Mapping HV Insulators' Pollution in the Mediterranean Island of Crete

Dionisios Pylarinos
Consultant,
Hellenic Electricity Distribution Network Operator S.A., Crete,
Greece

Kiriakos Siderakis
Assistant Professor,
Laboratory of Energy and PV systems
Technological & Educational Institute of Crete,
Greece

Nikolaos Mavrikakis
Electrical Engineer,
Technological & Educational Institute of Crete,
Greece

Emmanuel Thalassinakis
Assistant Director,
Hellenic Electricity Distribution Network Operator S.A., Crete,
Greece

Laboratory of Energy and Photovoltaic Systems
High Voltage Systems Section

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Insulator's Pollution Mapping

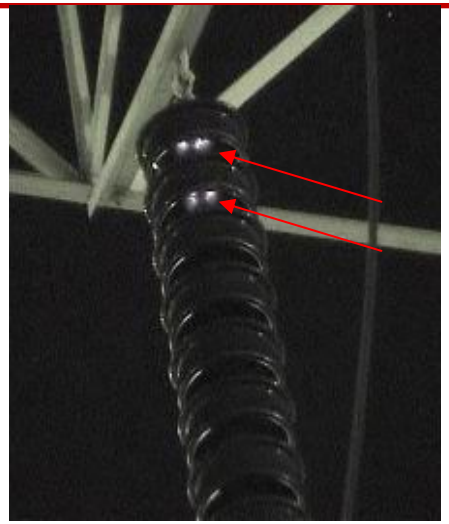
- Pollution
  - Any substance that can be deposited on the surface of an outdoor high voltage insulator and is capable of altering it's performance.
  - Usually we are interested in substances that have or can develop electrical conductivity, but non conductive may have an effect.
  - Many sources can be considered, sea is a common case for coastal outdoor high voltage systems
  - Wind is the usual transfer mechanism
  - Rain may also wash clean (depending on the intensity)

TEI of Crete
Technological Educational Institute of Crete
HEDNO

Flashover development

❑Development to a flashover

- pollutants deposition
- wetting (mist, dew, rain etc)
- creation of a conductive film
- leakage current (LC) on surface
- dry bands -> arcing
- arc propagation
- flashover under the nominal voltage
- different behavior in case of silicone insulators (similar during hydrophobicity loss periods)

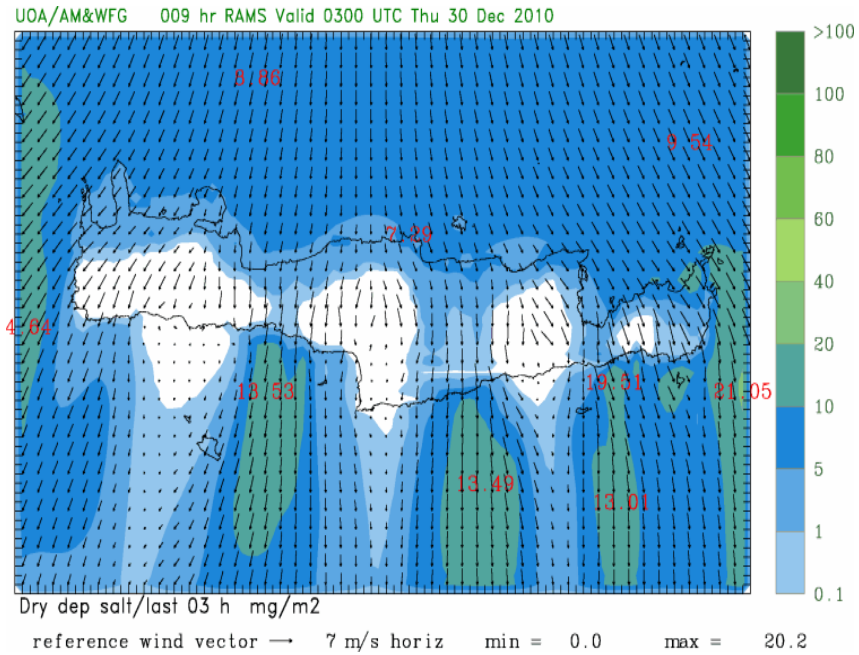


Dr-Ing Kiriakos Siderakis
Assistant Professor
Laboratory of Energy and Photovoltaic Systems
High Voltage Systems Section
ksiderakis@staff.teicrete.gr

