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 influences their operational reliability significantly. Real-time information about current ice load and also the knowledge of its recent development can be, in some situations, crucial for the dispatchers and their fast reaction.**

Building of an automated icing monitoring system started in the Czech Republic in 1999, when the first monitoring stations were put in operation on overhead lines. In recent years (2011-2012) a new generation of monitoring stations were deployed in the south part of the Czech Republic and the west part of the Slovak Republic. Within the next two years more than twenty monitoring stations will be installed in other parts of the Czech Republic.

The paper will describe the performance of these ice monitors, their present deployment and also the intended future development of the whole monitoring system.

Keywords: Icing, Overhead lines, Automated icing monitoring system

Legend and Abbreviations

PMS *Meteorological monitoring station*
SCADA *Supervisory Control And Data Acquisition*

Introduction

EGÚ Brno in cooperation with distribution companies has been involved in solving the problems of icing of overhead lines since its establishment in 1952. The experience obtained during the years of icing measurement and monitoring has been used for designing a measuring device which enables a continuous measurement of some meteorological quantities.

I. Project "Meteo"

EGÚ Brno started this project in 1999, when the first prototype of a measuring device called Meteo was tested on the territory of distribution company VCE. Two years later, in autumn 2001 12 Meteo devices were installed on the territory of distribution company JME. In February 2003 second Meteo device was installed on the territory of VCE.

II. Project "PMS"

The project of a new generation of meteorological monitoring station (called PMS) was started at the beginning of 2006. The new generation was based on the concept of Meteo device, new features have been supplemented.

A. Design

PMS is 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.

The PMS station consists of two basic parts:

- Box of the central unit and of the source part including the accumulator
- Support arm with sensors measuring climatic quantities.

The constructional parts are made either of stainless steel or of steel protected against corrosion by zinc coating.

The PMS may be supplied in three ways:

- in LV networks directly
- in MV networks across a voltage transformer
- in UHV/HV networks across a solar panels.

The disposition of the automated monitoring equipment on a separate pole can be seen in Figure 1.

Figure 1: Monitoring station PMS installed on MV line

The body of the measuring device also includes the electronic part for processing the measured data and for communicating with superior SW or with the system.

B. The measurement

The following quantities are monitored by the PMS station:

- air temperature
- relative humidity
- ice mass
- wind speed and direction (on the measuring rod or by the external ultrasonic anemometer)
- irradiance (external sensor, optional).

The measuring device PMS is made of stainless steel and it has no moving parts requiring any maintenance. It consists of a body with sensors for the measurement of temperature, ice mass and the velocity and direction of wind, and of a measuring rod (length 0,5 m, diameter 30 mm) fixed vertically downwards.

For measuring wind speed and wind direction we mostly use external Gill ultrasonic anemometer (heated if possible). Irradiance is measured by external pyranometer Kipp &

Zonnen. Both external sensors are suitable for such routine field measurements.

The measured data are evaluated, processed (with 1 minute time interval), archived (in daily files, the capacity of the flash memory is 5 years) and can be sent to a superior system.

Figure 2: Support arm with sensors

C. *Communication*

It is possible to communicate with the PMS either remotely via GPRS, optic cable or on the spot from the computer via Ethernet.

Distribution companies mostly use SCADA system. To allow communication PMS directly with SCADA, protocol IEC 60870-5-101/104 was implemented.

The PMS station is also able to send warning messages when the set parameters of quantities monitored have been exceeded. The warning messages can indicate:

- exceeding the set up ice mass value
- exceeding the set up steepness of ice growing
- exceeding the value of wind velocity
- outage of supply and its restoration
- foreign intervention into the monitoring equipment.

III. PMS INSTALLATIONS

So far we have installed 53 PMS in total. As can be seen from the table below, most of them were mounted into the distribution networks, on mv lines.

Company	State		Nr. installed	Place of installation
ČEPS	Czech Republic	TSO	10	Lines 400 and 220 kV, substations 400/110 kV
	Slovenia	TSO	1	Line 380 kV
E.ON Distribuce	Czech Republic	DSO	19	MV lines
E.ON Thüringen	Germany	DSO	13	MV lines & hv/mv substations
ZSE Distribuce	Slovak Republic	DSO	8	MV lines
NKT	Germany	-	1	testing
SEPS	Slovak Republic	TSO	1	400 kV line

In next two years we plan to install 24 PMS on the territory, which is supplied by the biggest Czech DSO ČEZ Distribuce. All PMS locations have been checked out regarding condition of poles, accessibility from public communications, acceptable quality of signal etc. This year we plan to install 8 PMS stations, next year the remaining PMS stations will be put in operation. When finished, the significant area of the Czech Republic, where icing can occur, will be covered and monitored by PMS.

