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Europe's Electricity Supply Security: Strengthening the Chain

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Introduction

Efficient development of electricity transmission infrastructure is crucial to achieving EU targets for a secure, competitive and sustainable electricity supply. However, many uncertainties, such as future load demand, generation supply, electricity prices and increasing time requirements for the realisation of transmission infrastructures in member states, increase the risk that these targets will not be reached. Given the forecasted increase of distributed generation and the introduction of demand response techniques to control load, new decentralised network architectures must be defined to guarantee the system's efficient use and stability. Each link in the chain of electricity security of supply is crucial, from generation to transmission to distribution to demand.

1. Generation: Adequacy and remedies for shortages

The main issue regarding electricity generation is ensuring both its short- and long-term adequacy; that is, making sure that the level of generation is capable of maintaining the supply/demand balance (taking into account network constraints). Generation adequacy is determined mainly by the reserve margin: the availability of an installed capacity sufficiently greater than the expected peak load. But ample installed generation capacity alone is not sufficient to ensure adequacy, since in addition the generation set (the device/plant/network used to convert electrical power) must be well adapted to the load demand and to the increasing penetration of intermittent renewable sources. In other words, the composition of the generation set in terms of base-load, mid-merit and peak-load power plants (characterised by different degrees of operating flexibility), and in terms of dispatchable (capable of being turned on or off on demand) and non-dispatchable power plants, must be correctly balanced.

In this respect, electricity market price signals are in themselves not sufficient to ensure generation adequacy, mainly due to informative asymmetries and to a lack of sufficient competition that makes market players unable to collectively achieve 'optimal' development of the generation set, both in time and in space (i.e. in terms of location in the network). Moreover, permitting procedures are long and

secure — Security of Energy Considering its Uncertainty, Risks and Economic implications

SEVENTH FRAMEWORK PROGRAMME

Research for this paper was carried out in the context of the SECURE project (Security of Energy Considering its Uncertainties, Risks and Economic Implications), funded by the European Commission under the Seventh Framework Programme. The project develops appropriate tools for evaluating the vulnerability of the EU to the different energy supply risks, and for promoting the optimisation of EU energy insecurity mitigation strategies, including investment, demand side management and dialogue with producing countries.

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uncertain, while risk aversion makes investors wait until they can be sure of the profitability of new investments. This causes significant delays before a new power plant becomes available, which in turn can cause so-called 'boom-and-bust' cycles: when periods of high-reserve margins and consequent low electricity prices that do not encourage new investments (due to subsequent progressive load increase and the decommissioning of old power plants) alternate with periods of low-reserve margins (and thus low security of supply) and consequent high electricity prices, this can lead to a new wave of investments.

To tackle these problems, regulatory authorities in several electricity markets worldwide, with the approval of governments, defined and/or implemented specific intruments, such as tendering procedures for new capacity, capacity payments, capacity markets/obligations and call options. We recommend the implementation of such instruments to push investors to pursue the 'optimal' development of the generation set and to avoid capacity 'bust' situations. However, we also recommend relying on only those 'market-based' mechanisms capable of finding the most efficient solution through competitive procedures (e.g. fixed capacity payments administratively defined should not be taken into account).

According to Regulation (EC) no. 714/2009, Transmission System Operators (TSOs) are in charge of assessing the present and future adequacy of the power system both at the national level and, through the European Network of Transmission System Operators for Electricity (ENTSO-E), at the European level. In doing so, TSOs should not only 'passively' try to envisage future generation development according to market player investment behaviour. They should support the implementation of adequacy instruments by being 'proactive' and providing a technical evaluation of how much new generation capacity of each type is needed, and when and where it is needed (as the location in the network is very important). This can be done on the basis of scenario analyses, especially of demand evolution, intermittent renewable sources penetration and network development. Ideally, this entire process would be coordinated and harmonised at the EU level to increase effectiveness and avoid market distortions. However, even a generation set that is adequate in terms of installed capacity and composition can become insecure again if its fuel mix is not sufficiently diversified: a large amount of capacity could become unavailable in the case of a fuel supply shortage.

