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Foreword

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The energy sector is at a turning point. Variable renewable energy sources and emerging technologies such as smart grids, storage and demand response represent both a challenge and an opportunity for the electricity system. Above all, there is a growing need for a new market design reflecting today's and future's energy framework in Europe setting the right conditions for ensuring security of supply and for urgently needed investments in energy infrastructures. At the same time, energy bills must not hamper economic recovery nor pose the threat of domestic energy poverty.

A resilient EU Energy Union with a forward-looking climate change policy is one of the European Commission's priorities. Affordable, sustainable and reliable energy supply is crucial to strengthen Europe's industrial competitiveness which is an essential driver for economic growth and job creation.

The urgency of climate protection measures as well as the dependency on energy imports require further action. The European Union has set out ambitious plans for a new climate and energy policy framework based on a more secure, sustainable and low-carbon economy, and substantial progress has already been made towards attaining the targets.

The EU is determined to reduce its greenhouse gas emissions by 40% by 2030 compared to 1990. A well-functioning, reformed Emissions Trading System (ETS) will be a key in this process. The EU has also committed itself to achieve at least 27% share of renewables by 2030 with the aim of encouraging private investment in infrastructure and low-carbon technologies. A target to increase energy efficiency by at least 27% will be reviewed by 2020 having in mind an EU level of 30% for 2030. In addition, the integration of rising levels of variable renewable energy sources requires a more and faster interconnected internal energy market, which should be coordinated as necessary at regional cross-border level. In this context, the European Council approved an additional target to increase the electricity interconnections between Member States by 15 % by 2030 and agreed to push forward important infrastructure projects.[1]

In this sense, already in 2013, the Joint Research Centre (DG JRC), the European Commission's in-house science service, organised in close cooperation with the Directorate-General for Energy (DG ENER), supported by the German Federal Ministry of Economics and Technology (BMWi), and European industry a series of Round Table discussions on scientific support to energy transition from a European perspective.

This report presents the main issues raised during these Round Tables. Topics addressed include the added value of European regional cross-border initiatives in particular with regard to electricity market design, scenario building for transmission and distribution grids, flexibility and balancing needs to better integrate renewables, energy mix development, and market liquidity needs.

[1] The European Council decision on EU 2030 Climate and Energy Policy Framework, 23-24 October 2014

Around 1.500 stakeholders from European and Member State authorities, energy utilities, transmission and distribution system operators, industry, financial services, and consumer organisations were involved in the Round Tables.

We would like to take the opportunity to thank all of those that participated in this process and contributed to making this report possible, aiming at contributing to a better science-based understanding of the current challenges of the energy transition including political, economic and technological aspects.

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Introduction

In 2013, the European Council agreed to increase efforts to build a fully functional Internal Energy Market taking into account the rapid evolution of energy systems with a growing share of intermittent renewable energy sources (RES). This came against a backdrop of serious profitability issues for conventional power generators and the competitiveness of European industry.

The setting of the EU Climate and Energy Framework for 2030 and beyond will shape the evolution of energy systems and markets, in a context of dramatic changes of the electricity sector in the light of the increased use of intermittent renewable energy sources. The large-scale deployment of RES creates new challenges for power generation, transmission and distribution.

Jean-Claude Juncker, President of the European Commission, identified a resilient European Energy Union with a forward-looking climate change policy as one of the ten priority policy areas of his mandate. Europe needs to join efforts to ensure the security of supply in view of external dependencies. A responsible climate change policy and affordable energy in the medium term require strengthening the share of renewable energies and enhancing energy efficiency beyond the 2020 objectives.

This report presents the main lines of arguments and discussions among the participants of a series of four Round Tables on Scientific Support to Energy Transition from a European Perspective hosted by the Joint Research Centre within its European Forum for Science and Industry between July and December 2013. Participants from the electricity sector, industry, financial services, consumer organisations and European and Member States authorities held discussions on the key questions outlined below:

- Integration of renewables: How should renewable energy sources best be integrated into grid and market to make renewable electricity production more responsive to system needs? How and at what costs can the increased need for flexibility of generation and energy demand be provided?

- Grid operations: Is the traditional focus of networks well placed to fully accommodate the on-going process of energy transition and to provide the security of supply in a least-cost approach? How to improve cross-border cooperation? What can be learned from existing initiatives of regional and bilateral cooperation between grid operators and regulators? Would common minimum standards for data quality from power plant operators help to create forecasts to optimise regional balancing power markets?

- Market design: In order to ensure the security of supply, what is the need of coordination in/between Member States for balancing, re-dispatch and storage? How to improve the convergence of renewables support schemes? Which role could European regional markets play in coordinated scenario building in view of asset optimisation?

- Financing issues: What are the market-based tools able to create the right conditions for investment in generation, transmission and distribution? Which governance framework is needed to trigger more capital for investments? Which are the interactions between energy

and financial markets to be taken into consideration in favour of lower electricity prices to consumers?

In order to cope with a growing need for flexibility in electricity production and consumption, Member States may consider more intensive regional cross-border co-operation. This could be pursued within and/or among countries interested in joining forces with regard to security of supply. Beyond market coupling, a cross-border approach should also encompass modernization and expansion of the grids and other infrastructure, as well as power generation development including RES. The need for closer cooperation in a bottom-up approach, especially between TSOs/DSOs[2], was highlighted at the Round Tables.

During the Round Tables the question arose how to develop common principles and technical standards for cross-border solutions, in order to ensure the security of supply and cost efficient RES integration. This would imply political answers on how to develop common energy policy approaches, complementing market design/market rules and appropriate technical standards (e.g. network codes) for cross-border solutions to ensure the security of supply and cost-efficient RES deployment. Such common approaches could consist of common and coherent scenario building and planning (as elaborated in Chapter 2) with regards to interdependencies between generation, transmission, distribution and storage of power. Such a common approach should also include monitoring and assessment of the implementation in participating countries, while fully respecting national and EU level competences in the energy field set out in the Treaty.

The Round Tables also widely recognised the need to improve the quality of data collection on power generation and grid operations. To this end, information sharing between power generators and grid operators should be enhanced to better understand existing and expected trends, and to better incorporate this information in coherent grid development and planning procedures.

Participants saw a growing need for a new market design reflecting today's energy panorama in Europe. A reshaped market design will have to take into account the increasing amount of volatile generation in the electricity mix. It needs to secure sufficient firm capacity and to address, explore and incentivise different flexibility options in wholesale and balancing markets. Regulatory framework conditions for investment in power generation, transmission and distribution, as well as in storage and demand response need to be further assessed in order to ensure the reliable and affordable supply of low-emission energy in the mid- and long-term.

Experiences in Member States with a high share of intermittent RES show the added value of planning and managing the energy transition at national but also at regional and European level. This should take into account that national energy policy decisions may impact other Member States. This entails a delicate balance between sharing responsibilities and keeping sovereignty, given that energy mix choices are national competences.

[2] This applies especially to regional DSOs operating in larger areas at the 110 kV-level

1. Internal Energy Market

The participants of the Round Tables expressed their expectation of a proactive and integrated EU-approach to the EU 2030 Climate and Energy Policy Framework bringing together all key actors.

As to the question of how to steer power generation, grid development and energy mix most effectively, participants stressed that **current market patterns may be unable to safeguard security of supply and price development in the long run.** They underlined the urge for a comprehensive analysis of generation capacity as spelled out in Communication of the Commission on state intervention in electricity markets[3]. **The EU could play a role in facilitating the coordination of regional initiatives and load management at a regional cross-border level. The involved Member States could adapt the framework according to specific regional needs.**

To complete the Internal Energy Market, the current governance-setup with a mix of Member State sovereignty and legislation as well as action on the European level should be improved. In order to do so, Member States and market participants should elaborate more effective cross-border coordination. It is also crucial to mention that climate policy and energy policy are closely linked and need to work together.

The European Commission's 2030 Climate and Energy package[4] called for the development of national plans for competitive, secure and sustainable energy, creating an inventory of key indicators at European level which will help to simplify and streamline the current separate processes for reporting on renewable energy, energy efficiency and greenhouse gas reduction. A consolidated governance process to establish effective cross-border governance among Member States could help to ensure that EU policy objectives for climate and energy are delivered. A consolidated governance process could be based on a mix of Union measures and national measures described in Member States' national energy plans and lead to greater coherence of Member States' approaches and thus promote further market integration and competition.

Participants noted that European-wide coordination should be implemented within regions; also neighbouring countries like Switzerland, Norway or the Western Balkans should be involved for enhancing the efficiency of the overall system.

It was stated that regional initiatives should be reinforced by Network Codes proposed by ENTSO-E and to be assessed if appropriate as a tool for completing the Internal Energy Market. Participants highlighted the importance of European standards and norms that should give a common framework with the possibility for national and regional cross-border shaped designs.

Overall, it was emphasised that the potential of the Internal Electricity Market could be better tapped, especially through cross-border planning and operations of grid infrastructure appropriate to further development of generation and storage capacities.

[4] Although not discussed at the Round Tables, the package published in January 2014 has to be taken into account. COM(2014) 15

2. Cross-border approach

Round Table participants emphasised that regional cross-border approaches could help with the challenges of grid stability, generation adequacy and rising electricity prices. Taking into account that national energy policy decisions have a possible impact on other countries, Member States should encourage cross-border communication and coordination of national targets with regard to their energy mix and grid expansion. They could explore advantages of cross-border participation (e.g. in national capacity solutions).

