The Power Electronics Grid Interface (PEGI) Platform

A research platform to validate inverter-based resources and power electronic-dominant energy systems

A paradigm shift has arrived on the electric grid: Power electronics are now the predominant way that new generation and modern loads connect to the grid. The fastest growing resources like solar photovoltaics, wind, and battery energy storage systems all interface to the grid via power electronics, which pose fundamental questions around the future grid's operation and design.

With the PEGI Platform, industry and utility partners can develop and evaluate their power electronic solutions in a safe, fully controllable energy system at a scale relevant to industry.

USE CASE

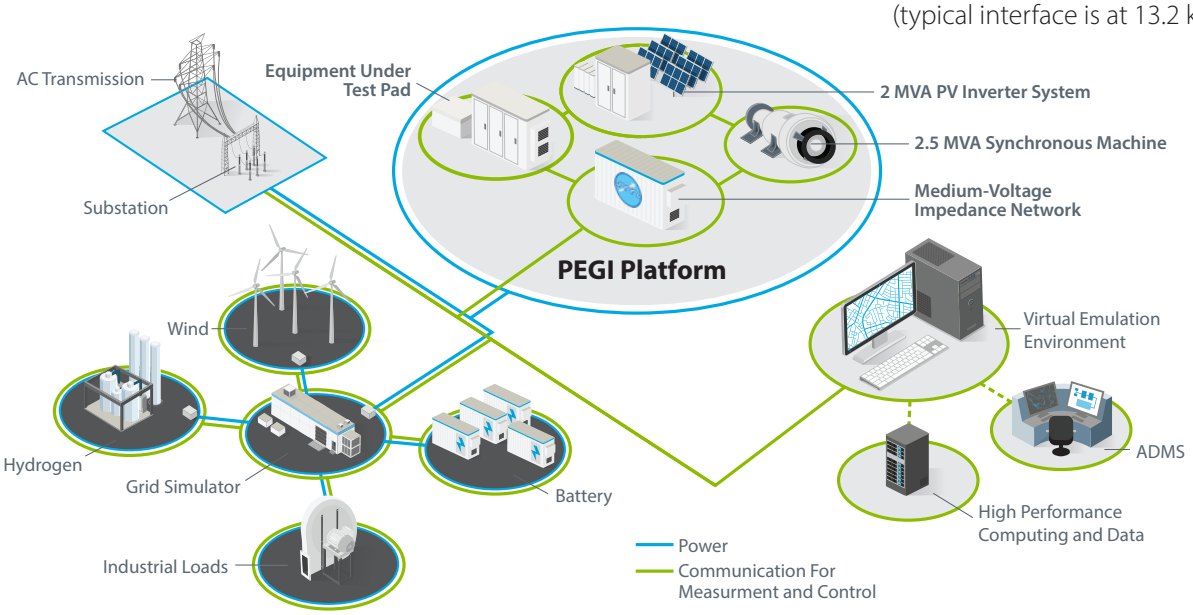
Overcoming Generation Reliability Concerns on the Road to 100% Renewable Energy

