capacity markets exist to make room for all types of demand-response products and market arrangements.

RES SUPPORT SCHEMES

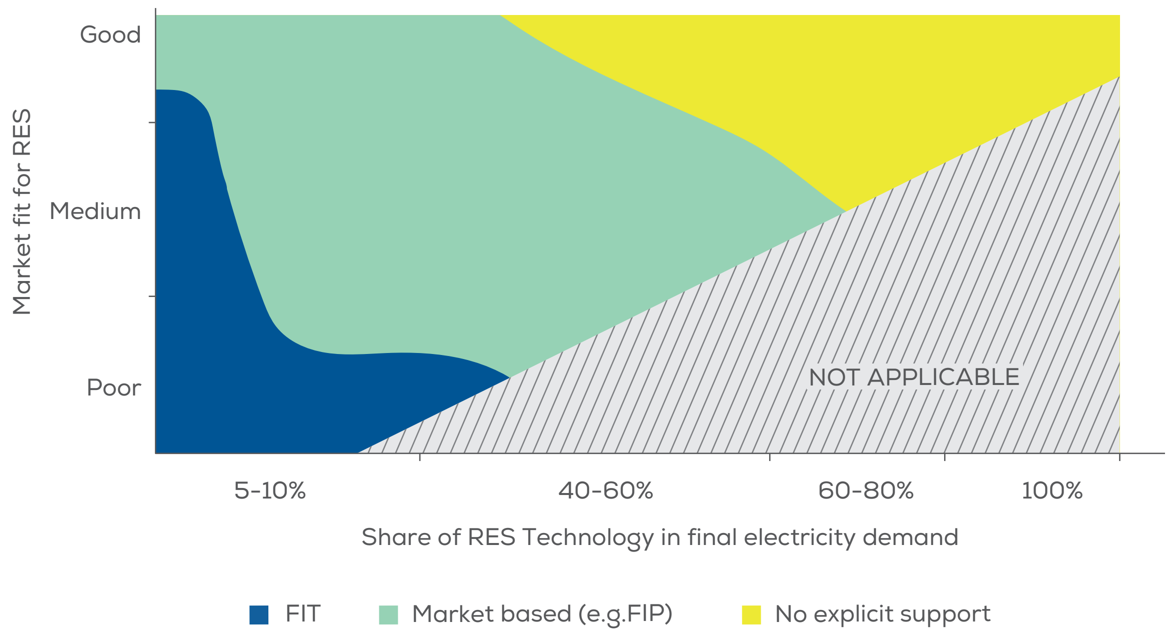
Assessment: Market4RES project partners have assessed RES support schemes using the following criteria: efficiency, effectiveness, robustness, implementability and risks for investors. The assessment is carried out both for short-term impacts on markets, and for the long-term impacts of schemes. Market4RES 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 control support payments. The following schemes performed well in the assessments overall: 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, nor support based solely on the provision of grid support services.

Discussion: clean capacity auctions performed very well in the assessment, both with respect to minimise interference with short-term market signal and its long-term impacts. However, a floating version of feed-in premiums reduces risk for investors with respect to future income (bringing down financing costs) and coincides better with the new State Aid Guidelines for Environment and Energy.

Recommendations: the Market4RES project recommends a floating feed-in premium. The total price is set through a tender/auction. The premium on top of the electricity price is the difference between the strike price (result of the tender) and a reference market price (expected average electricity price over a period of time). This reference price might be regularly adjusted (e.g. every 2-3 years) to shield 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).

To ensure an efficient short-term price signal, one of the following should be implemented: a) the supported volume is not reduced in cases when renewable generation units intentionally reduce output production to support the system operation (e.g. to provide downwards regulation

FIGURE 2
Market schemes depending on RES penetration & market conditions



Source: WindEurope

services), 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. Nevertheless, 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 with further technology development, RES production could eventually be financed without explicit support schemes.

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

CAPACITY MARKETS

A fully functional energy market is undoubtedly the desired scenario when workable. The Market4RES project does 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-adequacy assessment concludes that a capacity remuneration mechanism is required.

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

Procurement: it is recommended that a price-quantity curve is used to set the procured 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) were congested. Several options to include 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 or 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 of implementing the explicit participation in interconnections only, which is the solution selected in the United Kingdom and accepted by the Commission.


Photo: Thinkstock

2.

INTRODUCTION

2.1 MARKET4RES AND THE 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. 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, even before the development of a TM. This process has been important for the actual implementation of EU legislation. In particular, great 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 by seven Power Exchanges. The share of Europe's day-ahead markets connected by this algorithm has grown since 2014.

An enormous effort has been made to promote the accelerated integration of RES-E generation technologies in 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. Subsequently, this has led to a situation in which conventional electricity generation technologies have difficulties covering their costs, while financial support instruments (subsidies) further stimulate investments in wind and PV generation. This has led to increasing profitability risks for many of these conventional generation technologies. Some of them already have been – or are expected to be – mothballed. Furthermore, although the importance of promoting Demand Side Management implementation in the electricity market has been discussed for a long time, until now there were no significant, 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 necessary, how should they be designed?
- How to foster European electricity market integration with high shares of RES-E generation?

2.2 MARKET4RES STORYLINE

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 also 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 in the market by supporting the implementation of the 2020 targets and their follow-up towards reaching the 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 research priorities.

Market4RES 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 TU Wien in Austria. This defined the status of 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 for 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 (detailed below).

- Quantitative assessment of markets (pre-2020): Assuming the current generation fleet as an input and the 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;

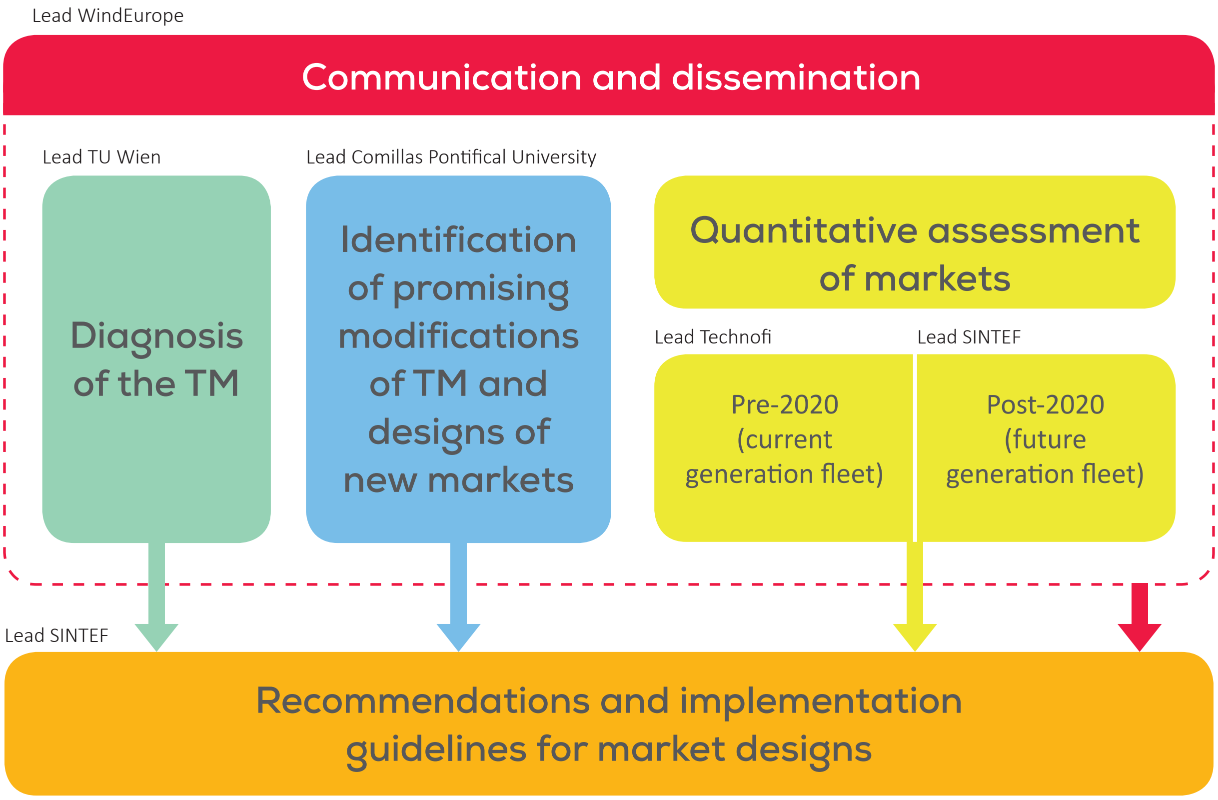
- Quantitative assessment of markets (post-2020) - Assuming the future generation fleet (beyond 2020) resulting from current market designs (and taking into account possible future changes in market design beyond the existing TM), the focus was on developing necessary additions or complementary instruments to the current design that 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 Comillas Pontifical University;
- EDisOn by TU Wien;
- Micado by RTE.

The results from previous work packages were analysed and gathered in a set of conclusions and recommendations , further developed with the support of the industry representatives in the consortium. After a series of consultations with relevant stakeholders (please see the section below), these results were validated and merged 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 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.

FIGURE 3
Set of actions performed in Market4RES



Source: SINTEF Energy Research

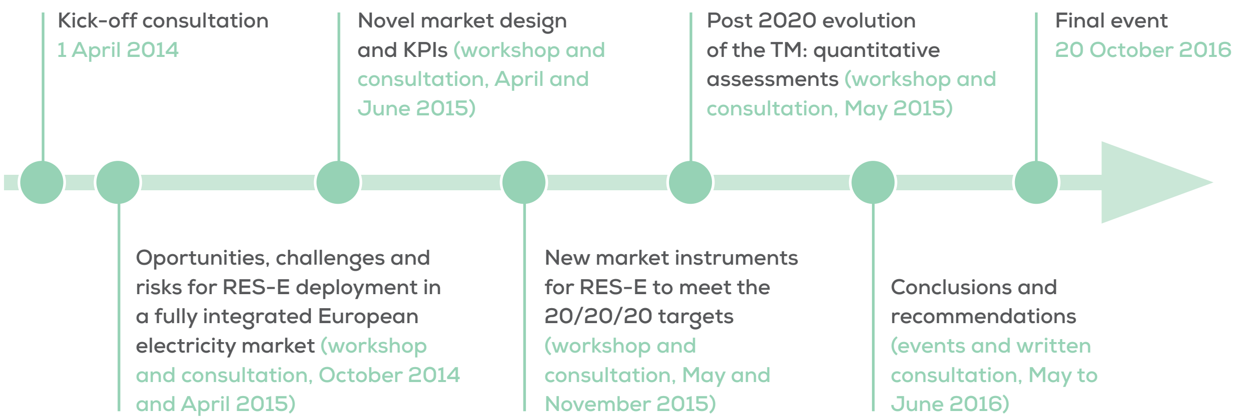
2.3 DIALOGUE WITH THE STAKEHOLDERS

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. A series of interactive, open-to-all and freely accessible events have been organised with stakeholders since the beginning of the project, with the aim of discussing 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 and 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 deals daily 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 4
Project timeline and milestones



3. MAIN FINDINGS, OVERALL RESULTS AND STUDIES

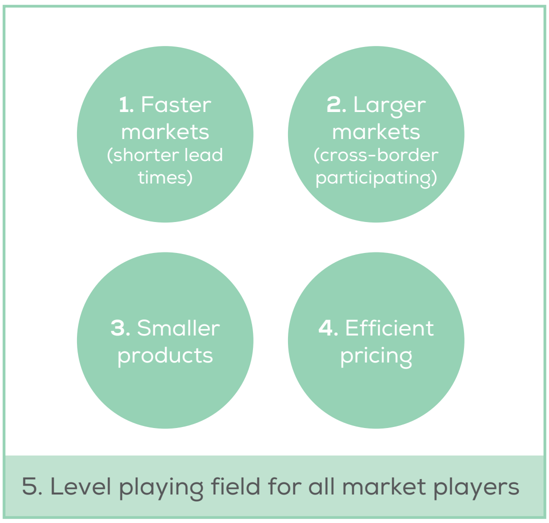
3.1 MAKING MARKETS FIT FOR RES

3.1.1 KEY MARKET FEATURES FOR SUCCESSFUL INTEGRATION OF RES

The following section summarizes 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 over all periods (day-ahead, intraday and balancing). These features are organized in five areas/aspects, as presented in Figure 5.

