Digitalization, ICT and AI Solutions for Modern Electric Power Grids

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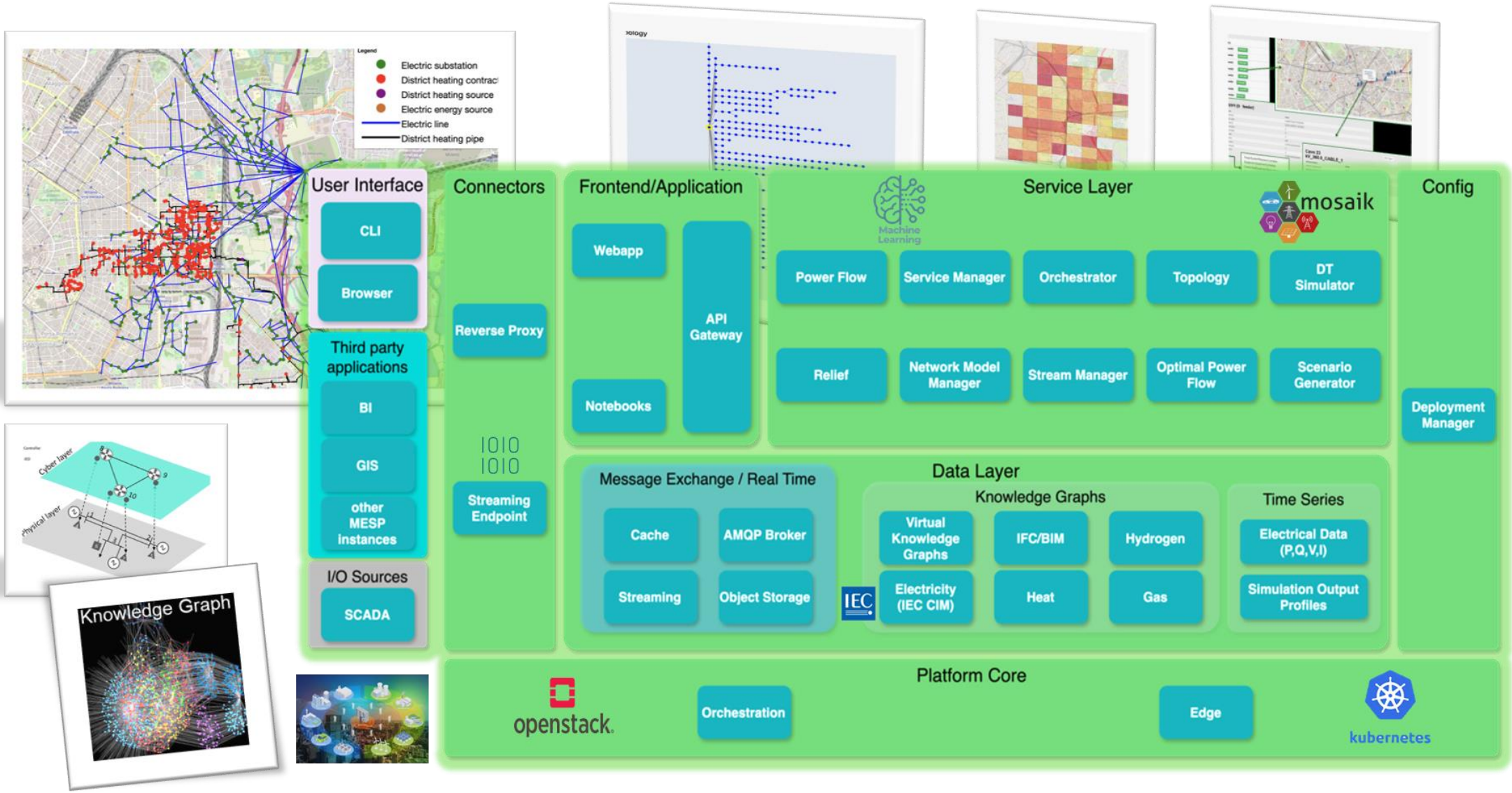
ICT Solutions for Energy Systems

