

System Effects of Intermittent Renewable Generators (Wind, Solar) – Balancing

Short Position Paper to assist the ERRA
Licensing and Competition Committee

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Description of the work-plan issue from the work plan of ERRA Licensing/ Competition Committee:

“The high penetration of intermittent renewable generators (wind, solar) could cause system regulation (flexibility) problems and system adequacy (capacity balance) problems. Some renewable generators are connected to the DSO, some others to the TSO system. Some are creating their own balance circle, some of them belong to other circles and there are practices, when the TSO is responsible for balancing these intermittent renewable generators. Some countries already introduced more market price based renewable support schemes (market premium, "floating premium system") and obliged the renewable generators for self-balancing (or balancing payment). The regulators, who are involved in the preparation of adequate renewable support -schemes should be familiar with the international tendencies and possibilities. The new EU rules (requirements) on more flexible and market based support schemes and other practices (e.g. NARUC) should be introduced.”

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List of Abbreviations

BRICS – The BRIC countries: Brazil, Russia, India and China

RES- Renewable energy sources

FACTS – Flexible Alternating Current Transmission System

HVDC – High Voltage Direct Current

CCGT – Combined-Cycle Gas Turbine

CRM – Capacity Remuneration Mechanism

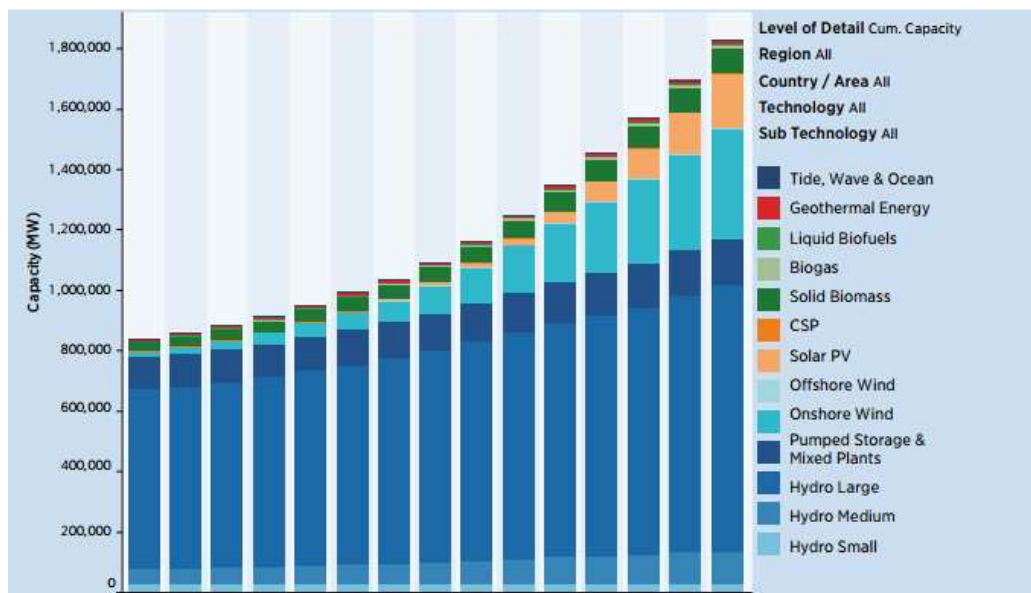
EEA – European Economic Area

ETS – Emission Trading System

Introduction and background

The role renewable energy sources have in energy production is becoming more and more significant, as the gaining ground of green energy production enhances the security of supply, reduces the burden on the environment and, at the same time, fosters economic growth. For the time being, however, it is a more costly, high-investment alternative to traditional energy production methods, and thus it is at a competitive disadvantage under current market conditions. Also this type of generation (especially the intermittent ones [solar, wind]) behaves very differently from conventional generation, and while the technologies are still being established they can be expensive to set up. Related industries and markets therefore need to adapt their structures and practices in order to fully integrate and enable these new types of energy. [1]

The next figures demonstrate the tendencies of increasing renewable capacity world-wide.