Member States could address regional adequacy by e.g. the establishment of joint capacity registers, dispatch and other mechanisms or markets. There is a need for stronger cross-border interconnections in order to attain a more efficient and effective regional electricity exchange. This would be particularly effective if there were important storage capacities in the region or if demand peaks for electricity varied for different Member States.

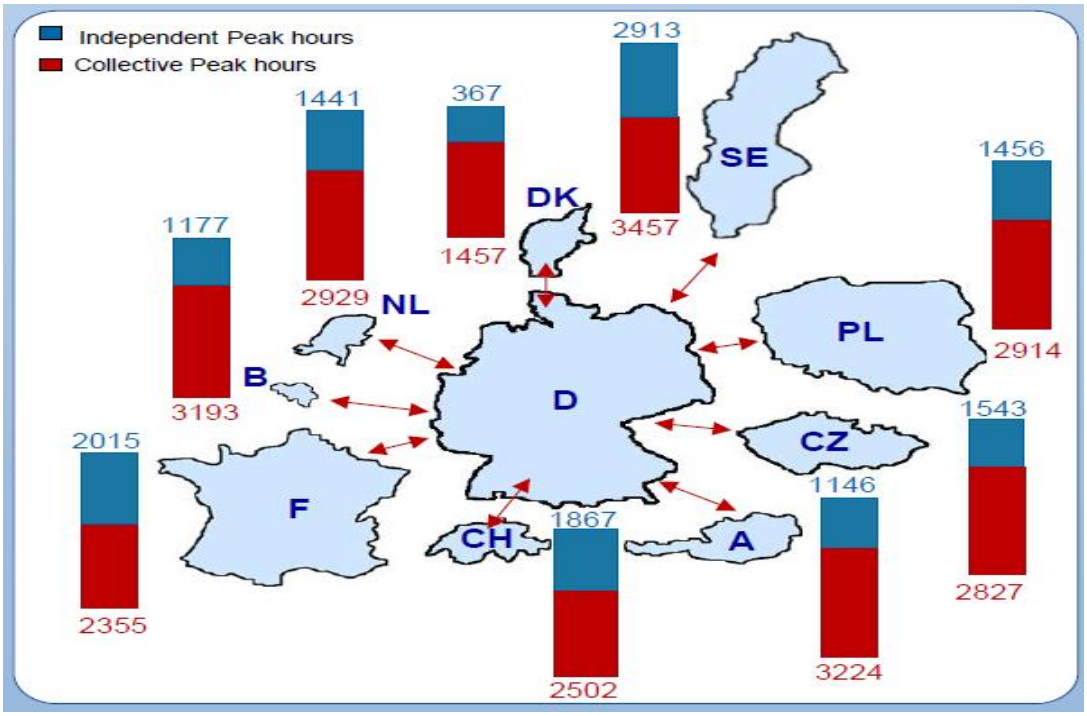

Figure 1: Simultaneous and non-simultaneous peak hours in Germany and its neighbouring countries. On the one hand, the figure shows that a significant portion of peak demand occurs simultaneously in different countries (Collective Peak hours). On the other hand it shows that some of the demand is non-simultaneous (Independent Peak hours) which might give scope for cross-border approaches. Opening capacity mechanisms to neighbouring countries could help to make them more cost efficient and competitive.

Source: Matthias Dürr, Head of RWE Liaison Office in Brussels, (2013) *What potential do regional initiatives have for the expansion and progressive integration of regional cross-border energy markets?*, retrieved from: https://ec.europa.eu/jrc/en/event/scientific-support-capacity-markets-and-integration-renewables-9935

Permit procedures and expropriation rights differ between Member States, which leads to different speeds for building interconnectors. Projects of Common Interest (PCI) may play an important role to speed up the development provided that there will be faster and more efficient permit granting procedures. Experience has shown that regional initiatives were already used for bottleneck management.[5]

There are many regional initiatives in Europe working primarily at a technical level towards improving the high-voltage electricity system. TSOs, power exchanges and market participants under the coordination of regulators are developing harmonised market and network operation rules (e.g. Network Codes). The target model for the design of European electricity markets, based on network codes and related guidelines, foresees price coupling of national and regional markets through power exchanges with harmonised market operations. This should help to optimise capacity towards flow based rolling risk forecast (presently 48 hours). So far this happens primarily only bilaterally between Member States. Stronger cross-border coordination between regulators, grid operators (at TSO and at DSO level), and power generators could help e.g. to improve security of supply, cost efficiency and integration of RES. Two important pre-requisites are energy infrastructure and a governance model.

The question was raised whether the target model based on network codes will provide a common governance model and common scenario standards or if the allocation of roles and responsibilities between TSOs and DSOs, regulators and market participants will need additional (regulatory) guidance. Participants emphasised that a combination and mutual reinforcement of bottom-up (regional security coordination centres) and top-down elements (European Network Codes) is crucial.

Furthermore, some participants underlined that cross-border optimisation of RES locations could lead to overall net savings even taking into account additional costs for the accompanying grid expansion.

2.1 Common scenario building and the energy mix

The Round Table participants highlighted possible efficiency gains of a more coordinated approach in planning and developing energy infrastructure and power generation. In this frame, national competences do not contradict the need for more intense coordination at EU-level. A comprehensive analysis of generation capacities including cross-border aspects is needed.

As explained in the chapter above, the development and reinforcement of the grids including cross-border interconnectors could help to optimize efficient power balancing. Common scenario building between regulators, grids operators and market participants is an important pre-requisite.

The TSO-DSO interface is becoming more important as a large part of RES is integrated at the distribution grid level. DSOs play a role as information hubs and as system managers (voltage control, data management, and congestion management). In view of system efficiency, it would be beneficial if DSOs exchange their data and information in a TSO-DSO

[5] CORESO et alia established on a contractual basis by companies (TSO)

interface. A joint interface between TSOs and, at least, large-area DSOs as well as generators providing firm capacities, could cost-effectively facilitate data collection and analysis. Such analysis could give an excellent overview of the market and set the basis for common scenario building. In this context, addressing data protection issues is a prerequisite.

Network Codes should allow adaptation of future solutions and regional-level initiatives according to the principle of energetic subsidiarity. Critical situations should - with priority - be solved where they occur, and EU and national regulation should allow and support market participants to do so. **There is a need to be able to plan a network combining European and local elements.** Coordination of procedures is a long chain from investments via scenario-building and planning through to markets. The closer market action and reaction is to real time, the greater the need for regional security centre initiatives (RSCIs) for an operational exchange on problems and actions harmonised by legal stipulations. Regional cooperation can help to deliver a manageable situation to e.g. national control centres. Open tools could play a role in facilitating a collaborative approach in order to avoid black boxes. In an ideal world this would be controlled independently of business interests.

2.2 Security of supply

The participants of the Round Table emphasised that the security of supply should be assured by non-discriminative, technology-neutral and cost-efficient solutions in shared responsibility of all power plant operators. **One question asked by participants was why customers should have to pay for intermittency instead of the intermittent generator? Some participants pointed out that the issue of intermittency should be seen from a holistic point of view also addressing intermittency of demand.** Ideally, reliable supply should be established through market prices and not through subsidies.

Other participants of the Round Table noted that security of supply is not only a responsibility of power plant operators but also a duty for the grid operators. They argued that to some extent, also prosumers should contribute to the security of supply.

One should take into account more flexible and cost-effective cross-border instruments for backup capacities and overcome the so far country-based definition of security of supply. From a perspective of integrating intermittent RES, adequacy should be looked at in a regional context to examine how to support neighbouring regions in deficit situations. In this context, participating Member States would benefit from consistent, potentially even common criteria regarding (e.g.): (i) stability of balancing, (ii) voltage, (iii) frequency, and (iv) dispatch especially of firm capacity in primary and secondary control.

The more electricity generation is decentralised, due to RES or other forms of micro-generation, the more important becomes the shared responsibility for centralised data needed to model and operate network systems. Some participants referred to the need for an efficient use of conventional and RES generation capacity in combination with the grids before considering additional storage options. To this end it is important that all new RES generation capacities, including in the kW-range, are integrated into the market. Moreover, the existing

potential of flexible generation could be incentivised either by additional capacity payments or by wholesale prices reflecting balancing costs.

Participants discussed how to develop and tackle power generation issues which are interdependent to transmission, distribution and storage planning. Some elements were mentioned as possible backbone for system stability and security of supply, such as joint security systems[6] at Member State level taking into account grid extension and RES integration.

2.3 Grid infrastructure

Participants of the Round Tables emphasised the role of network infrastructure to reinforce the security of supply and technical integration of RES. The European Commission identified investment needs only of transmission and distribution grids of about 600bn Euro in Europe between 2010 and 2020.[7] Network reinforcements are particularly needed on the distribution level (400bn Euro) as approximately 95% of RES are fed in at the distribution level.[8]

The main challenges are frequency and voltage control, data management, and possibilities to intervene more quickly including reactive power management. **The more balanced the situation is at the local level, the fewer tasks need to be handled via the transmission system.** The implementation of a flow based capacity allocation mechanism, which takes into account the network topology and grid constraints could significantly improve grid utilisation. The additional costs, mainly for power plant operators, have to be analysed in view of their impact on wholesale prices.

