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Primary Project: EV Charging and Grid Off and On-Grid Network Operating Systems for Resilient Hybrid Energy System for Puerto Rico

Secondary Topic: Automation Strategies for Rapid Energy Restoration and Monitoring

Proposing Team:
Fuller Equity Partners LLC PR, NovaCharge, University of South Carolina

Best-in-breed hardware with a commitment to open standards.

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Technical & Business Contact: Lancen Fuller, lfuller@fullerequitypartners.com

I. Proposed Technology:

The goal of this project is to develop and demonstrate an operating system for an integrated energy system for communities to deliver resilient and low cost electrical energy in Puerto Rico. The system will autonomously restore power to the load with the community in case of grid power disruption and will have the ability to support the grid for restoration. The concept of the proposed system builds on the expertise and experience of the proposing team on power conversion hardware and controls, system-level energy management, and operating system enabled by artificial intelligence. Major unique and innovative features of the proposed solution are:

- A streamlined operating system that does not require one off development and installation.
- It uses Electric Vehicle (EV) charging stations (NovaCharge Network Hardware and Software) and EVs as assets for resiliency.
- It uses only two types of converters to build and interface the energy system.
- It uses estimation, forecasting, and artificial intelligence for long-term and short-term decision making during normal and abnormal conditions.

Figure 1 describes a sample system that includes energy resources and interfaces, community system loads, and the operating system. The energy system includes solar PV, stationary energy storage, DC Fast Chargers (DCFC) for EVs, and fuel cells. The community consists of several buildings with diverse load profiles with a 480VAC distribution voltage. The operating system runs on an edge industrial PC receiving data from sensors, communicating with Distribution System Operator (DSO), and enabling communication with WebEOC and Energy Emergency Assurance Coordinators (EEAC).

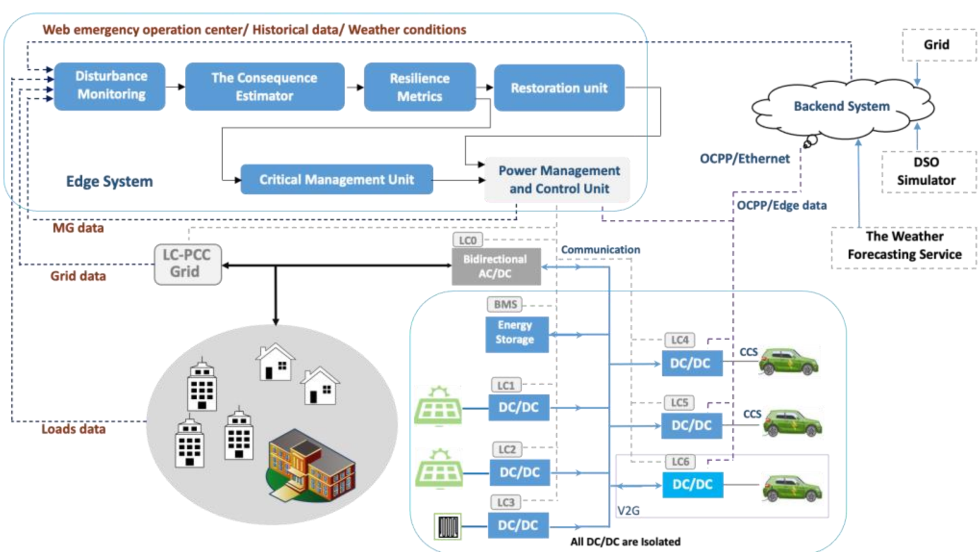

Figure 1. System topology including community, energy resources, and data-enabled power management system.

The energy system is built by our bi-directional 100kW AC/DC (IM-100) and isolated DC/DC (EV-100) converters. It has a 900V DC bus that connects solar PV, Fuel cell, energy storage, DCFCs together. The 100kW AC/DC inverter (480VAC/900VDC), developed under grants from NSF, is the interface for the stationary energy storage. It also connects the DC bus to the 480VAC grid acting as an active front end. The isolated bi-directional DC/DC converter, developed under ARPA-E and private funds, is a 200A DCFC. It can be paralleled to increase the charging current. It also connects the fuel cell to the DC bus. We have also implemented MPPT function in the converter to connect solar PV to the DC bus. The community includes several building loads connected to the AC system.

The system is multi-input, multi-output managed needing an operating system that can manage energy generation, energy storage, EV chargers, loads, and grid interface. It is installed on an industrial PC as an edge system receiving inputs from sensors and all intelligent sources, loads, and grid distribution system. In a normal operation, the goal of the operating system is to (i) reduce energy cost of the system, (ii) reduce demand charge, and (iii) perform energy arbitrage with grid. The system, as demonstrated in Figure 1, continuously monitors the system for any power disturbance from grid monitors and communication. After a grid disturbance is detected, the operating system will redirect all the power to support the community. Figure 2 describes the core models, data flow, data platform, data analytics, and outputs for the operating system.