Afterwards, in subsequent sections, we specifically address each of the market periods. Much of the structure and content is based on Market4RES report D6.2 [1]. However, the scope is widened slightly from how markets can be developed to fit better for RES producers to include other system needs for facilitating high-RES shares.

FIGURE 5
Key market features for successful integration of RES in all market timeframes



Source: WindEurope

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 scheduled 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 6 shows the sequence of various markets, from forward markets that can set energy bids in the long-term, to those close to real time, such as the balancing market. It can be observed that 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).

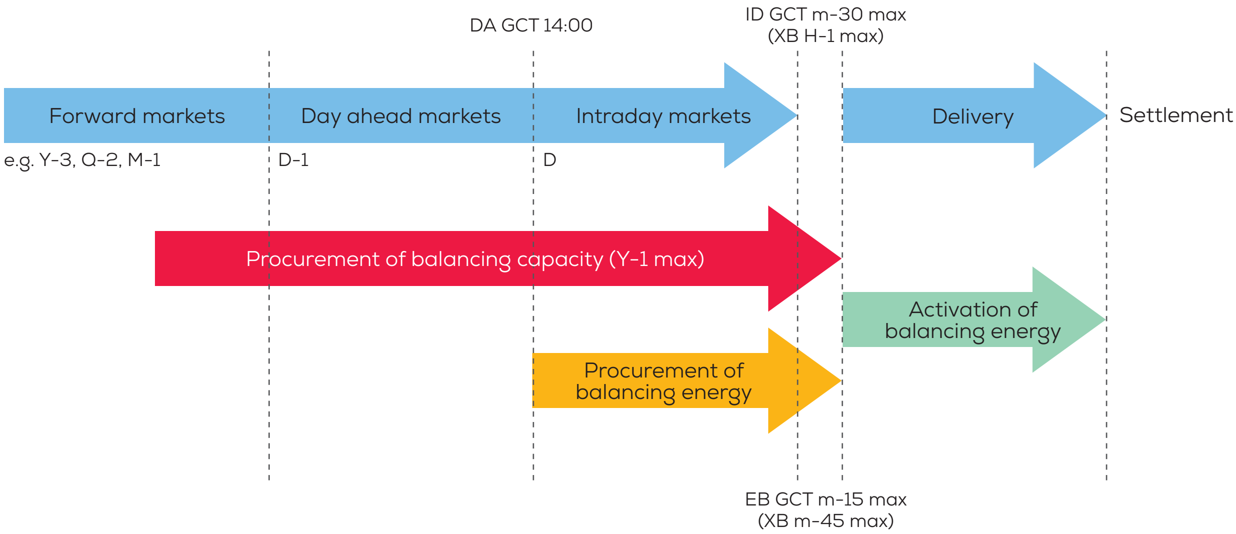
LARGER MARKETS

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 periods (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, or ATC, method). This frequently causes TSOs to 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 would thus 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 use of existing infrastructure.

Furthermore, markets are made larger by increasing the interconnection capacity between different areas and by allowing cross-border competition at different times.

FIGURE 6
Sequence of markets and interface between timeframes



Source: WindEurope

SMALLER PRODUCTS

Smaller periods for the products are positive for the participation of variable renewable generation units. This is very much related to forecasting and the predictability of renewable generation assets and their potential to adjust to demand ramp-up and ramp-down periods. The use of shorter-period 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 with specific products have a key impact on the participation of renewables, especially for balancing markets.

The introduction of 15-minute products in the German intraday market in 2011 has been hailed as a success for handling the variability of renewable energy when compared to traditional hourly-based contracts. Furthermore, although product volumes remain relatively low, they most likely will become higher as the share of renewables increases.

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 from revealing scarcity artificially. 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 or in flexibility.

Prices in the wholesale market should also relate solely to the marginal costs of producing electricity. The entire rationale for 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) should therefore be considered the common norm across all periods, 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 the exit of non-competitive generators.

LEVEL PLAYING FIELD

Above all, for renewable energies to contribute fully 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 pays 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] aims 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. However, balancing responsibilities for all parties should be accompanied by the existence of markets that allow trading close to real time (especially an 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 of operational procedures leading to the 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 for 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 the national and European levels. Historically, technologies such as nuclear and coal have received direct support considerably higher than the support provided today to various renewable energy sources. Indirectly, today nuclear energy still 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 parallel to the reform of market design rules and the revision of state-aid guidelines for environment and energy.

3.1.2 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 the granularity of network representation too much (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 [2]. A right balance therefore needs to be found in terms of the 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 or 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 [19], a review process for 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 multiple criteria of efficiency, price signals, liquidity and security of supply. The first results of the review are expected by the end of 2016, but work will continue in 2017.

ADMINISTRATIVE RELIABILITY PRICING

With higher shares of varying renewable generation, there is a need for 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 functioning well, 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 the 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. In 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 forecast at shorter time scales (for example, there is around a 10% error margin 24 hours ahead of delivery for wind).

Delaying the day-ahead closure time could therefore result in a decrease in errors made by RES operators when forecasting their available RES electricity production, as well as a reduction of error in forecasting demand. More adequate forecasts should lead to less rescheduling (and corresponding transaction costs), and overall allow the system to decrease the size of imbalances they must address in subsequent markets substantially (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 systems, there might be no significant added value to bringing it too close to real time. The analyses carried out in Market4RES report D5.2 [3] show that bringing the day-ahead market closer to real time by 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 be automatically out of the market. Thus, to tackle various forecasting 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.

3.1.3 INTRA-DAY MARKET

MARKET PERIOD

The intra-day period 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 a 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, the intraday platform becomes available for trading the day before delivery, at 14:00, and closes 5 minutes before actual delivery;
- **Intraday discrete auctions:** i.e. one or several auctions are called at a specific predefined time after the outcome from the day-ahead market has been published. For instance, EPEX SPOT launched on the German intraday market[3] a complementary 15-minute call auction at 15:00, allowing market participants to trade the 96 quarters for delivery the next day simultaneously. Then, the 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 (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 wide international experience both at the national and regional levels 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 in decisions on when to schedule discrete sessions for 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 largely is already implemented in Europe. With intraday auctions, it will also be possible to apply the implicit pricing of transmission capacity in the intraday period, which should improve efficiency.

There is potential to combine both approaches in 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 therefore best overall outcomes with regard to the assessment done by the Market4RES consortium Market4RES report D3.2 [2].

2. The Balancing process is generally financed through imbalance settlement. In some cases, its cost is also shared by all energy consumers through network charges.
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.

ENLARGING THE GEOGRAPHICAL SCOPE

When coupling cross-border intraday markets, regional auctions need to be introduced on a large scale, and this would require more regional coordination. Some homogenization is needed in the decisions on when to schedule discrete sessions of the markets and 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 the liquidity level in intraday markets, according to ACER [4]. For example, in the Netherlands, the national ID GCT is five minutes ahead of delivery, while different GCTs are in place on their borders (and 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 is 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 borders 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 unlock market parties' participation in this period. 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 the latter incentivises renewable generators to adjust their position in this period 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 [4] 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 period (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 the day-ahead period, most intraday markets trade standard hourly products. However, the introduction of 15-min contracts on the German intraday market in 2011 has fostered market participants' interest because it allows them to refine their schedules every 15 min, thereby limiting deviation from their real production compared to an hourly basis. In 2015, EPEX SPOT pointed out '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 liquidity by attracting market 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).

4. Regulation 2015/1222. See http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R1222&from=EN
5. 56% for French borders with Germany and Switzerland in 2014. Source: ACER Market Monitoring Report

3.1.4 BALANCING MARKET

CURRENT STATUS AND WORK WITHIN MARKET4RES PROJECT

Balancing electricity systems is one of the core activities of TSOs that 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 a cross-border level, nor 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, balancing market architectures (central dispatch, self-dispatch portfolio-based and self-dispatch unit-based) and parameter settings (period of products, gate closure times, minimum bid sizes, etc.). See Market4RES report D2.1 [5].

Progress with respect to harmonization and the cross-border trade of balancing production is therefore rather slow, as illustrated by the date of the first scoping of ACER Framework Guidelines on Electricity Balancing in October 2011 to ACER recommendation for the adoption of ENTSO-E Network Code on Electricity Balancing in July 2015. Afterward, the NC EB should be 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 yet been set for the comitology process regarding NC EB. In addition, once the NC EB enters 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 [19], 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 (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 [2]) and has carried out some simulations to quantify the effects of some design options (see Market4RES reports D5.1 [6] and D5.2 [3].

QUALITATIVE ASSESSMENT OF BALANCING MARKET DESIGN OPTIONS

Within Market4RES report D3.2 [2], different options have been assessed in terms of efficiency towards the achievement of a well-functioning, cross-border European balancing market (Figure 7). Those options are related to the procurement of balancing reserves, imbalance settlement arrangements and global coherence among the 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 balancing market efficiency.** Joint procurement of upward and downward balancing capacity may impose barriers to the participation of renewable generators, since variable RES is mostly 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 service provision, meaning **there should be no technology-specific products;**

- To foster the participation of small units in balancing markets, a **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 the 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 the capability to forecast prices.

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 respond actively to the system balance state in very close to real time operation. However, in the presence of market distortions, single pricing could provide incentives to BRPs to worsen system imbalance. Therefore, the Market4RES project recommends that whenever 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 [7], **only imbalances occurring after the closure of the intraday market should be balanced by TSOs within the balancing market period.** This can be explained by the fact that preventive balancing actions may compromise liquidity in the intraday market (by

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

FIGURE 7
Qualitative assessment of balancing market design options

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 (1-5MW)	Small (≤1MW)
	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 perion	Long (1 hour)	Average (30min.)	Short (15min.)
	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

Source: SINTEF Energy Research

moving bids from this market to balancing markets) and, at the same time, increase balancing costs (which could have been reduced through intraday trading);

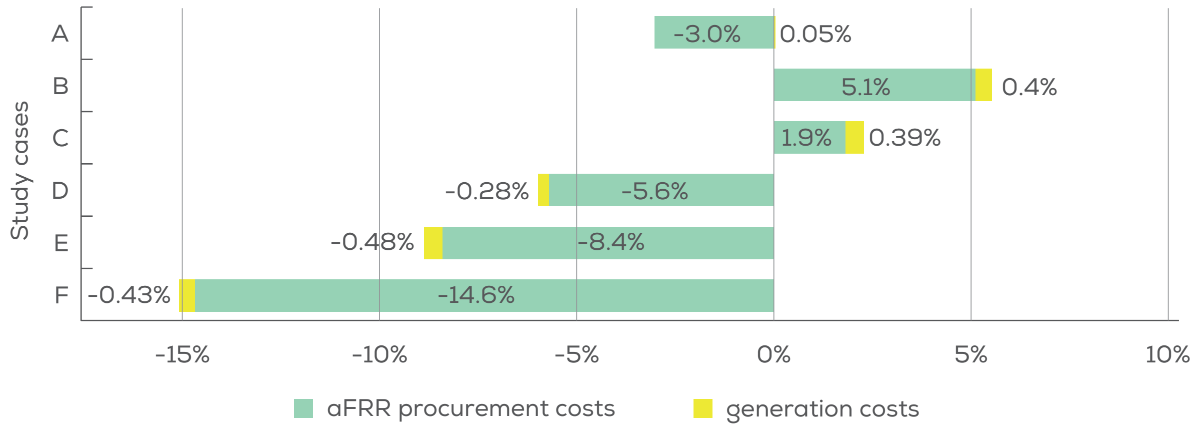
- While the Network Code on Electricity Balancing [8] emphasizes the right of TSOs to activate balancing energy bids for ensuring operational security, and consequently for congestion management purposes, it establishes that **bids activated for purposes other than balancing must not determine imbalance 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 TU Wien (see Market4RES report D5.1 [6] 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 [3], are:

- The **symmetric (joint) procurement** of upward and downward balancing capacity increases total

FIGURE 8
Differences of aFRR procurement costs and generation costs compared to reference case



Source: TU Wien

generation costs and total procurement costs, increases procurement exchanges between German TSOs, and is a **poor design for RES integration** because e.g. wind farms cannot use their full electricity generation to also provide upward-balancing capacity;

- **Common procurement** of balancing capacity by all balancing areas reduces total generation costs and total costs of procurement;
- **A shorter period** for block products reduces average implicit allocation of transmission capacity between balancing areas, reduces total generation costs and total procurement costs, and is a **good design to integrate RES in balancing markets** because the shorter the product length is, the more efficient RES can bid into the market.

