

The Role of Transmission System Operator in the Context of Energy Security the Case of Poland

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Abstract—This paper examines the role of transmission system operator (TSO) in the context of energy security, using Poland as an example. Analysis of the role of TSO in ensuring energy security in legal, technical and economical domain is shown. Moreover, the evaluation of possibilities and effectiveness of solution applied in Poland for TSO from a point of view assurance of energy security is described.

Keywords-energy security, transmission system operator

I. INTRODUCTION

The energy security of a country is the state of its economy enabling the coverage of the current and future consumer energy demand in a technically and economically feasible way and in conformance with the environmental protection requirements. The transmission system operator (TSO) plays a key role in ensuring national energy security. In Poland the company PSE-Operator PLC (with a 100% State Treasury share) controlled by the Minister of Economy responsible by law for national energy security is licensed to act as TSO. The latter handles electricity transmission and is responsible for network traffic in the transmission system, the current and long-term operational security of the system, the operation, maintenance, repairs and necessary expansion of the transmission grid, including its connections with other electric power systems (art. 3.[1]).

National legal regulations concerning energy security are contained mainly in the Energy Law which is the most important and key act for the functioning of the power energy sector in Poland. Detailed executive acts, in the form of orders issued by the Ministry of Economy or the Council of Ministers accompany the Energy Law. This includes a group of orders particularly relevant to national energy security, comprising: system orders [2], tariff orders [3] and [4], orders concerning electricity supply and consumption curtailments, and other orders.

II. LEGAL DOMAIN

The activity of TSO as the most important entity in the energy security area is defined by the Energy Law. TSO's

range of responsibility is very wide and to a large extent it covers elements directly or indirectly connected with national energy security.

According with art. 9c.it.2 [1], TSO is responsible for:

- the security of electricity supply by ensuring the secure operation of the power system and an appropriate transmission system capacity in the transmission grid;
- operation of the transmission grid in an effective manner, maintaining the required reliability of electricity supply and the quality of supply as well as coordinating the operation of the coordinated 110 kV grid in cooperation with the distribution system operators (DSO);
- the use, maintenance and repairs of the grid, installations and equipment, including the connections of the grid with other power systems, in a way that guarantees the reliability of the operation of the power system;
- ensuring long term operability of the power system in order to satisfy the substantiated needs of national and cross-border transmission of electricity, including the expansion of the transmission grid and – where applicable – the expansion of the connections of the grid to other power systems;
- cooperation with other systems operators or energy enterprises to ensure a reliable and effective operation of electricity systems and their coordinated development;
- using the generating units capacity connected to the transmission grid and the generating units of maximum capacity of 50 MW or higher connected to the coordinated 110 kV grid with a consideration for the agreements with the transmission system users and the technical restrictions of that system;

- managing the transmission capacity of the connections to other electricity systems;
- purchasing system services indispensable to the correct operation of the power system, its reliability and the maintenance of quality parameters of electricity;
- balancing the electricity system, including the balancing of the ongoing electricity demand with the supply of electricity in the national electricity system, the management of the system restrictions and conducting a settlement system with the system users;
- managing the electricity flows in the transmission system in coordination with other connected electricity systems and in cooperation with the distribution system operators in the coordinated 110 kV grid, with a consideration for the technical restrictions of that system;
- purchasing electricity in order to compensate the losses suffered in the transmission grid during the transmission of electricity in that grid, as well as using transparent and non-discriminative market procedures while purchasing that energy;
- developing action plans for large-scale power system failure scenarios and the plans of contingency reconstruction of the system after such a failure;
- implementing the restrictions in the supply of electricity, introduced on the basis of the ordinance [4];
- developing a normal transmission grid operation system and cooperating with the distribution system operators on the development of the normal operation system for the coordinated 110 kV grid.

The transmission system operator has the duty to maintain, both short- and long-term, the capability of the equipment, installations and networks for the continuous and reliable supply of electricity conforming to the quality requirements in force.

The duty to maintain the capability of the equipment, installations and networks for the continuous and reliable supply of electricity specifically relates to:

- the proper control of traffic in the grid,
- looking after the condition of the network infrastructure (operation, maintenance, repairs),
- taking care of the expansion of the transmission grid and the intersystem connections,
- the adaptation of the network infrastructure to the changing (locationwise and structurally) energy demand and power generation sites.

