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Mission 4 "Education and research"

RISK AND RESILIENCE DAY 2025

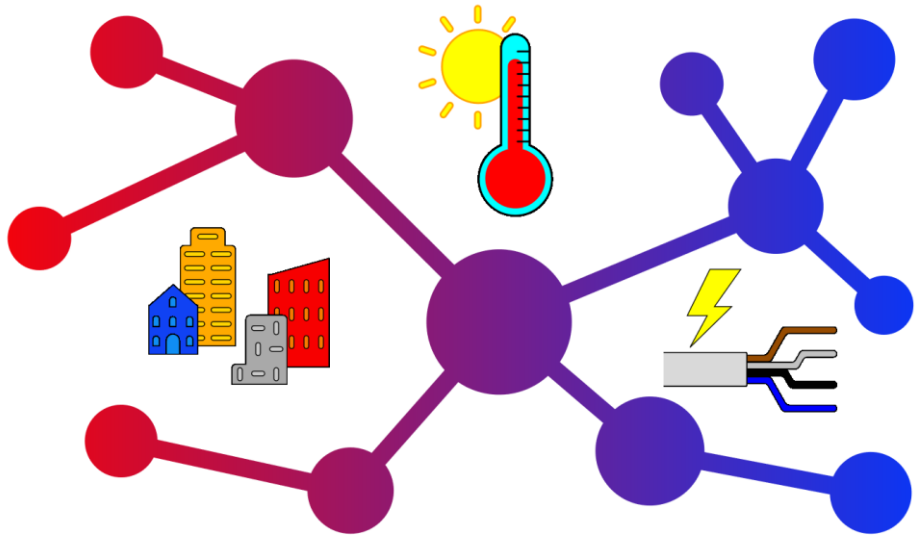
The Exchange, University of Birmingham

Birmingham City Centre, UK

Luigi CALCARA, Andrea MAZZA and Paolo ROCCATO

luigi.calcara@uniroma1.it

March 13, 2025



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Resilience Evaluation by **Ex**perimental and **T**heo**r**etical **A**pproache**s** in Elec**tr**ical Distribut**ion** Systems with Under**g**round Cables

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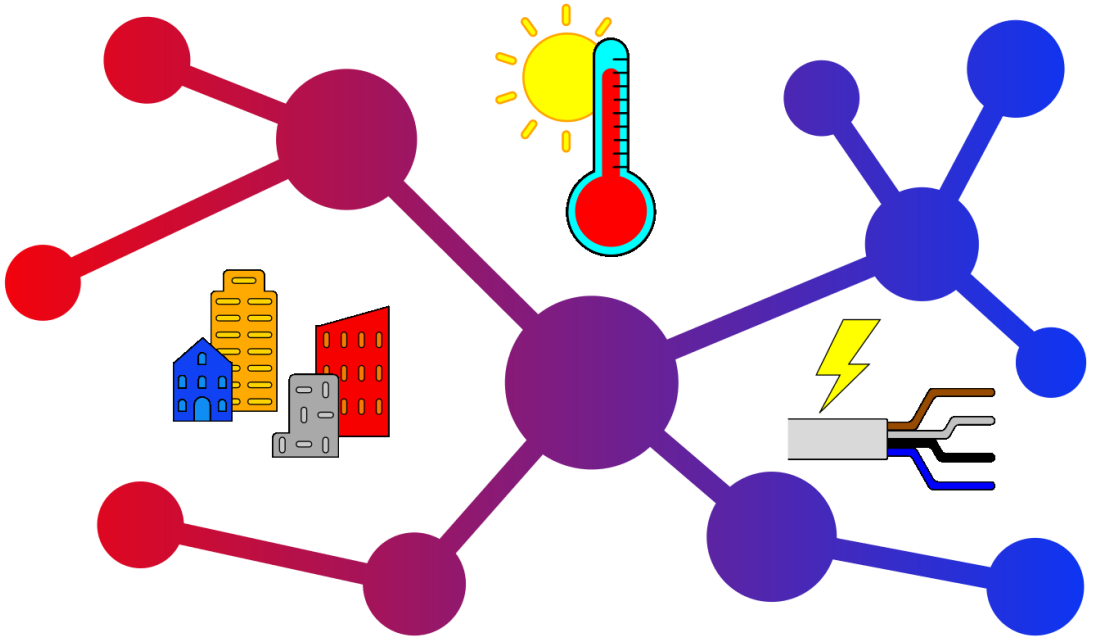
Advances in PRIN2022 "EXTRASTRONG" project



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Project context

- Project goals:
  - Proposing a standard measurement system: by installing it, the distribution system operators (DSOs) may check the system conditions and avoid failures due to HWs
  - Proposing standard laboratory test procedures to evaluate the electrical resilience of cables and joints
  - Creating a test bench replicating several load and HW conditions: manufacturers may verify the compliance of the products with the tests specified above
  - Improving the component models including HW effects, insulation degradation and ampacity modification
- Methodology: combined used of 1) field measurements, 2) laboratory experience, 3) simulation activities

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Why we started this research?

