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Microgrid Integrated Solar Storage Technology (MISST)

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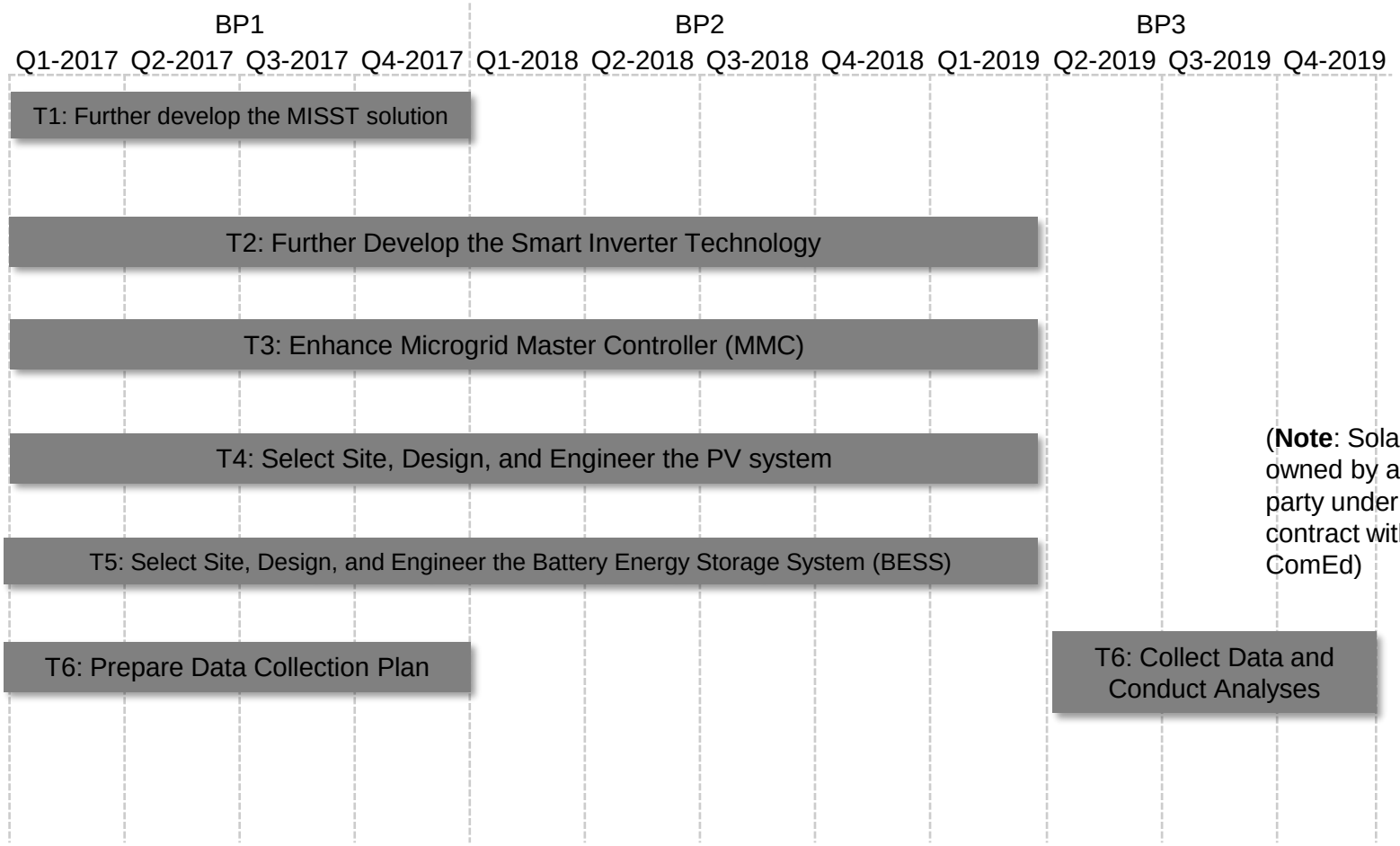
Microgrid Integrated Solar Storage Technology

Microgrid Integrated Solar Storage Technology (MISST) :
Development and demonstration of integrated, scalable, and cost-effective technologies for solar PV that incorporate energy storage in a microgrid

- $8 million project with $4 Million DOE grant
- The proposed technology, Microgrid-Integrated Solar-Storage Technology (MISST), addresses availability and variability issues inherent in the photovoltaic (PV) technology by:
  - Utilizing smart inverters for PV/battery storage and
  - Working synergistically with other components within a community microgrid
- MISST represents an enabling technology for the widespread sustainable deployment of low-cost, flexible, and reliable PV generation
- It enables a successful integration of PV power plants with the electricity grid

Timeline



- ✓ The project duration is 3 years and consists of 3 budget periods (BP)
- ✓ Completed BP1 and BP2 tasks. Started BP3.

