Towards a sustainable and integrated Europe

Report of the Commission Expert Group on electricity interconnection targets

November 2017

The European Council of October 2014[1] endorsed the proposal by the European Commission of May 2014[2] to extend the current 10% electricity interconnection target (defined as import capacity over installed generation capacity in a Member State) to 15% by 2030 *while taking into account the cost aspects and the potential of commercial exchanges in the relevant regions*.

To make the 15% target operational, the European Commission decided to set up a Commission Expert Group to provide specific technical advice, among others to examine if regional, country and/or border level targets should be considered, and to study any other relevant elements that can have an impact on interconnector development.

The Expert Group on electricity interconnection targets was established by the Commission Decision of March 2016[3]. The Expert Group started its work in October 2016, following a public call for applications. In line with Article 5 of the Commission Decision three members, the Agency for the Cooperation of Energy Regulators (ACER) and the European Networks of Transmission System Operators for electricity (ENTSO-E) and for gas (ENTSOG) did not undergo the public call and were appointed directly. The Expert Group consists of 15 members and 2 alternate members. The full list of appointed members is presented in Annex 1.

The minutes of all the Expert Group's meetings are publicly available on a dedicated website[4].

The views in this report are the sole responsibility of the members of the Expert Group and do not necessarily reflect the views of the European Commission. The European Commission cannot be held responsible for any use which may be made of the information contained therein.

[1] Council Conclusions of 23 and 24 October 2014 http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/ec/145397.pdf

[2] COM(2014) 330 final.

[3] Commission Decision of 9 March 2016 on setting up a Commission expert group on electricity interconnection targets COM(2016) 1406 (OJ C 94, 10.3.2016, p. 2–5) http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.C_.2016.094.01.0002.01.ENG&toc=OJ:C:2016:094:TOC

[4] https://ec.europa.eu/energy/en/topics/projects-common-interest/electricity-interconnection-targets/expert-group-electricity-interconnection-targets

Contents

Executive summary

The European Commission established the **Expert Group on electricity interconnection targets** in March 2016. The Expert Group transmitted its report to Commissioner for Climate Action and Energy **Miguel Arias Cañete** in October 2017.

The Expert Group acknowledges that achieving the EU's energy and climate objectives requires a well-integrated European energy market. Electricity interconnectors are the physical component of making this market truly European by connecting Member States' networks offering capacity for electricity trade, improved security of supply and allowing integration of the rapidly-growing share of renewable electricity production.

The Expert Group is of the opinion that the current interconnection target of 10% by 2020 has already given an important signal to the integration of the electricity markets. However, it acknowledges that the target was set in a radically different energy era when variable renewable energy comprised only a small share of total generation.

To address the new energy reality the Expert Group proposes a new approach for setting interconnection targets based on the underlying principle of maximising societal welfare.

Firstly, the functioning of the **European electricity market should be improved** and based on clear, stable and non-discriminatory regulatory rules to send consistent signals - both to investors in grids as well as to users of the infrastructure. This includes an effective and rapid implementation of the network codes and guidelines adopted in the framework of the Third Energy Package.

In particular, **the existing interconnectors should be used efficiently** and the capacity available to the market significantly increased compared to the current utilisation. For alternating current (AC) interconnectors, the net transfer capacity should be indicatively doubled. This should enable congestion management to be non-discriminatory and should maximise the European socio-economic welfare.

Secondly, new interconnectors must help exploit the benefits of market integration by enabling better prices for customers, help meet the electricity demand on the national markets and possibly offer supply of renewable electricity to neighbouring Member States. Therefore, the development of additional interconnections should be considered if any of the following three thresholds is triggered:

- **Minimising price differentials**: Member States should aim to achieve yearly average of price differentials as low as possible. The Expert Group recommends €2/MWh between relevant countries, regions or bidding zones as the indicative threshold to consider developing additional interconnectors;
- **Ensuring that electricity demand,** including through imports, can be met in all conditions: in countries where the nominal transmission capacity of interconnectors is below 30% of their peak load options for further interconnectors should be urgently investigated.
- **Enabling export potential** of excess renewable production: in countries where the nominal transmission capacity of interconnectors is below 30% of their renewable installed generation capacity options for further interconnectors should urgently be investigated.

The Expert Group recommends that any project related to interconnection capacity, helping the Member States reach any of the 30% thresholds, must apply for inclusion in the Ten Year Network Development Plan and future lists of Projects of Common Interest. In addition, countries above the 30% but below 60% thresholds in relation to their peak loads and renewable installed generation capacity are requested to investigate regularly possible options of further interconnectors regularly.

Thirdly, as a *conditio sine qua non*, each new interconnector must be subject to a socio-economic and environmental **cost-benefit analysis** and implemented only if the potential benefits outweigh the costs.

Fourthly, involvement of citizens, civil society groups and relevant stakeholder groups potentially affected by the development of new interconnectors is necessary at an early stage of interconnector development to address perceived concerns about health issues or adverse impact on the landscape and nature ecosystems. In this regard, the Expert Group recommends that the Commission as well as Member States continue and step up actions to **facilitate public involvement** in the relevant infrastructure projects.

Lastly, the Expert Group recognises that rapid technological developments in the near future are likely to strongly influence the functioning, the nature of and need for electricity network infrastructure. While many of these developments will open up new opportunities for electricity generation, transmission, distribution and consumption, their exact impact is difficult to predict. Therefore, the Expert Group recommends to **review the proposed methodological approach** of measuring interconnectivity and its associated methodologies regularly but not later than in five years.

Preamble

The work of the Expert Group takes place in the framework of the climate and energy objectives of the European Union for 2020, 2030 and 2050 as laid down in the Energy Union Framework Strategy and the Paris Agreement[5]. For the long term, the aim is to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C and to pursue efforts to limit the temperature increase to 1.5°C.

The Expert Group recognises that the electricity sector will be one of the main contributors to the decarbonisation of the European economy. Currently 27.5% of electricity in the EU is produced using renewable energy sources, half of which is variable (weather dependent); modelling shows that the renewable share of electricity will be around 50% by 2030 and might be even higher following the recent price reductions in renewable energy and the electrification trends in other sectors traditionally dominated by fossil fuels like transport, heating and cooling. An integrated smart energy systems approach is important, where synergies are explored across electricity, thermal and gas grids. This will also enable the use of energy storage in other sectors and with other energy carriers.

The ongoing energy transition to meet the EU's climate and energy objectives requires significant investments. In particular, investment is needed to remove infrastructure bottlenecks between and within Member States, to improve security of supply, competition and to integrate the growing share of renewables. In that context, whilst recognising that there is no scientific consensus to measure the "interconnectivity" of Member States with diverse characteristics using a single formula, the Expert Group considers the 2030 interconnection target an important and useful policy tool to guide the development of trans-European electricity infrastructure. In order to fulfil its role, the target must be well-designed and fit for purpose, i.e. it must be robust, sound and transparent to avoid non-viable or inefficient investments.

To foster cost-efficient investments, the Expert Group believes that a more competitive and better interconnected internal energy market in Europe is key. This is particularly important to integrate the rising share of renewable energy into the system in a cost-efficient and secure manner, while fully profiting from complementarities between Member States and broader regions. To these ends, the European electricity market, of which the electricity infrastructure, including interconnectors, is the backbone, requires clear, non-discriminatory rules and a stable regulatory framework. The Expert Group

---

5 http://unfccc.int/files/essential_background/convention/application/pdf/english_paris_agreement.pdf

notes that existing interconnection capacity is often used inefficiently, either because of internal congestions or possibly also because of undue discrimination against cross-border exchanges.

The Expert Group also recognises that flexibility services can – in view of technological developments - be increasingly provided by services such as electricity storage and demand response, among others. Though the importance and promise of these developments cannot fully and reliably be factored in at present in European transmission network expansion plans. While they will certainly influence the future need for and role of interconnections, the scope and the timeline of their impact - as well as the commercial maturity of the associated technologies - is difficult to assess from today's perspective.

For this reason the Expert Group is of the opinion that the interconnection target should contain a dynamic element allowing it to be adjusted in consideration of technological developments. The Expert Group also underlines that the development of cross-border interconnectors needs to be properly coordinated with the corresponding development of national transmission and distribution networks.

The Expert Group acknowledges that the Member States have different energy mixes, which impacts on commercial exchanges and interconnection needs between Member States.

1. Rationale and benefits of electricity exchange and interconnectors

A well-integrated energy market is considered a fundamental prerequisite to achieve the EU energy and climate objectives in a cost-effective way. Interconnectors are therefore a vital physical component of Europe's energy transition and offer capacity for energy trade.

The socio-economic value of electricity interconnectors comes from their ability to increase the efficiency of the electricity systems by reducing the costs of meeting electricity demand and in parallel improving security of supply and facilitating the cost-effective integration of the growing share of renewable energy sources. The Expert Group recalls the manner in which the original electricity interconnection target was established at 10% of import capacity over installed generation capacity per Member State.

