

SPECIAL SESSION 1 (SS1)

ENERGY STORAGE SYSTEMS: ADVANCED MODELING, SIMULATION, POWER CONVERSION, CONTROL, AND DIAGNOSTICS

CO-CHAIRS

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SPECIAL SESSION THEME

Energy Storage Systems (ESSs) are crucial for applications in e-mobility, robotics, drones, renewable energy, and micro/nanogrids. ESSs are complex and costly, integrating Battery Management Systems (BMSs) for optimal operation and AC/DC or DC/DC converters to process power flow. One of the main research challenges in ESSs is the identification of battery models that reach a balance between accuracy and ease of implementation in real control systems. Such models are often used in online algorithms for diagnostics and estimation of State of Charge/Health (SOC/SOH) and play a pivotal role in understanding and predicting the behavior of ESSs at short, medium, and long timescales. Furthermore, battery models are fundamental to devise suitable control systems for BMSs and power converters to ensure adequate ESS performance in terms of efficiency, autonomy, reliability, and safety.

This special session is aimed at presenting the latest advances and developments in ESS technologies of different kind (batteries, supercapacitors, hydrogen storage, flywheels, etc.) with particular reference to advanced modeling, accurate simulation, high-performance power electronic converters, high-performance linear and nonlinear control systems, accurate SOC/SOH estimation methods, and advanced ESS diagnostics.

TOPICS OF INTEREST

- Advanced electrical and thermal models for batteries, supercapacitors, and ESSs and related state estimation and parameter identification techniques
- Aging prediction for batteries based on data-driven models or physical electrochemical models
- Battery Management Systems (BMS)
- High-performance power electronic converters for ESSs

- Advanced control techniques for BMSs and power converters to ensure high-performance ESS operation
- Hardware in the Loop simulation and emulation of ESSs
- Hybrid generation/storage and Long Duration Energy Storage (LDES) systems
- Supercapacitor and hybrid supercapacitor modeling
- Electrolyzers supply and control, and hydrogen storage technologies
- Applications of flywheel ESSs
- Advanced algorithms and sensors for diagnostics and SOC/SOH estimation
- Electrochemical impedance spectroscopy for batteries and ESSs.

SPECIAL SESSION 2 (SS2)

PERFORMANCE, AGEING, AND DIAGNOSTICS OF HYDROGEN SYSTEMS

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SPECIAL SESSION THEME

Hydrogen production and utilization play a key role among tomorrow's sustainable energy solutions, actively contributing to the transition toward low-carbon energy systems.

This session focuses on the performance, diagnostics, and ageing of hydrogen systems, encompassing the entire powertrain chain, from hydrogen production and storage to its conversion into mechanical or electrical energy. A deep understanding of the behavior, degradation mechanisms, and efficiency of the various hydrogen components (fuel cells, electrolyzers, storage materials, and hybrid propulsion systems) is essential to ensure the durability, safety, and competitiveness of these technologies.

We welcome contributions that explore both experimental and modeling approaches for system diagnostics, lifetime prediction, and performance optimization under real operating conditions. By bridging fundamental studies and applied research, this session aims to provide a comprehensive perspective on how hydrogen technologies can meet the reliability and durability requirements of future energy systems.

TOPICS OF INTEREST

- Hydrogen systems (fuel cells, electrolyzers, storage materials, etc.)
- Modeling and simulation of hydrogen systems
- Ageing mechanisms and durability of the components
- Diagnostic tools and fault detection
- Influence of auxiliaries on performance and ageing
- Integration of hydrogen technologies.

SPECIAL SESSION 3 (SS3)

AI-DRIVEN METHODS AND SOLUTIONS FOR INTELLIGENT ENERGY SYSTEMS

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SPECIAL SESSION THEME

The accelerating digitalization and decentralization of modern power systems are reshaping how electricity networks are planned, operated, and optimized. Artificial Intelligence (AI) has emerged as a transformative enabler, driving new paradigms for achieving efficiency, resilience, and sustainability in energy systems.

This special session brings together cutting-edge research and practical innovations that leverage AI, data analytics, and machine learning to enable the next generation of intelligent power and energy systems. Contributions are invited that span from algorithmic developments to real-world deployments, addressing the technical, operational, and economic challenges of modern electricity networks.

