

Open Framework for Integrated Data Operations (OpenFIDO)

Deliverable 7.9: Draft Technology/Knowledge Transfer Report

California Energy Commission Project EPC-17-047

Last revised: 4/4/2022

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Abstract

This report documents the methods and tools used to publicly disseminate the results of the OpenFIDO project.

1. Introduction

In California, utilities, customer and consulting engineers and regulators need to exchange power system data to validate distributed energy resource plans, obtain permits, and verify compliance when integrating these resources in distribution systems. The data exchange process between the many different tools used can be cumbersome, slow and error prone. This raises a barrier to fast and effective resource planning and integration, which limits the growth of these resources and constrains how quickly California can decarbonize its electric power infrastructure.

OpenFIDO is a data interchange, synthesis and analysis platform that provides information exchange between widely used power system analysis and simulation tools such as CYME and GridLAB-D. OpenFIDO can transfer models and data between tools that are part of the suite of tools widely used by utilities, distributed energy resource (DER) engineers and regulators in California. OpenFIDO is designed for system planners, engineers, and analysts who need to quickly and reliably move data from one application to another as part of their regular activities. OpenFIDO also supports emerging user groups such as DER system integrators and aggregators that rely on diverse tools to manage the impact of DERs, as well as governments and agencies that use these models in identifying opportunities for clean energy deployments, addressing system resilience to extreme weather events, and mitigate the impact wildfires.

The long-term goals of OpenFIDO are to enable full interoperability between open-source software such as GridLAB-D and OpenDSS and various commercial power distribution system modeling tools such as CYME, Opal-RT, and RTDS. In addition, OpenFIDO enables easy

SLAC National Accelerator Laboratory is operated for the US Department of Energy by Stanford University under Contract No. DE-AC02-76-SF00515.

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development and adoption of new tools and analysis methodologies that depend on many diverse public and proprietary datasets for weather, demographic, system telemetry, tariff and market data, and other data collection programs run by utilities, regulators, and commercial entities.

The objectives of the OpenFIDO project are:

1. *Produce a widely usable and fully functional data platform and interoperability layer for various power systems tools*, with special attention to the needs of IOU, CEC and CPUC users, as well as the vendors, consultants and researchers who support regulatory, planning and operations activities that are supported by tools based on GridLAB-D.
2. *Deliver a data exchange platform along with a set of data adapters* to convert data from power systems tools' schema to a standardized, open-source format.
3. *Establish the foundation for long-term user and developer support*, including tools and services for data import, transformation, storage, access, and export.

Public dissemination of project results includes the following activities and systems, which are addressed in each section of this report.

1. **Source code** - this section addresses how the source code to the OpenFIDO platform is structured, maintained, and delivered.
2. **User documentation** - this section addresses how the user documentation is structured, maintained, and delivered.
3. **Instructional materials** - this section addresses how instructional material is produced and delivered.
4. **Continuous integration** - this section addresses how updates from developers, users, and researchers are incorporated into the platform.
5. **Validation** - this section addresses how the platform is validated by developers, users, and researchers.

2. Source code

OpenFIDO is distributed using a collection of GitHub repositories under two organizations. The OpenFIDO platform itself, which provides all the server, client, authentication, application, deployment, GridLAB-D, workflow services, as well as support utilities and examples, is distributed by the [OpenFIDO platform repositories](#). The pipelines, which implement all the data conversion and analysis tools that run within OpenFIDO are distributed by the [OpenFIDO products repositories](#).

2.1. Platform Repositories

The following repositories are used to build and deploy the OpenFIDO platform on Amazon AWS at <https://app.openfido.org/> and DockerHub at <https://hub.docker.com/r/openfido/openfido>.

The Amazon AWS deployment system uses a production account for online operations and a staging account for testing and validation. The production account support the following URLs:

- <https://docker.openfido.org/> - This provides public access the shell script used to run OpenFIDO in Docker. The script is named "start.sh" and can be downloaded from <https://docker.openfido.org/start.sh>
- <https://help.openfido.org/> - This provides public access to the online documentation for OpenFIDO
- <https://source.openfido.org/> - This provides public access to the publicly available OpenFIDO products.
- <https://www.openfido.org/> - This provides public access to the main OpenFIDO repository.

The Dockerhub images are publicly available at <https://hub.docker.com/repository/docker/openfido/cli>. The latest version and all previously tagged version of OpenFIDO's CLI server are maintained and delivered to users on demand.