- It is well known that underground **cable joints** are the **weakest point** of the MV network.
- It was found that the number of cable joint failures **increases during the summer period**, due to both higher ambient temperatures and lack of rain (heatwaves).
- The situation is appreciable worsening in the last decade due to:
  - the registered increase of the **summer temperatures**;
  - the progressive **aging of the joints**;
  - being completely unexpected this phenomenon at the time of the original **manufacturing** of the MV cable joints.

FIELD MEASUREMENTS AND TEST BED CALIBRATION

- Field measurement
  - Needed to have a benchmark on soil moisture, irradiance and heat transfer under defined electrical load and temperature of cables and joints
  - Used to calibrate and set up a test bench installed in the laboratory → replication of the measured irradiance (and therefore heat exchange) conditions.
- Test bench: once calibrated, can be used to replicate the typical irradiance and load conditions that occur during HW → both cables and joints will be studied
- **IMPORTANT**: Both the test bench and the measurement system in the field, will be designed paying attention to apply **metrological accuracy**

LAB ACTIVITIES AND COMPONENT MODEL REFINING

- Type of tests:
  - Insulation measurements (e.g., capacitance and tg δ)
  - High voltage withstand tests
- These tests have been carried out both on portions of cables and joints subject to replicated HWs and on portions of cable and joints not subject to HWs → effect of the phenomenon
- The results of the tests will be used to refine the cable mathematical model to determine the ampacity → simulation of the internal behavior of cables and joints subject to synthetic HW conditions

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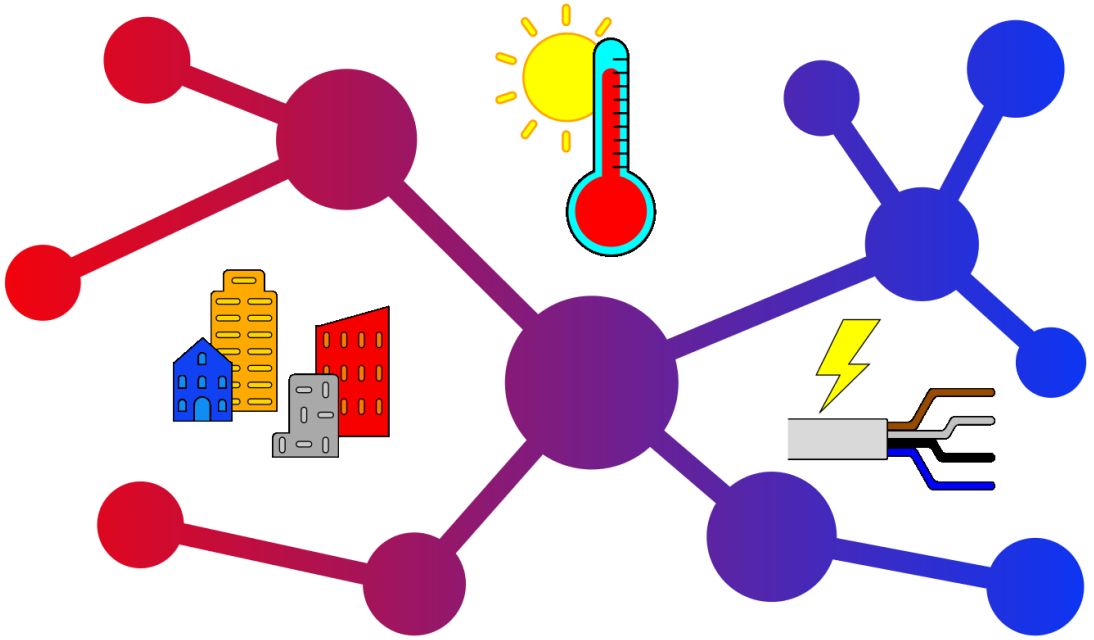
PARTNERS



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POLITECNICO DI TORINO

- The Electrical Energy (ELEN) research group is the National coordinator of EXTRASTRONG
- It has experience on developing simulation algorithms for network calculation, both in normal and faulted conditions
- It had numerous collaborations with DSOs about reliability aspects, predictive maintenance and resilience
- Main contact: Andrea Mazza (andrea.mazza@polito.it)

Politecnico di Torino
electrical energy

UNIVERSITÀ "LA SAPIENZA" - ROMA

- Sapienza University of Rome (SUR) has collaborated over the years with different Italian DSOs
- Since 2014 it started an experimental acquisition in several sites on underground Medium Voltage (MV) cables and relative joints
- It also developed an instrument able to measure the thermal resistivity of the ground
- Main contact: Luigi Calcara (luigi.calcara@uniroma1.it)

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INRIM - TORINO

- INRiM (Istituto Nazionale di Ricerca Metrologica) is a public scientific research body and is the National Metrology Institute of Italy
- It participates to the project with the INRIM-LATFC Laboratorio Alte Tensioni e Forti Correnti (High Voltage and High Power Lab), which is oriented to the research and calibration of testing measuring systems as well as testing for electrical apparatus
- Main contact: Paolo Roccato (p.roccato@inrim.it)

