Assessing Pollution of Outdoor Insulators in the Cretan Power System

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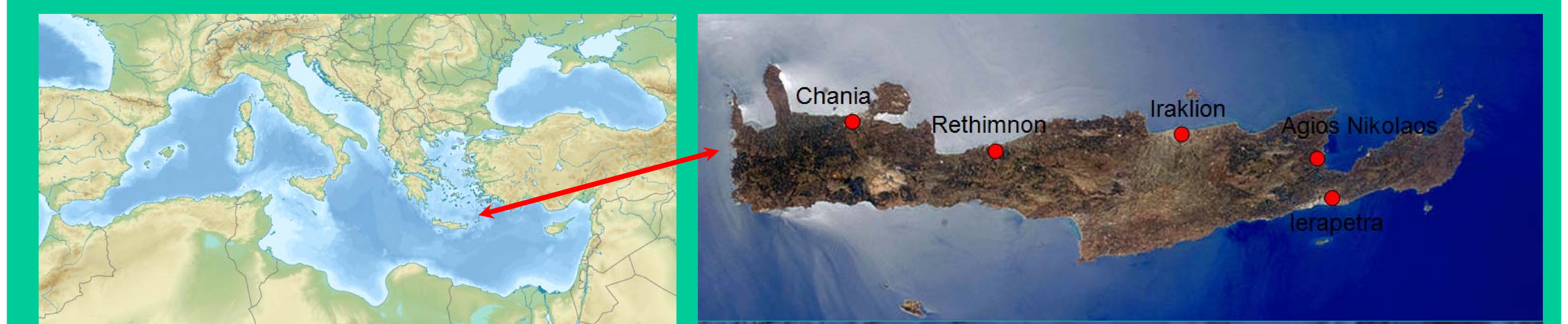
Insulators are key components of power systems as they are scattered throughout the network and a single insulator fault may lead to an excessive outage. Insulators' performance is strongly correlated to local conditions and especially to the experienced pollution. Therefore pollution mapping is an important procedure for power utilities that can be used for insulator maintenance, selection and replacement. For this purpose, several approaches can be followed considering the severity of the problem and also the available time and funds. These include the consideration of geographical and environmental data, human expertise/ experience, fault analysis and specially designed measurements such as ESDD, NSDD and DDDG. In this paper, the experience from pollution mapping in the Mediterranean Island of Crete, is presented. Crete provides an interesting case study due to the voltage level used, the island's shape and the experienced weather and climate that has resulted to a severe pollution problem and has forced the Greek utility (PPC and now HEDNO) to employ several different measures to cope with the problem over the years.

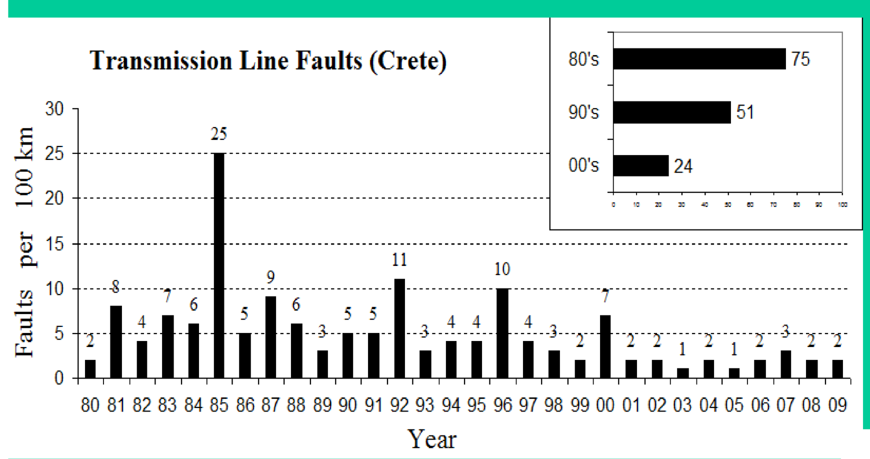
LOCAL CONDITIONS & POWER NETWORK

Crete is a Greek island located in the Mediterranean Sea, at the Southern end of Europe. It has a rather elongated shape (260 km long and 15-60 km wide) and has a coastline of 1046 km, mostly rocky. Three large mountain formations cover the center part of the island from east to west. The development of the island is mostly coastal with the four largest cities (Iraklion, Rethimnon, Chania, Ierapetra, Agios Nikolaos with a descending order) being located next to the coast.