*Flashover at **TALOS** H.V. Test Station, Crete (www.talos-ts.com)*

Insulator's Pollution Mapping

- Pollution mapping
  - The amount of pollution that may accumulate on the surface of an insulator is a function of many parameters
  - It is possible to have different influence levels along the same transmission line and for the same insulator
- Is it necessary?
  - Necessary when designing the insulation of a new or upgraded transmission line
  - Necessary when developing an maintenance strategy
  - Necessary within the assessment process of installed composite insulators
- How it can be done
  - Computer modeling
  - The hard way by field measurements



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High Voltage Systems Section
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Pollution Mapping - Measurements

- Field measurements
  - **Equivalent Salt Deposit Density (ESDD)**
    1. Standardized procedure included in IEC60815
    2. Measure on certain intervals the soluble deposits on a dead string by washing plates and measuring the solution's conductivity
    3. (+): profile, on site
    4. (-): frequent mounting/unmounting

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The power system of Crete – Field Measurements

Strings of not energized insulators hanged from the metal structure of towers

Pollution Mapping - Measurements

- Field measurements
  - **Equivalent Salt Deposit Density (ESDD)**
  - **Non Soluble Deposit Density (NSDD)**

    1. Standardized procedure included in IEC60815
    2. After ESDD filter the solution and then use the mass difference of the dried filter in order to acquire a value for the mass of non soluble deposits
    3. (+): non-soluble deposits
    4. (-): special equipment

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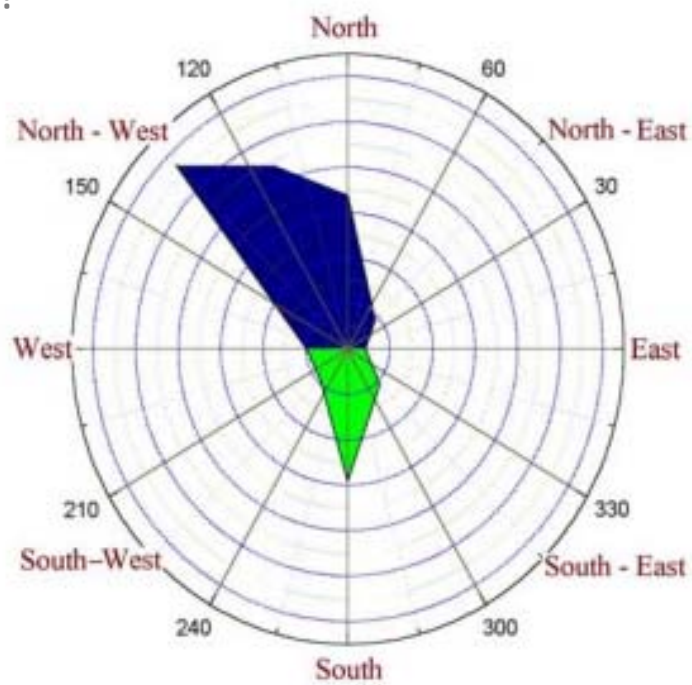
Pollution Mapping - Measurements

- Field measurements
  - **Equivalent Salt Deposit Density (ESDD)**
  - **Non Soluble Deposit Density (NSDD)**
  - **Directional Dust Deposit Density (DDDG)**

    1. specially designed kits to capture pollution from all 4 directions and measure monthly (conductivity)
    2. (+): easy to cover large areas
    3. (-): profile?



