Matthew R. Bernier
ASSOCIATE GENERAL COUNSEL

December 8, 2020

VIA ELECTRONIC FILING

Adam J. Teitzman, Commission Clerk
Florida Public Service Commission
2540 Shumard Oak Boulevard
Tallahassee, Florida 32399-0850

Re: *Duke Energy Florida, LLC's Demand Side Management Annual Report for Calendar Year 2019*; Undocketed

Dear Mr. Teitzman:

Please find enclosed for electronic filing Duke Energy Florida, LLC's Response to Staff's Second Data Request (No. 7).

Thank you for your assistance in this matter. Please feel free to call me at (850) 521-1428 should you have any questions concerning this filing.

Sincerely,

/s/ Matthew R. Bernier

Matthew R. Bernier

MRB/cmk
Enclosures

cc: Michael C. Barrett

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Duke Energy Florida, LLC's Response to
Staff's Second Data Request Regarding Duke Energy Florida, LLC's
2019 Annual FEECA Program Progress Report

7. In Duke Energy Florida's Response to Staff's First Data Request, Item 2, dated April 17, 2020, the Company provided information on research and development initiatives.

A. Please provide a detailed update on the project with the University of Central Florida to document the value of long-duration customer-side energy storage systems.
B. Please provide a detailed update on any other research and development initiatives that are related to energy storage.

<u>**Response**</u>**:**

A. Duke Energy/UCF Long-Duration Energy Storage Project

This project is a collaboration between DEF and the University of Central Florida (UCF) to document the value of long duration, customer-side energy storage systems. Long-duration energy storage (4 hours+) may be best achieved by employing technologies like flow batteries. This project will use the technology at UCF's Microgrid Control Lab to directly test a long-duration, vanadium flow battery energy storage system in multiple use cases including:

- Study of battery performance during charging and discharging, at various states-of-charge, loading, duration of discharge and documenting the effects (battery degradation, efficiency, etc.)
- Voltage and frequency control of a battery storage system in a distribution system with high penetration of solar energy
- Control of grid-following. PV/battery inverters for optimal operation while interconnected with the power system
- Operation and control of behind-the-meter distributed energy resources (PV, battery, EV, thermostatically-controlled loads and smart buildings) to provide various grid services, including peak capacity management, demand response (consuming or generating), frequency regulation, ramping capability, primary frequency response and voltage management
- Explore the capabilities of the energy storage system to support an islanded microgrid during grid power outages
- As the research progresses, additional testing may be developed and additional applications explored.

The project will install a vanadium flow battery, energy storage system rated at approximately 10 kW power output, 40 kWh of energy capacity, with a control system that will enable the advanced features discussed above. The unit will be located at the UCF Research Building I where Microgrid Control Lab is located on the campus of UCF. The energy storage system will be connected to a real-time digital simulator through a 4-quadrant amplifier power system that includes a PV system simulator.