Furthermore, symmetric (joint) procurement of positive and negative balancing capacity tends to increase total generation costs and total procurement costs because, typically, the price of the single product is determined by the sub-product (in this 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 [3] by simulating balancing markets in 2030 (see Figure 8). 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 can be seen in figure 8, procurement costs are higher, around 5% for week-ahead and 2% for day-ahead, than in the reference case.

3.1.5 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 considerable over-capacity. Rather, the load might increasingly follow 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 [5] and D6.1.1 [9], demand participation in markets could result in a decrease in system operation costs and an increase in the level of integration for renewable generation. This would pave the way for higher RES-E penetration levels and an increase in the level of competition, thus contributing to a reduction in prices, among other benefits.

GAME CHANGER: SMART METERS

As explained in Market4RES report D6.1.1 [9], demand response from big, industrial consumers has long been developed for 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 their potential and test the function 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 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 [2], addressing developments affecting the design of short-term markets, different approaches have been considered to make demand flexibility (or demand-side response – DSR) efficiently valued in short-term energy markets.

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

The qualitative assessment carried out in Market4RES report D3.2 [2] concludes that both implicit and explicit schemes should be allowed. Implicit schemes are the simplest and are reasonably efficient. However, under these schemes, agents cannot compete to access DSR resources. Therefore, 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 of both of them to be fair (and to promote market efficiency).

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 [10], and the detailed results are presented in the Market4RES report D4.3 [13]. 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 Euros in two different demand-response scenarios for the current situation, whereas the values are about twice as high for 2020. The abovementioned studies also show results for 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 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 [11], do not discuss demand participation in dedicated sections. However, throughout 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 also should be cost effective to include such options when incentivizing flexibility through capacity markets.

The participation of demand in long-term markets is discussed in Market4RES report D3.1 [12]. 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, but rather both of them should be allowed if capacity markets exist to make room for all types of demand-response objects and market arrangements.

BARRIERS

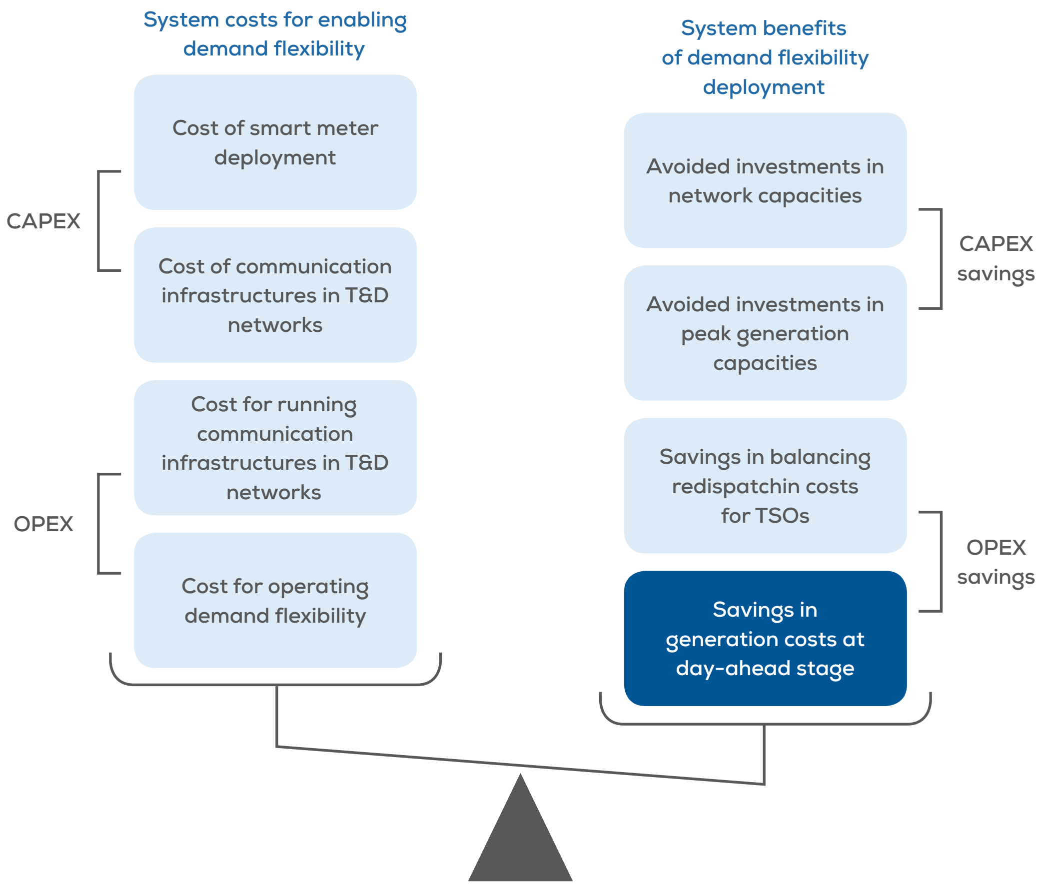
In order to realize the potential benefits of DSR, some barriers need to be overcome. A detailed discussion can be found in Market4RES report D3.2 [2]. The barriers include:

- Technological aspects of service provision, related to the need to have 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 [9];
- 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 relationship between the supplier and the DSR operator for their client: the consumer. These control issues open huge technical challenges on metering consumption and determining DSR volumes;
- Legal barriers. The contract between the supplier and the consumer could easily be used by suppliers to forbid future contracts between consumers and DSR operators. Responsibilities have to be clearly defined in law to allow all parties fair competition.

Figure 9 illustrates the costs and benefits at the system level of large-scale demand-flexibility deployment. To make sure that demand-response can kick off on a 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 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 9
Costs and benefits at system level of large-scale demand flexibility deployment



Source: Technofi

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 period, 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 auctions in addition to continuous trading, short gate-closure times, balancing responsibilities, the possibility of aggregated bidding, and implicit pricing of cross-border transmission rights in the intra-day period;

- 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, 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 from 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.

3.2 RES SUPPORT SCHEMES

3.2.1 RATIONALE FOR RES SUPPORT SCHEMES

As explained in Market4RES reports D2.1 [5] and D6.1.1 [9], 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 placed 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 the 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 limit curtailment of RES-E generation.

Overall, priority dispatch has been and still is an important tool to facilitate the integration of RES-E in the power system. The lack of transparency in curtailment rules for 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 are not fully internalized (global, regional or local). Considerable progress has been made for local and regional emissions with standards on technologies and abatement measures on, for example, SO2, 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 policymakers to set more ambitious 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 has 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 the 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 reduce 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 guarantee 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 and has led to significant generation capacities in Europe, up to almost 100 GW of PV capacities and 140 GW of wind capacity (see detailed figures in Market4RES report D6.1.1 [9]).

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.

3.2.2 SUPPORT SCHEMES CURRENTLY APPLIED IN EUROPE

Figure 10 provides an overview of the support schemes currently applied in Europe for solar generation (for both existing and new capacity). Figure 11 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 10

Support schemes applied to solar capacities in the EU (update March 2015)

France
- FiT
- Tenders
- VAT reduction

Germany
- FiT
- Premium tariff
- Storage system
- Tenders
- Energy sale on el. market
- Investment grants
- Beneficial credit terms
- Self consumption

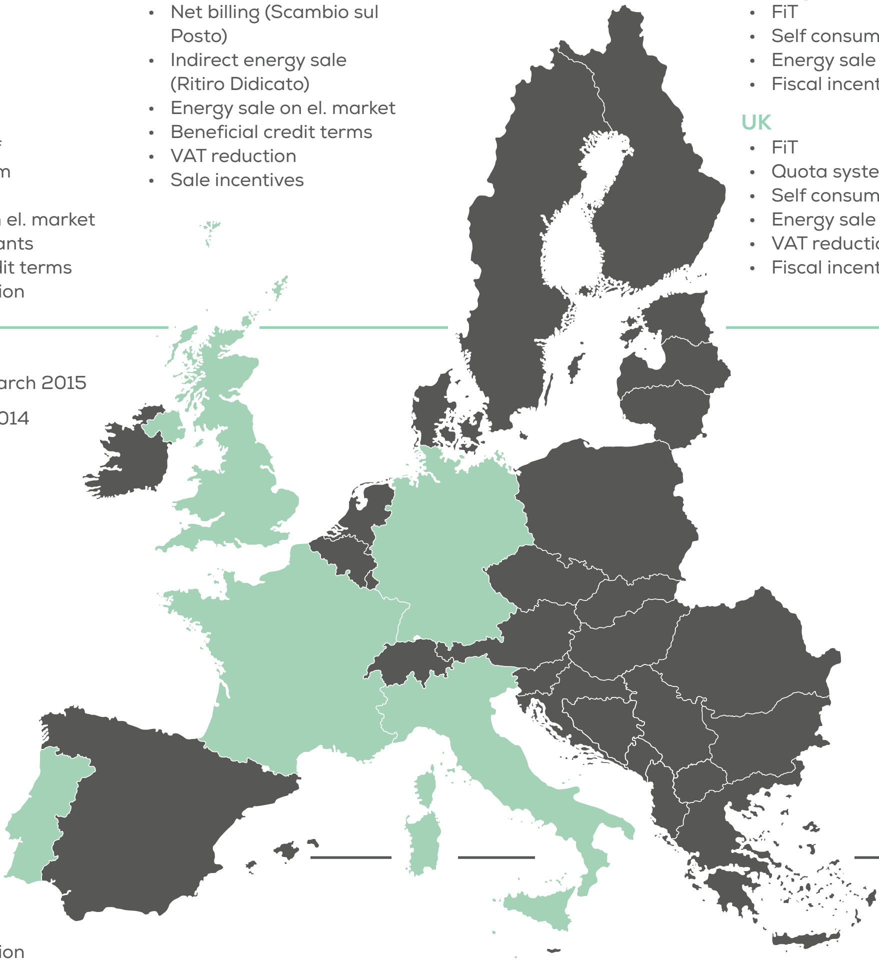
Italy
- Net billing (Scambio sul Posto)
- Indirect energy sale (Ritiro Didicato)
- Energy sale on el. market
- Beneficial credit terms
- VAT reduction
- Sale incentives

Portugal
- FiT
- Self consumption
- Energy sale on el. market
- Fiscal incentives

UK
- FiT
- Quota system
- Self consumption
- Energy sale on el. market
- VAT reduction
- Fiscal incentives