2.1.1. Platform

The OpenFIDO platform is distributed at <https://github.com/slacgismo/openfido>. This repository contains the main platform deployment code used to create the Amazon AWS deployment and the DockerHub images.

2.1.2. Client

The OpenFIDO client service is distributed at <https://github.com/slacgismo/openfido-client>. This repository contains the client services used to drive the browser interface and deliver the user experience.

2.1.3. Workflow Services

The OpenFIDO workflow service is distributed at <https://github.com/slacgismo/openfido-workflow-service>. This repository contains the workflow services used to dispatch interdependent pipelines. This service is not currently available from the client, but can be accessed via the workflow API.

2.1.4. Application Services

The OpenFIDO application service is distributed at <https://github.com/slacgismo/openfido-app-service>. This repository contains the application API

implementation for file upload, download, backup, restore, and other service needed by the client.

2.1.5. Examples

The OpenFIDO examples are distributed at <https://github.com/slacgismo/openfido-examples>. This repository contains example files that can be used to test and demonstrate OpenFIDO pipelines.

2.1.6. Authentication Services

The OpenFIDO authentication service is distributed at <https://github.com/slacgismo/openfido-auth-service>. This repository contains the user authentication services for client connecting to the server.

2.1.7. GridLAB-D Integration

The OpenFIDO GridLAB-D Integration utilities are distributed at <https://slacgismo/openfido-gridlabd>. This repository contains the utilities needed to access GridLAB-D converters, geodata, scripts, and tools from without OpenFIDO pipelines.

2.1.8. Utilities

The OpenFIDO Utilities are distributed at <https://slacgismo/openfido-utils>. This repository contains the common templates and database structures that are shared by the client and app services.

2.2. Product Repositories

The OpenFIDO platform gives users access to a diverse set of products that can acquire, convert, and analyze electric power system data and models. Each product may be used to create a pipeline, which the user can then run as needed to process data, run simulations, or perform analyses.

2.2.1. Cyme Extract

The *cyme-extract* pipeline is an OpenFIDO product to access system model data in a CYME database (MDB) file. The pipeline product can be used extract all the data tables, generate a network graph, create a GridLAB-D model, and plot the voltage profile. In addition, the pipeline can be provided data to fix or modify CYME models, link the CYME model with other data sets and models, such as weather data, weather forecasts, pole data, and customer load data.

2.2.2. GridLAB-D

The *gridlabd* pipeline is an OpenFIDO product to run GridLAB-D simulations. The pipeline can accept an arbitrary collection of GridLAB-D models (GLM) files, as well as all needed ancillary

files such as CSV input files, settings and configuration data, and other support files. Output include CSV recording, plot images, and other files generated by the simulation.

2.2.3. Loadshape

The *loadshape* pipeline is an OpenFIDO product to perform customer loadshape analysis from AMI data. The pipeline accepts AMI data and performs cluster analysis to generate the most common loadshapes. The loadshapes may be output as CSV tables or as GridLAB-D GLM files to facilitate attaching load models to a network model.

2.2.4. Census

The *census* pipeline is an OpenFIDO product to obtain US Census Bureau TIGER geographic data for census regions. The input is a list of latitudes and longitudes for locations where the data is needed. The output is a file containing the requested state and zipcode data.

2.2.5. Hosting Capacity

The *hosting capacity* pipeline is an OpenFIDO product to estimate the hosting capacity for solar, battery, and electric vehicles on a feeder. The input is a system model in GridLAB-D format, and the associated hosting capacity study parameters. The output is files and plots that characterize the hosting capacities for solar, batteries, and electric vehicle chargers on the feeder.

2.2.6. Electrification

The *electrification* pipeline is an OpenFIDO product to evaluate the impact of end-use electrification in residential buildings on feeders. The input is a system model in GridLAB-D format, and the associated electrification study parameters. The output is files and plots that characterize the impacts of electrification on the feeders, such as transformer overloads, regulator and capacitor bank controller problems, and other off-normal behavior in the feeder.

2.2.7. Tariff Design

The *tariff design* pipeline is an OpenFIDO product to perform revenue analysis and comparisons based on published tariffs given changes in residential end-use loads. The input is a system model in GridLAB-D format, and the associated tariff study parameters. The output is data files and plots that characterize the distribution of residential energy usage, demands, and costs, as well as technical losses on the feeder.

2.2.8. Resilience

The *resilience* pipeline is an OpenFIDO product to perform resilience analysis for feeders subjected to extreme weather events. The input is a system model, asset data for poles and equipment that are susceptible to weather events, weather data, and customer load models. The output is a set of data files and plots showing which assets may be adversely affected by

the weather event, and to what degree the effect impacts customers as measured using resilience metrics.