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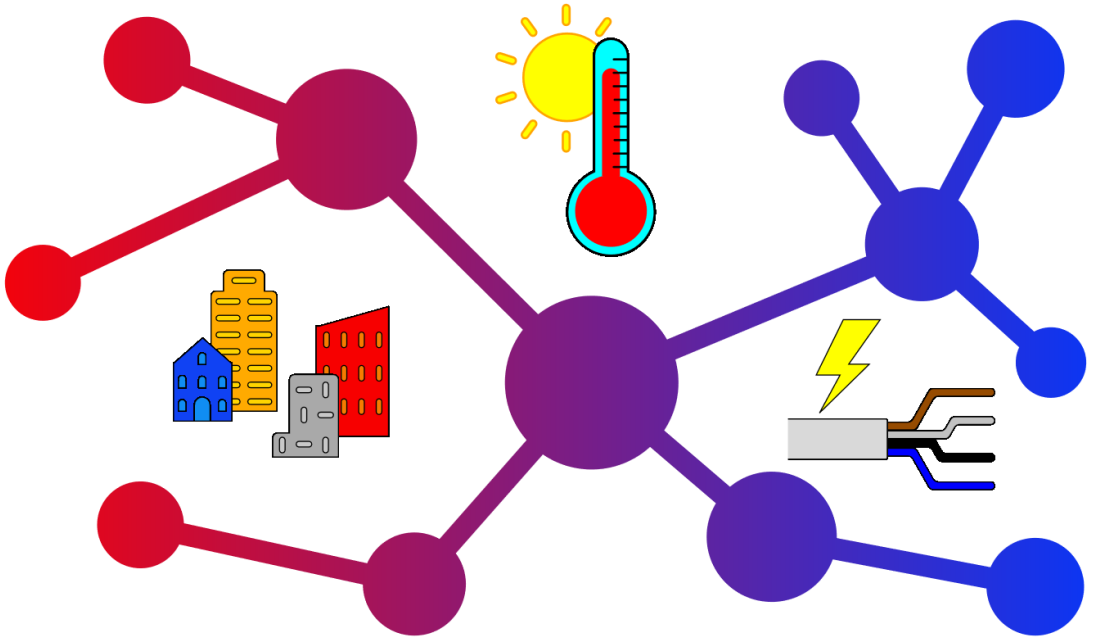
CURRENT ACTIVITIES



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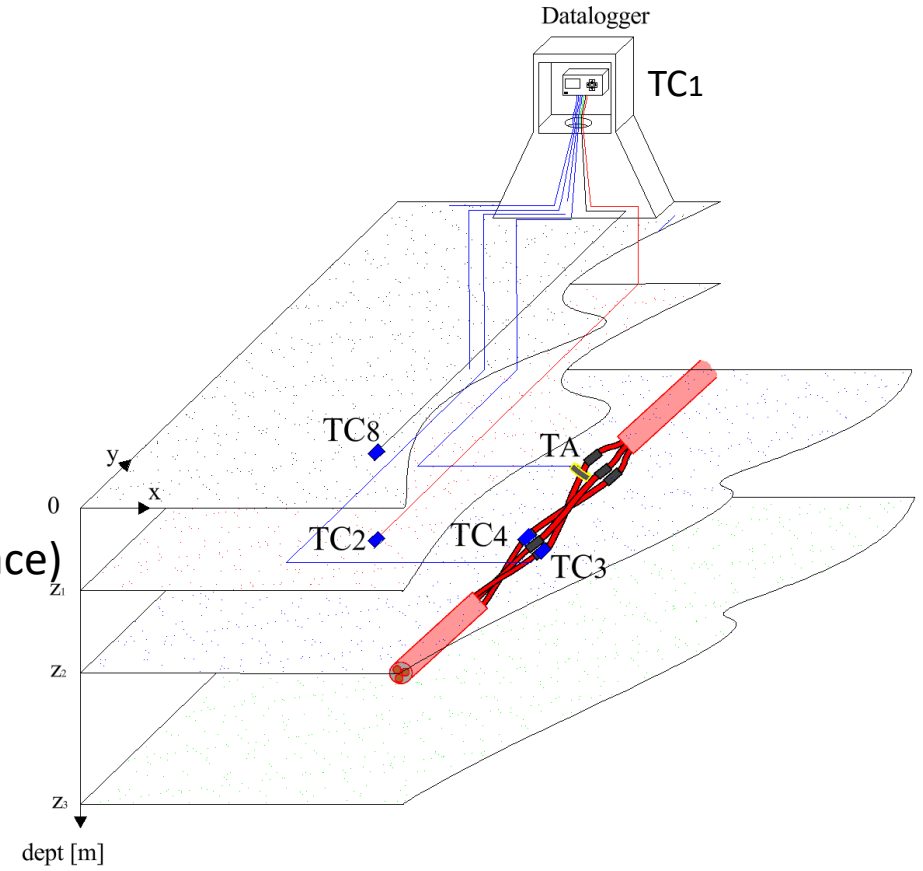
Monitoring temperatures and currents of n. 2 MV underground cables