Designs as of March 2015

Designs in Q4 2014



Austria
- FiT
- Self consumption
- Energy sale on el. market
- Investment grants

Belgium
- Green certificates
- Net metering
- Energy sale on el. market
- VAT reduction
- Fiscal incentives

Bulgaria
- FiT

Croatia
- FiT
- Self consumption

Cyprus
- FiT

Czech republic
- Energy sale on el. market

Denmark
- FiT
- Net metering
- Self consumption
- Investment grants
- VAT reduction
- Fiscal incentives

Estonia
- Premium tariff
- Energy sale on el. market
- Investment grants

Finland
- Investment grants

Greece
- FiT
- Net metering
- Fiscal incentives

Hungary
- FiT
- Net metering
- Fiscal incentives

Ireland
- FiT
- Self consumption
- Energy sale on el. market

Latvia
- Net metering
- Self consumption
- Energy sale on el. market
- Investment grants

Lithuania
- FiT
- Investment grants

Luxembourg
- FiT
- Investment grants
- Fiscal incentives

Malta
- FiT
- Self consumption
- Energy sale on el. market

Poland
- Green certificates
- Energy sale on el. market

Romania
- Quota system
- Net metering
- Investment grants

Slovakia
- FiT

Slovania
- FiT
- Premium tariff
- Energy sale on el. market

Spain
- Self consumption
- Energy sale on el. market

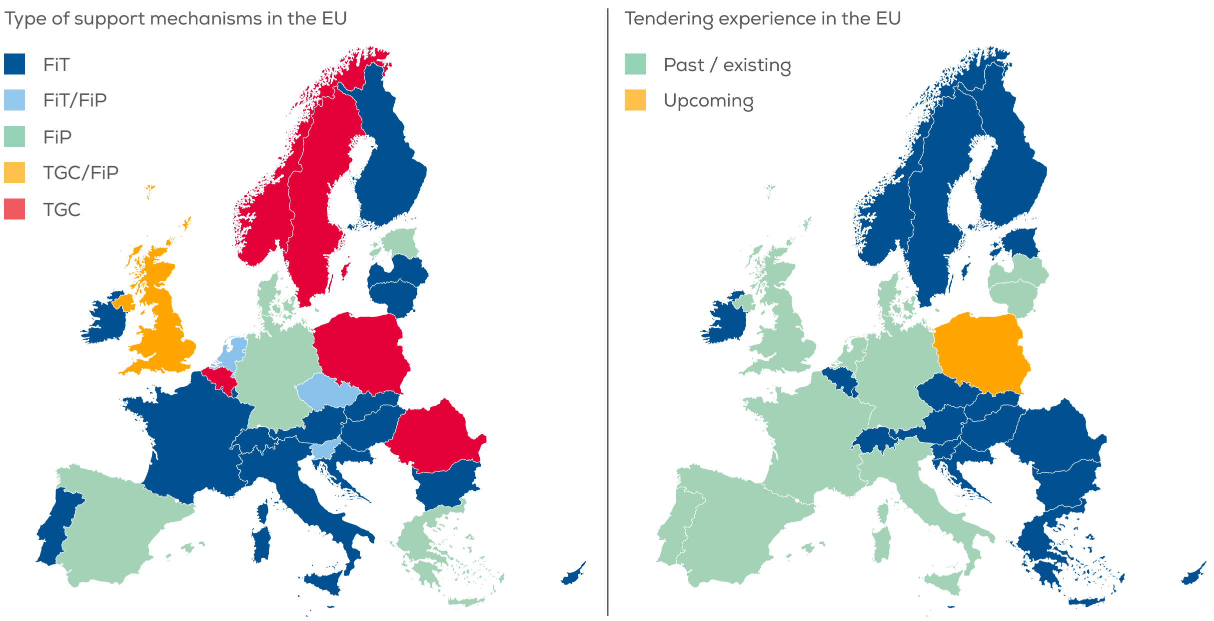
Switserland
- FiT
- Self consumption
- Energy sale on el. market
- Investment grants
- Fiscal incentives

Sweden
- Quota system
- Energy sale on el. market
- Investment grants
- Fiscal incentives

The Netherlands
- Green bonus tender scheme
- Net metering
- Energy sale on el. market
- Fiscal incentives

Source: SolarPower Europe

FIGURE 11
Support schemes applied to new wind capacities



Source: WindEurope

3.2.3 NEW ENVIRONMENTAL AND ENERGY STATE AID GUIDELINE

The European Commission's new Environmental and Energy State Aid [14] 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 that 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 [15]:

'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 [5]. The new guidelines therefore aim to better integrate renewables in the internal electricity market gradually, via the 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:

- aid is granted as a premium in addition to the market price (premium) whereby the generators sell its electricity directly in the market;

- beneficiaries are subject to standard balancing responsibilities, unless no liquid intra-day markets exist; and
- 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 the flexibility to take account of national circumstances (par 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 [...].

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.'

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

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

3.2.4 ASSESSMENT OF SUPPORT SCHEMES

CONSIDERED SCHEMES

In Market4RES reports D3.1 [12] and D3.2 [2], 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 1[9], whereas the corresponding assessment is described in the following.

The mentioned assessment in D3.1and D3.2 was extended in Market4RES reports D6.2 [1] and D6.3 [11] by discussing an extra support scheme and the design of tenders, and another assessment criterion respectively. This is described in Sections 3.2.5 –3.2.7, whereas the following discussions within the project and the final recommendations about RES support schemes are in Section 3.2.8.

TIME-FRAMES AND CRITERIA

Regarding impacts in the short and long terms

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 effects of operation and 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 [2], whereas the quantitative impacts in short-term markets are studied in Market4RES reports D5.2 [3] and D4.2 [13]. 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 [12] and D6.3 [11].

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

TABLE 1
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 a premium on top of the market price for every MWh produced over the given period. Also called Price Premium. Assessed with or 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 the 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 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 (in a predefined amount) 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 obliged either 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 the FIP or FIT types, is largely contingent on the provision of voltage support service by 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, this scheme has only been implemented in Germany.
No support	No support mechanism. RES producers would sell at the best price offered in the market.

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 (via technology development and economies of scale). Therefore, these incentives have been designed to trigger long-term investment decisions. However, these incentives did not pay much attention to how they affected the operation of short-term markets, as the share of renewables was still relatively small. 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 in the short and long term.

Regarding criteria

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

- Efficiency (the ability to minimize the overall system cost of provision of the product transacted on in them). Aspects related to this criterion include marginal cost reflectivity, liquidity, diversity of products and market transparency;

- Effectiveness (achievement of policy goals i.e. RES targets);

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

- Implementability (simplicity, experience with 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 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 to which 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. In 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 on 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); and
- 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 is leading to long-term cost reductions, which is motivating 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 12 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.

FIGURE 12
Overall assessment of RES support schemes considering their short and long-term effects, and reasons supporting this

DESIGN OPTIONS	
MOST PROMISING (overal strong grades)	DISCARDED (overall weak grades)
• Long-term clean capacity auction • Long-term clean energy auction • Certificates • FIP (auction)	• FIP regulated • Net metering • FIT • Support conditioned to the provision of grid support
☹ WEAK POINTS • FIP (auciton) 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 tot RES participation in markets	☹ WEAK POINTS • 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 conditions reduce liquidity in short term markets • Prone to political intervention • Regulated FIP and FIT: Large support
☺ STRONG POINTS • 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 Casuality	☺ STRONG POINTS • 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

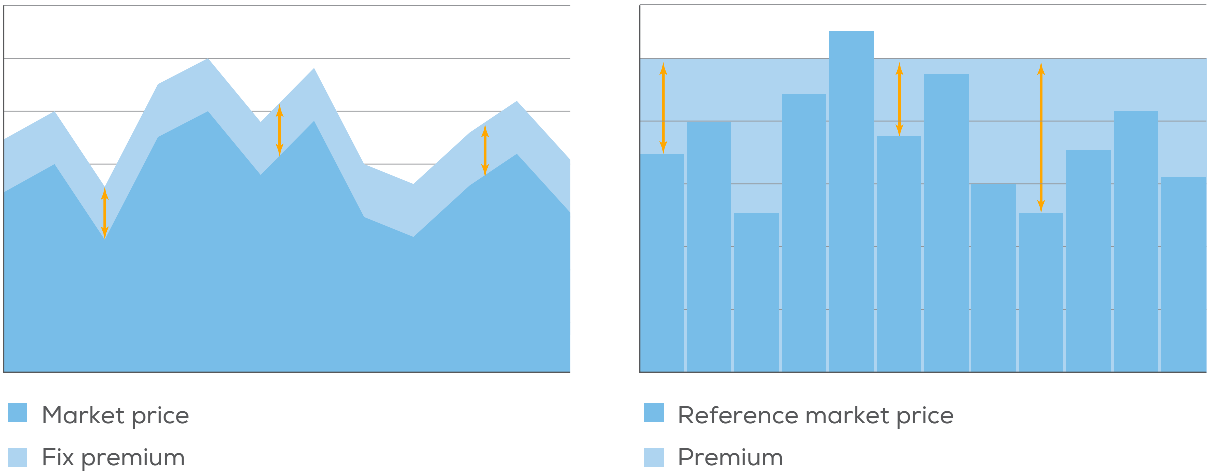
3.2.5 FLOATING FEED-IN PREMIUM

GENERAL IDEA OF THE MECHANISM

In the following, we describe the support scheme 'Floating feed-in premium', which is further elaborated in Market4RES reports D6.2 [1]. 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 or 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 the basis of forward electricity prices, or ex-post on basis of realized electricity prices. The resulting daily/monthly/annual average electricity price used for setting the floating feed-in premium is called the reference electricity price.

Even though the floating premium aims for the price of renewable generation (electricity price plus price premium) to be 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

FIGURE 13
Functionalities of a fix premium and floating premium scheme



Source: CEER, 2016

characteristic similar to fix feed-in premium). Thus, the floating feed-in premium combines two good characteristics for support schemes: it reduces risk with respect to cost recovery, and provides incentives in short term markets due to varying hourly prices.

If the horizontal axis in Figure 13 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.

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 as 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 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 ensure that the total average price is sufficient for cost-recovery.

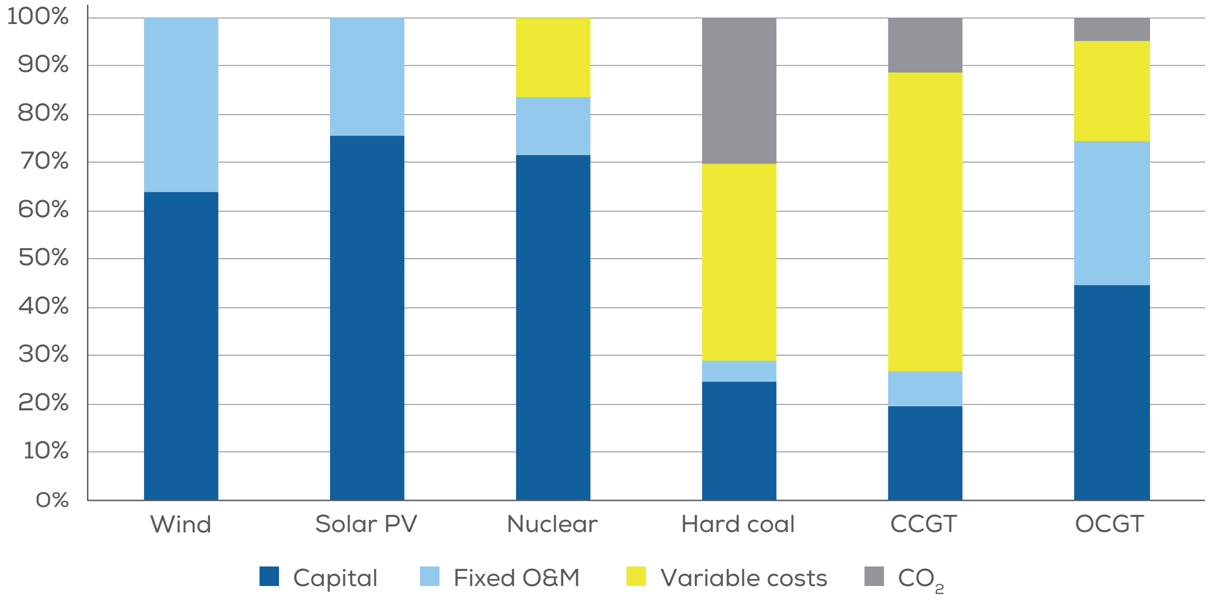
3.2.6 ADDITIONAL ASSESSMENT CRITERIA: INVESTOR RISK

COST OF CAPITAL FOR INVESTORS IN THE TOTAL COST STRUCTURE

The cost structures of different electricity generation technologies are analysed in Market4RES report D6.3, and shown in Figure 14. 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 15. 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 the costs of support schemes.

