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Interconnected system operation conditions in Continental Central Europe

A briefing paper to the European Commission

Introduction

Recent developments in the electricity sector have significantly affected system operation conditions on the Continent, especially in central-European countries. Some TSOs increasingly face a situation in which operational measures, to keep the system in normal operational conditions, are exhausted. Due to characteristics of the synchronous system, this potentially threatens the security in the wider areas and ultimately the need to use emergency measures such as load shedding with direct impact on consumers.

Transmission networks in the central Western and Eastern/South Eastern parts are highly meshed; however, the adaptation of their design in the last several years to accommodate new market tendencies as well as to securely transport significant amounts of fluctuating generation (wind and solar) is ongoing. Development is severely hampered in particular due to permitting delays.

Integration of wind and other renewable sources (RES) influences the operation of power systems in many ways, and exacerbates the speed of development as observed today. The results of the European Wind Integration Study (2010) show that among the main concerns seen from the perspective of the interconnected power systems on the continent are the so called “transit flows”. The intermittent nature of wind (and to some extent also photovoltaic units) changes the continent-wide generation pattern in an unpredictable manner and as a consequence load flows accentuate the issue of transit flows.

As long as RES generation in certain regions expands faster – partly as a function of national support schemes - than the transmission network can accommodate, the risk of insecure system operation coupled with costly generation curtailments will rise significantly. The increased efficiencies in operating the network brought by TSO cooperation and new effective market designs can only partially address the issue. The forthcoming ENTSO-E Network Code on Generation Connection Requirements will provide a no-regrets solution for the secure functioning of the system in the future; however, the Network Code will not solve urgent issues that have been identified. This includes outdated connection settings for PV generation that are not being modified through retrofitting fast enough to mitigate the risk. But most important of all is the pragmatic and firm application of the provisions for streamlining permitting processes as proposed in the draft Regulation on guidelines for trans-European energy infrastructure adopted by the Commission on 19 October 2011; this will be a significant step in reducing the lag between RES development and transmission infrastructure implementation.

Overview

Transit flows are a reality of the power system driven by laws of physics; in a meshed system, electricity flows on every branch of the network (avoiding circular paths) to reach the consumption points from the source. Transit flows are those occurring on networks that do not include the source or the sink of energy. These electricity flows, traditionally induced by a relatively stable generation pattern, are taken into account in the operational planning of TSOs, thus managing to cope with deviations between the scheduled flow on the interconnections and the actual observed flow.

The evolving generation and commercial patterns that affect electricity flows across the Continent are addressed by network reinforcements. However, these new assets are not always commissioned on time due to the difficulties identified earlier (and explained in ENTSO-E’s TYNDP). As a result, the rate of congestion occurring has increased in location and duration over recent years. The intermittency of significant new wind (and solar) generation only adds to this problem introducing new bottlenecks to the system that are relatively short-lived but represent a great threat to system security. The current power production from RES especially from wind generation in Northern Germany, Denmark, and North Sea and Baltic Sea regions is physically transported by

the German internal grid and also in large extent by parallel flows via transmission systems of neighboring countries to the Southern parts of Germany, to the Alps or even the Southern parts of the Continent. The limited predictability of these large flows has on occasion caused non-compliance with fundamental grid operational security criteria in parts of the Central Continental European region. Transmission lines overloading or (n-1) violations in parts of the network which endanger the network have been increasingly reported by TSOs.

On several borders the difference between physical and scheduled flows is of such magnitude that they are often in opposite directions. This is observed more than 90% of the time on PL/DE border, more than 90% on PL/CZ and more than 80% on PL/SK border. Heavy 'unplanned' transit flows added to scheduled flows cause severe loading on southern interconnectors (PL/CZ, PL/SK, DE/CZ, and also SK/HU and SK/UA) and lead to noncompliance with fundamental network security criteria. The high level of flows on the interconnectors leads to overloading of the network in Germany and neighboring countries Poland, Czech Republic, Slovakia and Hungary.