Recent advances in deep learning, reinforcement learning, and physics-informed, data-driven modeling enable predictive maintenance, adaptive control, state estimation, and self-healing capabilities. AI-based optimization and decision-making are also accelerating the secure and efficient integration of distributed energy resources (DERs), electric mobility, and active consumer participation.

TOPICS OF INTEREST

- AI and machine learning for network optimization, control, and forecasting
- Deep learning and hybrid models for DER and renewable integration
- AI for resilience, restoration, and self-healing distribution grids
- Data-enhanced state estimation and anomaly detection
- Transactive energy systems and intelligent digital markets
- Digital twins and edge AI for real-time monitoring and operation
- AI for microgrids, virtual power plants, and energy communities
- Multi-energy system management through AI-based coordination
- Integration of electric mobility and demand response via machine learning
- Explainable, trustworthy, and physics-informed AI for power distribution

SPECIAL SESSION 4 (SS4)

DESIGN, CONTROL, AND FAULT DETECTION OF POWER CONVERTERS FOR ENERGY STORAGE AND EV CHARGING SYSTEMS

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SPECIAL SESSION THEME

Electric storage devices, like batteries, supercapacitors, and electric vehicles, are usually connected to the grid for cogeneration or energy conservation for future use. This connection is made through power electronics interfaces that should guarantee high stability, voltage regulation, power flow control, and low electromagnetic emission, along with high power density, low cost, and high reliability. To increase the power density, passive devices that are considered the bulkiest components in these systems should be reduced or avoided. This can be achieved by considering multilevel topologies that would comply with power quality requirements without the need for passive filters. This session is dedicated to the various solutions adopted for high quality energy management at storage or EV charging levels. More specifically, it will present advanced power electronics topologies used for power quality enhancement in such applications. Model-based or intelligent control algorithms ensuring a compliance with grid requirements, especially regarding power quality and V2G connectivity, and EV-related standards are also considered as major topics in this session. In addition, fault detection techniques dedicated to the diagnosis of power converters for electric vehicles and energy storage devices are also covered.

TOPICS OF INTEREST

- Multilevel converters in grid-connected storage devices
- Fuel cells for EV drives
- Battery charging systems
- PV-assisted charging systems
- Power quality in V2G systems
- Model-based control design
- Artificial intelligence-based control
- Energy management in V2G systems
- Open-winding motor drives
- Current and voltage signature-based fault diagnosis methods for chargers
- AI-based fault detection techniques for EV and battery charging systems

SPECIAL SESSION 6 (SS6)

PHOTOVOLTAIC ENERGY SYSTEMS: ADVANCED MODELING, SIMULATION, POWER CONVERSION, CONTROL AND OPTIMIZATION, DIAGNOSTICS

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SPECIAL SESSION THEME

Photovoltaic (PV) systems are a central technology in the transition to clean, decentralized energy production. They support a wide range of applications, including residential, industrial, and utility-scale installations, as well as integration with microgrids and hybrid renewable energy systems. PV systems require sophisticated power electronic interfaces to manage energy conversion, grid integration, and coordination with other energy resources. Accurate modeling of electrical and thermal behaviors, along with effective control strategies, is essential to maximize system efficiency, reliability, and lifetime.

One of the key challenges in PV systems is creating accurate models for real-time use, which support simulations, state estimation, diagnostics, and controls in varying conditions. Furthermore, reliable power forecasting and effective maximum power point tracking (MPPT) algorithms are essential for optimizing energy output and maintaining stable grid operation, particularly in high PV penetration scenarios.

This special session aims to showcase the latest advancements in PV system technologies, addressing topics such as advanced modeling and simulation, high-performance power electronics, real-time control strategies, diagnostics, and the integration of emerging technologies like Photovoltaic Thermal (PVT) and Concentrated Photovoltaic Thermal (CPVT), which enhance overall efficiency by merging photovoltaic and thermal systems.

