Grid Resilience & Intelligence Platform (GRIP)

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AI & Climate Change: Workshop Prompt

Climate change is widely agreed to be one of the greatest challenges facing humanity. We already observe increased incidence and severity of storms, droughts, fires, and flooding, as well as significant changes to global ecosystems, including the natural resources and agriculture on which humanity depends. The 2018 UN report on climate change estimates that the world has only thirty years to eliminate greenhouse emissions completely if we are to avoid catastrophic consequences.

Introduction

Extreme weather events pose an enormous and increasing threat to the nation's electric power systems and the associated socio-economic systems that depend on reliable delivery of electric power. The US Department of Energy reported in 2015, almost a quarter of unplanned grid outages were caused by extreme weather events and variability in environment. Because climate change increases the frequency and severity of extreme weather events, communities everywhere will need to take steps to better prepare for, and if possible prevent, major outages. While utilities have software tools available to help plan their daily and future operations, these tools do not include capabilities to help them plan for and recover from extreme events. Software for resilient design and recovery is not available commercially and research efforts in this area are preliminary. In this project, we are developing and deploying a suite of novel software tools to anticipate, absorb and recover from extreme events. The tools will be integrated into an extensible and open platform, aiding future efforts in this area, and will include technology built with the unique capabilities of SLAC, LBNL, GoogleX, NRECA, Packetized Energy, Presence PG, and additional utility partners. This research will aid the DOE OE and EERE Resilient Distribution Grid R&D mission of developing cutting-edge resiliency technologies that are deployed to utilities and reducing outage costs to meet the MYPP goal and DOE major outcome of a 10% reduction in the economic costs of power outages by 2025. According to the DoE, the national cost of power outages in 2012 in the US, the year of Superstorm Sandy, was between \$27 to \$52 billion. Working towards a resilient grid is not just a matter of energy security, but also of economic security.

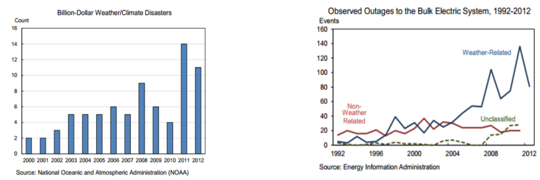


Figure 1 - trends in extreme weather events and grid outages.

The goal of this project is to respond to grid events by:

1. Demonstrating machine learning and artificial intelligence from different data sources to *anticipate* grid events due to extreme weather and distribution system events;
2. Validating controls for distributed energy resources for *absorbing* grid events by riding through with controllable loads; and
3. Reducing *recovery* time by managing distributed energy resources in the case of cyber attacks that impact communications.

The project builds on previous efforts to collect massive amounts of smart meter, SCADA, solar generation, electric vehicle charging, satellite imagery and weather data collection and use them to fine-tune grid operations, including SLAC's Visualization and Analytics with high Penetration of Distributed Energy Resources (VADER) project as well as other Grid Modernization Lab Consortium projects on distributed controls and cyber security.

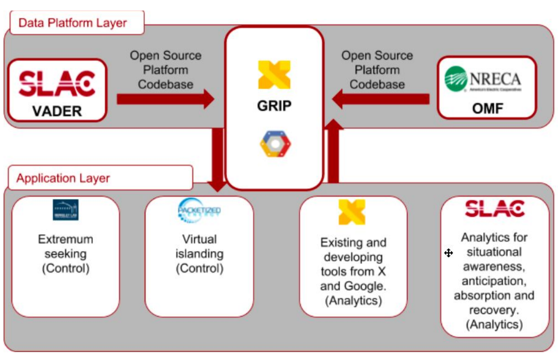
The innovations in the project include the application of artificial intelligence and machine learning for distribution grid resilience, specifically, by using predictive analytics, image recognition and classification, and increased learning and problem solving capabilities for anticipation of grid events. The project team will also demonstrate distributed control theory with and without communications to absorb and recover from grid events in Year 3.