However, the security risks observed today are the culmination of the deterioration of the overall system that can be observed by the gradual limitation of the Net Transfer Capacities (NTC) between these countries over recent years. NTC limits have traditionally been one of the tools TSOs utilize under current market rules to manage the increased magnitude of unforeseen physical flows. Clearly this tool is used only when necessary but is nowadays increasingly used due to increased volumes of unforeseen generation intermittency restricting commercially available capacity for market parties.

TSO responses to the challenge

Operation of the transmission network

Limiting NTCs on the interconnections are preceded by other countermeasures. TSOs increase transmission reserve margins, postpone planned network maintenance, or reconfigure the grid (if possible in the time available). Also, altering the unit commitment of generation units can provide some flexibility in anticipation of congestion. Curative countermeasures include altering the setting of phase-shifting transformers (PSTs), or further topological adaptations[1] which, in some cases, temporarily endanger the security of the system. Dispatching generation within constrained areas (and also curtailment of generation[2]) is also one of the tools that when available can help the security of operations, albeit at a high cost.

TSOs recognize that the effectiveness of the above actions is greatly enhanced when performed in a coordinated way. For example to keep the PSE Operator – 50 Hertz Transmission network cross section profile in secure operating conditions, both TSOs have developed a common list of remedial actions, regularly used on windy days. This list includes cross border re-dispatching, the cost of which is shared equally by both sides. Similarly, the first multilateral countermeasure consisting of the rescheduling of HVDC links over the Baltic Sea with the cooperation of German and Polish TSOs with two Nordic TSOs (Energinet.dk and Svenska Kraftnät) was developed in 2008 in order to relieve congestions on the Polish–German (50 Hertz Transmission) cross section. By rescheduling simultaneously on the two HVDC links in opposite directions, power is moved in a closed loop relieving congestions in the AC grid between HVDC terminals in the same way as cross border re-dispatching does. The important advantage of this so-called "DC loop flow" countermeasure is that there is no need to alter generation; thus there are lower costs. However, none of these remedial actions are guaranteed as they depend on prevailing system conditions.

[1] E.g. operation of Lemešany substation (SK) with disconnected bus bar breaker to redirect flows coming from Poland, that causes decrease of flows on SK/PL and SK/UA profiles, but at the same time to increase of flows on SK/HU, CZ/PL and CZ/AT profiles

[2] E.g. decrease of generation including RES in 50HzT according to the German Industrial Energy act §13 in case of danger for secure system operation

Regional Cooperation

TSOs are developing deeper and more permanent arrangements for TSO cooperation, looking for the best countermeasures at regional level (like the HVDC rescheduling described earlier). The need for increased regional coordination recognizes that relieving congestion in one area may directly lead to congestion in another. This particularly applies to areas with a highly meshed network such as the central part of the Continental interconnection. This rationale leads to the establishment of formal cooperation among TSOs (Regional Security Coordination Initiatives[3]) enabling TSOs from Central Europe to jointly analyze operational security analyses and remedial actions.

It is expected, that these measures, besides intervening with the market, shall not be sufficient because of the inappropriate relation between the scale and schedules of commissioning the new indispensable transmission infrastructure projects in the Continental Central Eastern region, especially Germany, on one hand, and the target EU level of renewable generation. It is already well recognized that the efficiency of already developed and future operational remedial actions, regardless of their sophistication level, can be limited and may be not sufficient in some areas in the near future.

These Regional Security Coordination initiatives aim to develop and implement more advanced day-ahead and intraday operational planning procedures. The practical implementation of multilateral re-dispatching is a major challenge, since it involves several different regulatory regimes and market arrangements. **For that reason regulatory authorities are directly involved in discussions on finding the relevant cost sharing mechanism of such multilateral countermeasures. One could argue that without full harmonization of market rules across the region, it is impossible to find proper solution.**

Planning the transmission network

If regional, or even pan-European, TSO cooperation is required to maintain security in a system operating closer and closer to its limits, the same also holds true for transmission grid planning. TSO cooperation over the last decades has been formalized in the establishment of ENTSO-E and, with the Ten-Year Network Development Plans (TYNDP) in 2010 and 2012.

