Current State of WAMS at ČEPS, a.s.

Marek Havrda [1)]
[1)] ČEPS, a.s., Praha, Czech Republic, havrda@ceps.cz

Abstract — **Aim of this document is to introduce the Wide Area Monitoring System used in the transmission grid of Czech Republic, to show some examples of unusual states in the transmission grid detected by the WAMS and to outline the future development in this area.**

Keywords — Wide Area Monitoring System (WAMS), Phasor Measurement Unit (PMU), Phasor Data Concentrator (PDC), Supervising Server (SVS).

I. INTRODUCTION

The main motive for start of the project WAMS ČEPS was the fact that current and future operation states of the electricity system in Europe is more and more characterized by a significant increase in operational situations where the transmission system capacities are used at their upper limits or these limits are in some cases exceeded. It is due to the increasing demands on the electric power transmission and control system, caused on the one hand by electricity trading on a national and international level and on the other hand, by increasing of renewable power sources outside the area of consumption.

Another important reason for investing in the Wide Area Monitoring System is the possibility of data exchange with other TSOs which will give us an overview of what is happening in the European interconnected system and can help dispatchers to intervene in time.

II. PROJECT MOTIVATION

The number and placement of phasor measurement units (PMUs) were chosen with regard to perspectives of future development and according to the usual criteria, which are – location near large power sources, outlets of border lines, electric remote locations with expected large angular differences, endpoints of major lines and corridors where it is useful to monitor dynamic features.

According to these criteria 36 PMUs have been installed in 10 substations. The locations of the PMUs are shown on this map.

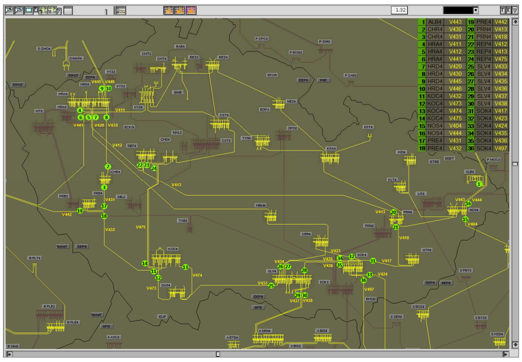

Fig. 1. PMUs placement.

III. SYSTEM HIERARCHY

This system has been designed to ensure the availability of 99.9 % with tolerance for one failure of one PMU up to 24 hours per month. Due to this the central PDC (CPDC) consists of two servers in redundant operation.

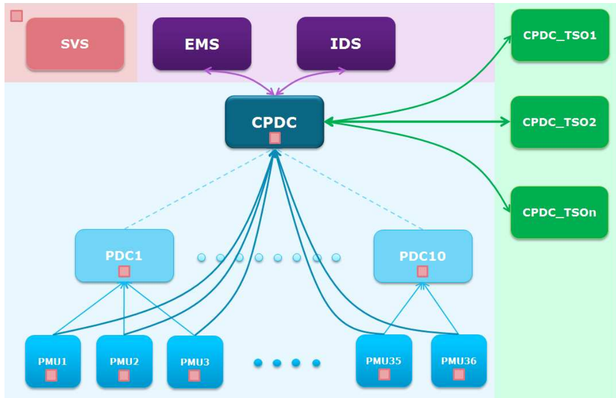

Fig. 2. System hierarchy.

The collection of synchrophasor data is done by 36 PMUs, strategically located in 10 substations at the 400 kV level. The supplier of the PMUs is the Elcom, a.s. company. The model which is installed in our substations is the ENA 460-PMU and it is connected through three voltage and three current inputs to the measuring transformer. Data are sent to the CPDC through optical fibres via the protocol IEEE C37.118 in density of 50 samples per second. Besides current and voltage phasors the PMU sends also frequency and frequency deviation. The PMU also contains the module ENA-TIR which allows the synchronisation of the PMU with the GPS signal.

Next parts of the WAMS represent PDCs (Phasor Data Concentrators) located in substations. There is one PDC per one substation, which receives data from PMUs with the density 50 S/s. In normal state, the data are stored in a buffer, where they stay for one month and then are rewritten by new ones. In case of disconnection between the PMU and CPDC, the PDC will automatically start with sending data and complements the data that were not available due to the communication loss. Next functionality of the PDC is supervising over all PMUs in a substation. The supplier of the PDCs is the TECHSYS – HW a SW, a.s.

The last part necessary for data collection is the central server. The main task of the CPDC is collecting and processing data from the PMUs and PDCs and providing them to user stations. The CPDC enables to receive data from about 120 PMUs, which is 3 times more than actual 36 PMUs. With this extension it would process about 100 000 analogue values per second.