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Smart Inverter Technology

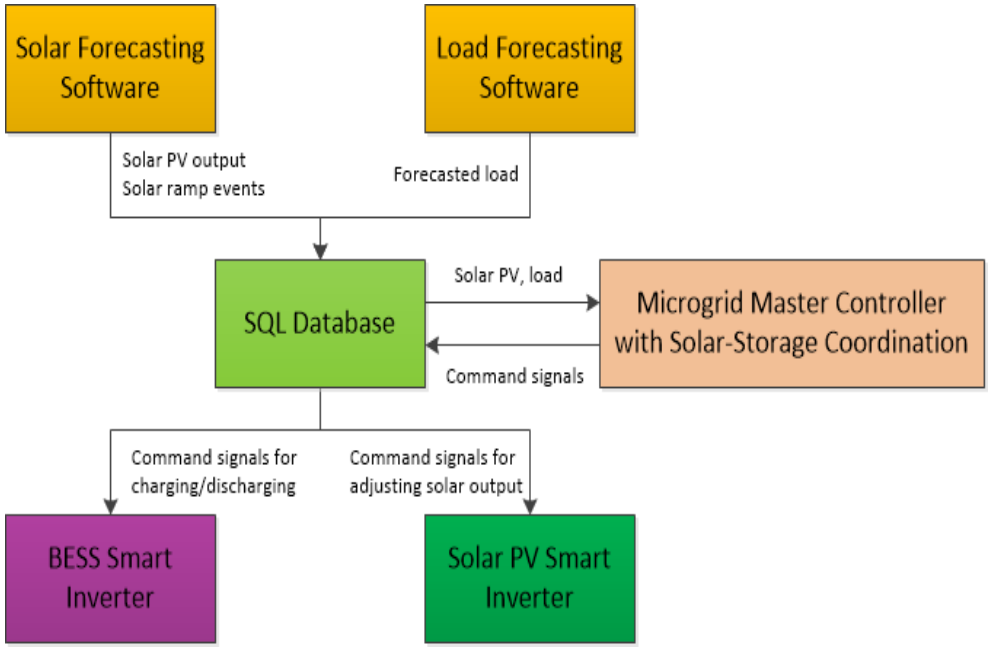
- Smart inverter in microgrid operates in two different modes- Grid Connected and Grid forming
- The Robust Droop Control (RDC) technology, based on synchronous machine characteristics, has been implemented in 100 kW smart inverter for PV and BESS applications and tested thoroughly via Power Hardware in the Loop (PHIL) tests.

Mode of Operation	Description	Current Status - Battery	Current Status - PV	w/BCM Model
Anti-Islanding	Refers to the ability to detect loss of utility source and cease to energize	✓	✓	
Adjustable constant power factor	Refers to Power Factor set to a fixed value. Some manufactures refer to this as 'Specified Power Factor'	✓		
Voltage – Reactive (Volt-var)	Refers to control of reactive power output as a function of voltage	✓	✓	✓
Ramp Rates	Refers to ability to have an adjustable entry service ramp rate when a DG restores output of active power or changes output levels over the normal course of operation	✓		
Voltage Ride through	Refers to ability of Smart Inverter to ride through a certain range of voltages before tripping off	✓		
Frequency Ride through	Refers to ability of Smart Inverter to ride through a certain range of frequencies before tripping off	✓		
Voltage – Active Power (Volt/Watt)	Refers to control of real power output as a function of voltage	✓	✓	✓
Frequency - Watt	Refers to control of real power as a function of frequency	✓	✓	✓
Grid Forming	Refers to ability of Smart Inverter to act as grid forming source in islanded mode	✓		
MPPT	Refers to the capability of the Inverter to maintain Power at maximum power point.	NA	✓	

Inverter Functionalities and Test Scenarios

Solar-Storage Coordinated Control

- The solar-storage coordinated control is the enhancement in the existing Microgrid Master Controller (MMC), developed during another DOE project.
- The control methodology considers robust modeling to accommodate the uncertainty in Solar PV with small time-step value to dispatch a constant aggregated output.
- Developed algorithm has been tested through Hardware in the Loop tests via RTDS.