- Dept of installation: 70 - 80 cm
- Cable “Morgari”: installation with pipe
- Cable “IEN”: installation directly in soil
- Focus on monitored period:
  - July 24 – August 2, 2024
  - August 11 – August 17, 2024



Sensors

- **TC1:** Temperature inside the datalogger cabin
- **TC2:** Temperature of the soil (middle point between cable and soil surface)
- **TC3, TC4:** Temperature of the 2 cable joints of «IEN»
- **TC5, TC6:** Temperature of the cable surface of «Morgari»
- **TC8:** Temperature of the soil surface

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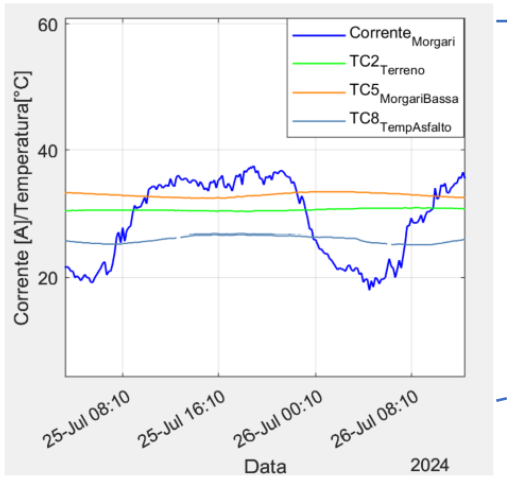
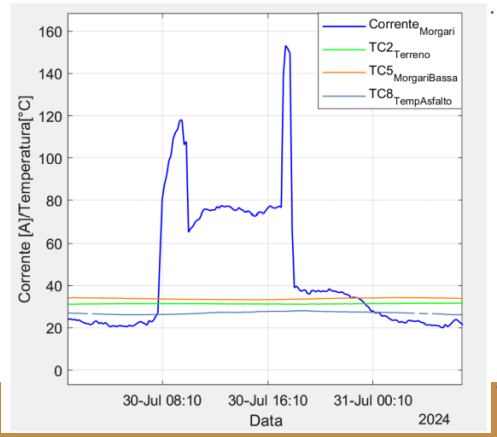
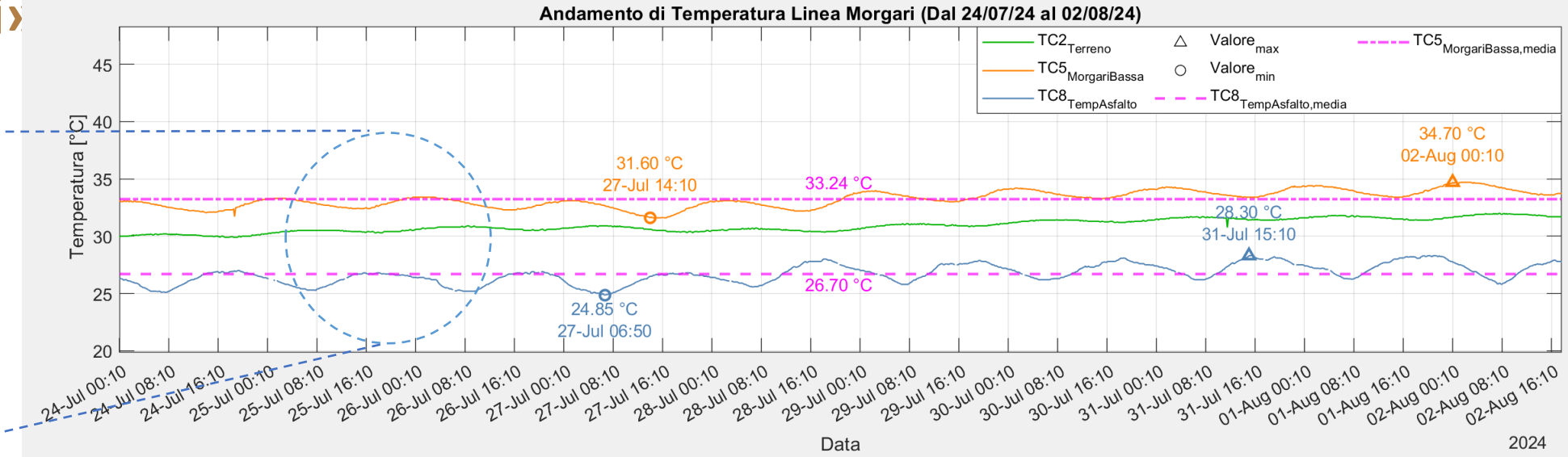
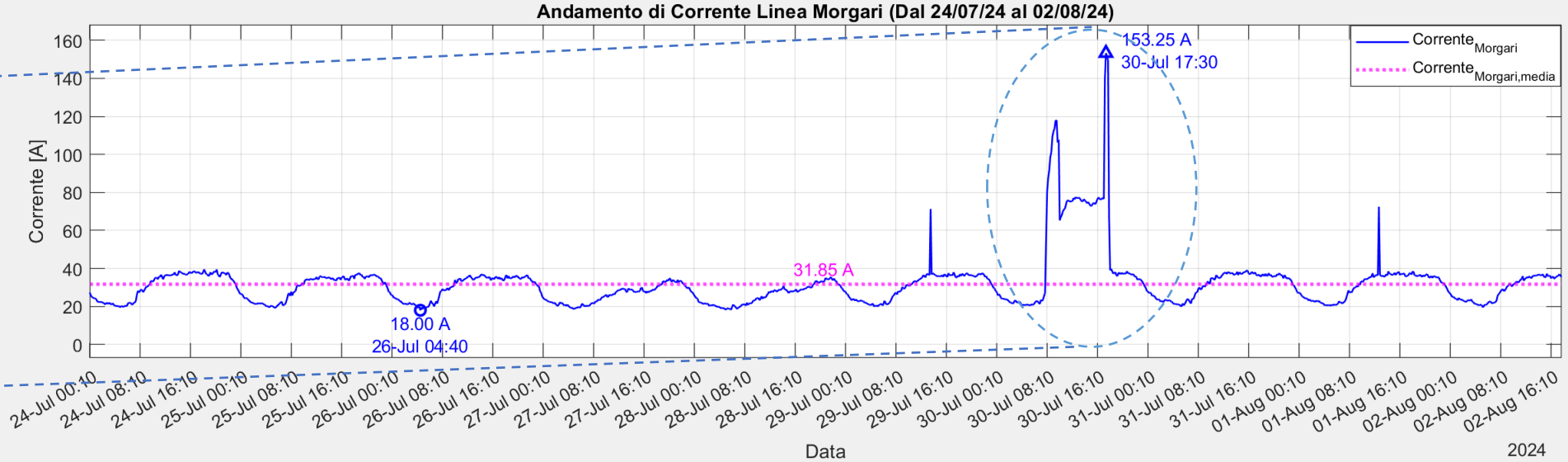
Results: «Morgari»

