Actual State of the Automated Icing Monitoring System on the Territory of the Czech and Slovak Republic

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Abstract— **Ice load on overhead lines is a major concern of the distribution utilities as it can influence their operational reliability significantly. The real-time information about actual ice load and also the knowledge of its recent development can be, in emergency situations, crucial for the dispatchers and their fast and relevant reaction.**

First stations, which enabled ice measurement, were put in operation in the Czech Republic in 1999. They were later replaced by the second generation. Since then, the stations have been gradually installed in the Czech Republic, Slovakia, Germany and Slovenia.

The paper describes their new features, deployment and operational experience. In the second part of the paper actual state of the Automated icing monitoring system on the territory of the Czech and Slovak Republic and its future development will be introduced.

Keywords—***Automated icing monitoring system (AIMS), Meteorological monitoring station (PMS), Ice measurement, Overhead line***

I. INTRODUCTION

EGÚ Brno has been dealing with ice measurement on electrical structures for many decades, very often in close cooperation with distribution utilities.

The experience obtained during the years has been used for designing a measuring station, which enables a continuous measurement of icing load and some other meteorological quantities, process and collect the data and can communicate to a superior system.

II. MONITORING STATION

The first generation of meteorological monitoring station, called Meteo, was developed in 1998-1999. Altogether 14 Meteo stations have been put in operation between 1999 and 2003 on the territory of two Czech distribution utilities.

The project of the second generation of meteorological monitoring station (called PMS) started at 2006. Based on the Meteo device concept, new features have been added based on experience resulting from the operation of these stations.

Since then, the station has undergone further development, such as the improvement of remote monitoring of the station, its heating or the implementation of a new generation of electronics.

A. Design

PMS is a compact equipment for monitoring and processing meteorological data. The object is monitoring of the main climatic quantities which affect in terms of the reliability the operation of overhead electric lines.

B. Power supply

The power can be supplied from low or medium voltage lines or by solar panels when installed on high or ultra-high voltage lines.

The disposition of the automated monitoring station on the pole of mv line can be seen in Figure 1.

Fig. 1: Mounting of monitoring station PMS installed on MV line

C. Measured values

The PMS system monitors the following meteorological parameters:

- Ice load
- Temperature
- Relative humidity
- Wind speed and direction – measured by wind pressure acting on the rod and (option) by the ultrasonic anemometer
- Solar irradiance (option).

Figure 2 shows the support arm with the sensor for measuring ice load, pyranometer, ultrasonic anemometer and sensor for measuring temperature and relative humidity.

D. Ice measurement

The ice detection system is an integral part of a PMS station. It includes a load sensor, situated in the body of the instrument that measures ice on a rigid (non-rotating), vertical rod of a length of 0.5 m and a diameter of 30 mm. The rod is attached to the bottom of the body. The bottom of the body can be heated to prevent ice from sticking the body and the rod together when icing occurs. The heating parameters, threshold of ice load to start the heating (kg/m), length of the heating period (min) and the heating interval within the heating period (min), can be set by the user.

The system can measure ice up to 20 kg, i.e. 40 kg/m. The resolution of the measurement is 0.01 kg, with an accuracy of 1 %.

Fig. 2: Support arm with sensors

E. System of measurement

The system PMS scans meteorological parameters in its environment continuously (each 2 seconds). The measured samples of meteorological quantities are processed each minute.

Ice load, temperature and relative humidity are provided as 30-value averages per minute. Wind speed is provided as an average, an instantaneous and a maximum value of 30 measurements for every minute. Wind direction is given in an instantaneous and a maximum value. Average and instantaneous values are calculated for the solar irradiance.

The processed data (with one-minute time interval), are then archived into daily files on the flash memory.

The data can be sent instantaneously (one-minute values), or as daily files, to the superior system (SCADA or a SQL server).

F. Communication

It is possible to communicate with the PMS either remotely via GPRS using router or convertor to IEC 60870-5-104 (each PMS station is equipped with two SIM cards) or locally from the computer via Ethernet.

Distribution companies mostly use SCADA (Supervisory Control and Data Acquisition) system to control their electrical networks. To allow communication PMS directly with SCADA, protocol IEC 60870-5-101/104 was implemented.

G. Warning messages and alarms

PMS can generate and send warning signals with transmitting them into the central computer – based on pre-set values. These values are established based either on the exceeding of the set limit for the instantaneous state of the quantity being measured or on the exceeding of the set limit for the trend of development of this quantity (e. g. the combination of the trend of icing growth with the instantaneous load of the ice deposit, etc.).

The signalisation of foreign intervention into the station and the loss of supply voltage are also a part of warning signals. The limits for the transmitted measured values with the signalisation of their exceeding can be set, checked and signalised directly in the central computer as well.