27/05/2026

MESP-DT *Multi Energy Semantic Platform - Digital Twin*



Digital Twin multi-energy network

Multi Energy Semantic Platform Digital Twin – MESP DT

Points Query | Lines Query | Feeders | Geosparql | Alert

Coordinate system

latLong

Query

positionPoints

Bus SPARQL Query

```
    cim:PositionPoint.yPosition ?y_position;
    cim:PositionPoint.Location ?loc.
 ?element cim:PowerSystemResource.Location
    a ?type;
    cim:IdentifiedObject.name ?codice_cabina.
FILTER (?type IN (cim:ServiceLocation)) }
```

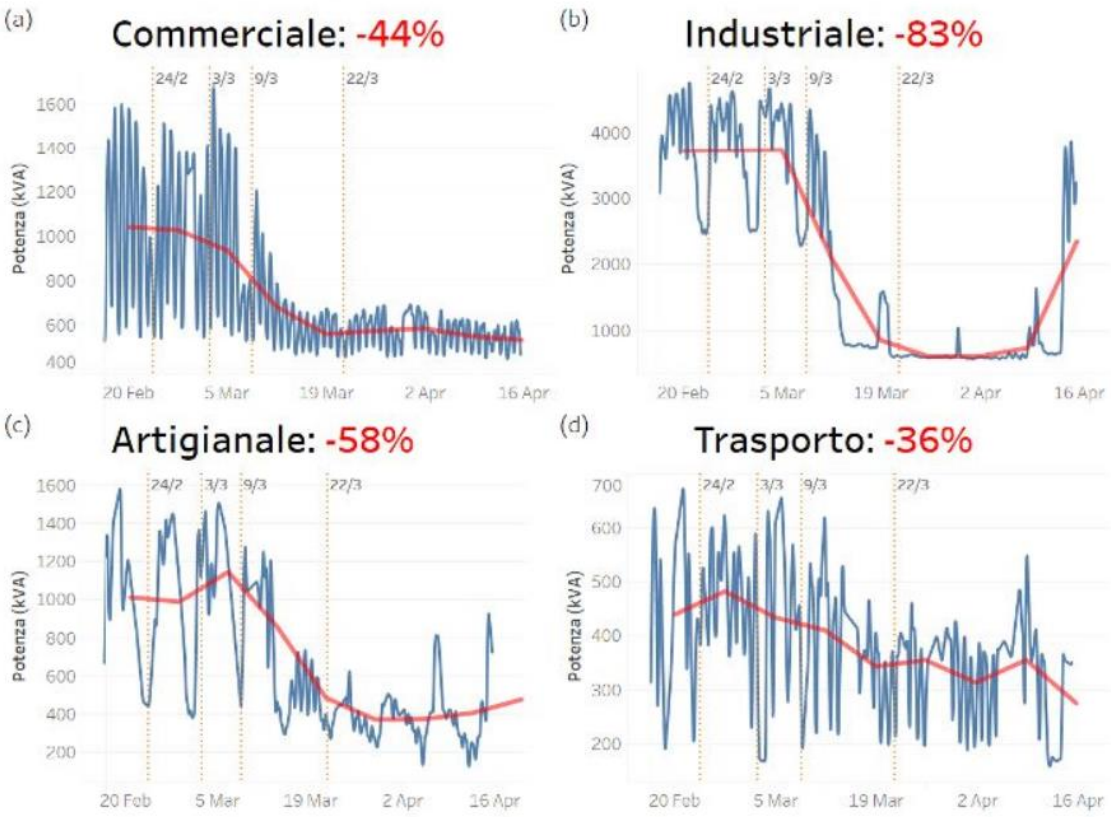
unareti

ACLineSegment

Attribute Name
cim:ACLineSegment.feederCable
cim:IdentifiedObject.aliasName
cim:Conductor.conductorType
cim:PowerSystemResource.aor
cim:IdentifiedObject.serviceState
cim:Equipment.private
cim:ACLineSegment.reducedCapacity
cim:IdentifiedObject.subTypeValue
cim:IdentifiedObject.mRID
cim:ConductingEquipment.importance
cim:PowerSystemResource.underground
cim:Equipment.costPerUnit
cim:ConductingEquipment.failureRate
cim:Conductor.length
cim:Equipment.model
cim:IdentifiedObject.name
cim:ConductingEquipment.ratedVoltage
cim:Equipment.manufacturer

