Overview of the activities at Politecnico di Torino in the energy transition framework

Politecnico di Torino

Dipartimento Energia "G.Ferraris"

Andrea MAZZA
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Politecnico di Torino

Politecnico di Torino at Glance

Historical notes

- Born as «Scuola di Applicazione per Ingegneri» in 1859 (L. Casati)
- Renamed in «Regio Politecnico di Torino» in 1906

Campuses

- Firstly at Castello del Valentino
- Historical Engineering Campus: opened in 1958, doubled with «Cittadella Politecnica»

Students

- 30,705 in total
- 5369 foreign students

Ranking

2021 QS World University Ranking Electrical & Electronic Engineering #43 worldwide

Research Topics

Energy system modeling and security

Physical, cyber & system security for electricity grids

Data analytics for power system analysis

Energy system operation & network integration

Electricity markets, incentives, regulation & pricing

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H2020 RESERVE

- Focused on **enabling up to 100% penetration of renewable with low inertia** (i.e., solar and wind-based power plant) by developing **new approaches for ancillary service** provision and using the pan-European simulation platform

- **Activities**
  - Definition of future energy scenarios
  - Development and implementation of the **pan-EU simulation platform based on Real time simulation**
  - Development of **innovative approaches for frequency and voltage regulation**
  - Studying the **provision of the virtual inertia** in low-inertia electricity systems

GLOBAL ENERGY INTERCONNECTIONS

- Two industrial projects from the Global Energy Interconnection Research Institute Europe (Berlin) of the State Grid Corporation of China to study the **technical-economical aspects of the global electricity infrastructure**s and further focusing on the compatibility with the EU transmission networks
- **Activities**
  - A **global interconnected model** with 21 geographic areas
  - **Needed infrastructures for 2030 and 2050 of GEI** for global electricity trading
  - **Best interconnecting schemes** under the EU planning of the transmission networks
  - **Identified bottlenecks of the EU transmission** network for accomodating large electricity exchanges under unified global electricity markets

ELECTRIFY ITALY

- Discuss **electrification as a major option for implementing energy transition in Italy**, starting from the present status of electrification and building a forward-looking vision of possible scenarios at 2022, 2030 and 2050.
- **Activities**
  - **Sectorial models** (industry, building, transport) for study the potential penetration of electrification
  - Generation scenarios with focus on **RES penetration** and **storage** in Italy
  - **Quantitative KPIs** for assessing the benefits of electrification (47 KPIs in 4 dimensions physical, economic, environment, social)

H2020 STORE&GO

- The project STORE&GO focused on the use of **green methane produced by Power-to-Gas** technology as means for the cross-sector energy transition
- **Activities**
  - Study the **impact of the PtG on the electrical system** by investigating the most relevant applicaitons
  - Developing case studies for addressing the **impact of PtG on the operation of the electrical system**
  - Developing case studied for addressing the **impact of PtG on the electrical system planning**

STORE&GO

RESILIENCE STUDIES

- This industrial project aimed to evaluate the impact of «**low probability-high impact**» events on the electricity network, with particular focus on the consequences of **heat wave on urban distribution grids**
- **Activities**
  - Study of the **weather conditions** for evaluating the definition of heat wave occurrence, by applying **data analytics techniques**
  - **Correlation** of the **weather** conditions with the **faults** through data analytics techniques
  - **Support the local DSO** during the preparation of the documentation regarding the CBA requested by the Italian Authority

ENEMED

- Annual survey on Energy & Mediterranean through the development of **ad hoc science-based methodologies** able to dynamically track along time the **evolution of the energy system** in the Mediterranean area, assessing the impacts on different dimensions of this evolution
- **Activities**
  - Development of a methodology/tool that could **accompany the energy transition in the Mediterranean region** (with a special focus on Italy and the energy interconnections with European and non-European areas)
  - Implementing a **multi-dimensional quantitative analysis** through a set of proper KPIs

