POWER HARDWARE-IN-THE-LOOP (PHIL) TESTING FACILITY FOR DISTRIBUTED ENERGY STORAGE

NREL NATIONAL RENEWABLE ENERGY LABORATORY

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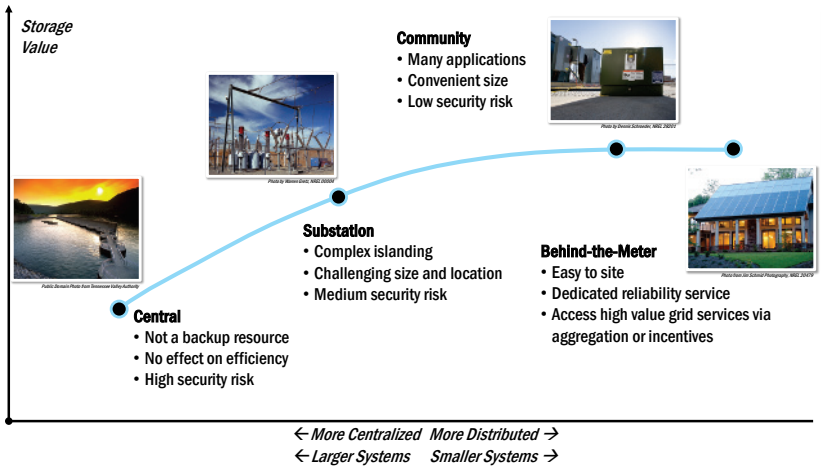
Why Distributed Storage?



Distributed storage is best positioned to address the challenges of high penetration distributed solar power and plug-in electric vehicles (PEVs)

Why PHIL?

Just like a field test...

- Test physical energy storage hardware and capture the effects of electrochemistry, inverter dynamics, communication latency, and more
- High resolution distribution feeder simulation with environmental conditions and residential, commercial, PV, and PEV loads based on historical data

...but better:

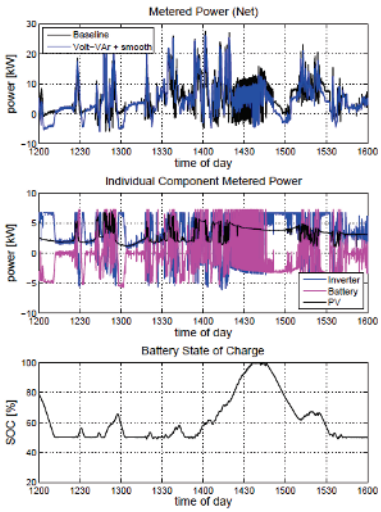
- Create repeatable conditions in highly complex environments
- Eliminate the risk of service interruptions and damage to equipment
- Avoid the long delays and high price of experimental field installations

Simulation + Hardware = Distributed Storage PHIL Testbed

Simulation

High resolution model of a distribution feeder with a high penetration of advanced technologies

- IEEE123 feeder with NREL-developed inverter and battery models in GridLAB-D
- PV, PEV, residential and commercial load profiles built from real-world historical data



Example response with Volt-Var + Smoothing control

Hardware

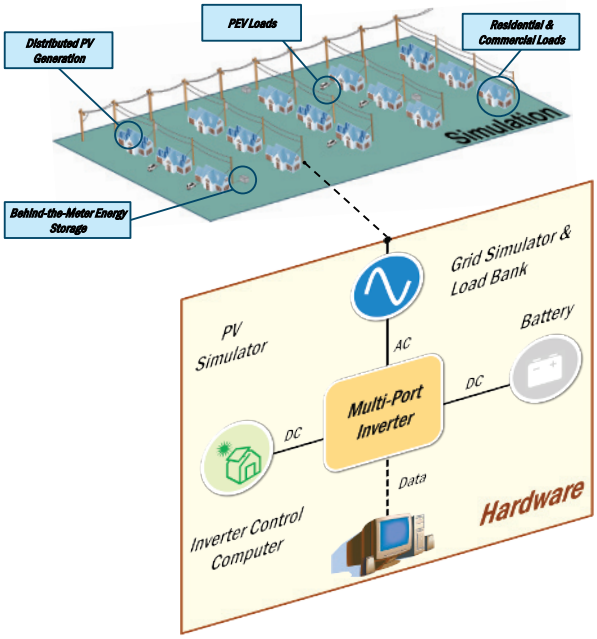
Real hardware replaces simulated inverter / PV / battery combination to evaluate limitations and non-linearities not captured in the simulation

- Interface simulation with hardware via a single point of common coupling (PCC)
- Demonstration configuration includes a multi-port inverter and Li-ion battery hardware connected to the ESIF grid and PV simulators

Grid Simulator: Elgar SW15750 Grid Simulator – 15.75 kVA
Load Bank: Simplex PowerStar 100 Resistive Load Bank – 100 kW
PV Simulator: TerraSAS ETS1000X PV Simulator – (2) Parallel 10 kW Modules
Real-Time Interface: Opal-RT eMegaSim Wanda 4U 16-core Real-time Simulator

Distributed Storage PHIL Testbed

Flexible platform for developing and testing distributed energy storage technologies and deployment strategies under life-like conditions.



Applications

Preliminary study:

- Assess the ability of distributed storage and simple smoothing, peak shaving, and voltage support controllers to support high penetration PV and PEVs

Potential subsequent studies:

- Develop and assess advanced energy storage control strategies
- Assess/compare off-the-shelf distributed energy storage products
- Evaluate candidacy of specific real-world feeders for energy storage

Timeline:

- PHIL system operational: August 2014
- Preliminary study complete: November 2014

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

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