Crete's climate is characterized by prolonged periods of dry (April-October) and then wet weather which combined with the strong winds and the rocky coast create an almost worst case scenario pollution-wise.

The Cretan power network is mainly coastal, which also exaggerates the marine influence.



The significant decrease of faults from a decade to next can be largely attributed to pollution maintenance procedures. For example, no washing (1982 to 1985) led to the increased number of faults in 1985 which resulted to the introduction of high pressure washing (1985) and eventually the use of helicopters (1995).

Limited installation of composite insulators started in the 90's (trial basis) and extended installation started after 2000. No flashover has been recorded on any HTV SIR composite insulator in the Cretan power system since their installation.

TLs AND INSULATORS

TL	Ins. Type (in general)	Year of large scale installation of HTVs
Atherinolakos-Ierapetra	HTV SIR	2004
Iraklion-Ierapetra	HTV SIR	2004
Atherinolakos-Sitia	HTV SIR	2006
Ierapetra-Sitia	HTV SIR	2010
Iraklion-Mires*	HTV SIR, Glass, Porcelain	2013
Iraklion-Chania*	HTV SIR, Glass, Porcelain	2013
Mires-Ierapetra*	Glass	-
Chania-Kasteli	Porcelain	-

*to be fully equipped by 2015

POLLUTION MEASUREMENTS

Three basic procedures have been standardized in order to measure pollution: the Equivalent Salt Deposit Density (ESDD), the Non-Soluble Deposit Density (NSDD) and the Directional Dust Deposit Gauge (DDDG). ESDD relies on collecting the pollution deposited on the surface of offline insulators in certain intervals, diluting it in water and measuring the conductivity and temperature of the solution in order to define the equivalent amount of salt in mg per cm^2 of the insulator's surface. To acquire the NSDD measurement the solution is filtered, the filter is dried and weighted to calculate the weight of non-soluble deposits. The DDDG measurement relies on the installation of special kits of cylindrical design that collect pollution from four directions (East, West, South, North).

ESDD measurements can be conducted on site, require no special equipment and consider the insulators' profile, therefore ESDD measurements were conducted on a number of 35 towers of 150 kV lines. Multiple towers were selected near the larger cities as these were areas also exposed to other pollution types (industrial, domestic etc).

Strings of insulators were hanged from the metal structure of towers from a lower height compared to live ones in order to be easily and safely accessible by the crew. A single measurement was conducted yearly at the end of the dry period and before rainfalls start. The procedure was repeated for three years in a row to minimize the risk of a local rain before the measurement. The maximum of the 3 measurements was then considered as the ESDD value for the location.