Before the late 1990's, when previously national electricity markets began to open up across borders, interconnections between Member States largely served security of supply needs, and were developed to enable electricity trade in the form of long-term contracts. Due to the then regional balancing of load and generation, these cross-border flows were considerably lower than the levels we see today.

The original electricity interconnection target of 10% was set in 2002, when the process of creating the internal market to enhance competitiveness had just started. Interconnectors were one important way to enable competition in markets that were largely monopolistic; the competition mainly had to come from abroad. At that time there was little penetration of variable renewables in electricity generation.

The situation on the electricity market has changed fundamentally since 2002. The most important reasons behind the investments in interconnection capacity are still related to security of supply and competitiveness; sustainability has now become a much more important driver. The Expert Group sees the following five areas as particularly benefiting from electricity interconnection:

Market integration

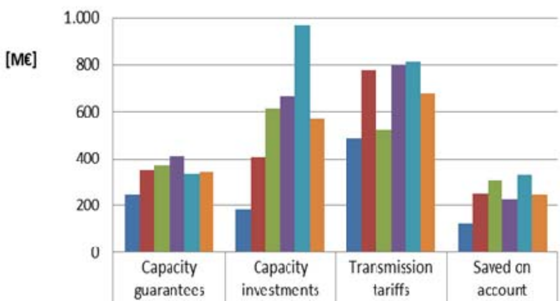
Interconnectors integrate European electricity markets in a number of ways, resulting in more competition and better prices for consumers and businesses. They contribute to revealing investment signals for generation capacity, provided there is a sufficient level of coordination between Member States. Interconnectors also allow better use of the complementarities that exist between the differing generation mixes across Europe, whether thermal baseload or renewable variable. They also contribute to generation adequacy in Europe, lowering the needs for operational security margins and reducing grid losses.

A number of examples already exist in Europe demonstrating these effects: market coupling between Slovenia and Italy has increased the liquidity and stability of prices in the SouthPool market; the NorNed interconnector between Norway and The Netherlands improved competition in both markets; and for the Baltic countries the operation of NordBalt - the first interconnector between Lithuania and Sweden - increased their accessibility to the Northern European power resources and created significant savings in electricity.

In the opinion of the Expert Group, interconnectors should be built only if they contribute to the energy and climate goals Europe has committed to and if their contribution to socio-economic welfare outweighs their costs. This means they lead to lower costs for end-consumers, enhance system stability, reduce price volatility and ensure that the electricity produced may be transported from areas with low electricity prices to areas with higher prices.

The size of congestion rents in the EU highlights that there may be economic reasons to build additional interconnectors capacity or increase cross-border capacity.

Congestion rents and their use in 2011-2015



	Capacity guarantees	Capacity investments	Transmission tariffs	Saved on account
2011	247	185	485	123
2012	352	409	779	255
2013	371	616	521	308
2014	412	666	797	230
2015	336	968	812	330
Av. 2011-15	343	569	679	249

Source: Based on ACER Market Monitoring Report 2015

The figure above gives an overview of the amount involved in congestion rents, and the ways in which the rents have been used from 2011 to 2015. It shows that, on average, in the years 2011-2015, less than a third of congestion rents have been invested in new capacity. The rest has gone to guaranteeing the availability of cross-border capacity, to lowering transmission tariffs and was put as savings on the balance sheets.

Climate and environmental benefits

The share of renewables is growing continuously, putting the EU well on track to reach its 2020 target[6]. Electricity interconnectors help reap the benefits of renewable generation and thus enhance the potential for CO_2 reduction.

Much of Europe's electricity grid network has been designed in consideration of the locations of conventional generation plants. However a large share of today's renewables production - notably variable wind and solar – does not correspond to this grid architecture. Interconnectors, in addition to internal infrastructure, are key to creating new electricity routes to connect areas of abundance to areas of scarcity. In this context, the Expert Group recognises that a fundamental role of transmission infrastructure is to enable the integration of areas of high renewable energy potential with main consumption areas. In this way, more available interconnection capacity would enable the grid to accommodate such increasing levels of variable renewable generation in a secure and cost-effective way.

Increasing the uptake of variable renewable generation also creates challenges in terms of grid management, price volatility and congestion. In extreme cases, this congestion may result in unplanned flows of electricity, giving rise to security concerns. More flexible and smarter energy grids are required, including at distribution level, to address these challenges and to cover peak loads both locally and trans-regionally. At the same time, well-interconnected countries can cover some part of their flexibility needs via interconnectors. Indeed, the variability of weather conditions (and consequently of renewables generation profiles) across Europe, along with the particularities in the generation mix of each country, entails lower flexibility needs when the electricity can be exchanged over large areas.

In peripheral countries, as much as half of system operators' needs for flexibility can be delivered by interconnectors, because these countries are generally not well interconnected mainly due to their geographical conditions (electrical peninsulas)[7]. As renewable electricity forms an increasing part of the energy mix, interconnectors are

---

[6] See e.g. Second Report on the State of the Energy Union, COM(2017) 53 https://ec.europa.eu/commission/sites/beta-political/files/2nd-report-state-energy-union_en.pdf

[7] "METIS Study S7: The role and need of flexibility in 2030. Focus on Energy Storage", Artelys (2016). http://ec.europa.eu/energy/sites/ener/files/documents/metis_study_s07_-_the_role_and_need_of_flexibility_in_2030._focus_on_storage.pdf

becoming an important tool in managing the variable power flows associated with these sources, thus avoiding unnecessary curtailment of clean and sustainable energy.

For example, the interconnectors between Norway and Denmark help balance the Danish system with the hydro storage in Norway. Another example is the planned interconnector deployment between Norway and the United Kingdom, which will allow the UK to displace high-carbon thermal generation with cheaper and greener Norwegian hydro, while UK will be able to export renewable electricity to Norway during periods of high-wind power generation. The INELFE interconnector between France and Spain is yet another example, which will enable the integration of a greater volume of renewable energy into the grid, especially wind energy from the Iberian system.

Insufficient interconnection levels together with renewables generation growth could increase the level of curtailment and the need for maintaining strong support schemes. It is important to note in this context that the absence of sufficient internal transmission capacity (or adequate market mechanisms reflecting available transmission capacity), as for instance the example of Northern Germany shows, can also hamper renewable generation growth and can cause serious congestion problems for internal and neighbouring networks, severely limiting commercial exchanges.

The same problems and limitations in renewables generation growth occur in the absence of internal interconnections with RES-rich isolated regions within a Member State, such as islands. For example, the larger Greek islands of the Aegean Sea (Crete, etc.), which possess a very high wind and solar energy potential, are completely electrically isolated from the mainland, thus unable to develop and exploit locally, or export, this rich resource. In this context, the Expert Group welcomes the political declaration to launch the new "Clean Energy for EU Islands" initiative, signed in May 2017 by the European Commission together with 14 EU countries[8].

A properly planned power grid can also provide services to nature and ecosystems while limiting any possible interactions with the environment. By adopting new corridors and management practices, the routes for the electrical power network may be able to play a part in creating new ecological and biodiversity areas, avoiding environmental segmentation by encouraging species and natural habitats[9].

Security of supply

Interconnectors allow electricity to be imported when there is not enough generation capacity in the home market, and sufficient generation is available in the interconnected markets. The Expert Group recognises that additional interconnection capacity makes it

---

[8] Political declaration on clean energy for EU islands: https://ec.europa.eu/energy/sites/ener/files/documents/170505_political_declaration_on_clean_energy_for_eu_islands-_final_version_16_05_20171.pdf

[9] For example LIFE Elia project, http://www.life-elia.eu/en/

possible to share generation capacities in parts where scarcity occurs at different times in differently connected systems. However, the Expert Group underlines the importance of and the need for a legal framework that goes further to address situations of simultaneous scarcity, if interconnectors are to be regarded as a reliable alternative to domestic capacity.

Interconnectors can provide additional system balancing tools such as frequency response - as in the case of the BritNed (United Kingdom – Netherlands) and IFA (United Kingdom – France) when they are not fully used for commercial energy exchanges. The LitPol Link (Lithuania – Poland) is another example of an interconnector that provides significant security of supply to the Baltic power system.

Crucially, well-developed European electricity grid enhances the integration of indigenous, mostly renewable, sources of energy, which helps reduce Europe's energy dependency by reducing fuel imports.