The carrying out of the main tasks and duties relating to the operational security of the electric power system or the security of power supply is monitored and checked by the President of the Energy Regulatory Office (ERO). For the improper performance of the tasks and any failure to carry out the statutory duties the transmission system operator can be fined by the President of ERO and in the extreme case, TSO's licence can be revoked. The latter eventuality is, however, only hypothetical since the Minister of Economy through the owner's supervision can force TSO to fulfil her/his tasks and duties in a proper way.

III. TECHNICAL DOMAIN

The activity of TSO in the technical domain in the energy security area is highly complex. It includes various elements connected with, among others, network infrastructure, technical standards, cooperation with distribution system operators, system balancing and system planning.

According to article 4 of the Energy Law, TSO has the duty to look after the condition of her/his own network structure in order to be able to supply energy in a continuous and reliable way and in conformance with the quality requirements in force. This constitutes an important element of energy security in the short-term. The improper operation or neglect or reduction of maintenance and repair of the network infrastructure by the operator increases the probability of failures and power cuts. The regulations of art. 4 of the Energy Law concern also long-term energy security with regard to replacement and development investments in the electric power transmission area. Neglect to develop the transmission network and intersystem connections and to adapt the network infrastructure to the changing (locationwise and structurally) electric energy demand and power generation sites leads to the inefficiency of the electric power system in the future. Therefore TSO needs to properly conduct her/his investment policy.

TSO is obliged to meet the minimum transmission system maintenance and development (including the interconnection capacity) requirements. The extent of undertaken measures and investments should not be smaller than the minimum below which the condition of the network infrastructure deteriorates and reduces TSO's ability to supply energy in a continuous and reliable way and in conformance with the quality requirements in force.

Unfortunately, currently the transmission grid in Poland is undercapitalized which results in its poor technical condition, which, in turn, may create barrier to economic development, particularly for some areas of the country.

TSO sets technical standards and enforces adherence to them by all the users of the national electric power system (NEPS), i.e. the operators, the producers and the consumers. This is particularly important for ensuring safe system operation.

The principal document, regulating the technical standards area, is the transmission grid use and operation manual

(TGU&OM). It specifies the conditions for the use of the transmission grid by the system users and the conditions and way of conducting traffic and operation, and planning the development of the networks. The manual was intended as a technical-economic document defining the rights and duties of the transmission grid users.

The manual contains, among other things, system operational security regulations specifying:

- the principles of connecting generation equipment, distribution networks, end-consumer equipment, intersystem links and direct lines;
- the technical requirements for equipment, installations and networks, including the necessary support infrastructure;
- the principles of cooperation between electric power system operators, including with regard to the coordinated 110 kV network;
- the principles and procedures for interchanging information between power utility companies and consumers;
- criteria for electric power system operational security;
- electric energy quality parameters and quality standards for servicing system users (art. 9g. it.4. [1]).

The transmission grid traffic and operation manual consists of two parts: a general part containing the terms of transmission grid use, traffic, operation and development planning and a detailed part containing system balancing and system constraints management.

The general part of TGU&OM contains the procedures and ways of performing actions connected with grid traffic and operation, covering:

- grid technical specifications;
- technical requirements for networks, equipment and installations to be connected to the grid;
- the way of and procedures for connecting and disconnecting installations and networks to the grid;
- the range of periodic surveys and inspections of the technical condition of the grid and the equipment, installations and networks connected to it;
- the procedure to be used in cases when electric power supply continuity may be disrupted or a failure may occur in the electric power system;
- procedures for supply interruptions and load curtailments;
- the way of conducting grid traffic (e.g. grid operation programming, grid traffic documentation, the range of traffic and operational cooperation with the

equipment, installations and networks connected to the grid);

- the planning of grid development and cooperation;
- systems and forms of collecting, transferring and interchanging information.

The detailed part of TGU&OM contains, among other things, the conditions which must be met with regard to system balancing and system constraints management, the procedures for system constraints management, including the system constraints cost accounting, and the procedure to be used in electric power supply security emergencies.