Several remedies for fuel supply shortages exist. In the context of the power system, the most obvious policy remedy is the long-term pursuit of greater primary source diversification in the generation set. In this respect, increased emphasis on sustainable development of renewable energy sources (RES), supported by Directive 2009/28/EC, is a must for several reasons, not least among them security of supply. Nevertheless, as indicated above, the intermittent nature of RES requires an adequate backup capacity comprised of conventional dispatchable power plants. In fact, greater primary source diversification could be achieved using the same regulatory instruments concerning capacity adequacy mentioned above. Of course, the highest political levels responsible for the overall energy policy are in charge of the quantitative definition of the objective itself: in this case TSOs could only play the role of consultants for technical aspects concerning the implementation of the objective and its impact on system adequacy.

Effective remedies for a fuel supply shortage can also be put in place outside the power system. SECURE project studies found that the best insurance for all gas consumers is a significant amount of gas storage, both for modulation and, especially, strategic purposes. The development of an adequate amount of gas storage infrastructure, both at the European level and, especially, in countries where natural gas accounts for a large share of primary energy consumption, should have a high priority in overall energy policy.

Diversification can also be applied as a fuel shortage remedy to both suppliers and supply infrastructure: diversifying the former reduces counterpart risk, while diversifying the latter reduces accident-related risk and the risk of shortages caused by transit countries. As for natural gas, LNG terminals are the most flexible way to implement diversification, since their supply is tied neither to a single supplier nor to a single pipeline. New energy supply infrastructure at the European level should be prioritised according to its diversification capability.

Finally, increasing cross-border transmission capacity can help foreign power systems better assist the countries affected by shortages. This is the next link in the electricity supply chain.

2. Transmission: Investing in new interconnections, dealing with uncertainty

The SECURE project assessed the impact of non-optimal development of European cross-border transmission capacity. Needless to say, the main remedy to such non-optimal development is to invest in new interconnections. The resulting reduction of bottlenecks will make it easier to transport cheaper energy to where it is needed and increase security of supply, but also allow for greater integration and more efficient operation (as a result of a reduction of local market power) of the internal electricity market and, in the end, for a more optimised operation of the generation set, with significant economic benefits. This remedy is of course not so easy to implement, neither by TSOs nor by private investors interested in merchant line projects. In fact, such investments are typically affected by several uncertainties,[1] mainly due to:

- complex legal and regulatory contexts, especially for permitting procedures, stemming from a multitude of authorities at different administrative levels (European, national, local), which may differ from one country to another and have different priorities;
- the lack of social acceptance that severely delays or jeopardises the realisation of such projects;
- the long-term time horizon that characterises network projects; and
- the inherent difficulty of predicting the future location, amount and type of generation and load.

To reduce such uncertainties,[2] several actions are necessary. The establishment of the Agency for the Cooperation of Energy Regulators, or ACER, foreseen by the EU legislative proposals collectively known as the Third Energy Package, should be a significant step towards a more harmonised regulatory framework at the European level. As for permitting procedures, it is necessary[3] to act on the legal framework, first by simplifying and rationalising the procedures (reduce the number of entities and phases involved, etc.); for strategic infrastructure projects, the procedures should be centralised at one (national) level, while upgrading existing lines should require simplified procedures with a shorter duration. Next, set reasonable maximum time limits for the completion of procedures; harmonise the procedures and criteria for authorisation at the EU level through binding guidelines; and secure early binding pre-approval of the projects as reported in TSO development plans in order to avoid TSOs spending time justifying the need for the projects during permitting procedures. Once these steps on the legal framework are taken, an 'arbiter' or 'facilitator' (e.g. ACER) can be designated to promote compromises, deal with controversies and speed up the realisation of strategic projects in transnational cases.

As for the lack of social acceptance, it is necessary to provide a clear and objective vision of the benefits and costs of the new infrastructure, to prioritise investments worthy of EU funding, and to clearly state the cost to society of inaction or suboptimal actions. The relationship between RES integration, security of supply and grid development, and the relationship between costs and technical solutions (e.g. overhead lines vs. underground cables), must be clarified. To facilitate informed appraisal of project 'pros' and 'cons', independent and competent bodies can help initiate a clear, sound, scientific discussion of all key issues related to the public perception of a new transmission line (negative impacts on human health, landscape, property value, noise, migratory paths, etc.; feelings such as "burden to me, benefits to others", "home invasion", "lack of democracy", lack of "serious" information, etc.). A thorough evaluation of property value must be promoted to guarantee fair compensation (including "immaterial" aspects) agreed to by all the parties. It is very important to find consensus among the involved populations on the economic side of the problem: they must know that the realisation of the projects will reduce their electricity bills (either by imports of cheaper energy or by direct compensation). Otherwise, the NIMBY attitude is their first and easiest recourse.