Political relevance and European integration

Electricity interconnectors are a major aspect of the trans-European networks for energy. The development of these networks is itself an important obligation for the European Union together with its Member States set out in the Euroepan Treaties to strengthen economic, social and territorial cohesion. The Expert Group considers that interconnectors, particularly as developed by the implementation of the Projects of Common Interest are truly European projects that stimulate and strengthen regional cooperation between Member States and increase socio-economic welfare. In addition, interconnections to third countries, such as neighbours in the Energy Community or the Mediterranean, have the potential of promoting the EU's external policy objectives, such as security of supply, regional and local socio-economic welfare, economic cooperation, peace and solidarity.

Industrial competitiveness and innovation

Making Europe's economy low-carbon and more energy efficient accelerates the modernisation of the entire economy with European companies becoming the forerunners of the most advanced energy technologies and business models. The European transmission and distribution industry has developed a strong technological leadership since the beginning of electrification, with European solutions being deployed across the world. The energy transition is an opportunity to maintain and even strengthen this leading position.

The Expert Group recognises that investments in interconnectors, that have a positive socio-economic impact for citizens, as a positive spill-over, offer opportunities to maintain and strengthen employment, competitiveness and global expansion of Europe's clean, low-carbon industries, renewables in particular.

2. The prerequisites and challenges to develop cross-border electricity exchange and infrastructure

While interconnectors bring concrete benefits to the economy and citizens, the Expert Group identifies a few important prerequisites that must be fulfilled in order for the interconnectors to unfold their full socioeconomic potential: establishing a well-functioning EU energy market, involving the public appropriately, meeting the investment and costs needs of interconnection; and accounting for the specificities of national energy mixes and profiles.

A well-functioning market as key prerequisite for the efficient use of cross-border infrastructure

Interconnection capacity is part and parcel of efficient capacity allocation in a well-functioning market. If all capacity is allocated according to the economics of the market, the outcome for consumers would be likely efficient.

While acknowledging that additional interconnection capacity is needed for the reasons given in the previous chapter, the Expert Group underlines that the current use of interconnection capacity is often insufficient and should be addressed through adequate internal network development and on the further development of operational processes that allow for the efficient use of existing interconnectors. Regional operations within the EU synchronous zone are also crucial for a well-functioning electricity market and sufficient utilization of the EU cross-border infrastructure.

The Expert Group recognises the relevance of the ACER Recommendation[10] on the common capacity calculation and redispatching and countertrading cost sharing methodologies issued in November 2016 (The Recommendation). ACER calculates that on average 31% of the maximal thermal capacities of the AC interconnectors for meshed and non-meshed networks is made available to the market in Continental Europe. The percentage on DC interconnectors is much higher on average – around 80% of the thermal rating.

The Recommendation states that the priority access given to internal exchanges leads to congestion being generally pushed to the borders. Such practice results in reduced and thus inefficient use of cross-border exchange capacities and existing cross-border infrastructure. For instance, the data from the Central West Europe flow-based market

10 http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Recommendations/ACER%20Recommendation%2002-2016.pdf

coupling shows that in case of congestion 72% of the time cross-border trade is limited due to internal constraints. This inefficient use of interconnectors boils down to the practice applied by Transmission System Operators (TSOs), endorsed by national regulatory authorities, who consider the cross-border transmission capacity as the main adjustment variable in the overall network security equation.

The Expert Group sees that one key reason for the practice of reducing the cross-border capacities is the significant and fast increase of variable generation from wind and sun. If the internal grid is not strong enough to accommodate this renewable energy production (e.g. in peak times of strong winds or sun), cross-border trade is often reduced or stopped. This is also partly due to operational processes by TSOs, which tend to reduce cross-border capacities preventively regardless of the relative costs of such procedure with respect to internal redispatching.

ACER proposes to address this by abiding by three principles, the first two of which are already enshrined in European legislation: 1) limitations on internal network elements' should not be considered in the cross-zonal capacity calculation methods; 2) the capacity of the cross-zonal network elements considered in the common capacity calculation methodologies should not be reduced in order to accommodate 1oop-flows, 3) the costs of remedial actions should be shared based on the 'polluter-pays principle', where the unscheduled flows over the overloaded network elements should be identified as 'polluters' and they should contribute to the costs in proportion to their contribution to the overload.

The Expert Group considers it important that the sufficient amount of cross-border capacity is allocated to the market for the full benefits of the interconnectors to materialise but also to better ensure public acceptance for the development of new interconnection infrastructures across Europe. In the Expert Group's opinion, the efficient use of grid infrastructure requires a coherent electricity market design that should be implemented without delay. Moreover, a coordinated development of all parts of the grid (internal and cross-border) has to be ensured.

During the last 15 years, the design of the European electricity market has improved through various EU-measures. Continued strengthening of the market principles will provide stronger price signals and better incentives to invest. The Expert Group acknowledges that the functioning of the internal market needs to be improved, which is also foreseen in the *Clean Energy for All Europeans* package. However, it assumes that these additional measures will be taken and that they will ensure correct market functioning.

Public involvement

In the opinion of the Expert Group, in order for Europe to advance with its ambitious energy and climate objectives, new transmission assets including interconnectors, and their efficient use, are needed to transmit renewable electricity from remote and isolated generation sites (e.g. off-shore or islands) to consumption centres and storage sites and to connect regions with complementary characteristics or renewable generation, and thus enabling the consumption of clean energy by European citizens.

However, the Expert Group also recognises that many transmission infrastructure projects have had important public acceptance problems to deal with because of opposition on grounds of perceived risks to health or intrusiveness of infrastructure in the landscape and impact on nature. As a result, in some cases public disputes led to significant delays or redesign of some projects, such as for instance change from overhead technology to technologically more challenging undergrounding, in the middle of the process.

Building an interconnector is a highly complex task. Therefore, the Expert Group insists that early involvement of the concerned local communities, as foreseen in the Guidelines for trans-European energy infrastructure (TEN-E Regulation)[11], is important when designing a project in order to overcome justified concerns, as is professional communication to national, regional and local decision makers. This involves a thorough explanation right from the start that sets out why a project is necessary, what benefits it brings to European citizens and the involved communities, how any adverse impact is minimised and what the wider benefits are, for instance, in terms of increased possibilities for reliance on renewable energy sources. Collaborative decision-making processes are considered useful and important to build trust and reduce public opposition. Therefore the Expert Group considers it worthwhile to elaborate clear and comprehensive approaches for costs recovery of activities aimed at delivering better and faster projects on the ground.

In some cases, where finding agreement on new pathways for infrastructure seems an insurmountable problem, the Expert Group recommends considering involving citizens to find feasible alternatives such as expanding current lines, or changing them from alternating current to direct current technology to enable better use of these lines (for example partial undergrounding in sensitive areas, a solution applied in some Member States). This would still mean that necessary permits have to be secured, but the net result is less impact on the landscape as no new pathways have to be found. It could also mean that more capacity can be allocated to the market, as seen in the beginning of this chapter.

[11] Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 Text with EEA relevance http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32013R0347

The Expert Group notes the availability of a number of good public involvement practices developed across Europe (for example Good Practice of the Year[12]) and encourages their sharing and learning as well as better communication in that regard. This work could continue in the context of the work of this Expert Group.

Investment and cost challenge

Developing cross-border exchange capacities through interconnectors involves significant costs, for example for deploying new transmission assets, reinforcing the surrounding grids and maintaining the infrastructure. It some cases these costs exceed the purely economic benefits detailed earlier in this report. In such situations, projects are being postponed or possibly cancelled. Often, capital costs (CAPEX) of infrastructure projects require long pay-backs periods. For non-regulated investments (e.g. merchant lines) this increases the financial uncertainty for investors and puts a strain particularly on small operators or merchant promoters. In addition, sometimes highly innovative technological solutions must be found to progress with the project.

The Expert Group notes that the European Commission PRIMES modelling estimates the necessary investments in electricity transmission infrastructure of trans-European relevance until 2030 to be between EUR 125 and 148 billion, depending on the scenario, and between 300 and 420 billion until 2050. The 2016 Ten Year Network Development Plan (TYNDP) of ENTSO-E confirms these figures. These investments represent less than 1% of the total electricity bill over a 15-year period, but their volume represents a step change compared with past trends; some TSOs will have to more than double their annual investment volumes. In addition, some cross-border projects are implemented by TSOs with very different asset bases.

The correct implementation of the regulatory regime of the TEN-E Guidelines, the incentives it contains and the cross-border cost allocation between involved national regulatory authorities, needs further attention. Best practice, however, would be first to secure the support of all involved parties, based on good cooperation, trust and simplified procedures.

Even though nearly all interconnection projects, which are economically viable from a cost-benefit point of view can be financed on market terms, the Expert Group acknowledges that in some specific cases (e.g. when the tariff increase due to the project would not be acceptable) some support from the Connecting Europe Facility can be necessary to lift a project off the ground. Furthermore, grants for studies can be important in early stages of a project development phase when the cost benefit analysis and the technical feasibility of the project is still not clear, and also for studies to determine which technology can best be used for a particular project.