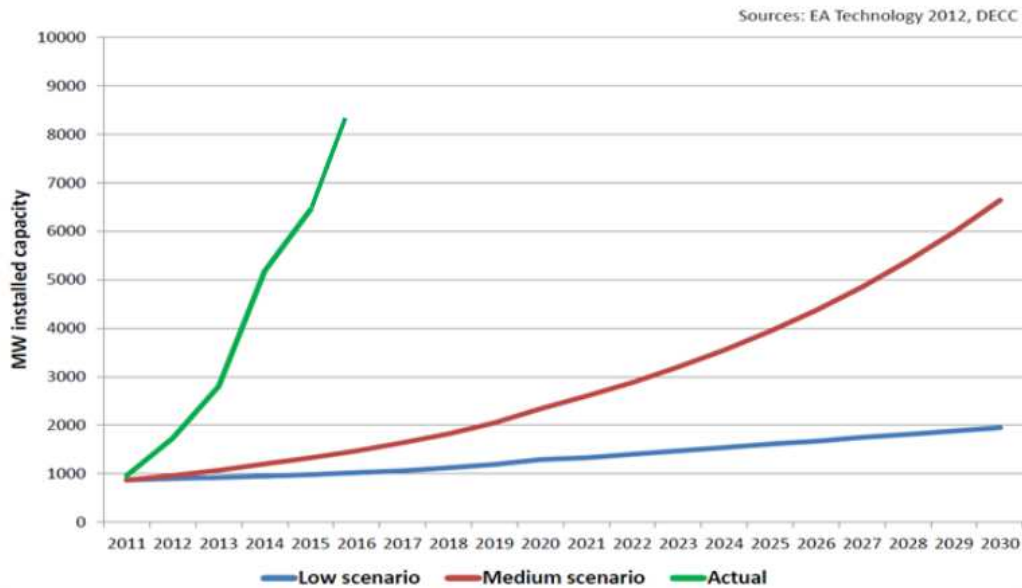


1. Figure: Installed renewable capacity monitored by IRENA [11]

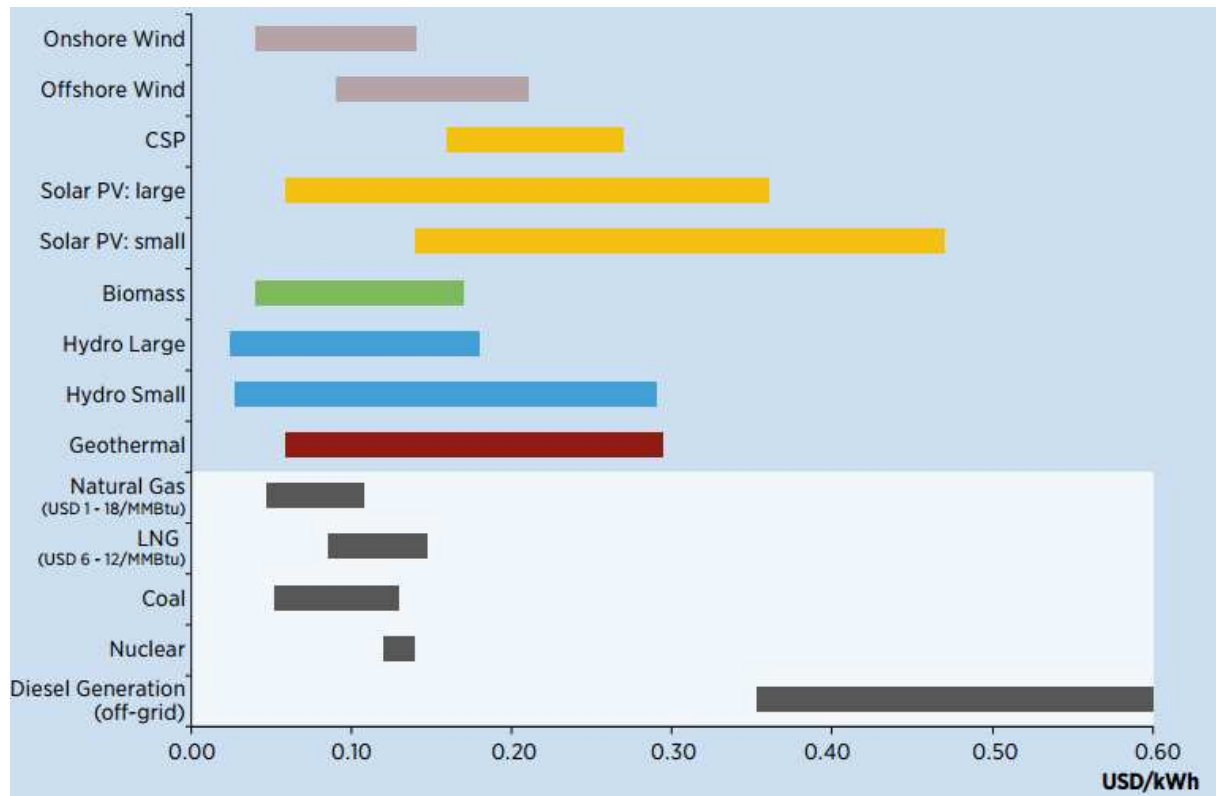
Renewable power generation capacity accounted for 1,828 gigawatts (GW) in 2014, compared to around 1,500 GW from gas-fired power stations and 1,880 GW from coal-fired power stations globally according to IRENA. The majority of power generation comes from hydropower (1,172 GW), followed by wind power (370 GW), and solar photovoltaic (175 GW) [11].

The British tendencies are surprising on Figure 2: the power system is changing and evolving very fast. Technologies, the strategies and the behavior of system and market parties will also come to change. [12].

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2. Figure: Expansion of the renewable energy technology [12]



3. Figure: Falling costs of renewables [11]

As it can be seen on the 3rd Figure, Renewable power generation technologies have achieved remarkable improvements in their competitiveness, and are increasingly competing head-to-head with incumbent technologies. [11]

Intermittency and unpredictability of renewable technologies (wind above all) introduces higher necessity of reserves in the system as well as flexible backup capacities (power plants and/or demand response). According to several studies, it is currently necessary roughly 1 MW of conventional sources back-up capacity for each MW of intermittent renewable energy. Given the role of these

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plants (or flexible demand side) in serving the demand in case of fluctuations of production patterns of intermittent sources, while promoting renewable technologies, it is essential to ensure market conditions able to stimulate also investments in conventional back-up generation (and demand response) and to provide a balanced energy mix in terms of sources, flexibility and geographical distribution of plants.

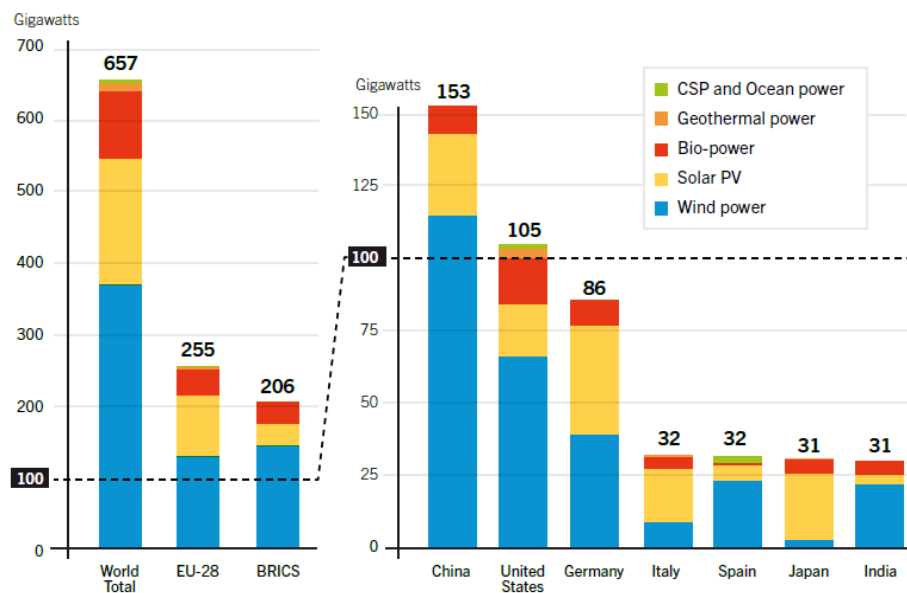
Existing grids are normally designed to connect conventional plants to load centres and in most cases they are not ready yet to pass from a centralized dispatching system to a distributed one. The increasing share of renewable energies on the market will imply a significant upgrading of networks both in terms of interconnections capacity to connect and transfer the renewable power and ability to use “smart” technologies in order to securely manage a much more complex system (i.e. distributed and characterized by intermittent power).

