The First Experiences with Ice-Monitoring System for Transmission Network in Slovenia

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***Abstract*— The paper is addressed to first experiences with icing monitoring system of Slovenian Transmission Network after two years period. Second part of the paper describes ice storms in Northern part of Slovenia at the end of January 2009. Networks owners have suffered losses from damages on four towers of 110 kV lines, which is very important for evacuation of electric energy from hydropower chain from Drava River (/2/). Recently weather changes (in last few years period) approved needs of own (by transmission company) weather monitoring system and special care for continuing network development of observes equipment (sensors) in transmission infrastructure.**

Experimental icing monitoring system started with operation in autumn 2007 using METEO weather station integrated in existing OHL monitoring system named DAMOS (/1/). In years 2007/2008 it was not recorded any icing data but in January 2009 system recorded interesting icing events.

Experiences with first recorded ice data from monitoring system DAMOS have been positive. The paper describes more in details the event of February 3 at 11.45 a.m. when was icing with suddenly changing of temperature. The gusts of wind reached speeds more that 50m/s. Data from monitoring system have shown needs for changing previous determined references for ice loads in some geographical regions of Slovenia.

I. Introduction

TRANSMISSION network provider in Slovenia is national company ELES (Elektro-Slovenija) who is responsible for system operation, transmission network maintenance and system development. The territory of the Slovenian transmission network is impacted by three different climatic zones (Mediterranean, Alpine, and Continental) and frequently exposed to different level of ice storms (Fig.1). In the past period network had suffered a couple of ice storms events which caused a lot of damages. This was the reason that Transmission Company ELES decided to install an ice monitoring system to collect data for support operation and development and design network activities.

Fig. 1: Slovenia is exposed by three climatic zones

All transmission networks are of about 3000 km of corridors on very different altitudes, surroundings and weather conditions.

From operational aspects, icing data are important information for operators to be ready for possible critical states in system, but also it is very important information for network designers for construction of new lines or re-construction of old lines. Regulators are very interested for implementation of new technology with aim to increase system reliability and security of the system.

From 2009 the company have some experiences with ice monitoring system, what is subject of this paper.

II. Slovenian Monitoring System - DAMOS

Few years ago ELES established a concept for monitoring of overhead lines called DAMOS. Model is designed in GIS platform, connecting weather stations and sensors over optical communication network, which is part of transmission infrastructure. Program DAMOS enables to monitor different applications as weather conditions (ambient temperature, wind speed and direction, solar radiation, air pressure, and at one location icing), thermal ratings, sag checking, every 5 minutes re-calculating data. With changing the scale it is possible to monitor trace profiles and technical data details. Presently all data are transmitted over intranet every 5 minutes updated and it is possible to use inside transmission utility. The system is in trial operation with ongoing extensions with new weather stations and upgrading applications. The aim of the project is to set up 15-17 weather stations locating in switching substations as well as at the sensitive locations on the towers in the line corridors (i.e. quite valley for thermal condition monitoring, icing sensitive points for icing conditions, etc). Important innovation of the model is predicting weather conditions in the line corridor for 4 hours in advance using artificial neural networks approach. At the moment it is implemented for 2 line corridors (one for 400 kV line and other for 220 kV line). For wind intensity and ambient temperatures are quite good results but for other parameters is the mathematical model still at the research level.

The location of icing sensors have located on the same place as some 20 years ago were huge ice storms and collapses of 400 and 220 kV single line towers (740 m above the sea level, geographical region Brkini, weather station location Tatre). At that altitudes and distances from the Adriatic Sea from experiences point of view it is typical glaze icing region and region with very strong winds called bora.

Due to statistical data of events Slovenia changed standards for actions on lines (ice and wind loads). Ice loads were changed from previous (for example for conductors ACSR 490/65mm^2 with diameter 30,6mm) from 16 N/m to 25 N/m. In the in cones with previous 25 N/m it was changed to 50 N/m.