[12] http://renewables-grid.eu/activities/best-practices.html

Efficient carbon pricing could also increase economic viability of interconnectors as it increases the price spread between bidding zones with rates of renewable generation and bidding zones with high demand and high rates of fossil fuel generation. The use of interconnectors for other services than energy exchange, such as exchange of reserves, could also improve revenue creation.

National energy mix and inherent energy profiles

Member States demonstrate considerable differences in terms of their energy mix, size of the energy market and geographical location, which influence their interconnectivity potential and needs. In the Expert Group's opinion it is important to take these inherent different energy profiles into account when planning electricity infrastructure respecting Member States' right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply profiles.

At the same time, the Expert Group emphasises the need for cooperation in energy infrastructure and renewables deployment, especially between areas of renewable abundance and renewable scarcity but also between renewable sources with complementary generation patterns (e.g. wind/photovoltaic) as well as with dispatchable renewables, such as sustainable biomass. Therefore, the capacity of the EU Member States to supply renewable electricity to the EU market should be taken into account when setting interconnection targets.

3. Interconnectors in a changing energy system – the impact of energy, climate and technology trends on the role of and the need for cross-border electricity infrastructure

In the opinion of the Expert Group, rapid technological development driven by digitalisation and integrated services with a number of disruptive solutions, is likely to have a strong impact on the functioning, nature of and need for the electricity network infrastructure already in the near future. While many of them will open up new opportunities for electricity generation, transmission, distribution and consumption, their exact impact is difficult to predict.

The Expert Groups recognises seven trends that are likely to have an impact on electricity infrastructure in Europe and should be considered in view of the future review of the interconnection target:

Electrification

The Expert Group recognises that electrification is expected to play a major role in the transition to a clean energy system. Most notably, the largest decarbonisation benefits will be achieved in those sectors that still rely very heavily on fossil fuels, such as transport and heating and cooling.

In the EU, transport still depends on oil for about 94% of its energy needs and accounts for almost one fourth of the total carbon emissions, of which 70% by road transport. Given the European ambitions for low emission mobility, a significant increase in the use of electricity can be expected in that sector. While electric vehicles will certainly increase demand for electricity, putting a strain on electricity networks and causing risks of higher peak loads, at the same time demand response solutions might offer a significant relief potential due to improving storage possibilities, and thus help optimise the electricity systems.

Similarly, the decarbonisation of heating and cooling, which account for half of the EU's energy consumption, of which 84% is generated from fossil fuels, seems to be another game-changer in the electricity systems. Energy efficiency impacts from waste heat sources and low temperature heat sources could potentially cover the entire heat demand in Europe's buildings. In combination with electrification this can be another game-changer.

Energy efficiency

Energy efficiency measures, underpinned by ambitious EU targets, have significantly reduced energy intensity in the European Union. The Expert Group recognises that the proposed 2030 target of at least 30% and additional measures as proposed in the *Clean Energy for All Europeans* package will continue to lower the energy intensity of products and services. Electricity, which is not produced nor consumed, does not need to be transported. From this point of view, further efficiency gains might have potential to decrease the demand for electricity.

Evolution of the energy mix

Consistent with European policies, Member States have engaged in energy policies aimed at increasing the share of decarbonised, especially renewable generation, in their energy mix. The Expert Group believes that this trend affects decisions on the retiring of and investing in generation assets and consequently operating conditions and price formation in Europe. It is a key driver for the value of interconnectors.

Decentralisation

The current technological developments bring solutions for decentralised, distributed energy production. The technologies underpinning distributed renewable electricity generation and consumption, and local flexibility services are now available. Such technologies may result in provision of electricity close to the point of use and may reduce the need for grid infrastructure. However, this does not happen automatically, as many of the distributed generation technologies are more or less dependent on geographically constrained primary energy or availability of space.

The challenge of the institutional and legal framework is therefore to ensure local balancing of load and generation wherever economically suitable, resulting in an optimal balance between local supply and trans-regional exchange of energy. With the right framework scalable technologies, which are available today, will enable smart energy communities, smart cities and active energy customers and citizens to play an increasing role. This means that the status and future role of the transmission grids might require redefinition over the next decades.

Digitalisation

Digitalisation is probably the biggest disruptive development over the last years, which is the real game changer across all sectors of the economy, including generation, transmission and consumption of electricity. Digital technologies allow for data collection and demand management taking place at an unprecedented scale and speed. The Expert Group recognises the potential of digitalisation and its contribution to optimisation of volatility of flows and system adequacy, through demand response programmes that could optimise electricity generation and thus its transmission.

For example, the better and faster processing of meteorological data or dynamic pricing of electricity supply and demand response are prominent examples for how digitalisation can help balancing energy systems and affect the role of grid infrastructure. Moreover, digitalisation combined with fast active grid components, such as flexible AC Transmission Systems or embedded HVDC elements, may also increase the use of transmission grid infrastructure and so release additional capacity.

Storage

Electricity storage (including more recent technologies such as advanced batteries, compressed air, hydrogen or heat storage, as well as established technologies such as hydropower and pumped storage) has a significant potential to contribute to system balancing, network management and further renewable energy integration in the system. The rapid technological progress and cost reduction over the last years has been giving rise to various cost-effective solutions at the distribution and transmission levels.

Energy storage brings benefits to the electricity system in a similar way as demand response, flexible generation and grid extension including interconnections: it helps shave the peaks and provides flexibility solutions to market participants. At a local level, storage is an indispensable element of smart grids enhancing empowerment of citizens.

The observations of the Expert Group point out to further cost reduction trend in storage technologies and potential for large-scale market uptake over the next decade.

Further integration of the energy system - smart energy systems

Further integration of the electricity, gas, heat and transport sectors, including through power to hydrogen and synthetic gas, and hybrid technologies for transport and heating, could be a game-changer. As electricity is only one part of the energy system, the emerging smart energy systems approach emphasises the need to look across sectors to identify synergies and cost-effective energy storage options as well as energy efficiency and energy savings options.

In such integrated energy system technologies (most of them already commercially available) are used to ensure a high flexibility both on the energy supply and demand side using the grids and storage available in the system across sectors (thermal storage, gas storage and electricity storage). A high accommodation of renewable energy can be achieved in such systems without batteries or electricity storage.

Holistic view on energy infrastructure development

The Expert Group acknowledges that the policy and legislative measures the EU has adopted since 2009 have provided a powerful and sound foundation for the European infrastructure planning. The *Third Energy Package* laid the basis for the European network planning and investment. On the one hand this has been done by requesting Transmission System Operators to cooperate and elaborate regional and European Ten-Year Network Development Plans (TYNDP) for electricity and gas in the framework of the European Network for TSOs (ENTSOs) every second year. On the other hand rules of cooperation for national regulators on cross-border investments in the framework of the Agency for the Cooperation of Energy Regulators have been established.

Since 2013 the European Union has been adopting a holistic approach to infrastructure planning and implementation through the guidelines for trans-European energy infrastructure, the TEN-E Regulation. The Expert Group acknowledges that the TEN-E Regulation addresses for the first time the specific issue of projects that cross borders or that have an impact on cross-border flows, the so called Projects of Common Interest. Most notably, a harmonised energy system-wide cost benefit analysis at Union level provides clear rules for the preparation of each subsequent TYNDP for electricity and for gas. This is also the basis for the socioeconomic assessment of individual Projects of Common Interest.

Given the fast-changing energy landscape, the Expert Group recommends that the European electricity system must continue to be seen in a holistic and dynamic way while taking into account the interdependencies between the development of new energy and technological solutions, different energy sources and different generation and consumption patterns. In that context, the European Union should step up its efforts to develop a consistent and interlinked electricity and gas market and network model.

4. Measurement of interconnectivity

Current interconnectivity measurement and its assessment

To assess if the existing definition of interconnectivity is still fit for purpose in the context of the challenges, prerequisites and trends set out in the previous sections, the Expert Group firstly analysed the current way of measuring the 10% interconnection target to be reached by 2020 by Member States as defined by the Barcelona Council in 2002[13]. First and foremost, the Expert Group acknowledges that the 10% interconnection target - measured as a ratio of net transfer capacity to installed generation capacity - has given an important boost to the integration of the electricity internal market.

However, the Expert Group notes that the 10% target was set in a radically different energy situation where only around 2% of total energy was generated from variable, non-dispatchable sources and where the discrepancy between installed generation capacity and the peak load was negligible across Europe. At present, it is estimated that variable solar and wind combined will account for more than 29% of electricity generation in 2030[14], thus increasing significantly the variability of the electricity system. The source of data for this analysis is the ENTSO-E TYNDP 2016 scenarios[15] and assessment by ACER. Those scenarios foresee a continuous growth of renewables in the system and point to the changing consumption patterns and the role of electricity. Put in perspective Europe expects that in 2030 the total RES generation in electricity sector will cover from 45% up to 60% of the overall demand within Europe.