FIGURE 14

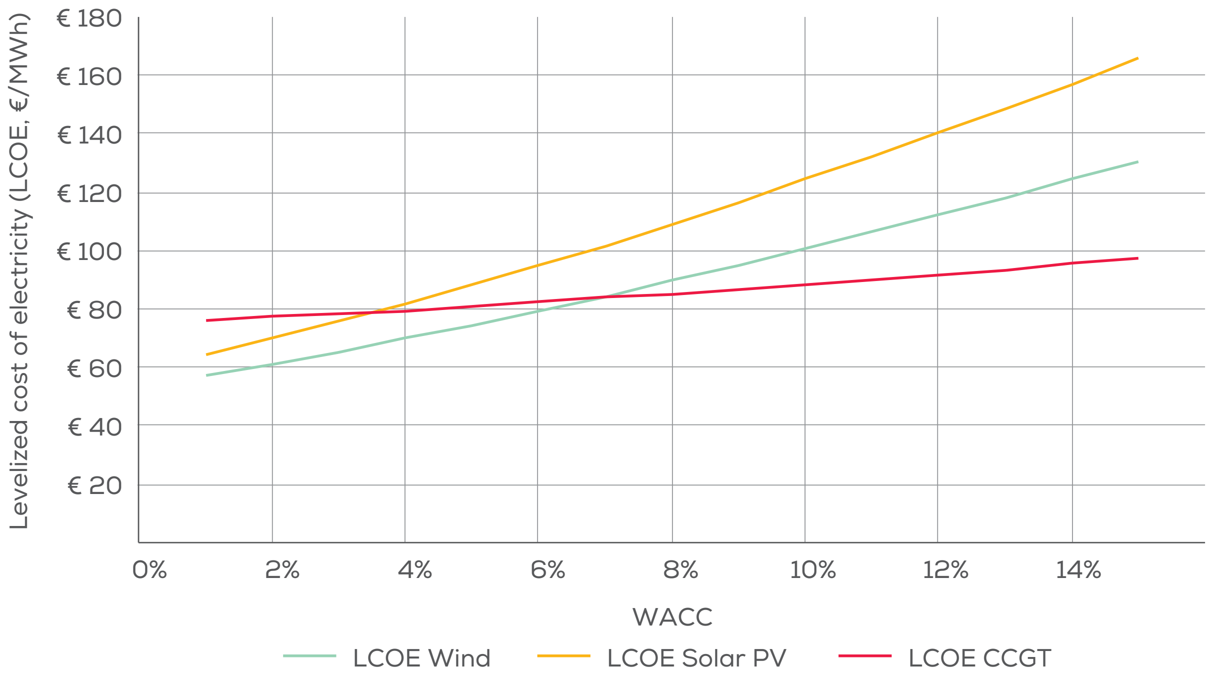
Split cost of the energy generated for different technologies. Result from market simulation in Market4RES project



Source: RTE

FIGURE 15

Levelised Cost Of electricity (LCOE) in function of the Weighted Average Cost of Capital (WACC)



Source: RTE

RISK'S IMPACT ON SOCIETAL COSTS FOR CO_2-MITIGATION

Market4RES report D6.3 [11] 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 16 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.

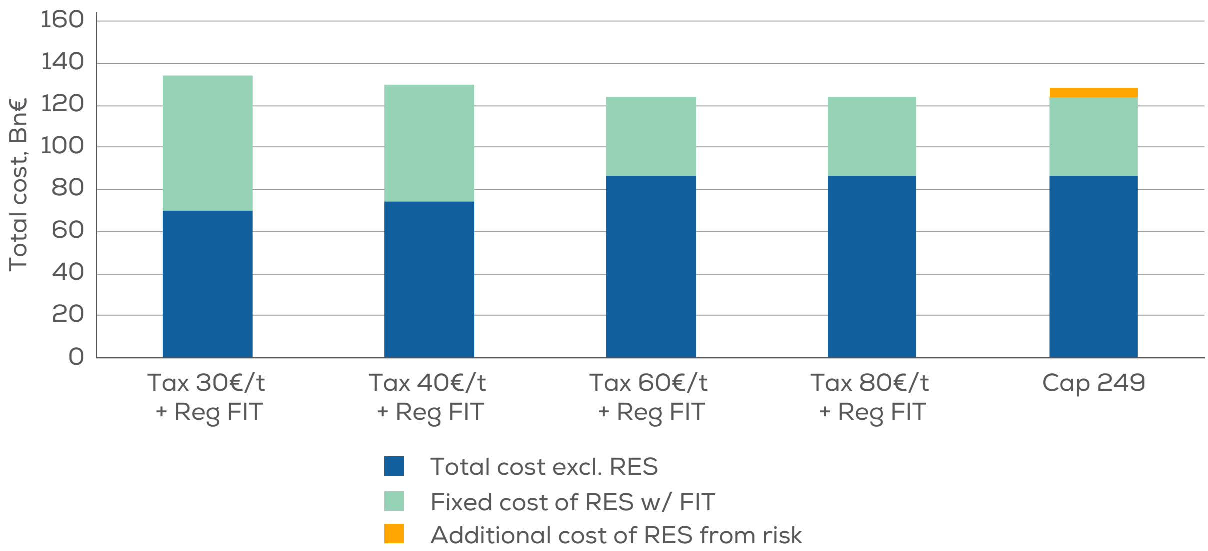
RISK PROFILES IN DIFFERENT SUPPORT SCHEMES

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 17.

Three types of risks are considered: price risk (indicated by the vertical arrow), volume risk (indicated by the horizontal arrow), and profile risk (curvature arrow). The colours 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 the sale of electricity (upper part), and income from a RES support scheme (lower part).

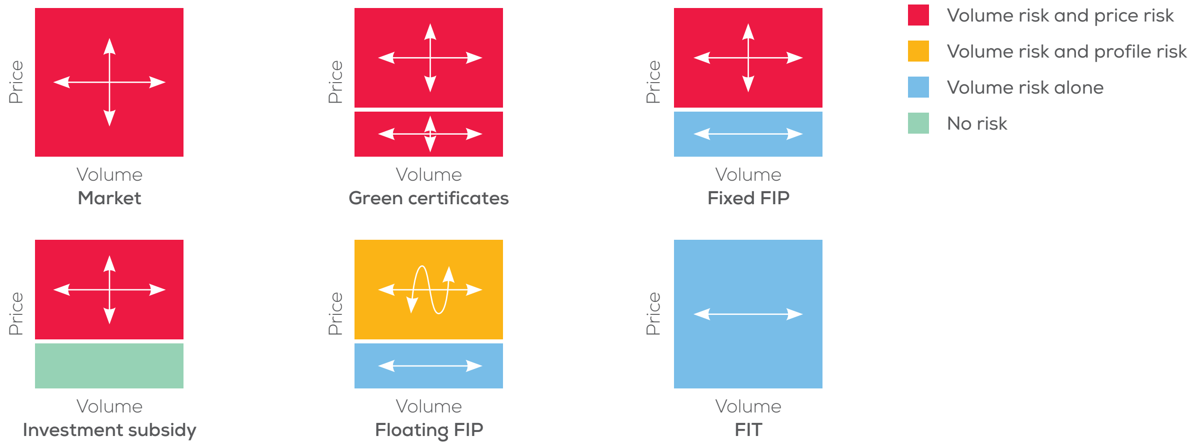
FIGURE 16

Total costs as a function of the support mechanism's designs at a regional perimeter



Source: RTE

FIGURE 17
Support schemes and risks for renewable projects



Source: RTE

Below, some comments are provided to explain the assessment for each support scheme. See Market4RES report D6.3 [11] 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 that for green certificates and fixed feed-in premium. However, the income and transfer from the RES support scheme is subject to neither 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 or tenders via the transaction costs of participating in them. On the other hand, the application of auctions or tenders can and will be 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 because the production profile, and therefore the average electricity price, will deviate from the average. It can be better or worse, but since it is an uncertainty, it is by definition a 'risk'. However, the income from the RES support scheme is only subject to volume risk.

Compared to the investment subsidy, the floating feed-in tariff has a lower risk for electricity sale income, but a higher risk for 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 that for either green certificates or 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.

3.2.7 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 above 1 MW). However, the continuation of this part of the regulation will have to depend on the experience gathered by implementation of these complex mechanisms in coming 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 [12]), but for this to happen the tender design options need to be carefully defined.

Due to 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 institutions) to adapt to frequent changes in tender arrangements. Tenders present participants with higher risks (costs of applications under uncertainty of 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. However, such a design seems unlikely to be implementable within the short to medium term, because aspects such as compatibility with national energy policy and system integration requirements call for 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 a long-term perspective regarding volumes to be auctioned would increase investor confidence and help the industry sustainably plan manufacturing capacity and optimize the supply chain. Finally, the creation of a database providing insights on globally tendered and successful connected capacities is recommended.

Photo: Thinkstock

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

3.2.8 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 affect 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;
- Furthermore, with respect to implementability, feed-in premium-type systems coincide better with the new Environmental and Energy State Aid Guidelines.

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 they provide incentives to produce even 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 a floating feed-in premium in Market4RES report D5.2 [3]. 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, not the amount 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 were not cut voluntarily.

In the latter approach, it is a challenge that several prices exist for any given hour in different segments (day-ahead, intra-day hours and balancing energy). The simplest would be to condition 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 to the two approaches mentioned above 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 impacts on the short-term market signal and long-term efficiency, accounting also for effects on investment risks;
- A floating feed-in tariff system 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 the 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 (which 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, and land acquisition), rather than bidder-specific (experience, project portfolio);

- Tendering design parameters should be progressively harmonized 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 increased investor confidence and helping industry to plan accordingly.