Due to the early stage of development of many renewable technologies, dedicated policies and focused subsidy schemes (e.g. feed-in tariffs, green certificates, dispatching priority and so on) have been set up in most countries in order to facilitate their penetration into the market. If not properly designed and limited in time, these subsidy schemes will result in significant market distortions and increased costs for customers. Moreover, the increasing share of renewable energies, combined with dispatching priority and renewable subsidies is progressively reducing the load-factor of conventional back-up plants, making their return uncertain, these investments unattractive and ultimately reducing security of supply. The 4. Figure shows the spreading of the renewable energy sources (especially the intermittent generation). [6]

Renewable Power Capacities* in World, EU-28, BRICS, and Top Seven Countries, 2014



* not including hydropower.



4. Figure: Renewable Power Capacities in World, 2014 [6]

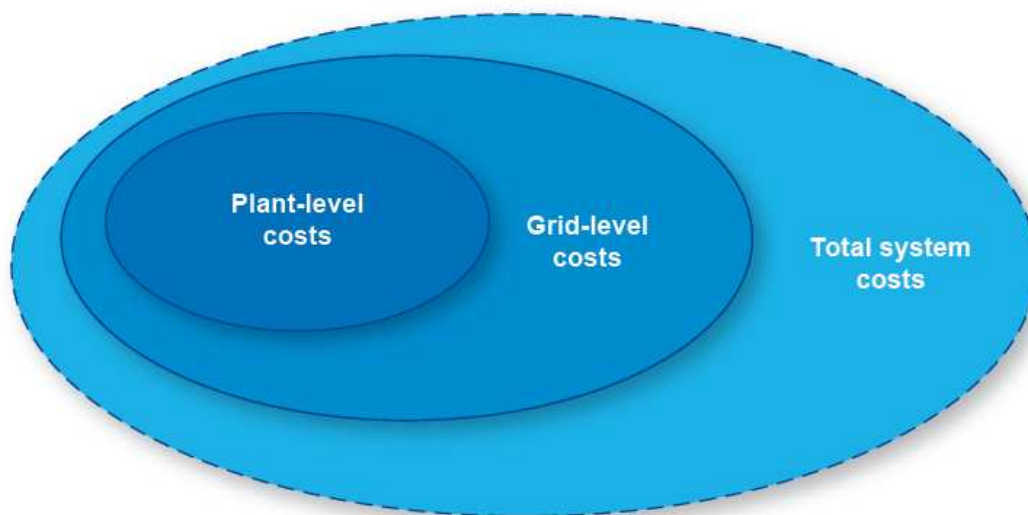
System Effects of Intermittent Generation

Electricity generating power plants do not exist in isolation. They interact with each other and their customers through the electricity grid as well as with the wider natural, economic and social environment. This means that electricity production generates cost beyond the perimeter of the individual plant. Such external effects or system effects can take the form of intermittency, network congestion or greater instability but can also affect the quality of the natural environment or pose risks in terms of security of supply. Accounting for such system costs can make significant differences to the social and private investor costs of different power generation technologies.

The introduction of significant amounts of variable renewables generates a number of hitherto unaccounted for impacts that are composed *inter alia* of the increased cost for transmission and distribution grids, short-term balancing and long-term system adequacy. The deployment of electricity from variable renewables is also significantly affecting the economics of dispatchable power generation technologies.

In the short run, with the current structure of the power generation mix remaining in place, all dispatchable technologies will suffer due to lower average electricity (commodity) prices and reduced load factors. In the long run, however, high-fixed cost technologies will be affected disproportionately by the increased difficulties in financing further investments in volatile low-price environments. The outcome of these competing factors will depend on the amount of variable renewables being introduced, local conditions and the level of carbon credit prices. [4]

Classification of Cost Elements



5. Figure: A possible classification of the costs [4]

By virtue of being connected to the same physical grid and delivering into the same market, they exert impacts on each other as well as on the total load available to satisfy demand at any given time. The interdependencies are heightened by the fact that only small amounts of cost-efficient electricity storage are available. Variable renewables such as wind and solar, however, generate

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system effects that can be an order of magnitude greater than those caused by dispatchable technologies. System costs could be defined as the total costs above plant-level costs to supply electricity at a given load and given level of security of supply. In principle, this definition would include costs external to the electricity market such as environmental costs or impacts on the security of supply. The subset of system costs that are mediated by the electricity grid are referred to as grid-level system costs (Figure 4).

Grid-level system costs already constitute real monetary costs. They are incurred as present or future liabilities by producers, consumers, taxpayers or transmission grid operators. Such grid-level system costs can be divided broadly into two categories:

- The costs for additional investments to extend and reinforce transmission and distribution grids as well as to connect new capacity on the grid.
- The costs for increased short-term balancing and for maintaining the long-term adequacy of electricity supply in the face of the intermittency of variable renewables.

Total system costs are hard to identify clearly, but it definitely would include those effects that affect a country's wider economy and well-being beyond the power system itself. This broader set of system costs would include environmental externalities other than CO₂ emissions, impacts on the security of energy supply and a country's strategic position as well as other positive or negative spill over effects relating to technological innovation, economic development, accidents, waste, competitiveness or exports.

The pecuniary and dynamic effects of variable renewables are also important. These are difficult to conceptualise clearly, may not constitute externalities in the traditional sense of the term and are difficult to quantify fully. They may well constitute the impacts that are most acutely felt by electricity producers and may in the long run have the most profound effect on the operations and structure of electricity markets. The three principal effects falling into this category could be:

- Lower and more volatile electricity prices in wholesale markets due to the influx of variable renewables with low marginal costs.
- The reduction of the load factors of dispatchable power generators (this referred to as "compression effect") as low-marginal cost renewables have priority over dispatchable supply.
- The de-optimization of the current production structure coupled with the influx of renewables implies an increasing wedge between the costs of producing electricity and prices on electricity wholesale markets.

In assessing grid level costs, total system costs and financial impacts of different power generation technologies it could be recognized that it is participating in an ongoing and sometimes highly technical discussion that has yet to deliver generally accepted results in an area – the structure of a country's electricity supply – that has strong advocates for differing viewpoints. Present conclusions and to some extent and even methodologies are likely to be refined or further developed in the future.

Nevertheless, it is important to draw attention to the fact that system costs are an increasingly important portion of the total costs of electricity and must be recognized and internalized in order to avoid serious challenges to the security of electricity supply in the coming years.

Imbalances and back-up capacity

Electricity systems developed so far have been designed on the basis of a system architecture mainly characterized by programmable and non-embedded generation, with a well-balanced mix between flexible and non-flexible systems (base-load, load follow/mid-merit and peak-load functions).

