SUMMARY

A group of twelve TSOs\(^1\) in Central and Eastern Europe have set up the TSO Security Cooperation (TSC) with a permanent TSO Security Panel, new video based cooperation tools for Control Centres and a common IT platform for data exchange (CTDS) performing joint N-1 security assessments. TSC’s main goal is to ensure the overall system security of a large supranational region of the European network.

All participating TSOs have the same view of the grid of the whole TSC region. Depending on the nature and the location of identified problems, the involved TSO(s) are jointly proposing solutions. Proposed or requested remedial actions are based on technical and economic analysis. A coordinated decision can be made jointly amongst the TSOs during the day-by-day conference call in the evening (DOPT) where TSOs whose grid might be affected by a remedial action have the opportunity to discuss any unintended side effects and alternatives that may be considered in order to resolve the congestion.

In June 2012, TSC TSOs have started an operational trial phase on Multilateral Remedial Actions (MRAs). Following discussions with representatives of the relevant National Regulatory Authorities (NRAs) of the TSC region, cost recovery for activation of selected types of MRAs was approved on a temporary basis.

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The MRA procedure shall help the operational planners to propose multilateral remedial actions to resolve security violations when all other available single or bilateral remedial actions are already exhausted. TSC operational planners may now order redispatch capacities from all TSC members and not only from neighbouring TSOs as is standard in other regions.

Based on the experiences on MRAs during the Trial Phase, the successful implementation of MRA operational procedures shall be further optimized and an enduring solution for cost sharing shall be developed and implemented consequently. The experiences gained in the TSC region will provide significant input for the work of ACER and ENTSO-E to identify an appropriate regulatory framework for cross-border redispatch including cost-sharing arrangements.

At the end of 2012, the TSC TSOs have decided to implement a new Central Service Providing Entity (CSPE) in order to increase the efficiency, quality, coordination and a faster realisation of new tasks and TSOs’ common services. The decentralised approach of TSC will not be altered by the implementation of this new entity but undoubtedly supported by various supportive services.

From experience, the results of security assessment have been heavily depending on the data quality of the input data. Therefore CSPE shall establish common quality assessment and supervision processes which shall be available 24/7. CSPE will also be responsible for proposing improvements regarding data quality, adaptation of data models and exception handling. CSPE and TSO bodies, like the Security Panel of Expert, will work hand in hand when developing new processes, e.g. operational planning, MRAs, capacity calculation or crisis coordination.

Further on, CSPE shall become a facilitator for knowledge sharing (operational planning) and training of operators (planning and real-time operation) for TSC TSOs and partners providing learning content, trainers and facilities.

As preliminary measures for the envisaged additional coordination, three so-called Cooperation Areas were established within TSC developing implementation concepts for Common Medium and Long-term Outage Planning (CA I), a D-2 Common Grid Model (CA II) and a Joint Training and Certification Program (CA III).

All TSC activities follow an open approach addressing TSC and general TSO issues at the same time. TSC is open for additional TSOs which are interested to cooperate in the process of implementing an efficient, effective and secure system operation.

The paper outlines the recent experiences of the cooperation of the TSOs in the TSC. In addition to the technical aspects the economic and regulatory aspects for implementing multilateral remedial measures are described. Furthermore an outlook towards the future developments of the TSO Security Cooperation (TSC) project is described.

**KEYWORDS**

Day-ahead congestion forecast (DACF), Intraday Congestion Forecast (IDCF), Common Grid Model, Load Flow calculation, Contingency Analysis, Congestion management, System security, Security Assessment, Inter-TSO-Coordination, Multilateral remedial actions
Introduction

The increased influx of renewable energy sources into the European grid and the integration of a growing share of dispersed generation pose new challenges to the transmission system operators (TSOs) in the daily operation of the grid. At the same time, any major extension of the grid is massively delayed in most of the countries. The TSOs have to handle more and more different and growing production with the same grid. The huge amount of dispersed generation has tremendous implications on large supranational regions. Therefore, joint coordination of operational planning and real time operation is of utmost importance. Even more, the TSO Security Cooperation (TSC) partners aim at maintaining the high quality of security of supply in the region.