MODEL-BASED APPROACHES FOR BIDDING ZONE

- Definition and implementation of methodologies model-based to identify **alternative zonal structures** with respect to the current bidding zones
- **Activities**
  - **Clustering analysis** with different methods customized to take into account the **network topology constraints**
  - Performance assessment of the resulting bidding zones by considering general-purpose metrics used for clustering validity assessment, together with dedicated metrics that incorporate the nature of the problem (including market power aspect)
  - Testing of the clustering algorithms on the results of the real networks (**Locational Marginal Prices** and **Power Transfer Distribution Factors**)

Global Real Time Simulation Lab

Global Reat Time Simulation Lab @Energy Center Lab

- The G-RTS lab, is an **internationally interconnected** lab of real-time simulation
- It is active in studying the **role of electricity in energy transition**, as well as new smart grids and super grids for electricity
- In RTS, the amount of time required to compute all equations/functions is exactly equal to the duration of the time-step (**1 second in the real world means 1 second in the simulation**)
- RTS is a virtual environment where **new control strategies (SW) or technologies (HW) can be tested ex-ante**, before implementing in the real world
- The Electrical Energy Group (ElEn@polito.it) at the Energy Department (DENERG) of Politecnico di Torino started developing and designing the real time simulation facilities in the **last 7 years**
- ElEn **actively contributed to design the first RT multi-site co-simulation** within Europe, with USA and China

ERIC-LAB CONCEPT

- **European Real-time Integrated Co-Simulation Lab**
  - A practical implementation of a **federation of laboratories** located in different European member states, and at the premises of the Joint Research Center of the European Commission
  - Enabling a **cost-effective sharing of hardware and software** facilities with special focus on real-time simulation
  - Demonstration Setup Parties: **EIEN@Politecnico di Torino** (Italy), **RWTH-Aachen University** (Germany), **JRC-Petten** (Netherlands), **JRC-Ispra** (Italy)
- **<u>October 29th 2015</u>: first co-simulation** in the occasion of the **inauguration the European Interoperability Centre for Electric Vehicles and Smart Grids**

JOINT RESEARCH CENTRE

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E.ON Energy Research Center

RWTH AACHEN UNIVERSITY

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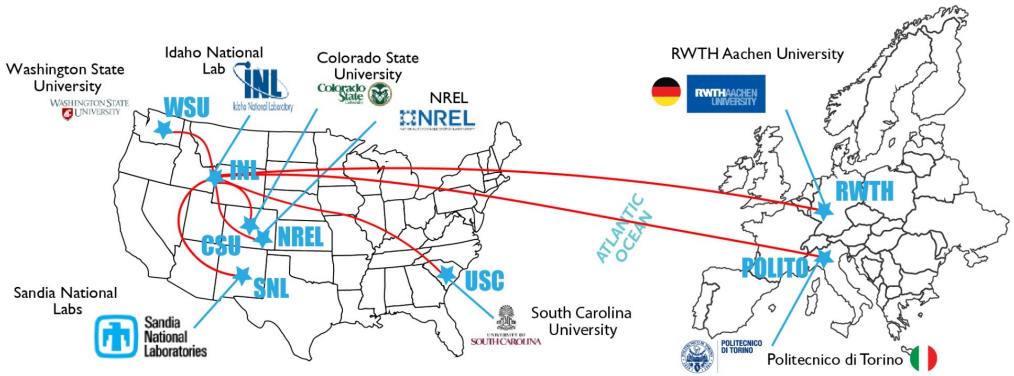
GLOBAL RT-SUPER LAB