2.2.9. Weather

The *weather* pipeline is an OpenFIDO product to obtain historical weather and weather forecasts for any location in North America. The input is a list of geographic coordinates, and the output is a set of GridLAB-D weather files associated with each coordinate.

2.2.10. Address

The *address* pipeline is an OpenFIDO product to convert between geographic coordinates and legal addresses, such as those typically associated with utility service locations. The input is either a latitude/longitude pair or an address and output is a data file containing the corresponding location information.

3. User documentation

OpenFIDO user documentation is delivered using the [SLAC GISMo Documentation Browser](https://help.openfido.org/) at the URL <https://help.openfido.org/>.

By default, the documentation browser allows unauthenticated users rate-limited access to the latest documentation distributed from the *master* branch of the main OpenFIDO platform repository (<https://github.com/slacgismo/openfido>). The rate limit per GitHub policy is roughly 50 requests per hour. Users with GitHub accounts may access up to 5,000 requests per hour using the documentation's login facility to enter their GitHub Access Token.

The main sections of the online user documentation include the following:

1. **Getting Started** - Provides matter on developer setup, generating API keys, and installation on hosts.
2. **How to Videos** - Provides instructional videos on how to create new users, change organization settings, update a user profile, create a new pipeline, start a pipeline run, and visualize the output of a pipeline run.
3. **Pipeline Developer** - Provides an example of how to create and deploy a pipeline.
4. **Technical Documentation** - Provide detailed technical documentation related to the system architecture and database model.
5. **API Specifications** - Provide direct access to the API documentation from the platform micro-services.

4. Instructional materials

Instructional videos will be produced for all the platform and product repositories, released on SLAC GISMo' Youtube channel, and published in the repositories' *docs* folders. Platform training videos will be oriented toward developers. Product training videos will be oriented toward end-users of the OpenFIDO pipelines.

5. Continuous integration

Each repository implements its own validation and deployment system using GitHub Actions. Validation and deployment badges are published by GitHub indicating the status of the repository. When validation passes, the badge shown appears as shown in Figure 1(a) and when the validation process fails it appears as shown in Figure 1(b). A similar status mechanism is used for platform deployment.



(a)



(b)

Figure 1: GitHub Action "passing" badge image (a) and "failing" badge image (b)

6. Validation

OpenFIDO hosting capacity, tariff design, electrification, and resilience use-cases will be validated using one or more real-work utility network models. Utility network models are protected sensitive data. Consequently, the details of the validation result cannot be disclosed and will not be made public. This section describes the validation methodology and how the results will be communicated with the public such that sensitive utility data remains protected.

6.1. Hosting Capacity

The hosting capacity analysis performs solar, energy storage, and electric vehicle resource hosting limits for distribution feeders. The analysis includes thermal, voltage, current, and control limits for a specified time-range given a network model and customer load models.

At present, only an IEEE-123 solar host capacity reference model is available for public evaluation. The other reference models use utility data, and/or resources for which no existing reference is available. In the former case, only a summary of the test results will be presented, absent any details which would violate customer privacy or utility commercial data non-disclosure agreements. In the latter case, the results will be presented without comparison such that future attempts to perform the same analysis using a different tool or methodology can be compared. The reference data is published as part of the implementation of the analysis template at <https://github.com/slacgismo/gridlabd-template>.

6.2. *Tariff Design*

The tariff design analysis performs a revenue analysis for a distribution feeder or load model. The analysis uses tariff data from the OpenEI database published by the National Renewable Energy Laboratory (NREL) to compute the customer costs for electricity usage. Load models may be provided as AMI recordings or physics-based loads with demand response and distributed energy resources implemented optionally. The outputs include total revenue, customer costs, and associated plots.

At present, no public reference data sets are known for tariff analysis validation. The validation process instead uses simple test cases which can be verified manually using spreadsheets. The reference data is published as part of the implementation of the analysis template at <https://github.com/slacgismo/gridlabd-template>.

6.3. *Electrification*

The electrification analysis performs distribution feeder impact studies as a result of end-use electrification for the four primary gas end-uses, and electric vehicles chargers. The analysis required a feeder model, load models, and corresponding weather data, as well as electrification parameters such as which end-uses are electrification and to what degree. The outputs include asset overloading, reliability, and resilience impacts, if any.