The TSC was launched in December 2008 [1]. The main goal is to foster regional European cooperation for system security in the countries concerned and in the whole of Europe based on decentralized processes and infrastructure. Its members are 50Hertz Transmission (Germany), Amprion (Germany), Austrian Power Grid, ČEPS (Czech Republic), ELES (Slovenia), HEP OPS (Croatia), MAVIR (Hungary), PSE Operator (Poland), swissgrid (Switzerland), TransnetBW, TenneT TSO (Germany) and TenneT TSO (The Netherlands). The involved TSOs have set up the TSC with a permanent TSO Security Panel (group of security experts), new video based cooperation tools for Control Centres and a common IT platform for data exchange (CTDS) performing joint N-1 security assessments. TSC’s main goal is to ensure the overall system security of a large supranational region of the European network, covering an area with 170 million citizens, and is open to the participation of additional TSOs.

Common Congestion Forecast Processes

The participating TSOs have been operating a common coordinated Day Ahead Congestion Forecast process for more than one year and are actually implementing an Intraday Congestion Forecast (IDCF) procedure. The IDCF process is of major importance because of the fluctuating production due to unpredicted wind and solar in feed and subsequently growing intraday trades. A common decision making procedure for network security counter measures and remedial actions has been agreed and is being fully integrated into daily operations. Based on the results of the common IT-system, each TSO performs its own analyses. The individual grid security assessments have been superseded by common results generated by the common CTDS System. Each operational planning engineer can replicate the assessment like all the other operational planning engineers. Furthermore a “common language”, common grid model, harmonised procedures and unified representation of results have been speeding up joint problem-solving and decision-making.

In addition a Video Conferencing System has been installed at each grid control centre easing discussions between TSC operational planning engineers and control/security centres, thus creating a kind of TSC-wide regional virtual control centre.

The common security assessment process is a derivative of the ENTSO-E Day Ahead Congestion Forecast (DACF) process established at the beginning of this century within the whole Continental Europe interconnection.
In order to carry out loadflow calculations and network security analyses to identify possible congestions or N-1 violations and, in the next step, to apply relevant remedial actions for resolving congestions or violations, it is necessary to exchange all relevant data and to maintain data accuracy and quality. Hence, one of the main tasks for TSOs is to organize this data exchange, to agree upon the preparation of the data sets and to ensure the confidential treatment of the data exchange. A major achievement, amongst others, is an improved process for sharing of wind and solar in feed forecast information within the TSC region.

As a consequence, all participating TSOs have the same view of the grid of the whole TSC region. Depending on the nature and the location of identified problems, the involved TSO(s) are jointly proposing solutions – typically the TSO in whose control area the problem arises takes the lead. Proposed or requested remedial actions are based on technical and economic analysis. Consequently, a coordinated decision can be made jointly amongst the TSOs during the day-by-day conference call in the evening (DOPT) where TSOs whose grid might be affected by a remedial action have the opportunity to discuss any unintended side effects and alternatives that may be considered in order to resolve the congestion.

However, it has to be noted that the recommendations elaborated in the coordination process are not binding for the control centre shift engineers who are responsible and have to manage the grid in real-time solely. Each TSO stays responsible for his own control area. In real-time operation, once again, the TSO originally proposing or requesting the intervention at the DOPT is the coordinator. Nevertheless, decisions for real time operation have to be taken jointly. Sound planning and predefined coordination processes and communication infrastructure have been introduced to reduce stress and workload of control centres' shift engineers in those critical situations. Ultimately, it is their responsibility to ensure security of supply and take all decisions to cope with the real-time situation. For that reason, cost minimisation of remedial actions shall not be their primary concern. Nevertheless, cost aspects are taken into account in real-time operation, but most of the optimisation (cost minimisation) work is performed by operational planners in preparatory processes. Control-centre engineers can build their decisions on these recommendations in real-time.

**Multilateral Remedial Actions (MRAs)**

In an interconnected power system remedial actions may solve problems for one TSO but may create new problems for other TSOs. The cooperation processes and the common view on the entire system have been installed to prevent this by taking into account all side effects of a remedial action elsewhere in the system.

The following figure illustrates the new Multilateral Remedial Actions process, which TSC TSOs may use to agree on MRAs in their common coordination process.
In June 2012, TSC TSOs have started an operational trial phase on Multilateral Remedial Actions (MRAs). Following discussions with representatives of the relevant National Regulatory Authorities (NRAs) of the TSC region, cost recovery for activation of selected types of MRAs was approved on a temporary basis.

The MRA procedure shall help the operational planners to propose multilateral remedial actions to resolve security violations when all other available single or bilateral remedial actions are already exhausted. Unprecedentedly, TSC operational planners may now order redispatch capacities from all TSC members and not only from neighbouring TSOs as is standard in other regions.

