HiPAS GridLAB-D

(EPC-17-046)

Orientation and Education

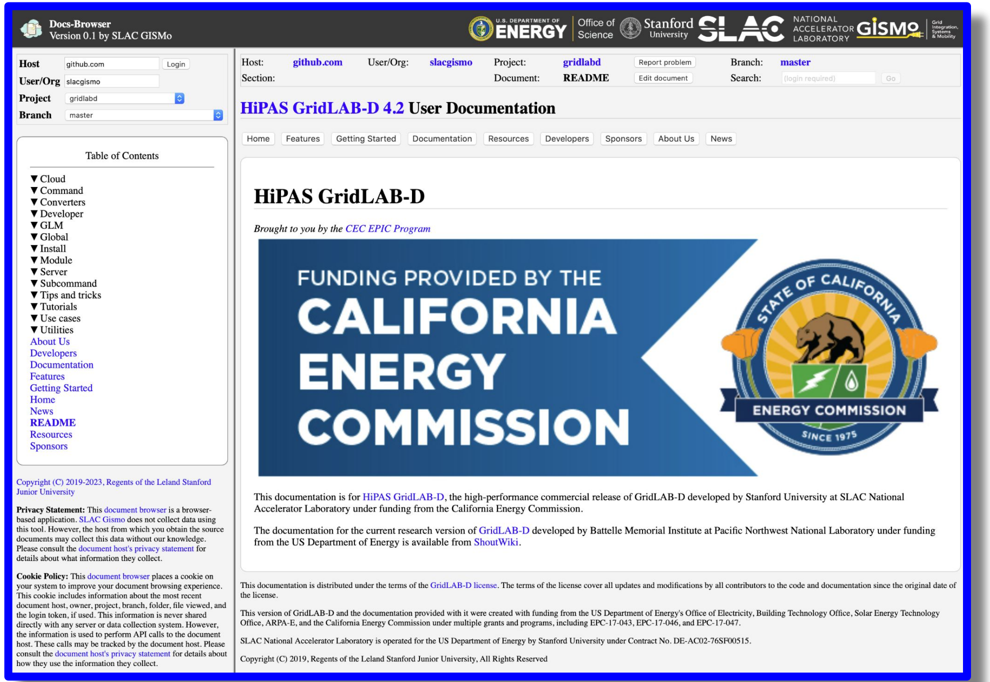
6 April 2023

U.S. DEPARTMENT OF ENERGY | Stanford University

SLAC NATIONAL ACCELERATOR LABORATORY

Workshop Agenda

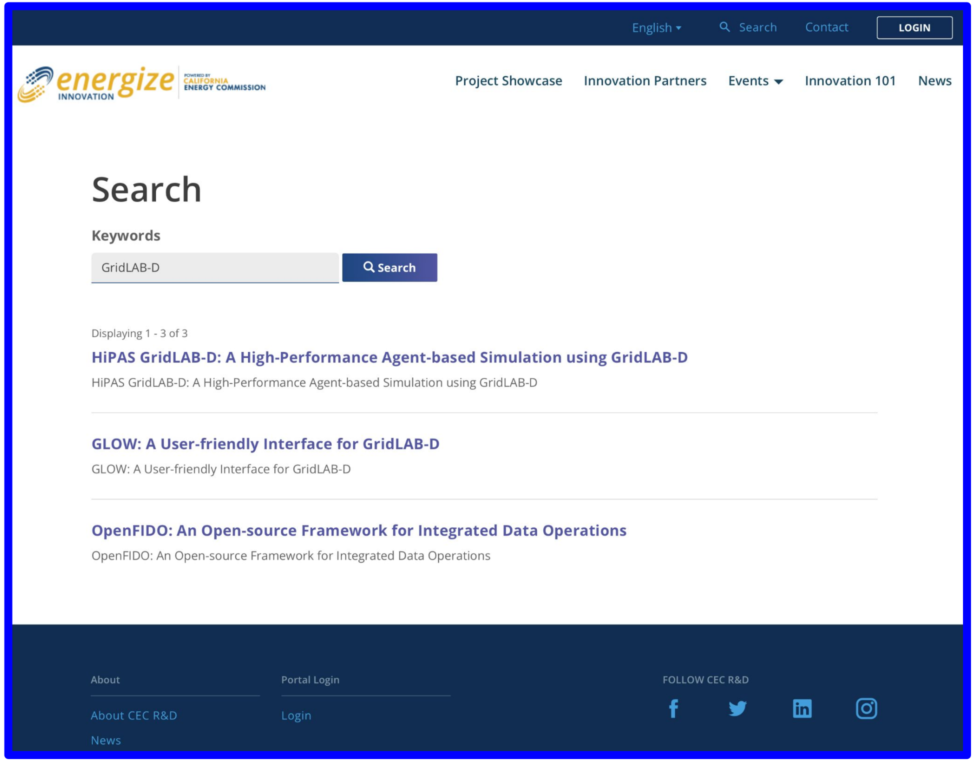
1. Product Overview
2. Download and installation (video)
3. Accessing sample models (video)
4. Getting weather data (video)
5. Creating load models (video)
6. Poll questions