Solar-storage controller high-level architecture

Multi-time scale model

- The model considers the sub-hourly variation of the PV outputs to handle the rapid changes

Robust modelling

- The model considers all possible scenarios to mitigate the forecasting error or uncertainty

Constant hourly aggregated solar-storage output

- The output of the solar-storage system in the proposed model will remain unchanged on an hourly basis even if the PV unit outputs deviate from the forecasted values.

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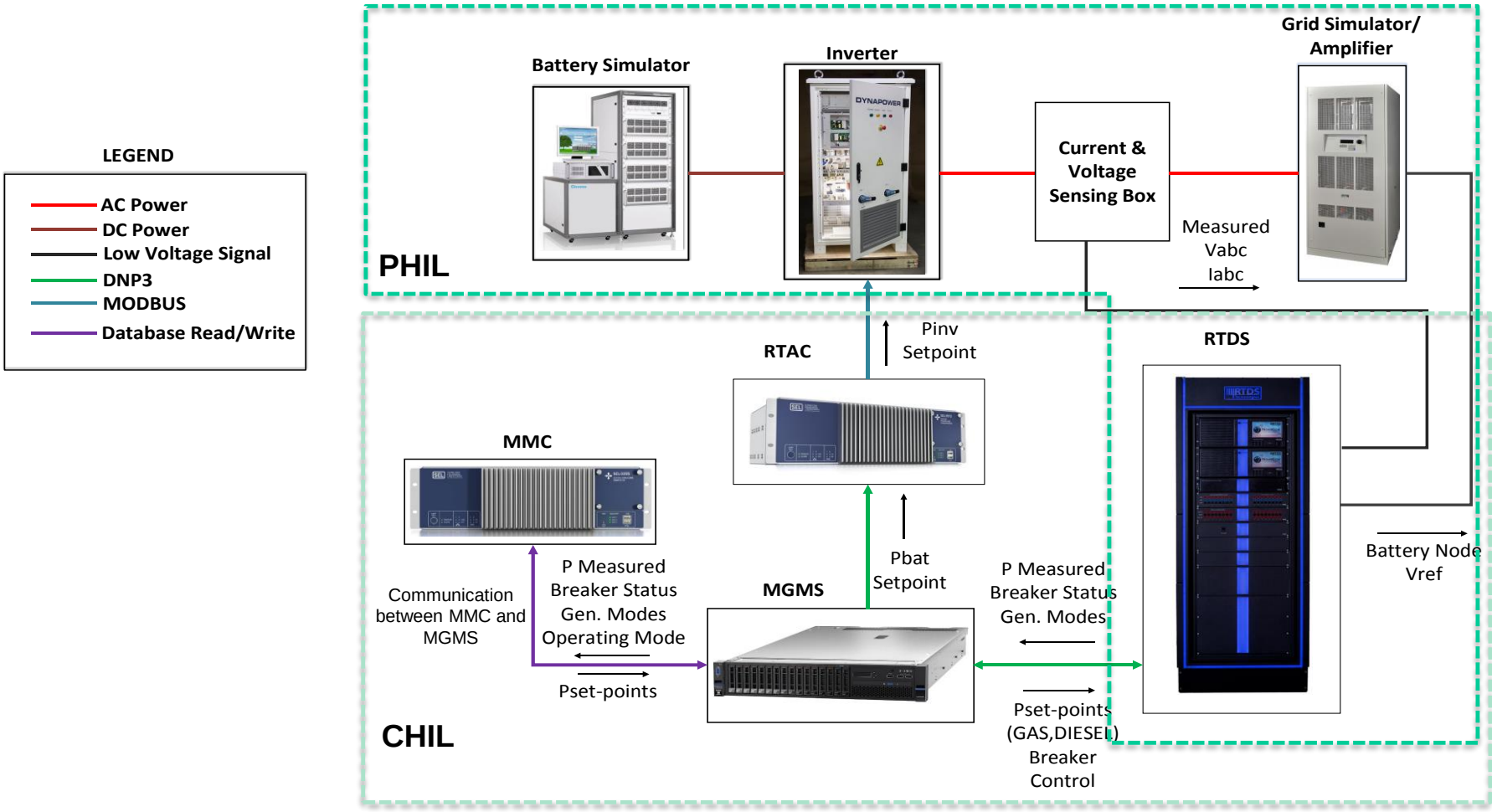
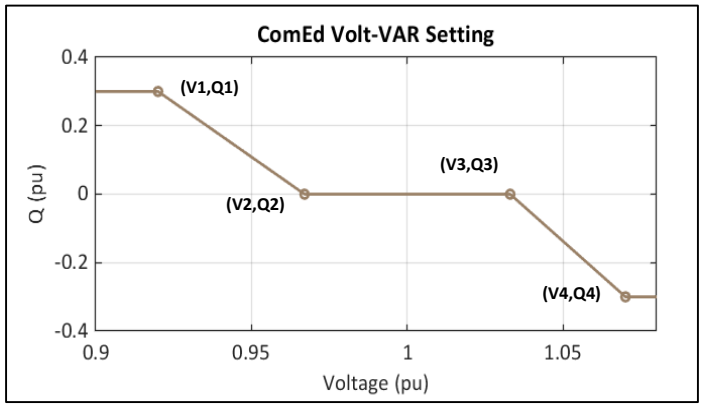
Integrated PHIL and CHIL Test Setup