TOPICS OF INTEREST

- Advanced electrical and thermal models for solar systems
- State of health estimation and parameter identification techniques
- Data-driven models for energy production forecasting
- Power converters and control for PV system integration and energy management
- MPPT algorithms and Grid-forming (GFM) strategies for ensuring stable and resilient operations of microgrids with high PV penetration

- Optimization of active and passive components for high-performance PV systems
- Integration of PVT and CPVT technologies in various renewable energy systems
- Real-time simulation and Hardware in the Loop for distributed renewables energy systems and Storage System Integration
- Multiphysics simulations of solar system architectures
- Monitoring and diagnostics techniques for solar systems.

SPECIAL SESSION 8 (SS8)

ADVANCES ON HIGH-PERFORMANCES POWER CONVERTERS: SIMULATION AND MODELLING OF NEW ARCHITECTURES, MATERIALS, DEVICES AND CONTROLS.

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SPECIAL SESSION THEME

Power converters play a crucial role in the nowadays life. The increasing electrification in many sectors, from both the industrial and the domestic areas, and the large diffusion of renewable energy sources (with the respective storage systems) comes to a growing necessity of devices for the electric power conversion with high performances under multiple points of view (efficiency, power density, reliability, costs, ...). The performance optimization of power converters can be done by intervening in several aspects: materials (especially for the magnetic parts, to limit the losses of the inductors), components (electronic devices to reduce the switching losses), and architectures (for example DAB or resonant converters, wired or wireless, to work at high frequency with high efficiency).

Advanced techniques on modelling and simulation are a key-point in the development of optimized solutions for each specific application. In this sense, they can represent a reliable tool for designers, strongly reducing the amount of required experimental measurements and prototypes, saving costs and times.

For this reason, this section welcomes all the contributions, focused on modelling and numerical simulations (frequency domain, time domain, finite element method, ...) for materials, components, and architectures which can improve the design of advanced power converters.

TOPICS OF INTEREST

- Modelling and simulation of innovative topologies of power converters
- Modelling and simulation of electronic devices and magnetic materials for power converters
- Simulation of advanced magnetic materials for power converters (new generation powder cores, ferrites, 3D-printed materials, amorphous cores, nanocrystalline cores)
- Comparison of numerical approaches for the simulation of power converters (frequency domain approaches, time-domain approaches, finite element approaches, neural network approaches, ...)
- Modelling and simulation of innovative wireless power transfer systems
- Modelling and simulation of new architectures of power electronic converters
- Artificial Intelligence applied to power electronic converters and its devices
- Modelling and simulation of power converters integrated into complex Energy Systems.

SPECIAL SESSION 9 (SS9)

ADVANCED ELECTRICAL SYSTEMS FOR ENERGY-EFFICIENT SHIPS

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SPECIAL SESSION THEME

The maritime industry is undergoing a significant transformation driven by the urgent need to improve energy efficiency and meet international decarbonisation goals. With the International Maritime Organization (IMO) and other regulatory bodies setting ambitious targets for reducing greenhouse gas emissions, the sector is increasingly turning to advanced electrical systems as a key enabler of sustainable operations.

Electrical technologies play a pivotal role in this transition, enabling innovations in propulsion, power conversion, energy storage, and intelligent control. This special session will focus on the latest advancements in electrical engineering that contribute to energy-efficient and low-emission ship design and operation. It aims to foster interdisciplinary collaboration among researchers, engineers, and industry professionals working on the electrification and digitalisation of maritime systems. It will provide a platform for sharing innovative solutions, discussing challenges, and exploring future directions in ship energy efficiency.

TOPICS OF INTEREST

We invite contributions that address modelling, simulation, control, and implementation of electrical technologies in maritime contexts. Topics of interest include, but are not limited to:

- Electric Propulsion Systems: Design, modelling, and control of electric drives for marine propulsion; integration with hybrid and fully electric architectures.
- Power Electronics for Marine Applications: High-efficiency converters, reliability, power system protection, and thermal management in shipboard environments.
- Energy Storage and Management: Battery systems, supercapacitors, and energy management strategies for hybrid and electric vessels.
- Renewable Energy and System Integration on Marine Electrification Systems: Solar and wind energy onboard, fuel cell integration, power conditioning, and synchronisation with onboard systems.
- Smart Shipboard Grids: Microgrid architectures, load balancing, fault tolerance, and energy distribution optimisation.
- Energy Management Strategies: Energy forecasting, optimisation and adaptive control systems.