The added value of a European Electricity Highways System was underlined: Peak demand of energy is high in winter in Northern Europe and in summer in Southern Europe. **Currently, insufficient interconnections are setting limits to additional capacity transfer that could close future gaps between supply and demand.** The Baltic countries, Scandinavia and the Iberian Peninsula need to be better connected to the European grid. Permit procedures and expropriation rights differ between Member States, which leads to different speeds of building interconnectors. National regulators could contribute to solutions and agree on cross-border issues. There is a need for coherent dialogue at European, national and regional level.

Business cases for the extension[9] of electricity transportation need to be considered carefully in view of costs and competitiveness. RES producers to date usually do not have to contribute to the costs of collecting, transporting, distributing (or storing) the electricity they produce. These costs

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[6] TSO/DSO and regulators, if required together with operators of firm capacity assets, relevant for the security of supply

[7] Approximate figure from DG ENER calculations based on data from PRIMES, ENTSOs, KEMA etc.; see also: Klaus-Dieter Borchardt, Director, Internal Energy Market, DG Energy, European Commission, (2013) *Towards a single energy market - required investment in gas & electricity infrastructure*. Retrieved from: https://ec.europa.eu/jrc/en/event/scientific-support-energy-markets-28063

[8] Offshore wind parks and other sources will eventually change this pattern.

[9] Cross-border as well as within countries in length (km) as well as into higher voltage levels: e.g. 500/800 kV DC.

are covered by network and user tariffs. **A robust cost-benefit assessment of decentralisation has to be done from an energy system perspective accounting for additional costs for grid and storage capacity extension.**

There is global competition for the financing of infrastructure projects and we need a stable regulatory framework that drives investments. One has to clarify the conditions under which investors can invest in both generation and related infrastructure and to what extent unbundling or other regulatory changes may move investment risks.

There is a need for European and national financing institutions to bridge gaps in financing (e.g. Connecting Europe Facility). Projects of Common Interest (PCI) would benefit from faster and more efficient permit granting procedures.

The main points of discussion can be summarised as follows:

- The current enhancement of infrastructure is not keeping up with the expansion of RES power generation capacity, which risks increasing system instability: Fast power-load changes from intermittent RES power production, in a magnitude that imperils system stability, stress grids and fuel based generation assets more frequently and closer to their limits. Smarter distribution networks could lower transmission line needs.
- There should be no discriminatory treatment to any grid users in terms of ancillary services, congestion management and balancing. This might require more coordinated action.
- There is a need for reinforced cross-border cooperation for balancing power. This might require a new governance model between regulators and grid operators (TSOs & DSOs) in Member States within their respective European region.
- Macro-economic beneficial interconnector projects should be made top priority in regard to national subsidies for new generation capacity as subsidies as such would imply unnecessary costs.
- It is important that top-down approaches (e.g. Network Codes) comply with and support bottom-up solutions at regional level following the concept of energetic subsidiarity (The idea of this concept is to give priority to least-cost measures in the process beginning with the lowest appropriate level in order to manage as much renewable energy as possible at local and subsequently regional level).
- More research and innovation related to grids is needed, e.g. on optimisation through better regional interconnection, more flexibility (including storage technologies) and a better demand response (including reactive power concepts).

2.4 Storage

The Round Table participants recalled that the intermittent nature of wind and solar energy requires back-up generation or cost-effective storage solutions. Currently, the majority of electricity produced by RES is fed into the grid directly, in real time. Energy storage could help the integration of RES in two ways: In the short term, more effective energy storage could be used to increase flexibility by mitigating intermittency related to the feed-in of RES. Over a longer period, large storage capacities could allow seasonally produced of RES to be used in any period of the year in

order to secure the energy needs and reliability of supply that are currently met mainly by fossil fuels.

Participants highlighted the need for further research and development (R&D) and ongoing demonstration projects which examine and test business models for storage solutions. In addition to pumped hydro storage, district heating and combined power and heat, larger additional storage potentials could be offered in the future by power-to-gas and enhanced battery technologies (e.g. redox-flow, hydro-storage beyond conventional, compressed air, central/decentral storage solutions like system-adequate off-peak storage heating). This depends also on effective public framework conditions for the deployment of these technologies.

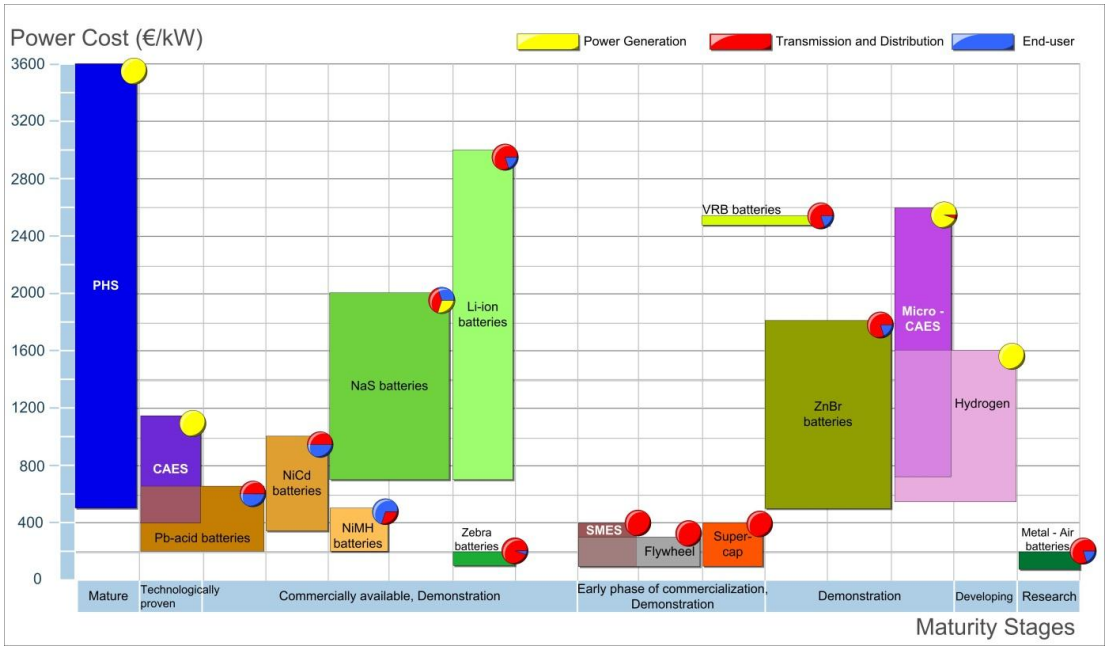

Figure 2: Power storage technologies as a function of their cost and development stage. Today, only pumped hydro is able to facilitate grid scale RES integration.

Source: Stathis Peteves, Head of Unit, Energy Systems Evaluation, Joint Research Centre, European Commission, (2013) *Technology Aspects of the Energy Transition.* Retrieved from: https://ec.europa.eu/jrc/en/event/scientific-support-energy-mix-27972

Some Round Table participants argued that intelligent combinations of conventional and RES power generation capacity in combination with grid solutions could avoid the need for complex storage systems at extra costs. Strong grids could be part of a very effective and economic solution for flexibility.

Other participants underlined that with a RES share exceeding 30%, grid solutions might become insufficient and curtailment or storage might be required. Energetically it might sometimes be preferable to curtail RES rather than to store. If it is decided to enhance the development of new storage solutions, then R&D investments and effective public framework conditions are needed.

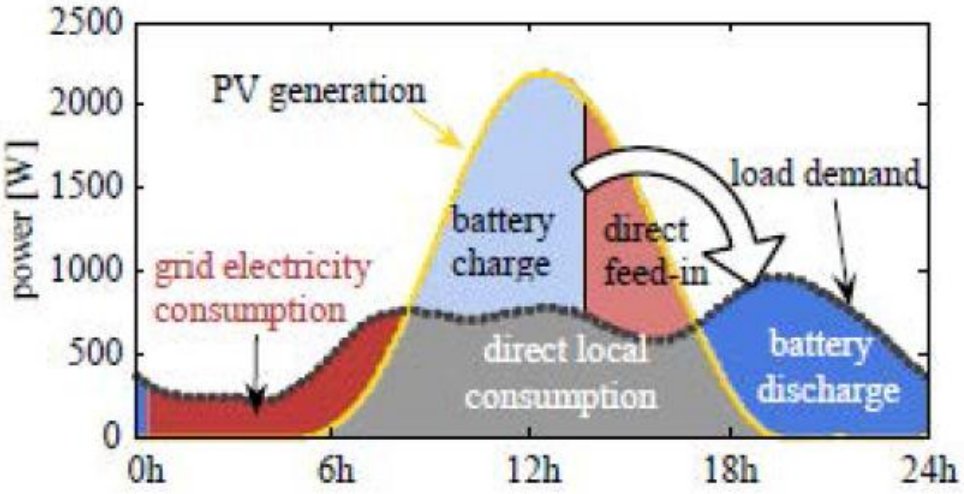

Figure 3: Energy storage systems for households. A combination of a residential PV system with a battery system can store the solar energy of very sunny hours for periods of peak demand or when there is no sun, allowing self-consumption or grid support. The key benefit is the reduced impact of intermittent injection to the grid, thus allowing a higher penetration of PV energy in the electricity mix.

Source: Håkan Feuk, Vice-President for Policy and Regulatory Affairs, E.ON, (2013) *Integrating RES-E into the market*. Retrieved from: https://ec.europa.eu/jrc/en/event/scientific-support-capacity-markets-and-integration-renewables-9935

The biggest share of RES capacity is in private hands. If small scale storage (e.g. batteries, compressed air) becomes a business case then these RES producers can not only feed in but also fit in the grid. In combination with smart demand response, storage could help to alleviate energy demand spikes (smart home-energy control systems, electric vehicles, etc.).