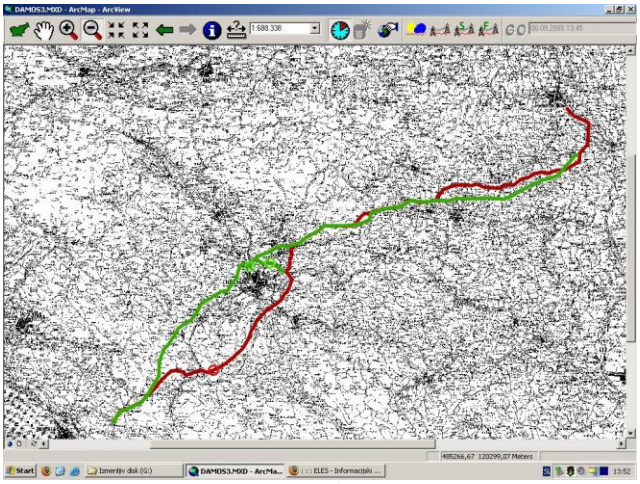


Fig. 2: DAMOS monitoring system for overhead lines including ice monitoring

As it could be seen from figure 2, the GIS supported monitoring system is equipped for monitoring 220 and 400 kV lines from Austrian to Italian border. Icing zones there are close to Italian border and to Adriatic Sea. Location of the first icing sensors are presented in the fig. 3 – location (A) Tatre in region Brkini at altitude 740 m, in the tower of the interconnection 400 kV line Meline (Croatia) – Divaca (Slovenia). Station is connected in intranet transmitting data every 5 minutes to all eligible users.

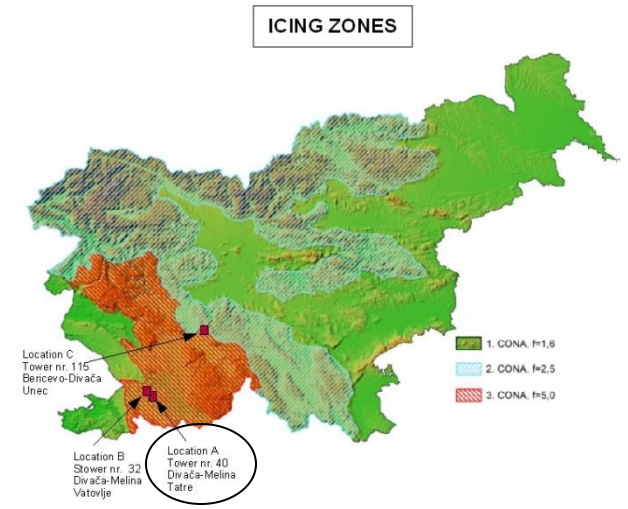
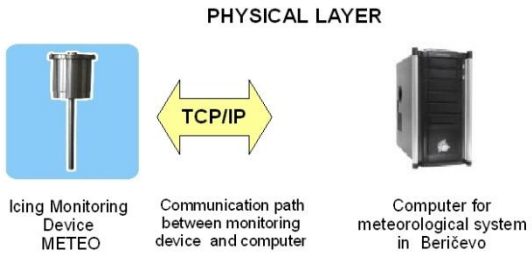


Fig. 3: Location of the icing monitoring sensor at the tower Tatre

As presented in Figure 4 and 5, the communication between weather station and system DAMOS is applied by optical network installed at overhead line. The sensor is also equipped with an Ethernet communication port. The sensor is connected to the optics or the clamp on the OHL tower with the aid of a converter, where it is connected to the optical cable, which is terminated in the substation Divaca. At this substation, it is with the aid of another converter connected into the Ethernet network of ELES. Within the Ethernet network of ELES all data are collected in the data collection centre DAMOS at central substation Beričevo.

The output data of the sensor is the mass of the ice on the measuring rod, the sensor is also measuring the air temperature as well as the speed and direction of the wind. It is capable of collecting measurement data from additional external sensors (solar radiation, ultrasonic sensor for the measurement of wind speed and direction). System started with trial operation in autumn 2007.