SPECIAL SESSION 10 (SS10)

CONTROL, FAULT DIAGNOSIS, AND FAULT TOLERANCE OF POWER CONVERTERS FOR RENEWABLE POWER SYSTEMS

CO-CHAIRS

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SPECIAL SESSION THEME

With the increasing demand for energy in industrial, residential and civil applications and the incoming large-scale diffusion of electric vehicles, electricity is becoming the main power source of the modern world. Since it is clear that the future of energy must necessarily rely on renewable energy sources, being the only solution that can help both sustainability and environmental issues, it is necessary to ensure their smooth integration in the power system. At the same time, the future power system is required to have high power capability, should be highly efficient and flexible, and dynamic changes of loads and power sources should not influence power quality. An efficient and effective network management is the key to the integration of renewable sources in an efficient way that ensures cost-effectiveness and affordability, security of supply, and grid stability. Actually, power electronics technologies play a vital role in efficient energy conversion and utilization. Today, 70% of electrical energy is processed by power electronics devices, and this will increase in the coming decades. Therefore, it is evident that the reliability of power converters is a fundamental aspect in the present and future energy scenario.

This special session is aimed at presenting the latest developments and achievements in the control, diagnosis and fault tolerance capabilities of power converters particularly suitable to renewable sources applications.

TOPICS OF INTEREST

Control techniques, fault detection methods, and fault tolerance approaches applied to power converters for renewable power systems, such as (but not limited to):

- Converters for wind power systems
- Multilevel converters
- Multicell converters
- Converters for PV applications
- DC-DC converters

SPECIAL SESSION 11 (SS11)

INTEGRATION, FLEXIBILITY, AND RESILIENCE IN SMART MULTIVECTOR MICROGRIDS: DEMONSTRATIVE PROJECTS AND REAL-WORLD APPLICATIONS

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SPECIAL SESSION THEME

The energy transition requires innovative solutions capable of integrating electricity, heat, gas, and hydrogen into flexible and resilient systems. Multivector microgrids play a central role in this shift, enabling the combination of renewable sources, advanced storage, and conversion technologies such as power to gas and power to heat. By coordinating multiple energy carriers, they improve efficiency, support demand response, enhance resilience to extreme events, and open new pathways for sector coupling and decarbonization.

This special session will examine recent advances in architectures, control strategies, and digital tools for multivector microgrids, while also addressing regulatory challenges. It will feature theoretical developments as well as insights from demonstrative projects and real-world applications, showing how multivector approaches can accelerate smart grid deployment and contribute to sustainable energy systems. The session aims to bring together researchers, industry leaders, and policymakers to foster collaboration and outline a roadmap for widespread adoption of multivector microgrids in Europe and beyond.

Contributions are invited on architectures, control, enabling technologies, digitalization, resilience, regulatory frameworks, and case studies or demonstrative projects.

TOPICS OF INTEREST

- Architectures and control strategies for multivector microgrids and related coupling technologies
- AI-based management, digital twins, optimization of multivector microgrids
- Demand response and optimal resources dispatch
- Microgrids and Renewable Energy Communities: energy and economic optimization
- Resilience and reliability: strategies for extreme events, cybersecurity, and grid stability
- Regulatory and market frameworks enabling multivector integration
- Sector coupling and decarbonization pathways through microgrid deployment
- Demonstrative projects and case studies at local, national, and European level
- Socio-economic impacts and business models for multivector microgrids

SPECIAL SESSION 12 (SS12)

MODELLING AND PREDICTIVE MULTI-ENERGY MANAGEMENT FOR FLEXIBLE AND RESILIENT MICROGRIDS INTEGRATING ELECTRICITY, HEAT, AND GAS