Linked to

cim:PowerSystemResource.PSRType
cim:ACLineSegment.PerLengthImpedance
cim:Equipment.Circuit
cim:Equipment.EquipmentContainer



Integration of Water Infrastructure and Weather Data

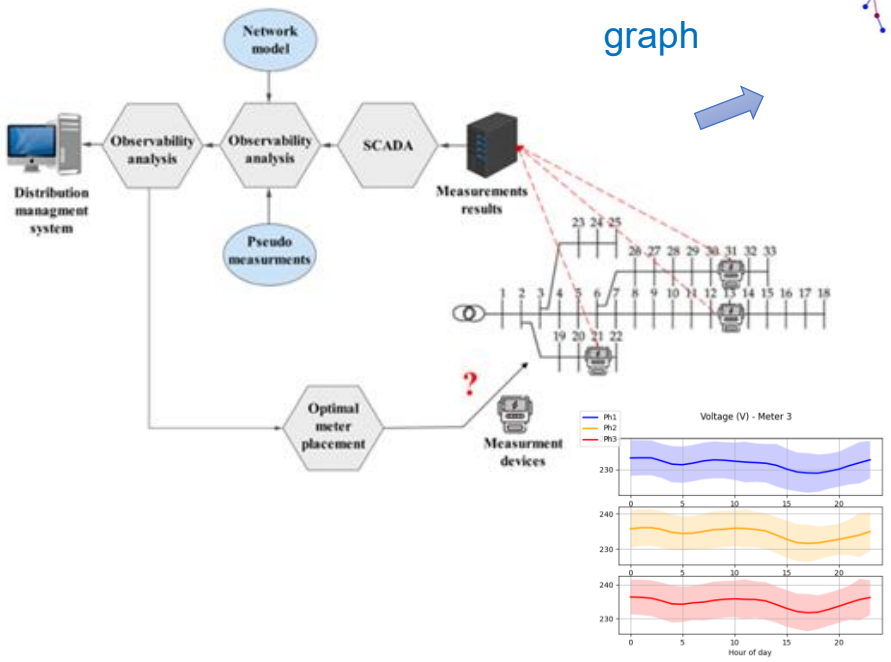
- Substation flooding, heat waves
- Mobility planning

2020 – COVID effects on electricity consumption

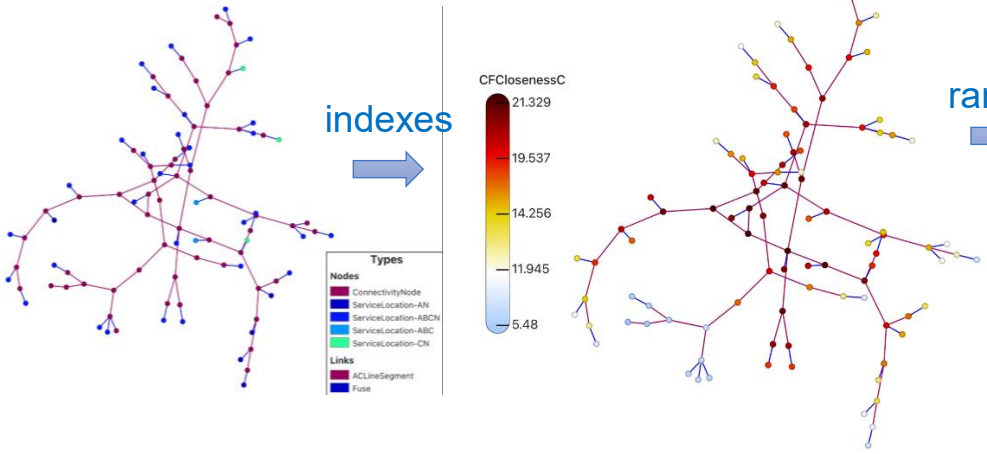
Graph – ML for LV network indicators

Study of graph-based algorithms to analyze loads and forecast utilization of energy networks

