SCADA AND HPMS FUNCTIONS TO BE ACHIEVED BY HYDRO POWER DISPATCHER SYSTEM (DHA SYSTEM), IN CASE OF CASCADED HYDROELECTRIC POWER PLANTS.

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Abstract. This paper wants to present some aspects regarding to the National Power System Dispatching Control and underlines those functions significant from the point of view of a complex hydro power system needs. These aspects are part of the contribution of ISPE at the MAREA research project, developed under CNMP management.

Key words: HPMS, SCADA, functions, hydro, dispatching,

1. INTRODUCTION

The "Distributed Intelligent System for technological resources management of a hydropower establishment - MAREA" research project belongs to the thematic area S/T according to Schedule/Program 4 -"Partnerships in priority areas": 1. Information Technology and Communications 1.4 Artificial Intelligence, Robotics and Advanced Autonomous Systems 1.4.8. Intelligent systems for decisions assisting.

2. OBJECTIVES

MAREA project is a PC project, being scheduled to be completed in 36 months and primarily aims to increase operational efficiency in the exploitation of resources and equipment into the hydropower cascade establishment by adopting an intelligent, distributed , with integrated components to perform monitoring and control of electricity generation process into the hydropower cascade establishment and the management of power/energetics and technological resources to comply with the rules of the European market for electricity producers. MAREA software application is intended to provide functions for monitoring, control and acquisition for the hydropower plants from the hydropower cascade establishment (SCADA functions) supplemented with a set of new features designed to help energy resources management decisions and the main installation of hydropower cascade establishment, depending on HPMS (Hydro Power Management System).
Expected result will be a qualitative improvement of technical and production process by implementing a system of intelligent hydro dispatching and decision support for power management of the hydropower cascade establishment [1,2,3,4,5,6,7,8,9].

3. THE MAIN FUNCTIONS OF DISPATCHING CONTROL LEVELS

3.1. The Central Power Dispatcher (DEC)

The Central Power Dispatcher (DEC) provides permanent balance between production and consumption of electricity in compliance with SEN (National Power System) normed quality technical parameters and Commercial Code of Wholesale Electricity Market, electricity exchanges with other countries' power systems, control the operation regimes of RET (Transmission Power Network), protection and automation systems from RET, the coordinate manoeuvres from RET and exercises direct control in the power plants and electrical power substations in compliance with the investiture order.
In accordance with the investiture criteria of dispatching centres with attributes of Authority of Dispatch Control in SEN, the Central Power Dispatcher (DEC) has:

a) Decision Authority and is responsible for:

- Frequency control in SEN, in case of isolated (separated) operation;
- Adjusting the frequency and power exchanges on interconnection lines with other power systems, in case of interconnected operation;
- Adjusting the voltage of 750 kV, 400 kV and 220 kV networks;
- Neutral earthing of 750 kV, 400 kV and 220 kV networks.

Typically, DEC is invested with Decision Authority mainly for:

- 750 kV 400 kV and 220 kV power lines that can operate in loop, at voltage in question (including the bays);
- The interconnection lines with other power systems regardless of voltage (including bays); related metering systems;
- 750 kV, 400 kV and 220 kV bus-bars, including measuring and arresters bays;
- 750/400 kV and 400/220 kV autotransfor-mers and 400/110 kV transformers (including bays,