The data are sent first from each PMU directly into the central PDC which provides them to user workstations. Simultaneously, data from the PMUs are sent to the substation PDCs. They are there archived for case of communication loss between the PMU and central PDC. The central PDC enables data exchange with other TSOs and also enables two-way communication with the Dispatching Control System (EMS) and Integrated Data Store (IDS).

Data from the PMUs, PDCs and other Central PDCs are sent by the protocol IEEE C37.118. Communications between the Dispatching Control System, IDS and CPDC are done by the protocol IEC 60870-5-104.

The supervision of the functionality of each device is ensured by the supervising system (SVS). It consists of one server, PDCs on substations and TEK servers. This system is independent on the CPDC and is completely separated from the Wide Area Monitoring System. Devices on substations are monitored by the PDCs and supervising of the central server and communications is ensured by the supervising server. Access to this system is done by the Techsight application – product of the TECHSYS – HW a SW, a.s.

IV. PhasorPoint Application

The PhasorPoint (PP) is product of the Psymetrix Ltd. which was recently acquired by Alstom and now forms the Alstom Grid Centre of Excellence for Synchrophasor Applications. This software is running on the CPDC and client stations. It enables to display live data, historical data or results of these analytic functions:

- Monitoring of phasor angles.
- Detection and monitoring of islands.
- Detection and analysis of frequency and active power oscillations.
- Indication of sources of oscillations.
- Detection of decrease of the static stability reserve.
- Monitoring of voltage stability.

The PP contains also the Events Diary, enables to create user defined calculations, composite events or graphs (in MyViews module).

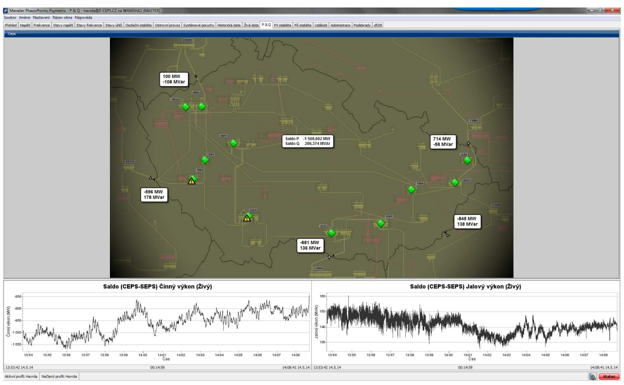

Fig. 3. PhasorPoint Workbench.

Because the PP enables to create more layers of visualization, we have created 3 views – map of Europe, map of a TSO and diagram of a substation. Every monitored line has its own signalization for alarming in case of exceeding some of user configurable limits.

The system is open and in future it may be extended by further analytical applications using phasor measurements. The overall PP is very intuitive program that allows users to adapt to their needs.

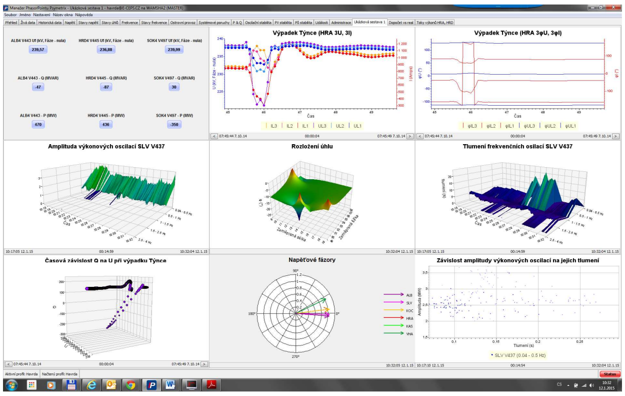

Fig. 4. Graphs in MyViews module.

V. Examples From Practice

Currently we are still working on integration of the PhasorPoint into Dispatching Control System, so the PhasorPoint is for the time being used to detect faults in the transmission system and their subsequent analysis.

First example is from the substation Kočín. In the Kočín substation the measuring transformers are placed inside the appropriate field of the substation (behind the line switch). In practice it means that in case of switching line to the transfer busbar, data from the WAMS are unavailable during reconnection.

One such switching occurred on 3rd November 2014. In this case the WAMS probably detected arcing in the line switch as you can see in Fig.5.

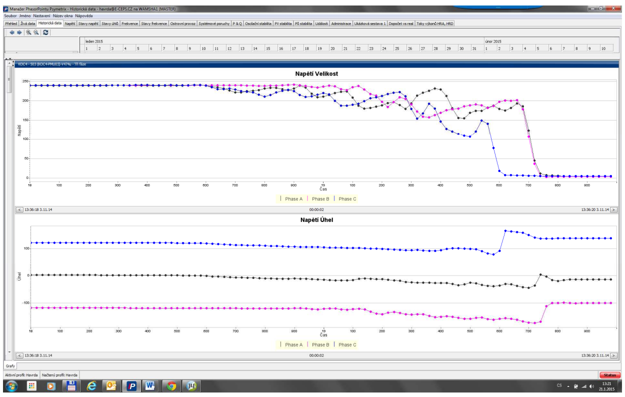

Fig. 5. Event recorded by WAMS (1).

