Advanced Grid Simulation Program

Joint GLOW/HiPAS/OpenFIDO Technical Advisory Committee Meeting #5 Notes

On September 11, 2020, Gridworks facilitated the Technical Advisory Committee (TAC) of the Advanced Simulation Program from California Energy Commission. This meeting covered project development updates for OpenFIDO (EPC 17-047) and HiPAS (EPC 17-046), provided a live demonstration of the user interface for GLOW (EPC-17-043), gathered recommendations from the participants, and secured collaboration from TAC members on ongoing GLOW development.

The TAC is composed of representatives from California's electric investor-owned utilities (PG&E, SDG&E, SCE), the California Energy Commission, the California Public Utilities Commission, and energy leaders from Kevala Analytics, National Grid, National Rural Electric Cooperative Association, and Sunrun. Representatives from each of these organizations attended the September 11 meeting.

An immediate next step is to confirm participants in a Test Master Group for GLOW. The testing group will participate in monthly feedback sessions led by Hitachi with the objectives to validate, improve, develop, test, and enhance the user interface, GLOW.

OpenFIDO Briefing

OpenFIDO is the open source framework and translation tool for data and model acquisition. Currently the work focuses on the production version of the prototype, specifically the data and model acquisition and exchange (import/export) including some supporting analytics and data processing. All data converters are transferred from GridLAB-D to OpenFIDO, including some converters that are under development. The transfer process will complete upon validation.

OpenFIDO's next phase will be focused on completing the data processing production pipeline, workflow management, and data visualization tools. The team will also be working on extending OpenFIDO with a wide variety of analytics, data sources, and data delivery mechanisms. Presence Group is a new subcontractor that will support OpenFIDO development in a variety of architectures.

OpenFIDO is being built from the LoadInsight tool, which was developed to create load models from advanced metering infrastructure (AMI) data and SCADA data from distribution systems, but OpenFIDO is generalizing the tool and enabling the data to be used for a variety of purposes.

Next phase deliverables list:

1. Data pipeline platform
2. Data visualization tool
3. Extensibility framework
4. Customer technical Environment Support

Responses to the Q&A Session for OpenFIDO

- *Is the final commercial version of OpenFIDO going to be open source?* Yes, the licensing for OpenFIDO final version still will be open source under GPL-3.

- *Who is Presence?* Presence Group is a product development company specialized in energy that recently partnered with SLAC to develop the GRIP platform. They will serve as the software and technical architect of the project. The same structure is being considered for OpenFIDO.

- The effort to deploy the integrated environment mentioned in the next phase deliverables requires the ability to take all the data conversion tools and deploy in an environment commercially viable in the long term, as well as supportable to those who are deploying it, while maintaining the open source capability.

- *What is the difference between NREL's Ditto and OpenFIDO?* Ditto is a python module developed by NREL to convert distribution system models between different formats used by various software tools. OpenFIDO is a cloud-deployable user application that converts data and models between different formats. OpenFIDO users will be able to use Ditto as an external converter much in the same way it can use any other converter deployed on GitHub using the OpenFIDO API.

- *Is the output from the commercialization expected to be open source?* Yes, it will be open source. It is designed to not solve the data conversion problem instead leverages on tools that can solve the problem and allow them to be integrated.

HiPAS Briefing

Work completed this year focused on supporting the four principal use-cases: ICA, resilience analysis, tariff design, and load electrification. Work performed in GridLAB-D includes:

- Speed enhancement of the simulation initialization phase and main solver loop;
- Deployment of the Amazon Web Services web environment and the development of a full Python application programming interface (API); and
- Acceptance of import/export data in a variety of formats and internal data conversions. New database models were included to support this data format exchange.

The ability to run moderate scale simulations using GridLAB-D on the web in a continuous integration environment is a valuable advantage for the user community.

The work on the development of use cases included:

1. Integration Capacity Analysis. Support of the GLOW ICA analysis method, development of a family of IEEE-123 ICA test cases, and creation of an ICA project template for alternative ICA analysis methodologies
2. Resiliency. Support GRIP project analytics, in anticipation of OpenFIDO for evaluation of extreme resilience performance metrics.
3. Tariff Design. New and emerging rates design and evaluation, including revenue and customer cost impacts.
4. Electrification. Decarbonization of the building stock and transportation and implication for the electric power system in the distribution side.

The high-performance simulation results from machine learning (ML) power solvers is promising; findings about the performance of the ML methods were presented. The adaptive recursive method demonstrated accuracy and efficiency in terms of memory usage and simulation time. Neural architectures tend to have good performance for smaller networks; scalability is a challenge due to the increasing data needed for training purposes. Linear regression tends to have good performance for networks with low loading networks, but as loading increases the performance decreases.

The goal for the next year is to validate the performance of the machine learning power flow estimation in large networks, with more complicated scenarios integrating the framework into GridLAB-D.

The performance of machine learning power flows depend on several factors:

- Network loading level. Variety of cases were studied analyzing the performance of the method, ranging from a typically loaded network to an overloaded network.
- Network size. Several taxonomy feeders and networks analyzed (up to 2000 nodes) currently working on including larger networks in the analysis.
- Model hyperparameters. The performance is dependent on a variety of factors. The idea is to do the fine tuning of the parameter behind the scenes in GridLAB-D with no supervision from the user.
- Amount of training data. Highly dependent on the complexity of the algorithm.