control/adjustment systems, the neutral earthing systems)
- 220/110 kV Autotransformers for evacuation of power from power plants (including bays, control systems, systems of neutral earthing)
- coupling bays (CT, CL, CLT, CC, CTf) of 750 kV, 400 kV and 220 kV;
- Reactive power compensation coils with installed power of at least 20 MVAr connected in networks 750 kV, 400 kV, 220 kV and 110 kV, and 400/220 kV autotransformer tertiary (including bays);
- Synchronous compensators with installed power over 20 MVAr;
- Equipment and network elements regardless of their operating voltage, which can lead to reducing or limiting of power plant (or group) with more than 20 MW, for thermoelectrical power plants and more than 10 MW for hydropower plants;
- Groups of CNE (Nuclear Power Plant), loading and unloading;
- Groups with installed power greater than or equal to 20 MW for thermoelectrical power plants;
- Groups with installed powers equal to or higher than 10 MW for hydropower plants;
- Hydroelectric groups with installed power below 10 MW, which can lead to operation blocking to ensured power of power plants whose installed capacity is more than 10 MW;
- Centralized control systems of frequency - power;
- The relay protection systems and related automation equipment in its decision-authority (except technological protections);
- Telecommunications installations, tele-measuring, telesignalling, teleadjustment / telecontrol, remote control/telecontrol, etc., which are used for dispatching control of SEN by DEC;
- DAS of frequency;
- Power decreasing on areas, exceeding 20 MW simultaneously, of DAS stages, and those under 20 MW for a period exceeding 2 days;
- Automation system of networks of 750 kV, 400 kV, 220 kV and 110 kV with implications on SEN operation safety.

b) Coordination Command for:
- 750 kV power lines;
- 400 kV power lines that have at least one cell at a station where DEC exercise direct control;
- 400 kV and 220 kV power lines that have their cells into substations that are under direct command of different DETs;
- Interconnection power lines with other power systems regardless of voltage.

c) Jurisdiction/Competence over:
- 750 kV OHL;
- Transformers no. 1 and 2 of 400/110 kV 400 kV Cernavoda Substation;

d) Direct control/command in:
- Very important substations with the higher voltage of 750 kV and substations with the higher voltage of 400 kV (Isaccea, Cernavoda and River);
- Thermoelectric and hydroelectric plants with total installed power greater than or equal to 500 MW;
- Nuclear power plants.

3.2. Territorial Power Dispatchers (DETs)

Territorial Power Dispatchers ensure the achieving of operating conditions and of DEC coordinated manoeuvres, carry on the operating conditions and coordinate the manoeuvres in power installations, in compliance with the investiture order.
In accordance with the investiture criteria of dispatching centres with attributes of Authority of Dispatch Control in SEN, the Territorial Power Dispatchers (DETs) have:
a) Decision Authority and is responsible for:
- Voltage adjusting of 110 kV network, in their area of responsibility;
- 110 kV network neutral earthing in their area of responsibility.

Typically, DETs are invested with Decision Authority, mainly for:
- Power lines of 400 kV and 220 kV that can not operate in loop;
- 110 kV power lines that can loop (including bays);
- The 220/110 kV autotransformers (incl. bays, control systems, earthing systems of neutral), except those that delivery the power from the power plants;
- 110 kV Bus-bars from the substations with the higher voltage of 400 kV and 220 kV, including the measuring and arresters bays;
- 110 kV Bus-bars of power plants with installed power greater than 50 MW, including the measuring and arresters bays;
- Bus-bars of 110 kV electrical substations that are connected to power lines which can operate in loop as part of RED (Power Distribution Networks), including the measuring and arresters bays;
- Reactive power compensation coils with installed power lower than 20 MVAr;
- Synchronous compensators that are not under the Decision Authority of DEC;
- Equipment and network elements, regardless of their operating voltage, which can lead (due to unavailability or withdrawal of service) to reduce or limit the power plants power over 10 MW - in case of thermoelectric power plants and, respectively, more than 4 MW in case of hydropower plants, and which are not under the decision authority of DEC;
- Units with installed powers equal to or higher than 10 MW of thermoelectrical power plants, which are not under decision authority of DEC; their loading and unloading;
- Units with installed power greater than or equal to 4 MW of hydropower plants that are not under decision authority of DEC; their loading and unloading;
- Automatic control systems of voltage and reactive power of groups under its decision authority;

- The relay protection systems and automation associated to the mains equipment that are under decision authority of DET and from 110 kV substations (excluding technological protections);
- Telecommunications installations, tele-measuring, telesignalling, teleadjustment / telecontrol etc., which are used for dispatching control of 110 kV network by DET;
- Power decreasing on areas, temporary (up to 2 days), between 5 and 20 MW at the same time, associated to DAS stages in their area;
- Automation of 110kV networks that are in decision authority of DET;
- Capacitor banks connected to MV network with installed capacity greater than or equal to 5 MVAr.

