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CleanStart DERMS

Modeling Effort Update

June 2018

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PNNL-27644

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Abstract

This document describes the model conversion approach taken to transform the Synergee distribution feeder models received from Riverside Public Utility (RPU) to GridLAB-D models. The document briefly introduces the tools and software applications used in this process. Then, the model validation results acquired from GridLAB-D simulations are shown. Finally, several test-cases are presented that the research teams are planning to implement with the GridLAB-D models. The document presents the current state of the project and the planned next steps.

Acknowledgments

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Acronyms and Abbreviations

DER	Distributed Energy Resources
PV	Photovoltaics
RPU	Riverside Public Utility
CIM	Common Interface Model

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Introduction

This document describes the model conversion approach taken to transform the Synergee distribution feeder models received from Riverside Public Utility (RPU) to GridLAB-D™ models. The document briefly introduces the tools and software applications used in this process. Then, the model validation results acquired from GridLAB-D simulations are shown. Finally, several test-cases are presented that the research teams are planning to implement with the GridLAB-D models. The document presents the current state of the project and the planned next steps.

1.0 Current Status

1. Converted Synergee models provided from RPU in the form of a Microsoft Access database into GridLAB-D.
2. Based on overall energy consumption, loads are classified into residential, commercial, and street lighting, and added representative load profiles to each load.
3. Performed model cleaning, testing, and validation (steady state).
4. Identified potential critical loads, added backup distributed generator (Diesel Generator) to those locations, PV modules per geographical map, and updated the steady state model.

2.0 Planned Next Quarter Activities

1. Validation of model using SCADA (and meter measurement data, if any) from RPU (Waiting to receive data).
2. Update the steady-state model based on information about type, size, and location of existing backup generators from RPU and planned integration of DERs.
3. Review simulation results with RPU staff.
4. Update steady-state model to dynamic, and simulate different use cases and scenarios.
5. Expand the dynamic model based on developed control, operational, and restoration strategies as a part of CleanStart DERMS project.
6. Review simulation results with RPU staff.

3.0 Current Status Overview

PNNL received Synergee models of two different feeders – each connected to a separate substation. In total, PNNL received two substation models and two feeder circuits totaling of ~2000+ nodes. Those models were received in the form of Microsoft Access database (.mdb) from Riverside Power Utility (RPU). According to RPU's naming, the substations are Casa and Freeman substations and the circuit id numbers are 1506, which is connected to the Freeman substation, and 1351, which is connected to the Casa substation.

The model conversion process was performed in a multi-tiered approach. In step-1, a python-based application was used to convert RPU's models to OpenDSS model. The python application is an embedded part of another GMLC tool – an open-source advanced distribution planning and operation applications platform, GridAPPS-D™[1]. Therefore, the application was well-tested and regularly maintained. In step-2, the OpenDSS in-built feature is used to convert the DSS model to distribution common interface model (CIM) model. In step-3, the converted CIM models were converted into GridLAB-D model using a JAVA based application that is also part of GridAPPS-D. Post-conversion, PNNL performed model cleaning, testing, and validation of the converted GridLAB-D model. The first version of the converted steady-state model is available to perform clean-start studies. Please note that the on-going GridLAB-D model changes are geared towards quasi-steady state simulations representing system dynamics. As part of steady-state model testing, voltages at various nodes were observed to see if the values are reasonable. Figure 1 below illustrates voltage profile of the given test system at three phases based on the power flow performed for the load values provided by RPU. One of the notable observation is that the voltage in phase A is relatively lower compared to the other phase in most of the nodes. Such voltage unbalance could be adjusted via proper setting of voltage regulators. We will want to confirm this observation with measurement data, as it is received.