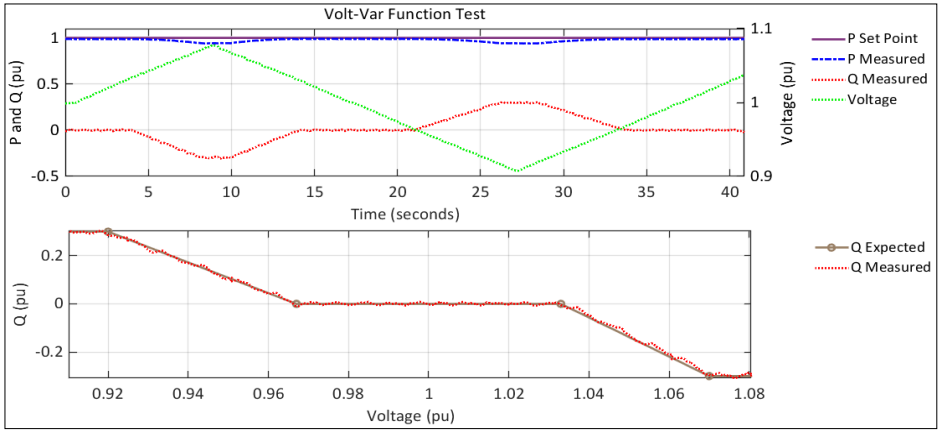
Smart Inverter Test Example: Volt-var

ComEd Volt-var Setting:

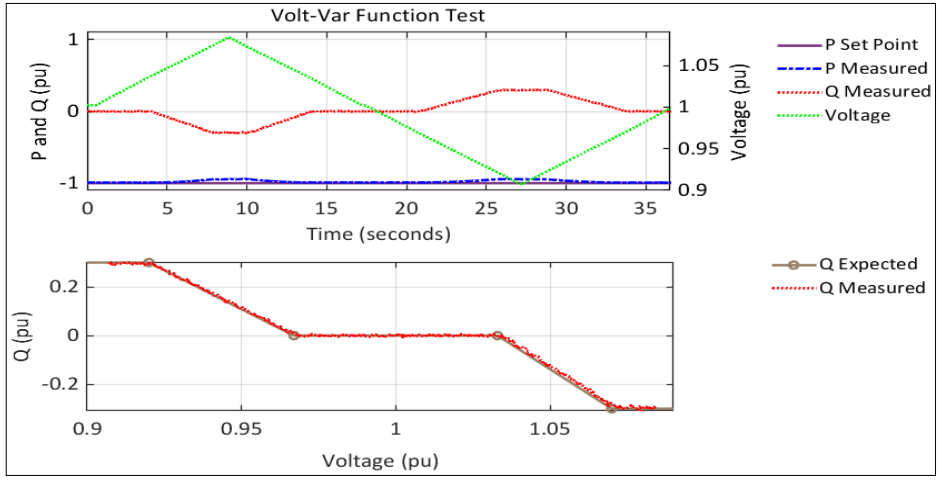
Parameter	Value (%)
V1	92
Q1	30
V2	96.7
Q2	0
V3	103.3
Q3	0
V4	107
Q4	30