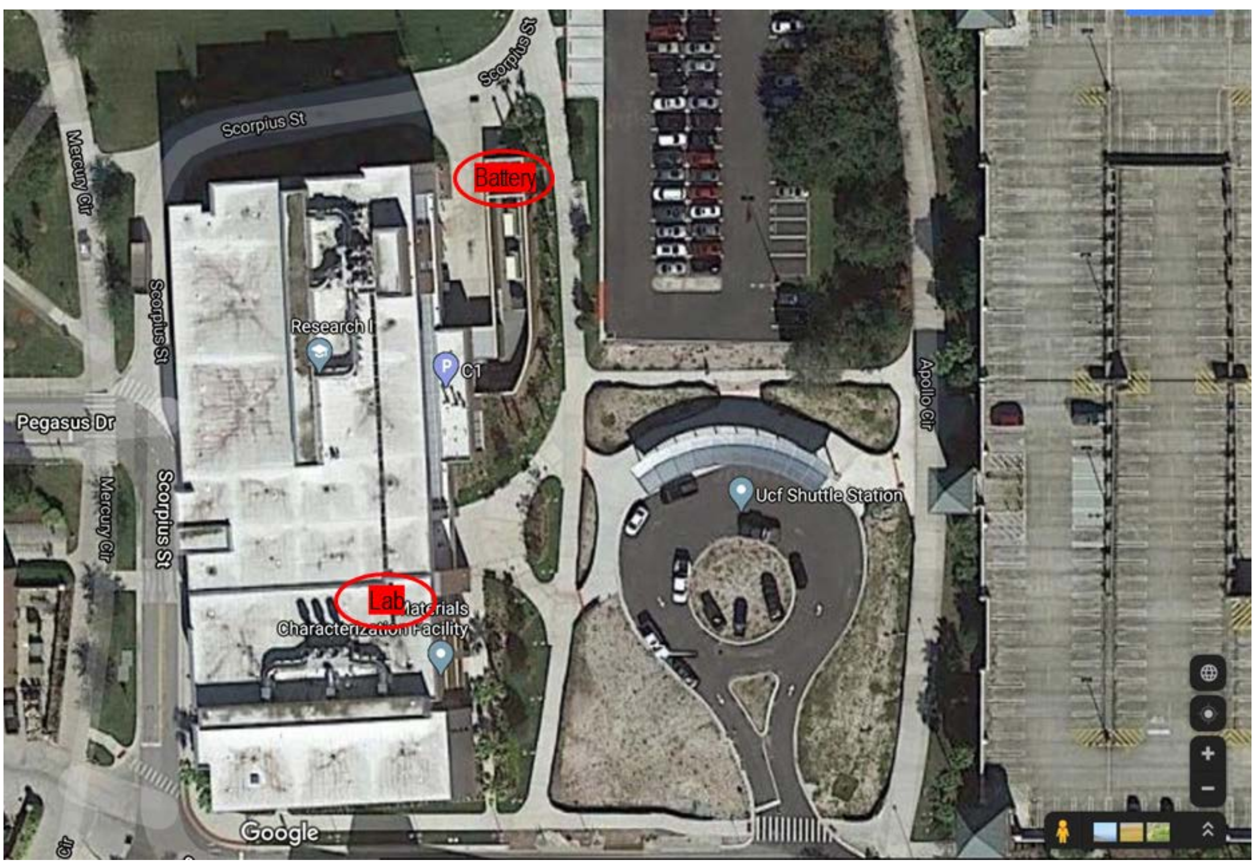
Project Status

Installation:

The Avalon (now Invinity) Vanadium Flow Battery was procured and commissioned on-site. The battery specifications are:

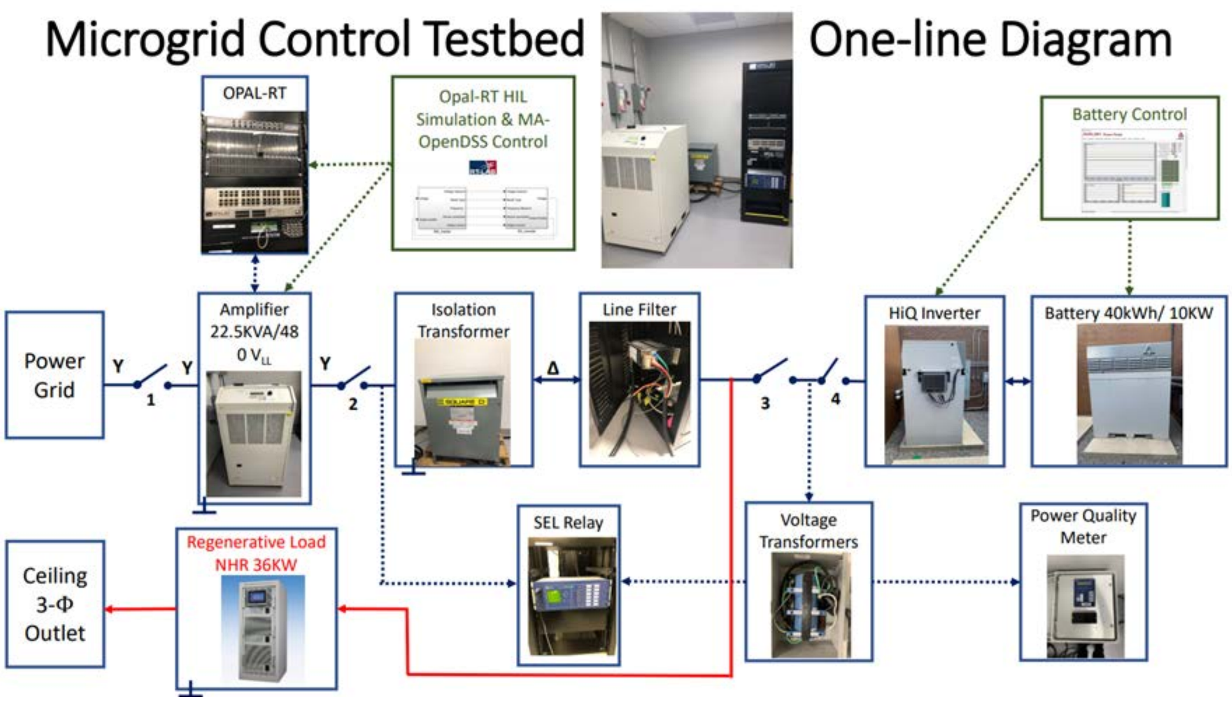
Rated energy storage capacity	40 kWh
Max continuous DC power	12 kW
Rated DC power	10 kW
Nominal energy storage duration	4 hours
Nominal operating voltage	950 DC V
Battery Voltage Range	800 to 1000 DC V
Annual degradation of energy storage capacity	<0.5% per year
Round-trip (DC) battery energy efficiency	>75%
Annual degradation of energy efficiency	<0.1% per year
Ambient operating temperature range	-5-45°C
Extended ambient operating temperature range with optional cold weather kit	-25-45°C
Storage temperature range	-25-50°C