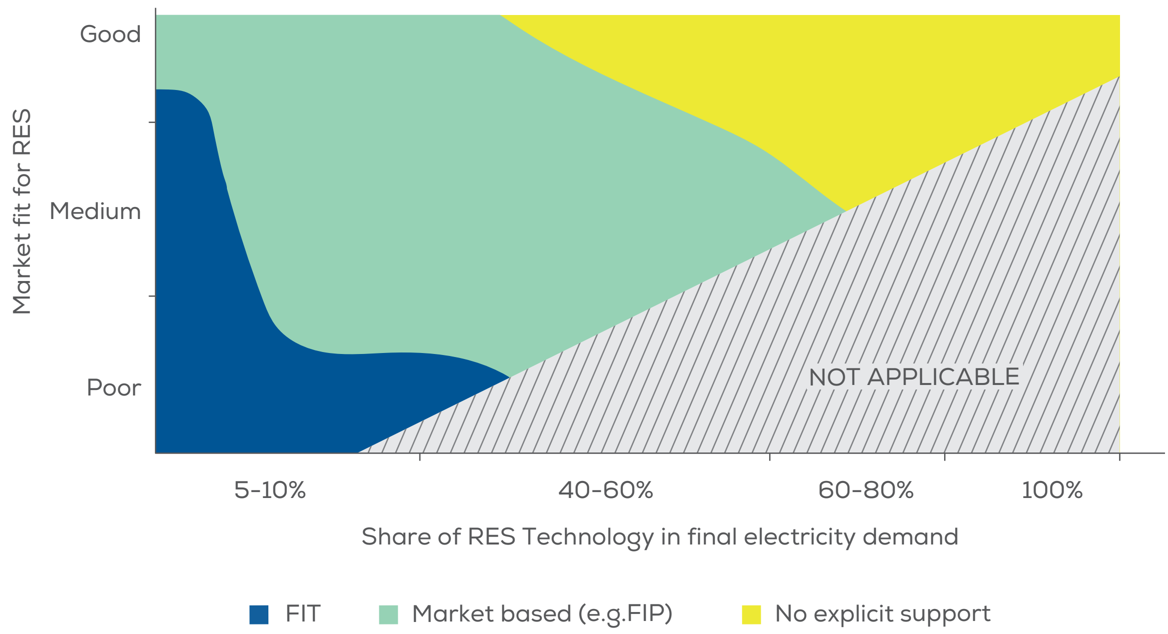
3.2.9 ROADMAP TOWARDS 2020 AND BEYOND

Based on the assessment of market design aspects and on the penetration rates of a certain renewable technology (which is an indicator of technology and market maturity), we have provided an illustrative representation of a potential support scheme evolution (see Figure 18). In this conceptual model, two dimensions are central to which support scheme is appropriate: technology maturity, represented by market share, and the degree to which the market is adopted to account for specific characteristics of the technology.

In the early stage of market deployment, new technologies are generally expensive and not yet competitive. Still,

FIGURE 18

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



Source: WindEurope

if they represent 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 a technology matures and increases its share in the energy mix, it is important to adjust the market instrument, reducing 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 with 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 of achieving significant market penetration (e.g. above 10-15%) in a system where the market conditions are somehow not adapted to these new technologies (as 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.

3.3 CAPACITY MARKETS

3.3.1 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 had already done so by 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 has experienced 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 [5] 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 producing the investment signals needed to ensure an adequate generation mix, able to meet demand at all times. Several European countries (see Market4RES report D6.3 [11]) have already implemented capacity markets, some countries are in the process of implementing them, and still others are debating introducing them.

3.3.2 GUIDANCE TO ENSURE GENERATION ADEQUACY

In its staff working document [17], the European Commission presented 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, may Member States opt to intervene by implementing a CRM mechanism to ensure generation adequacy (also including State aid, cf. Market4RES report D3.1 [12]).

3.3.3 CONCERNS ABOUT IMPLEMENTATION OF NATIONAL SCHEMES

The national initiatives to establish capacity markets have taken place in an uncoordinated manner, affecting the progress of achieving the objectives of European regulation. This situation has raised 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 [18]:

'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.'

3.3.4 QUALITATIVE ANALYSIS OF CAPACITY REMUNERATION MECHANISMS

An overview of the different types of capacity mechanisms is provided in Table 2. See Market4RES report D6.3 [11] for further details. The classical way to structure discussions of capacity mechanisms is to follow the categories mentioned in this table. The alternative, which is more complex, but allows more details in the characterization, is to identify all relevant design decisions that need to be specified by the regulator.

TABLE 2
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 model[11]	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 model[12]	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.
Reliability 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 sets 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.

11. Also known as Central Obligation model
12. Also known as De-Central Obligation model

TABLE 3
Considered design elements of capacity remuneration mechanisms

TYPE	BRIEF DESCRIPTION
The product	Firmness of supply, financial energy contract (including 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 all Europe, national mechanisms implicitly considering the contribution of neighbours, the explicit participation of foreign capacities, and different isolated CRMs.
Fixed payment per MW installed capacity	Negotiated when a capacity provider enters the market, and provided by the system operator to that provider for the term of that agreement.

The assessment carried out in the Market4RES report D3.1 [12] 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 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 3. 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:

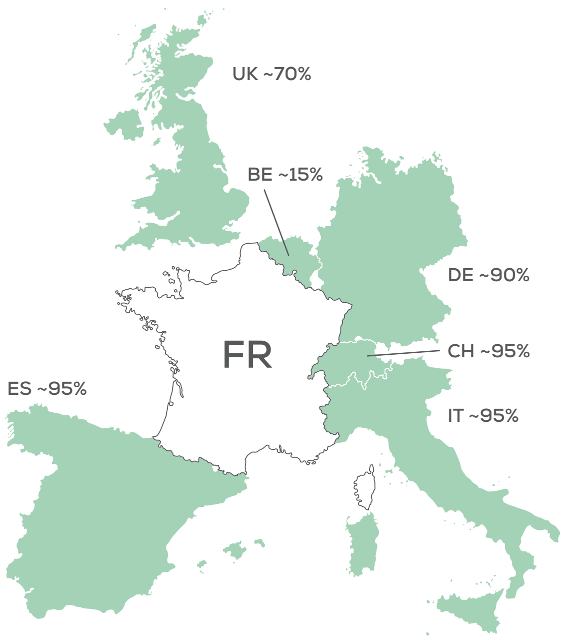
- Financial options with a high strike price[13] seem to achieve the right balance between the provision of certainty to investors in firm capacity and the provision of incentives for agents to participate in short-term markets;
- Regarding the price vs. quantity nature of the mechanism to contract firm capacity, expressing system needs in terms of a price-quantity curve seems preferable. This avoids the amount of firm capacity contracted being too high or too low, as well as the possibility that its price is too high. Setting a price-quantity curve partially curbs market power and would be implementable in the EU;
- The procurement should probably take place through a centralized auction, which would be effective, efficient, and accepted widely (even when not allowing a wide variety of products to be traded);
- Lastly, cross-border provision of firm capacity should be allowed to increase the efficiency in provision of this product. The amount of transmission capacity available for this should be computed through statistical means, since this is the most reliable method.

3.3.5 PROCUREMENT OF INTERCONNECTION CAPACITY

The Market4RES report D6.3 [11] elaborates further on the possible need to procure capacity on interconnectors in case of participation by foreign capacities in capacity markets. In some cases, generation in one country may not contribute to meeting the domestic load for another if interconnectors are congested.

13. 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

FIGURE 19
Frequency of congestion between France and neighbouring countries during French peak load periods



Source: WindEurope

Figure 19 shows the constraints on cross-border interconnections during 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) were congested.

Several options for including interconnections in capacity markets are discussed in the Market4RES report D6.3 [11], and it is concluded that an accurate mechanism corresponds to the simultaneous explicit participation of interconnections and generators/demand-responses entities. However, legal issues 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 of developing explicit participation from interconnections only, which is the solution selected in Great Britain and accepted by the Commission.

3.3.6 ANALYSIS OF ENERGY ONLY VS. CAPACITY MARKETS

MISSING MONEY

The Market4RES report D2.1 [5] 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 in recovering investment costs.

The first situation is the development that has occurred in Europe, in general because of overcapacity. Renewable generation enters the market and produces at zero marginal cost. The corresponding positive shift in the supply curve gives lower equilibrium prices, which are below levelised 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 prevent 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 shortages of supply from time to time, with corresponding curtailment of consumption and load shedding.

A price cap set below the value of lost load can therefore be considered an imperfection, leading to a less-than-optimal system. On the other hand, 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, as the total capacity is higher than optimal and the shares installed for different production types may not be optimal.

QUANTITATIVE SIMULATION

The Market4RES report D5.2 [3] describes a long-term electricity market study. Here, long-term means that investment and decommissioning decisions are considered in addition to day-to-day decisions for demand and supply. In this study, it is presumed that all agents are risk natural. Three different cases are analysed:

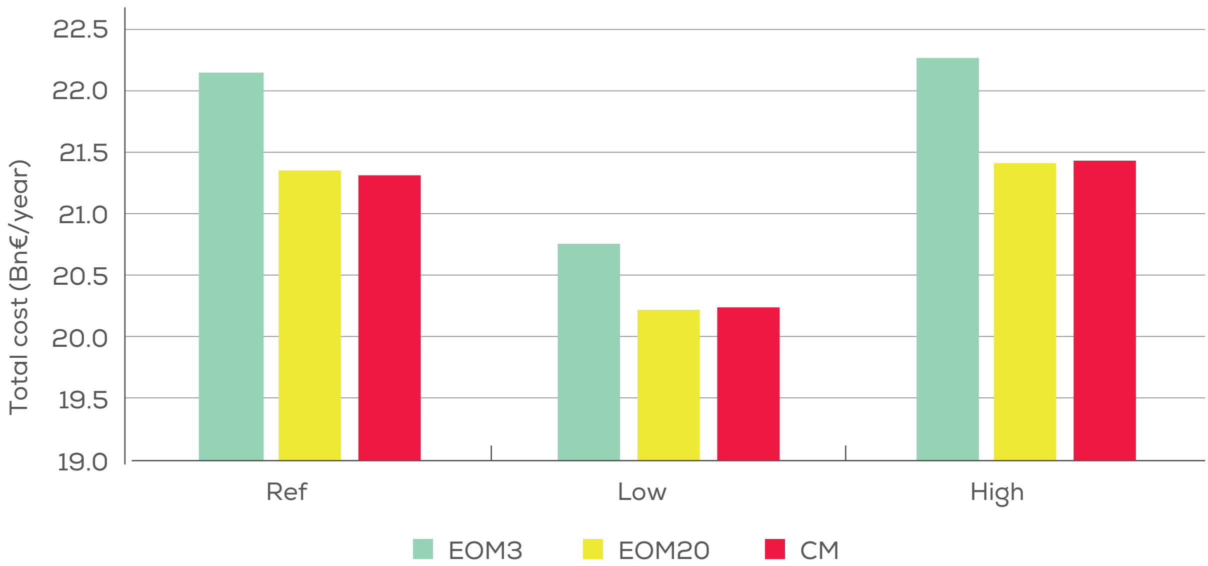
- EOM20: Energy-only market with high a price cap corresponding to value of lost load (VLL), i.e. 20,000 €/MWh;
- EOM3: Energy-only market with a lower price cap; 3,000 €/MWh;
- CM: A system with combined energy- and capacity market. The price-cap is set to 3,000 €/MWh.

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 20. There are results for three different scenarios: Ref, Low and High, which are explained in Market4RES report D5.1 [6].

For each scenario, total system costs are highest for an energy-only market with a low price cap. As expected, an energy-only market with a price cap corresponding to the value of lost-load gives 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.