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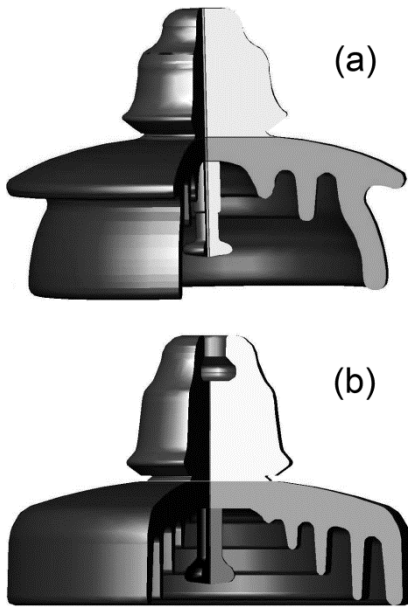
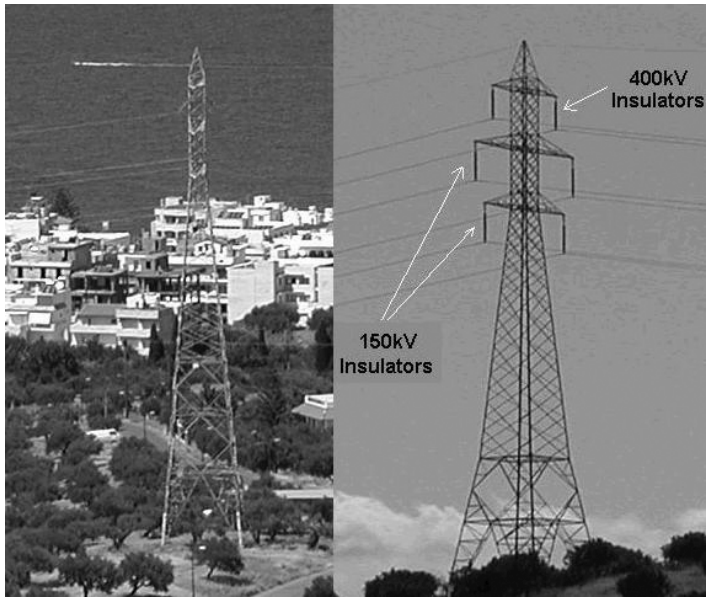
Why don’t just over-insulate?

- Obvious reasons (cost, weight, clearance etc)
- Insulation coordination
- **Case 1:** At the transition of the transmission system in Rhodes from 66kV to 150kV
  - TL lines at 150kV
  - Substations at 66kV
  - Increased frequency of lightning faults near substations
- **Case 2:** Application of 400 kV insulators in a part of a 150 kV TL in Crete
  - 55% of them had to be replaced due to pollution originated flashovers from 1985 to 1994
  - At the same time, only 0.7% of the 150 kV insulators were damaged and replaced due to flashovers
  - Reason: the 400kV profile was less subjected to natural cleaning (rain)





K. Siderakis, D. Agoris, J. Stefanakis, E. Thalassinakis, Influence of the profile on the performance of porcelain insulators installed in coastal high voltage networks in the case of condensation wetting, IEE Proceedings, Science, Measurement and Technology, Volume 153, Issue 4 , p. 158 - 163

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The power system of Crete

- south Mediterranean
- elongated shape
- coastline: 1046 km
- coastline: mostly rocky
- strong winds (N-NW)
- coastal growth
- dry period (April-October)
- strong winds in the east
- more rains in the west
- tourism (summer)

The power system of Crete - Pollution

- coastal 150kV network
- intense pollution problems at the East
- main source: sea