The battery was installed at the UCF Microgrid Lab:



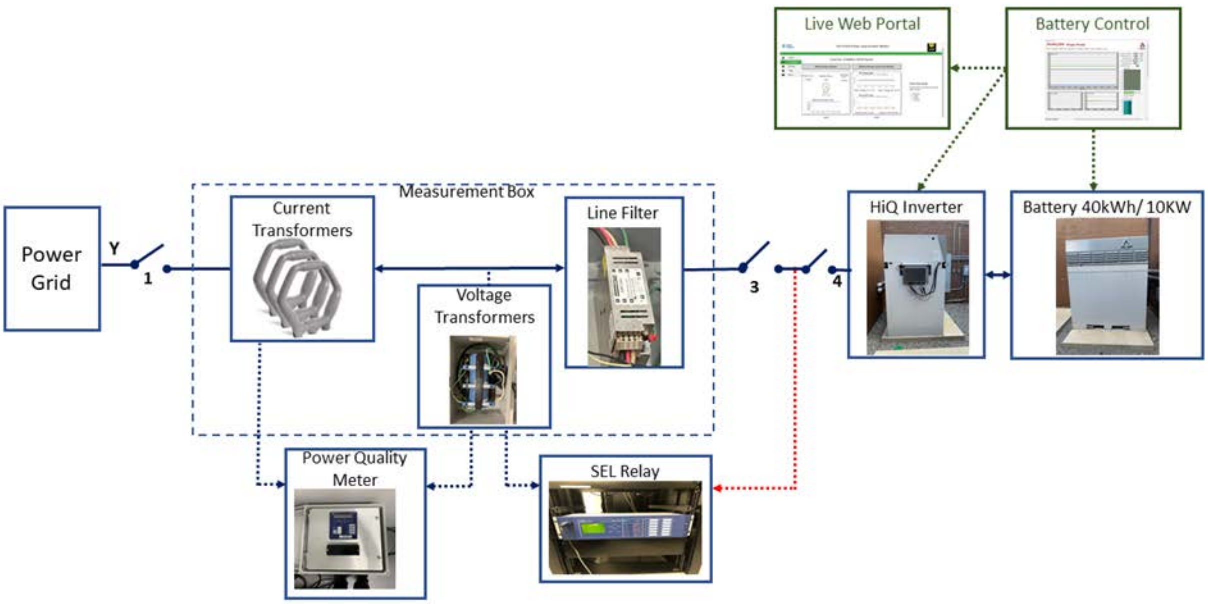
- Avalon Vanadium Flow Battery Installed
- Systems uses HiQ Solar Inverter mounted to battery
- AC wiring brings the battery power into the Microgrid Lab for interfacing with the PHIL System