Optimal placement problem of meters on distribution networks



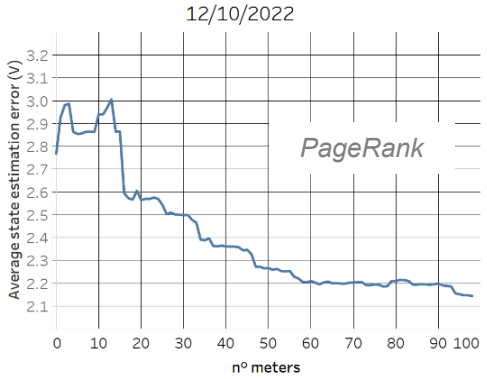
graph



indexes

ranking

Progressive allocation of *meter* to nodes based on the *ranking*



Test network > 150 nodes
Stable estimation error with N > 30% of nodes

No.	CFBetweennessC				KatzC				PageRank				Random			
	20/04	*15/06*	*12/10*	*22/12*	*20/04*	*15/06*	*12/10*	*22/12*	*20/04*	*15/06*	*12/10*	*22/12*	*20/04*	*15/06*	*12/10*	*22/12*
20	3.43	2.62	2.58	3.42	3.55	2.65	2.71	3.26	3.60	2.69	2.66	3.47	3.41	2.67	2.61	3.29
30	3.26	2.51	2.48	3.27	3.57	2.65	2.71	3.28	3.54	2.67	2.58	3.38	3.39	2.47	2.60	3.06
40	3.24	2.47	2.43	3.19	3.54	2.61	2.65	3.32	3.34	2.51	2.44	3.22	3.65	2.40	2.50	2.96
50	3.19	2.42	2.37	3.11	3.14	2.41	2.38	2.98	3.12	2.43	2.35	2.97	3.27	2.42	2.55	2.90
60	3.19	2.42	2.39	3.12	3.08	2.38	2.36	2.95	3.03	2.35	2.29	2.83	3.25	2.36	2.53	2.80
70	3.13	2.35	2.30	3.14	3.06	2.37	2.33	2.89	3.01	2.34	2.29	2.82	3.24	2.35	2.36	2.74

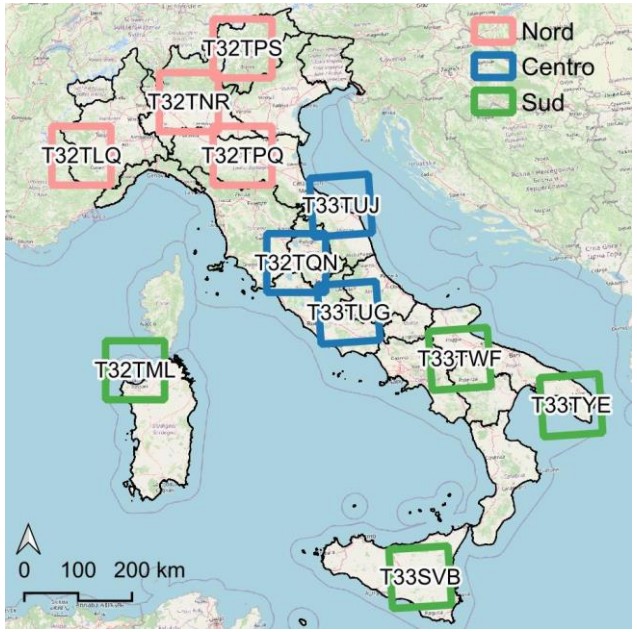
Mean absolute state estimation error [V] based on the number of *meter*

Satellite imagery for photovoltaic mapping

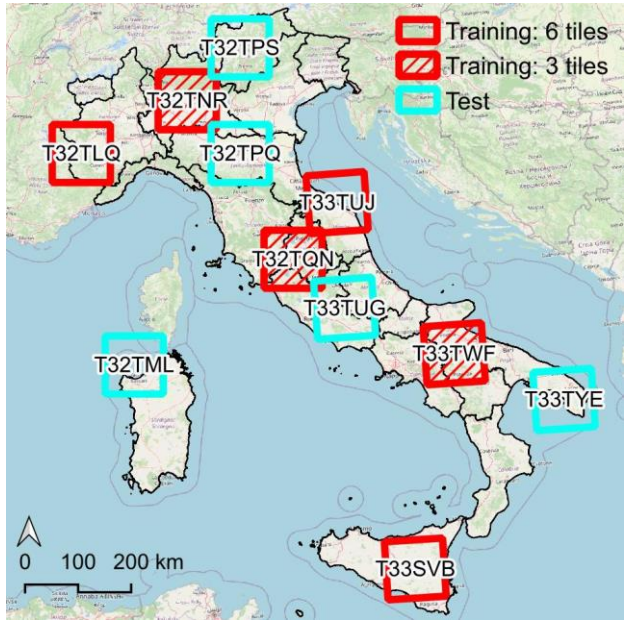
Open Access Article

Leveraging Semantic Segmentation for Photovoltaic Plants Mapping in Optimized Energy Planning