July 24 – August 2, 2024



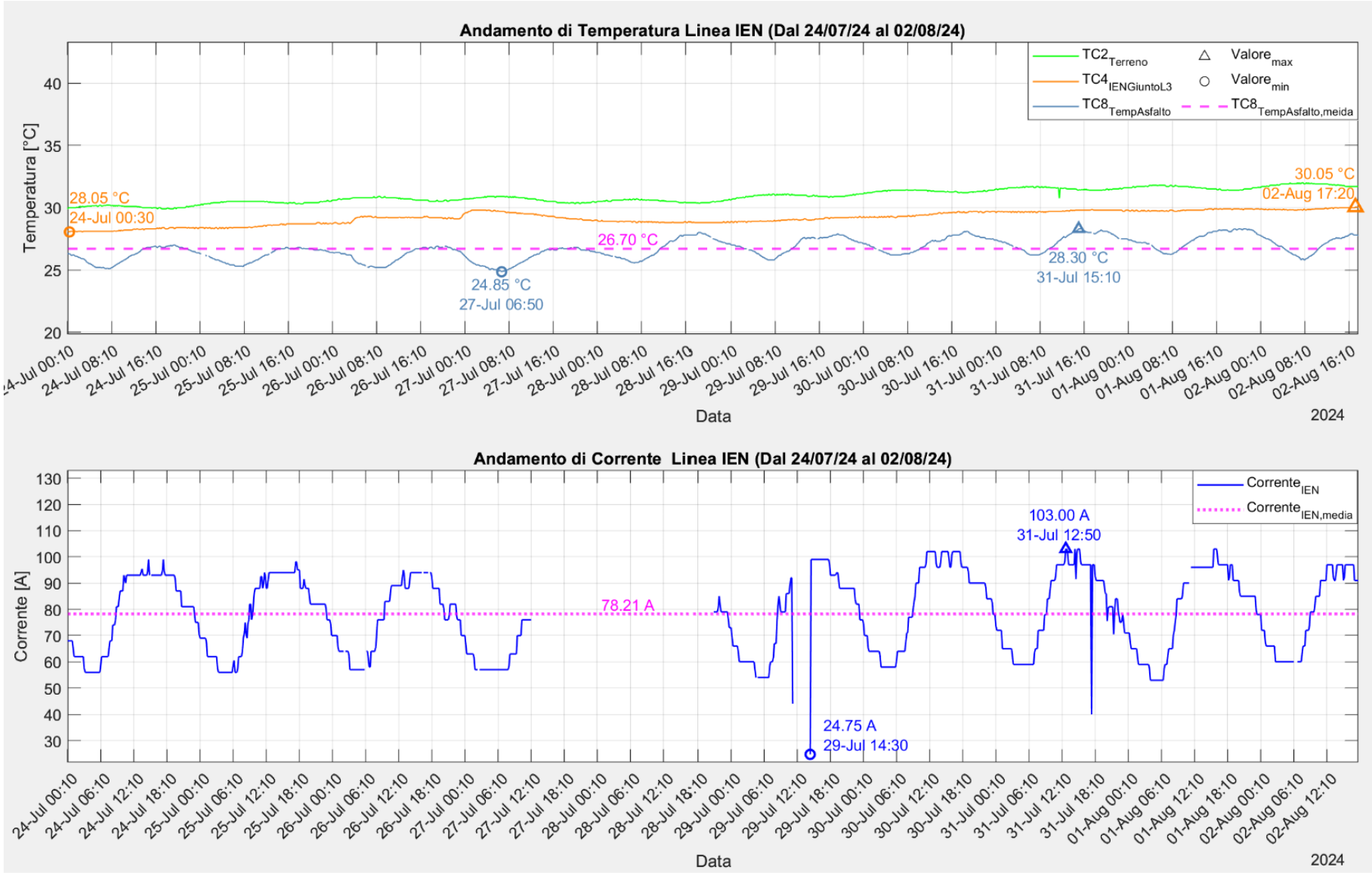






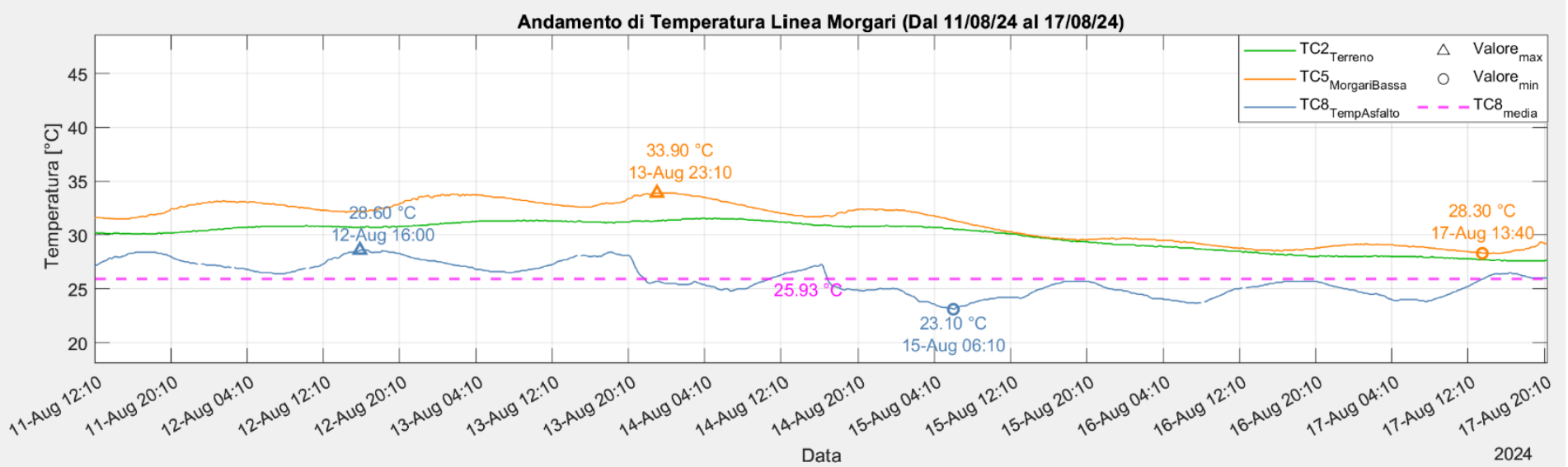
Results: «IEN»

