European Research Infrastructure supporting Smart Grid Systems Technology Development, Validation and Roll Out

TRANSNATIONAL ACCESS PROVISION

RESEARCH INFRASTRUCTURE DESCRIPTION AND
TRANSNATIONAL ACCESS CONDITIONS

AIT Austrian Institute of Technology

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1   Research Infrastructure

Name of Infrastructure/Installation	**Smart Electricity Systems and Technologies Laboratory (SmartEST)**
Location	AIT – Vienna, Austria
Web Site	*www.ait.ac.at*

2   Description of the Research Infrastructure

The AIT SmartEST, located in Vienna, Austria, provides a multifunctional research, validation, and testing infrastructure allowing the testing of single devices as well as analysis of the interactions among multiple power system components – especially Distributed Energy Resource (DER)-based inverter systems – and the power grid under realistic, nearly real-world situations. The laboratory includes three configurable three-phase low-voltage grids; a high-bandwidth, programmable power grid simulator; several Photovoltaic (PV) array simulators; and an environmental test chamber for emulating various environmental conditions. This permits the validation and testing of DER-based inverter systems at full power under extreme temperature and humidity conditions and the investigation of their interactions under various power grid conditions. The facility is capable of testing inverters, storage units, grid controllers, and Combined Heat and Power (CHP) units as well as charging stations/supply equipment for electric vehicles in the power range from a few kVA up to 1 MVA.
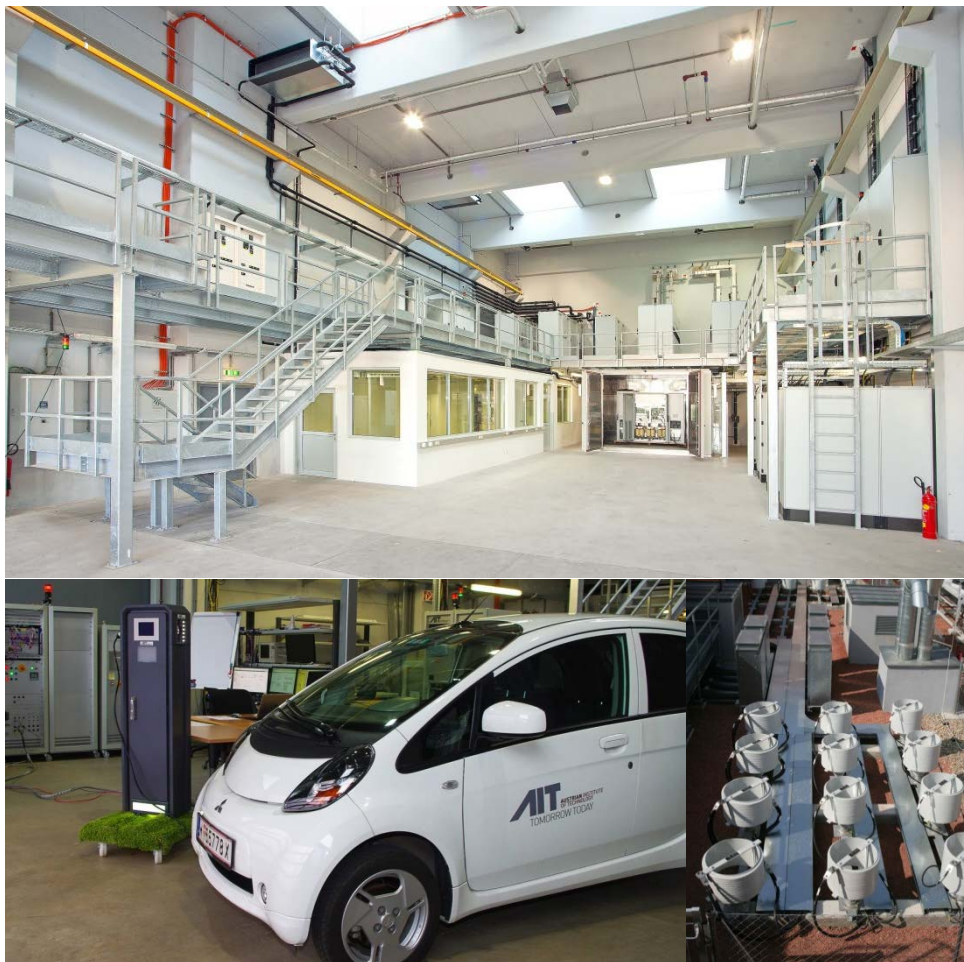