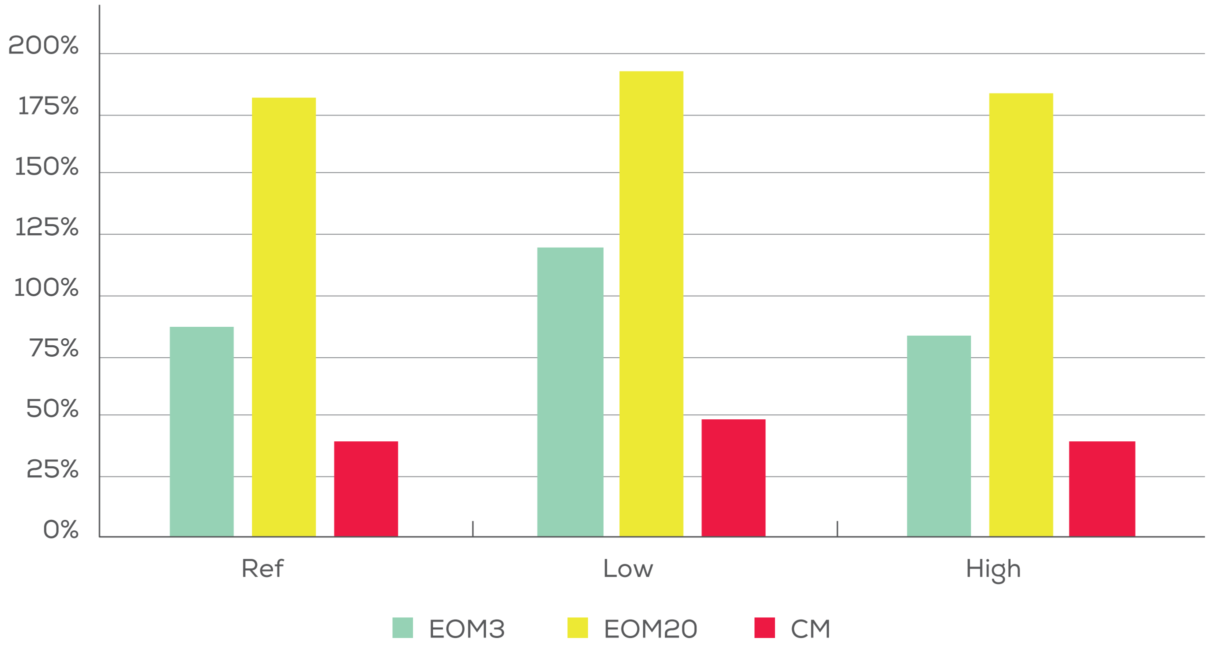
As explained in Market4RES report D5.2 [3], no risk aversion was included in the above-described study. However, an important motivation for having a capacity market is to avoid occurrences of very high prices that are needed to yield the same capacity in energy-only markets. Figure 21 shows the variability in 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 20
Total cost (Bn€/year) by scenario and market design



Source: RTE

FIGURE 21
Variability of revenues of a peaking generating unit



Source: RTE

3.3.7 CONCLUSIONS ABOUT CAPACITY MARKETS

- A fully-functional energy market is undoubtedly the desired scenario when workable. For CRMs, the Market4RES project does 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 building new generation units, maintaining existing units, and developing 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).

3.4 MESSAGES TO POLICYMAKERS

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.

4. HIGHLIGHTS FROM STAKEHOLDERS INVOLVEMENT

On 17 June 2016, the Market4RES project organised the stakeholder consultation 'An electricity market fit for renewables. Considering design options for the electricity market post 2020', where the draft recommendations to policymakers were presented and discussed with the audience. Benedikt Günter (Policy Advisor, German Federal Ministry for Economic Affairs and Energy), Susanne Nies (Corporate Affairs Manager, ENTSO-E), Jan Papsch (Policy and Legal Officer, DG Energy, European Commission), Marion Labatut (Coordinator Wholesale & Retail Markets Issues, EURELECTRIC), Iván Pineda (Director of Members & Markets, WindEurope) and Louis Olmos (Researcher & Professor, Pontifical University of Comillas) were all speakers in a very interesting panel debate, moderated by James Watson (Chief Executive Officer, SolarPower Europe).

FIGURE 22

Panelists. From left: Benedikt Günter (German Federal Ministry for Economic Affairs and Energy), Iván Pineda (WindEurope), Susanne Nies (ENTSO-E), Jan Papsch (DG Energy, European Commission), Marion Labatut (EURELECTRIC), Luis Olmos Camacho (Pontifical University of Comillas)

Some interesting statements that came out of the discussion are reported below:

'In our view it is a high time to look at the market design. *Exemptions for balancing responsibilities should be removed. Removing priority dispatch is important. On the other hand, RES should be allowed to participate in all electricity market types. 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.'*

Marion Labatut

'Day-ahead markets have improved a lot in recent years. *Still, there are many things to do. Priority list of actions now is: 1) Remove distortions and interventions in electricity markets, 2) Enhance flexibility of markets, and 3) Support schemes should have as little impact on markets as possible.'*

Jan Papsch

'In the future we will need more flexibility. *This flexibility should be provided by markets' prices rather than specific market designs / new incentives. Focus should be on removing barriers for the provision of different types of flexibility, rather than new market designs. Intraday markets will play a central role for trading flexibility.'*

Benedikt Günter

'It is key to keep momentum on markets. *It is important to use support in the RD phase, to have a resilient framework for sustainability, but once things get closer to the market, the market has to decide upon uptake. 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.'*

Susanne Nies

'Market exposure for RES must be conditional on level playing field. *Do not forget the background leading to the implementation of priority dispatch.'*

Iván Pineda

'Capacity markets are needed to avoid too much price variation in the future with higher RES shares. *Technologies will not come automatically. Some market-mechanisms are needed for the provision of RES and flexibility. Those market-mechanisms should not be considered subsidies, but rather a way to make sure that markets provide the services we need from them.'*

Luis Olmos Camacho

5.

INTERVIEWS WITH THE PROJECT PARTICIPANTS

Interview with Sophie Dourlens-Quaranta, Technofi (FR) Leader of work-package 'Appropriate new market instruments for RES-E to meet the 20/20/20 targets'

In your opinion, what is Technofi's most significant contribution to the Market4RES project?

Sophie Dourlens-Quaranta: "Technofi was in charge of a full work package, consisting in specifying studies relative to the electricity short-term market design, setting up scenarios to support these studies and running the studies with the OPTIMATE prototype simulation tool.

Within the concluding work package of the project, we have also led the project's recommendations work regarding the market design evolution for the 2020 horizon. This work was challenging but also very interesting. We worked with all project partners and managed to put together (in a consistent manner) all their inputs.

We had also been involved in every other work package, with various contributions regarding the target model diagnosis, short-term market design analyses, data gathering to prepare other studies, etc. These various contributions allowed us to have a broad overview of the full project and provide consistent recommendations."

What is the relevance of the Market4RES topics for Technofi?

Sophie: "Technofi has been working in the electricity sector for years. We have been involved in many different topics, from grid planning to system short-term reliability. Market design is naturally one topic of utmost importance to us. We are deeply involved in the elaboration of R&D

roadmaps in the electricity sector: market design is one of the aspects we are dealing with in this framework. Being involved in a project like Market4RES, which dealt with so many different market design topics (demand-response, capacity remuneration mechanisms, RES support schemes, etc.), is clearly an asset to us.

More specifically, we have dedicated most of our resources on specific studies using the OPTIMATE simulation tool, which was developed during an FP7-funded European project. The tool used for the Market4RES studies was in a prototype stage, but functional developments are ongoing and the tool is currently in a process of industrialization. We believe that the OPTIMATE simulation tool, when enriched with a full functional scope (from day-ahead to intraday and balancing markets) and improved robustness, is going to become a reference tool for market design analysis."

Can you explain the topics you have studied with this OPTIMATE tool?

Sophie: "One of our studies was about the possible impacts of demand-response on short-term market outcomes. Demand-response is clearly a hot topic: nowadays, and even more importantly, with the future electricity system integrating higher shares of wind and solar generation, demand-response is increasingly needed because the generation fleet will decreasingly be able to follow the load. Part of the loads will become controllable so as to follow the non-dispatchable generation by being decreased or shed during low-production hours and possibly increased during high-production hours. In our studies, the impacts of demand-response on short-term market prices, on cross-border exchanges and on the costs and profits of various market players have therefore been studied and quantified. To perform this simulation work, we have designed several variants, from a low to a higher deployment of demand-response. Demand shift has also been investigated since it can occur when the load is shed. In principle, a certain proportion of the load, which is shed during high-price hours, should be shifted to low-price hours. We have therefore also considered several variants for demand shifts. All these different variants have been assessed considering different setups for the electricity system, with a scenario corresponding to the current situation in terms of generation fleet and peak demand, to a scenario corresponding to the 2020 objectives in terms of RES penetration and finally a scenario with higher RES levels than the 2020 objectives. All in all, we have run 15 different cases with OPTIMATE! In terms of results, we have been able to quantify for 10 different countries the impacts of demand-response. We have, for example, quantified the amount of CO_2 saved for each of the different variants and estimated the impact on market prices. We have also observed very interesting interactions between load shedding, corresponding demand shifts and cross-border flows. We have also analysed differences in the impacts on the revenues of thermal, solar and wind producers."

Do you intend to continue the work undertaken under Market4RES?

Sophie: "Sure, we have some ideas to continue this work. We are also involved in other initiatives related to market design. We are, for example, developing an evaluation tool of different business models for smart grid and energy storage technologies: this is related to market design since the profitability of a given business model is impacted by market design choices."

What are your personal impressions from the project?

Sophie: "These two years and a half have been very interesting. Exchanges with other projects' partners have been truly enriching. The strength of this project was to put together different types of stakeholders, from academics to industry representatives. We have been very pleased to participate in such a rich project."

Interview with Ove Wolfgang, SINTEF Energy Research, Leader of work-package 'Recommendations and implementation guidelines for market designs'

In your view, what are the most important findings from the project?

Ove Wolfgang: "As I see it, the project is not asking the Commission to change its course in the harmonization of European electricity markets. It is already an ambitious task to fully implement existing goals, and the intended development of markets is to a high degree considerate towards the needs for renewable generation.

The phase-out of priority dispatch and implementation of balancing responsibility for all producers needs to go hand-in-hand with the development of well-functioning intraday markets, so that renewable power producers get the opportunity to adjust their position.

European harmonization and integration should be simpler for intraday markets than for ancillary services, since the former is similar to already integrated day-ahead markets. However, there should be implicit pricing and thus more efficient cross-border trading in this period too.

It is the project's opinion that this is not the time to stop supporting renewable power generation, as this will 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.

However, the project supports the adopted guideline for RES support, which specifies a transition from the traditional feed-in tariffs to systems based on price premiums set through tenders. The project also has some specific proposals regarding the design of the support schemes, including a floating version of price premiums to reduce risks for investors, and a mechanism to improve the short-term price signal for renewable generation."

Did any of the results surprise you?

Ove: "Through the project, I have had the opportunity to learn about the EU's legislation process for electricity markets through the development of Network Codes and Guidelines, and to study some of them in detail. For me, it was a surprise that parts of this regulation describes future processes and goals, whereas the specific implementation will be developed later.

Therefore, when reading the regulations, one always needs to have the full context in mind – which makes it more complex. Still, in the broader perspective, there is currently a high speed in the harmonization of European power markets."

What has been SINTEF Energy Research's role in this project?

Ove: "SINTEF Energy Research has been the coordinator for the project. We have also been work package leader for three work packages, which included quantitative studies for electricity markets after 2020 and the development of final recommendations from the project. In the post-2020 studies, we applied our own electricity market simulator, EMPS."

How are the addressed research questions in Market4RES relevant for your company?

Ove: "The development of planning and optimization tools for electricity markets is an important activity at SINTEF Energy Research. We therefore need to understand the current market designs, and know about expected changes. With the increasing shares of wind and solar power generation in Europe, the importance of those markets designed to handle forecast errors between the traditional day-ahead market and real time has increased. Since Norwegian hydropower is very flexible with huge energy storages, it is ideal for balancing those forecast errors. Thus, the utilization of hydropower for balancing the fluctuating renewable generation is an important research area at SINTEF Energy Research."

What are your personal impressions from the project?

Ove: "It has been a great experience and educational to work with the partners in the project, which are experts in this field. From our dialogue with representatives from the Commission, we also understood that the project was timely and relevant for their work. This is always very satisfactory for a researcher."