The increasing diffusion of intermittent renewable energy may strain the ability of electricity systems to respond to variations: in fact, the equilibrium of electricity system is characterised by a careful management of variations in both demand and supply and the level of intermittency of RES may vary not only across sources but also across geographies. [5]

Due to both intermittency and unpredictability of some renewable resources production is often subject to unexpected and sometimes frequent variations, so only a small share of installed capacity can be considered as firm. Error reduction in RES forecast will reduce system balancing requirements and will improve the process of RES integration in the system, reducing the need of provision of reserves and costs.

To strengthen system reliability, the amount of capacity working for back-up purposes needs to be carefully adjusted when intermittent RES generation significantly penetrates the electricity system. Non-flexible plants need flexible plants (and/or demand response, energy storage capacity) as a backup capacity, which will constitute a well-balanced generation mix and more flexible demand side. On a yearly basis, such additional back-up capacity can essentially be provided by flexible hydro (i.e. dams and pumped storage) or conventional thermal plants (e.g. gas turbines). On a daily basis, dynamic management of the system will require to be able to manage higher ramp up rates due to unforeseen variations in wind or solar output. Hydro and all other conventional plants have a role to play (coal plants, gas-fired plants, oil-fired plants and nuclear). Balancing refers to the situation after markets have closed (gate closure – when the TSO aggregated and finalized all of the schedules delivered by the generators and the demand side players) in which a TSO acts to ensure that demand is equal to supply, in and near real time (balancing the deviation from the schedules). Efficient balancing markets ensure the system security at the least cost and can deliver environmental benefits by reducing the need for back-up generation. Among the European electricity markets there is a desire to increase harmonization of the rules for balancing and for using ancillary services in order to extend effective pan-European competition to these markets and increase efficiency. [5]

Grids and infrastructures

The increased renewable generation has an impact on grid systems and the growth foreseen for the coming years will necessarily require additional network development, both in terms of additional grid/cross border capacity and “smarter” technologies. In fact, such trend will further increase the demand of decentralized generation and micro-generation. In such respect two different issues have to be considered simultaneously: the first being the need to increase the physical grid capacity, in order to face the rising connection requests, and the second related to the enhancement of its flexibility.

With respect to network capacity reinforcement, distribution and transmission networks have already proved to be, at least potentially, inadequate in many countries, where requests for new renewable plants connection and the speed of such requests have reached very significant values.

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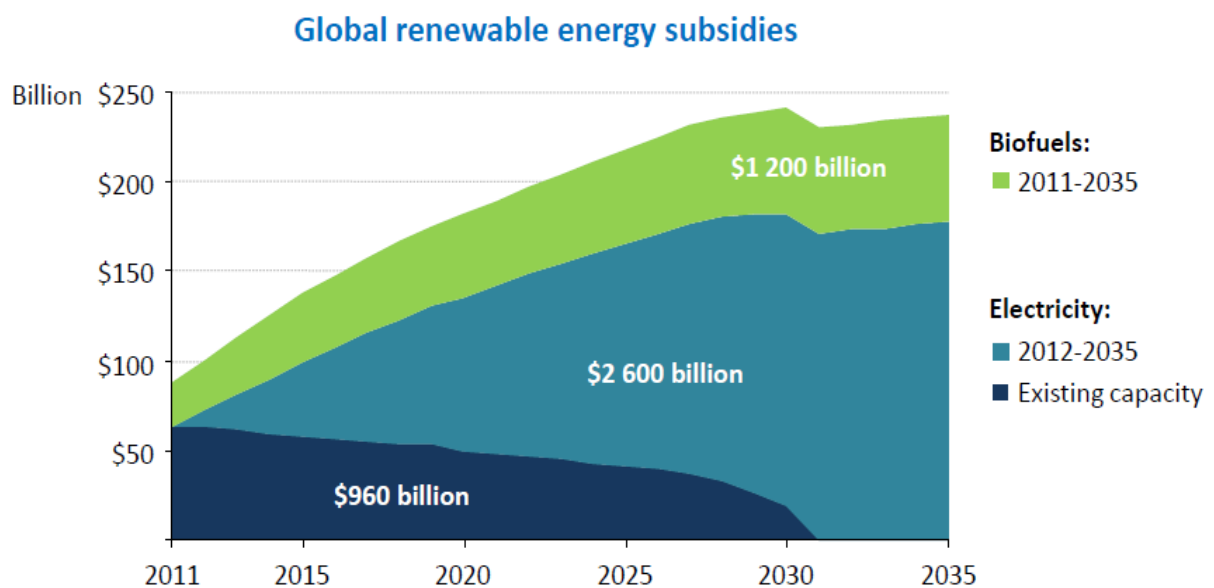
The upgrading of networks requires an appropriate remuneration scheme which guarantees a secure and appropriate return on investments.

As far as network infrastructures are concerned, the management of intermittent renewable energy sources should be ensured through robust grid reinforcement and active network management models. This implies the introduction of smart technologies and enhanced dialogue between grid operators and producers, so that investments are realized where they entail the maximum possible benefit for new producers, consumers and the system.

Potential asymmetries between renewable and conventional technologies, concerning connection and access to the grid, may emerge on the market. In this case they should be properly assessed and possibly eliminated, in order to avoid discriminations, conflicts in grid access and other distortions.

The growing share of renewable will imply a substantial upgrading of the grid both to technological upgrading and reinforcement of connections. The investments required on the grid to face RES development will be substantial, as the advantages for the whole system in terms of more flexibility and security and to this end it will be essential that the cost burden is properly allocated to all entities on the market, with the renewable sources contributing their own part.