The one-line diagram of the test setup for this project is:

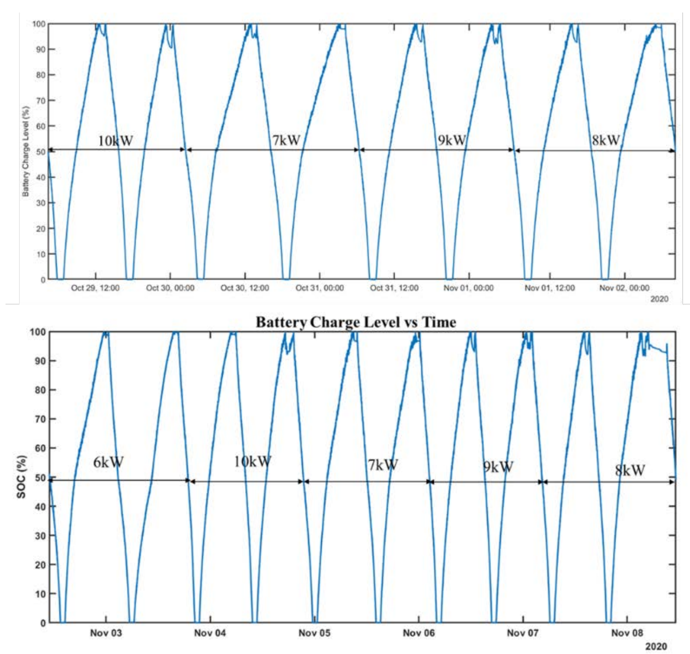


Testing:

We are currently testing the performance characteristics of the battery system. Charge/Discharge testing is underway. The testbed configuration for this testing is:



We are doing repetitive charging and discharging the battery at different power rates. Some preliminary test output:



Multiple cycles at different charge / discharge rates for a 2 week period during October and November 2020

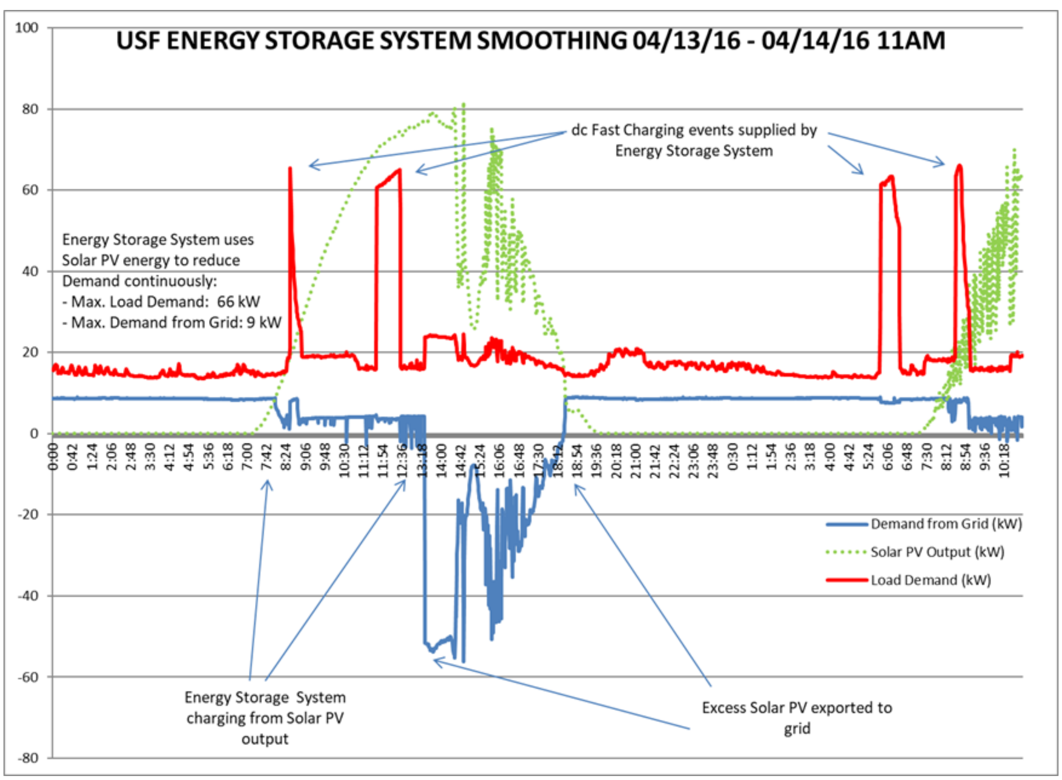
Extensive charge/discharge testing is continuing. Full analysis of these test results will determine observed battery response time, capacity, round-trip efficiency, etc.