While the total installed capacity in Europe (EU28) increased by around 45% on average i.e. from 682GW to 977GW between 2000 and 2014, this growth was mostly due to renewables, which are characterised by a much lower load factor than the traditional thermal generators. While the cumulative installed capacity of wind and solar amounted 12.9 GW in 2000, that capacity soared to 218.2 GW in 2014.

---

[13] http://www.consilium.europa.eu/en/european-council/conclusions/pdf-1993-2003/PRESIDENCY-CONCLUSIONS_-BARCELONA-EUROPEAN-COUNCIL_-15-AND-16-MARCH-2002/

[14] EUCO30 scenario (the EUCO27 and EUCO30, were created using the PRIMES model with the EU Reference Scenario 2016 as a starting point. They model the achievement of the 2030 climate and energy targets as agreed by the European Council in 2014 (the first scenario with a 27% energy efficiency target and the second with a 30% energy efficiency target) and were prepared as part of the European Commission's impact assessment work in 2016 https://ec.europa.eu/energy/sites/ener/files/documents/20170125_-_technical_report_on_euco_scenarios_primes_corrected.pdf

[15] https://www.entsoe.eu/Documents/TYNDP%20documents/TYNDP%202016/rgips/TYNDP2016%20Scenario%20Development%20Report%20-%20Final.pdf

Given the more rapid increase – driven by renewables – in electricity generation capacity than in interconnector capacity, the interconnection level, as determined at the Barcelona 2002 Council, tends to decrease progressively[16]. It should be noted that some Member States will not reach the 10% target by 2020.

Analysis of different alternative measurement approaches

Maintaining the current formulation of the target would offer certain continuity and consistency in measuring interconnection levels as initially defined. Nevertheless, the Expert Group concluded that this target would not be suited to the reality after 2020 and would not adequately account for the identified benefits of and prerequisites for the development of the interconnectors. As a consequence, the Expert Group agreed that for defining a more policy-relevant and functional target for 2030 the current methodology must be properly adapted.

To this end, the Expert Group carried out several analyses aiming to encompass the future reality of the electricity landscape. To this end, it considered in the denominator of the formula such elements like: installed generation capacity (current variable used in the denominator), generation capacity weighted by the load factor of different technologies (both variable and dispatchable), installed renewable capacity and peak load.

To assess most appropriate parameter for the denominator of the updated interconnectivity ratio, the Expert Group drew the following conclusions on each of the possibility:

- **Installed generation capacity** (used as the denominator of the current formula): This parameter measures the amount of installed generation capacity within a country and offers the advantage of continuity with regard to the 2020 target. However, it does not reflect the degree to which imports can satisfy demand in a given country, but only the export abilities of the given system without taking technical characteristics of different technologies into account. Following a significant increase in installed capacity in Europe, mostly due to new wind and solar capacities, with much lower load factors compared to traditional fossil fuel generation, the parameter seems obsolete in view of the changing reality of generation profiles.

- **Generation capacity weighted by load factors:** This parameter reflects the reality where different technologies cannot all be used to the same extent - wind and solar, most notably, can only be used when weather conditions permit. However, this parameter presents the same disadvantage as the one mentioned

[16] As the denominator (installed capacity) increases while the numerator remains the same (net transfer capacity of interconnector) the value of the ratio (interconnection level) decreases

under installed generation capacity, without the advantage of continuity. Furthermore, it does not reflect the potential of a country to export in situations of high production levels of variable renewables and low domestic demand.

- **Installed renewable generation capacity:** This parameter reflects the expected future development of the energy mix and the theoretical maximum potential of production from renewable sources. In addition, it offers continuity with regard to the 2020 target whilst better taking into account the potential need for exports.

- **Peak load**: The electricity system has to be designed in such a way that peak demand, or peak load, can be fulfilled at all times. This parameter, therefore, reflects security of electricity supply concerns. Interconnectors contribute to the ability of the system to cover the current demand for power, provided that sufficient generation is available in the interconnected market, as explained in chapter one. It is characteristic for each of the power systems and a fundamental underlying reason for which the system is built.

- **Sum of the peak load and share of renewable installed electricity:** This parameter combines the peak load with the share of renewable electricity, taking into account the change in the generation mix. While at first sight such parameter might seem a good combination, mixing these two variables turns out to be complicated and erroneous in terms of the formula transparency and its consistency.

In the following step, the Expert Group assessed two alternative variables that could be used in the numerator of the new formula: the net transfer capacity and nominal (thermal) transmission capacity of interconnectors. The main reason for the Expert Group to review the suitability of the net transfer capacity was the insufficient and varying utilisation of the existing interconnectors due to the capacity allocation practice of pushing internal congestion to the border as outlined in chapter two of this report.

The Expert Group drew the following conclusions on each of these possibilities for the numerator of the updated interconnectivity ratio:

- **Net transfer capacity (NTC)**: The advantage of expressing the numerator as NTC is that it offers continuity with the target expressed in 2002. Moreover, it is an attempt to reflect that in a meshed network physical capacity of a line may be misleading because it may in the worst case not be available due to the structure of the surrounding network. However, the NTC can only be meaningfully calculated at the borders of bidding zones. The additional disadvantage of NTC is that it is inherently impacted by existing market mechanisms and rules and by the use of the existing infrastructure by neighbouring countries, and not by the lack of physical interconnections. In a meshed European grid the level of NTC is strongly interrelated and interdependent between many lines including interconnectors. Therefore, the calculation of available capacities will turn in the future towards flow based allocation (FBA).

– **Nominal transmission capacity**: This reflects the physical capacity for which the interconnector was designed. It corresponds to the maximum power flow that the cross-border asset can transmit in accordance with the system security criteria. Nominal transmission capacity is not influenced by market design, mechanisms and rules. Its numerical value is not dependent on the cross-border capacity calculation rules, which will evolve in the future. It can also be applied at any geographical level, which is not possible for the net transfer capacity.

The Expert Group notes that the above two metrics display intrinsically lower values for larger countries, as interconnections between two areas within a country are not taken into account.

Recommendation for the measurement of the interconnection levels

The Expert Group concluds that the national level of electricity interconnectivity should be measured by taking into account both electricity demand (import need) and supply (export potential). In practice, this would mean putting the nominal capacity of interconnectors in relation to the peak load as well as putting the nominal capacity of interconnectors in relation to the installed renewable generation capacity. In addition, the Expert Group notes that the formula to measure the interconnectivity in the 2030 perspective must refer to the estimated peak load and the estimated installed renewable generation capacity for 2030:

The first formula reflects the electricity demand and possible import need:

nominal transmission capacity / peak load 2030

The second formula reflects the electricity supply and the export potential:

nominal transmission capacity / installed renewable generation capacity 2030

The Expert Group notes that a yearly maximal peak demand can vary significantly depending on the weather conditions; therefore the 99th percentile of the yearly demand distribution should be considered by convention.

The Expert Group recommends that the nominal transmission capacity computation should account for all interconnectors within the EU including Norway[17] and Switzerland, as these two countries are connected only to the EU electricity systems and do not have any other interconnectors with the electricity systems of third countries. The calculations presented in Annex 2 and Annex 3 are based on this approach.

Nevertheless, the Expert Group recognises the need to address the interconnectors with other EU neighbouring countries. For that reason, further work is needed to investigate the relevance and role of interconnectors with third countries, which is however beyond the scope of this report.

A change in the denominator and numerator of the previous formula leads to a different outcome in terms of percentages as well. It means that for the current interconnection target to be compatible and comparable with the thresholds recommended in the following chapter as derived from the above formulas, would require an adaptation.

[17] Norway does have a production-radial crossing the Russian border, connecting two Russian hydro power plants (total 56 MW). Connecting the Norwegian system to the synchronous Russian system is however not possible.

5. Critical elements underpinning the interconnection target

As identified in the previous chapters, electricity interconnectors bring a number of benefits to the economy and society in terms of market integration, integration of renewables, and security of supply. Interconnectors also generate important political and economic spill overs. At the same time, however, for the benefits to materialise the efficient functioning of existing interconnectors must be ensured and the challenges in terms of public acceptance and access to finance must be successfully faced when developing new interconnectors. Therefore, the Expert Group carried out a comprehensive process assessing a variety of elements that could be relevant when developing a new electricity interconnection target.

Acknowledging that no single formula alone can fully reflect the changing energy reality, the Expert Group thought it vital to stress that the use of the interconnection formulas should always be accompanied by the following considerations:

1. Better prices on wholesale markets

The Expert Group acknowledged that the rules of the *Third Energy Package* have had a positive effect on competition and integration of markets over the last years. The cross-border trade has intensified thanks to the ongoing market coupling and wholesale prices have decreased. Also, electricity interconnectors proved to be instrumental in increasing liquidity of the electricity markets in Europe.