b) Coordination Command for:

- Power lines of 400 kV and 220 kV that have the all bays located in substations that are under direct control of DET;
- 110 kV power lines that have at least one bay into a substation that is under direct control / command of DET;
- The interconnection power lines of 110 kV between DET sites - the coordination command is given to one of them.

c) Competence in the area of activity over:

- 400 kV and 220 kV Power Networks;
- 110 kV interconnection power lines with neighbouring power systems;
- Units, with installed power greater than or equal to 20 MW, of thermoelectrical power plants;
- Units, with installed power equal to or higher than 10 MW, of hydropower plants;
- Hydroelectric units with installed power below 10 MW, which can lead to blocking, of the operation to the ensured power of some power plants whose installed capacity is greater than 10 MW;

d) Direct control/command in:

- 400 kV electrical substations that are not in direct command of DEC and the 220 kV substations;
- Electrical substations of 110 kV with the higher voltage of 400 kV and 220 kV, except those in direct command of DEC or DHE;
- The thermoelectrical power plants with total installed capacity below 500 MW that are under decision authority of DET and DEC;
- Hydropower plants with total installed capacity below 500 MW, that are under decision authority of DET and DEC, which are not part of a DHE.

3.3. Hydro Power Dispatchers in case of Cascaded Hydroelectric Power Plants (DHA)

Hydro Power Dispatchers in case of Cascaded Hydroelectric Power Plants (DHA), organized under the management units of hydroelectric power plants establishment, ensure the operative control by dispatching both of the respective establishment installations and equipment from respective area and some electrical equipment that assure its interconnection with SEN, in accordance with the authority by dispatching, assigned by investiture order.

Also correlated with operating schedules and provisions of the higher dispatching level, DHA coordinates the production of electricity and the water needs/use by under discussion establishment.

In accordance with the investiture criteria of dispatching centres with attributes of Authority of Dispatch Control in SEN, the Hydro Power Dispatchers in case of Cascaded Hydroelectric Power Plants (DHAs) usually have:

a) Decision Authority for:

- Lines, bays, bus-bars, couplers, transformers under the hydroelectrical establishment management, to which are administrative pertaining, that are not under the decision authority of DEC or DET;
- Units with installed power or with influence on the total cumulative power produced on the whole cascade less than 4 MW, from the hydropower plants that are not under the decision authority of DED;
- Control/Adjustment Systems of voltage and reactive power of the units/groups that are under decision authority of DHA;
- Transformers control systems that are under decision authority of DHA;
- The relay protection systems and automation associated to the electricity networks that are under decision authority of DHA;
- Telecommunications installations, tele-measuring, telesignalling, teleadjustment / telecontrol etc., which are used for dispatching control of the Cascaded Hydroelectric Power Plants or of the electricity networks under decision authority of DHA;
- Distribution of the power generation and complex use of water accumulation between cascade accumulations.

b) Coordination Command for:

- 110kV power lines from the area, that are not under the coordination command of DET or DED;
- MV power lines which have all bays in installations that belonging to the same management unit to which DHA administratively pertaining.
- Some MV electric lines which also have bays in installations that belonging to other management unit than DHA administratively pertaining.

c) Competence in the area of activity over:

- Installations which condition/restrict the power delivery from CHE to SEN;
- Installations which condition/restrict the power supply of CHE auxiliaries.

d) Direct control/command in:

- Hydroelectric power plants and the electrical installations under the management of respective hydroelectric establishment (to which also belongs

administratively DHA), which are not under direct control/command of DEC and DET.

The Operative Control by dispatching, at DHA level, involves the performing of the following specific activities:

3.3.1.- Surveillance of operation and ensure continuity in operation of installations and equipment under the dispatching control authority and direct control/command of DHA and DEC or DET.