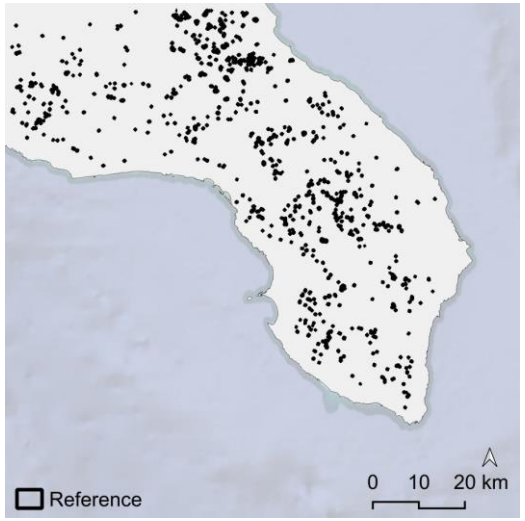
by Giulia Ronchetti [1,*], Martina Aiello [1] and Alberto Maldarella [2]

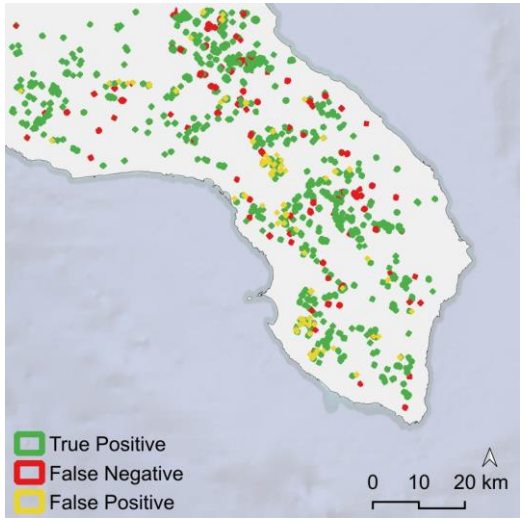


Selected study areas



Model	No. of tiles	Loss function	Plant pixels [%]	Dice score [%]
North	2	Focal+Dice	1,13	60
Center	2	Focal+Dice	1,26	75,6
South	2	Focal+Dice	1,77	69,8





Model	Threshold	No. of plants	Power [MW]	Area [ha]	IoU [%]
Training 6 tiles	0	2455	2518	4530	48
	25	1747	1958	3523	61
	50	1551	1661	2991	67
Reference dataset		**1655**	**2017**	**3630**	-