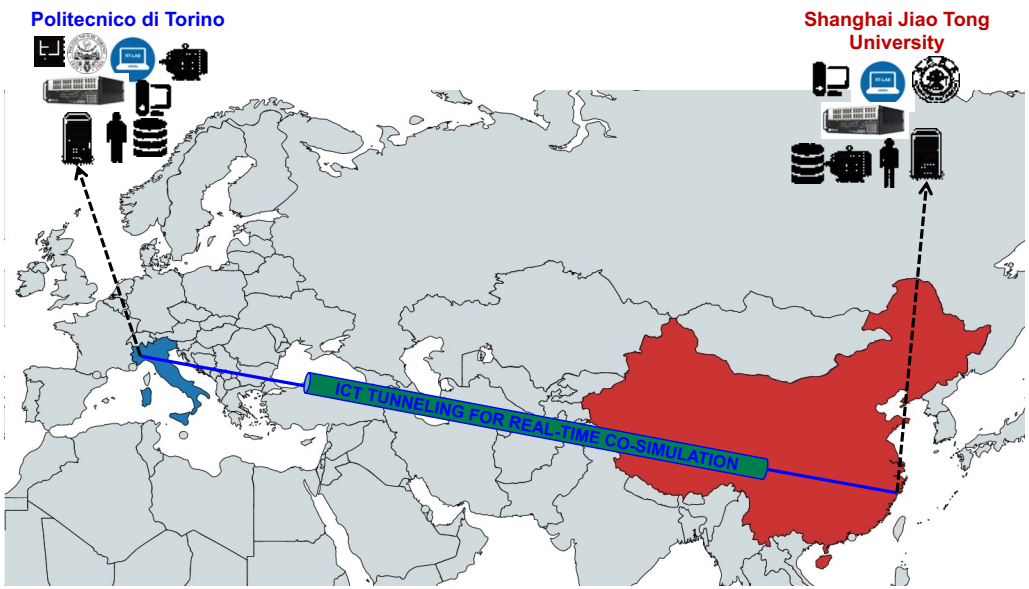
- **Global RT-Super lab demo** aimed to conceptually and technically prove feasibility of multi-site **co-simulation across the Atlantic Ocean**



- It demonstrate potential and advantages of a holistic research approach enabled by a “laboratory in a network” through **interconnecting EU-US laboratories** and collaboration between research institutions

JOINT RESEARCH CENTRE ON ENERGY TRANSITION, MODELING AND SIMULATION

- The lab is focused on actions on clean electricity towards **energy transition**
- It brings up **Belt and Road Initiative** (BRI) in global interconnection
- It is **a brand new concept** to make people from **distant locations** and **different expertise** work together
- It fosters **common understanding** based on a **two-node** interconnected lab facilities in **Torino**, Italy and **Shanghai**, China



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ENSiEL National Energy Transition Real-Time Lab

- The research group actively contributed in the realisation of **ENET-RT Lab**
- The lab was presented on **April, 11th 2022** with a public webinar where a remote cosimulation of a electrical system with high share of non-dispatchable Renewable Energy Sources was developed
- The first «**Italian RT node**» has been established

Un laboratorio nazionale di co-simulazione Real-Time multi-sito per supportare la transizione energetica

ENET-RTLab

ENSiEL National Energy Transition Real-Time Lab

EQUIPMENT @G-RTS-Lab

- **Both RTDS and Opal technologies are available**,
- **Power amplifiers** (switching and linear) in the range **15-60 kVA**
- **Rotating** DC, induction and synchronous **machines**
- Advanced **automatic measurement systems**