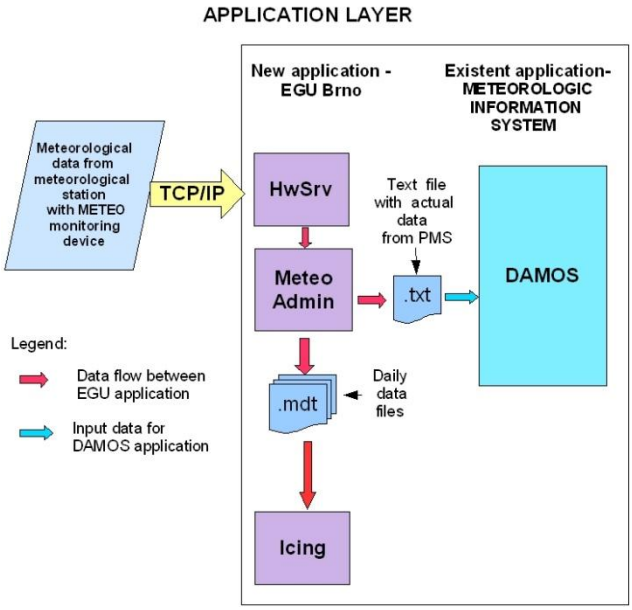


Fig. 4: Concept of ice monitoring device and DAMOS system

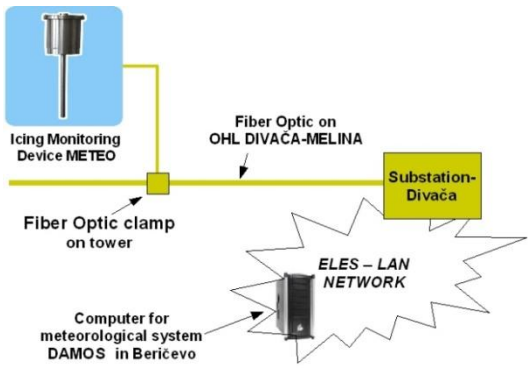


Fig. 4: Communication between ice monitoring device and main computer

III. RESULTS FROM ICE MONITORING STATION

In years 2007 and 2008 there wasn't any indication of icing in the vicinity of the observed line. But in January and February 2009 there were a couple of examples recorded as icing on the line. Very interesting conditions have been indicated on February 3 between 11 AM and 12 AM.

From Fig. 5 it is evident in correlation icing – temperature that icing started day before at 2.30 PM with ambient temperature minus 1°C and wind velocity 3.5 m/s. These conditions enabled to rising ice up to 0.5 kg/m. In same time period it is evident of fast changing weather condition with very strong wind with gusts up to 60 m/s. At 11.45 AM ice disappeared due to fast temperature changing and wind actions. In the same altitude level and same distances from sea but about two hundred km southern in region of Velebit mountains news have been reported on huge glaze icing.

Figure 5 and 6 present's correlation between icing, temperature and wind at selected date and time.

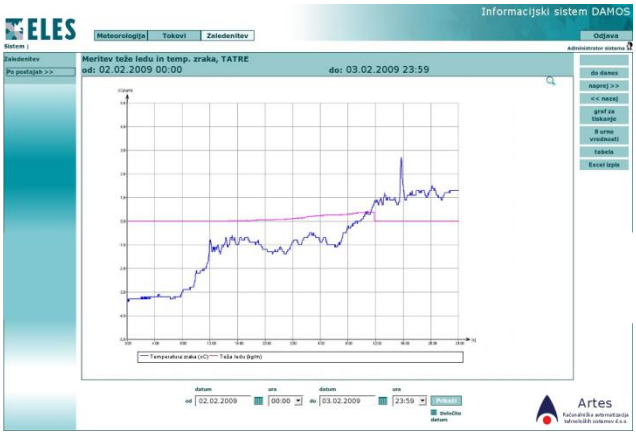


Fig.5: Correlations between icing and temperature

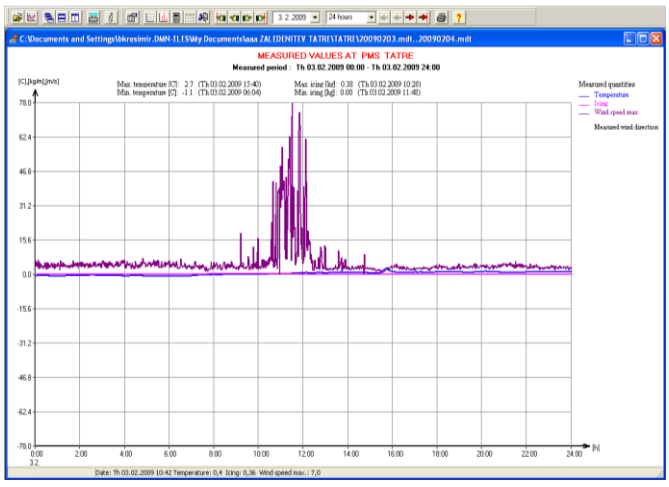


Fig.6: Correlations between icing and wind

Interesting information was time for making icing giving enough time to operators for intervention. In this example it was not needed but experiences confirmed a good possibility for actions. Fortunately this 400 kV line is quite often loaded with high flows what is benefits for line and icing events.