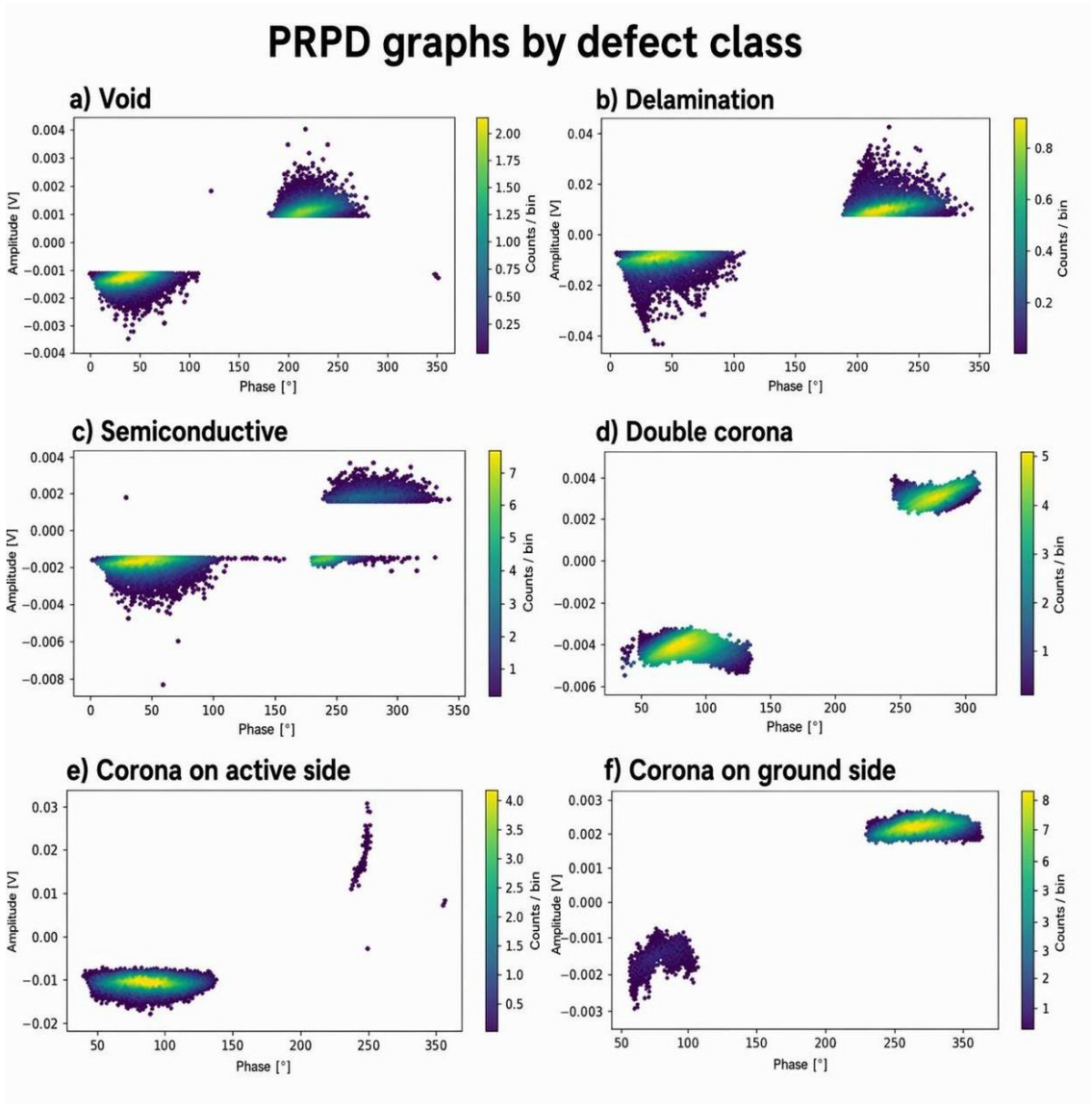
Application of the general model to the national territory

Detection of insulation defects through AI partial discharge pattern analysis

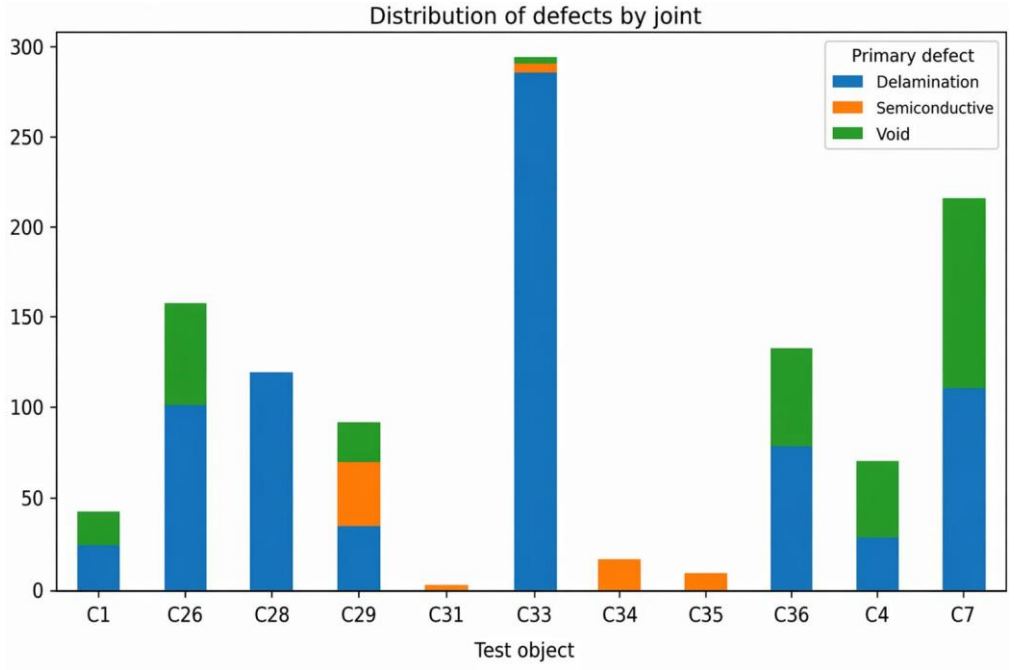
Image of RSE's MV Cable Diagnostics Laboratory.