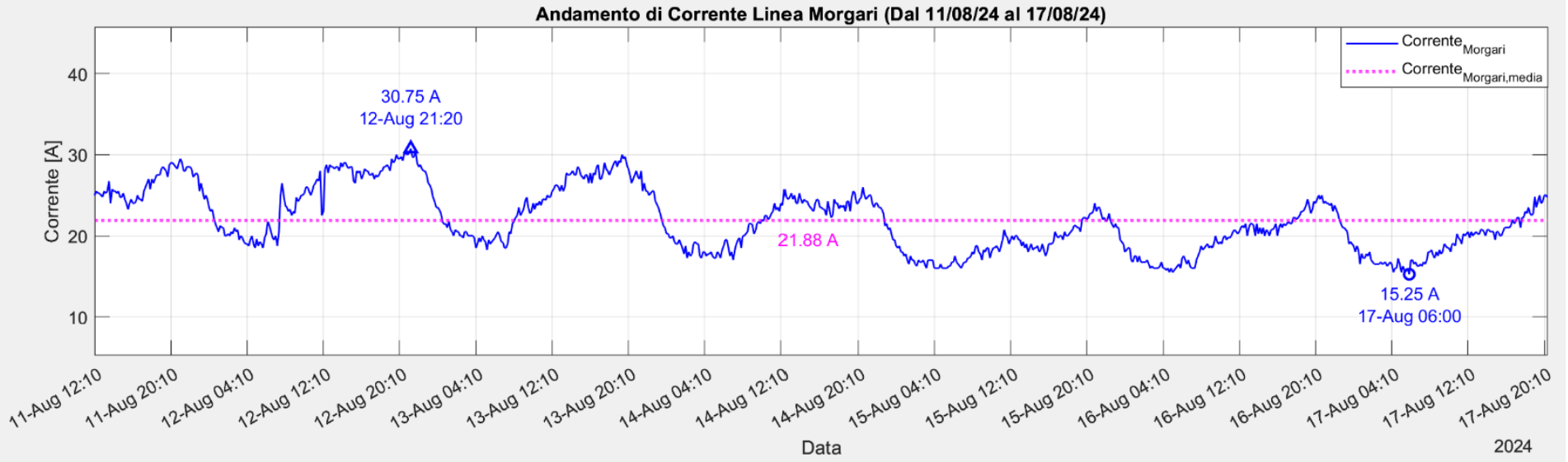
July 24 – August 2, 2024



Results:Morgari

August 11 – August 17, 2024





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