ComEd Volt-var Setting: 100% Discharging



ComEd Volt-var Setting: 100% Charging



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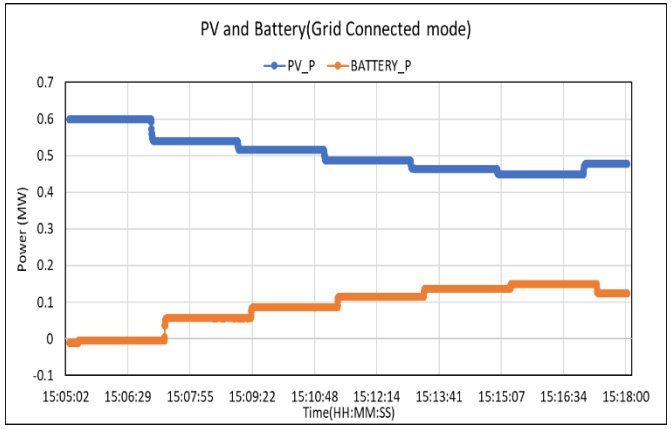
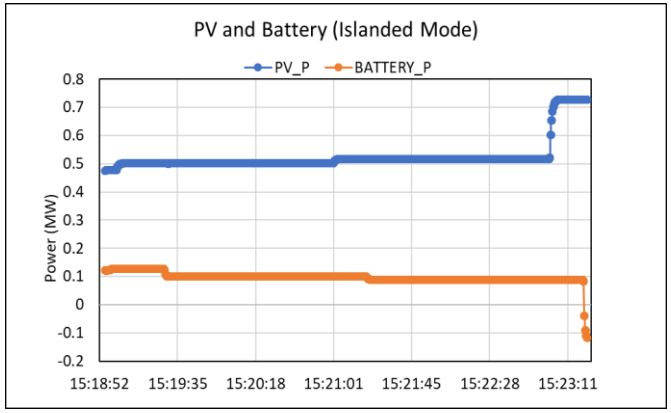
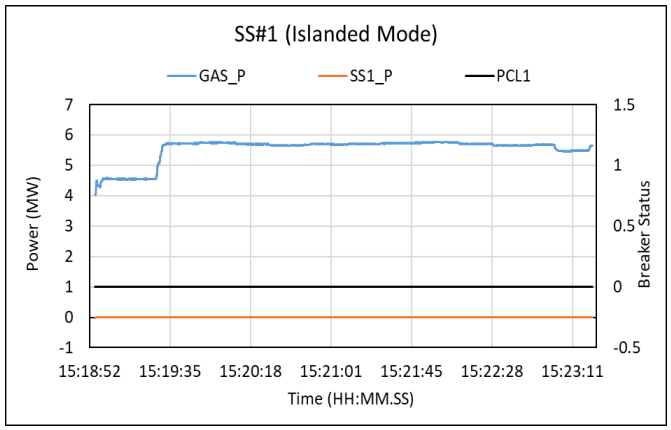
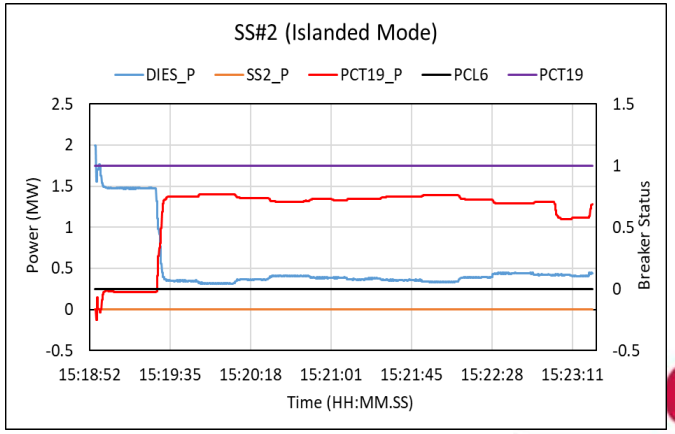
MISST in Grid Connected and Islanded Mode

- In the grid connected mode, only BESS and PV are used as DERs.
- MMC calculates the BESS setpoint to retain the integrated BESS and PV output constant and to address the variability in PV.
- In islanded mode, MISST algorithm provides optimal setpoint for BESS and PV along with other generators