Next steps:
The next steps for this project include reconfiguring the testbed for operation in the Power-Hardware-In-Loop configuration (PHIL). The energy storage system and PHIL system will be used together to test all the energy storage system functions including renewable smoothing, time-shifting renewable energy output, peak shaving, demand response and others.

B. Duke Energy/USF Renewable Energy Storage Project

This project is a collaboration between DEF and the University of South Florida. The purpose of the project is to explore the integration of intermittent renewable energy and distributed energy storage. Combining the high efficiency of a lithium ion energy storage battery system with the locally, available energy from Solar Photovoltaics (PV) in a microgrid allows the renewable energy to be used when it is most valuable. Through advanced controls, the intermittent solar PV output can be used at any time for a multitude of value-added applications. These applications include energy shifting, frequency response, peak shaving, demand response and islanding critical loads during utility power outages. This project also includes integration of Level 2 and dc fast charging for electric vehicles.

Project Status
The Solar PV array, 200 kW / 400 kWh energy storage system, a dc fast charger, and a level 2 EV charger were integrated into a microgrid at USF's 5th Avenue Garage in May 2015. The system was shown to successfully achieve the applications of energy shifting, peak shaving and load leveling for the dc fast charger.



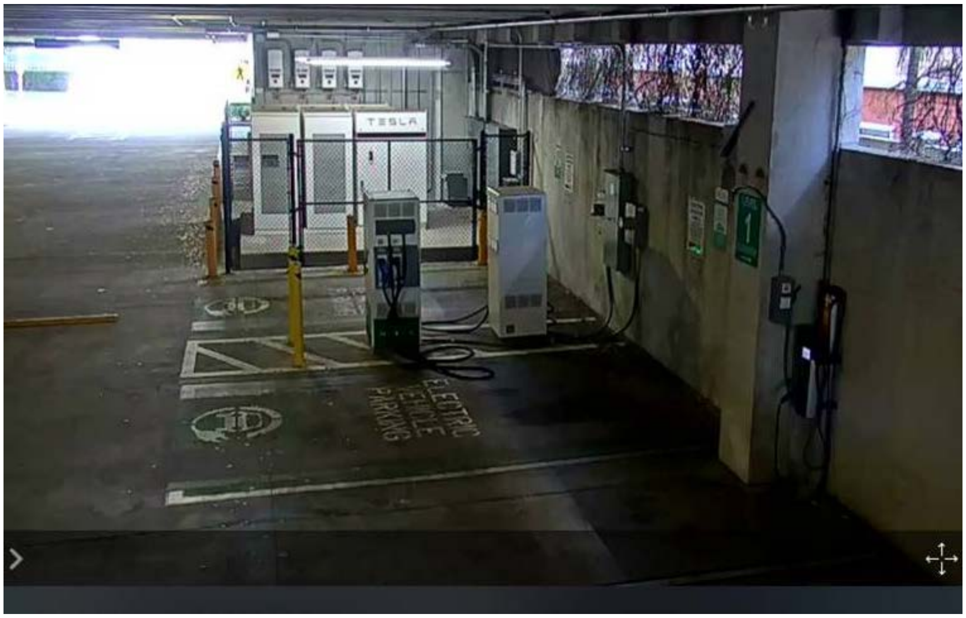
In order to achieve demand response and islanding operation for the microgrid, the energy storage system needed to be upgraded. In May 2018, Tesla (at their expense) upgraded the energy storage system to a 250 kW/475 kWh Powerpack 1.5 Li-ion energy storage system. During this upgrade, DEF replaced the single dc fast charger at this site to two 50 kW dc fast chargers. The level 2 charger remained in service.