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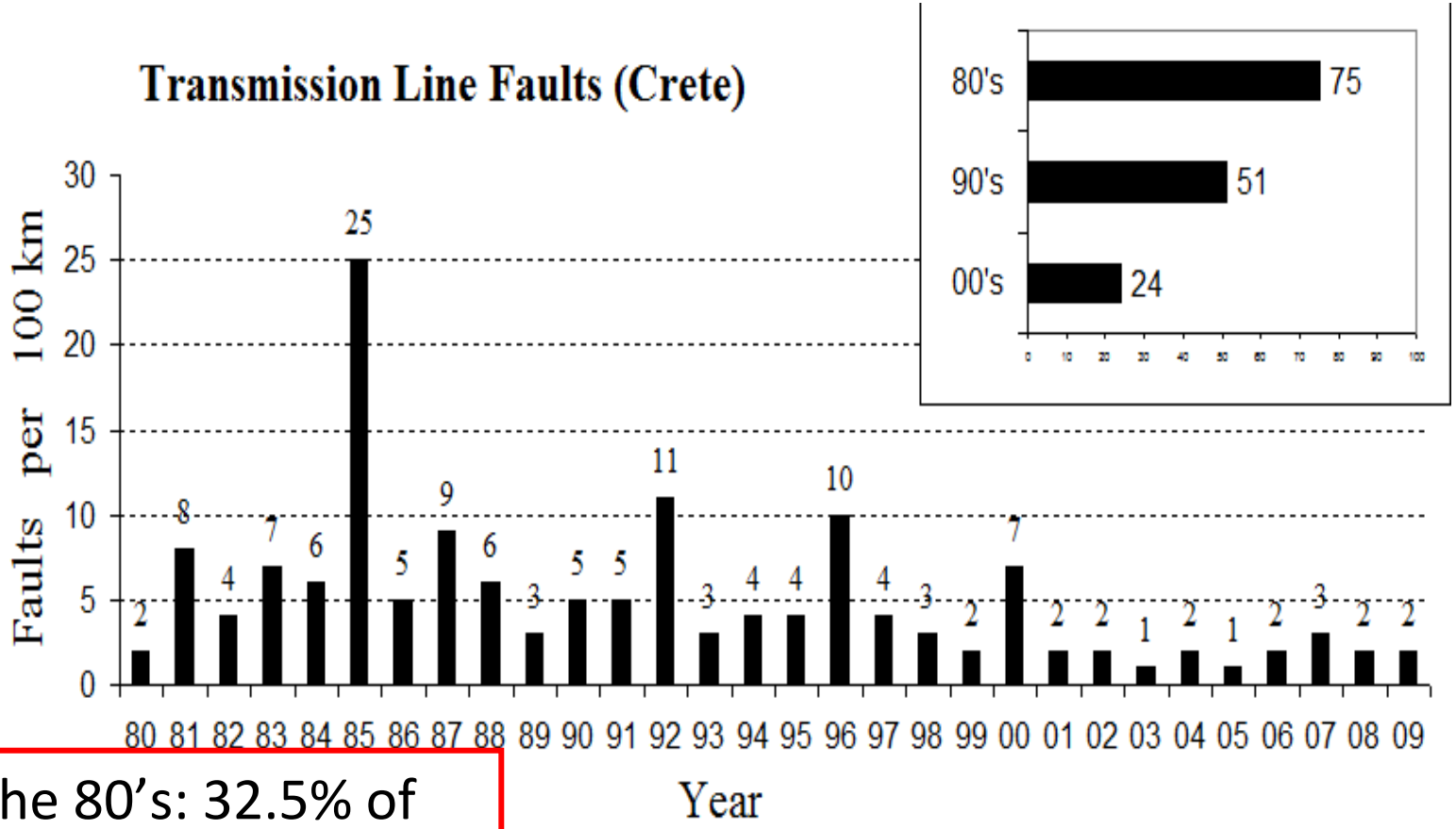
The power system of Crete - Pollution

- coastal 150kV network
- intense pollution problems at the East



e.g. in the 80's: 32.5% of all TL faults -> pollution

a single insulator fault may "cost" more than the total purchase cost for all the insulators of the transmission line