The JRC published a report *Assessing Storage Values in Energy Markets.*[10] The study identifies the most relevant issues that electricity storage is facing. There is no universal answer on whether storage is a profitable investment or adds value to the system. The storage business case is strongly affected by technological parameters. For less mature technologies (batteries, hydrogen) those parameters are still evolving.

The impact of market designs and capacity mechanisms on RES related storage deployment need to be better understood. **The business case for energy storage will be affected by the ongoing regulatory discussion on market design, rules for RES integration, considerations on ownership and operation of storage.** The potential of pumped hydropower energy storage in suitable mountainous topologies might allow regional, cost-efficient integration of intermittent RES. In Europe, the installed capacity of pure pumped hydropower energy storage amounts to approximately 40 GW_{el}. The capacity of planned or ongoing projects in Europe is estimated to about 7 GW_{el} to be built by 2020. The JRC report on "Assessment of the European

[10]A. Zucker, T. Hinchliffe, A. Spisto, (2013) Assessing Storage Value in Electricity Markets, JRC Scientific and Policy Reports. http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/29496/1/2013-10-09%20edf%20jrc%20power%20storage%20final%20%20%28online%20version%29%20.pdf

potential pumped hydro power energy storage" shows that the theoretical potential in Europe is significant.[11]

A comparison with the existing pumped hydro power storage reported in 14 countries suggests that the theoretical potential with existing reservoirs is 3.5 times the current capacity whereas the realisable potential based on additional reservoirs is 10 times as much as the existing capacity.

2.5 Cost transparency and symmetry of information

Round Table participants underlined the importance of cost transparency and symmetry of information for decision making.[12]

There is a need for a (standardised) method to disaggregate and express the real cost of energy including commodity cost, transmission/distribution, balancing and re-dispatch, subsidies, and costs for capacity mechanisms.

At present some relief measures are mooted for fuel based power plants, like the removal of price ceilings for trading electricity ("Energy-Only Market 2.0"), or subsidies for capacity supply ("Strategic Reserve"), etc. However, there is a risk awareness of undesirable development through malpractices within the merit order which could hardly be detected and verified by cartel authorities.

Transparency, standards and sufficient data in quality and quantity at a near-real-time level will allow market participants to be more responsive to flexibility needs and to optimise assets and operations.

Grids are facilitators which need to take into account all system elements, generation, storage, and the market model. This requires all major stakeholders (regulators, TSO, DSO, generators, flexible consumers, etc.) to discuss the key issues for standards to be implemented throughout Europe in a regional cross-border strategy.

[11] M. Gimeno-Gutiérrez, R. Lacal-Arántegui, (2013) Assessment of the potential for European pumped hydropower storage, JRC Scientific and Policy Reports.
http://ec.europa.eu/dgs/jrc/downloads/jrc_20130503_assessment_european_phs_potential.pdf

[12] The European Commission published in January 2014 an in-depth analysis of energy prices and costs in Europe: http://ec.europa.eu/energy/doc/2030/20140122_communication_energy_prices.pdf

2.6 Balancing and flexibility

The quick expansion of RES in some regions led to mismatches primarily with grids. The Round Table participants emphasised that today, **most RES are connected to distribution grids and could be balanced in the region itself, reducing the tasks for the transmission grid.**

However, the precondition would be a full market integration of RES, including at the kW scale. Better coordinated management of balancing of power between grid operators (power generation and grids) together with strong grids and the integration of demand response would make the integration of RES more cost-effective. In this context, one needs to be aware of the fact that for power generation, an increasing amount of interventions (primarily re-dispatch by TSOs) shorten life times of power generation assets, drives maintenance costs and thus poses additional profitability risks for investors. **All energy producers should have to accept balancing responsibility and no distinction should be made between RES and conventional power.** Grid operators, generators, power exchanges, and consumers should be able to participate in the balancing process. The responsibility and impact of balancing on the cost structure, which is currently reflected in grid fees, should be shared more fairly, including all actors. Consumers (industry and households) should be economically incentivised to contribute to solutions leading to more flexibility.

To integrate a high share of RES, well-planned balancing is needed. Participants underlined that the technical integration of RES is mainly a distribution issue where voltage control and congestion/overload are the main challenges. Market parties (grid operators, power generators) need to be able to obtain relevant data from power generation and smart meters close to real-time in order to balance the network more effectively. **Harmonisation and integration of market based balancing services would provide grid operators with more opportunities to reduce the costs of balancing and to minimise the distortion of imbalanced settlement prices.**

Weather forecast systems can also contribute to analyse and better integrate RES generation. This includes short-range weather forecast as well as medium and long-term geographical data on solar radiation, wind weather patterns, biomass resources as well as water resource data.

Common or at least interoperable standards for digital control technology could then allow more precise control of power generation to match the current demand situation. In order to manage a higher amount of intermittent RES at adequate cost, smart design options combining different sectors should be further evaluated. **New forms of cooperation between utilities, industry (e.g. chemicals) and transport (e.g. electro-mobility) could be established. In this context, DSOs could act as moderators, enablers and facilitators helping to integrate RES.**

The more balanced the situation at the local level, the fewer tasks need to be handed over to the transmission level. Existing infrastructure should be used in innovative ways to create and reach most cost-effective solutions for partial local generation adequacy and thereby reducing tasks for the transmission grid level. The development and reinforcement of the grids – including cross-border interconnectors and common scenario-building between regulators, generators and grids operators – could help to optimize efficient power balancing.

2.7 Dispatch

Priority dispatch for RES in combination with re-dispatch of fuel based power plants has had a detrimental effect on market functioning. **Wholesale prices dropped dramatically with RES operating at near zero marginal cost. In the current system, conventional power production units are mainly used in load-following mode to help stabilise the electricity grid.**

In case of re-dispatch of fuel-based electricity by the TSO, only marginal costs are paid and the utility makes little (coal) or not sufficient (gas) profit to further invest in, maintain and run fossil fuel based power plants. This makes the use of conventional power plants, including high-efficient and low emitting state-of-the-art generation units, increasingly economically unattractive, preventing further investments. Therefore, priority dispatch for RES can have negative effects on carbon emissions depending on the merit order for power plants used in load-following mode. Furthermore, re-dispatch should leave fuel based power plants financially indifferent, compared to power generating assets which are not re-dispatched. Costs for dispatch and re-dispatch should also be transparent.

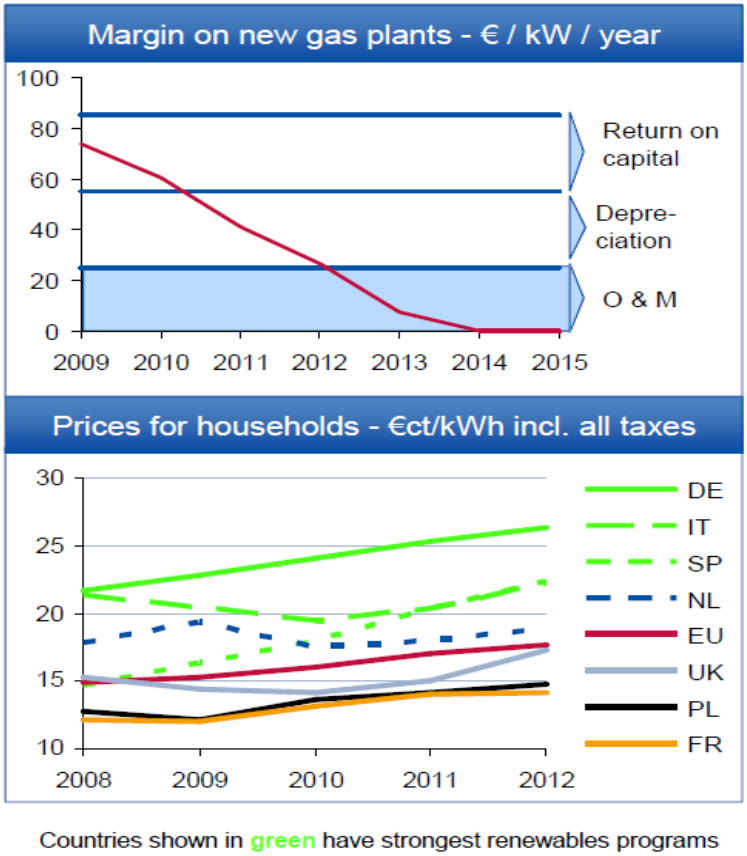

Figure 4: The current margins for electricity generation force many conventional power plants out of the market, which endangers the security of supply in the future. At the same time, electricity prices raise the most in countries with the strongest RES programmes. The reasons being: Costs of RES support schemes, grid adaptations and costs of firm capacity backups in load following mode.

Source: Graham Weale, Chief Economist, RWE AG, (2013) *Which market design can enable a secure, low-carbon power supply at lowest cost?* Retrieved from: https://ec.europa.eu/jrc/en/event/scientific-support-energy-markets-28063

Participants noted that there is a **need to think about the milestones of a relatively long transition period, supporting the gradual phase out of subsidies and mitigating priority dispatch for technologies that have reached maturity level.** It was discussed that, **with a RES share of 30%, RES curtailment or RES storage might be required, and that depending on the storage cost it may sometimes be preferable to curtail RES rather than to store.**

Round Table participants highlighted the need for an appropriate future dispatch model taking into account balancing responsibility.