At the same time, the Expert Group noted that considerable price differences between bidding zones still exist and are expected to persist for the time being. Since the primary value of the interconnectors derives from their abilities to exploit and reduce price differences, the Expert Group recognised further integration potential.

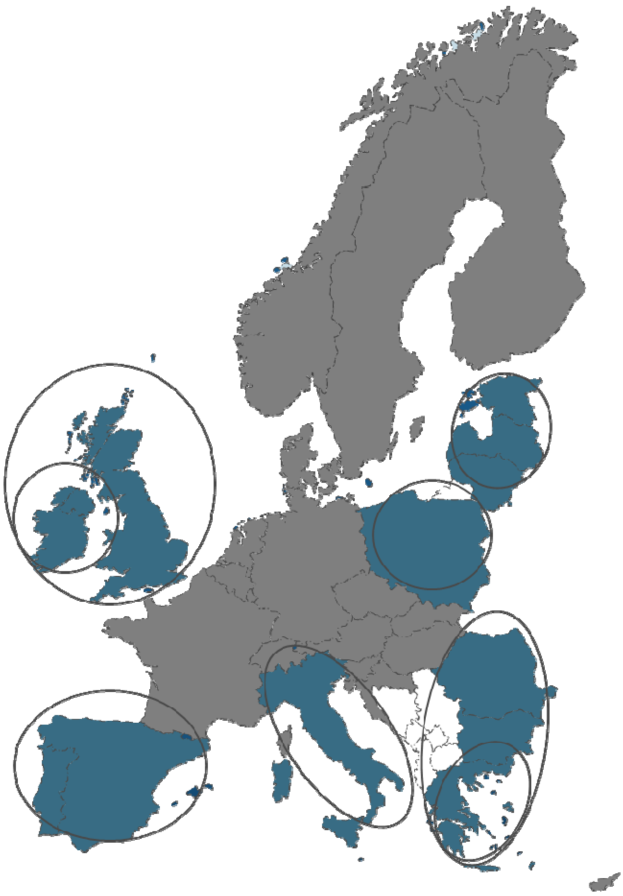
Looking at forecasts of 2020 absolute marginal price differences between bidding zones at country-level[18], a few regions can be identified where the potential of price differences could be further exploited. The Expert Group considers the €2/MWh a proper threshold above which the Expert Group sees a strong need to investigate further interconnection in order to reap the benefits of market integration.

These regions are: a) the island of Ireland, b) the island of Great Britain, c) the Apennine Peninsula, d) the Iberian Peninsula, e) Poland, f) the Baltic States, g) South-Eastern

[18] Source of data ENTSO-E TYNDP 2016 – http://tyndp.entsoe.eu/documents/OUTPUT_PEMS_EP2020_POWRSYM.xlsx

Europe, and h) Greece. The figure below shows these eight regions, identified based on the relevant yearly average of absolute hourly price differentials of €2/MWh or more in 2020 in relation to Central/North-Western Europe and the Nordic Countries.

Regions, identified based on the relevant yearly average of absolute hourly price differentials of €2/MWh or more in 2020 in relation to Central/North-Western Europe and the Nordic Countries



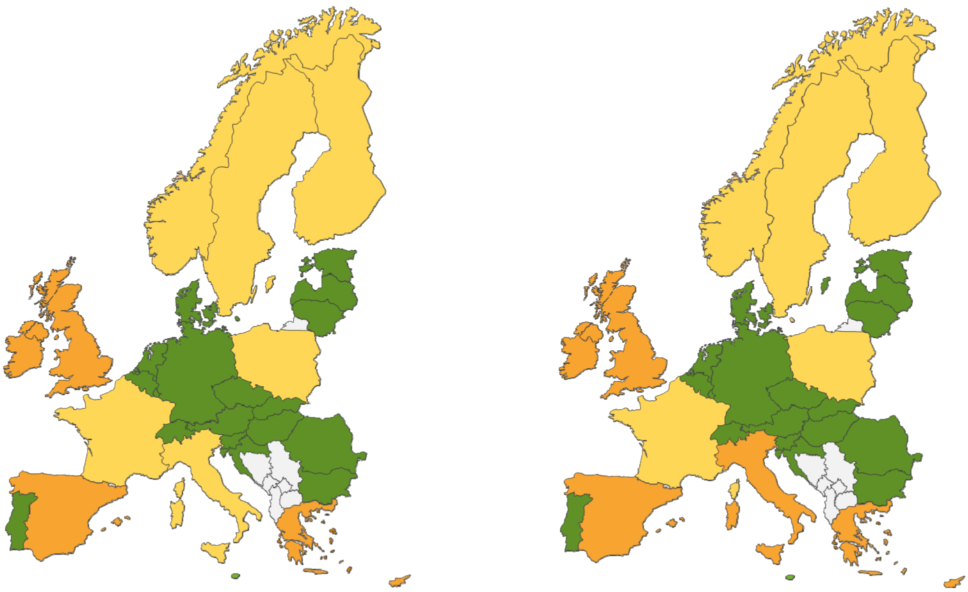
2 *Secure electricity supply – electricity at any time*

Electricity networks should ensure that all citizens and business in Europe are supplied with electricity at each moment, also where production is tight and demand is at a peak. The relevance of trans-regional networks has even increased because of the growth of variable and geographically constrained renewables.

Based on the current formula and following further assessments, to account for the contribution of interconnectors to security of supply the Expert Group considers that the interconnection levels should be measured by a new formula to reflect peak demand in 2030 (as the relevant reference year for the interconnection target).

The following map demonstrates the interconnection levels in the EU member states, based on the "demand" formula, proposed in chapter 4, for vision 3 (left map) and 4 (right map) of the TYNDP 2016 scenarios.

Member States by interconnection level as measured in relation to the peak load in vision 3 (left map) and vision 4 (right map).



For detailed Member State interconnection levels in all scenarios please see annex 2. The countries in orange, Cyprus, United Kingdom, Ireland, Greece, Spain and Italy (in vision 4) have interconnection levels equal or below 30%; the countries in yellow, Italy (in vision 3), Finland, France, Poland, Norway and Sweden have interconnection levels between 30% and 60%; while the countries in green, Malta, Germany, Romania, Bulgaria, Belgium, Portugal, Czechia, Netherlands, Denmark, Estonia, Hungary, Slovakia, Lithuania, Austria, Switzerland, Croatia, Latvia, Luxembourg and Slovenia, have interconnection levels above 60%.

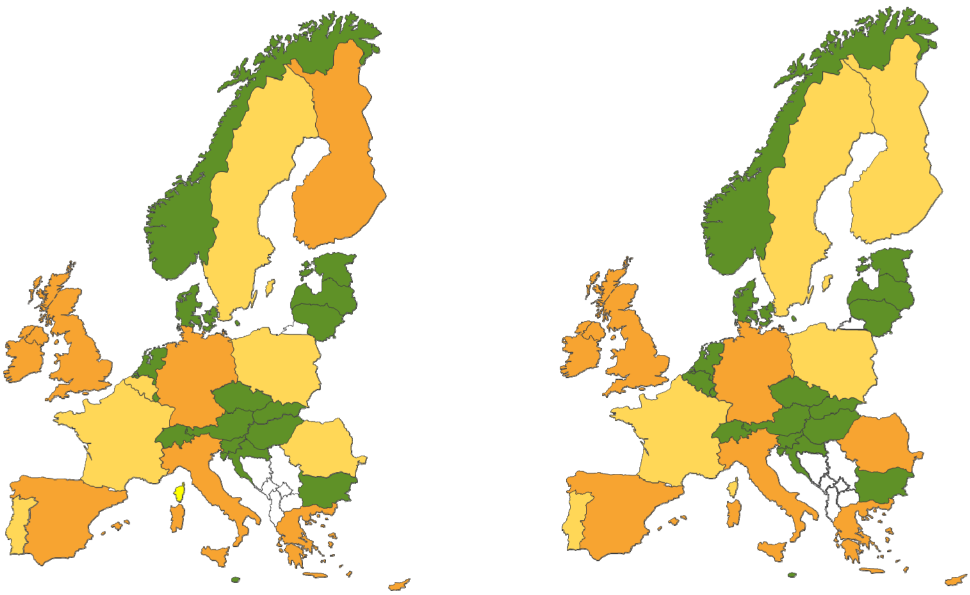
The above analysis can also be made, if deemed necessary, to groups of neighbouring countries or bidding zones.

3. Efficient integration of renewables

Electricity networks should also ensure that interconnections allow efficient integration of renewables. Based on the current formula and following further assessments, to account for the contribution of interconnectors to integration of renewables the Expert Group considers that the interconnection levels should be measured by a second complementary formula to reflect the potential export capacity of a country as defined by installed renewable generation capacity.