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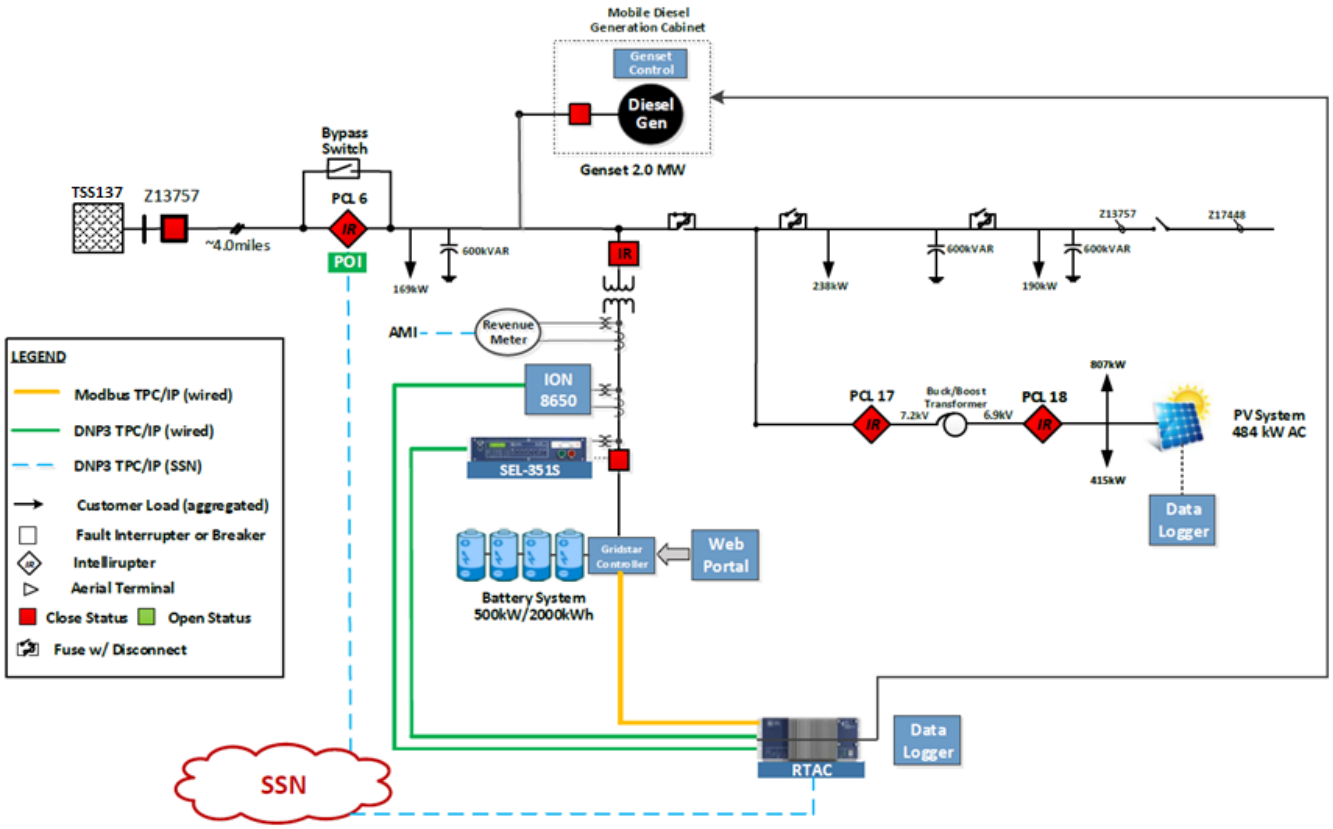
Solar PV and BESS in BCM

Solar PV Installation

Battery Energy Storage Installation

Simulated Islanding Test

- Simulated islanding on portion of the BCM feeder using portable generation, PV and BESS in preparation for actual island test later in 2019
- Controllable generation is used to maintain the POI flow within the threshold
- 500 kW battery used to zero out POI power while 2 MW generator used to offset load



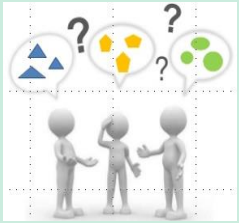
Schematic diagram of the Phase 1 test system

Challenges

Innovative scope including both research and field demonstration

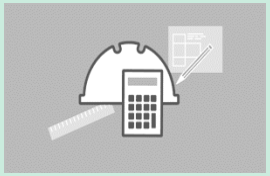
Coordinate with stakeholders, including research partners, vendors, system integrators, 3rd party PV owners, etc.