https://www.gridlabd.us/

Product Overview

1. **Commercial GridLAB-D funded by CEC**
2. Four primary use-cases
   a. Hosting/integrated capacity analysis
   b. Electrification impacts analysis
   c. Resilience analysis
   d. Tariff design analysis
3. Derived from [DOE GridLAB-D]
   a. Not all DOE capabilities preserved
   b. Significant new capabilities added
4. Commercialization by Linux Foundation
   a. Product called [Arras Energy]



https://www.energizeinnovation.fund/search?keywords=GridLAB-D

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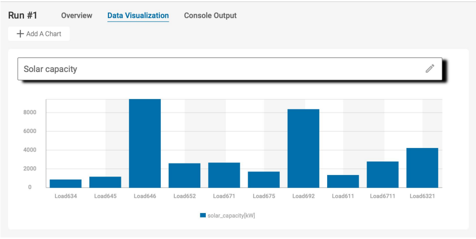
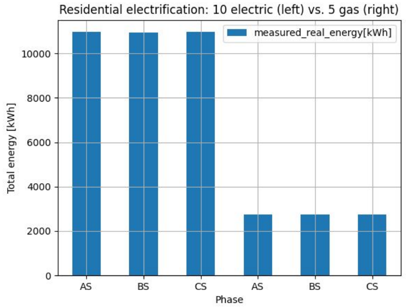
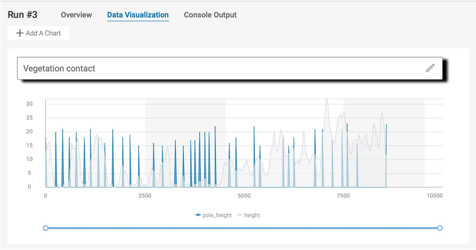
PIPELINE RUNS: INTEGRATION CAPACITY ANALYSIS

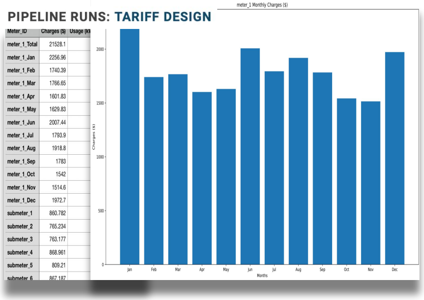




PIPELINE RUNS: RESILIENCE ANALYSIS



PIPELINE RUNS: TARIFF DESIGN



https://app.openfido.org/

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DOE GridLAB-D

- ~~Build system~~
- Compiler
- Validations
- Libraries
- Weather data
- Solvers
- Load models
- Compilers
- ~~Transients~~
- ~~Co-simulation~~
- ~~Wiki docs~~