Another event was detected by the WAMS on 9th November 2014 on one of generator lines. The reason of such oscillations is still under investigation.

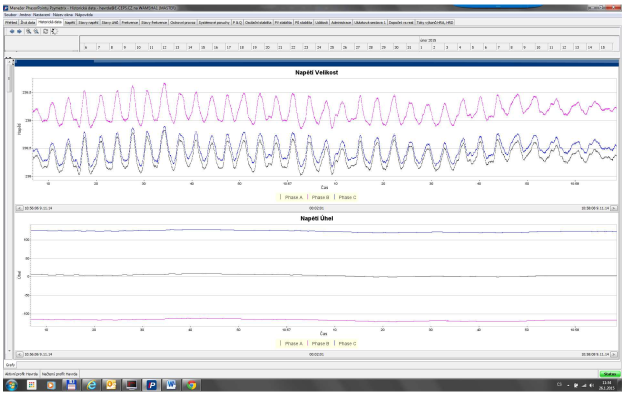

Fig. 6. Event recorded by WAMS (2).

The last event demonstrates the detail of the pumped-storage hydro power station Dalešice when starting into the storage pumping operation. The graph comes from the substation Slavětice into which Dalešice are connected. From 12 s window it is evident how the large power oscillation origin in electric surroundings of the hydro power station. At time of one of generators starting the maximum delta P, measured by the WAMS, was 27 MW.

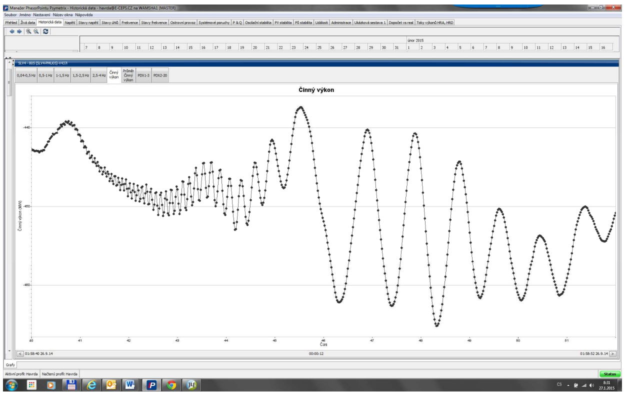

Fig. 7. Event recorded by WAMS (3).

The same situation is shown in SCADA:

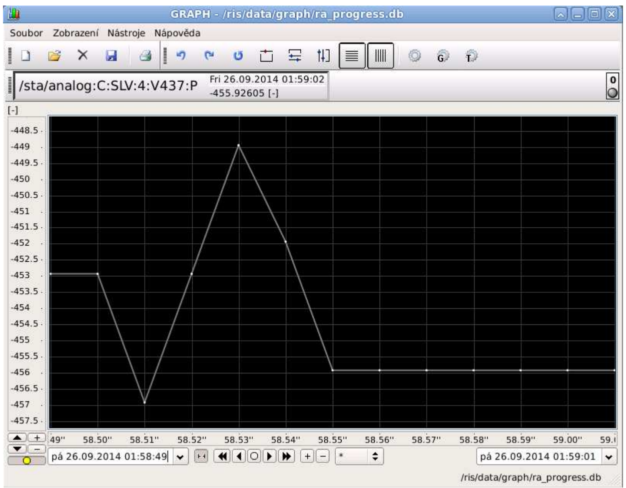

Fig. 8. Event recorded by SCADA.

V. Current State and Future Perspectives

As was already mentioned, the WAMS in ČEPS, a.s. is currently used for analysing faults in the transmission system.

Currently we cooperate with suppliers to adapt the WAMS system to dispatcher needs. Simultaneously we are working on creating graphical test reports in the new control system TRISQ, so that dispatcher could have all the important data together.

Regarding data exchange with other TSO within the ENTSO-E is currently running with the Danish Energinet.dk and Swiss Swissgrid. Furthermore, other European TSOs were contacted (Slovenian ELES, Greek ADMIE, Spanish REE and Portuguese REN). With some of them an agreement has been already reached and we hope that the data exchange will begin soon.

Finally the WAMS should be one of the reliable support dispatching tools that will be used for a transmission system secure control. It could be said that these systems are worldwide in its infancy and there is still a long way to achieve our goals.

References

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