Platform Architecture

This three-year project will deploy, test and validate developing capabilities around the country.

- *Anticipation analytics* will be tested and validated with Southern California Edison;
- *absorption algorithms* will be tested in Vermont with 150+ controllable loads that demonstrate virtual islanding capability; and
- *extremum seeking controls* that support recovery by following an objective function, such as voltage stabilization, broadcasted at the feeder will be tested with one of NRECA members.

The Grid Intelligence and Resilience Platform consists of two layers: the data platform layer and the application layer (as shown below).



The data platform layer includes data ingestion, transformation, and management. The design and implementation of the data platform layer is led by Presence PG with GoogleX as an advisor. Presence PG has access to existing open-source code from Open Modeling Framework (OMF) and VADER platforms, developed by NRECA and SLAC respectively.

The application layer is being built on top of the data platform layer. It will be hosted by X on the Google Cloud platform. The application layer will provide access to real-time and historical data stored in the data platform layer, and provide the users with elastic compute capabilities to run batch and streaming analytics. Different members of the project team will deploy their applications to the GRIP platform using the application layer supported by X. These applications are generic software blocks that are necessary for the individual demonstrations.

To successfully execute the demonstrations proposed in this project, GRIP requires site-specific data. The site specific data ingestion algorithms will be developed with project team members and will be readily available for each application as part of the data platform layer. To facilitate this process, each team member will provide a validation plan identifying their data needs to run execute their demonstration application using data from host utilities. SLAC will coordinate each demonstration with the main application developer and the host utility.

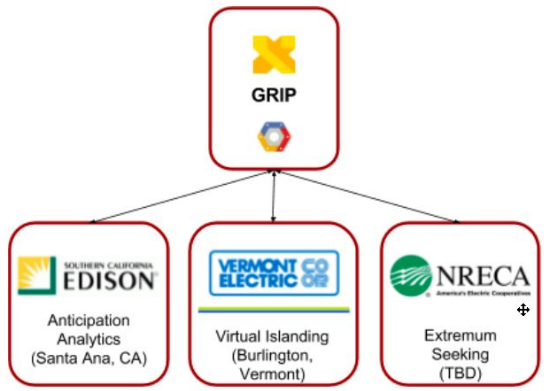


Figure above shows that the project team will demonstrate a different capability at each site and that each site will be connected to the GRIP. All the demonstrations will be managed using the GRIP with appropriate connectivity to each demonstration. In the case of SCE, the connectivity will be to the data being provided by the utility. In the case of Vermont Electric Coop, the connectivity will be to the Packetized Energy's platform and in the case of extremum seeking, the connectivity will be to the DER aggregator or to the individual DERs at a certain location on the distribution network.

Project Locations and Demonstration Sites

The project will have at least three demonstration sites as described in detail below:

Santa Ana, California. Camden Substation (figure below). This substation has 6 MW of existing generation with 3 MWs of additional queued generation and serves 44.8 MW of loads. SCE is providing AMI, SCADA data as well as calibrated models of the substation for grid events anticipation analytics development.

Burlington, Vermont. We have deployed 100 of 150 thermostatically controlled devices (water heaters) in residences with storage and PV systems. The DERs are equipped with monitoring and control devices to deliver grid services for another project and will be used to validate virtual islanding capability for GRIP.

Midwest NRECA member. At a Midwest utility location, we will be demonstrating extremum seeking algorithms with inverter-based DERs within a distribution feeder. We plan to have PV and storage devices that stabilize the voltage at a distribution substation without the need for centralized communication. The distribution feeder will be equipped with a line sensor which will be used as a proxy for extremum seeking controls.