The transmission grid use and operation manual is currently in its entirety approved by the President of ERO, and the system users, including the consumers whose equipment, installations or networks are connected to TSO's grid are obliged to comply with its terms, requirements and procedures and ways of interchanging information.

In order to ensure the safe operation of the electric power system it is necessary to specify, among other things, the terms of cooperation of TSO with other electric power system operators with regard to network traffic, the management of flows and generating units' power and emergency procedures. TSO plays the key role in this area, defining, among other things, coordinated operation configurations for the 110 kV network and the way of cooperating in planning and conducting traffic in this network. Moreover, it specifies the way of cooperating in: planning the technical means to meet the demand for electricity in the electric power system, developing plans for preventing and eliminating failures and hazards to the safe operation of the electric power system and rebuilding the system, planning the development of the grid and drawing up plans to meet the current and future demand for energy in one's own operating area, etc.

TSO also ensures cooperation with producers whose generating units are connected to the transmission grid and to the coordinated 110 kV network, to an extent necessary for the safe operation of the electric power system and for assuring the power of the electric energy sources. TSO specifies, among other things, the technical requirements for the generating units, the way of reporting the new or changed technical parameters of the generating units, the way of harmonizing scheduled outages connected with the repair of the generating units and reporting power losses, the principles of dispatching power, the principles of synchronizing and shutting down generating units, the way of collaborating in the development of plans for preventing and eliminating failures and hazards to the safe operation of NEPS, etc.

Electric energy supply continuity means the capability of an electric power network to ensure the supply of this energy with a specified quality and reliability. This capability is determined by, among other things, such system operator activities as hourly electric energy demand and supply balancing or providing system services.

NEPS is balanced by the transmission system operator. When doing the balancing, TSO takes into account: the balance between electric energy demand and generation, the network constraints in electric energy supply, the technical parameters of the generating units and the submitted balancing offers (§19.pt.1[2]). The offers are submitted to TSO by producers having centrally controlled generating units (CCGU) and are for each hour in the twenty four hours for which the system operation plan has been made.

In order to ensure the operational security of the transmission system and the execution of the sale contracts, TSO organizes a balancing market within which it draws up a plan of electric energy production and flows and when carrying it out, balances the electric energy production with the actual consumption of this energy; after the day in which the electric energy was supplied, it settles accounts for the interchange of this energy between the participants in the balancing market.

TSO draws up a plan of electricity production and flows on the basis of the forecasted demand for electricity in the electric power system, the submitted load charts and sale contracts, the balancing offers, the available power reserves and system services, the flows of electricity between the national electric power system and foreign electric power systems (determined according to the international interchange procedures), and the identified electric energy supply constraints due to the operating conditions of the grid and the connected generating units.

In the context of energy security, grid development planning by the transmission system operator is her/his major duty. TSO draws up development plans, concerning the satisfaction of the current and future energy demand, for a minimum period of 3 years (art. 16. it.1 [1]). The development plans drawn up by TSO cover: the anticipated range of electric energy supply, undertakings aimed at modernization, expansion or building of transmission networks and possible new electric energy sources, undertakings aimed at modernization, expansion or building connections with the electric power systems of other countries, undertakings rationalizing the consumption of fuels and energy by the consumers, the anticipated way of financing investments, the anticipated revenues needed to carry out the plan and the anticipated investment schedule.

TSO is obliged to draw up the development plan and to coordinate the development of the transmission grid with that of the 110 kV network.

IV. ECONOMIC DOMAIN

TSO bears economic liability for electric power security, stemming from mainly transmission service provision contracts or from a comprehensive contract's part concerning transmission services. The terms and conditions for the provision of transmission services by TSO are specified not only in the contract, but also in the licence, the tariff and the transmission grid traffic and operation manual (§ 13 it. 1 [2]).

The latter is also a part of the electricity transmission service provision contract or the comprehensive contract.

Transmission service provision contracts include clauses concerning electric energy quality standards and supply reliability standards. Depending on the consumer's demands, it may also include clauses concerning elevated supply reliability standards. Noncompliance with the standards results in the economic liability of the operator and entails giving the consumers (on their request) price reductions and discounts in the amount specified in § 37 [3] or in the transmission service provision contract or the comprehensive contract. Moreover, such contracts may include additional clauses concerning the operator's economic liability (contractual fines, etc.) for nonadherence to the terms of the contract or for its improper implementation.