Surveillance of operation and ensure continuity in operation of installations and equipment is achieved by monitoring the operating schemes and parameters, state estimation and taking preventive measures to avoid the incident state. To achieve this function is necessary to be performed at DHA level, the followings:

- Recording and registration:
- The values and status change, the signallings and events, in all operating regimes/conditions;
- Information which formed the basis for decisions to perform manoeuvres, establish or change the operating regimes / conditions of installations/equipment and of the electricity networks;
- Verify whether the values are within the imposed limits;
- State estimation of installations/equipment.

3.3.2.- Put in practice the Operation Schedule for the power units, according to the schedule issued by the Electricity Market Operator and the received instructions from DEC for system services.

3.3.3.- Perform operative control of power and energy produced and delivered

3.3.4 .- Ensures optimal operation of accumulations of water in normal regime/conditions and flood conditions:

- Calculation of power and energy produced in power plants.
- Calculation of the tributary flows, turbined, discharged and disposed on each unit, respectively power plants.
- Calculation of hydropower balances per sub-pools and, per entire pool.
- The performance of hydrological forecasts per entire pool for 1, 6, 24, 48 hours and 7 days.

3.3.5.- Establish the optimal utilization conditions of lakes in view of their capacity and tributaries flow forecasts, the available power units/groups and the technical operating rules of accumulations (linked with the operating program/schedule of large accumulations, previously established between ANAR and HIDROELECTRICA)

3.3.6.- Forecasting of economical available powers, of daily operating schedules and hourly maximum usable power for SEN

3.3.7.- Optimal allocation on CHE and CHC of active and reactive power imposed value/ instruction.

3.3.8.- Bandwidth optimal allocation on CHE and CHC for system services.

3.3.9.- Distribution on CHE and CHC of frequency - power order (usually, this function is carried out automatically by EMS functions from DEC)

3.3.10.- Maintaining the level of voltage on the electrical substations bus-bars.

3.3.11.- Performing the scheduled manoeuvres.

3.3.12.- Remote control of aggregates, switching equipment and facilities exhaust flow.

3.3.13.- During regimes of incident, coordinate and direct command the measures to remove the alarm or incident in accordance with powers granted by technical management of the establishment and attributes of dispatching control function.

3.3.14.- Setting the flows evacuation regimes / conditions for each accumulation and assuring their coordination at the level of the entire establishment.

3.3.15.- Setting up the pre-discharge conditions of accumulation lakes to avoid inundation/flooding during the flood period.

3.3.16.- State Monitoring of the HPMS/SCADA Data System from endowment

3.3.17.- Operation scheduling/planning and analysis out of real-time, as following:

- The assessment of the units operation.
- The assessment of the maximum electrical powers which can be produced.
- Setting the power supply output Offer of the power plants.
- Setting the bandwidth for system services.
- Planning the operation of power units.
- Water Resource Management.
- Post-factum analysis of the operation.
- Analysis of incidents.
- Analysis of the relay protections operation.
- Operational safety assessment based on the calculation of state indicators.
- Operator guidelines development.
- Application software development, for real time and out of it.

3.4. Distribution Power Dispatcher for 110 kV

Distribution Power Dispatchers for 110 kV (DED) are organized as part of the Electricity Distribution Operators, providing the operative control by dispatching of the 110 kV installations and 110 kV networks from the area of responsibility, in compliance with the dispatching operative control authority, assigned by investiture order .

To this aim, they assure the achieving of operational conditions and of the manoeuvres coordinated by the higher dispatch levels, establish the operating conditions and coordinate the manoeuvres for the installations/equipment and networks within their area of responsibility and which are not under decision authority or coordination command of an another Dispatching Centre.

3.5. Local Distribution Power Dispatcher for MV

Local Distribution Power Dispatchers (DEDL) are organized as part of the Electricity Distribution Operators, providing the operative control by dispatching of the MV networks and 110 kV electrical power distribution installations (mainly the 110 kV / MT transformers from the 110 kV / MV substations and the 110 kV radial lines) from the area of responsibility, in compliance with the investiture order.