In fact, since a significant share of the upgrade investments is required for RES, any subsidy scheme should be updated in order to allow these generators to face the appropriate part of connection costs while benefiting from the mechanism: this would make the RES promotion schemes more transparent and their impact on competition less relevant. [5]



Renewable subsidies were \$88 billion in 2011; over half the \$4.8 trillion required to 2035 has been committed to existing projects or is needed to meet 2020 targets

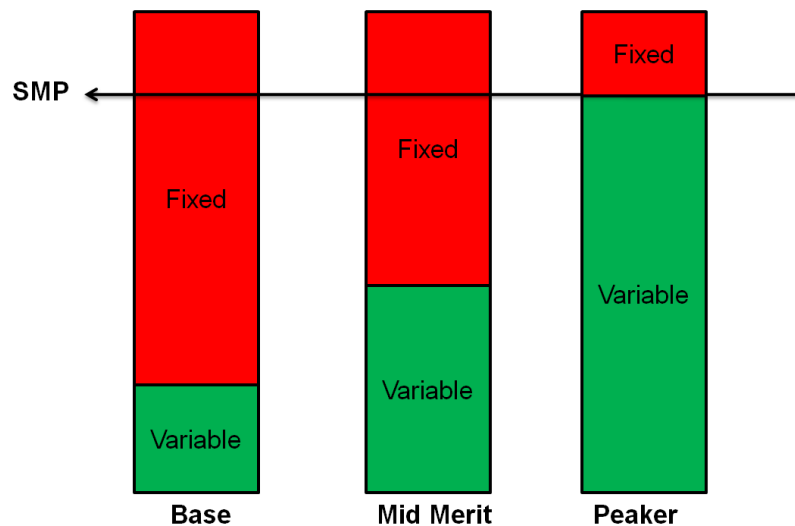
6. Figure: Renewable energy subsidies [IEA]

Effects on the Electricity Market

Taking into account that many RES technologies are still developing (but unit costs are highly decreased and some technologies have been developed significantly until now), most of the countries have planned important subsidies policies to promote electricity production by renewable energy sources in the mid-term, bringing new elements in the equilibrium of the market. However the possible evolution of the generation mix is also driven by the fact that conventional plants will remain necessary for the functioning and security of the electricity system: technologies like gas combined cycles (CCGT), and a few special coal plants are able to provide flexibility to the system and act as a back-up of wind and solar, playing an essential role in the system operation.

The rapid introduction of intermittent renewable electricity in wholesale markets may affect prices, in terms of increased volatility and occurrence of very low electricity prices. To this end, clear and stable regulatory frames should be envisaged in order to limit the impact that the growing share of renewable sources is generating on the market and specifically on prices. In fact, due to the combined RES effect of reduced average spot prices and reduced operating hours of flexible conventional plants, the revenue flows for some market participants are becoming more and more uncertain and can even prevent them from recovering their fuel costs and from returning of investment decisions taken in a different context.

The low spot prices (short run marginal price (SMP)) are insufficient to cover the expenses of the “peaker” plants, as the figure below demonstrates. Based on this situation most of the flexible generators (mostly gas turbines) have not enough income on the ‘energy – only’ markets creating the so called “missing money” problem.



7. Figure: Cost structure of power plants [8]

Some power exchanges already show a growing number of hours with negative prices (e.g. Germany, Spain), something which can be explained for those cases when wind output is high, demand is low and paying to produce (remain in operation) is more convenient than stopping and restarting thermal plants. Although the decrease of market prices might be considered as positive for final customers, since they can get lower prices, long term security of supply can be compromised: there is the risk of under-investments on the mid-term, since market price signals do not ensure adequate

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returns of investment. Moreover, it should be noted that if intermittent RES were to receive market prices instead of other forms of remuneration (i.e. feed-in tariffs) they should stop as soon as the market price becomes negative. [5]

In order to make intermittent RES an effective solution to climate change, it is necessary that their introduction is accompanied by the removal of market distortions, the increase in demand response to changing prices, the development of transmission and interconnection grids. Most of all, RES subsidies and Feed-in tariffs, though they can enhance the introduction of renewables, should be considered as a transitory solution, designed to boost costs efficiency for those technologies which are not mature enough, especially until mid-term production targets are reached. When maintained for too long and for larger volumes subsidies can undermine private and public investment in the energy sector, which can hamper the expansion of distribution networks and the development of other technologies. Many countries are adapting subsidies to changing market conditions and policy goals in order to achieve a long-term transition to a truly sustainable and secure energy system.

Where necessary, other possible solutions to ensure the availability of the back-up capacity (of some peak and mid-merit plants) could envisage appropriate ad hoc remuneration mechanisms (e.g. via market or regulated payments). Specifically the regulatory measures should be focused on allowing them to recover their full cost also in a context of reduced load factor, in order to avoid the risk of anticipated disposal decision and of jeopardizing the conventional generation fleet. This could be combined with measures that control and program the installation of new supported RES capacity in order to facilitate a gradual integration into the system. In addition, price caps and interventions in wholesale energy transactions should be avoided at this purpose (in the same way as the introduction of negative prices means that no floor for spot prices is in place). Moreover, ancillary services markets should be improved, so that the flexibility of customers and generators could be easily traded for the sake and the security of the system. Otherwise, in order to reduce the risk of severe price increases and wholesale market perturbations the necessity comes up of updating market rules and design.

In Europe, a sustained reduction in demand due to energy efficiency and the prolonged impact of the financial crisis has been coupled with a strong increase in weather variable renewable generation, principally wind and solar. Renewable output has a hard to predict nature, and its contribution to peak demand is disproportionately low compared to its overall energy output. This has an impact on conventional generation. Base-load operation is no longer a reality, and there is greater reliance on peak (scarcity) pricing to recover fixed and investment costs. However, renewable generation contributes to some (but not all) of the demand peaks, making peak periods more infrequent. In an 'energy-only' market fixed and investment costs would need to be recovered from fewer periods with extremely high prices.

This increased price risk is compounded by volume risk, which arises from far less predictable operating patterns, posing a significant challenge for investors and giving rise to skepticism about the ability of 'energy-only' markets to attract investment. The standard market contracts – for firm patterns of delivered energy – do not give market participants appropriate tools to hedge their risk through forward contracting. Such a combination of price and volume risk is dealt with in other commodity markets by trading options, but options are not widespread in European energy markets. Irrespective of whether they face 'missing money', European energy markets appear to have 'missing contracts'.

Many (including EURELECTRIC, the European electricity association) are now loudly advocating the need for a separate market to reward capacity. This notion has been supported by policymakers in

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some countries, and Capacity Remuneration Mechanisms ('CRMs') are now a reality in some main European markets; including Great Britain, Spain and Italy, with advanced designs in place in France and Ireland and heated discussions in Germany. Yet this outbreak of CRMs is in the face of strong agreement by all stakeholders to complete the European Internal Market for Electricity, which aims at promoting trade across borders (based on market coupling through spot energy prices). There is a serious concern that top-up capacity products will distort energy pricing and undermine the market coupling. The capacity mechanisms to date are each national and very different in design and – it is feared – will undermine the operation of the integrated European electricity market. The European Commission has launched a Sector Enquiry into the operation of capacity mechanisms.