The standard electricity supply reliability parameters for each electricity supply point include: the allowable duration of a supply interruption and the total annual time of supply interruptions. The interruptions may be long and very long, scheduled and unscheduled (failures). The parameters are specified in the contract. The exceedance of the durations results in the necessity of paying rebates amounting to the fivefold increased price for electric energy for the period in which the interruption in the supply of this energy occurred (§ 37 it.2 [3]).

In energy supply security emergencies not only the contract concluded with a consumer but also the provisions of the Energy Law and its executive acts [2] and [4] have a bearing on the economic liability of the system operator.

TSO does not bear economic liability for the consequences of load curtailments introduced in the normal mode or in accordance with order [4], provided that the proper procedures are adhered to and proper measures are taken, with utmost care, by the system operator.

In accordance with § 35 it. 6 of order [2], in the case of a failure in NEPS or a risk of such a failure or an electric power system security emergency, the operator may cut off equipment, installations and networks in the mode specified in the transmission grid traffic and operation manual, irrespective of the supply interruption or emergency cutout durations specified in the contract.

Load shedding by the operator in the process of eliminating a network failure, a system failure or a hazard to NEPS is permissible when the situation justifies such measures.

TSO has an obligation to take necessary measures to ensure the continuity of electric energy supply and to prevent failures as well as to limit the effects and duration of such failures in collaboration with the producers and the end users connected to the grid and with other distribution system operators.

The Energy Law defines the principles concerning the liability of the transmission system operator for any damage suffered by affected electric power system users connected to

the national electrical power grid, as a result of the measures taken to eliminate a hazard to electric energy supply security.

In the case when damage arose as a result of force majeure or solely through a fault of the aggrieved party or a third party, the system operator does not bear any liability. Whereas when damage arose as a result of circumstances for which the transmission system operator bears liability or in the case of negligence in assessing the validity of introducing load curtailments, the operator is liable for damages.

The transmission system operator is liable for damage caused by load curtailments, solely within the actual damage suffered by the electric power system users as a result of damage to or destruction or loss of a movable or damage to or destruction of a fixed property (art.11e it. 2 [1]). Moreover, the transmission system operator is liable for damages up to a specified amount (5 thousand PLN) to an electricity consumer in a household.

The total amount of TSO's liability for damages in a situation when power interruptions or load curtailments affected a considerable number of system users (including electricity consumers) has been fixed depending on the number of affected consumers (art.11e it. 4 [1]). In extreme cases, the total liability amounts to 25 million PLN (up to 25 thousands consumers) and 250 million PLN (over 1 million consumers).

V. ANALYSIS OF SOLUTIONS FOR ELECTRICITY SUPPLY SECURITY EMERGENCIES

The effectiveness of the legal, technical and economic solutions concerning TSO is of key importance to the operational security of the system and so to the country's energy security. It is particularly important to verify the solutions in the case of failures resulting in electricity supply security emergencies.

In the light of the national legal regulations, when an electricity supply security emergency arises, TSO undertakes, in collaboration with all the NEPS users, all possible measures using all available means to eliminate this hazard and prevent its negative effects. In addition, he/she may introduce constraints in electricity supply and consumption over the territory of Poland or its part until a government order introducing the constraints comes into force, but not longer than for a period of 72 hours (art.11c it. 2 [1]).

The transmission system operator immediately notifies the Minister of Economy and the President of ERO about the occurrence of an electricity supply security emergency and the measures and means taken to eliminate this hazard and prevent its negative effects and indicates the necessity to introduce constraints. Within 60 days from the date of the removal of the constraints, it submits a report containing the findings on the causes of the electricity supply security emergency, the legitimacy of the measures and means taken to eliminate this hazard and the diligence and care of the system operators and users taken to ensure the security of electric power supply

(art.11c it. 4 [1]). Then within 30 days from the day when he/she receives the report the President of ERO gives his/her opinion on the legitimacy of the introduction of the constraints by the transmission system operator.