AIT SmartEST research and testing facility for smart grid systems and components

In addition, AIT SmartEST allows the real-time simulation of complex power grids and components as well as the coupling of this virtual environment with the laboratory grids. This kind of Hardware-in-the-Loop (HIL) setup lets researchers integrate real power system components into a virtual grid environment and test them as they interact with the grid under realistic conditions. Besides the HIL-based integration of power system components, Information and Communication Technology (ICT)/auto-mation approaches, concepts, and developments can be integrated into the whole set-up, allowing a comprehensive analysis of smart grid-related topics. The combination of a state-of-the-art testing infrastructure with HIL-based simulations (i.e., of the power system and ICT/automation infrastructure) provides cutting-edge testing capabilities for component manufac-turers and network operators.

HIL and smart metering capabilities of SmartEST

Designed as a pure low-voltage research and testing environment, all AC buses are rated for op-eration at voltages of up to 480 V (line to line). The laboratory itself is supplied from the local 20 kV medium-voltage power grid via two independent medium- and low-voltage (MV/LV) transformers. The test facility has been used for comprehensive performance testing of DER equipment as well as qualification testing to national and international grid codes and standards based on the exten-sive range of accreditations held by AIT. Research on procedures for advanced interoperability testing of single as well as multiple DER units under different grid control schemes supports the integration of DERs into a future smart grid through standardized communication and coordination among generators, consumers, and storage units.
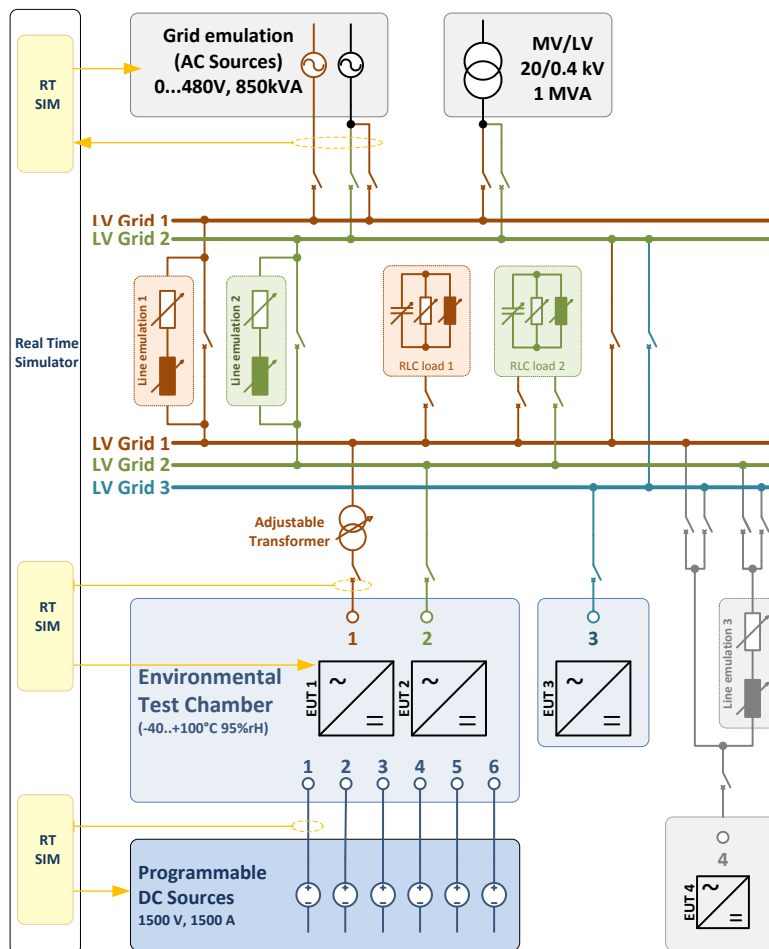
Schematic overview of the SmartEST lab

The following components are available in the SmartEST lab and provided for ERIGrid:

Electrical setup and components

- Grid simulation (3 independent laboratory grids; 2 independent high bandwidth grid simulators – 0-480 V, 800 kVA; 3-phase balance or unbalanced operation; LVRT/FRT testing possibilities)
- Line impedance emulation (adjustable line impedances for various LV network topologies: meshed, radial or ring network configuration)
- Adjustable loads for active and reactive power (freely adjustable RLC loads up to 1 MW, 1 MVAr – capacitive and inductive behaviour; individual control possibilities)
- Environmental simulation (test chamber for performance and accelerated lifetime testing)
- DC sources (5 independent dynamic PV array simulators: 1500 V, 1500 A, 960 kVA)
- DAQ and measurement (multiple high precision power analysers with high acquisition rate; simultaneous sampling of asynchronous multi-domain data input)

Simulation tools and components

- Multicore Opal-RT Real-Time Simulator (i.e., eMegaSim)
- Typhoon HIL Real-Time HIL Simulator
- Mathworks xPC-Target Simulator
- Power-HIL and Controller-HIL experiments at full power in a closed control loop
- General simulation tools: Matlab/Simulink, SimPowerSystems, PSpice/Cadence
- Network simulation tools: DigSILENT PowerFactory, PSAT
- Communication network simulator: OMNeT++
- Powerful simulation cluster for complex and large-scale system simulations

ICT/automation tools and components

- SCADA and automations system (highly customizable laboratory automation system, remote control possibilities of laboratory components, visualization and monitoring)
- Distributed control approaches: IEC 61499/4DIAC
- Communication methods: IEC 61850, Modbus/SunSpec, OPC/OPC-UA, Industrial Ethernet (Ethernet POWERLINK, Modbus/TCP, etc.)
- Planning methods, interoperability and compatibility, integration: IEC 61970/61968 (CIM)
- Network information system
- Cyber-security assessment methods and tools for Smart Grid systems and components
- Smart metering testing facility

Data Analytics

The AIT SmartEST lab also includes a Data Analytics Lab with a 24 node / 48 CPU / 288 core parallel cluster infrastructure, including 3TB RAM and 100TB distributed storage systems. The scalable network filesystem is based on GlusterFS, a large distributed storage solution for data analytics and other bandwidth intensive tasks. Interconnection is provided via fast high bandwidth networks, based on Infiniband technology. The cluster's host systems support open virtualization to enable highly flexible processing of parallel applications, making it highly suited to data analytics activities. Various open source stacks for MapReduce (e.g. Hadoop Ecosystem) based data exploration provide high configurability..A Teradata/ASTER commercial database is currently used in conjunction with MapReduce functions that can be realised via open source means (e.g., Python/R/Java), is used for performing MapReduce analytics in research projects with grid data. The high performance Data Analytic workstations flexibly offer tool support for various applications (e.g. anaconda/R/eclipse/Python) also with ease of access to and working on the various data bases.

3   Services offered by the Research Infrastructure

In the AIT SmartEST lab the following services are offered (but not limited to):

Smart grid system and DER-oriented expertise and validation/testing activities

- Integration of DER, standards, national requirements in EU and USA
- Power Quality (PQ) lab test and field monitoring: impact of DER components including storage on PQ (e.g., harmonics, flicker), impact of PQ disturbances on Distributed Generation (DG) components (e.g., voltage sags, over-voltages)
- Safety of DER components (research and testing): PV inverters (e.g., DC current, Loss of Main protection) and PV modules
- Quality and performance of DER components including storage and systems: inverters performance (e.g. efficiency, MPPT efficiency, de-rating), quality and performance control of PV-modules, performance assessment of PV systems, online monitoring, mutual interference of multiple DERs in distributed power system
- Qualification testing and conformity assessment of PV and battery inverters and protection devices according to diverse national standards and recommendations
- Energy storage system validation
- Electric vehicle supply equipment/charging system validation

Smart grid simulation/HIL-based and automation application development/testing activities

- Experimental real-time simulation platform for advanced Power-HIL and Controller-HIL analysis
- Distributed/coordinated/central voltage control approaches with many distributed generators across a section of network
- Validation of energy management systems and distribution SCADA
- Standard-based controller implementation (e.g., IEC 61850/61499, SunSpec)
- Interoperability and communication testing