HiPAS' next steps are focused on calibrating the building model based on energy and load shape data collected by utilities.

The cloud deployment effort has been focused on Amazon Web Services deployment, most of the tools are using GitHub as the repository of all the code and tools and the data set required for GridLAB-D operation, giving full access, control, and development information on Docker.

Responses to the Q&A Session for HiPAS

- *How does the building modeling work being done for HiPAS relate to the Residential Stock and Commercial Stock (ResStock/ComStock) work being done by NREL (particularly as they calibrate to the End Use Load Research data coming in?* Residential and commercial building simulation U.S. data sets of different cities can be used as inputs to GridLAB-D to calibrate the physics/space model. Some data may require verification.

- *It is possible to add any object to an existing file on GLOW? (For example: recorders/tapes, DERs)* Changes to models, deletions, insertions and customization is possible directly on GLOW.

- *Which network loading cases are used in the Machine Learning-based power flow estimation?* The efforts in machine learning-based power flows studied various loading cases. The network models studied have multiple buses and the loads are defined for the simulation to study the performance of the solver. Pecan Street data is being used for that purpose.

- *What use cases in the context of the project?* Four use cases have driven the domain of HiPAS: integration capacity analysis, resiliency, tariff design, and electrification. The idea is to apply the machine learning work to the entire pool of use cases in the future.

- *Would loading provide enough information about how well the models are performing? Or further testing will be needed, variation of the loading will push the limits of the grid into edge cases?* Edge cases are not being explored yet using the machine learning-based power flow model. For example, a high solar case with backflow might not emerge from the data previously used, this case will bring a negative power injection, kind of a different scenario in the mathematical sense, which might impact the performance of the models.

- *Are dynamic conditions explored? (Solar inverters and possible interaction in the order of seconds, in response for partial shading on a neighborhood)* HiPAS focus has been in quasi steady state simulations, even though GridLAB-D has the capability for fast transients analysis. But the work has not addressed any of the dynamic models, with fast changing loads.

- *How training and testing of the model for Machine Learning happen? A single or multiple models are used for the training and testing?* The machine learning process training and testing generates several data sets. Once sufficient data is being collected for training purposes the validation, test and trading sets emerge. By training these models adaptively changes occurred in the grid are accounted for and registered. The model uses an initial model that will evolve with the data acquisition.

- The vision for the ultimate implementation no offline training will happen, as the simulation starts the machine learning module absorbs the solver samples until it starts predicting reliably, if it senses a significant change in the system it will defer to the Newton-Raphson solver until it has enough data to predict reliably again.

- *Is the plan to use utility data and applying it to the model of the use cases?* Once all modules in HiPAS and OpenFIDO are integrated with GLOW a system wide testing and validation will begin. Before that the testing will happen individually.

GLOW Briefing

The user interface live demonstration presented by Hitachi resulted in a web-based interface GLOW with the features discussed and recommended in past TAC meetings with implementation and design prowess. GLOW allows the analysis and visualization of GridLAB-D results for the integration capacity analysis in a color code scheme as granular as a feeder level. Future integration with OpenFido and HiPAS will add data conversion and high performance computing capabilities.

The Alpha test work plan for the upcoming year gives the opportunity to the TAC to tailor needs, identify must-have features, and prioritize development through a Test Master Group. The Test Master Group will work jointly with the GLOW team to provide feedback and perform comparative studies which will define the action steps in the implementation pipeline.

The planning for the next two years is mainly focused on production test with two milestones:

- *Alpha test by August 2021*. Minimal viable product: basic functionalities.
- *Beta test by 2022.* Scalability and robustness enhancements

Recently, the team used GLOW to conduct the integration capacity analysis based on the CPUC's current methodology, and compared results obtained to other simulation tools with similar threshold violations criteria and power flow solver. This exploration analyzed the impact DERs integration on the distribution system at a nodal level. Results include:

- For over-voltage criteria 0.1% threshold deviation from 105% will cause up to 30% integration capacity analysis variations.
- For voltage fluctuation criteria the integration capacity analysis is less sensitive to variations. 0.1% threshold variation causes 3% capacity changes.

These results are aligned with the results obtained by the utility when conducting the analysis with similar settings and feeder conditions. GLOW's implementation aligns with CYMDIST ICA implementation and is comparable to the results published in CPUC demonstration projects reports.

The next steps for GLOW include:

- Improvement in computational efficiency.
- Amplifying the test in feeders and models. Include methodology changes if needed and
- Incorporate the features collected from the Test Master Group in the alpha test release.

Responses to the Q&A Session for GLOW

- *Is it possible to test GLOW by desktop version instead of cloud based version? If so when a Desktop version will be available?* GLOW has the capability to run on desktops or from web-based environments (Google Chrome recommended). It is recommended to have Alpha test on AWS to avoid glitches due to local computer environment. . It is recommended for on Premise operation during Beta testing phase.

- *What data will be used for testing purposes?* No sensitive data is envisioned to be used for testing purposes. Public data which represent no confidentiality issues will be good enough for the testing and enhancement of the user interface. The use of proprietary feeder data is also possible and can be done only on Hitachi domain.

- *How secure will be the cloud information platform?* The data exchange between modules on GLOW's platform is secured by a dynamic tokens system (industry common practice). A user account will be provided for Test Masters and each participant.