III. PMS DEPLOYMENT

In total 81 monitoring stations have been deployed on the territory of the Czech Republic, Slovak Republic, Germany and Slovenia since 2006.

As can be seen from the table, most of them were mounted in the distribution networks, on mv lines.

TABLE I. OVERVIEW OF PMS INSTALLED

Company	**Country**	**Nr. of PMS installed**	**Place of installation**	**Year of installation**
ČEPS (TSO)	Czech Republic	12	Lines 400 and 220 kV, substations 400/110 kV	2006 (3) 2007 (1) 2011 (3) 2012 (2) 2014 (1) 2016 (1) 2017 (1)
ČEZ (DSO)	Czech Republic	25 *+6*	MV lines	2015 (6) 2016 (13) 2017 (6) *2019 (6)*
E.ON Distribuce (DSO)	Czech Republic	20 *+4*	MV lines	2010 (1) 2011 (14) 2012 (3) 2015 (1) 2017 (1) *2019 (4)*
Total CR		**57 + *10***		
SEPS (TSO)	Slovak Republic	1	400 kV line	2014
ZSD (DSO)	Slovak Republic	8	MV lines	2013
Total SR		**9**		
	Slovenia	1	Line 380 kV	2007
E.ON Thüringen (DSO)	Germany	13	MV lines &HV/MV substations	2008 (1) 2009 (3) 2010 (6) 2011 (3)
NKT	Germany	1	testing	2009
Total others		**15**		
Total		**81 + *10***		

TSO… Transmission system operator

DSO… Distribution system operator

The deployment of stations in property of DSO corresponds to the areas where icing usually occurs (Figure 3, 4). Some stations were installed in locations with possible high wind speed occurrence.

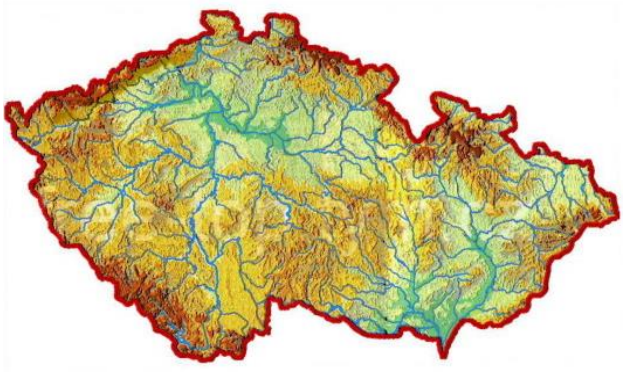

Fig. 3: Geographic map of the Czech Republic

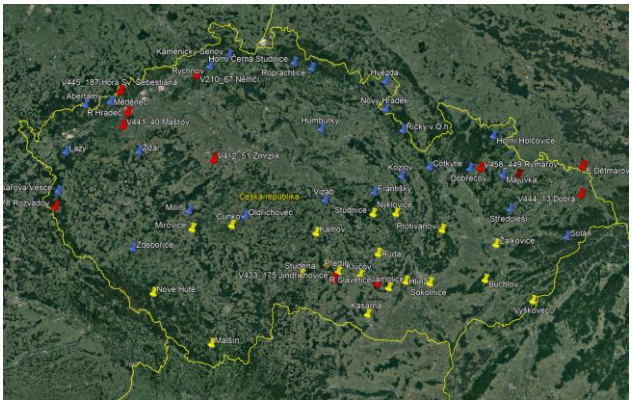

Fig. 4: Map of the Czech Republic with current PMS deployment (red – ČEPS, blue – ČEZ, yellow – E.ON)

Although a significant number of stations have been deployed in the Czech Republic, there are still areas that are not well covered, in terms of icing occurrence (Czech-Moravian Highland, regions near mountains). This year the monitoring network will be expanded by another 10 stations on the territory of the Czech Republic. When put in operation, they will also be connected to the monitoring network.

IV. Automated (Icing) Monitoring System

PMS stations were initially equipped with one SIM card and thus communicated only with the SCADA system. The data obtained from PMS stations were "visible" and utilizable only within the utility itself.

Later, EGU Brno came up with the idea of building a monitoring station network, which would enable to share the data from PMS stations among utilities. By obtaining approval from all parties involved, the project has been resolved.

The solution of the project was divided into several steps:

1. Adding a second modem to each PMS station
2. Creating second communication channel from PMS stations to SQL server in EGÚ Brno (it means each PMS station will communicate in two channels: to a utility SCADA system and SQL server at EGÚ Brno)
3. Setting up a SQL data server in EGÚ Brno for the data storage from all PMS stations
4. Development of software for communication with PMS stations, downloading data and storing them in the SQL database
5. Development of Internet web page for visualisation of the data measured by PMS stations
6. Creating a data format in which the data from SQL database will be provided to other participants (DSOs, TSOs, …)
7. Setting up a communication channel for data transfer between SQL server and SCADA systems of TSOs/DSOs
8. Testing phase of providing the data to SCADA systems
9. Visualisation data from "new" PMS stations in SCADA systems (for the dispatchers) on side of DSOs and TSO respectively.