At present, no public reference datasets are known for electrification study validation. The validation process instead uses simple test cases which can be verified manually using spreadsheets. The reference data is published as part of the implementation of the analysis template at <https://github.com/slacgismo/gridlabd-template>.

6.4. *Resilience*

The resilience analysis performs extreme weather event impacts analysis on distribution feeder assets, with particular emphasis on poles and pole-mounted equipment. The analysis requires a network model, asset data, weather data, and load models. The analysis produces resilience metrics such as unserved load, repairs costs, and emergency services impacted.

At present, no public reference datasets are known for resilience analysis validation. The validation process instead uses simple test cases for which results have been computed manually using spreadsheets. The reference data is published as part of the implementation of the analysis template at <https://github.com/slacgismo/gridlabd-template>.

7.0 Knowledge Transfer Results

Implementation of the Knowledge Transfer Plan results in the following performance. These metrics were collected on February 6, 2023. To obtain the latest information, please contact the OpenFIDO project current administrator, which may be found at <http://github.com/openfido>.

7.1. Technical Advisory Committee Membership

During the conduct of the OpenFIDO project, the following members joined the Technical Advisory Committee representing their respective organizations:

- Kristen Brown, ComEd
- Jameson Thornton, PG&E
- Aram Shumavon, Kevala
- Eric Lightner, DOE
- Merrian Borgeson, NRDC
- Justin Regnier, CPUC
- Pedram Jahangiri, National Grid
- Jamie Patterson, CEC
- Audrey Lee, Sunrun
- Raul Perez-Guerrero, SCE
- Rachel Huang, SMUD
- Davianna Olert, EDF
- Jim Baak, STEM
- Andy Bilich, EDF,
- Laura Fedoruk, Sunrun

7.2. Field Deployments

At the current time, OpenFIDO has been deployed to an on-premise server application at Southern California Edison, as part of their EPIC project to perform climate resilience analysis.

The online deployment on AWS at <https://app.openfido.org/> currently has 12 registered users.

7.3. Training Videos

The following training and how-to videos are available to the public at

Video Topic	Video URL
<i>Tutorials</i>	
Getting started	http://help.openfido.org/assets/getting_started.mp4
Use-cases tutorial	http://help.openfido.org/assets/use_case_tutorials.mp4
New developer build	http://help.openfido.org/assets/new_developer_tutorial.mp4
<i>How-to Videos</i>	
Invite a new user	http://help.openfido.org/assets/invite_new_user.mp4
Change a user role	http://help.openfido.org/assets/change_org_member_role.mp4

Video Topic	Video URL
Update profile/password	http://help.openfido.org/assets/update_profile.mp4
Create a pipeline	http://help.openfido.org/assets/create_pipeline.mp4
Start a pipeline	http://help.openfido.org/assets/start_pipeline.mp4
Data visualization	http://help.openfido.org/assets/data_visualization.mp4

7.4. Ongoing Metrics Data Collection

Ongoing metrics are collected for OpenFIDO pipeline usage. These reports can be accessed in real-time for the past week as follows:

Pipeline name	Real-time Usage report
Tariff design	https://github.com/openfido/tariff_design/graphs/traffic
Loadshape analysis	https://github.com/openfido/loadshape/graphs/traffic
Weather data	https://github.com/openfido/weather/graphs/traffic
HiPAS GridLAB-D	https://github.com/openfido/gridlabd/graphs/traffic
Census geodata	https://github.com/openfido/census/graphs/traffic
Resilience analysis	https://github.com/openfido/resilience/graphs/traffic
Hosting capacity analysis	https://github.com/openfido/hosting_capacity/graphs/traffic
Electrification analysis	https://github.com/openfido/electrification/graphs/traffic
Address resolution	https://github.com/openfido/address/graphs/traffic
Cyme converter	https://github.com/openfido/cyme-extract/graphs/traffic

The tool run usage from February 6th, 2022 to February 6th, 2023 are as follows:

Repository	Total Clones
Address resolution	2
Census geodata	1
Cyme converter	18

Repository	Total Clones
Electrification analysis	0
HiPAS GridLAB-D	1
Loadshape analysis	1
OpenFIDO	334
Resilience analysis	1
Tariff design	1
Weather data	0

The tool documentation usage from February 6th, 2022 to February 6th, 2023 are as follows:

Repository	Total Visitors
Address resolution	1
Census geodata	1
Cyme converter	109
Electrification analysis	2
HiPAS GridLAB-D	2
Loadshape analysis	11
OpenFIDO	79
Resilience analysis	3
Tariff design	6
Weather data	2