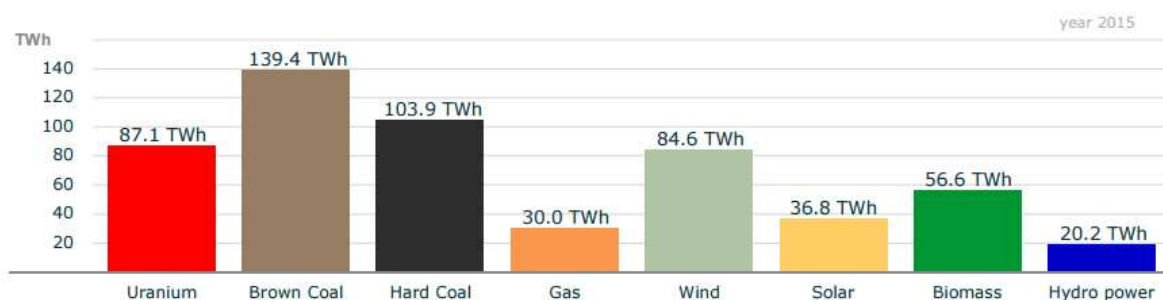
The existing and proposed CRM designs have a narrow definition for qualifying capacity, failing to reward flexible capacity that is key to the operation of systems with increased weather variable renewable generation. Focus of CRMs has traditionally been on generation adequacy, meaning ensuring that sufficient capacity is on the system to meet peak demand. In order to incentivize the right type of CRM in markets with increasing levels of weather variable generation, CRMs will need to be able to cope with emergent system performance requirements, and in particular should consider flexibility as one of the parameters of their design.

In the integrated European markets, a common approach for rewarding capacity would be highly beneficial, if distortions in the energy markets can be minimized. This design needs to maintain the positive aspects of CRMs, providing greater investor certainty, and minimize the undesired consequences, price and trade distortions! [7] [8]

The German Situation

In total, renewable energy sources – solar, wind, hydropower, and biomass – produced approximately 190 TWh of electricity in 2015, 30 TWh more than in 2014, equivalent to a 20% increase. Renewables thus made up around 35% of public net power supply. The share in gross power supply – including power plants in the processing sector, the mining sector, quarries, and excavation – is around 32.5%. On some peak days in 2014, solar and wind supplied close to 80% of peak power demand at specific times of the day. In the future, Germany is targeting a 35% average share by 2020 and a 50% average share by 2030.

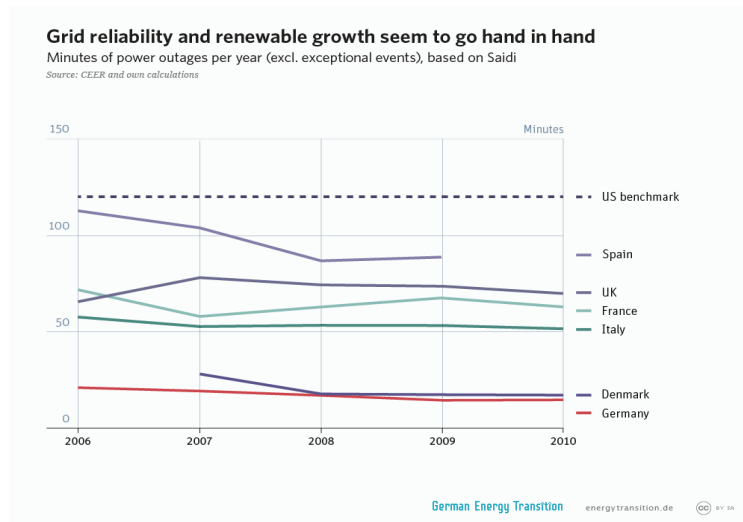
Electricity production in 2015



8. Figure: Net power generation on the German public grid [3]

Germany's grids are already very strong, relative to typical grids found in other countries. This "grid strength" means that outages almost never occur, and that the grid has more capacity than necessary given current demand. From the beginning, when Germany started connecting renewables in the 1990s, this underlying strength has meant that few upgrades have been necessary to accommodate renewables. Even with these, Germany has needed to substantially strengthen some transmission lines, although not too many yet. Germany has also needed to plan for further transmission capacity to accommodate higher renewables. In particular, there is a need for substantial additional north-south transmission capacity to manage the regional imbalance of generation and demand and to avoid loop flows through neighboring countries.

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9. Figure: Grid reliability and renewable growth [9]

There is a surplus of coal fired power capacity, and this excess coal power capacity is being used very effectively to provide sufficient balancing power to offset (or balance out) the variability of renewables. This surplus coal power capacity could be viewed negatively because it results in lower revenue for coal plant owners, and also results in more coal being used relative to natural gas (high gas prices have also contributed). However, on the positive side, the surplus does provide a high degree of balancing capacity.

The balancing and intra-day electricity markets have been modified in ways that provide greater flexibility for renewables. Both of these markets provide additional power on short time frames (minutes and hours) to handle the imbalances between supply and demand that might occur as renewable output varies. The design and features of these markets are complex, but to put it simply, the market rules and designs have improved flexibility, opened the markets to more participants, allowed for faster balancing and ramping responses, and made it easier for demand response and storage to participate in these markets.

Power system operators (ISOs) have greatly improved their power control and dispatch software and analytical tools. One of the impacts of high shares of renewables is that the German network has had to contend with much higher system ramp rates than in the past due to swings in renewable power output. ISOs have been able to successfully modify their software to accommodate higher ramp rates. In addition, day-ahead weather forecasting was greatly improved, which is an important part of integrating and balancing renewables in several countries. Modest technical improvements have been made to local-level distribution systems. At the distribution level, power utilities in Germany have had to cope with two-way (“reverse”) flows of power from solar generators. This happens when solar generation increases in a local node higher than power demand in that node. In general, power systems were never designed for reverse flows at the distribution level. Some distribution utilities have had to do grid upgrades, including substations, transformers, and power lines. Some distribution utilities have installed special tap-changing transformers to manage reverse flows and done pilot projects about smart solutions along the entire value chain of the power system, and it is inevitable to integrate the smart metering to improve data acquisition.

When wind and solar generation reach very high levels, this causes electricity market prices to decline in Germany, even go to zero or negative in some hours. This price mechanism has the effect of reducing output from other sources like coal and gas, and also causing those other sources to export their power to neighboring countries instead of trying to sell into the German market.