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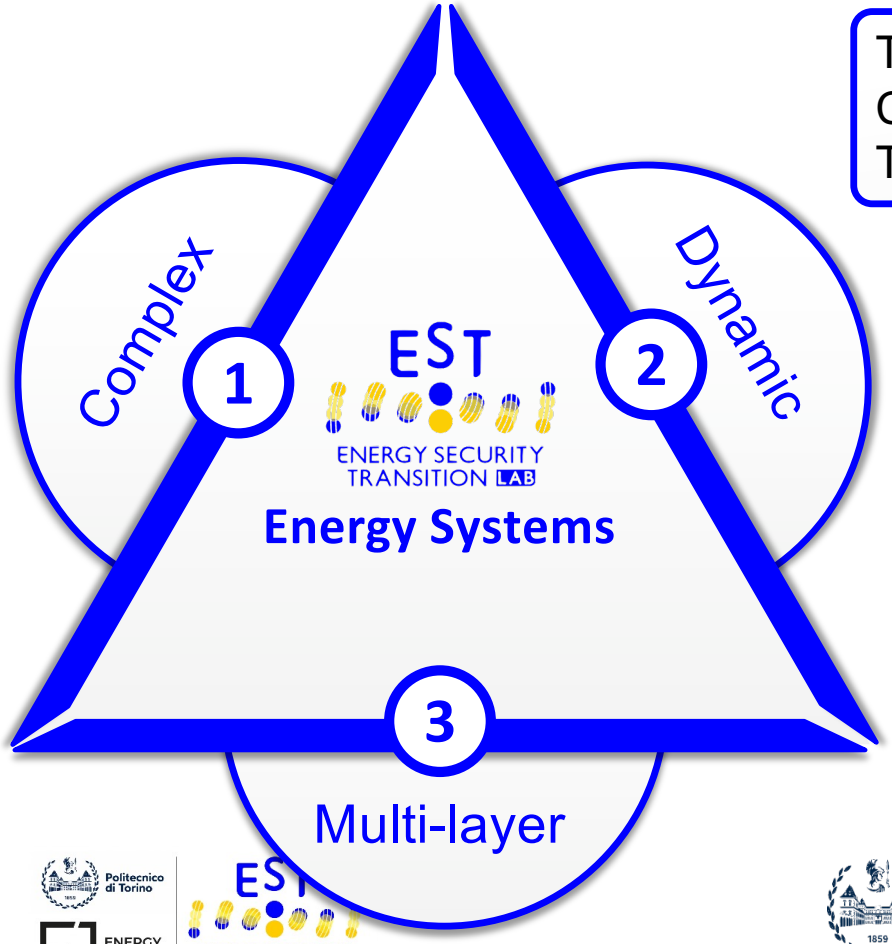
Energy Security and Transition Lab

THE VISION OF ENERGY



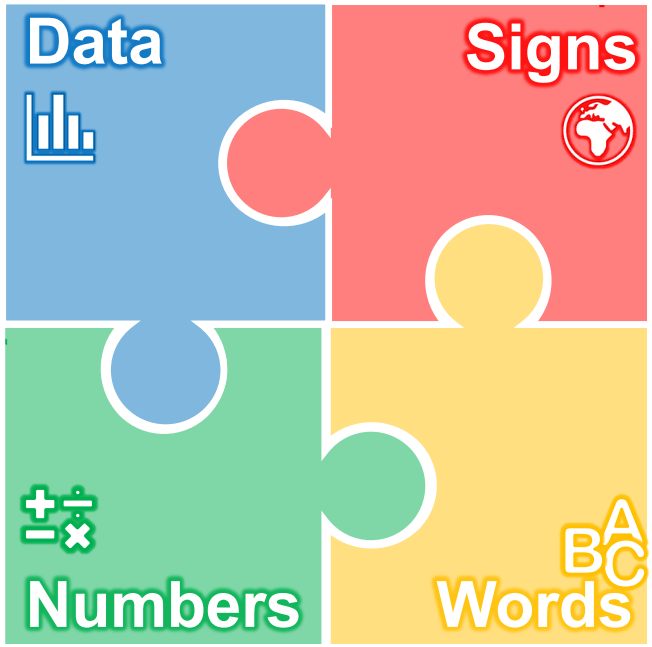
The Energy Security Transition (**EST**) Lab @ Energy Center is one of the reference poles of Politecnico di Torino, w.r.t. **energy transition** and **security**

Need for an **HOLISTIC** vision

- **Science-based** support to the policy **decision-making** process (public or private)
- "**Instance-based**" approach: EST does not autonomously hypothesize problems, but answers to real instances from external stakeholders (public bodies, energy companies, financial institutions, universities, ...) through a vision and "technologies" able to generate impact on society

THE PILLARS OF THE VISION

- **Numerical Datasets & Database**
  - Numerical information on the physical, technical and economic dimensions of energy systems, obtained by crawlers from datasets and processed for data analytics purposes, and stored in databases that ensure data intelligence