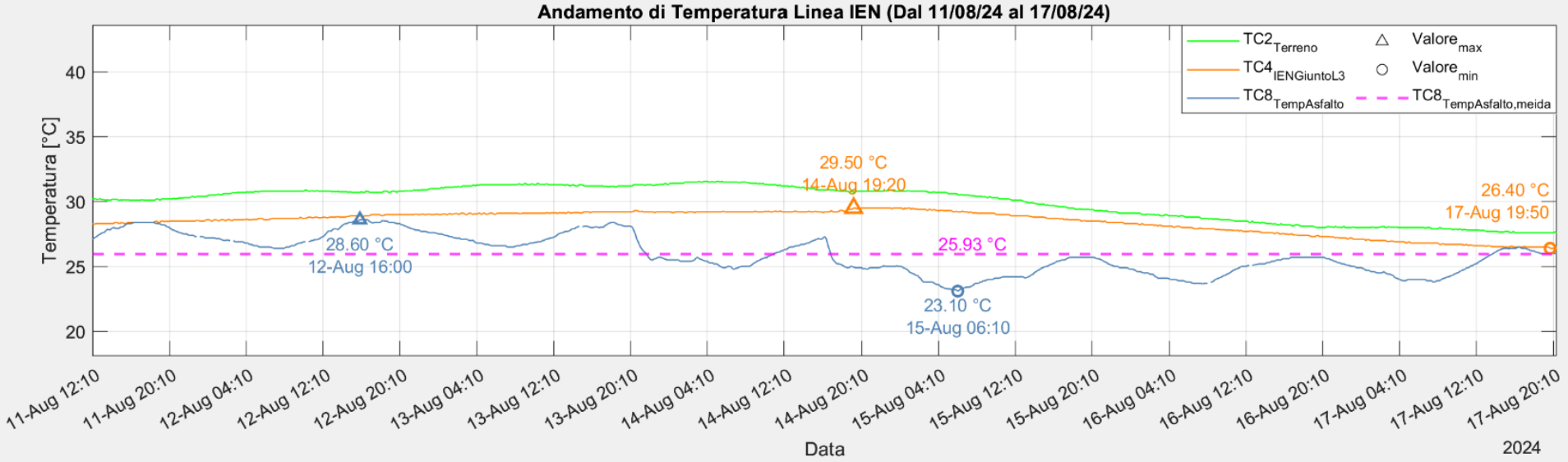
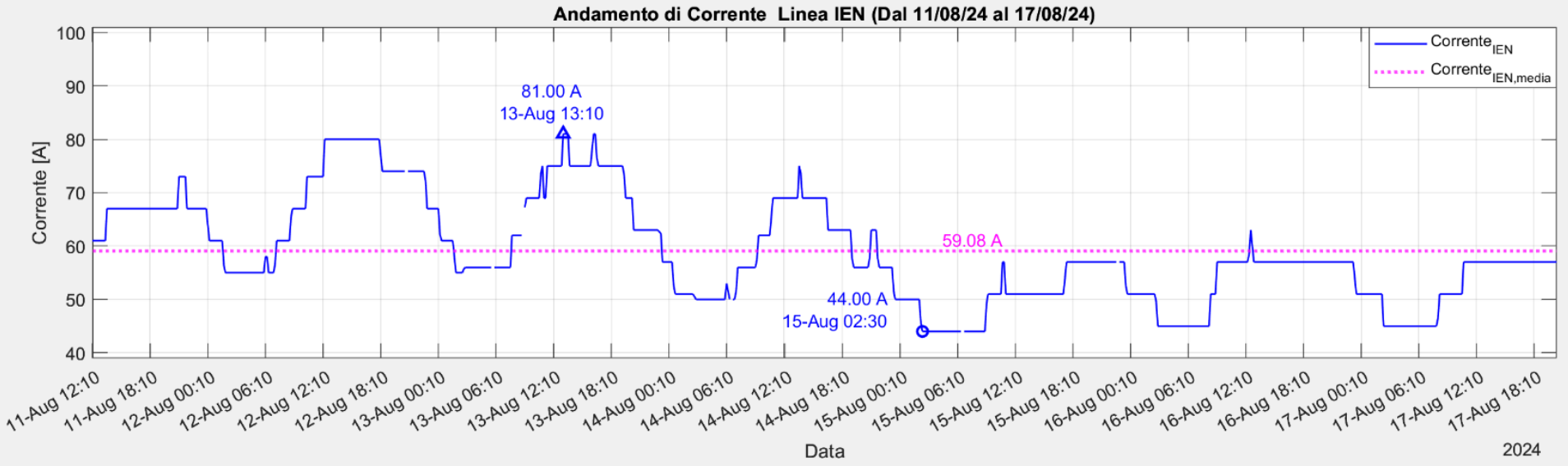
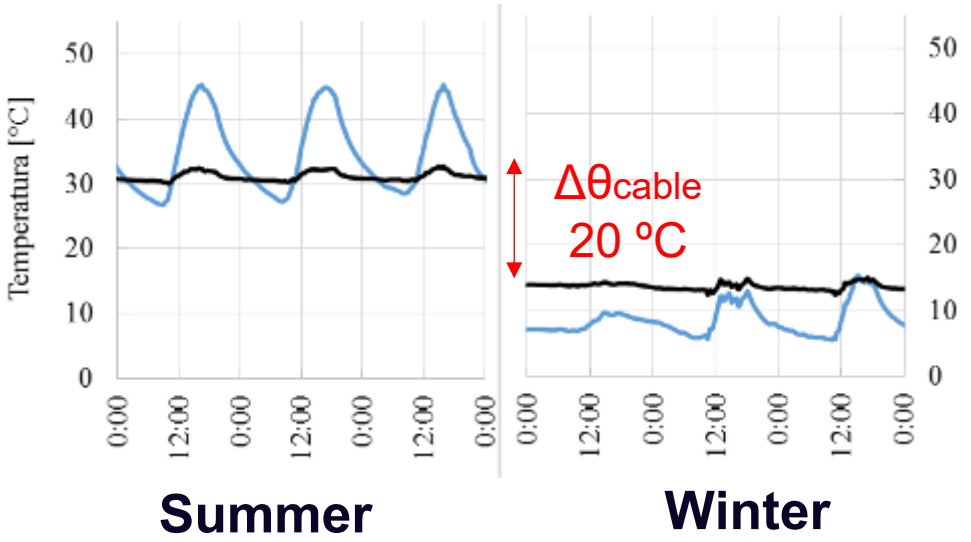
Results: «IEN»