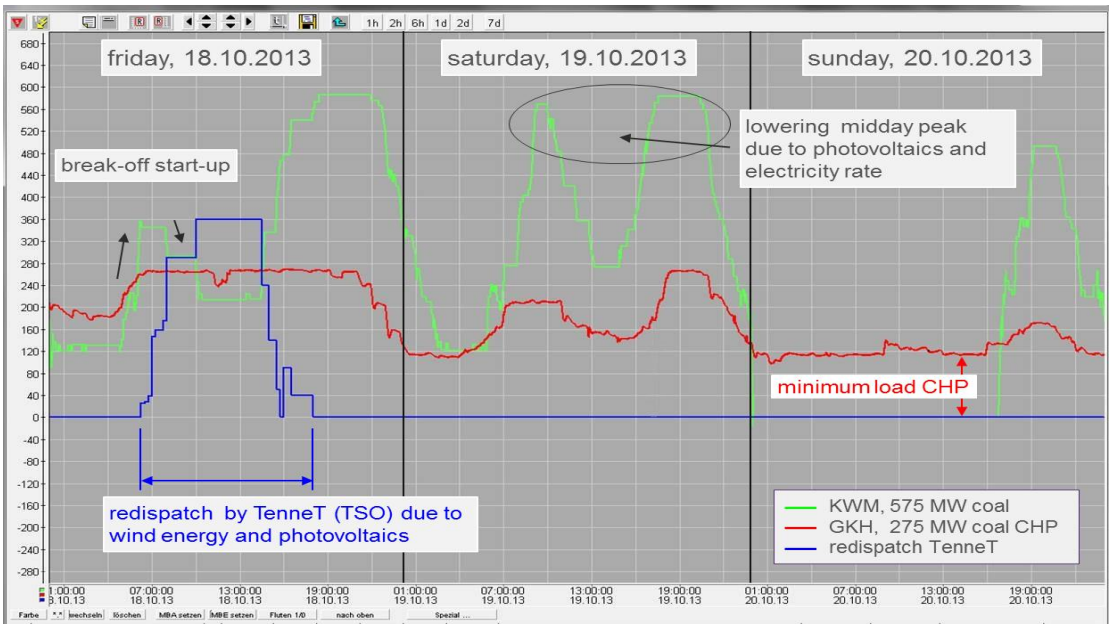

Figure 5: Example of power generation of two German coal power plants in load-following mode with re-dispatch (left) due to priority dispatch of RES, partial load (middle) due to low energy prices and high RES production at midday and idle status (right). There is a trend towards lower base and peak prices for electricity generation, while marginal costs increase when conventional power plants are in load-following mode.

Source: Christoph Kollenda, Head of Department, enercity - Municipal Energy Supplier Hannover, Germany, (2013) *Wettbewerbsfähigkeit und Flexibilität in Zeiten der Energiewende*. Retrieved from https://ec.europa.eu/jrc/en/event/scientific-support-energy-mix-27972

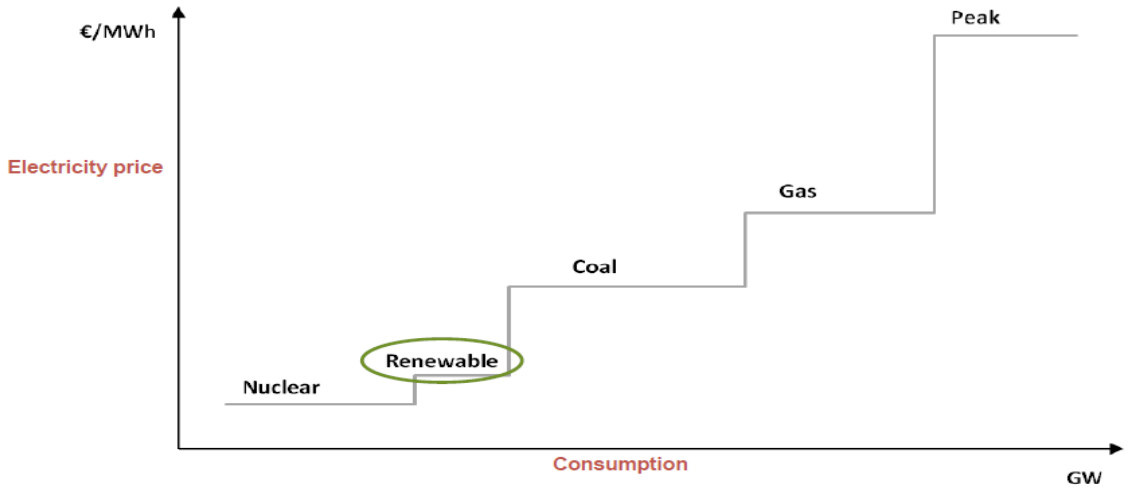

Figure 6: The merit order of short-run marginal costs of available energy sources underlines that even without RES priority dispatch, RES with near zero marginal cost will still dispatch on the energy market before conventional power plants as long as the integration cost of intermittent energy sources is not taken into account.

Source: Olivier Musset, Global Head of the Energy Group, Natural Resources and Energy Financing Group, Société Générale, (2013) *Financing Perspective*. Retrieved from: https://ec.europa.eu/jrc/en/event/scientific-support-energy-markets-28063

2.8 Demand response

During the Round Table discussions the need was mentioned to **set incentives for modernising and increasing demand-side flexibility on a voluntary basis.** Demand response measures could provide a strong economic signal and play an important role in providing affordable and competitive prices for consumers (industry and households).

Demand-response could lead to a system with a more flexible profile if end-consumers could benefit from cheaper off-peak electricity prices. Electricity intensive industries as well as regional or municipal utilities are particularly suitable for demand response programmes. Various industrial processes and district systems can offer additional advantages, such as thermal storage or the use of distributed generation through combined heat and power (CHP) systems. Also commercial consumers with large loads (e.g. refrigerated warehouses) are well suited to participate in a smart electricity system.

Currently, end-users do not face marginal energy prices but unit prices, which stay the same regardless of the marginal energy price. This discourages consumers to participate in demand response measures as the financial incentive is missing. A more capacity-oriented pricing could mitigate this situation. DSOs/LSOs have a proximity contact with consumers, and could help to manage consumption and demand response. Smart home-energy control systems could allow households to play an active role and to buy and sell (e.g. with photovoltaic and storage) at optimum prices. Decision making by smart consumers could benefit from: (i) time-based price signals (e.g. hourly feed-in), (ii) energy management systems to control appliances and equipment, and (iii) access and respectively shift to the day-ahead market. Their implementation will require technical solutions that could facilitate their take-up by lay people.

3. Market design

Participants emphasised that **energy markets today are increasingly pan-European in a global context.** New market designs should be developed from a European perspective especially with regard to security of supply and be more coordinated to improve compatibility with the Internal Energy Market. Regional adequacy (establishment of e.g. joint capacity registers, dispatch rules and other mechanisms) is likely to also require action at national as well as cross-border level. A more structured cooperation also needs an appropriate allocation of tasks. Legislative adjustment is needed in relations to TSO/DSO role models, energy trading tasks, and the target oriented efficiency of unbundling rules. The challenges in the energy transition could be managed more efficiently if grid operators and power generators could synchronize their planning of actions based on rules for shared information and responsibility for security of supply. **Some participants indicated that ownership unbundling unintentionally tends to undermine on-going and much-needed coordination between grid operators and power plant operators.**

In order to ensure future security of supply, market design needs to foster investments in firm capacity, storage and demand response technologies. The market should be able to remunerate flexibility. At the same time, it should minimise barriers to participate in the Internal Energy Market and thus should strengthen competition. The European Commission has published guidelines on public intervention in electricity markets, addressing

further market integration of RES support.[13] The majority of participants saw a need to phase out priority dispatch gradually and to introduce balance responsibility for RES and increase cross-border trade in RES as soon as possible.

Currently, the costs of RES and conventional power generation are not comparable at the same level in the same system as long as direct and indirect subsidies are not factored out in a transparent manner. There are not only direct costs due to subsidies, but also indirect costs due to distorted market prices, intermittency, and higher grid fees. At the same time, there is a trend towards lower base load and peak prices for power generation, while average costs increase due to partial load operations of power plants in load-following mode (resulting from priority dispatch of the growing share of RES). The European Commission has published a communication on energy prices and costs in Europe.[14] Some participants noted that the externalities of power generation beyond CO_2-emissions are not harmonised, with distorting effects on competition between operators within and across borders.

In some Member States, all RES volumes sell on the market irrespective of price, knowing they will be fully remunerated through – direct and indirect – subsidies. However equal rules should apply to all market participants. RES can participate already today not only in spot markets but also in intraday and longer term forward electricity markets. There is a need to analyse regulatory and market based incentives how to increasingly shift RES from spot to future markets and to fully integrate them in the forward, day ahead, intraday, and balancing markets. The governance-setup should be smarter and more Europe-wide, with better cooperation of power exchanges and the creation of regional virtual hubs to collect area information as required. There is no one-size-fits-all market design and every Member State/region has its own energy mix; common principles and minimum requirements should be explored.

Three pillars to enhance the political framework have been named:

- embedding transformation of the electricity system in one European level-playing field across technologies and borders with three priorities:
  - Security of supply
  - Market-based approach
  - Low-emission generation
- the most effective use of regional cross-border synergies, and
- ensuring the long term competitiveness of European industry.