Develop, test, commercialize and deploy technologies in the field



HIL test design and implementation

Design Hardware in the Loop testbed, install and configure all hardware and validating innovative technologies via HIL through RTDS



Field implementation and testing

Deployment and site acceptance tests for PV (3rd party owned) and BESS with smart inverter functions

Perform islanding tests for microgrid islanding capability

Data collection and analytics

Develop data collection plan, install measurements, collect data to analyze microgrid performance and benefits

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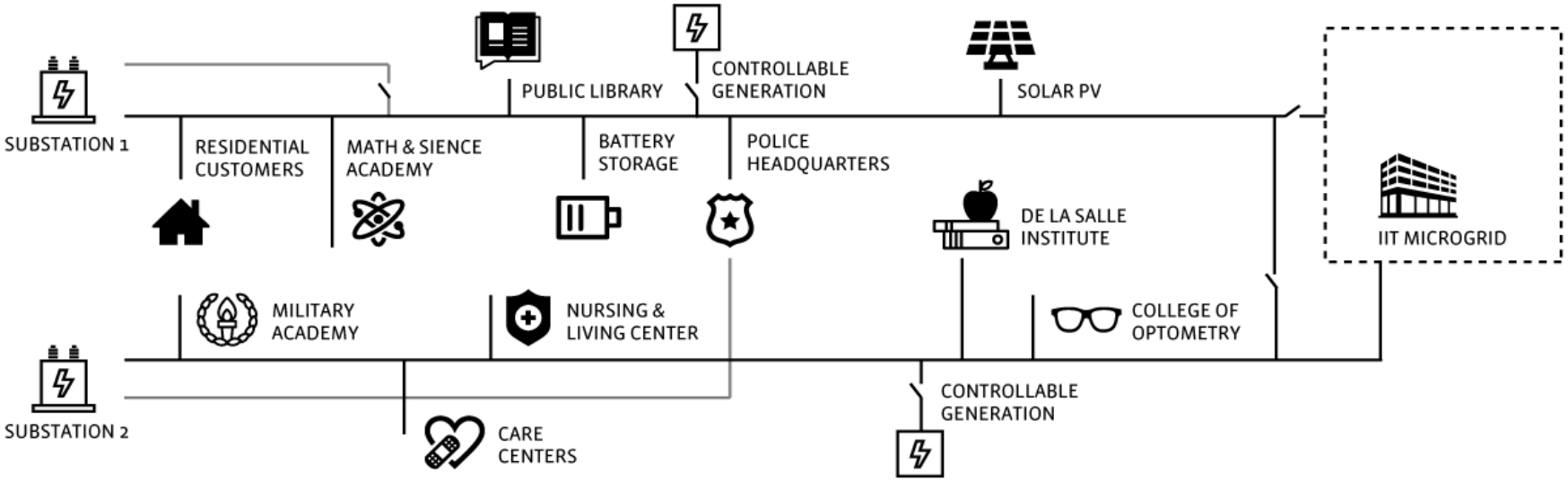
Next Steps

- Integration & commercialization of the developed MISST technology within Microgrid Master Controller – ongoing project to integrate within Microgrid Management System (MGMS) commercial platform
- Islanding test for the microgrid
- Comprehensive data collection and analysis for budget period 3. Reports and lessons learned
- In addition, SHINES is part of ComEd bigger Bronzeville Community Microgrid project

SHINES is Part of ComEd BCM Project

- Illinois Commerce Commission (ICC) approved ComEd's microgrid project in Feb. 2018.
- The Bronzeville Community Microgrid is being built in two phases:
- **Phase I** – 2.5 MW load, PV (3rd party owned) and Battery Energy Storage System, mobile generators for testing
- **Phase II** – 7 MW total load, Controllable generation (3rd party owned), clustering with Illinois Tech microgrid
- Five U.S. Department of Energy grants to develop, test and further advance microgrid controller, integrate PV and Battery Energy Storage System, develop intelligent sensors as well as EV technologies



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Thank You!