From Fig. 7 it is evident a very strong winds at this line corridor.

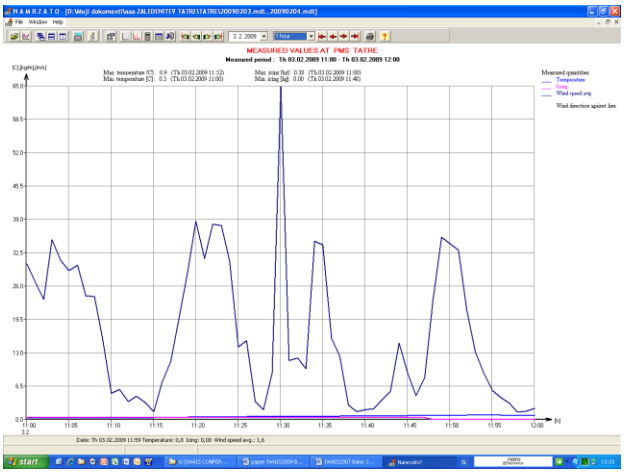


Fig.7: Correlations between wind speed, icing and temperature at the tower weather station.

So, the **first experiences with icing in the selected line corridor have shown that this ice monitoring system can be very useful to warning the system operator for action as well as for line designers for collecting data in the case of refurbishments of lines.** But this kind of ice (glaze) is only appearing in this region. In the other regions in Slovenia it is recorded a different kind of icing, mostly rime-icing and wet very heavy snow. For these examples we need different types of sensors. The concept of Damos system enables to extent with any kind of sensors at any point of transmission network.

IV. ICING STORMS IN SLOVENIA IN JANUARY 2009

On January 27-28, the Northern parts of Slovenia have been occurred with rime-icing storms. In very short time it was heavy snowing with over 50 cm of snow. In the trace of the double circuit line 110 kV HPP Vuhred – Pekre substation were huge damages of 3-4 towers and interruption of supply. This line is very important for evacuation electrical energy from Hydro Power plant from Drava river HPP chain. The reason for this collapsed line was extremely high winter load. The seven spans and three towers were completely re-constructed and renewed. All actions including redesigning line were completely done in 30 days.

Figure 8 have shown situation of line and completely collapsed towers. The photo on fig. 9 presents damaged tower.

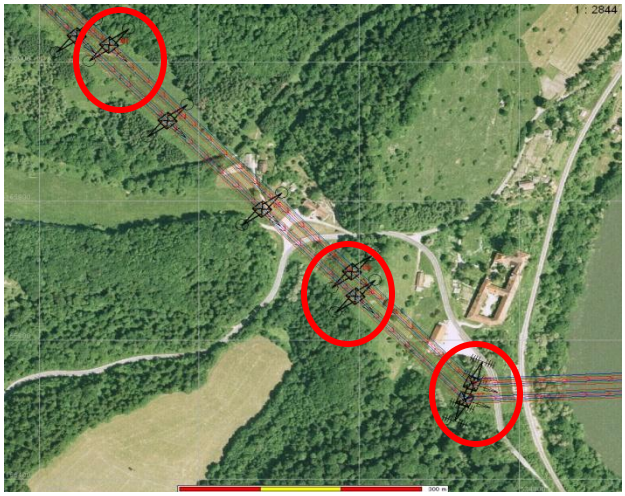


Fig. 8: Situation of collapsed towers of double circuit 110 kV OHL in Northern part of Slovenia on January 28, 2009

Fig.9: One of collapsed towers

New task of the DAMOS monitoring system designers is now how to make extensions of the existing system with new sensors able to recognize different models of atmospheric icing? In the Northern part of Slovenia are more frequent events with rime-icing and wet-snow storms. Same situation is indicated in the Alps region.

V. References

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