In one of the regional plans that form part of the TYNDP 2012, the issue of high transit flows in Central Europe has been addressed: for example the installation of PSTs on the Polish-German border is considered to be a measure to solve congestion in Poland. Similar measures may also be indicated for the Czech Republic or the Slovak Republic but such solutions have not been analyzed in the TYNDP 2012. Studies on the use of PSTs show that power flow control in general and PSTs in particular could deal with congestions and enhance grid security in the current and future situation due to added controllability allowed by PSTs, regardless of the amount of the new transmission line corridors. The power flow through the Polish and Czech network and possible transit flows could be controlled by PSTs, and limited if needed. The transit flows through these countries will be reduced significantly. This will partially unload the networks of PSE Operator and ČEPS, but will increase the flows inside Germany. These additional flows inside Germany, will call for more operational countermeasures as explained above. In the short term, it allows safe conditions of reinforcement of 220 kV transmission lines to 400 kV in the Western part of Poland, which is a necessary condition for increasing transmission capacity on the Polish – German border. The import and export capability from the view of the Polish and Czech networks can be increased, compared to the situation without controlling the power flows by PSTs. As a conclusion, the installation of PSTs is considered as a timely, financially and technically manageable measure, however in the long-run and as far operation of the interconnected system is concerned, it cannot be classified as a sustainable solution. Even more importantly, TSOs are working towards the definition of common principles for the operation of PSTs to eliminate unwanted effects of these devices working against each other.

[3] There are three formal co-operations involving ENTSO-E members they are TSO Security Cooperation (TSC), CORESO, SSC

The overall picture of sustainable solutions is included in the TYNDP 2012. Among them, the reinforcement of the German-West and German-East[4] corridors amount to about 30 billion Euros for the next decade but they should not be seen in isolation from investments in neighboring countries. Considering the fact that operational measures are not always available due to system conditions, **the timely implementation of the TYNDP 2012 projects poses once more a major challenge for European policy makers; this stresses the particular importance of the provisions for streamlined permitting procedures proposed by EC in its Regulation on guidelines for trans-European energy infrastructure adopted in October 2011.**

Market Design

None of the solutions above will reach their full potential without consistent market mechanisms that provide the "software" to make optimal use of existing infrastructure. The exact benefits are dependent on the system specificities. Where the causes of unplanned transit flows are lack of TSO's ability to measure and forecast accurately enough the power consumption/generation at all relevant nodes in a system as well as instruct generation or demand at a node to a given level, both zonal and nodal markets provide incentives to address the issues. These are dependent on the geographical scale of the markets and on the implementation options of each design.

A general rule is that the larger the perimeter under a common/coordinated market mechanism, the more likely the market design will contribute to managing unplanned transit flows, as it pools together more resources to the same purpose at the same time and under the same conditions. Care should be given also to the gate closure times; while it is recognized that close to real time market operations enable market actors to contribute to the management of unplanned flows, at the same time they limit the operational flexibility for TSOs as explained above.

The definition of bidding areas whose borders reflect structural congestions on the grid may also help to solve the issue of unplanned transit-flows. The principles behind the definition of bidding areas can be summarized as: efficient congestion management; secure grid operation; and overall market efficiency. The potential impact of bidding areas on neighboring bidding zones should also be carefully considered. Taking this into account, the Central-East Europe region is identified as one where a re-thinking of existing bidding areas in the context of the forthcoming implementation of the market target model by 2014 might be a useful exercise. The principles, procedures and responsibilities for such a task are currently well defined within the draft Capacity Allocation and Congestion Management (CACM) network code being developed by ENTSO-E and under public consultation since 23 March 2012. However, the NC CACM will not obtain its status of EU legislation before its formal approval which could be around end 2013. Therefore, there is an opportunity to improve the current arrangements by an early trial application of some of the provisions of the CACM network code in the region.