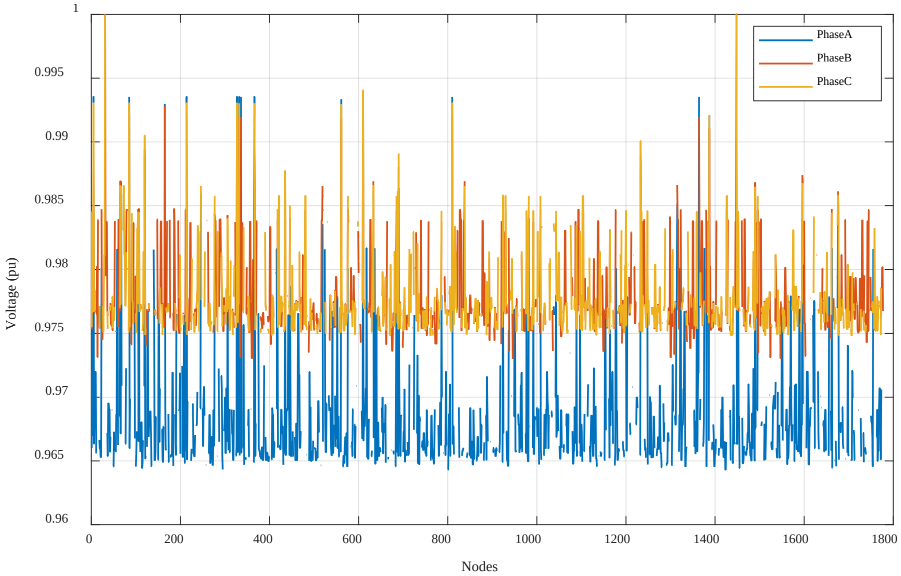

Figure 1. Voltage profile of system at given loads from RPU (before including load profile)

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[1] https://readthedocs.org/projects/gridapps-d/

In order to make the model more representative, each load is classified into residential, commercial, or street lighting, and typical load profiles corresponding to these load types are integrated. Historical load data from PG&E repository was used to generate various load profiles for testing purposes[1]. Figure 2 below illustrates snapshot voltage of all nodes in the system at low load periods (1:00 AM), and Figure 3 illustrates the voltage profile at one of the feeder end nodes (6208700_2283663).

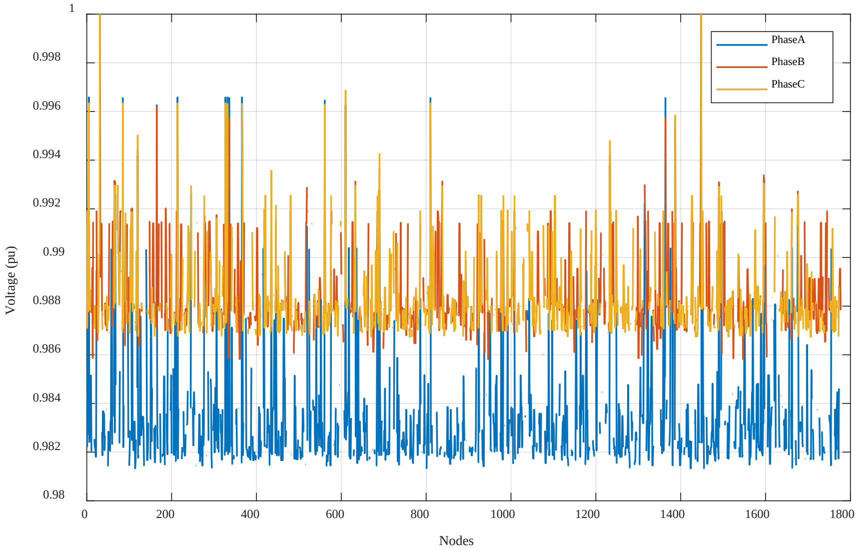

Figure 2. Voltage profile of system at given loads from RPU (after including load profile)

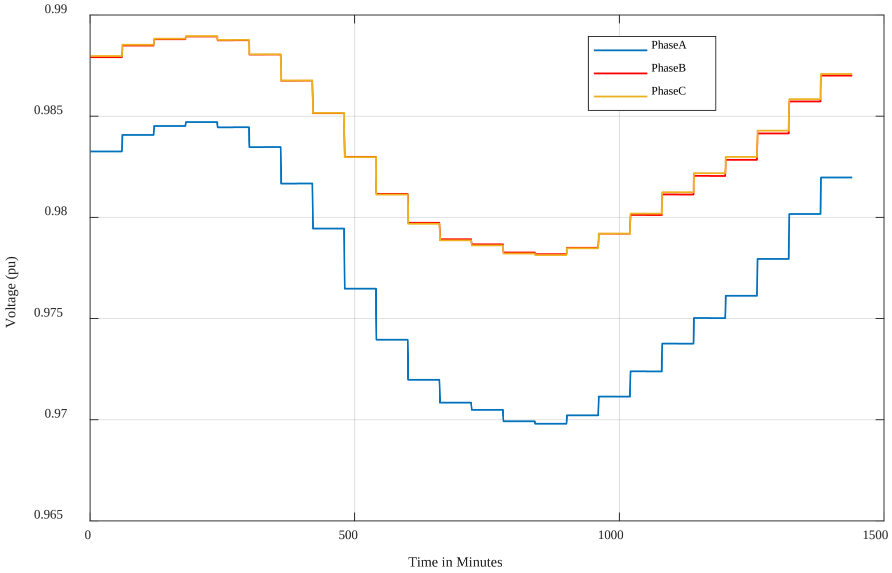

Figure 3. Voltage profile at the farthest end node for a typical day of simulation

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[1] https://www.pge.com/nots/rates/2017_static.shtml