To this aim, they assure the achieving of operational conditions and coordinate the manoeuvres in power installations and distribution networks, in their area of activity, and perform the operating conditions and manoeuvres established by the higher dispatch levels for the installations that are supplying the medium voltage distribution network from the electricity power system.
Usually, one DEDL Centre is organized in each county but depending on the particularities of electrical distribution network and the importance of consumers, can be organized more DEDL Centres within the same county.

3.6. Local Power Dispatchers of Electrical Power Plants (DLC)

Organized at the level of thermal power plants, the Power Dispatcher of Electrical Power Plant (DLC), also known as the Power Plant Shift Chief Dispatcher (DST), provide operative control by dispatcher of plant facilities and equipment in respective plant, both in compliance with the investiture order issued by the dispatching centres and with the internal investiture order issued by the management of respective unit.
Where appropriate, the DLC provides and coordinate the production, transport, distribution and use of heat produced in the plant.

4. SCADA AND HPMS SOFTWARE FUNCTIONS ACHIEVED AT DHA LEVEL

The MAREA project, taking also into account the in force norms, recommends the achievement of the following software functions at DHA level:

4.1. SCADA functions:

- Data Acquisition and Exchange;
- Sequence of Events Recording;
- Data Processing and Real - time calculation;
- Post Disturbance Review;
- Database Snapshot;
- Historical Information System;
- Telecontrol and teleadjustment in installations;
- Tagging;
- User Interface;
- Alarm handling;
- Word Processing;
- Wallboard Display;
- Operator Guide run;
- State Monitoring of the Data System

4.2.- HPMS software functions (software functions specific to operative control by dispatch of hydropower plant from a cascade establishment)

HPMS software functions must allow the achieving at DHA level of the following applications specific to operational/operative control by dispatch of hydropower plants cascade establishment:

- The performance of hydrological forecasts per entire pool for 1, 6, 24, 48 hours and 7 days.
- Forecasting of economical available powers and maximum usable, on short (for 60 minutes) and medium term;
- Optimal distribution on DHA of the power value/ instruction, imposed by DEC
- Allocation on CHE and CHC of system services;
- Distribution on CHE and CHC of frequency - power setting/order (usually, this function is carried out automatically);
- Determining the optimum regimes / conditions of use of lakes, in normal conditions;
- Verify whether the values are within the imposed limits;
- Calculation of power and energy produced per power plant/group(s);
- Calculation of hydropower balances per sub-pools and, per entire pool.
- Evaluation of transactions;
- Setting the operating conditions during floods;
- The processing of information regarding to monitoring of water constructional works behaviour;
- The operating schedule/planning and analysis out of real time:
  - Evaluation of units' performance/ operation;
  - Detection of the states of incident;
  - Evaluation of maximum powers that can be produced;
  - Post-factum analysis of the operation;
  - Analysis of incidents;
  - Analysis of the relay protections and automation operation.
  - Elaboration of summarizing reports regarding to operation and operating status of power plants / groups;
  - The overall situation of power plants;
  - The overall situation of each power unit, as a whole and on its components;
  - Situation of power supply of power plants auxiliaries;
  - Situation of the electricity supplied by the power plants;
  - Monitoring the operating conditions and the economic progress of the power plants installations;
  - Calculation of power plants capacity to be loaded;
  - Forecast of economic powers available and maximum usable;
  - Calculation of the optimum operation regime of power plants/generating units;
  - Establishment of the production offer of power plants to supply for dispatcheable days;
  - Establishment of system services offer for dispatcheable days;
  - The values/instruction working-out for each power group, regarding to the active and reactive power, taking into account the total amounts/instruction received from the dispatching centres of SEN;
  - Calculation of indicators on units and power plants;

- Monitoring (automatic) of insulation conditions;
- Diagnosis of power plants status and of the status of certain installations and equipment;
- Technological forecasting and assessment of status of certain equipment technical characteristics;
- Supervision of production costs;

- Simulator for operators training.

5. CONCLUSIONS

Expected result following the implementation of HPMS and SCADA functions will be an improvement of technical and qualitative level of production process for hydropower plants cascade establishment.

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