



SYSTEM AND ANCILLARY SERVICES

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ABSTRACT

This paper deals with support and ancillary services which are provided by CEPS a. s. Czech republic System service ensured a balance between production and consumption of electricity and the quality and control of the entire electricity system. The aim of the paper is to create a small overview about this sphere.

KEYWORDS

System services, Ancillary services, Primary frequency control, Secondary voltage control, ČEPS

1. INTRODUCTION

System services ensure immediate balance between generation and consumption of electricity, even in case of volatile consumption and faults on generation side.

The basic condition to electricity system works correctly is that generation and consumption of electricity have to be continuously equal. The quantity of energy in the electricity system isn't constant. Immediate quantity of energy depends on day time, season or temperature...

For this reason there has to be a control authority. According to the Act No. 458/2000 Coll. is this responsibility at the transmission system operator CEPS a.s. in the Czech republic.

These services can be divided to four groups:

- Maintaining the quality of electricity
- Real time active power balancing
- System restoration
- Dispatch control

2. SYSTEM SERVICES

2.1. Technical-organisational tools for ensuring system services

2.1.1. The maintenance of the summary power reserve for frequency primary control

The maintenance of the summary power reserve for frequency primary control involves the procurement of this reserve at a determined value and quality (with the required static and dynamics). Primary frequency control in any interconnected power system is based on the so-called solidarity principle. This means that in the case of imbalance between the load and the power source (e.g. caused by unit outage or load change) all the sources within the interconnected system involved in primary frequency control in each control area are responsible for restoring power balance.

The purpose of primary frequency control is to correct frequency deviation within a period of a few seconds by increasing or decreasing the power supply. The power response ΔP depends on the stationary frequency deviation and can be represented mathematically as follows:

$$\Delta P = -\lambda \Delta f \text{ [MW, MW/Hz, Hz]}$$

λ represents the so-called power frequency characteristic of the control area. The summary of power reserves for the primary control of all the control areas is specified as a standard determined by the

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value of the maximum power outage to be covered by the primary frequency control. Ensuring this power reserve (mutually agreed within the UCTE) constitutes a basic TSO obligation i.e. it is a condition for the synchronous operation of systems belonging to companies which agree to such interconnection. Consequently, every control area maintains a specified summary power reserve for primary frequency control with a given summary static.

Units participating in primary frequency control provide primary control AnS.

2.1.2. *Secondary f/P kontrol*

Secondary f/P control automatically maintains both frequency at a nominal value and power balance within the control area (exchange of power with neighbouring systems at a scheduled value).

Secondary f/P control is provided automatically by the central controller located at the CEPS Dispatch Centre.

Power station terminals providing the unit secondary active power AnS and terminals at border substations measuring the amount of power exchanged are connected to the central controller. The central controller itself works according to the network characteristics method which guarantees the so-called non-intervention principle. That means that the control area directly affected (in which the power imbalance has arisen) restores the power balance and returns the frequency to the nominal value. The area control error (represented by G according to) is calculated as follows:

$$G = \Delta P + K\Delta f \text{ [MW, MW, MW/Hz, Hz]}$$

ΔP is the deviation of exchanged power from the scheduled value and K is the adjusted parameter, the so-called K-factor (frequency bias), which should be equal to the power factor λ to ensure the smooth functioning of the non-intervention principle.

When restoring the power balance, secondary f/P control supplements primary frequency control in such a way as to gradually replace all the power provided by the interconnected system according to the solidarity principle. Secondary f/P control is implemented by sending the required value of power from the central controller to units providing secondary active power control AnS.

Secondary f/P control should restore the set frequency and exchanged power values within 15 minutes of the commencement of the imbalance. Secondary f/P control is further supplemented by tertiary active power control.

2.1.3. *Tertiary active power control*

Tertiary active power control maintains the necessary secondary power reserve.