The following map demonstrates the interconnection levels in the EU member states, based on the "supply" formula, proposed in chapter 4, for vision 3 (left map) and 4 (right map) of the TYNDP 2016 scenarios.

Member States by interconnection level as measured in relation to the installed renewable generation capacity in vision 3 (left map) and vision 4 (right map).



For detailed Member State interconnection levels in all scenarios please see annex 3. The countries in orange: Cyprus, United Kingdom, Greece, Ireland, Spain, Italy, Germany, Finland (vision 3) and Romania (vision 4) have interconnection levels equal or below 30%; the countries in yellow, Romania (vision 3), Finland (vision 4), France, Portugal, Sweden, Poland and Belgium (vision 3) have interconnection levels between 30% and 60%, while the countries in green, Belgium (vision 4), Denmark, Bulgaria, Austria, Netherlands, Norway[19], Switzerland, Malta[20], Hungary, Latvia, Slovakia, Lithuania, Croatia, Estonia, Czechia, Luxembourg and Slovenia have interconnection levels above 60%.

The above analysis can also be made, if deemed necessary, to groups of neighbouring countries or bidding zones.

4. Measurable benefits to the society

As the ultimate condition and irrespective of any minimum interconnection target, in the Expert Group's opinion, each planned interconnector should demonstrate that its benefits to society outweigh its costs. Individual interconnectors might bring value to the society even if the minimum interconnection target has been reached, as in some cases more interconnection capacity could be needed. Therefore, planned interconnectors should always be accompanied by a thorough cost-benefit analysis (CBA) test as a prerequisite for any investment decision in line with the methodology developed by ENTSO-E as part of the Ten-Year Network Development Plan and selection of Projects of Common Interest.

As specified in Article 11 of the TEN-E regulation[21], the methodologies for the harmonised energy system-wide cost-benefit analysis shall be drawn up in line with the principles laid down in Annex V and be consistent with the rules and indicators set out in Annex IV. The Expert Group stresses that further work on the refinements of the current CBA methodologies is needed to ensure that the complexity of the electricity systems is fully reflected.

5. Better utilisation of existing infrastructure

The Expert Group stresses that the existing and new infrastructure, whether interconnectors or internal network, should be used efficiently. In this context, the maximum possible transmission capacity of interconnectors - taking into consideration the operational and security concerns - must be made available to the market participants.

[19] Since the Norwegian system is based almost entirely on renewable sources, installed renewable generation capacity for Norway includes all renewables like wind, solar and hydro/run of river, but excludes RES-hydro having a reservoir."

[20] The RES values for Malta were taken from the scenario sustainable transition for the TYNDP2018 since Malta was not subject of the anlysis in TYNDP 2016 .

[21] Regulation (EU) No 347/2013 of the European Parliament and of the Council of 17 April 2013 on guidelines for trans-European energy infrastructure and repealing Decision No 1364/2006/EC and amending Regulations (EC) No 713/2009, (EC) No 714/2009 and (EC) No 715/2009 Text with EEA relevance

Today's average, computed by ACER, of 31%[22] of existing interconnector capacity made available to the market results in inefficient functioning of the European electricity markets as it limits the electricity trade between Member States. An efficient use of interconnectors is deemed important in terms of public acceptance for infrastructure projects.

[22] ACER report on the current use of the interconnectors – http://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Recommendations/ACER%20Recommendation%2002-2016.pdf

6. Interconnection targets – recommendations

Following the previous assessments and identification of relevant elements for the functioning and development of interconnectors, the Expert Group proposes that a combined approach would be needed to determine the interconnection targets, which means that the new formulas would be accompanied by a set of key conditions that must be taken into account. Such approach would consolidate all the key elements of energy policy such as market integration, security of supply, sustainability and cost effectiveness. The Expert Group recommends that:

1) Efficient functioning of the European electricity market should be improved

The European electricity market requires clear, non-discriminatory rules and a stable regulatory framework that will give consistent signals both to investors of grids as well as to users of the infrastructure. In that respect, the Expert Group considers the effective and rapid implementation of the network codes and guidelines adopted in the framework of the Third Energy Package a top priority.

2) The existing interconnectors should be used efficiently

The Expert Group stresses that the efficiency of the use of interconnectors, as expressed by the ratio of net transfer capacity to nominal capacity, should be raised significantly. This means that congestion management should be non-discriminatory and should maximise the European socio-economic welfare. For AC interconnectors, for which ACER reports a current very low capacity made available to the market, this ratio should be indicatively doubled[23]. The Expert Group calls for the introduction of an operational target aiming at maximising the efficiency of the existing infrastructure.

3) All EU countries must investigate interconnection development in order to deepen the European market integration and develop security of supply.

Member States should aim at achieving yearly average of price differentials as low as possible. Developing additional interconnectors should be seriously considered and rigorously investigated whenever the price difference between relevant bidding zones, countries or regions exceeds €2/MWh

[23] A specific utilisation threshold should be determined taking into account the outcome of the relevant ongoing ACER study.

4) The interconnection level should be measured based on two new formulas: a) the ratio of the nominal transmission capacity to the peak load (demand) and b) the ratio of the nominal transmission capacity to the installed renewable generation capacity (supply).

The Expert Group recommends that countries below the threshold of 30% on any of the two formulas should urgently investigate options of further interconnectors and report annually the results of such investigation to the High Level Regional Groups and the Infrastructure Forum.

Any project, helping the Member States reach the 30% threshold must apply for inclusion in the TYNDP and future PCI lists.

The countries above the 30% but below 60% thresholds on any of the two formulas are requested to investigate possible projects of further interconnectors regularly. Such projects should consider applying for inclusion in the TYNDP and a future PCI lists.

The Expert Group recommends the electricity interconnection levels to be annually measured by ENTSO-E and reported to the Commission and ACER.

5) The Cost-Benefit Analysis is a conditio sine qua non

Each individual interconnector must be subject to a cost-benefit analysis as part of the TYNDP analysis, which should serve as the final assessment of the potential socio-economic welfare generated by new investments. Only interconnectors that can demonstrate potential benefits outweighing costs should be developed.

6) Involvement of the public is necessary at an early stage of interconnector's development

In addition, the Expert Group recommends the early involvement of citizens and relevant stakeholder groups potentially affected by the development of new interconnectors, to minimise the length and impact of procedural delays. In this regard, the Expert Group recommends the Commission as well as the Member States to continue and step up actions to facilitate public involvement in the relevant infrastructure projects.

7) The measurement methodologies should be reviewed regularly

Finally, due to the fast technological developments, as explored in chapter three, the Expert Group recommends the review of the methodological approach to the measurement of the interconnection level and the assessment methodologies regularly but not later than in five years.

Annex 1: Composition of the Expert Group and the profiles of its members

1. **Mr Christophe Gence-Creux**, Head of the Electricity Department representing the Agency for the Cooperation of Energy Regulators (ACER);
2. **Mr Sebastien Lepy**, Chair System Development Committee, and **Ms Irina Minciuna**, System Development Advisor, representing the European Networks of Transmission System Operators for electricity ENTSO-E;
3. **Ms Céline Heidrecheid**, Business Area Manager System Development, and **Mr Malcolm Arthur**, Business Area Manager Markets representing the European Networks of Transmission System Operators for gas ENTSOG;
4. **Ms Paulina Beato Blanco**, member in a personal capacity, Professor of economics, former CEO of Red Electrica de Espana, former principal economist of the Interamerican Development Bank;
5. **Ms Ivona Štritof**, Director of EU and Regulatory Affairs Department at Hrvatska elektroprivreda d.d., representing Central Europe Energy Partners (CEEP);
6. **Mr Yannick Phulpin**, Senior Engineer EDF, representing Eurelectric;
7. **Mr Nikolaos Vasilakos**, Member of EREF Advisory Board, former President of the National Regulatory Authority for Energy in Greece, representing European Renewable Energies Federation;
8. **Mr Pierre Bernard**, CEO, representing Friends of the SuperGrid;
9. **Mr Daivis Virbickas**, CEO, and his alternate **Mr Liutauras Varanavicius**, Director of Strategy Department, representing Litgrid AB;
10. **Mr Brian Vad Mathiesen**, member in a personal capacity, Professor in energy planning at Aalborg University;
11. **Mr Michal Smyk**, Head of Strategy, Polska Grupa Energetyczna (PGE), representing Polish Electricity Association (PKEE);
12. **Mr Terry McCormick**, European Business Development and his alternate **Mr Jonny Hosford**, representing National Grid;
13. **Ms Antonella Battaglini**, CEO representing Renewable Grid Initiative (RGI);
14. **Mr Auke Lont**, CEO and his alternate **Mr Tor Eigil Hodne** Senior Vice President European Affairs, representing Statnett;

15. **Mr Jochen Kreusel**, Market Innovation Manager Power Grids Division and Senior Vice- President at ABB; Professor RWTH Aachen, T&D Europe Vice-President, representing T&D Europe;
16. **Ms Cécile George**, alternate member in a personal capacity, former Director of Electric Grid Access at the French energy regulatory authority;
17. **Mr Alejo Vidal-Quadras**, alternate member in a personal capacity; professor of atomic and nuclear physics, former Member and Vice-President of the European Parliament, EP rapporteur on Regulation concerning measures to safeguard security of gas supply;

Chair of the Expert Group: **Ms Catharina Sikow-Magny**, Head of Networks and Regional Initiatives Unit, Directorate-General for Energy, European Commission, assisted by Policy Officer **Tomasz Jerzyniak** and Katrien Prins, Networks and Regional Initiatives Unit, Directorate-General for Energy, European Commission.