The capabilities of the new energy storage system included the capability to operate the microgrid during an outage. The microgrid has been islanded during many simulated outages where the connection to the grid was opened. The battery supported the loads and the Solar PV rejoined the microgrid. When the grid connection was closed, the microgrid synchronized with the grid and reconnected.

New controls enabled automatic control of the energy storage system to optimize customer cost on TOU rates. The system can also use the renewable energy available for demand response.

The microgrid consists of the 100 kWdc solar PV array, PV inverters (4@ 20 kW), 250kW/475 kWh energy storage system, interfacing equipment and loads including 2@ 50 kW dc fast chargers.

100 kW PV Array

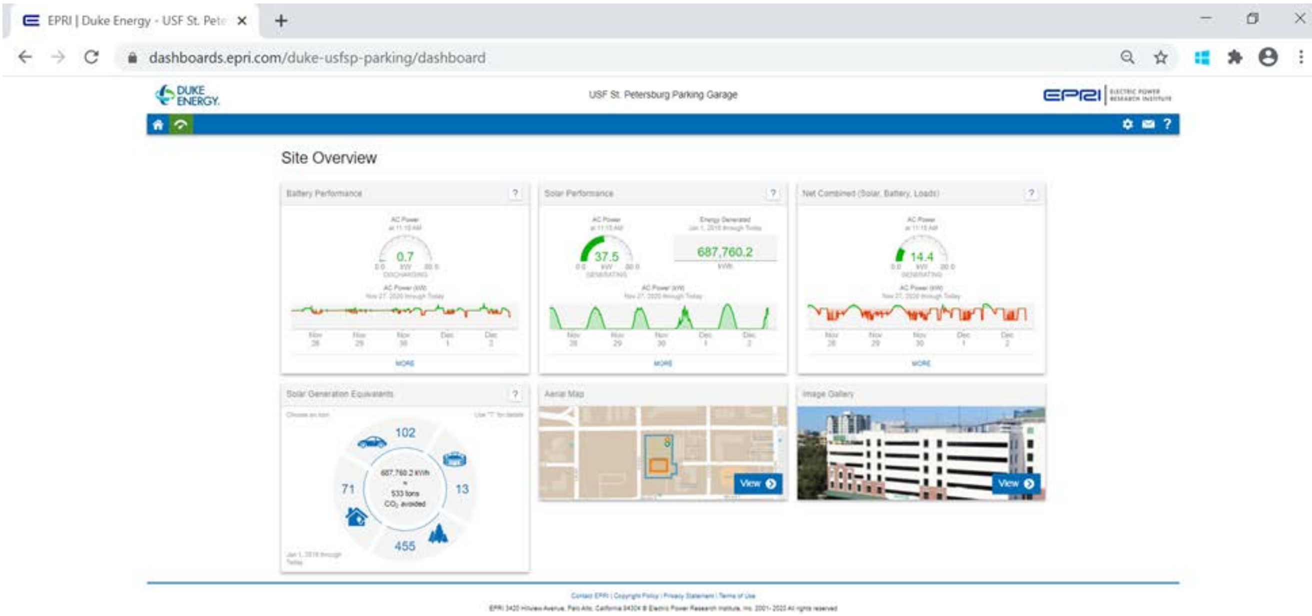


Microgrid with battery, PV inverters (far wall), interconnecting equipment (right wall) and dc fast chargers (foreground).

Tesla Powerpack 1.5

Dc Fast Chargers

To monitor the system, DEF worked with the Electric Power Research Institute (EPRI) to add this site to their Distributed Photovoltaics Project. This included installing metering to monitor the output of the Solar PV system, energy storage system and the total microgrid output or input power from the grid. For this site, EPRI developed an online dashboard that is open to the public and provides solar, energy storage and net load data (https://dashboards.epri.com/duke-usfsp-parking). The dashboard is very user friendly and provides near real time information on the operation of the microgrid. This dashboard enables daily monitoring, troubleshooting and data acquisition.



USF St. Petersburg 5th Avenue Garage Microgrid Dashboard Site Overview Screen

Next steps:

The next steps for this project include USF research including data analysis to document capacity, round trip efficiency, degradation and suitability for grid services applications. USF will perform simulations of microgrid operation under various conditions. They will also study transient operation during dynamic system conditions including grid disconnection, reconnection and fault conditions.