Tertiary control serves to replace the spent secondary power reserve, i.e. that power consumed by secondary f/P control. It is possible to employ quick starts when necessary along with the spinning reserve (on units providing tertiary control AnS).

The quick start reserve QS_{10} is used for covering large unit outages in cases where it is necessary to comply with the criterion of restoring the power balance within 15 minutes of an outage occurring. The QS_{10} reserve is replaced upon the activation of tertiary P control AnS or by dispatcher reserve start up after recovery of the power balance.

2.1.4. *Use of the dispatcher reserve*

The dispatcher reserve covers power imbalances caused by market participants unable to comply with the scheduled load diagram or base points over an extended period of time (more than two hours).

The dispatcher reserve covers power deficiencies caused by unit outages or larger consumption than was originally agreed. Generators or consumers are unable or unwilling to cover such eventualities by their own means.

2.1.5. *Secondary voltage and reactive power control (SVC)*

Secondary voltage and reactive power control automatically maintains the reference voltage at the transmission system pilot nodes. Reference voltages are determined by tertiary voltage control.

The purpose of SVC is to maintain reference voltages specified by tertiary voltage control at the pilot nodes. The SVC system is initiated using the automatic voltage controller (AVC) which reacts to deviations in actual voltage from the reference value voltage at the pilot node and determines the amount of active power required to eliminate such deviations.

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The required power is sent to those power stations the units of which provide secondary U/Q control AnS. If a power station has more than one unit then it must be equipped with a reactive power group controller which allocates the required reactive power from the AVC to individual units according to predetermined rules. Individual arrangements must be agreed between the ancillary service provider and the TSO. The AVC system comprises compensation reactors employed when the appropriate generator regulation reserves are exhausted. Regulation by means of compensation reactors should commence before the technical potential of the alternators is fully exhausted. A permanent emergency reactive power reserve should be maintained on alternators. The control system includes network transformer tap changing (on-load tap changer control – OLTC). The AVC must allow communication with tertiary voltage control as well as the performance of basic diagnostics and control quality assessment.

2.1.6. Tertiary voltage control

Tertiary voltage control coordinates the reference values of voltages in the pilot nodes to ensure the secure and economically efficient operation of the power system as a whole.

2.1.7. Ensuring transmission stability

This is a supervisory and coordinating activity which assures the stability of active power transmission and dampens oscillations within the system.

The operation of interconnected transmission systems requires the verification of the static and dynamic stability of power transmission. Consequently, inspections are carried out by ČEPS, which monitor and evaluate the measured phenomena in real time, and stability calculations are made which suggest the measures to be put in place for the setting of under excitation limiters, the increasing of excitation controllers and the setting of power system stabilizers (PSS) in the excitation controllers. These issues are addressed in the defence Plan by measures which are designed to prevent oscillations and loss of synchronization.

2.1.8. Restoration of operation after full or partial blackout (loss of supply)

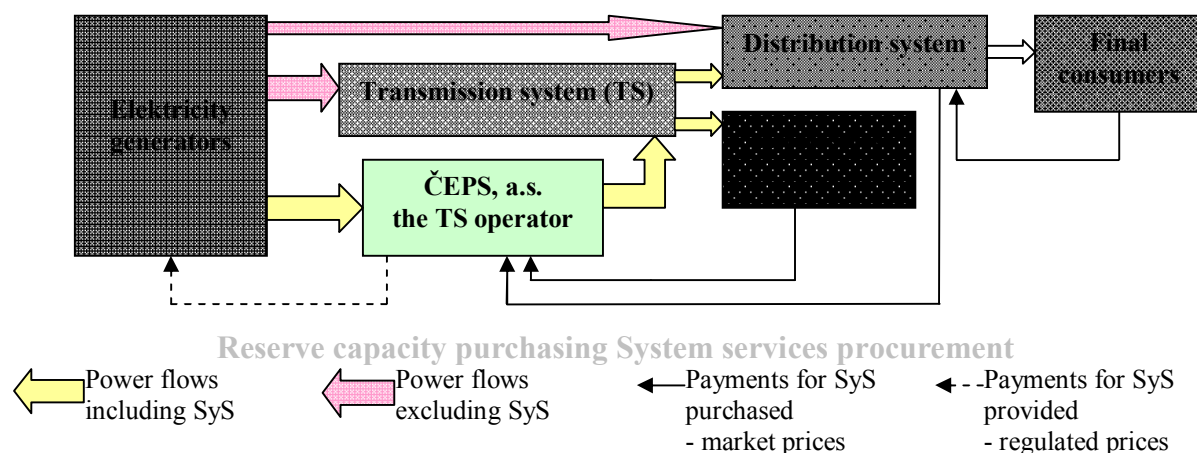
A process consisting of unit start up without support from the network (black start), subsequent network voltage recovery and supply to predetermined priority consumers and release from island operation of parts of the network and their gradual synchronization and reconnection.