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However, the mechanism of importing and exporting power with neighboring countries plays a very modest role in balancing renewables. This is because imports are prohibited from participating in Germany's balancing markets, and the bidding time frames for exports and imports (i.e., multiple days in advance, not day-ahead or intra-day) are too long to provide balancing functionality.

Finally, one of the most comprehensive technical changes has been in response to the "50.2 hz inverter problem." An inverter is the equipment that feeds solar power into the grid, converting the power from DC to AC. The inverter can sense the state of the grid and "decide" to "cut off" the solar output to the grid if conditions indicate an abnormal state (like an over- frequency of 50.2 hertz). Initially, all inverters on distributed solar PV systems around the country were designed with the same "cut off" frequency. However, with the growing share of power from solar, this meant that if the grid frequency went above 50.2 Hz, all the solar could go off-line at once, which became a huge threat to system stability since there was so much solar. So inverter firmware was redesigned and inverters modified to vary the cut-off frequency. [3][9]

Further issues for the future

A number of issues remain for the future, and will play a role in the future, but have not yet significantly contributed to or impacted Germany's ability to integrate and balance renewables today.

Some coal and gas plants are required by the regulatory authority to remain operating, even if they generate very little power. These plants have been determined to be necessary for covering regional bottlenecks or seasonal variations (where the plant might only be needed in winter, for example). These plants receive "capacity payments" to cover their costs of operating at zero output. However, a full "capacity market" does not exist in Germany, although many have been debating the merits of one.

There has been some movement towards demand response in Germany, but this is still small relative to the potential for providing flexibility and balancing. Some large power generators are selling this flexible demand into the balancing markets. Some generators are integrating demand response with their coal plants to give them economic flexibility for selling into the balancing market. Some system operators (ISOs) have also been contracting directly with large demand response providers on a pilot basis. However, the regulator does not explicitly include demand response in its planning, or set rules specifically for demand response. There are possibilities to learn effective demand response methods and regulatory incentives introduced by the US system operators and regulators.

Germany still enjoys very low curtailment. Curtailment is when wind power output must be shut-down to balance the grid, resulting in economic losses. In 2013, only 0.3% of wind turbine output was curtailed. Strict curtailment rules have been instituted for ISOs, which have to curtail wind power output if transmission bottlenecks appear. Curtailment may become a bigger issue in the future, depending on progress with transmission upgrades and planning.

Energy storage has played almost no role in Germany's integrating and balancing renewables so far. Many in Germany do not expect storage to play a role in the coming decade, or at least until the share of renewables goes above 40%. Among many experts interviewed, no one pointed to a company that had plans to invest in storage in Germany. Only a few pilot projects exist. And of course, there is interest in household-level storage in conjunction with the "self-consumption"

Guidelines on State Aid for Environmental Protection

In this chapter some renewable energy integration related points have been listed for better understanding of the policy goals in the European Union. The Europe 2020 strategy focuses on creating the conditions for smart, sustainable and inclusive growth. To that end, a number of headline targets have been set, including targets for climate change and energy sustainability: a 20 % reduction in Union greenhouse gas emissions when compared to 1990 levels, raising the share of Union energy consumption produced from renewable resources to 20 %; and a 20 % improvement in the EU's energy-efficiency compared to 1990 levels. The first two of these nationally binding targets were implemented by 'The climate and energy package'. The following statements are based on communication of the DG Competition regarding State Aid for Environmental Protection (Guidelines on State aid for environmental protection and energy 2014-2020) [10].

Aid to energy from renewable sources

The Union set ambitious climate change and energy sustainability targets in particular as part of its EU 2020 strategy. Several Union legislative acts already support the achievement of those targets, such as the Union ETS, Directive 2009/28/EC (58) ('the Renewable Energy Directive' or 'RED') and the Directive 2009/30/EC (59) ('the Fuel Quality Directive'). However, their implementation may not always result in the most efficient market outcome and under certain conditions State aid can be an appropriate instrument to contribute to the achievement of the Union objectives and related national targets.

Market instruments, such as auctioning or competitive bidding process open to all generators producing electricity from renewable energy sources competing on equal footing at EEA level, should normally ensure that subsidies are reduced to a minimum in view of their complete phasing out.

However, given the different stage of technological development of renewable energy technologies, these Guidelines allow technology specific tenders to be carried out by Member States, on the basis of the longer-term potential of a given new and innovative technology, the need to achieve diversification; network constraints and grid stability and system (integration) costs.

Specific exceptions are included for installations of a certain size, for which it cannot be presumed that a bidding process is appropriate, or for installations at demonstration phase. The inclusion of such installations is optional.

In particular while the EU Emission Trading System (ETS) and CO₂ taxes internalise the costs of greenhouse gas ('GHG') emissions, they may not, yet, fully internalise those costs. State aid can therefore contribute to the achievement of the related, but distinct, Union objectives for renewable energy. Unless it has evidence on the contrary, the Commission therefore presumes that a residual market failure remains, which can be addressed through aid for renewable energy.

In order to allow Member States to achieve their targets in line with the EU 2020 objectives, the Commission presumes the appropriateness of aid and the limited distortive effects of the aid provided all other conditions are met.

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With regard to aid for the production of hydropower, its impact can be twofold: on the one hand, such aid has a positive impact in terms of low GHG emissions, on the other hand, it might also have a negative impact on water systems and biodiversity.

Aid to energy from renewable sources can be granted as investment or operating aid. For investment aid schemes and individually notified investment aid, the conditions set out in the whole document [10] applied.

The Commission will authorise aid schemes for a maximum period of 10 years. If maintained, such measure should be re-notified after such period. Concerning food-based biofuel, existing and newly notified schemes should be limited to 2020.

Aid to electricity from renewable energy sources should in principle contribute to integrating renewable electricity in the market. However, for certain small types of installations, this may not be feasible or appropriate. [10]

Operating aid granted to energy from renewable sources

In order to incentivise the market integration of electricity from renewable sources and to reduce the adverse effects of intermittent renewable sources on electricity systems, it is important that beneficiaries sell their electricity directly in the market and are subject to market obligations. Based on the Guidelines of the European Commission on State aid, 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.
- Measures are put in place to ensure that generators have no incentive to generate electricity under negative prices.

The conditions established do not apply to installations with an installed electricity capacity of less than 500 kW or demonstration projects, except for electricity from wind energy where an installed electricity capacity of 3 MW or 3 generation units applies.

In a transitional phase covering the years 2015 and 2016, aid for at least 5 % of the planned new electricity capacity from renewable energy sources should be granted in a competitive bidding process on the basis of clear, transparent and non-discriminatory criteria.

