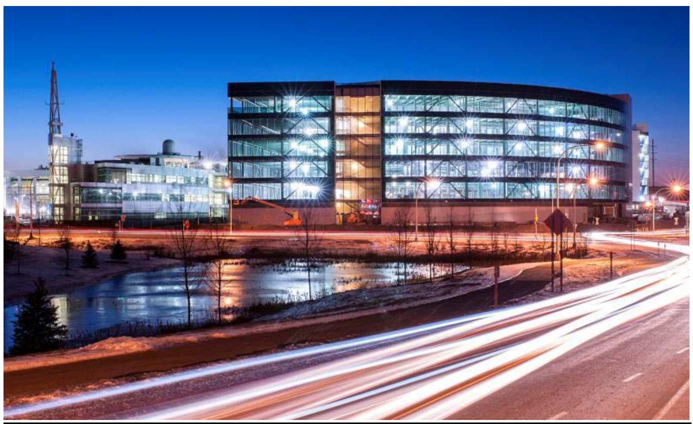
SUNY POLYTECHNIC INSTITUTE

CATN2
Center for Advanced Technology in Nanomaterials and Nanoelectronics

SUNY Polytechnic Institute's Back-up Power Test-Bed Assets




Smart Energy Test-bed (SET)

The Research Foundation for SUNY on behalf of SUNY Polytechnic Institute's (SUNY Poly) Colleges of Nanoscale Science & Engineering (CNSE) created the Smart Energy Test-bed for manufacturers, developers and installers for in-depth, pre-commercial product testing of emerging fuel cell, photovoltaic (PV), backup power integration, and natural gas purification and reformation technologies through National Grid's Renewable Energy & Economic Development (REED) grant. The result of a collaboration with the Japanese government's investment by the New Energy and Industrial Technology Development Organization (NEDO), Shimizu, and Fuji, and Solar Frontier, this real-time, real-condition test lab has supported installers, developers and manufacturers on ways to be competitive within the industry and region by alleviating the costly burden of prototype testing and verification.

The Smart Energy Test-bed (SET) operates under ZEN and includes:

- Photo Voltaic Production-scale Test Bed composed of sixteen 2 megawatt (MW) PV solar power arrays (14,000 modules/site) sites totaling 32 MW utility-scale installations in the Capital Region;
- Roof Top PV Module Test-bed located on the roof level of NanoFab North and NanoFab East;
- Phosphoric Acid Fuel Cell (PAFC) Test-bed providing 100kw power and 147 kw waste heat;
- Capacitor Energy Storage Test-Bed (CES Test-bed) for ultra-capacitor evaluation;
- Power Back-up Synchronization Test-bed (PBS Test-bed) for power quality and resiliency testing.

Capacitor Energy Storage Test-Bed (CES Test-bed)

The Energy Storage Test-Bed aims to advance high voltage electrolyte by first optimizing the electrolyte composition in Electric Double Layer Capacitors (EDLC) cells. A SUNY Poly researcher leads an effort to identify the high voltage degradation mechanism through post-mortem materials analysis of the bench top cells: the electrolyte composition is being adjusted to minimize device resistance and account for the high voltage degradation mechanism; and the electrochemical characteristics of these devices are being evaluated using chronopotentiometry and electrochemical impedance spectroscopy.

SUNY Poly's Smoothing Capacitor for Power Harmonics between Traditional Generator and Fuel Cell operating in parallel for on-site emergency generation.

Power Back-up Synchronization Test-bed (PBS Test-bed)

The Power Back-up Synchronization (PBS) Test-bed simulates a back-up power systems response to a sudden power shut-down and black-start operation of emergency generators. When multiple generators are connected to a common Auto Transfer Switch (ATS) and Emergency Power Panel (EPP), often the power harmonics do not synchronize if there is a mismatch between the inverters from multiple emergency power generators. The PBS Test-bed currently operates a phosphoric acid fuel cell (PAFC) and a traditional diesel generator. The PBS Test-bed has an active filter and a unique smoothing capacitor that can be positioned at different locations (generator side its isolation transformer or EPP panel side) to adjust the power harmonics to operate in parallel to maintain power quality.

SUNY Poly's fuel cell operating in parallel with the on-site emergency generator.

Phosphoric Acid Fuel Cell Test-bed (PAFC Test-bed)

One of the leading obstacles to the deployment of emerging clean energy (CE) technologies is access to real-world operational data used in determining both technical and financial viability. SUNY Poly established a unique public private partnership to establish an electrochemical power generation system test-bed that includes a Fuji Electric 250 kW (rated 105 kw electric & 145 kw heat output) Phosphoric Acid Fuel Cell (PAFC), with external fuel desulfurizer unit, adjacent diesel back-up generator, Auto Transfer Switch (ATS), Emergency Power Panel (EPP), data capture and analysis systems, and an active filter and smoothing capacitor to improve wave form harmonics.

With over $4.5 million of total investment, the Phosphoric Acid Fuel Cell (PAFC) Test-bed includes: NYSERDA ($711,000) to install, operate and evaluate power resiliency application, Japan's New Energy and Industrial Technology Development Organization ($1,900,000) for the PAFC, National Grid ($750,000) for measurement, validation and workforce training and the Research Foundation for SUNY ($1,000,000) for traditional power infrastructure and program management.

The PAFC Test-bed evaluated technical viability to assess operational efficiency (system reliability, power quality, etc.), measurement of environmental benefits (direct & indirect emissions reductions), and integration with legacy and emerging technologies for traditional and smart building applications. It also evaluated financial viability to measure net capital investment using return-on-investment (ROI) and total operating costs using total cost-of-ownership (COO). These were then used to evaluate PAFC for transitioning to smart grid environment (distributed system pricing, demand response, etc.), potential market applications (e.g. mission critical resiliency, load pocket response, etc.), and facility design considerations (e.g. combined cooling, heat & power-CCHP, power density & scalability, etc.).

SUNY Poly's Dr. Harry Efstathiadis provides an informational tour of the fuel cell.

The ZEN test-bed provided the opportunity for the team to examine PAFC test-bed performance within a SoS configuration to: 1) examine the opportunity to pair the PAFC power and heat output with the power and cooling load associated with the ZEN data center with inclusion of absorption chillers in a combined cooling, heat and power (CCHP) deployment; 2) model system contribution within in a zero energy "smart" building application; 3) develop a machine learning algorithm; and, 4) establish a workforce training stand for hands-on learning by faculty and students, facility engineers and technicians, and, design engineering and end- users.

The PAFC Test-bed is supported by an Itron Delta 2M meter, measuring gas input, and a GE kV2c meter, measuring electrical output, wired via conduit to an Obvius AcquiLite data logger. The data logger connects to the internet via a 3G Cradlepoint cellular modem and uses a dedicated external static IP address, which allows access to configure the logger remotely. The data logger records data from the meters every fifteen minutes.

The data is uploaded once per day to NYSERDA's database (via the cellular connection provided by CDH energy), where it gets checked for validity and posted to the integrated data web site. Based on the number of data points monitored, the logger can store up to 30-days of data if communications are interrupted.

The data collected is used to determine the electrical efficiency of the fuel cell using the following formula, based on the lower heating value of the natural gas:

$$EFF_{ele} = \frac{3{,}413 \cdot WG}{LHV_{gas} \cdot FG}$$

WG	-	Net generator output (kWh)
FG	-	Generator gas consumption (Std CF)
LHVgas	-	Lower heating value for natural gas (~927 Btu/CF).