August 11 – August 17, 2024





What we expect from the comparison of summer-winter data (Monitoring in progress)



Ambient temperature

Cable temperature

NEXT ACTIVITIES (some in progress)

- move forward with experimental monitoring
- diagnostic measurements of faulty and non-faulty joints (insulation resistance and contact resistance)
- Analysis of new fault datasets, given by different DSOs in Italy

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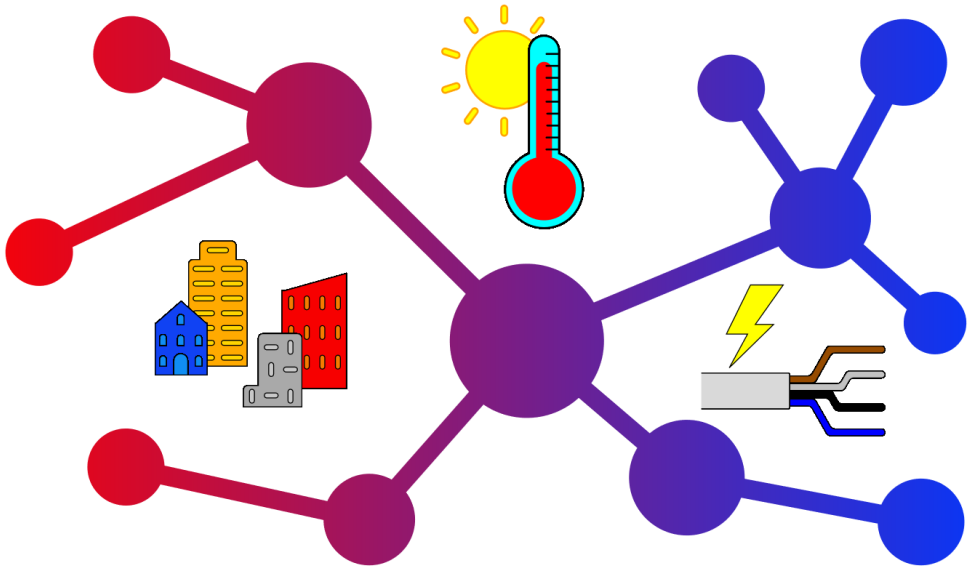

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Contact: luigi.calcara@uniroma1.it