Uncertainties concerning the future of generation and demand can be effectively tackled by carrying out adequate scenario analyses similar to those in the SECURE project, based on POLES (Prospective Outlook on Long-term Energy Systems) model scenarios. This approach is also supported by ENTSO-E, which states, "[S]cenario analyses at national, regional and pan-European levels are key elements in order to decide on grid extensions and to adequately assist political reasoning", taking into account "fuel prices, economic and monetary conditions, geopolitical developments, meteorological conditions, technological breakthroughs, market mechanisms, regulatory and legal frameworks". Moreover, generation companies should be discouraged (with economic penalties) from initiating permitting procedures if they are not strongly committed to realising the investments. Finally, the use of appropriate technology solutions (e.g. a flexible alternating current transmission system, or FACTS) can increase the transmission capacity of existing infrastructure, thus avoiding the need for investments in new lines. These faster and less expensive solutions

[1] As a general remark, one of the main barriers to long-term energy sector investments (which are usually quite capital intensive) is regulatory and legal uncertainty: it is crucial to guarantee investors by establishing some basic key conditions under which they will have to operate, in order to let them correctly assess their risks.

[2] Some of the following policy recommendations are discussed in more detail within the EC REALISEGRID project coordinated by RSE.

[3] Additional detailed recommendations are reported in "ENTSO-E position paper on permitting procedures for electricity transmission infrastructures", 29 June 2010.

must be adequately encouraged and remunerated by regulation.

Up to this point we have discussed the problems related to each generic development of the European cross-border transmission network (and most of the above mentioned issues are relevant to expansions of national transmission networks, too), but it is very important to end up with an optimal set of developments, according to the considered reference scenarios. Again, this is exactly what has been done in the SECURE project, following an approach supported by ENTSO-E, which in its recent "Research and Development Plan" endorses the development of "Advanced tools for analyzing the pan-European network expansion options according to energy scenarios for Europe (i.e. expansion optima that must be searched to maximize European welfare)", specifying that optima are to be searched at the EU level and no longer only at the national level.

As it is desirable to harmonise generation and transmission development, regulation must foresee the provision of 'locational signals', i.e. the spatial (zonal/nodal) differentiation of electricity prices (due to maximum transfer capability constraints and losses on the lines) and of transmission charges (calculated on the basis of how much each agent uses the network). Locational signals can therefore provide adequate economic incentives to market players about the dependency of energy supply costs on the physical location of production/consumption facilities, thereby leading to more efficient system operation in the short term and promoting a more optimised siting of new generators and loads in the long term. Moreover, as mentioned above, consumers who are exposed to locational electricity prices may directly benefit, e.g. from price reductions due to the installation of a new nearby power plant or transmission line,[4] and thus receive incentives not to assume an a priori NIMBY attitude.

3. Distribution: distributed generation and 'smartness'

The main challenge to distribution is its progressive transformation from a "passive" to an "active" network, due to the increased penetration of distributed generation. In this respect, Directive 2009/72/EC states that "Member States should encourage the modernisation of distribution networks, such as through the introduction of smart grids, which should be built in a way that encourages decentralised generation and energy efficiency".

Generally speaking, current distribution networks have some margins to host a limited amount of distributed generation, but, over a certain level, the quality and reliability of service can no longer be guaranteed, so additional measures, ranging from simple changes in protection or control settings to massive network investments, are needed. Therefore, development and deployment of new communication and control technologies is the key to making distribution grids "smarter", i.e. able to "cost efficiently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to ensure economically efficient, sustainable power system with low losses and high levels of quality and security of supply and safety", as stated in the "Position paper on smart grids" by ERGEG (European Regulators' Group for Electricity and Gas).

From the technological point of view, cooperation among international, European and national standardisation bodies, regulatory authorities, grid operators and manufacturers should be encouraged to further improve open communication protocols and standards for information management and data exchange, and achieve interoperability of smart grid devices and systems so as to avoid any technical barrier to their deployment.

From a regulatory point of view, a key question is how to support distribution network companies in their investments in such innovative technologies, in order to ensure that their deployment provides a cost-effective solution to the needs of network users. To this end, we share ERGEG's view that regulators must not attempt to choose or impose specific solutions – they must remain technologically neutral – leaving network companies to manage their business (which they have ultimate control over) in the most appropriate way: regulation should focus on the benefits for network users and not on the technical details to get them. Therefore, regulatory schemes for promoting improvements in performance of electricity distribution networks require the quantification, through appropriate indicators, of the effects and benefits of such investments in "smartness".