Constraints in electricity supply and consumption should cause the least disturbance in the operation of the electric energy market and should be used to the extent necessary to restore the proper operation of the electric power system and be based on the criteria adopted for the current balancing of the electric power system and for managing system constraints. Moreover, they should be agreed on with the proper system operators in accordance with the contract provisions.

Procedures and duties for system operators and users in the case an electricity supply security emergency have been introduced. Among other things, measures to be taken by the proper TSO services have been specified (art.11d it. 1 [1]). These include:

- giving orders to the proper producer services to start up, shut down, change the load of or disconnect a centrally controlled generating unit (CCGU) from the network;
- making emergency purchases of power or electric energy;
- giving orders to the proper DSO to start up, shut down, change the load of or disconnect a generating unit, which is not a CCGU, connected to the distribution network in his/her operating area;
- giving orders to the proper DSO to reduce the amount of electricity drawn by the end consumers connected to the distribution network in his/her operating area or to interrupt electricity supply to the necessary number of end consumers connected to the distribution network in this area;
- giving orders to the end consumers connected directly to the transmission network to reduce the amount of drawn electricity or to disconnect consumer equipment or installations from the network, in accordance with the schedule of constraints;
- reducing the transmission capacity in intersystem exchange.

In the period when the operations are executed the system users are obliged to obey the orders given by the system operator's proper dispatching services, provided that the execution of the orders does not pose any life or health hazard.

During an electricity supply security emergency the switching instructions given by TSO's dispatching services are superior to the dispatching instructions given by DSO's dispatching services.

In the period when an electricity supply security emergency occurs the system operator may impose constraints

on the provided electricity transmission services to an extent necessary to eliminate the hazard to electricity supply security.

The costs borne by the system operator in connection with the necessary measures taken to eliminate the hazard to electricity supply security constitute legitimate operational costs.

The solutions adopted for TSO in electricity supply security emergencies are proper and fully effective. In order to ensure electricity supply security and take proper and coordinated measures in an electricity supply security emergency, relations between TSO's dispatching services and the services of: the distribution system operators, electricity producers and large consumers should be precisely defined and the superiority of the orders given by TSO's dispatching services should be clearly stated. A hazard to electricity supply security makes it necessary for TSO to take several measures in order to eliminate it. The measures can be questioned by the system users since they put a strain on the proper services of the utility companies and on the consumers and have serious technical and economic consequences for them. Moreover, for the electric power system operator the implementation of the measures entails considerable expenditures, which should constitute his/her legitimate operational costs. Therefore a detailed catalogue of such measures should be made and all the system users should be obligated to carry out the instructions given by the proper dispatching services of TSO in a situation when this does not pose an immediate hazard to life or health.

VI. CONCLUSIONS

The transmission system operator is the most important entity in the sphere of national energy security. His/her range of responsibilities is very wide and to a considerable extent covers elements connected directly or indirectly with national energy security. TSO also plays a key role in the prevention and elimination of failures and hazards to the safe operation of NEPS. Therefore the effective and efficient performance of the operator's tasks and duties relating to the safe operation of NEPS is of primary importance.

The transmission system operator has the duty to maintain, both short- and long-term, the capability of equipment, installations and networks to supply electricity in a continuous and reliable way while meeting the quality requirements in force. This is vital for the operational security of NEPS. Improper operation and abandonment or curtailment of maintenance and repairs of the network infrastructure by the operator increases the probability of a failure and nondelivery

of electricity to the consumers. Failure to expand the transmission grid and the intersystem connections and to adapt the network infrastructure to the changing (locationwise and structurally) demand for electric energy and its generation sites leads to the inefficiency of the electric power system in the future.

From the system operation security point of view, the transmission grid traffic and operation manual is the most important document developed by the transmission system operator. It is crucial to define the responsibility of the system users for compliance with TGU&OM, and the range of the latter's regulations. The manual defines, among others, the duties of network users, the proper performance of which greatly affects the operational security of NEPS.

The legal solutions used in Poland enable TSO to take effective and efficient measures when power shortages occur in the system, by introducing procedures and defining the duties of TSO, DSO and the system users in electricity supply security emergencies and by giving the system operator the right to impose constraints on electricity supply and consumption in an electricity supply security emergency, before the government (Council of Ministers) order imposing the constraints comes into force.

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