The following figure describes the application of the MRA procedure on 22\textsuperscript{nd} of August 2012.
MRAs executed on 22\textsuperscript{nd} of August 2012 were triggered by a highly relevant security violation. Presumed reasons were high flows from Northern to Southern regions of Continental Europe (high export in Germany and high import in Austria and South-East European countries).

In the respective MRA procedure four TSOs were involved in total:

The Requesting Party was PSE Operator, the Connecting Parties were:

- ČEPS (increasing generation in its control area by 100 MW from 01:30 pm. to 03:00 pm.),
- APG (increasing generation in its control area by 800 MW from 02:00 pm. to 04:00 pm.) and
- 50Hertz (decreasing generation in its control area by 100 MW from 01:30 pm. to 03:00 pm. and by 800 MW from 02:00 pm. to 04:00 pm.).

This MRA was not anticipated before real time as simulated power flows on D-1 were lower than the real ones observed during operation on 22\textsuperscript{nd} of August 2012 and intraday congestion forecast process has not yet been in place.

PSE-O’s decision to activate the MRA procedure was taken after all possible internal and bilateral countermeasures had been applied and it was clear that more remedial actions were needed. Firstly, the possibility of generation increase in its neighbour’s (ČEPS’) system was requested. However, due to limited generation capabilities in that area (availability of additional 100MW only), APG was requested for available production (800 MW available found). Simultaneously, the production was reduced in the 50Hertz control area by up to 900 MW to compensate for the aforementioned increase. Moreover, the execution of the MRA led to a suspension of intraday market trades in the direction from Germany to Austria in order not to counteract the applied MRA.
The applied MRA proved to be effective as a reduction of the flows was measured on tie lines from 50Hertz to PSE-O and from PSE-O to ČEPS by approximately 300 MW respectively, what allowed to keep n-1 secure state on these network profiles.

Based on the experiences on MRAs during the Trial Phase, the successful implementation of MRA operational procedures shall be further optimized and an enduring solution for cost sharing shall be developed and implemented consequently.

The experiences gained in the TSC region will provide significant input for the work of ACER and ENTSO-E to identify an appropriate regulatory framework for cross-border redispatch including cost-sharing arrangements.

**Central Service Providing Entity (CSPE)**

In recent years, TSC has successfully implemented a decentralized IT-infrastructure (CTDS) and a joint D-1 security assessment process. The responsibility of real-time operation for each control area remains clearly at the individual TSO. Responsibilities of operational planning and real time operation have been harmonised within TSC remaining uniquely assigned to each single TSO.

At the end of 2012, the TSC TSOs have decided to implement a new Central Service Providing Entity (CSPE) in order to increase the efficiency, quality, coordination and a faster realisation of new tasks (e.g. capacity calculation) and TSOs’ common services. The decentralised approach of TSC will not be altered by the implementation of this new entity but undoubtedly supported by various supportive services (e.g. IT, communication infrastructure, public relations, etc.)

From experience, the results of security assessment have been heavily depending on the data quality of the input data. As first instalment, CSPE shall establish common quality assessment and supervision processes which shall be available 24/7. CSPE will also be responsible for proposing improvements regarding data quality, adaption of data models and exception handling. CSPE and TSO bodies, like the Security Panel of Expert, will work hand in hand when developing new processes, e.g. operational planning, MRAs, capacity calculation or crisis coordination.

Further on, CSPE shall become a facilitator for knowledge sharing (operational planning) and training of operators (planning and real-time operation) for TSC TSOs and partners providing learning content, trainers and facilities.
New Cooperation Areas

In recent years, TSC TSOs strongly focused on the requirements in line with the new ENTSO-E Network Codes, above else Operational Planning and Scheduling (NC OPS) [2], Operational Security (OS), Capacity Allocation & Congestion Management (CACM) [3] and the ENTSO-E Operational Handbook Policies [4]. As preliminary measures for the envisaged additional coordination, three so-called Cooperation Areas were established within TSC developing implementation concepts for Common Medium and Long-term Outage Planning (CA I), a D-2 Common Grid Model (CA II) and a Joint Training and Certification Program (CA III).

Based on the European outage planning regions' multiple separated processes are in place to coordinate the year-ahead to the week-ahead outage planning. CA I has developed an outage planning approach integrating planning processes within CEE, CSE and CWE regions meeting the requirements of the latest NC OPS proposal. The NC OPS requirements go far beyond the current planning approach and comprise a common platform for data exchange as well. The concept of CA I strongly relies on NC OPS requirements but further integrates the outage planning processes both inter-TSOs and throughout all planning horizons. Thus, Operational Planning and Asset Management information shall be collected and joined with the help of the newly designed Medium- and Long-Term Outage Planning Tool (MLTOP tool).