A. *Actual state*

The steps one through seven have already been completed. We have set up the data server, developed and installed special software for communication with PMS stations and for storing the data into SQL database.

In order to access the measured data from PMS stations, we have developed a web application, which uses the data from SQL server and present them on a special web page. Users, who have the right to access to this web page, can observe current values of meteorological quantities as well as short history of each quantity from all PMS stations (users have different rights).

Next picture presents map of the Czech Republic with PMS on its territory. The user chooses the station and then quantities to display measures values (Fig. 7).

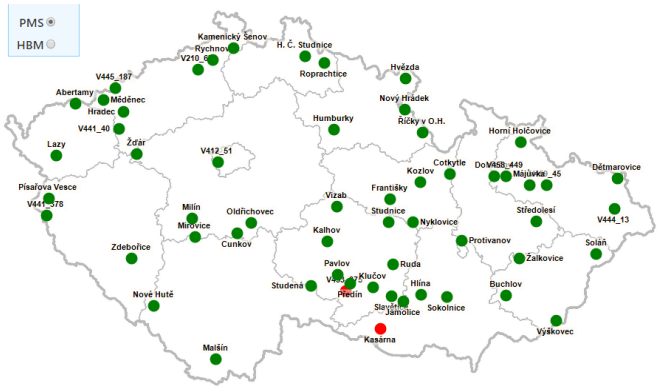

Fig. 5: Map with PMS on the territory of the Czech Republic (current state)

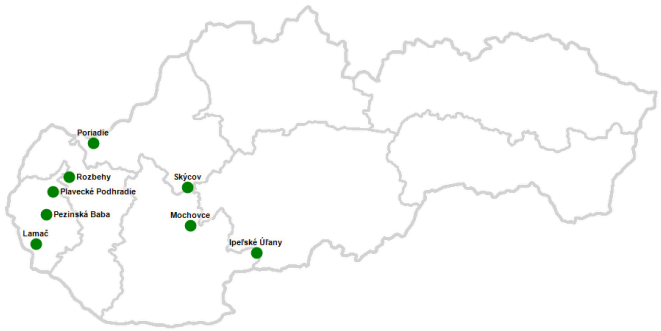

Fig. 6: Map with PMS on the territory of Slovakia (current state)

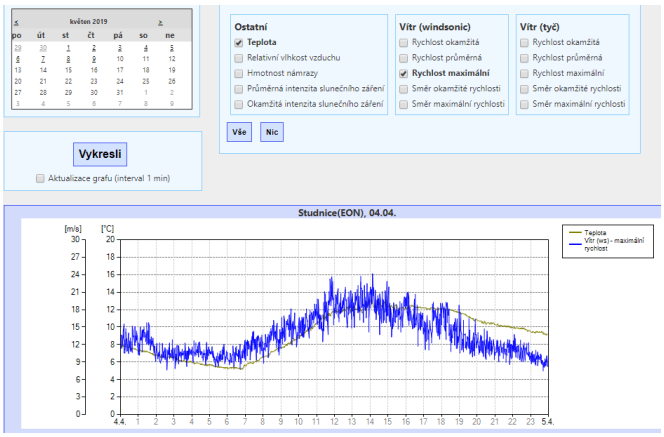

Fig. 7: Temperature and wind speed recorded by a PMS station

B. *Next phase*

Most steps have already been completed, now we are dealing with data transfer from SQL server to users (SCADA system of DSOs/TSOs).

Early discussions with other participants indicated that due to mainly cyber safety reasons and also some technical obstacles it would be difficult to exchange the data in a simple way. Because SCADA system belongs to a critical infrastructure, data transfer will first have to go to the so-called demilitarized zone, and from there it will be transferred to SCADA itself. Such a solution will meet all the safety criteria and requirements.

We also intend to allow access to some data from the SQL server to special users (planners from utilities e.g.).

V. CONCLUSION

Until now 57 PMS stations have been deployed on territory of the Czech Republic and we gradually connected all PMS into AIM system. We also succeeded in connecting 9 PMS stations installed in Slovakia (ZSD and SEPS) to SQL data server and thus extended the area where meteorological data are measured and make them available to other users.

To allow utilities access to data from all PMS stations we have started a project of AIMS, which enables sharing of data among Czech and Slovak DSOs and TSOs. First steps of the projects have been successfully completed. We assume that we will begin testing the transfer of data from the SQL server to users in the near future.

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