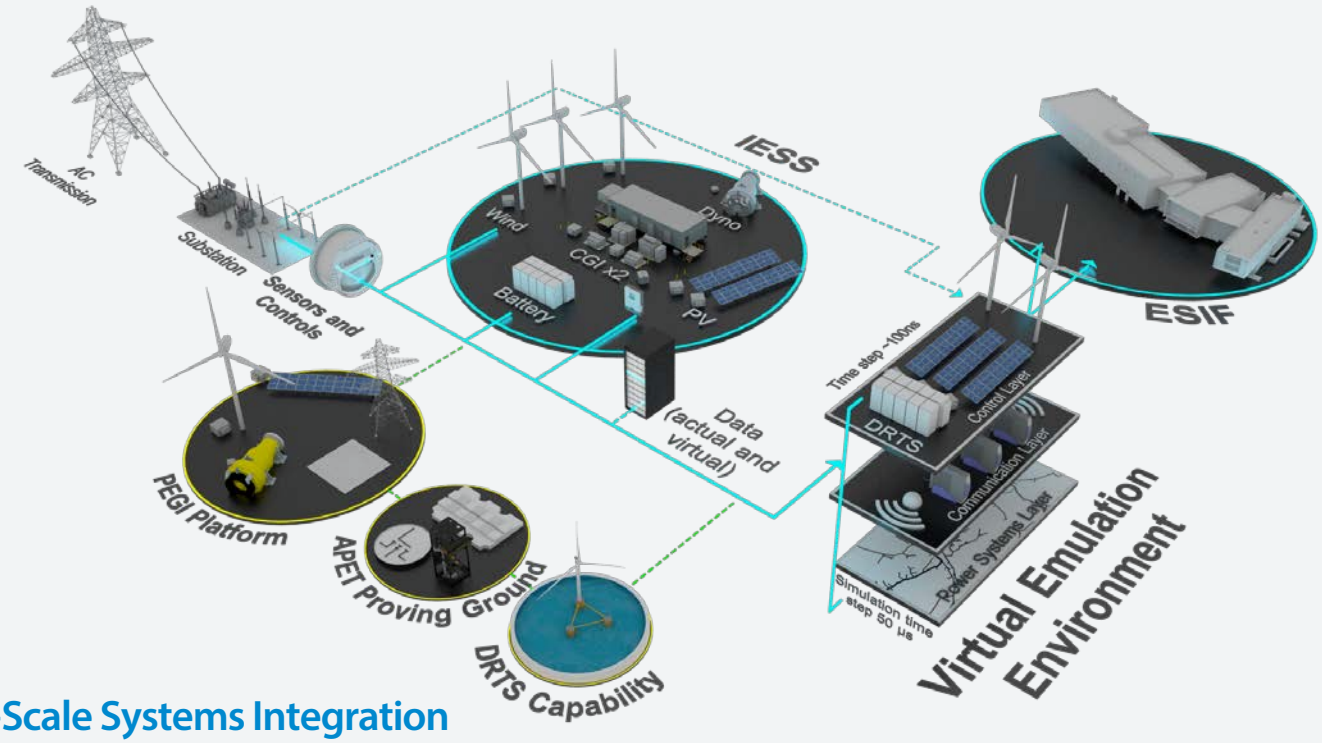
Bulk power system-level disturbances that involve large amounts of inverter-based resources (e.g., solar photovoltaics, wind, and battery energy storage), starting with the Blue Cut Fire disturbance in California in 2016 and more recently exemplified by the Odessa disturbance in Texas in 2021, continue to threaten reduced power system reliability as the amount of integrated renewable generation increases. The critical technical compromises between traditional synchronous generation and the rapidly increasing inverter-based generation sources remain to be definitively determined. The PEGI Platform allows research partners to derisk solutions to these reliability concerns including advanced inverter controls, such as synchronization techniques and voltage ride-through capability, and the coordinated operation of synchronous and inverter-based resources.

PEGI Technical Specifications

The PEGI Platform consists of specialized equipment that can be used in combination with other Advanced Research on Integrated Energy Systems (ARIES) assets at NREL's Flatirons Campus for maximum adaptability. The result is a flexible research system capable of supporting many different types of experiments. The main PEGI assets are:

- **2 Megavolt-Amperes (MVA) Photovoltaic (PV) Inverter** serves as a controls research platform for grid-forming algorithms, response to abnormal grid conditions, etc.
- **2.5 MVA Synchronous Machine** driven by a fully controllable dynamometer, simulates various prime mover technologies and acts as a representative device for conventional generation or as a synchronous condenser.
- **Medium-Voltage Impedance Network (MVIN)** emulates weak grid conditions between inverter-based resources and a large interconnected grid and enables the evaluation of high-frequency grid interactions such as sub-synchronous resonance and unwanted plant controller interactions.
- **Equipment-Under-Test Pad** serves as a drop-in space for direct interface of partner equipment to the PEGI platform (typical interface is at 13.2 kV at 1-2 MVA).





At-Scale Systems Integration

PEGI supports a wide range of research, thanks to its connection to other physical and virtual assets in ARIES, which contributes an even wider research capability that encompasses cybersecurity, high-voltage infrastructure, energy storage, and powerful data integration tools. With ARIES, experiments are extended by virtual and physical (20-MW) energy assets.

Example Research Applications

- Design and demonstrate grid-forming and grid-following controls for inverter-based resources
- Evaluate grid stability limits in scenarios (e.g., evaluating system non-synchronous penetration limits for specific technologies)
- Characterize the impact of weak grid connections on inverter-based resources and their controllers
- Develop methods to mitigate and avoid sub-synchronous oscillations for power systems with high inverter levels
- Develop, demonstrate and validate hybrid energy system designs.

New Research Potential with PEGI

Using the PEGI Platform, industry and utility partners have the unique capability to evaluate and validate technologies under similar conditions to what they experience in real-world power systems: the same power levels, the same operating scenarios, and the same shares of renewable and synchronous generation sources. Researchers can configure this high-power laboratory-scale power system to derisk any grid environment with high levels of inverter-based resources.

The power sector, including utilities, equipment vendors, independent system operators, renewable energy developers, and regulators now have a dedicated space to validate power electronic-based systems and move ahead confidently with the realization of ever higher inverter-based resource dominant grids.

Prove Your Solution

Break through the barriers to clean and resilient energy by using PEGI for high-fidelity power system validation. Learn about calls for proposals at nrel.gov/aries/ or contact PEGI Research Manager, Dr. Barry Mather at Barry.Mather@nrel.gov.

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