One prerequisite for a harmonized outage planning process is a common data exchange format. Until now, TSOs exchange outage information in different formats reaching from email texts to database extracts. Adapting the different data formats causes an evitable workload at the receiving TSOs and therefore hampers coordination between TSOs. Therefore, CA I has developed a data exchange format with a highly flexible structure to facilitate efficient data exchange processes. For a smooth integration procedure, the data exchange format enables data provision as before by defining minimum requirements (mandatory fields). Thereby, the data exchange format strongly increases efficiency enabling an easy import of outage information from different TSOs into the outage planning tool of each individual TSO.

Based on the common data exchange format, the MLTOP tool will store outage planning information centrally. Stepwise, the tool shall provide related information on planned outages by reference ID and shall be used to determine optimal multi-TSO outage plans for related projects. With these functionalities, the tool may easily act in concert with the planning tool which is currently in the planning phase at ENTSO-E.

CA II has developed a concept for a two-day ahead Common Grid Model (CGM) for Capacity Calculation in the TSC region. Grid models in the Central East Europe (CEE), the Central South East (CSE) and the Central West Europe (CWE) regions have been designed to pursue the same target: i.e. to combine individual TSO data and model sets to perform a common two-days ahead capacity calculation. However, the underlying processes and functions differ across market regions. This causes challenges when combining information across market regions.

The major prerequisite for a cross-regional CGM is the integration of the differing merging processes of individual TSO data and models to a process forming a common dataset. CA II has done an in-depth analysis of the various regional approaches. While the general mechanisms are similar, the individual approaches differ in many details and sub-processes. Therefore, so-called functional areas have been defined as parts of the overall merging and capacity calculation process. Functional areas combine sub-processes which produce similar
outputs in the regional processes. However, sub-processes and their order within each functional area differ across market regions. Having identified these differences, CA II has developed a proposal for the integration of the regional processes into a common model. The outcome is a first European proposal on the ENTSO-E-wide integration of multiple market regions. Thus, CA II has prepared a key input to the current work of the ENTSO-E Common Grid Model Task Force. By entering into the Capacity Calculation (CC) field TSC has learned, that it is absolutely necessary to have also a so-called “feedback process” in place. After each CC, the experience gained by the security analyses shall be used to assess the CC result and optimize the data for the next possible CC step. This is valid for D-2 CC as well as for intraday CC. Having a process like that intraday CC established, it shall be optimized by adapting the parameters continuously and based on the experience gained at previous timeframes. Finally, CC, assessment of results and feedback loop shall be a continuous 24/7-process without specific difference for the different planning horizons (long-term, mid-term, D-1, D-1, intraday). The following figure illustrates the principle feedback process for CC.

Establishing an integrated European energy market requires the adjustment of historically established processes on national and regional level. The goal of this massive change is to meet a European-wide efficient, effective and, last but not least, secure operation of the common transmission system. Besides developing new tools and adjusting processes, the key task is to train and educate operators who have to facilitate the change and use the new models in the day-to-day business. Therefore, common training for operators is necessary in addition to training offered by the individual TSOs. This requires additional coordination across TSOs and the joint development of common learning content and training facilities.

As a consequence, CA III has developed a joint training and certification concept which fills the gap between the ENTSO-E Academy cooperation and individual TSO training. A framework concept has been developed which is the platform for trainings within TSC and which builds the structure for individual modules. In contrast to the ENTSO-E Academy, the CA III concept shall bring together operational employees from multiple TSOs for joint trainings on specific topics. The modules follow a similar structure and can thus be easily combined and adjusted.
After each training phase, a certificate is granted to successful participants. Depending on the importance of the trained topic, a practical test or exam has to be passed to reach the certificate of the training module. TSOs individually decide on the relevance of the certificate to reach particular levels of licenses for their operators.

A pilot training workshop will be implemented in October 2013 on general TSC topics to gain experience on joint trainings together with external and internal training partners. In parallel, further training modules are developed on TSC-training topics such as CTDS user trainings or MRAs across multiple TSOs.

Conclusion:
All TSC activities follow an open approach addressing TSC and general TSO issues at the same time. TSC is open for additional TSOs which are interested to cooperate in the process of implementing an efficient, effective and secure system operation.