The power system of Crete – Field Measurements

- 35 different 150 kV towers selected
- mainly to the east and the line connecting Iraklion with Ierapetra
- multiple towers near large cities
- ESDD measures, once a year (September/October), 3 years in total
- max of all measurements considered for Site's Pollution Severity (SPS)

The power system of Crete – Field Measurements

Field sampled insulators

Dr-Ing Kiriakos Siderakis
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The power system of Crete – Field Measurements

Things to consider

- standards refer to disc insulators but PPC used also fog insulators for pollution measurements
- ESDD values are calculated per surface unit (cm^2) but surface area not provided by the manufacturers

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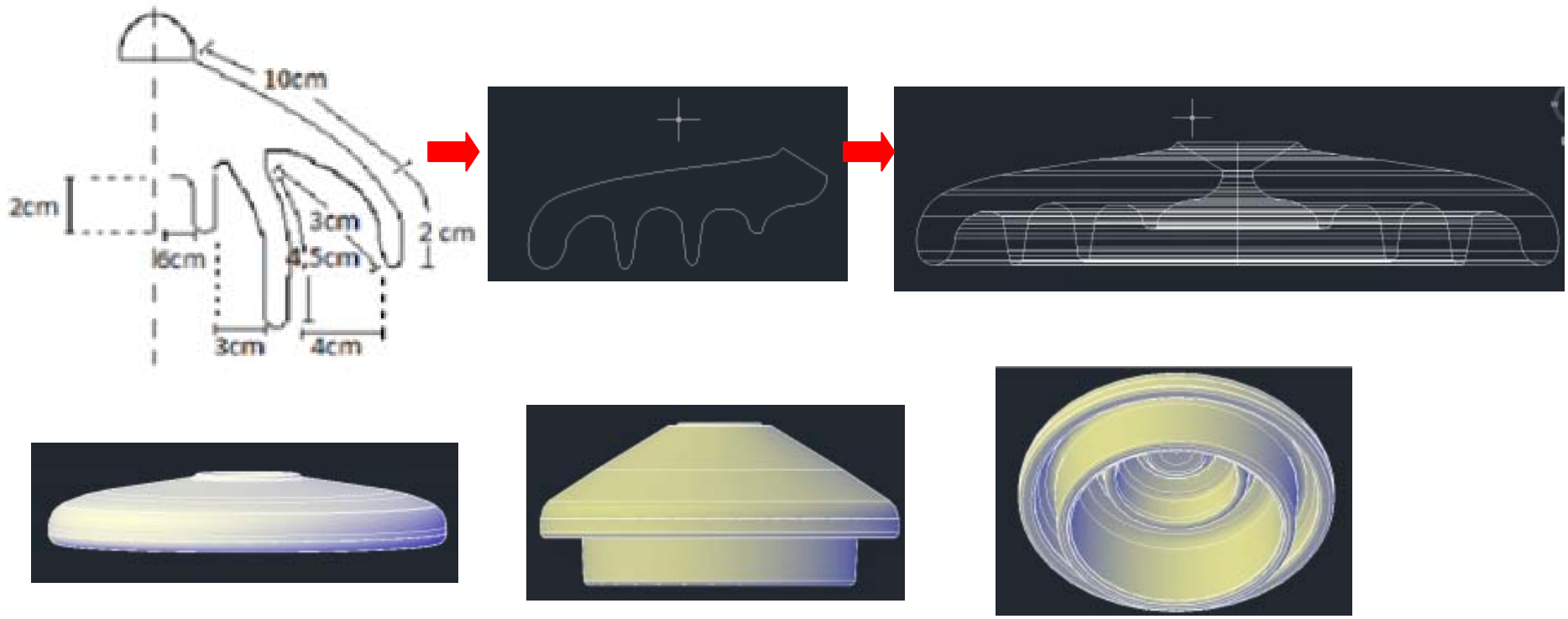
The power system of Crete – Field Measurements

Going forward - surface area

- use original drawings (if available)
- measure and create new drawings if originals not available
- use CAD to calculate surface area