CEC GridLAB-D

- Easy install
- CI/CD build
- Cloud deploy
- Model library
- Object library
- Python module
- Geodata
- Converters
- Subcommands
- Tools
- Templates
- Tutorials
- Online docs

Product Overview

SLAC

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   a. **Product called Arras Energy**

LF ENERGY ARRAS

Arras Energy

The purpose of the Arras Energy project is to enable and support the use of DOE's GridLAB-D technology by utilities, researches, and vendors with special attention to energy delivery systems. The scope of the project include collaborative development under the Project License (as defined in The Arras Project Charter) supporting the missions, including documentation, testing, integration, and the creation of other artifacts that aid the development, deployment, operation, and adoption of the open source project.

https://github.com/arras-energy/tsc

Download and installation

SLAC

Three quick-start methods

1. Docker

   `docker run -it hipas/gridlabd`

2. Amazon AWS

   AMI: search for "`gridlabd`"

3. GitHub project

   Use `hipas/gridlabd-project` template

Accessing sample models

Three libraries of sample models for GridLAB-D

```
$ gridlabd model [-u USER] [-r REPO] [-b BRANCH]
      {get GROUP/NAME,index PATTERN}
```

IEEE: 13, 37, 123, 342, 8500

- GLM version of standard IEEE test models

Taxonomy: 5 climate regions, 25 feeders

- Multiple voltages (24.47 kV to 35 kV)
- Various residential/commercial densities

PG&E: 12 taxonomy feeder models

- Created by PNNL for CEC project

Getting weather data

Three weather data types accessible

- Typical meteorological years (TMY)

  ```
  $ gridlabd weather COMMAND [OPTIONS ...]
  ```

  https://github.com/hipas/gridlabd-weather

- National solar radiation database (NSRDB)

  ```
  $ gridlabd nsrdb_weather [OPTIONS ...]
  ```

  https://nsrdb.nrel.gov/

- NOAA Forecast

  ```
  $ gridlabd noaa_forecast [OPTIONS ...]
  ```

  https://api.weather.gov/points/LAT,LON

Creating load models

Static loads

- ZIP is typical for most powerflow solvers
- Many sources, e.g., CYME, NERC, NAICS

Physics-based load modules

- Residential
- Commercial

Loadshapes

- ELCAP, RBSA, CEUS, etc.

Data-driven models, e.g., AMI, SCADA

- Transfer functions and filters
- Loadshape analysis

HiPAS GridLAB-D
(EPC-17-046)

Technical Advice and Discussion

6 April 2022

U.S. DEPARTMENT OF ENERGY | Stanford University

SLAC NATIONAL ACCELERATOR LABORATORY

Project status overview

Deployment & validation of new capabilities

1. Weather data (forecasts)
2. Geographic data and models (vegetation)
3. Advanced load models (AMI data)
4. Utility assets (poles)
5. Resilience analysis (pole failure, line contact)
6. Market data (CAISO, ISONE)

Validation results

1. NG 2000-feeder performance test
2. SCE resilience analysis

Use-Cases templates

1. Hosting capacity analysis
2. Tariff design analysis
3. Electrification analysis
4. Resilience analysis

Technology transfer

1. Linux Foundation Energy (Arras Energy)
2. AWS and Dockerhub support
3. Training and tutorial videos
4. IEEE Credentialed Instruction (CEU, PDH)

NG Long Term Load Forecast Methodology

Objectives:

- 15-year load forecast for NY
- Include renewables and DERs

Approach:

- Convert CYME to GLM
- Link GLM to annual loadshapes
- Simulation 8760 for year 1
- Extract feeder demand
- Extrapolate year 2 to 15