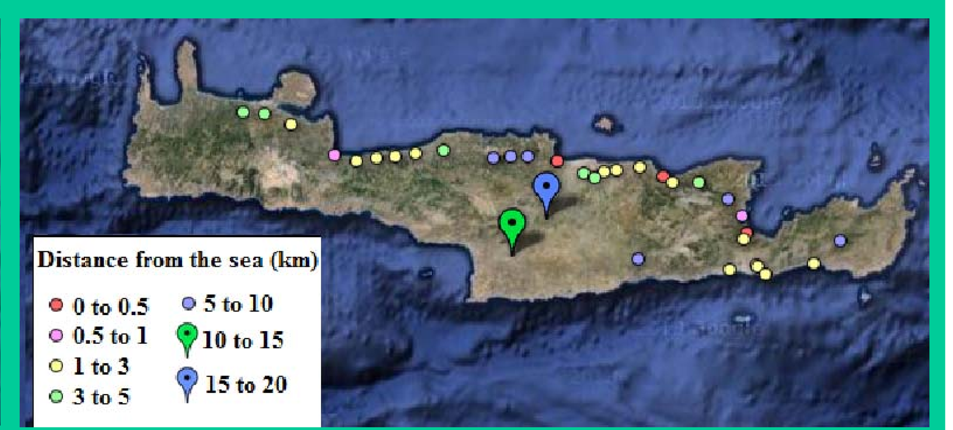
RESULTS & DISCUSSION

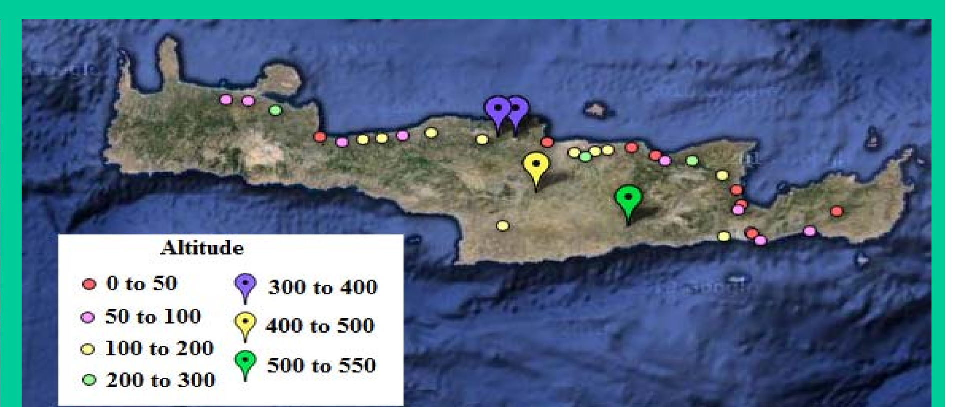
In order to classify a Site's Pollution Severity (SPS) to the three basic classes (light, medium, heavy), slightly different ranges of ESDD measurements have been proposed by IEC, IEEE and CIGRE. The IEC values are given through an ESDD-NSDD diagram and have relatively large cross-areas, therefore the more specific IEEE and CIGRE values shown are used.

SPS and ESDD values

SPS	ESDD value (mg/cm^2) (IEEE)	ESDD value (mg/cm^2) (CIGRE)
light	<0.06	<0.06
medium	0.06-0.10	0.06-0.12
heavy	>0.10	>0.12

Overall results verify the pollution profile acquired via experience, as coastal areas appear to be subjected to heavier pollution compared to the central areas, and the east part of the island seem to face a more severe influence compared to the western part. However, some added characteristics emerge. The SPS of some locations changed classes when moving from IEEE to CIGRE limits. This shows that a more tolerant approach as the one proposed by IEC is probably closer to reality, even though a strict definition is usually preferred by utility engineers. A strong correlation with the proximity to pollution sources is evident but one should add cities as a major pollution source (besides sea). Heavy pollution has been recorded next to Iraklion, Rethimnon, Agios Nikolaos and Ierapetra. However, not near Chania even though Chania is larger than Agios Nikolaos and Ierapetra. This verifies the different conditions experienced on the west part of the island as described earlier in this paper. Further, the measurements conducted on coastal towers located in the south part of the island shows a lighter pollution image which should be largely attributed to the direction of the experienced winds which is mostly north-west.





CONCLUSION

Assessing the pollution of outdoor high voltage insulators is an important piece of information for power utilities. Several approaches can be followed to map the experienced pollution depending on the available time and funds. Crete is a Greek island located in the Mediterranean which offers an interesting case study due to its location, shape, climate and power network design. The Greek power utility has employed several remedies to cope with the problem and has also participated in several research schemes that investigate the phenomenon's various different aspects, including pollution mapping. Various factors are considered and presented in this paper: the island's morphology and location, the experienced weather and climate, the network's development, past fault and maintenance experience as well as pollution measurements conducted on 35 different spots throughout the island. The island's pollution profile is portrayed through the use of descriptive maps. The overall conclusion is that pollution mapping is a rather complex procedure and even though the distance from the sea is a strong indication, additional data such as the distance from other pollution sources as well as wind strength, wind direction and rainfall patterns should also be considered. As a general rule, pollution is heaviest near the coast and in proximity to large cities to the eastern side.

FUTURE WORK

The pollution map acquired will be considered for the selection of towers from which polymer insulators will be removed for the scopes of the POLYDIAGNO research project, that has as a final goal to establish a procedure and a diagnostic technique for assessing the performance and aging of polymer HV insulators. The acquired pollution maps will be revised with the introduction of added pollution measurements and the exact definition of needed correlation factors, via the use of comparative pollution measurements conducted in TALOS High Voltage Test Station (www.talos-ts.com).

ACKNOWLEDGMENT

This work was partially supported by the POLYDIAGNO research project (project code 11SYN-7-1503), which is implemented through the Operational Program "Competitiveness and Entrepreneurship", Action "Cooperation 2011" and is co-financed by the European Union (European Regional Development Fund) and Greek national funds (National Strategic Reference Framework 2007 - 2013).

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