Further proposals on a future-oriented market design were discussed, comprising e.g.:

- Symmetry of information for all market participants based on high quality and high-frequency sampled data
- Close cross-border cooperation between TSOs and DSOs (bottom up)
- Review of least-cost approach for the integration of RES with regard to competitiveness (e.g. auctions)

[13] C(2013) 7243

[14] COM(2014) 21

- The EU Emission Trading System (ETS) should focus on CO_2-emissions with regard to efficiency (g CO_2emission/kWh).
- Long-term storage capacity concepts should be developed in order to avoid stranded investments
- Capacity remuneration to ensure the security of supply with regard to sub-marginal revenues from wholesale prices
- Wholesale prices reflecting the full costs of generation, including CO_2-emissions and further externalities
- Cross-border balancing markets, including contribution to balancing:
  - between production and consumption (phase shifter, data exchange)
  - by all generators, including RES, and grid operators
  - through incentives for demand response
- Improved allocation of interconnection capacities

Participants saw a need for these measures in order to tackle the three biggest factors creating distortions:

- lack of investments,
- regulated price spikes,
- scarcities of rent.

This could be further supported through (i) new trading products of short notice at European energy exchanges (e.g. solar or wind bail-out hourly products, which can be bought in case RES cannot generate electricity); (ii) cost-efficient integration of intermittent RES and (iii) establishment of an European CO_2-emission market as key driver for decarbonisation. Further consideration is needed on how to revisit user price regulation and how to remove wholesale price caps.

In this context, the proposed split in two markets for commodity and for capacity has to be carefully analysed with regards to effects for further price developments and additional market distortions. National subsidy schemes and capacity mechanisms already in place need to be assessed in view of such a target model. One could for example design capacity mechanisms close to the distribution level. There is a need to analyse to which extent distributed generation can provide ancillary services, such as reactive power compensation.

Four elements of the distribution system need to be considered for the optimisation of costs:

- National power flow control concepts, with special regard to reactive power components;
- European standards with the possibility for national and regional cross-border designs;
- Efficient power balancing;
- Reduction of demand/supply asymmetry.

3.1 RES support and ETS

Round Table participants underlined the need to analyse the different national RES support schemes for best practice and to explore possibilities of more Europeanised approaches. A clear framework is needed to provide confidence to investors. From the investors' point of view, more clearly-defined roles and targets of all actors are needed.

Generous support schemes in some Member States helped to quickly expand RES share since the early 2000s. **The focus of RES support schemes was oriented on capacity growth (kWh-generation) and less on efficiency or demand.** As long as RES were a minor share in the energy mix, they were easy to integrate. **The future drivers of the roll-out of RES technologies should focus on the responsibility to maximise the economic efficiency and the system integration of a high share of RES.**

In many countries with higher RES share, this already raised issues of who ultimately pays the bill for non-market based support schemes, which shield investors from market risks and shift costs and risks to other actors (market-based generation, TSO/DSOs, and in the end to non-privileged consumers[15]). Support schemes should be embedded in a market-based approach (e.g. market based feed-in premiums, curtailment when prices are negative) in order to increase responsiveness to market price signals. **Maturity of a technology is reached gradually and support schemes should be adapted and eventually phased out, following closely the learning curve of the technology.**

Some participants pointed to the need of reducing the complexity and variety of RES support systems in Member States. They called for three basic criteria:

- RES-contribution to the reduction of CO_2-emissions,
- cost-efficiency of RES and
- technology-neutral support to RES.

[15] In case of a privileged consumer costs will not be shifted, but his risk will be to lose this privilege.

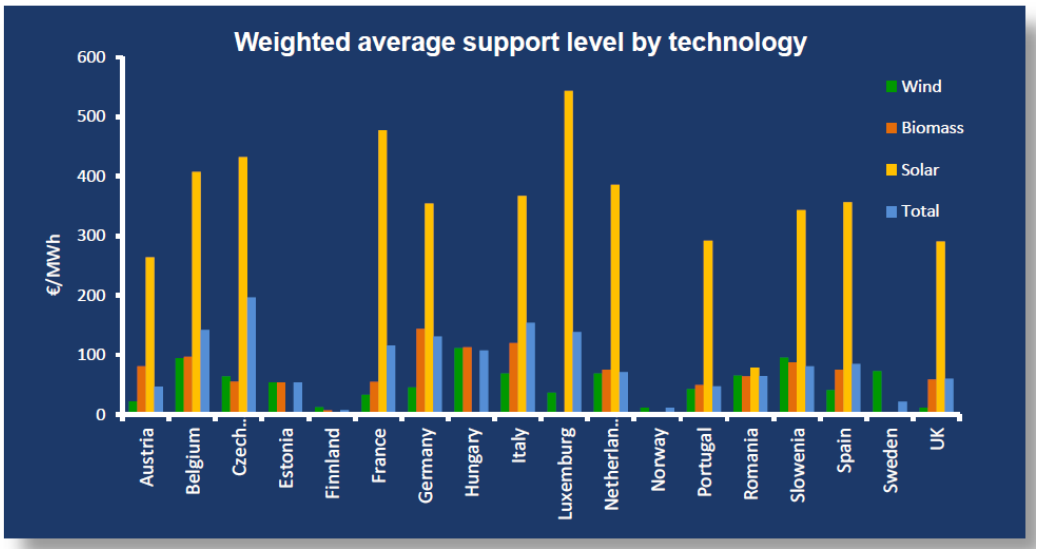

Figure 7: Market-based determination of support levels (integrating costs as well as benefits) suggests that technology specific support systems might reduce the efficiency of investment allocation (Data: Council of European Energy Regulators, CEER[16]). Quantitative RES goals should let the market decide on technology choices.

Source: Karen Pittel, Director of the Ifo Center for Energy, Climate and Exhaustible Resources, Representative of Euro-CASE Energy Platform, (2013) *Flexibility as a driver for a more market based energy mix*. Retrieved from: https://ec.europa.eu/jrc/en/event/scientific-support-energy-mix-27972

Round Table participants emphasised the need for common minimum and non-distortive requirements that make support schemes and their effects consistent. Member States could decide on how to promote RES in a local market according to economic and target-oriented effectiveness.

The JRC assesses generation cost for e.g. residential photovoltaic systems and prices for household electricity. Photovoltaic (PV) electricity cost maps show that PV can already compete in many regions without any support scheme and on the basis of household consumer prices.[17] Special attention should be paid to the question of whether the business case is based on avoiding paying grid tariffs and taxes or other fees, as this entails the risk that the power system will be developed suboptimally. In countries where PV contributes already to more than about 5% of annual electricity production, system operators are known to have difficulties in matching demand and supply. The extent depends on availability of local storage, back-up capacity and the demand pattern. In order to manage such situations, measures (e.g. curtailment) will be required. This could stimulate market solutions to utilise the excess power (e.g. battery storage for self-consumption or discharge to the grid when the load demand is higher).

[16] Status Review of Renewable and Energy Efficiency Support Schemes in Europe, CEER, 25 June 2013, Ref: C12-SDE-33-03

[17] H. Ossenbrink, T. Huld, A. Jäger-Waldau, N. Taylor (2013), Photovoltaic Electricity Cost Maps, JRC Scientific and Policy Reports.

http://iet.jrc.ec.europa.eu/remea/sites/remea/files/reqno_jrc83366_jrc_83366_2013_pv_electricity_cost_maps.pdf

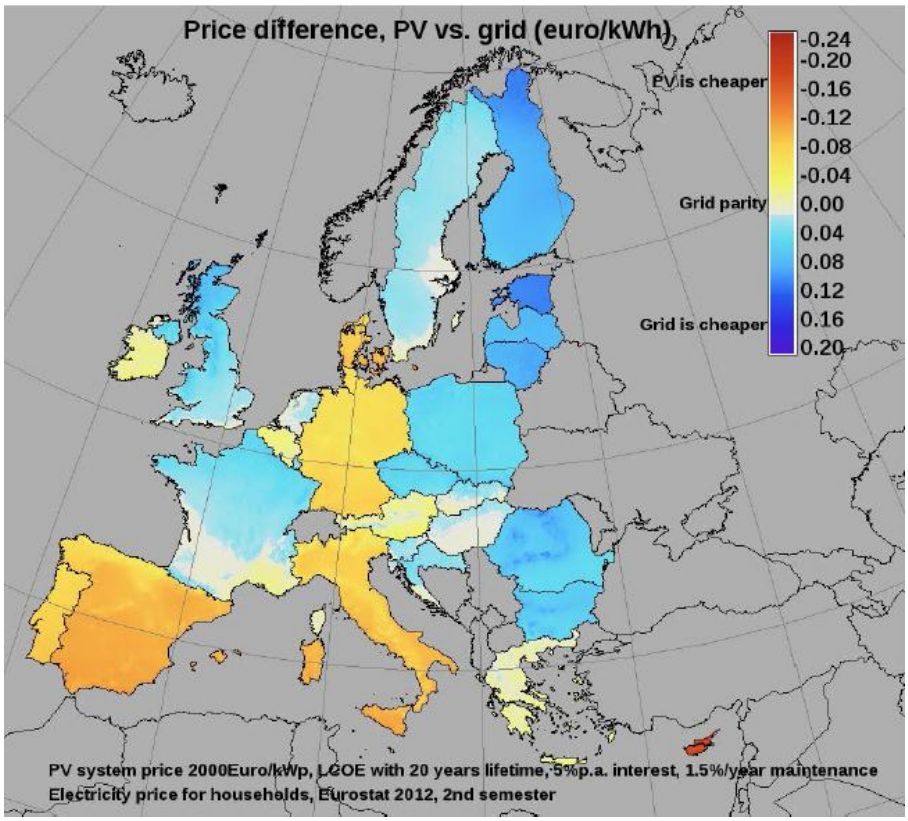

Figure 12: Electricity price difference between PV roof-top systems and household retail prices: red colours indicate PV is cheaper than current residential electricity and blue the reverse. This price comparison does not include any national incentive or subsidy scheme. What can be read from the map are those locations, where either a pricing for a feed-in tariff can be lower than the household electricity price (colours from white to red), or where subsidies would be required to make a PV system profitable for the investor (colours from white to blue).