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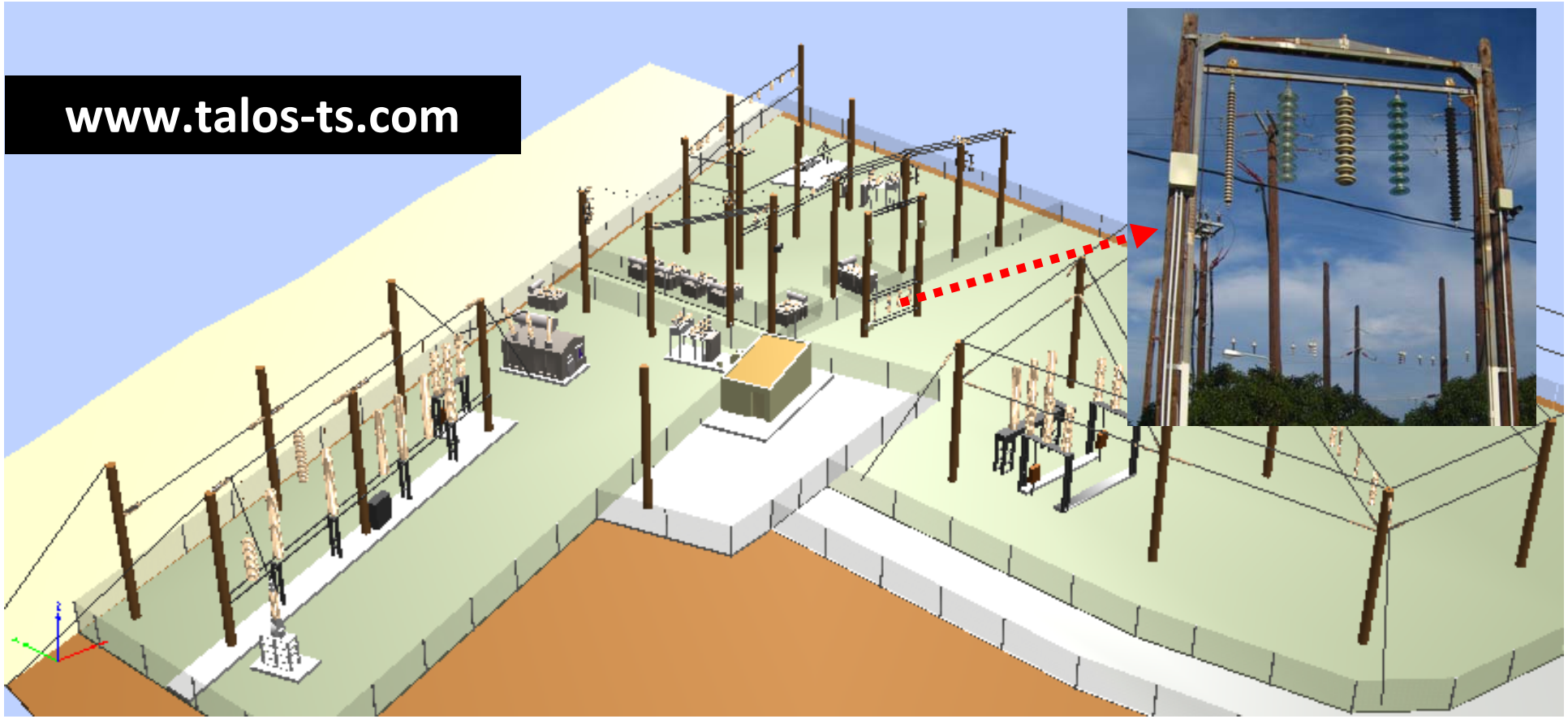
The power system of Crete – Field Measurements

Going forward – profile correlation

- initiate additional comparative series of measurements in TALOS High Voltage Test Station (to be published)



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The power system of Crete – Field Measurements