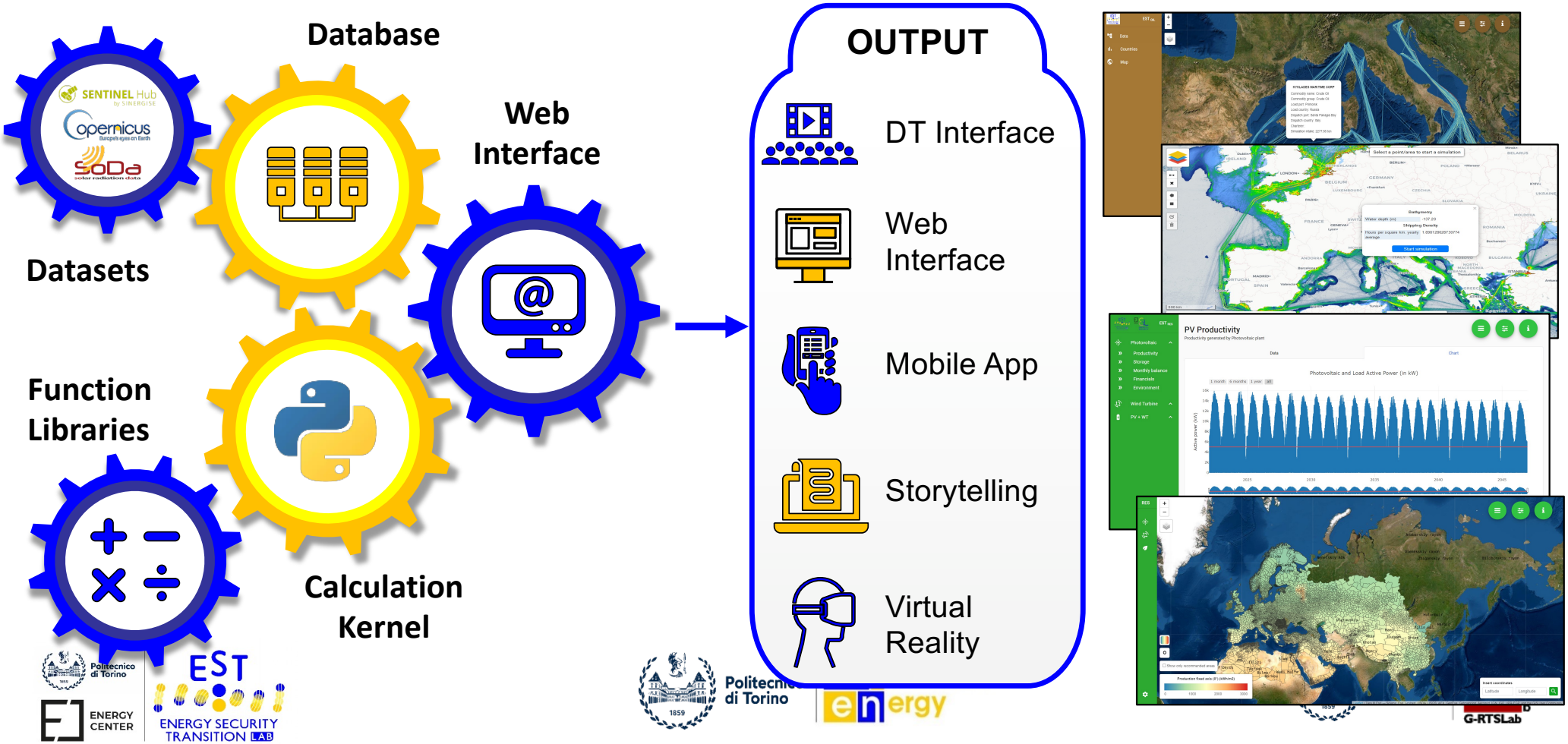


- **Interactive maps**
- **Satellite images**
  - Geomatic representations (maps and satellite images) that allow to take into account the spatial and geographical dimension of energy systems