- Partial Discharges (PD) as an early indicator of insulation degradation.
- Role of PD in predictive maintenance of Medium Voltage (MV) systems .
- Objective of the work:
  - create an **annotated experimental dataset;**
  - support the training of **AI algorithms** for the classification and identification of insulation defects.
- Work carried out at the **RSE MV Cable Diagnostics Laboratory.**

Classification of insulation defects



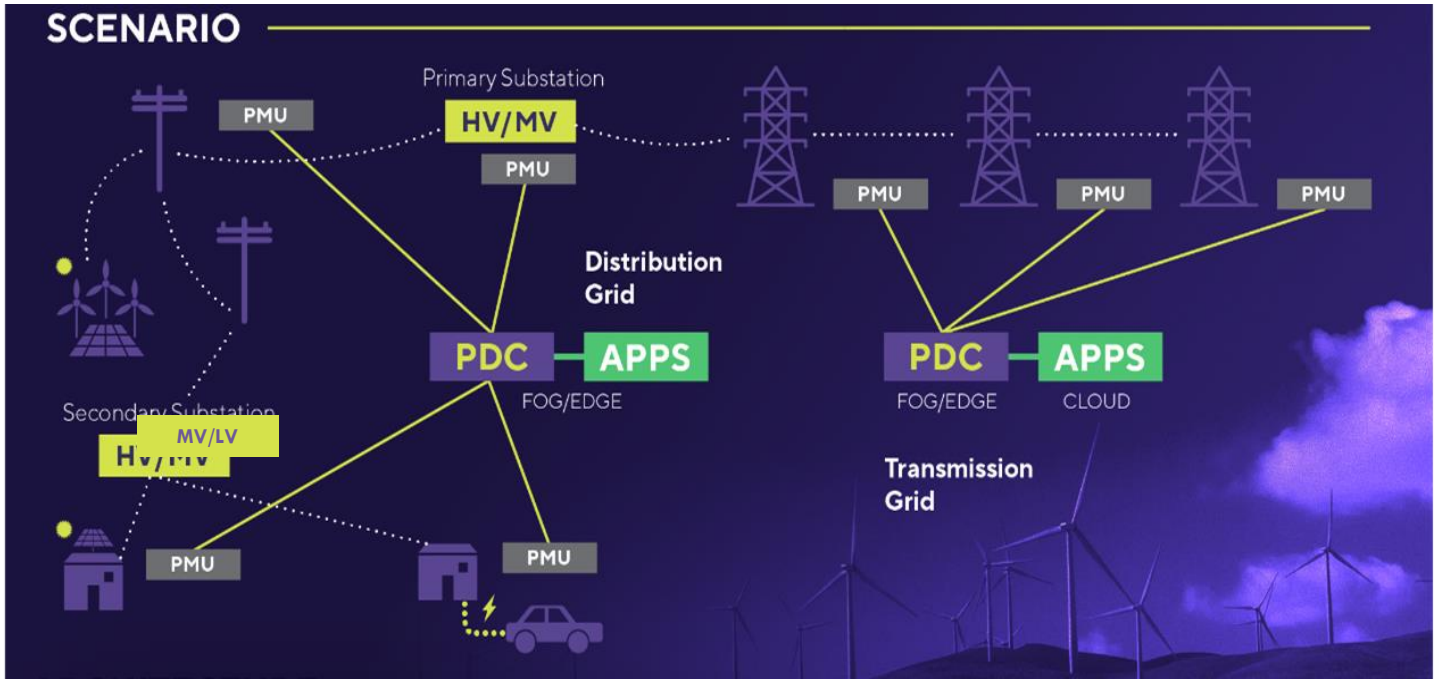
PRPD (Phase Resolved Partial Discharge) patterns for the defect classes collected during laboratory tests: a) Void, b) Delamination, c) Semiconductive, d) Double corona, e) Corona on the active-part side, f) Corona on the ground side. Each graph represents the distribution of partial discharges as a function of the voltage phase and signal amplitude, highlighting the typical characteristics of each defect. The colour indicates the occurrence density of the partial discharges.