In the case of a large system failure which cannot be managed by the normal safeguards in place to prevent the spread of such a failure (the Defence Plan), full or partial blackout of the system may occur. In such cases it is ČEPS's responsibility to restore the system to normal operational conditions. With this purpose in mind, ČEPS has drawn up its so called Restoration plan, which is included in the dispatch centre operational instructions of distribution system operators. Regular training is carried out on the content of the Restoration plan and certain parts of the plan are subject to regular testing for example the start-up of units without an external voltage and power supply (black start) and the testing of the ability of units to work in island operation.

2.1.9. Ensuring the quality of the voltage sine wave

Containing both passive (monitoring and checking) and active (filters) elements. [2]

3. POWER FLOWS IN THE POWER SYSTEM AND PAYMENTS FOR SYSTEM SERVICES



The electricity generators can transmit the electricity through the distribution or transmission system. Transmission system operator gets the ancillary services from the electricity generators to ensure the system services. Power flows including System services are provided to retail sales through the distributing system also to the final customers.

3.1. Payments for System services

Payments for system services are being subsequently paid to ČEPS through regional DSOs (that collect them from end customers), when 80% of the expected monthly system services payment is paid in four equal instalments evenly distributed in time.

The actual price for system services is being set up each year by Energy Regulatory Office (ERO) by issuing a price decision for the following calendar year. There are up-dated tariffs stated in a valid Price Decision on webpage's of Energy Regulatory Office. [1]

3.2. The relationship between system and ancillary services

The following table outlines the relationships between system (SyS) and ancillary (AnS) services.

Table 1 Overview of system services and corresponding ancillary services

SYSTEM SERVICE	Technical – organisational instrument	Producers -unit operators	Other users
Maintenance of electricity quality	Primary frequency control	Unit primary f control	
	Secondary voltage control	Secondary U/Q control	
Active power balancing in real time	Secondary f/P control	Unit secondary P control Vltava cascade	
	Tertiary active power control	Quick start reserve Unit tertiary P control Dispatcher 30-minute reserve Generation shedding Vltava cascade	Load changing
	Dispatcher reserve use	Dispatcher reserves	Load changing
System restoration		Island operation capability Black start capability	

4. ANCILLARY SERVICES

ČEPS uses so-called ancillary services (AnS), provided by particular transmission system users, to ensure its system services.

4.1. *Unit primary f control (PR)*

Unit primary f control is a local automatic function ensured by the primary regulation circuits. It is based on a precisely defined change in a generating unit's output dependent on the frequency deviation from its predefined value. Such a change in a generating unit's output required by the primary regulation circuits and dependent on frequency deviation.

4.2. *Unit secondary P control (SR)*

The unit secondary P control (SR) is a process involving a regulated generating unit output value change as required by the secondary regulator of frequency and transferred power balance. The utilization of a regulation reserve of SR (hereinafter RZSR) is dependent upon the ČEPS Dispatch Centre secondary regulator algorithm.