4.0 Assessment of Load Types and Identification of Potential Critical Loads

The team performed an assessment of the facilities that are located on Freeman-1506 and Casa-1351 circuits. This was done by laying the electrical drawings across Google Maps. This converged layout was used to identify potential critical loads in the feeders and map them to the planning model. It was observed that Casa-1351 seems to serve mostly residential loads, while Freeman-1506 serves small commercial loads and some critical loads such as police station, fire station, and highway patrol. Other interesting entities on Freeman-1506 are PV array and EV charging station (location #5 in Figure 4). In addition to that, RPU'S control center is located on Freeman-1506. The following figure illustrates potential critical loads on Freeman-1506 and it was assumed that these critical loads may already have back-up generators. With that assumption, diesel generators (from 200 kVA to 500 kVA) are placed in the GridLAB-D model at each of the critical load areas (locations #1, 2, 3, 4 in Figure 4) and added a PV system (location #5 in Figure 4) beside the RPU control center (location #4 in Figure 4). The modified model with newly added DGs and PV is simulated in steady-state and the model converged as expected. Model development is planning to update the model with accurate DG parameters as soon as the information is received from RPU.

Figure 4. Potential critical loads to be served in the system

5.0 Planned Activities (Test Scenarios and Use Cases)

The following test scenarios and use cases will be used to test and validate proposed control, operational, and restoration strategy. These test scenarios will be expanded and be updated as the project proceeds based on project scope, practical operational constraints/preferences from utility, and/or feedback from DOE.

Test Scenario – 1: System has no microgrid & DERs (blackstart is not applicable, only service restoration can be done via feeder reconfiguration). This scenario will be simulated as a base case, and will serve as reference to quantify performance comparison for other scenarios.

> **Use Case-A:** Partial outage of system due to downstream faults (There will be still supply of power to some parts of the network. Only need to identify and locate fault(s), and restore the service to another healthy portion of the network).
>
> **Use Case-B:** Complete outage due to upstream outage (no supply to system, there is no capability of black start and service restoration since there won't be any supply at all. Reliability metrics may be calculated for given outages to compare against other scenarios).

Test Scenario – 2: Test system has some DERs (e.g., storages, PV systems, Diesel Gensets), but no microgrid(s). As such, seamless transition is not possible, but DERs can be utilized for blackstart and service restoration to critical loads.

> **Use Case-A:** Partial outage due to downstream faults (there will be still supply of power to part of the system. Only need to identify and locate fault(s), and restore the service to maximum number of consumers by using combination of both upstream feeder supply, and supply from DERs).
>
> **Use Case-B:** Complete outage of supply to system due to upstream outage (there will be complete outage, the only available source would be DERs if they can be restored.
>
> **Use Case-C:** Perform both complete outage and partial outage considering different locations of DERs (to justify the selected DER locations are best/optimum/strategic).

Test Scenario – 3: Test system has microgrids (with some DERs), but no DERs outside the microgrid (seamless transition, blackstart and service restoration can be done, as well as service can be extended beyond microgrid, i.e., to nearby critical loads).

> **Use Case-A:** Predictive analytics indicates faults/outage events (No actual fault/outage conditions exists, but we simulate this use case to demonstrate emergency preparedness by intentional islanding of microgrids).
>
> **Use Case-B:** Partial outage of system due to downstream faults (There will be still supply of power to the network. Only need to identify and locate fault(s) and restore the service to maximum number of consumer by using combination of both upstream feeder supply and microgrid. May need to operate microgrids in islanded mode depending on fault location).
>
> **Use Case-C:** Complete outage of supply to system due to upstream outage (only supply during this case are from microgrids, we can demonstrate service restoration by:
>
> > a) Seamless transition of microgrids from grid connected to islanded followed by further service restoration potential via networked operations of microgrids,
> > b) Black starting microgrids and service restorations.

Test Scenario – 4: Test system has microgrids (with some DERs) as well as some DERs not part of microgrids (DERs which are not part of microgrid cannot make seamless transition, but can be included in black start and service restoration).

> **Use Case-A:** Predictive analytics indicates faults/outage events (intentionally island microgrid or formulate networked microgrid to supply critical loads).
>
> **Use Case-B:** Partial outage of system due to downstream faults (There will be still supply of power to the network. Only need to identify and locate fault(s) and restore the service to maximum number of consumer by using combination of both upstream feeder supply, microgrid, and DERs. May need to operate microgrids in islanded mode depending on fault location, and supply beyond the microgrid premises by bringing DERs on).
>
> **Use Case-C:** Complete outage of supply to system due to upstream outage (only supply is from microgrids and DERs.) Service restoration can be done via:
>
> > a) Seamless transition of microgrids from grid connected to islanded followed by further service restoration potential via networked microgrids & DERs,
> >
> > b) Complete outage of supply. Black start, service restorations using microgrids, DERs.

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