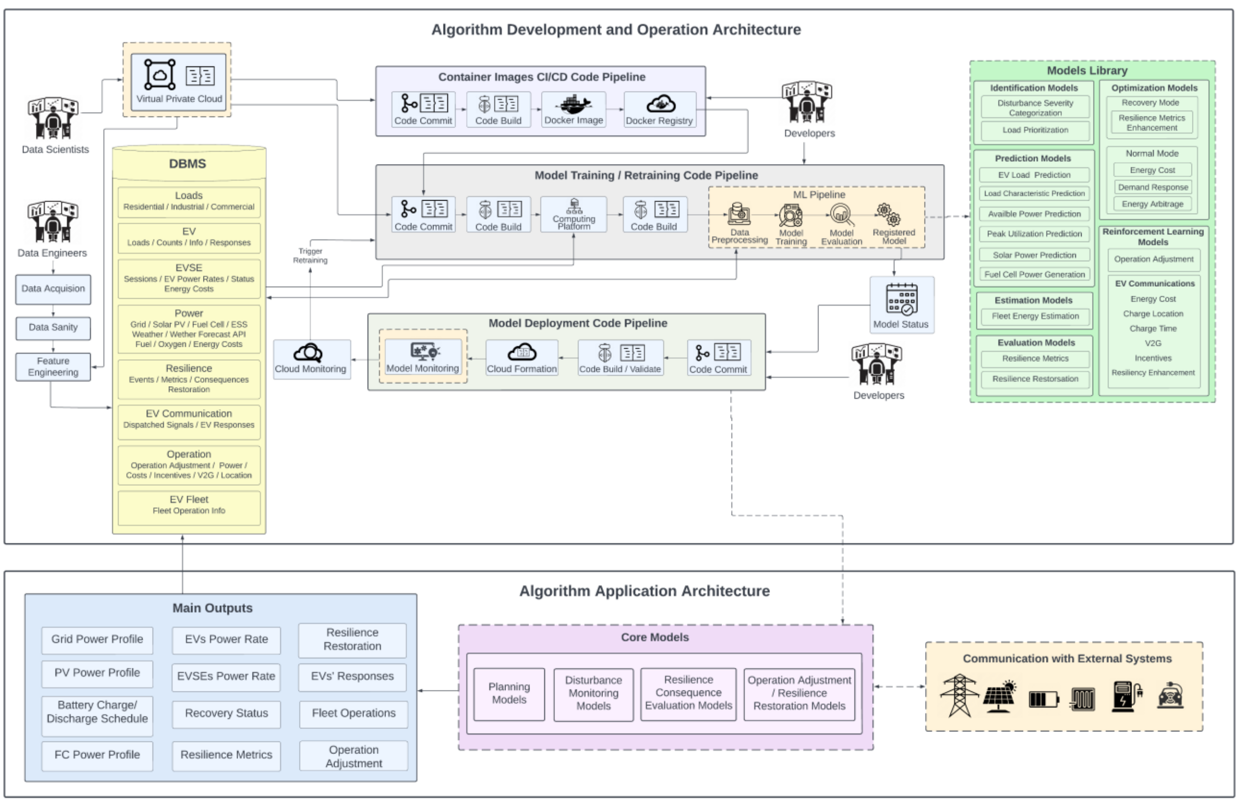

Figure 2. Data analysis flow algorithm for the operating system.

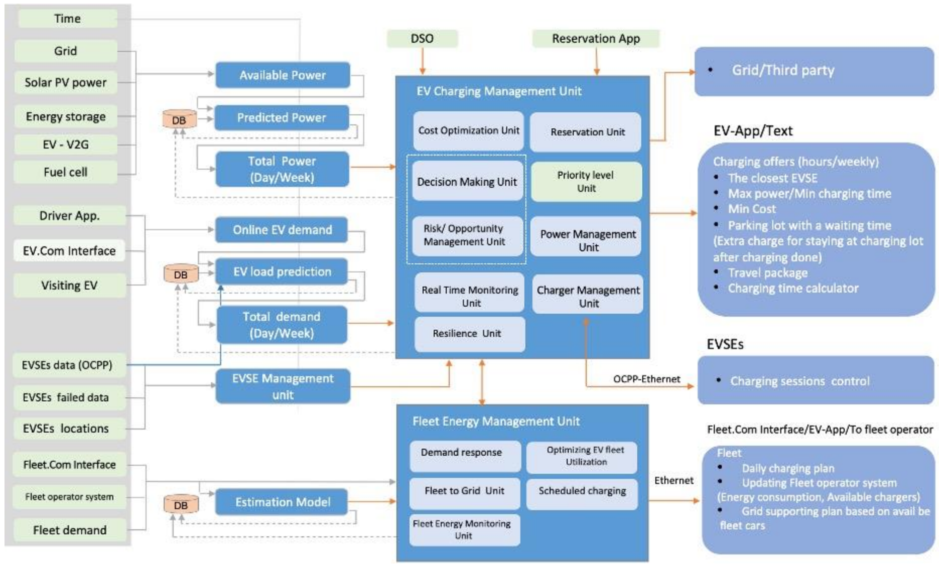

Figure 3. Block diagram of data flow and analysis for the energy management system.

II. Target Level of Performance


Figure 4. Compact bi-directional 100kW isolated DC/DC converter, and Compact bi-directional AC/DC converter.

The funding is critical for the team to construct and test a pre-production, and test them at medium voltage. The fund will take the current technology from prototype where it is currently running in a laboratory environment (TRL4) to a demonstration prototype in operational environment (TRL7). Imagen will be able to use its existing commercial channel to market the technology.

Inputs from WebOC, Sensors, Energy Emergency Assurance Coordinators (EEAC), and communications with DSO (will not provide real time bidirectional communication from the field).

Puerto Rico is significantly behind in solar PV development.

Puerto Rico has a large percentage of underrepresented minority groups compared to Florida.

Puerto Rico is one of the states which are prone to natural disasters especially hurricanes and flood.

In the context of this FOA, projects will focus efforts on Puerto Rico community energy resilience to investigate the relationship between power systems resilience and community resilience and determine the ability of a community to prepare, recover, and adapt from an event that can cause power or energy disruption blackout and natural disaster relief effort.