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Instituto Superior Técnico
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Digital Twin Evolution: Harmonizing AI for Resilient and Carbon Neutral Power System

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The energy transition calls for a fundamental transformation in the integration and management of Distributed Energy Resources (DERs), focusing on the coordinated operation of flexible DERs alongside short-term and long-term energy storage systems. The rapid growth of non-programmable renewable sources, when effectively combined with established technologies such as hydroelectric storage and emerging solutions including Small Modular Reactors (SMRs), has the potential to significantly enhance the stability, resilience, and reliability of modern power systems. Despite this potential, several structural barriers continue to limit the full exploitation of system flexibility. These include insufficient interoperability among heterogeneous technologies, the absence of shared and scalable digital platforms, regulatory uncertainty in flexibility and ancillary service markets, and the limited engagement of end-users and aggregated DERs. Collectively, these challenges limit the development of a more sustainable, dynamic, and resilient system. In this context, the global shift toward decentralized and decarbonized energy systems has positioned Digital Twins (DTs) as a critical enabling technology for utilities and grid operators. While early implementations of DTs were largely confined to static monitoring and visualization, recent advances have expanded their role toward intelligent, dynamic, and predictive system representations. The current state of the art lies in the integration of Digital Twins with Generative Artificial Intelligence, high-fidelity physics-based models, and edge-to-cloud computing architectures. This Special Session aims to present advanced research contributions and real-world case studies that highlight the evolution of Digital Twins as a key tool for managing the increasing complexity of modern power grids. Particular attention is given to applications involving large-scale integration of electric vehicles, distributed energy storage systems, and highly volatile renewable energy sources, with the objective of enhancing grid flexibility, resilience, and decarbonization. Key Topics of Interest Lisbon, Portugal Centro de Congressos Instituto Superior Técnico University of Lisboa From 29 June to 02 July 2026

We invite original research articles, comprehensive reviews, and industrial case studies addressing, but not limited to, the following topics:

- **AI-Enhanced Predictive Maintenance and Asset Management for power system components and DERs.**
- **Real-Time Grid Monitoring and Resilience Enhancement under high penetration of renewable and distributed generation**
- **Digital Twins for Sector Coupling, enabling intelligent coordination of active flexibility from distributed energy resources, short- and long-term energy storage, hydroelectric assets, and emerging technologies**
- **Virtual Commissioning and Integration with Building Information Modeling (BIM) for power system planning, validation, and operation**
- **Human–Machine Collaboration and Decision Support Systems for grid operators and energy stakeholders**
- **Optimization Frameworks Integrated with Digital Twins for Renewable Energy Systems, focusing on multi-objective, real-time, and AI-assisted optimization of planning, operation, and control of renewable-rich and distributed energy systems**
- **Scalable Edge-to-Cloud Architectures for real-time Digital Twin deployment and data-driven grid management**
- **Cyber-Physical Security and Trustworthy Digital Twins for resilient and secure energy infrastructures**

TARGET AUDIENCE

This Special Session is intended for a broad yet focused audience, including academic researchers and graduate students working in power systems, energy informatics, and applied artificial intelligence; power system engineers and Transmission and distribution system operators involved in the planning, operation, and modernization of electricity networks; data scientists and software engineers developing digital platforms for energy system analytics and control. In addition, the session addresses policymakers, regulators, and energy market designers who are engaged in the digital transformation of national and regional energy infrastructures, particularly those concerned with flexibility markets, grid resilience, and decarbonization strategies. Industrial stakeholders, technology providers, and utility companies seeking advanced Digital Twin–based solutions for resilient and carbon-neutral power systems will also find this session highly relevant.