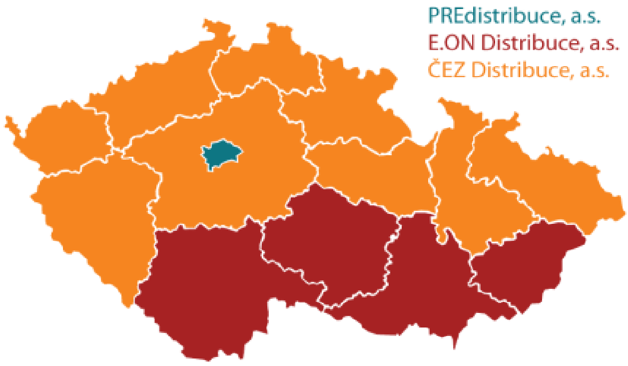

Figure 3: Map of the Czech Republic with areas supplied by DSOs

IV. USABILITY OF MEASURE METEOROLOGICAL DATA

Meteorological data, measured by PMS stations, can be used not only by dispatchers when operating the networks, but there are other fields they can be used in.

A. *Operation of the networks*

By dislocating PMS in areas which are important from the icing, dispatchers are obtaining sufficient information for the operative control of the distribution networks.

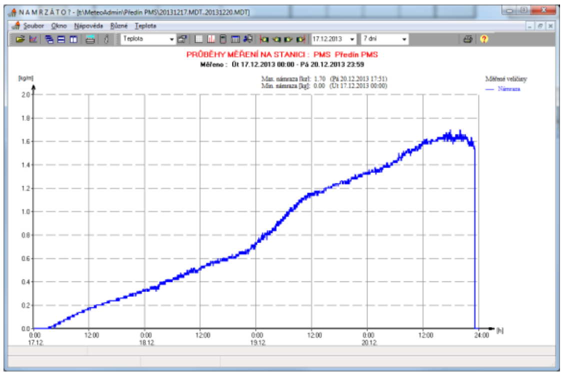

Figure 4: Example of icing cycle recorded by PMS

But for dispatchers not only information about icing is valuable. From experience we know measured wind speed is also of high interest to them, especially when wind speed exceeds limits set up and possible break downs in the networks can be expected (e. g, falling branches or trees).

Information from pyranometers can be used for evaluating energy produced by photovoltaics in the given region.

B. *Desing of OH lines and statistics*

Another very important effect is gathering all the data for further statistical evaluation. Information obtaiined about icing (and wind speed) is used when designing overhead lines. Determination of loading conditions on overhead lines (not only) and dimensioning of towers and overhead lines can result in possible savings on investment costs.

Knowledge about ice loads can then be used for further of icing maps and standards for designing overhead lines.

C. *Icing prediction*

Also seems to be important for cooperation with meteorological institution as far as the prediction of situations with icing occurrence and its verification are concerned. Such cooperation may result in making the prognoses more accurate from the point of view of the real occurrence of icing, of its size and the length of the icing cycle.

D. *Determination of dynamic line capacity*

Besides monitoring and processing meteorological data from PMS stations for control centres we used the data to verify a computational model for dynamic line rating on transmission lines (400 and 220 kV). PMS were used as a source of current meteorological data.

The project was divided into several phases and was finished last year, when the model of dynamic line rating was introduced into the dispatcher control system. The transmission capacity of some lines is now calculated based on current meteorological conditions. For these lines capacity for intraday, day ahead and two days ahead is also calculated.

V. AUTOMATED MONITORING SYSTEM

It was mentioned the PMS can be operated separately or can be connected to a superior system. It is obvious that the connection of PMS stations into the network of the monitoring system give the users additional benefits.

A. *Present state*

PMS stations operated on the territory of a utility are connected (mostly) to its SCADA system and data measured are downloaded into the SCADA database.

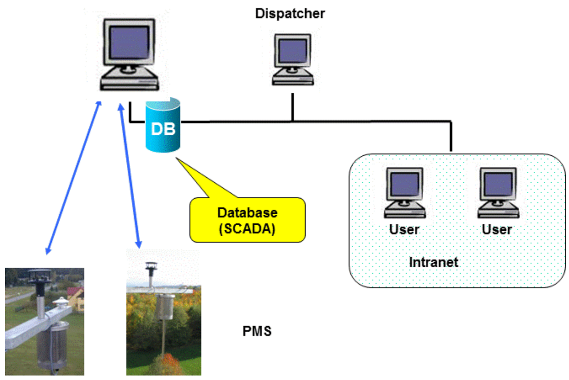

Figure 5: Scheme of processing data measured

A special software application displays the data measured to the dispatchers in table form or graphically. The dispatcher can see current values of meteorological quantities as well as the history of each quantity. When icing occurs, the dispatcher decides, based on current ice load and the recent development, how to cope with the situation (to start preparing a line for heating, for example).