Defect distribution by joint: shows the number of primary defects detected in each joint, divided into the three types of defects that cause internal discharges (delamination, semiconductive, void).

Intelligent Power Grid

The Intelligent Power Grid **use case** includes electrical measuring devices called **PMUs** (Phasor Measurement Units), services performing data collection and synchronization called **PDCs** (Phasor Data Concentrators), and **monitoring and control applications**, based on the grid state estimation algorithm. This is the application of Continuum Computing to Power Grid.



CURRENT APPROACH

- Centralized processing using monolithic bare-metal workloads.
- Operator assistance needed to deal with outages.
- Potential cybersecurity issues due to integration of advanced ICT infrastructure with power grid control system

Contatti

Rimani sempre aggiornato con RSE perché

#wemoversearch

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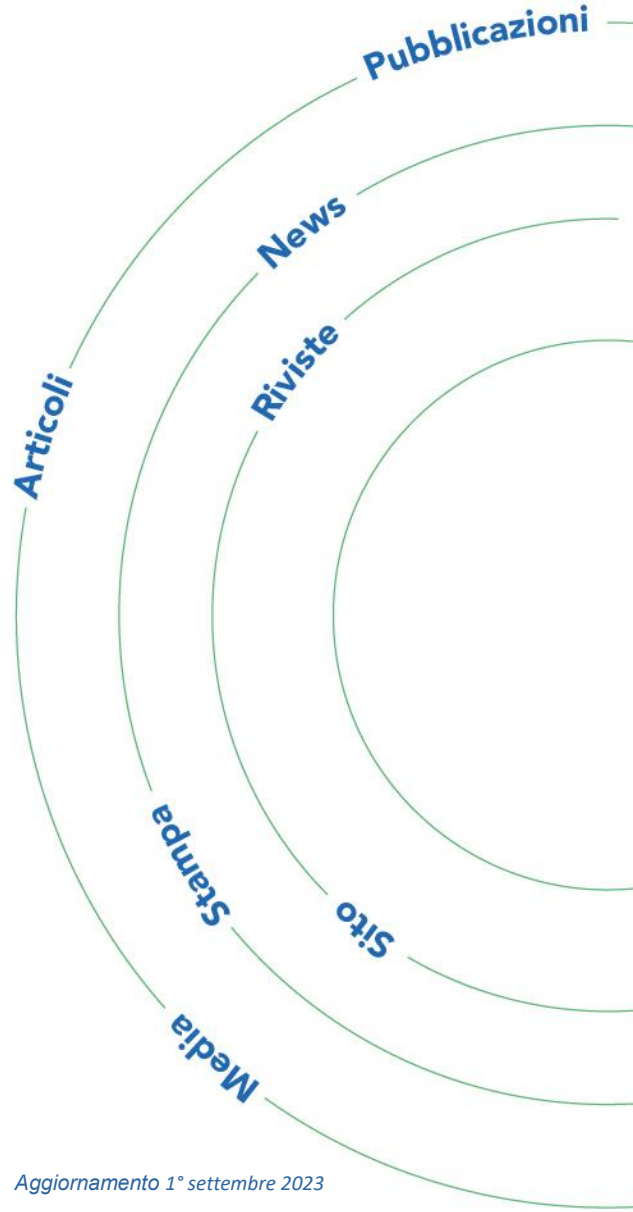

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