Another important issue is the priority dispatch as provided for in European Directive (2009/28/EC). This Directive is transposed into national laws often with little regard to the impact on neighboring systems. As a consequence, and irrespective of the market design, the ability of TSOs to control transit flows using market designs is limited. **Therefore, the transposition implementation of priority dispatch using the principle of subsidiarity may hamper the management of these unplanned transit flows through market, or indeed operational, mechanisms.** These unplanned transit flows will likely require a coordinated European approach.

[4] The German West corridor starts in the North-West of Germany, an area with high surplus of RES production (planned and existing) and connections with Scandinavia (planned and existing). It continues to the Rhine-Ruhr area (high consumption and a great amount of a conventional power generation). The German East corridor begins in the North-East of Germany, an area with high RES generation (planned and existing), conventional generation and connections with Scandinavia (planned and existing). Both corridors end in the South of Germany, an area with high consumptions and connections to Austria and Switzerland (pump storage in the Alps and transit to Italy).

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Conclusions

The issue of transit flows in Central-Eastern Europe is a combination of several elements:

- The slow implementation of transmission infrastructure to follow structural changes in generation patterns due to long and complex permitting procedures
- The increased uncertainty in predicting flows due to the variable generation characteristic of (mostly) wind and solar RES that becomes more and more decisive in the generation mix
- The lack of regulatory arrangements that would permit a sound coordination of regional operational countermeasures
- The design inconsistency of national markets that does not allow optimal use of current infrastructure

TSOs are in the front line in dealing with the consequences of these shortcomings. The operational tools available today are constantly improving through regional cooperation, or via the ENTSO-E operational network codes; however **the system is working closer and closer to its limits and more sustainable solutions must be put forward**. TSOs study these sustainable solutions and expose them to public scrutiny by means of the Ten-Year Network Development Plan. The goal is now to transform this plan to actual transmission infrastructure across Europe and for that the provisions proposed by the EC in its Regulation on guidelines for trans-European energy infrastructure, and in particular with respect to the permitting obstacles, are big steps in this positive direction. **If this infrastructure does not materialize in due time then the rate of RES increase should be examined under a more pragmatic prism.**

Acceleration of grid infrastructure investments is seen to be a long time target to attain. Unless all needed grid infrastructures are realized in the CCE region, huge power production from RES, which is foreseen in the near future in order to comply with the EU Energy Policy, can only be possible with the adoption of a comprehensive toolbox of countermeasures including a real RES curtailment mechanism for critical situations on the network system. Moreover, the rate of increase in RES needs to be put in line with the realization of grid infrastructure investments. All projects that aim to strengthen the North – South interconnection in the CCE region and identified as projects of pan-European significance should be encouraged by the European Commission and given the highest priority in the grid development plan. ENTSO-E's position is that the EU goals of market integration and RES integration must be reached without endangering secure operation of the interconnected system.

TSOs therefore call for:

1. the pragmatic and firm application of the provisions for streamlining permitting processes as proposed in the draft Regulation on guidelines for trans-European energy infrastructure adopted by the Commission on 19 October 2011;
2. acceleration of already identified retrofitting programs of installations that have been identified as outdated and posing threats to the security of the system;
3. acknowledging the urgency to adopt no-regret solutions for the integration of RES in the future with the timely adoption of the generation connection requirements network code;
4. maintaining the focus on European aspects of transmission planning as this is reflected on the central role of the TYNDP in European legislation;
5. accelerating the implementation of the target market model in Europe and in particular identifying the Central East Europe region as one of the early trial regions where the provisions of the draft ENTSO-E Capacity Allocation and Congestion Management network code on bidding area definitions can be swiftly applied;
6. urgent discussions to agree cost sharing mechanisms for multilateral countermeasures; and
7. changing of national energy policies concerning generation which significantly affect neighbouring countries should be accomplished only after finding appropriate solutions for secure grid operation.