# RESEARCH GROUP

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# Active Power Grid

The Active Power Grid research group is based on an evolutionary conception of power infrastructures enabling it to create efficient and reliable automatized energy systems. These involve communications, control, power conversion and automation capabilities in energy grids, heterogeneous energy sources, decentralized generation based on power electronics, active consumers, energy storage capabilities, large-scale energy interconnections, flexibility and services markets, and cross-jurisdictional energy regulation structures.
The research of the group requires collaboration and integration between a wide array of specializations, including power system planning and analysis, the operation of transmission and distribution networks, communications technology, networked control systems, computer science, power processing, digital markets and regulation services. The research and development activities of the APG group address not only technical challenges but also new business models, policies and societal benefits

## Main Expertise

Specialization fields:

- Automatic grids
- Micro-grids
- Super-grids
- Virtual power plants
- Power processing
- Distributed control systems

Transversal fields:

- Big data
- Artificial Intelligence (machine learning models)
- Deep Learning
- Cyber-Physical Energy Systems
- Software Engineering
- Energy Cloud Computing

## Research Challenges

- Shifting energy production to renewable and low-carbon sources;
- Enabling power converter dominated power systems;
- Expanding digitalization among energy systems to achieve previously unseen levels of coordination and optimization;
- Exploiting computational advances to spread intelligence throughout the system, from physic-edges to extensive clouds;
- Improving power processing capacities of power systems, moving from electromechanical generation and passive demand to power active converter-dominated power systems at both the generation and demand sides;
- Managing bi-directional energy flows, as consumers play an active role in energy supply and demand;
- Unlocking demand response and integrating small-scale generation and storage, from the residential and industrial sectors;
- Developing new energy conversion options (P2X) and integrating different energy vectors (electricity, molecule-based energy vectors, heating/cooling etc.).

## Application areas

- Renewable energy generation/conversion systems
- Electric grids and infrastructures
- Smart grid technologies
- Distributed control systems
- Microgrids
- Multi-terminal dc and hybrid ac/dc networks
- Power conversion systems
- Energy storage systems
- Fuel-cell conversion systems and electrolysers
- Electric vehicle charging
- Energy Internet and digital platforms
- Computational energy intelligence

## Main assets

- FLEXITRANSTORE - An Integrated Platform for Increased Flexibility in Smart Transmission Grids with Storage Entities and Large Penetration of Renewable Energy Sources. (H2020 / 2017-2021)

## Equipment

- Three interconnected RT-simulation systems
- Smart meters, PMU and RTU measurement systems interfaced with RT simulators
- Networked controllers supporting multiple communication protocols for edge-control
- Local HPC for fog-control of systems
- High-level HPC for cloud-computing
- Power amplifier for HIL
- Grid emulator
- PV and battery emulators
- Programmable loads
- Several power conversion systems

## Selected publications


- AI-based Damping of Electromechanical Oscillations by using Grid-connected Converter. Baltas, G. N.; Lai, N. B; Tarasso, A.; Marin, L. Blaabjerg, F.; Rodriguez, P., 2021. Frontiers in Grid Connection of Converters in Renewable Applications, vol.9, pp. 39
- Grid-Forming Power Converters controller with Artificial Intelligence to Attenuate Inter-Area Modes. Baltas, G. N.; Lai, N. B.; Marin, L.; Tarasso, A.; Rodriguez, P., 2020. IEEE Workshop on Control and Modeling for Power Electronics, Aalborg, Denmark, November 9-12
- Voltage Sensorless Control for Grid-connected Power Converters based on State Feedback and State Observer. Lai, N. B.; Baltas, G. N.; Marin, L.; Tarasso, A.; Rodriguez, P., 2020. 2020 IEEE 21st Workshop on Control and Modeling for Power Electronics (COMPEL), pp. 1-5
- Small-signal Model and Analysis of a Grid-forming Power Converter based on the Synchronous Power Controller. Marin L., Tarrasó, A., Lai N. B, Baltas G. N. and Rodriguez P., 2020. 2020 IEEE 21st Workshop on Control and Modeling for Power Electronics (COMPEL), pp. 1-6.
- Grid-Forming Power Converters Tuned Through Artificial Intelligence to Damp Subsynchronous Interactions in Electrical Grids. Baltas, G. N. ; Lai, N. B.; Marin, L.; Tarraso, A.; Rodriguez, P., 2020. in IEEE Access, vol. 8, pp. 93369-93379
- Inertia Emulation in Power Converters with Communication Delays. Lai, N. B.; Tarraso, A.; Baltas, G. N.; Marin, L.; Rodriguez, P., 2020. 2020 IEEE Energy Conversion Congress and Exposition (ECCE), pp. 1665-1669
- A Growing Self-Organising Maps Implementation for Coherency Identification in a Power Electronics Dominated Power System. Baltas, G. N.; Lai, N. B.; Marin, L.; Rodriguez, P., 2020. 2020 IEEE Energy Conversion Congress and Exposition (ECCE), Detroit, MI, USA, pp. 1963-196.
- Virtual Admittance PLL Structure for Grid-forming Power Converters in Microgrids. Tarrasón, A.; Candela, J. I.; Lai, N. B.; Baltas, G. N.; Rodriguez, P., 2020. 2020 IEEE Energy Conversion Congress and Exposition (ECCE), Detroit, MI, USA, pp. 5007-5011.


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SnT – University of Luxembourg
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DET – Aalborg University


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