CO-CHAIRS

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SPECIAL SESSION THEME

The increasing penetration of distributed renewable energy sources and the progressive coupling of electrical, thermal, and gas infrastructures have strengthened the role of multi-energy microgrids as key enablers for efficient, low-carbon, and reliable energy systems. Ensuring coordinated operation of such heterogeneous resources requires advanced methodologies for modelling, predictive management, flexibility provision, and resilience enhancement. This Special Session focuses on recent advances in multi-energy system modelling, including physical, data-driven, and hybrid modelling approaches covering the dynamic interactions between electricity, heat, and gas networks. Accurate multi-domain models are essential for predictive control, co-simulation, system identification, and performance assessment under operational uncertainties. A central theme of this session is predictive multi-energy management, relying on Model Predictive Control (MPC), stochastic and robust optimization, and hierarchical or distributed control structures. These approaches enable proactive scheduling and real-time coordination of Distributed Energy Resources (DERs), storage units, power-to-heat and power-to-gas technologies, and flexible loads. The session also emphasizes flexibility mechanisms, including thermal inertia, multi-energy storage, conversion pathways, demand response strategies, and aggregated flexibility characterization. Moreover, contributions addressing resilience and fault tolerance, such as disturbance mitigation, topology reconfiguration, cyber-physical security, islanding strategies, and restoration planning, are strongly encouraged, as well as papers presenting simulation frameworks, multi-domain co-simulation tools, and digital twins. By gathering theoretical, methodological approaches, this Special Session aims to consolidate recent progress in multi-energy modelling, predictive decision-making, and resilient operation of next generation microgrids.

TOPICS OF INTEREST

- Dynamic modelling of DERs, CHP units, heat pumps, thermal networks, and gas components
- Co-simulation frameworks and interoperability between electrical, thermal, and gas models
- Model Predictive Control (centralized, distributed, hierarchical)
- Multi-horizon predictive scheduling (day-ahead, intra-day, real-time)

- Predictive coordination of conversion technologies (P2H, P2G, hybrid systems)
- Demand response strategies
- Quantification and aggregation of multi-energy flexibility
- Resilient control architectures for multi-energy microgrids
- Data-driven forecasting (loads, renewable generation, prices)
- Hybrid AI-physics modelling for predictive and resilient operation

SPECIAL SESSION 13 (SS13)

RENEWABLE ENERGY SOURCES, LOAD POWER AND EV SHORT-TERM FORECAST FOR THE GRID MANAGEMENT

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SPECIAL SESSION THEME

Electrical grids integration of renewable energy sources (RES) presents significant challenges for operators and energy managers. The variability of photovoltaic and wind generation, combined with fluctuating loads and Electric Vehicle (EV) demand, require advanced forecasting techniques to ensure grid stability, optimize energy dispatch, and enhance microgrid economic efficiency.

This special session brings together experts to discuss state-of-the-art power forecasting methodologies and their implications for grid management, exploring the link between forecast accuracy, time horizons, and optimal decision-making in grid environments, with particular emphasis on:

- Short-term and ultra-short-term forecasting and Nowcasting techniques: Advanced machine learning and statistical approaches for PV power, wind power, and electrical load forecasting with time horizons from minutes to 24 hours ahead
- Forecast accuracy and time horizon impact: how prediction horizons and accuracy levels influence optimal energy management strategies, including unit commitment, economic dispatch, and demand response programs
- Forecasting-based Microgrid optimization and control: Integration of forecasting output into real-time control systems for grids, energy storage management and coordination between distributed energy resources and EV loads
- Uncertainty quantification and probabilistic forecasting: characterizing uncertainty and incorporating probabilistic predictions into risk-aware decision-making frameworks

TOPICS OF INTEREST

- Machine learning and deep learning methods for renewable generation and load forecasting
- Hybrid physical&data-driven forecasting approaches
- Ultra-short-term and short-term forecasting (sub-hourly to 24-hour ahead) for operational and market applications
- Probabilistic and interval forecasting for uncertainty quantification
- Spatial-temporal forecasting for distributed renewable energy resources
- Transfer learning and domain adaptation for data-scarce forecasting environments
- Impact of forecast accuracy on microgrid economics and operational efficiency
- Energy storage scheduling and real-time energy management based on renewable forecasts

- Demand response, frequency regulation, and voltage control using short-term forecasts
- Multi-objective optimization of microgrid operation under forecast uncertainty
- Market participation and energy trading applications, including bidding strategies and peer-to-peer systems
- Practical implementations and evaluation frameworks, covering industrial microgrids, smart buildings, EV charging, grid stability, and benchmarking datasets.