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 ((66) in the reference), 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 (for example to avoid strategic bidding); or
- Member States demonstrate that a competitive bidding process would result in low project realisation rates (avoid underbidding).

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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 to an extent contrary to the internal market.

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.

Aid may be granted without a competitive bidding process (as described in the whole document at (126)) to installations with an installed electricity capacity of less than 1 MW, or demonstration projects, except for electricity from wind energy, for installations with an installed electricity capacity of up to 6 MW or 6 generation units.

In the absence of a competitive bidding process, the conditions of paragraphs (124) and (125) and the conditions for operating aid to energy from renewable energy sources other than electricity (as set out in paragraph (131) in the whole document) are applicable.

The aid is only granted until the plant has been fully depreciated according to normal accounting rules and any investment aid previously received must be deducted from the operating aid.

These conditions are without prejudice to the possibility for Member States to take account of spatial planning considerations, for example by requiring building permissions prior to the participation in the bidding process or requiring investment decisions within a certain period. [10]

Aid for energy from renewable sources other than electricity

For energy from renewable sources other than electricity, operating aid will be considered compatible with the internal market if the following cumulative conditions are met:

- The aid per unit of energy does not exceed the difference between the total levelised costs of producing energy ('LCOE') from the particular technology in question and the market price of the form of energy concerned;
- The LCOE may include a normal return on capital. Investment aid is deducted from the total investment amount in calculating the LCOE;
- The production costs are updated regularly, at least every year; and
- Aid is only granted until the plant has been fully depreciated according to normal accounting rules in order to avoid that operating aid based on LCOE exceeds the depreciation of the investment. [10]

Conclusion and Message to Regulators

In developed countries high volumes of intermittent renewable generation begin to impact security and management of the power system resulting in an increase of the operational costs. This spurs debate on the extent to which renewable generators should be responsible for system imbalances and ancillary services to ensure grid/system stability (e.g. South Australia, EU countries, USA). In developing countries, power sectors are often characterised by insufficient grid infrastructure and less flexibility in terms of power production, load management and storage. Thus, connecting even a relatively small amount of intermittent generation can exacerbate power system stability and balancing issues. In both scenarios, regulators are facing with similar challenges:

- to what extent should regulators require renewable generators to bear imbalances risks and to be equipped with devices enhancing their control capabilities,
- how to adjust renewable supports schemes to reduce adverse effects of intermittent renewable generators on system stability and strengthen market instruments.

Nonetheless the growing share of RES will take several effects both on energy infrastructures and the market. In this context, it will be essential to detect them and set up the proper regulatory framework, in order to minimise investments risks, to allow the secure and reliable operation of the electric system and to promote competition on the market. In order to minimise adverse impacts of RES on electricity systems, it will be necessary to carefully manage the mix of regulatory policies and the level of regional integration. Market rules should be designed and adapted in order to enhance the ability of the system to securely manage higher levels of intermittence and unpredictability and to enhance the reliability of system operation. Due to the intermittent nature of most of RES technologies, their integration in system operation requires a more sophisticated approach, i.e. to boost the development/use:

- from supply side point of view, of power electronic devices (such as Flexible Alternating Current Transmission System (FACTS)), of High Voltage Direct Current (HVDC) multi terminal links, of smart grids
- from demand side point of view, to promote energy efficiency and demand side management
- from the economic (return of investment) point of view, evaluate/introduce reliable mechanisms for capacity remuneration, in order to help back-up (conventional) plants to cope with decreasing load factors, while performing their essential role to ensure the proper functioning and security of the system.

In the future energy regulators around the world will be tasked with implementing national carbon reduction policies in the electricity sector via clean energy initiatives. As emphasized, integration of RES into the market and electricity grid can present a number of new challenges and opportunities to regulators. Regulators will find that their expertise opens unique possibilities for them to engage in RES, through preparation, planning, design, regulation drafting, public consultation, public outreach and ultimately, implementation of regulations designed to encourage RES production. While conditions will differ across countries due to a variety of factors including policy, resources, economics and energy outlook, some overriding principles can help regulators navigate the developing environment of RES:

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- Clearly defined goals inform and guide the regulatory framework and lead to the creation of predictable, consistent rules. Mixed goals, unclear goals, or inconsistent goals create uncertainty for investors, jeopardizing efforts to increase RE penetration.
- Transparency of regulations and implementation creates an environment of certainty and predictability that encourages new entrants to the market and guards against discriminatory practices or unfair advantages to certain participants, particularly incumbents that can distort efforts to open the market. Flexibility provides opportunities to improve and adjust. While predictability of framework is important, the regulator and policymakers benefit from openness to adjustment when needed.
- The choice of incentive scheme or schemes is individual to each country. There is no one right answer to designing support mechanisms for renewable energy projects.
- Designing and implementing a renewables policy takes a great deal of work, and different organizations will have different and valuable inputs. A cross-section of government and industry can provide valuable direction and regulators can play an essential role in facilitating collaboration.
- The process is continual. Experience in other countries teaches that it is important to have periodic reviews of both the price mechanisms and actual prices for renewables as well as the entire process of tenders, long-term contract terms and conditions, location and fuel preferences, and portfolio mixes. While governments and regulators should avoid retroactively changing contract terms and conditions, especially price conditions, if at all possible, the renewable business is dynamic, technologies mature quickly, costs of production drop, and customers should receive the benefit of these changes and not get locked in to policies that fail to keep up with a dynamic renewable market place.
- Renewables should be part of a comprehensive plan that also includes energy efficiency, technical loss reduction, and other “smart” technologies to optimize use of energy while minimizing its waste and unnecessary deployment. The policies for energy efficiency should be meshed with the policies for energy renewables.
- Regulators should also review legal and administrative processes in other sectors that may impact RE advancements, including environmental permitting restrictions, environmental standards, and investment and procurement rules, and understand the economic and sector implications of selected incentive schemes in order to maximize effectiveness and minimize harm.
- Regulators can help prepare by becoming familiar with the landscape of national and international renewable energy initiatives and by collaborating with other regulators, experts and stakeholders within their country and/or region.

It is particularly important for regulators to learn from one another when it comes to renewable energy because often the speed and ambitiousness of national policies tend to leave little time for the renewable energy market to naturally develop and mature. By sharing knowledge, lessons learned and best practices with regional and/or international counterparts, regulators can respond to the international and national policy commitments their governments have made and help the furtherance of renewable energy in their countries. [1] [2]

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