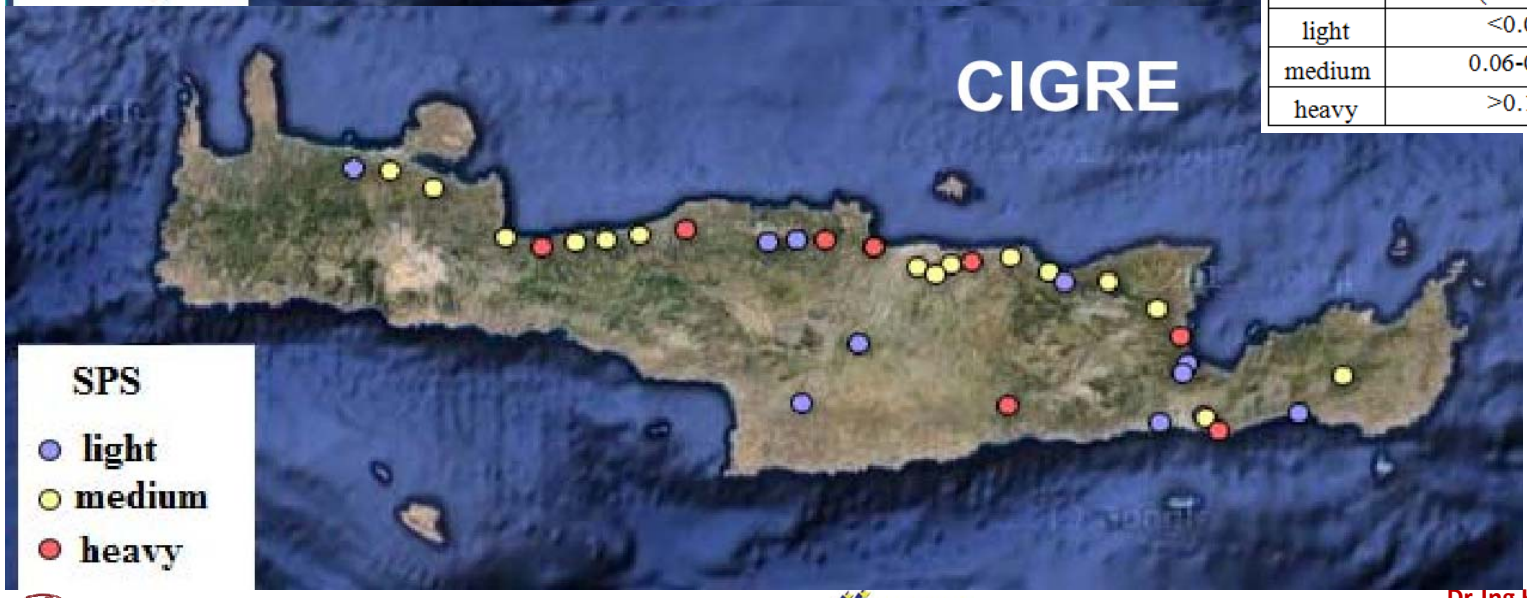

Table I. SPS and ESDD values

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

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The power system of Crete – Results

- distance from the sea crucial but not the only parameter to be considered
- lighter pollution at the south (N-NW winds)
- lighter pollution at the western side (rains)
- cities emerge as a primary pollution source

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Conclusions

- ESDD measurements confirm the experience and underline the role of cities as pollution sources and of the experienced weather
- Basic problem: coastal areas
- Basic scheme: two different zones (west-east)
- West: light-to-medium pollution, east: medium-to-heavy
- Route having the most problems: Iraklion to Atherinolakos (the first that was equipped with polymer insulators back in 2004)
- Pollution maps - Useful also when composite insulators are used
- This work continuous:
  - comparable ESDD and NSDD measurements at TALOS and detailed weather monitoring
  - Extend the measurement network
  - along with material analysis, leakage current monitoring and lab tests

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