Source: Heinz Ossenbrink, Head of Unit Renewable Energy, Joint Research Centre, European Commission, (2013) *European Energy Transition - Renewable Electricity and Markets.* Retrieved from: https://ec.europa.eu/jrc/en/event/scientific-support-energy-mix-27972

Some participants argued that in order to achieve smooth market integration of RES during an adequate transition period, binding targets for RES should be avoided to organise a gradual phasing out of subsidies and to implement full market integration. The main policy objective should aim to reach the CO_2-emission targets.

Some participants noted that a consistent European system for cross-border RES support should be subordinated to ETS and the CO_2-emission target. In any case, a European scheme for RES would further increase cost-efficiency by enlarging markets and mitigating the link between intermittent generation and the need for back-up capacity. It was pointed out that massive RES electricity exports can also be detrimental to the economic situation of power generators in the importing country and thus impair their ability to provide flexible backup capacities. This needs to be taken into account in future market designs. This challenge cannot be solved by a single country and, therefore, national competences need not contradict coordination at EU level. **A common coordinated approach seems to be cogent to integrate large volumes of intermittent renewables into the energy system.**

Round Table participants underlined that decarbonisation, which would also reduce the import dependency from fossil fuels, should be at the heart of the European economic policy. Participants called for an evaluation of support schemes with regard to the maturity level of technology as well as with regard to distorting effects of support schemes on ETS and the reduction of CO_2-emissions. **There was consensus that ETS is the most harmonised instrument at European level. Price signals are not always comprehensive with regard to the current lack of supply/oversupply of ETS-certificates and external factors like cheap coal imports.** Therefore, ETS has currently not the intended impact and is currently not the leading system as politically intended. Most participants agreed that a reinforced ETS should remain the primary decarbonisation instrument.

Participants stated that only a competition-driven European energy market model focusing on lowering carbon and associated emissions could go beyond national approaches. Quantitative goals for RES might be desirable in combination with ETS-certificates so as to encourage market decisions on remuneration. Carbon Capture and Storage (CCS), enhanced storage and other technologies should be further researched and demonstrated, taking into account cost effectiveness, environmental protection, social acceptance and marketability.

Support schemes should not contradict the Internal Energy Market and should not threaten investment in generation, transmission and distribution. In order to follow a least-cost approach, national regulation could make use of regional cross-border synergies. Key drivers enabling the completion of the Internal Energy Market should include system integration and security of supply as well as an orientation towards consumer needs. The impact of support schemes on the cost structure should also be evaluated in view of affordability and sustainability of energy supply to European households and industry.

3.2 Regulation

During the Round Table discussions it was stated that regulatory uncertainties and market distortions are currently the main obstacles for positive investment decisions in flexible generation and infrastructure. **Projects take a long time before completion and changes in regulation make it necessary to realign loan agreements and projects.**

Regulators need to agree on cross-border issues. National regulation should neither contradict nor foil the Internal Energy Market. At local and regional level, actors will have to deal with increasing levels of decentralised electricity generation. This changes roles and tasks, and would require a non-discriminatory regime with equal rights and obligations, (ancillary services, congestion management, balancing) for all users connected to the grid, according to standardised industrial norms (e.g. for batteries, demand response). This would also require Member States to work hand in hand, e.g. on transmission and distribution issues, in order to facilitate timely deployment of the required infrastructure.

Currently, price signals are not sufficient to trigger and steer necessary investments. Participants discussed different market models addressing the challenges of ensuring the security of supply. In this context, it was hotly debated whether in the short run an intermediate, strictly limited phase of regulated investment is possible until other market based solutions are available.

For some participants, an integrated market model with capacity payments is seen as the way forward to secure reliability of supply. For other participants, capacity mechanisms are seen as just another layer to the problem; they argued that already today consumer electricity prices are composed of only one-third market-based pricing and two-thirds regulated fees and tariffs.

3.3 Investors' confidence – financing issues

The Round Table participants recalled that the EU 2030 Climate and Energy Policy Framework will influence the energy mix for the next decades. Stable framework conditions are key to market functioning as long-term signals are needed to ensure effective financing. It was debated whether the energy-only market is sufficient to generate these signals and it was noted that infrastructure companies (TSOs/DSOs) can raise only a limited amount of debt. **New technologies are challenging the way of financing investments and managing markets.** Most important seems to avoid changing direction every 2 or 3 years as the energy transition is a long-term process. Roles and tasks for all actors (especially for reliability of supply related to RES-development) will have to be defined clearly. All markets are characterised by entrepreneurial risks (e.g. technological risks) but there are also regulatory risks for investments (e.g. changes in feed-in tariffs). Therefore, **the policy design must enhance predictability while having sufficient flexibility to adjust the framework to investment needs.** Many participants argued that a single and leading CO_2-emission target with an effective CO_2-price could be met more cost-effectively than multiple targets, as it would allow more targeted allocation of investments and increased investor confidence. Other participants argued that, in addition to an efficient and reliable ETS system, coordination of RES targets and support schemes is required in order to increase investor confidence.

Participants emphasised that, while capital is generally not a scarce commodity, there is a global competition among infrastructure projects to find private sector investors. The cost of capital depends on the risk the lender is taking as well as the return the owner is expecting to make the investment profitable. In order to engage capital at low costs, an investment opportunity needs to be competitive and secure at least mid-term profitability. Increasing the share of intermittent RES in power generation, producing electricity at near zero marginal cost, reduces operating hours of conventional plants and lowers the average wholesale market prices for electricity. This loss of profitability of conventional power plants leads to fewer investments.

There is a particular need for investment models to finance firm capacity assets which are necessary to upkeep the security of supply by controlling frequency and voltage (e.g. capacities could be auctioned in a competitive, transparent manner). In a competitive and market-based solution, each provider of generation adequacy should compete on equal terms allowing fair competition whilst minimising costs. This should take into account providers of existing and new domestic or cross-border capacity, as well as demand-side options, and should be irrespective of technology/fuel. It was debated whether the energy-only market can provide price signals for longer periods which are important for triggering investments in new power plants and infrastructure needed to secure the reliability of supply. Some participants emphasised that there is the need for a capacity market or at least for capacity payments for a period of at least 15-20 years (90€/kW_e p.a. to 120€/kW_e p.a. for combined cycle plants) to ensure these investments.

It was mentioned that **long-term debt can bring down financing costs.** There are two lending conditions of banks to look at long-term financing: either it concerns a highly competitive asset, or there is an acceptable regulatory framework.

Regarding the current situation in European wholesale markets, prices in most Member States with high RES shares are dominated by low marginal power generation costs. In some European countries peak load will soon be 20% below the installed RES capacity (or twice as high as minimum load). Depending on the availability of interconnectors and purchasing arrangements, countries with high shares of RES might impact the wholesale price level in neighbouring countries. In this environment, it may not be consistent with investors' fiduciary interests to invest in flexible generation assets, although these are needed to safeguard the security of supply. If capital can be mobilised in such an environment, it may come with a high investment risk at a corresponding degree of leverage.

Changes in market design do not change the underlying financial economics of raising asset values in the event of capacity shortage. There are always two-sided benefits of effective regulatory capacity pre-commitments: (i) de-risking for operators/investors; (ii) guarantee of security of supply for politicians/customers. With the current market design, low carbon generation of substantial equity is not affordable. Intermittent renewables currently cannot ensure the security of supply but create a huge risk of sunken cost for fuel-based electricity generation. Private investors are reluctant to invest in new electricity generation assets. Meeting climate and energy targets at lowest power generation costs will remain very capital intensive. Therefore annuity costs of capital should be minimised and investors' risks should be limited primarily through a stable regulatory framework.

Apart from that, financing has to meet several criteria to be of value for investors:

- economies of scale;
- high leverage (e.g. 80% debt; 20% equity);
- tenure of debt to match cash flow profile of utility sector (16-18 years);
- fair allocation of risks between the developers and the investors.

Besides commercial banks there are four different financing opportunities for developers:

- venture capital companies could enter in the early construction stages (particularly in offshore wind) and later sell the plant to an energy utility;
- energy utilities could take the power purchase agreement on their balance via corporate finance;
- new products on the energy-only market could secure the necessary reliability (e.g. long forward contracts with more than 4 years);
- capacity mechanism could secure necessary investments.

In order to attract more capital for the energy market, one needs to be aware of:

- the market environment;
- at what cost this capital should be raised;
- at what risks investors finance the market.

3.4 Capacity issues

It was hotly debated by the Round Table participants whether Member States should implement capacity mechanisms as a market intervention to secure the future reliability of supply, or if the roots of the problem can be tackled via the energy-only market. Within the existing system, the problem will enhance with the increasing share of RES.