Interview with Luis Olmos Camacho, Pontifical University of Comillas, Leader of work-package 'Novel market designs & KPIs'

What is the relevance of the M4RES topic for Comillas Pontifical University?

Luis Olmos-Camacho: "Within the University, the Institute for Research in Technology (IIT) is devoted to conducting research on a number of areas related to the use of technology in our society. A large fraction of the research projects and publications within the IIT are focused on the electricity industry and, within it, making the integration of RES generation, as well as other clean technologies, compatible with the safe and efficient functioning of the system, organized in the form of markets, probably is the most relevant challenge. Thus, this topic is of much relevance to the IIT and the University as a whole."

What are the most relevant modelling tools applied within the project by Comillas Pontifical University?

Luis: "We have made use of a simulation tool able to compute the system-wide unit commitment while potentially taking into account the uncertainty existing at the time of the computation of this commitment about the system conditions that will apply in real time. This tool is called ROM (Reliability Operation Model). The ROM model has been used to assess the economic efficiency of short-term markets under the several RES support schemes considered, as well as the influence of getting day-ahead markets closer to real time on the efficiency of system operation."

Did any of the results computed surprise you?

Luis: "I must admit I was initially surprised by the fact that, according to our results, getting day-ahead markets closer to real time by a small number of hours could actually be counterproductive, thus resulting in a decrease of system efficiency, when the system includes a relevant fraction of inflexible resources, like certain types of nuclear and CCGT power plants."

What did you find the most challenging task in the project?

Luis: "Probably, factoring in the experience and knowledge from the many different types of stakeholders comprised within the consortium team when conducting analyses and drawing conclusions, while, at the same time, preserving the coherence of all those analyses has proven to be most challenging. It seems quite clear that the interests and experience of members of academia and research institutions, RES operators, Market Operators and TSOs may enter into clear conflict in some situations."

Is there anything that should have been done differently in the project?

Luis: "The structure of analyses included in the original plan (the so-called Description of Work) turned out to be a bit restrictive at some points when actually conducting these analyses. Hadn't it been for the Description of Work, some analyses could have been structured in a slightly different way, which looked more appropriate after having conducted already some previous analyses."

Any intentions to continue the work?

Luis: "Further work should be carried out related to the integration of balancing markets and capacity ones. The use of the former should be made compatible with having a truly integrated European market. Our research group would be happy to participate in projects or analyses focused on these issues taking as a starting point the knowledge gathered in the Market4RES project."

What are your personal impressions from the project?

Luis: "I believe Market4RES has been a challenging project, mainly due to the vast array of regulatory issues covered by it. Despite this, interesting analyses have been conducted that we hope will contribute to having a better understanding of the electricity market developments to implement in the years to come."


Photo: WindEurope

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7. LIST OF MARKET4RES REPORTS

OPPORTUNITIES, CHALLENGES AND RISKS FOR RES-E DEPLOYMENT IN A FULLY INTEGRATED EUROPEAN ELECTRICITY MARKET

D2.1 Market failures, distortions, challenges and benefits in the European electricity market with increasing shares of RES-E generation

D2.2 Implementation status and market-focused diagnoses of the Target Model

D2.3 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

NOVEL MARKET DESIGNS AND KPIS

D3.1 Developments affecting the design of long-term markets

D3.2 Developments affecting the design of short-term markets

D3.3 Indicators for the assessment of market options

APPROPRIATE NEW MARKET INSTRUMENTS FOR RES-E TO MEET THE 20/20/20 TARGETS

D4.1 Specifications of the most adequate options for flexibility markets and RES support schemes to be studied in a cross-border and transnational context

D4.2 Quantification of the expected benefits coming from evolutions of RES support schemes – intermediate report

D4.3 Quantification of the expected benefits coming from evolutions of RES support schemes – final report

MODELLING OF ELECTRICITY MARKET DESIGN & QUANTITATIVE EVALUATION OF POLICIES FOR POST-2020 RES-E TARGETS

D5.1 Report on choice of models, scenarios and assumptions for qualification

D5.2 Report on quantitative evaluation of policies for post 2020 RES-E targets

CONCLUSIONS, RECOMMENDATIONS AND PROCEDURE GUIDELINES

D6.1.1 Roadmap for RES penetration under the current Target Model high-level principles (2014-2020) – Part 1: Recommendation about RES support schemes and demand flexibility.

D6.1.2 Roadmap for RES penetration under the current Target Model high-level principles (2014-2020) – Part 2: Recommendations about other short-term market topics

D6.2 Guidelines for the implementation of new market designs in Europe with large shares of RES-E penetration (post-2020)

D6.3 Necessary additions to target models as regards the long-term nature of market design in Europe when taking into account high shares of RES-E penetration and the necessity to maintain security of supply (post-2020)

D6.4 Final project deliverable: Summary of D6.1, D6.2 and D6.3, plus minutes and recommendations of the expert workshop and follow-up consultation process & stakeholder event allocated in WP6.

DISSEMINATION TO STAKEHOLDERS – FINAL POLICY RECOMMENDATIONS

D7.4.2 Final project publication

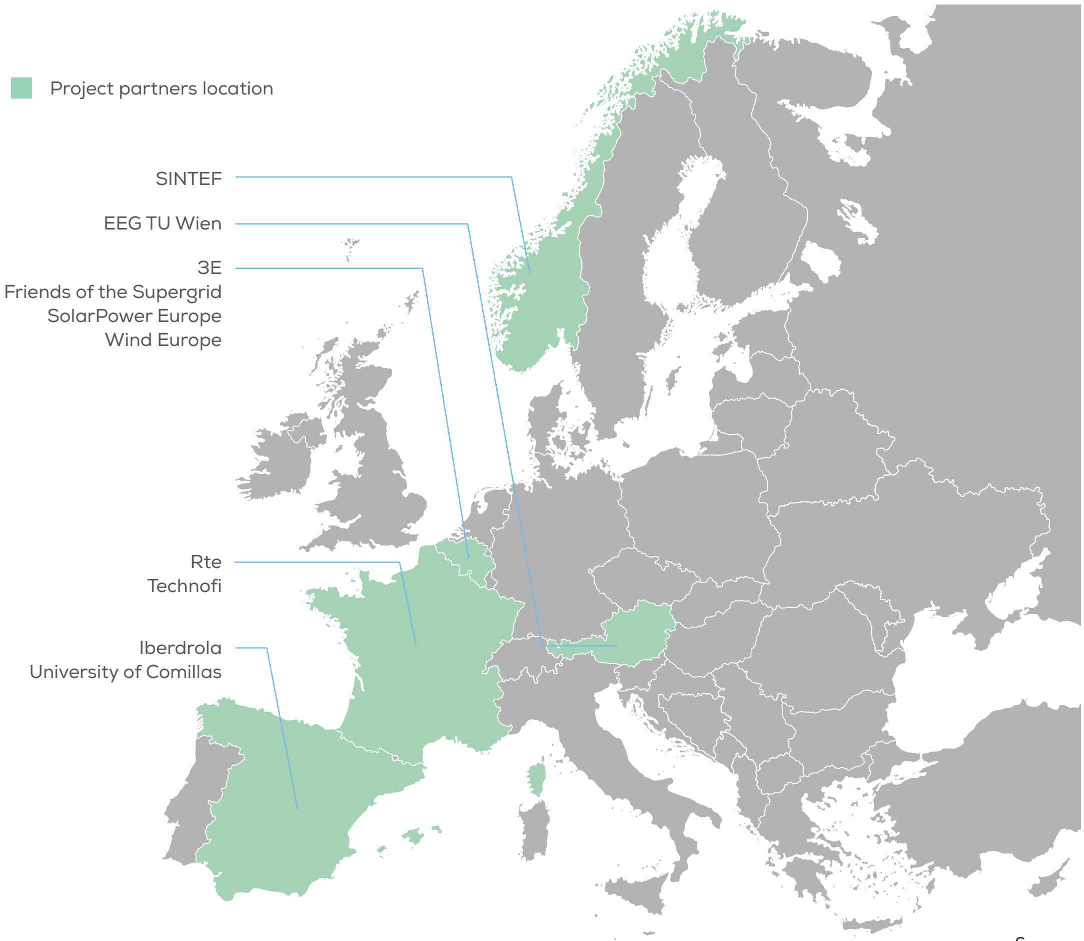
The Executive Summary of this publication is translated into French, German, Italian, Polish, Spanish. These versions are available at www.Market4RES.eu.

8. DIVISION OF WORK AND RESPONSIBILITIES OF MARKET4RES PARTNERS

TABLE 4
Division of work and responsibilities of Market4RES partners

WORKPACKAGE NUMBER (WP)	TITLE	RESPONSIBLE PARTNER
1	Project management	SINTEF Energy Research
2	Opportunities, challenges and risks for RES-E deployment in a fully integrated European electricity market	Energy Economics Group, TU Wien
3	Novel market designs and KPIs	Comillas Pontifical University
4	Appropriate new market instruments for RES-E to meet the 20/20/20 targets	TECHNOFI
5	Modelling of electricity market design & quantitative evaluation of policies for post-2020 RES-E targets	SINTEF Energy Research
6	Conclusions, recommendations and procedure guidelines	SINTEF Energy Research
7	Dissemination to stakeholders	WindEurope
8	Intelligent Energy Europe (IEE) Common Dissemination Activities	SINTEF Energy Research

FIGURE 23
Project partners location



Source: WindEurope

TABLE 5
Division of work and responsibilities of Market4RES partners

PARTNER ORGANISATION	COUNTRY	RESPONSIBILITY
SINTEF www.sintef.no/en/sintef-energy	Norway	• Project coordinator • Leader of work-packages ‘Conclusion, Final Recommendations and Guidelines’ and ‘Modelling of electricity market design & quantitative evaluation of policies for post-2020 RES-E targets’ • Main author of reports 5.2, D6.4, D7.4.2 (this publication) • Contributor to several other activities
Wind EUROPE windeurope.org	Belgium	• Leader of work-package ‘Dissemination to stakeholders’ • Main author of report D6.2 • Contributor to several other activities, especially in WP2, WP3 and WP6

PARTNER ORGANISATION	COUNTRY	RESPONSIBILITY
www.eeg.tuwien.ac.at	Austria	• Leader of work-package 'Opportunities, challenges and risks for RES-E deployment in a fully integrated European electricity market' • Main author of report D2.1 • Contributor to several other activities, especially in WP3, WP5 and WP6
www.solarpowereurope.org	Belgium	• Contributor to report D6.2 • Contributor to several other activities, especially in WP2, WP3, WP6 and WP7
www.3e.eu	Belgium	• Main author of report D2.3 • Contributor to several other activities, especially in WP2, WP3 and WP6
www.technofi.eu	France	• Leader of work-package 'Appropriate new market instruments for RES-E to meet the 20/20/20 targets' • Main author of reports D4.1, D4.2, D4.3, D6.1.1 and D6.1.2 • Contributor to several other activities, especially in WP2, WP3 and WP5
www.comillas.edu/en	Spain	• Leader of work-package 'Novel market designs and KPIs' • Main author of reports D2.2, D3.2, D3.3 • Contributor to several other activities, especially in WP2, WP5 and WP6
www.rte-france.com/en	France	• Main author of reports D5.1 and D6.3 • Contributor to several other activities, especially in WP4, WP5 and WP6
www.iberdrola.com	Spain	• Contributor to several activities, especially in WP2 and WP3
www.friendsofthesupergrid.eu	Belgium	• Main author D3.1 • Contributor to several activities, especially in WP3 and WP6

9. CONTACTS

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Photo: WindEurope

Market4RES is a EU-funded project that investigates the potential evolution of the current design of the European electricity market, the so-called Target Model, in a way that allows the sustainable integration of large amounts of renewable sources. This publication sets guidelines for policy makers in the implementation of electricity market design.

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