The definition of performance targets and indicators should be accompanied by clear, transparent and objective measurement rules that make it possible to observe, quantify and verify such targets. Moreover, performance targets should be benchmarked to define their expected values and should be strictly related to the pursued objectives: they should therefore be cleansed of external effects outside the control of network operators. Then, having defined targets and indicators, it is possible to use either incentive regulation, where regulated entities are either rewarded if they overperform or penalised if they underperform; minimum requirements regulation,

[4] Nevertheless, it must be taken into account that increasing transmission capacity along a congested path reduces prices in the importing area, but increases them in the exporting area.

where a minimum performance level must be accomplished by the regulated entity; or a combination of both. In the above mentioned ERGEG position paper a set of indicators is proposed.

4. Demand: Demand response techniques and energy efficiency

The last (but not least) link in the chain is demand. The two main issues related to security of supply are "demand response" and "energy efficiency". Demand response is related to the capability of consumers to respond to price signals or to signals concerning the criticality of system operation with a variation of their consumption profiles. Demand response's main beneficial effect is to reduce demand in peak load/high price periods, possibly moving part of it to less critical/lower price hours. A lower peak load:

- increases reserve margin (thus increasing security of supply) and, in the longer term, reduces the need for investments in new generation capacity;
- reduces the stress (and possible congestion) on both transmission and distribution networks, delaying the need for network expansions;
- reduces the necessity of dispatching costly and low efficiency power plants during peak hours, thus also reducing fuel consumption and CO2 emissions;
- reduces both the possibility of exercising market power by producers and price volatility, by making demand more elastic to price.

In fact, electricity demand has always been quite inelastic and an increase of its flexibility requires:

- a way to communicate the price/criticality signals to consumers;
- signal strength (or rewards for responding) significant enough to convince consumers to respond; and
- the genuine possibility for consumers to respond to the signals, according to their way of life and to the electric devices they manage manually and/or automatically.

The communication requirements and the necessity to measure and record the amount and the time of the response entail the availability of 'smart meters', which is also endorsed by Directive 2009/72/EC. It states that given a positive economic assessment of their long-term costs and benefits, at least 80% of consumers shall be equipped with intelligent metering systems by 2020. Such timing does not seem very ambitious taking into account best practices in countries such as Italy. Again, signal strength is critical to the success of demand response programmes: simple peak/off-peak tariffs with limited price differences that allow consumers to save mere tenths of a euro per year will not have any significant success. Moreover, the signals must be simple and easily understandable by consumers, so that they can correctly respond to them. Finally, provided that the proper communication and metering devices are in place and that there is substantial economic convenience to participate in demand response programs, information campaigns are necessary to enrol as many consumers as possible.

Regarding 'energy efficiency', EU energy policy foresees its implementation as an important means to reach the mandatory targets concerning CO_2 emissions reduction and RES development (whose objective is proportional to gross final consumption). To this end, several European directives (such as Directive 2006/32/EC of 5 April 2006 on energy end-use efficiency and energy services, Directive 2009/125/EC of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products, Directive 2010/30/EU of 19 May 2010 on the indication by labelling and standard product information of the consumption of energy and other resources by energy-related products, Directive 2010/31/EU of 19 May 2010 on the energy performance of buildings, etc.) and national laws and regulations (such as the National Energy Efficiency Action Plans) have been passed and are being implemented.

Generally speaking, it is clear that lower energy consumption reduces stress on the whole supply chain, thereby increasing security of supply. Moreover, most of the actions that can be carried out to increase energy efficiency have a 'negative' cost, i.e. they pay for themselves, therefore they are more economically efficient than actions to support RES development and reduce CO_2 emissions (such as Carbon Capture and Storage technologies). Nevertheless, some promotion is necessary, typically with fiscal incentives together with obligation schemes, such as White Certificates, and minimum standard requirements, in order to overcome possible barriers, such as the financial capability of customers to invest in more efficient appliances, the impact on their way of life of the implementation of such actions, the short-term view of some industrial management, that would avoid reducing the profits of the current financial year (by investing in more efficient technologies), in exchange for future lower production costs.

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