It was stated that the more successful capacity mechanisms will be, the more they will dampen peak prices. Potential capacity mechanisms tend to further constrain the energy-only market and have a (distorting) effect on energy prices; they will ideally have to be preceded by improvements to market functioning. Capacity mechanisms are already implemented or are being implemented in several Member States. The methods to determine the needs for capacity mechanisms are diverging. Efforts should be made to harmonize these methods on a European scale in order to reach the same diagnosis and to avoid negative impacts of incoherent mechanisms on the market.

Other participants argued that peak prices are necessary for the energy-only market, although in several cases high prices triggered market interventions by the policy maker. Some participants proposed a design where the electricity consumer would define the level of security of supply and pay for it, according to his/her decision on the desired reliability level. The consumer or the utilities would be responsible to purchase verifications of security of supply, which are also thought to potentially incentivise investments in flexible generation.

Part of the discussion was whether security of supply is just another "tradable good" to be additionally paid for by consumers, without distinction between industry and households. Participants underlined their concern about affordable energy prices for all consumers.

The following capacity mechanism requirements have been named by participants:

- Capacity mechanisms should be compatible with the Internal Energy Market, open to cross-border cooperation and close to the market in line with European standards to be developed and to be implemented according to needs in Member States.
- Capacity mechanisms should be designed to ensure security of supply under the condition of growing intermittent RES shares and should not be used to meet other objectives.
- Capacity mechanisms should be market-oriented, non-discriminatory, technology-neutral, and taking into account demand response and avoid windfall profits for generators.
- Capacity mechanisms may also mobilise cross-border capacities and reduce national margins accordingly. Whether in a regional approach or not, no distinction should be made between RES and fuel based power generation.

An uncoordinated implementation of a capacity mechanism in one country could have negative impacts upon neighbouring countries. Incompatibility of different capacity mechanisms should also be avoided.

<u>Pro capacity mechanisms</u>

For some participants it seemed unavoidable that the energy-only market will be complemented with solutions for capacity financing – at least mid-term – in many European markets, often driven by a large and fast growing share of intermittent RES at near zero marginal cost power generation.

A high degree of security of supply (e.g. loss-of-load disruptions of less than 3h/p.a.) requires back-up power plants that will only be operated a few hours per year. There is no business case for that and a mechanism ensuring these backup capacities is needed.

In economic terms, the energy-only market has a major shortcoming: prices are high when markets are tight. For new investments and for fully written-off assets needed to secure the reliability of supply, prices would need to be high for a longer period – implying unacceptably high risks for the security of supply. On the long-run the operator of power plants must earn more than marginal costs in order to cover the maintenance of aging generation assets.

In countries with high shares of RES, the market is dominated by RES generation assets at near zero marginal cost, resulting in insufficient revenues for many conventional power plants from the energy-only market**. A capacity mechanism appears to be needed to address on average 20 year payback period of a power plant.** Following a least-cost approach, any capacity solution will have to be market-based, technology-neutral and open to cross-border participation. The resulting electricity market design would then consist of an energy component and a capacity component.

Participants asked how the consumer can benefit from a capacity mechanism in one country if this capacity is consumed in a neighbouring country. Coupling and a graduate harmonisation of capacity mechanism are deemed possible.

Contra capacity mechanisms

State intervention in generation capacity investments can slow down cross-border interconnection investments and could lead to negative side effects upon neighbouring countries. An uncoordinated implementation of a capacity market in one country can distort competition in the market coupling region.

The more successful capacity markets will be, the more they will dampen peak prices. But in the end, capacity mechanisms further constrain the energy-only market and have a distorting effect on energy prices and markets. Therefore the design is crucial. Capacity should rather be managed with improvements to market functioning.

In any case, customer energy prices consist of more taxes and subsidies than actual energy costs. First of all, there is a need for cost reflective prices, and for cross-border balancing markets with improved interconnection capacities.

4. How to proceed

The participants welcomed the Round Table discussions on *Scientific Support to Energy Transition from a European Perspective* as a forum to exchange views on the needs of industry in the light of the rapid evolution of the electricity sector.

The transition to a low-emission and resource efficient economy providing affordable and sustainable energy to households and industry is one of the major challenges Europe is facing. In order to lead to a stable arrangement, this requires the provision of qualified scientific support to

European and national policy-making processes taking into account all factors influencing the energy transition. The future climate and energy framework should increase the competitiveness of energy systems, while gradually reducing greenhouse gas emissions and strengthening the national as well as the European security of supply.

Round Table participants expressed their interest in continuing a structured dialogue with the European Commission.

Possible topics to be discussed further could include:

- The development and coordination of legally ensured and applied common principles and technical standards for cross-border cooperation related to the maintenance of the security of supply in European regions.
- The development and promotion of renewable energy sources in accordance with the Internal Energy Market, including the identification of best practices on how to finance the related costs and how to phase out the support when it is no more necessary.
- A cost-effective system for reducing industrial greenhouse gas emissions with an emphasis on (power generation) efficiency.
- Cost-effective mechanisms for encouraging energy efficiency and demand response.
- Close coordination between grid operators at different levels.
- National target plans for competitive, secure and sustainable energy, deriving from jointly analysed and justified quantitative EU targets.

The Joint Research Centre as the in-house science service of the European Commission supports energy policies with a broad range of scientific and techno-economic analyses. In order to support the reform and reorganisation of Europe's energy policy into a new European Energy Union, the JRC intends to create a European Science for Energy Policy (ESEP) network.

The network aims at providing the best and most relevant scientific evidence-based support to the European policies concerning energy security, systems and market. ESEP-N will be a federation of interconnected research centres and laboratories, pooling together available resources and expertise in key European research institutions. The network will be organised as a set of National Scientific and Technical nodes, which will structure the contacts with all concerned stakeholders for each of the topics under discussion.

The main output of the Network will be the ex-ante production of scientific and technical assessment focusing on the emerging systems, technologies and services, thus supporting the policy making processes,. For meeting this goal, ESEP-N will structure its activities along Working Groups, specifically set up in connection to concrete policy initiatives of the European Commission.

ESEP-N will be a key component of other high-level initiatives by the JRC, such as the **Knowledge Centre on the European Energy Union,** proposed for offering a full-fledged backing to the European energy Union initiative of the European Commission; and the **Knowledge Centres for a Resilient Europe**, proposed to support the development of a coherent and comprehensive EU approach to resilience in the EU.

5. References

5.1 Abbreviations and acronyms

ACER	Agency for the Cooperation of Energy Regulators
BMWi	German Federal Ministry for Economic Affairs and Energy (former Federal Ministry of Economics and Technology)
CCS	Carbon Capture and Storage
CHP systems	Combined heat and power systems
DG ENER	European Commission, Directorate-General for Energy
DG JRC	European Commission, Joint Research Centre
DSO	Distribution System Operator
ENTSO-E	European Network of Transmission System Operators for Electricity
ESEP-N	European Science for Energy Policy network
ETS	EU Emission Trading System
Firm capacity	The amount of power generation which can be guaranteed to be available at a given moment.
LSO	Local System Operator
Member States	Member States of the European Union
Network Codes	A set of rules drafted by ENTSO-E, with guidance from ACER, to facilitate the harmonisation, integration and efficiency of the European electricity market.
PCI	Projects of Common Interest: To help create an integrated EU energy market, the European Commission has drawn up a list of projects of common interest. These projects may benefit from accelerated licensing procedures, improved regulatory conditions, and access to financial support from the Connecting Europe Facility (CEF) between 2014 and 2020.
Prosumer	An energy consumer who is creating or storing electricity and, in some cases, selling it back into the grid.
PV	Photovoltaic
RES	Renewable Energy Sources – here: intermittent photovoltaic and wind
RSCI	Regional security centre initiatives
Security of supply	here: available, affordable and reliable source of power
TSO	Transmission System Operator

5.2 Participants of the Round Tables

on Scientific Support to Energy Transition from a European Perspective

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Abstract
This report presents the main lines of arguments and discussions among the participants of a series of four Round Tables on Scientific Support to Energy Transition from a European Perspective hosted by the Joint Research Centre within its European Forum for Science and Industry between July and December 2013. Participants from the electricity sector, industry, financial services, consumer organisations and European and Member States authorities held discussions on the key questions outlined below:

Integration of renewables: How should renewable energy sources best be integrated into grid and market to make renewable electricity production more responsive to system needs? How and at what costs can the increased need for flexibility of generation and energy demand be provided?

Grid operations: Is the traditional focus of networks well placed to fully accommodate the on-going process of energy transition and to provide the security of supply in a least-cost approach? How to improve cross-border cooperation? What can be learned from existing initiatives of regional and bilateral cooperation between grid operators and regulators? Would common minimum standards for data quality from power plant operators help to create forecasts to optimise regional balancing power markets?

Market design: In order to ensure the security of supply, what is the need of coordination in/between Member States for balancing, re-dispatch and storage? How to improve the convergence of renewables support schemes? Which role could European regional markets play in coordinated scenario building in view of asset optimisation?

Financing issues: What are the market-based tools able to create the right conditions for investment in generation, transmission and distribution? Which governance framework is needed to trigger more capital for investments? Which are the interactions between energy and financial markets to be taken into consideration in favour of lower electricity prices to consumers?

The report intends to contribute to a better science-based understanding of the challenges for the electricity system created by intermittent energy sources and to lead to further analysis of the current energy challenges including political, economic and technological aspects.

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