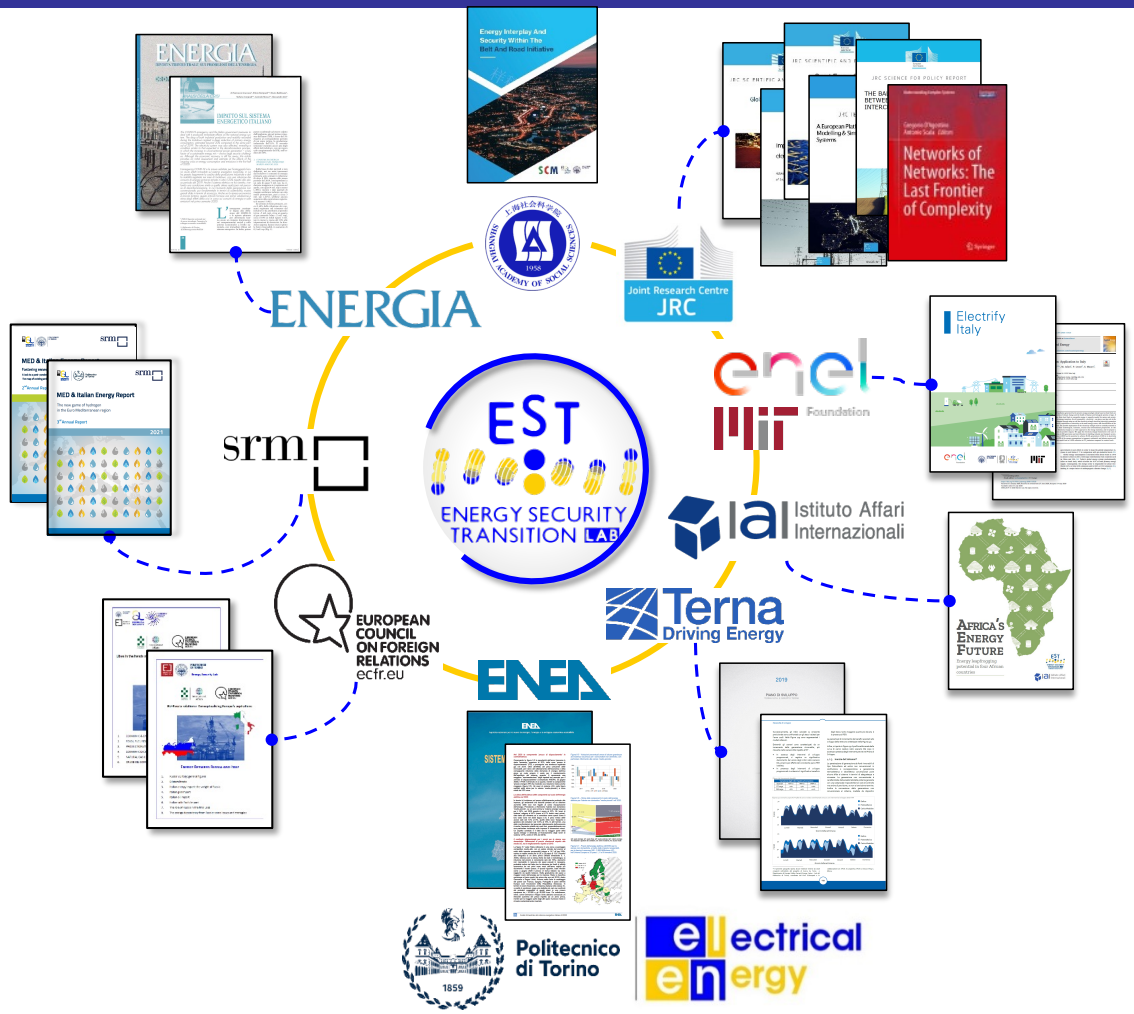
- **Mathematical methods & models**
  - Methods and models (simulation, optimization, contingency management, risk, environmental and economic impacts, etc.) that use the information stored in the databases

- **Quantification of qualitative aspects**
  - Qualitative aspects (e.g. geopolitical and social) which, although not directly measurable, can be associated with numerical values and included in the analysis

THE SYSTEM OF WEB PLATFORMS



SOME COLLABORATIONS AND OUTPUTS



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