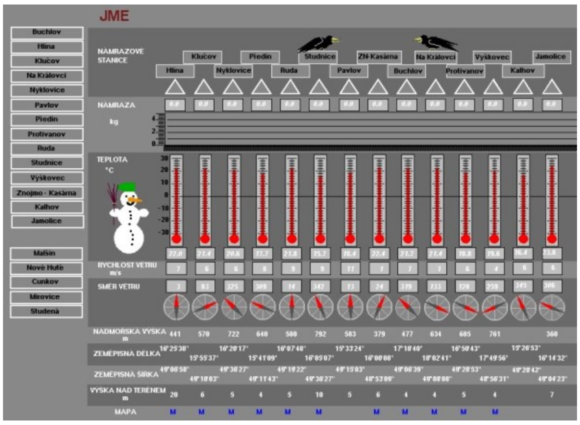

Figure 6: Values displayed to the dispatcher (E.ON)

At E.ON Distribuce, some data are also provided to Intranet where they are available for selected workers. Current values and history of meteorological quantities are presented in a simplified table or graph form.

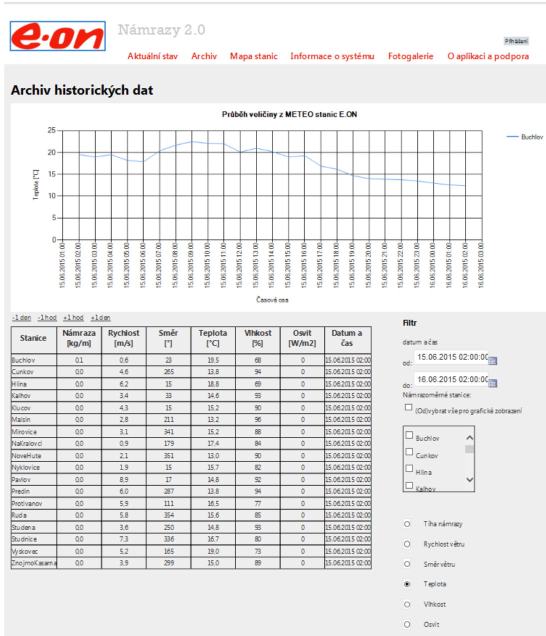

Figure 7: Displaying values on the E.ON Intranet

B. *Concept of a new project*

At the moment the data obtained from PMSs are "visible" and utilizable only within the utility itself. As a larger area of the Czech Republic is or soon will be covered with PMS stations we have decided to come up with a project which would enable us to share the data from PMS stations among utilities.

The first issue, which had to be solved, was to obtain content from all potential participants (DSOs, TSO) to provide the data to other entities. When the agreement was made we started preparing the technical solution. Discussions with other participants indicated that due to (cyber) safety reasons and other technical obstacles it would very difficult to exchange the data in a simple way. The solution, which will be implemented, is divided into following steps:

- Setting up a new data server in EGÚ Brno which will communicate to all PMS stations, download and store the data. It means each PMS station will communicate in two channels: to a utility SCADA system and server at EGÚ Brno.

- Creating parallel communication channel from PMS stations to data server in EGÚ Brno
- Creating a data format in which the data will be provided to other participants (DSOs, TSO, …)
- Testing phase of providing the data
- Visualisation data from “new” PMS stations for the dispatchers on side of DSOs and TSO respectively.

The first step has already been completed, last month we built the data server and installed special software for communication and storing the data into SQL database. A communication link from the server was established to a small number of PMS stations, which had been chosen for testing purposes. In the near future the communication will be spread up with remaining PMS station.

C. *Outlook*

We plan to gradually connect all PMS stations (E.ON, ČEPS) into this system and later on, when put in operation, also PMS stations from the territory supplied by ČEZ Distribuce.

In the title of this paper the territory of the Slovak Republic is mentioned. As the area, which is supplied by ZSE, borders the area supplied by E.ON Distribuce, it would make sense to connect to the system PMS stations from its territory. We believe that in near future we will be able to connect PMS stations installed on the area supplied by ZSE distribution utility to the data server and thus extend the area where meteorological data are measured and make them available to other parties.

We also intend to allow access to the data on the server to special users (planners from utilities e.g.) to see the current data and history. The access will be via a special Internet application. The first version of the application is being tested now.

VI. Conclusion

In recent years 29 PMS stations have been deployed on territory of the Czech Republic. Another 24 PMS stations will be mounted in the next two years. Then significant area of the Czech Republic, where icing occurs, will be monitored by PMS stations.

To allow utilities access to data from PMS stations we have proposed a project which would enable sharing of data among Czech utilities and TSO.

We consider this project very useful and challenging. It is obvious this solution will bring mutual profit to all parties involved as it would allow them to “see” the meteorological situation beyond their region with little cost and effort.

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