Annex 2: Interconnection levels by Member State as measured by nominal electricity interconnection capacity to peak load in 2030

V1			
Country	Nominal cap [MW] 2020	peak Load 0,999 percentile [MW] 2030	Nominal cap2020/peak load 2030 [%] 2030
SI	10227	2404	425%
LU	3760	1161	324%
LV	4938	1628	303%
HR	10266	3793	271%
CH	29605	11914	248%
AT	24675	11677	211%
LT	4116	2068	199%
SK	9306	4665	199%
HU	13861	7041	197%
EE	3038	1705	178%
DK	11143	6771	165%
NL	23303	19033	122%
CZ	16202	11335	143%
PT	8882	9712	91%
BE	11683	14050	83%
BG	5434	7109	76%
RO	6319	9544	66%
DE	52628	85242	62%
MT	381	600	64%
NO	13144	23351	56%
SE	12886	26231	49%
PL	10057	27655	36%
FR	33906	77793	44%
FI	4650	14862	31%
IT	17817	61387	29%
ES	14487	51240	28%
EL	1762	11176	16%
IE	500	5037	10%
UK	4500	58896	8%
CY	0	1074	0%

V2			
Country	Nominal cap [MW] 2020	peak Load 0,999 percentile [MW] 2030	Nominal cap2020/peak load 2030 [%] 2030
SI	10227	2322	440%
LU	3760	1147	328%
LV	4938	1557	317%
HR	10266	3548	289%
CH	29605	11282	262%
AT	24675	10903	226%
LT	4116	1876	219%
SK	9306	4536	205%
HU	13861	6842	203%
EE	3038	1718	177%
DK	11143	6623	168%
NL	23303	18751	124%
CZ	16202	13103	124%
PT	8882	9359	95%
BE	11683	13311	88%
BG	5434	6545	83%
RO	6319	8696	73%
DE	52628	81369	65%
MT	381	600	64%
NO	13144	24256	54%
SE	12886	25165	51%
PL	10057	25426	40%
FR	33906	87400	39%
FI	4650	14782	31%
IT	17817	59282	30%
ES	14487	61157	24%
EL	1762	9865	18%
IE	500	5184	10%
UK	4500	61365	7%
CY	0	988	0%

V3			
Country	Nominal cap [MW] 2020	peak Load 0,999 percentile [MW] 2030	Nominal cap2020/peak load 2030 [%] 2030
SI	10227	2250	455%
LU	3760	1156	325%
LV	4938	1275	387%
HR	10266	3643	282%
CH	29605	10376	285%
AT	24675	10810	228%
LT	4116	1623	254%
SK	9306	4382	212%
HU	13861	6372	218%
EE	3038	1590	191%
DK	11143	6910	161%
NL	23303	18546	126%
CZ	16202	10564	153%
PT	8882	9592	93%
BE	11683	12612	93%
BG	5434	6027	90%
RO	6319	8471	75%
DE	52628	78298	67%
MT	381	600	64%
NO	13144	24844	53%
SE	12886	22685	57%
PL	10057	24124	42%
FR	33906	81905	41%
FI	4650	13442	35%
IT	17817	53945	33%
ES	14487	57955	25%
EL	1762	8322	21%
IE	500	5239	10%
UK	4500	64736	7%
CY	0	766	0%

V4			
Country	Nominal cap [MW] 2020	peak Load 0,999 percentile [MW] 2030	Nominal cap2020/peak load 2030 [%] 2030
SI	10227	2322	440%
LU	3760	1147	328%
LV	4938	1557	317%
HR	10266	3548	289%
CH	29605	11282	262%
AT	24675	10903	226%
LT	4116	1876	219%
SK	9306	4536	205%
HU	13861	6842	203%
EE	3038	1718	177%
DK	11143	6623	168%
NL	23303	18751	124%
CZ	16202	13103	124%
PT	8882	9359	95%
BE	11683	13311	88%
BG	5434	6545	83%
RO	6319	8696	73%
DE	52628	81369	65%
MT	381	600	64%
NO	13144	24256	54%
SE	12886	25165	51%
PL	10057	25426	40%
FR	33906	87400	39%
FI	4650	14782	31%
IT	17817	59282	30%
ES	14487	61157	24%
EL	1762	9865	18%
IE	500	5184	10%
UK	4500	61365	7%
CY	0	988	0%

Annex 3: Interconnection levels by Member State as measured by nominal electricity interconnection capacity to installed renewable generation capacity in 2030

		2030 Total RES capacity installed					Nominal interconnection capacity over total RES installed							
Country	Nominal interconnection capacity 2020 [MW]	Vision 1 [MW]	Vision 2 [MW]	Vision 3 [MW]	Vision 4 [MW]	Country	Nominal capacity over total RES - Vision 1	Country	Nominal capacity over total RES - Vision 2	Country	Nominal capacity over total RES - Vision 3	Country	Nominal capacity over total RES - Vision 4
SI	10227	2354	2354	2500	3495	SI	434%	SI	434%	SI	409%	SI	293%
LU	3760	1694	1624	1824	1774	LU	222%	LU	232%	LU	206%	LU	212%
CZ	16202	7850	6420	7850	7850	CZ	206%	CZ	252%	CZ	206%	CZ	206%
EE	3038	1296	1296	1726	1551	EE	234%	EE	234%	EE	176%	EE	196%
HR	10266	4500	3800	5000	5829	HR	228%	HR	270%	HR	205%	HR	176%
LT	4116	2305	2145	2525	2425	LT	179%	LT	192%	LT	163%	LT	170%
SK	9306,1	4354	4264	4970	5486	SK	214%	SK	218%	SK	187%	SK	170%
LV	4938	2681	2291	3041	2936	LV	184%	LV	216%	LV	162%	LV	168%
HU	13861	1626	1626	2550	8803	HU	852%	HU	852%	HU	544%	HU	157%
MT	381	277	277	277	277	MT	138%	MT	138%	MT	138%	MT	138%
CH	29605	21880	20980	25900	25267	CH	135%	CH	141%	CH	114%	CH	117%
NO	13144	11980	11980	14710	11495	NO	110%	NO	110%	NO	89%	NO	114%
NL	23303	11338	11598	33218	24813	NL	206%	NL	201%	NL	70%	NL	94%
AT	24675	23718	23098	28671	31194	AT	104%	AT	107%	AT	86%	AT	79%
BG	5434	6150	5300	7468	7516	BG	88%	BG	103%	BG	73%	BG	72%
DK	11143	8759	10979	14449	15959	DK	127%	DK	101%	DK	77%	DK	70%
BE	11683	12088	12088	19530	17169	BE	97%	BE	97%	BE	60%	BE	68%
PL	10057	19903	16453	24626	22326	PL	51%	PL	61%	PL	41%	PL	45%
SE	12886	29383	29383	33943	31663	SE	44%	SE	44%	SE	38%	SE	41%
PT	8882	14598	15888	17877	22419	PT	61%	PT	56%	PT	50%	PT	40%
FR	33906	60600	49000	92700	95051	FR	56%	FR	69%	FR	37%	FR	36%
FI	4650	10340	10340	17100	14007	FI	45%	FI	45%	FI	27%	FI	33%
RO	6319	15737	14437	17187	20921	RO	40%	RO	44%	RO	37%	RO	30%
DE	52628	151507	128277	188467	179802	DE	35%	DE	41%	DE	28%	DE	29%
IT	17817	67855	70415	93675	99913	IT	26%	IT	25%	IT	19%	IT	18%
ES	14487	78400	86650	94450	125469	ES	18%	ES	17%	ES	15%	ES	12%
IE	500	5378	4368	7758	7198	IE	9%	IE	11%	IE	6%	IE	7%
EL	1762	15189	13669	18449	25735	EL	12%	EL	13%	EL	10%	EL	7%
UK	4500	42104	76444	85152	85866	UK	11%	UK	6%	UK	5%	UK	5%
CY	0	890	820	860	850	CY	0%	CY	0%	CY	0%	CY	0%