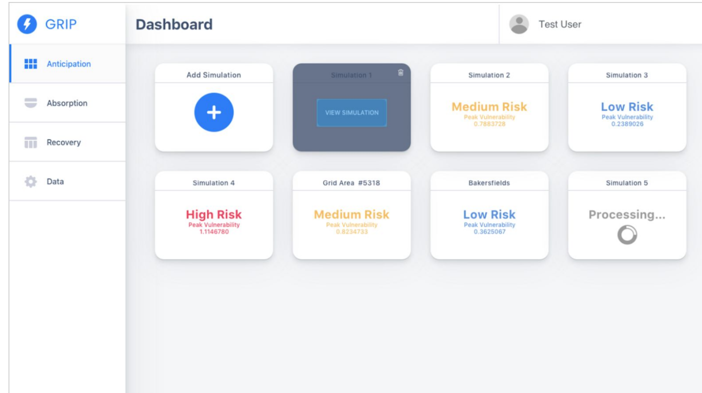
Anticipation Analytics Simulation Analysis

For the first phase of this project (Anticipation), we built custom GridLAB-D implementations incorporating a vulnerability analysis, which includes an analytical pole and line vulnerability model using input weather data. This was done by calculating the pole vulnerability index, electrical fault propagation and restoration time. We also used a unidirectional wind simulation to represent the worst case scenario. We also made enhancements to the pole vulnerability model which include adding in the effect of changing wind direction, adding an ice build-up model and line loading effects, and extending the taxonomy of impacts of vegetation on lines, poles, and equipment.

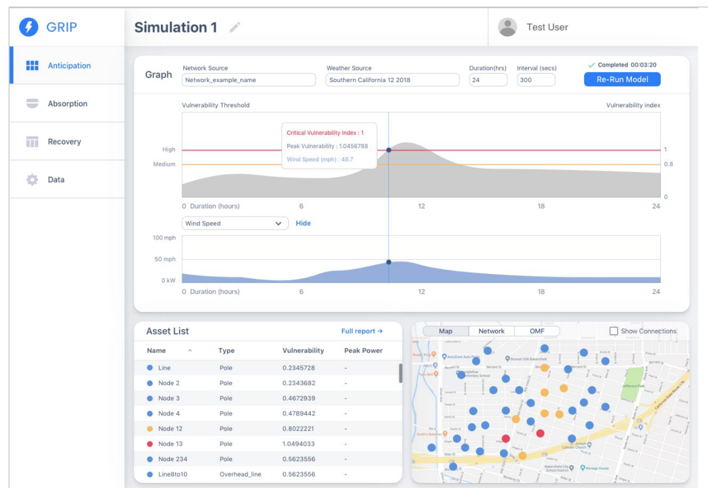
Next Steps

We are currently working towards finalizing the predictive analytics requirements for the Anticipation use case and will be demonstrating power balancing with water heaters through virtual islanding for the Absorption use case in July.

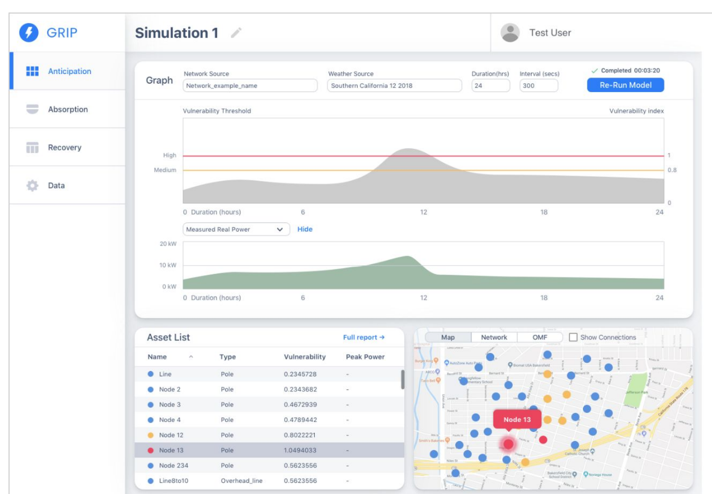
Current GRIP Portal for Anticipation Analytics



Simulated scenarios with different model outputs



Situational awareness of current grid assets



Identification of potential vulnerable asset