Data Analytics Activities

- Data extraction, loading and transformation into appropriate data structures
- Data filtering and mining for events and anomalies
- Descriptive and predictive data analytics, including clustering, prediction and machine learning based model training
- High performance parallel data processing based on MapReduce
- Time series analysis, event detection
- Forecasting and model prediction
- Visualization, Reporting and interactive exploration techniques
- Network data and measurement data analysis for e.g. asymmetry, voltage band reserves, topology extraction
- Communication data analysis, for pattern detection (e.g. topology)
- Customer data analysis
- Data fusion with other data sources (e.g. GIS, SAP)

4   Brief description of the organization managing the Research Infrastructure

The AIT Austrian Institute of Technology GmbH is an Austrian research institute with a European format and focuses on the key infrastructure issues of the future. The company, employing about 1.260 scientists and research engineers, takes a leading position in the Austrian research and innovation system and a corresponding key role in Europe.

In the field of electricity networks and distributed energy resources AIT's main expertise is in low and high voltage technology, power quality, safety and reliability analysis. Furthermore, AIT provides an excellent national and international network. It is represented in several technology platforms, namely the National Technology Platform Smart Grids Austria (NTP), the European Technology Platform for Electricity Networks of the Future as well as in DERlab e.V. It is also involved in the European Electricity Grid Initiative (EEGI), the EERA Joint Programmes on Smart Grids and PV and several Implementing Agreements of the International Energy Agency (ISGAN, IEA-PVPS).

5   Transnational Access conditions offered by AIT

All the offered experimental systems included in the AIT SmartEST are in the same building in Vienna, Austria.

For **safety reasons**, for **critical applications**, the users are not expected to operate the systems by themselves; even when safety instructions will be provided, tests will be carried out by staff of AIT. For **the rest of applications** and after ad-hoc training, the user group will have full access to the related facilities for the duration of the stay (with the support of AIT's researchers and laboratory technicians when necessary). The **scheduling of the experiments** will be agreed and booked prior to the stay according to the availability of the involved staff and equipment. Administrative documentation for the access (contract, non-disclosure agreement, etc.) will comply with ERIGrid common indications.

In addition to the general corporate services (Internet connection, canteen, etc.) and the support and advice on accommodation and transportation to AIT's infrastructure, the access being offered includes supervision and help of AIT's staff:

- As a complement to the pre-access contacts between the user group and AIT, the stay will start with an introductory meeting with a senior researcher for confirming the stay conditions (confidentiality, safety indications), scheduling the activities, explaining the on-site procedures, clarifying the logistics and technical details.

- Preparatory work: a laboratory technician will assist the users for the installation of the devices, electrical connections, use of the specific instrumentation, preparation of a test procedure (if necessary) on the basis of the users requests, and programming of the experimental conditions.
- AIT's researchers will support the realisation and follow-up of the experiments.
- AIT's researchers will support the results interpretation, data processing and analysis, and test report preparation.

In principle, a typical stay of 2-4 weeks is foreseen for a single user group but this period could be extended depending on the concrete user project. The user group (usually 2-3 persons) can use the infrastructure for the defined time.

Reimbursement of expenses:

User expenses for the Trans-national Access (TA) are paid by ERIGrid (EU H2020 Programme). This includes travels to AIT SmartEST by plane/trains, accommodation, daily subsistence, and daily transportation during the stay.

For the user projects taking place in SmartEST, AIT will refund the stay expenses when the stay is finished: the user must declare the incurred expenses and present the invoices/receipts to AIT in order to get the refund.

Logical expenses must be made by the user: travels will be made in economy class and conventional hotels (not luxury) or equivalent accommodation will be used. As an indication (it is not a daily allowance), a maximum subsistence fee of 160 €/person must be considered per day. Lunch will be provided at AIT's canteen free to the user.

6   Contact details for Research Infrastructure

Smart Electricity Systems and Technologies Laboratory (SmartEST) – AIT	
Address: Giefinggasse 2, 1210 Vienna, Austria	
Website: _www.ait.ac.at_	
For lab management/technical issues (DER, storage, etc.):	*For lab technical issues (DER, HIL, etc.):*
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