4.3. *Unit tertiary P control (TR)*

Unit tertiary (spinning) P control consists of a change in unit output based on a request sent to the power plant by the ČEPS Dispatch Centre. The reserve marked RZTR- is used for power decrease and that marked RZTR+ for power increase.

4.4. *Quick-start 10 minute reserve (QS₁₀)*

The quick start **10 minute** reserve concerns units capable of providing the agreed reserve RZQS₁₀, the discontinuation of pumping (in the case of PVE) or the discontinuation of pre-planned pumping within 10 minutes of a command from the ČEPS Dispatch Centre.

4.5. *Quick-start 15 minute reserve (QS₁₅)*

This concerns the units capable of providing, within **15 minutes** since ČEPS dispatching command, the agreed RZQS₁₅ reserve. The quick-start 15 minute reserve is understood as a power increase on terminals of the supplying unit.

4.6. *Dispatch reserve available within t-minutes (DZ_t)*

The dispatch reserve accessible within t-minutes (DZ_t) concerns shut down, reserve-state generating units which, at the request of the TSO, are capable of guaranteeing synchronization and able to reach nominal or previously agreed power no later than **within the agreed t-time**. The dispatch reserve accessible within t-minutes is defined as the terminal output of the relevant unit less self-consumption (**net**). T-time assumes one of the following discrete values: **30, 60, 90, 360** minutes.

4.7. *Load change (ZZ₃₀)*

The load change, assured by the provider, consists of a load decrease or increase by a predefined and guaranteed value of regulation reserve (RZZZ₃₀₋ or RZZZ₃₀₊) according to the request from the TSO. [2]

4.8. *Generation shedding (SV₃₀)*

This concerns those units capable of decreasing power output by a reserve value RZSV₃₀ agreed in advance, or capable of being shut down completely or of not starting up a PP programmed source within 30 minutes of receipt of an instruction from the ČEPS Dispatch Centre.

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4.9. *The Vltava (VSR)*

This service, using the Vltava river virtual unit, is based on an agreement between ČEZ, a.s. and ČEPS. It provides RZQS_{10V} and, depending on hydrological conditions, RZVSR.

4.10. *Secondary U/Q control (SRUQ)*

The secondary U/Q control is an automatic function exploiting the entire certified (contractually agreed) regulation range of the reactive power of units in order to maintain given voltage values at ES pilot nodes and concurrently, it distributes the generated reactive power to individual generators.

4.11. *Island operation capability (IO)*

The island operation capability concerns the ability of a generating unit to be operated in a separated part of the outer network, a so-called island. Island operation is characterized by high demands on a unit's regulation capabilities.

4.12. *Black start capability (BS)*

The capability of the unit to start up without an external voltage supply, to reach nominal speed and nominal voltage and to connect to the network during island operation.

EregZG and EregZ

The terms EregZG and EregZ are to be interpreted as cross-border electricity supply, provided on instructions of the dispatcher (rather than automatically). Therefore, it may be understood as a specific kind of a planned international exchange. [2]

5. METHODS FOR ENSURING ANCILLARY SERVICES SERVICES

AnS are being purchased by ČEPS company by the means of two commercial instruments:

- Long-term and mid-term contracts
- On Day-ahead ancillary services market

AnS categories purchased through tenders and day-ahead market (DT PpS):

- Primary frequency control
- Secondary control of generating unit output
- Quick-start reserve available within 10 minutes
- Quick-start reserve available within 15 minutes
- Tertiary power control of generating unit output
- Operating reserve
- Load-shedding reserve available within 30 minutes

AnS categories of a local character with a minimum chance to create a market for:

- Voltage and reactive power control
- Black start (under preparation)
- Island operation (under preparation)

Assistance from synchronously interconnected power systems:

- Emergency assistance from abroad
- Purchase of balancing power from abroad [1]

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