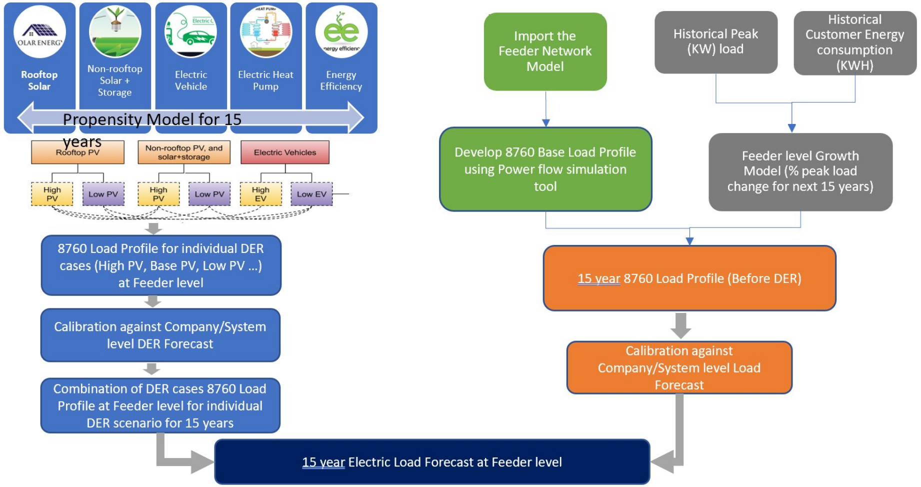


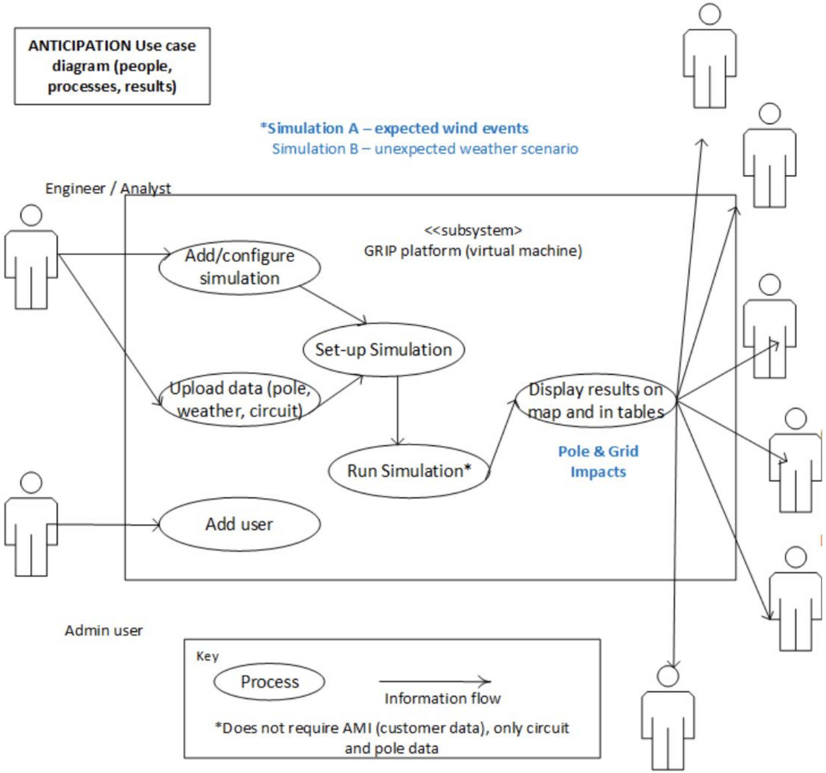
Image courtesy Hitachi America

NG 2000 Feeder Performance Evaluation

Test on 2000+ feeders from National Grid

- Feeders processed with CYME converter (>98% ok)
  - Solutions verified against 2021 load forecast solutions
  - Remaining errors due to model/data issues in CYME
- Findings using HiPAS GridLAB-D vs. DOE GridLAB-D
  - Simulation speed up (>99% faster)
  - AWS (c5a.8xlarge 32 vCPU 64GB) cost reduction (>99% savings)
  - Validated also on c5a.24xlarge 96 vCPU 192GB

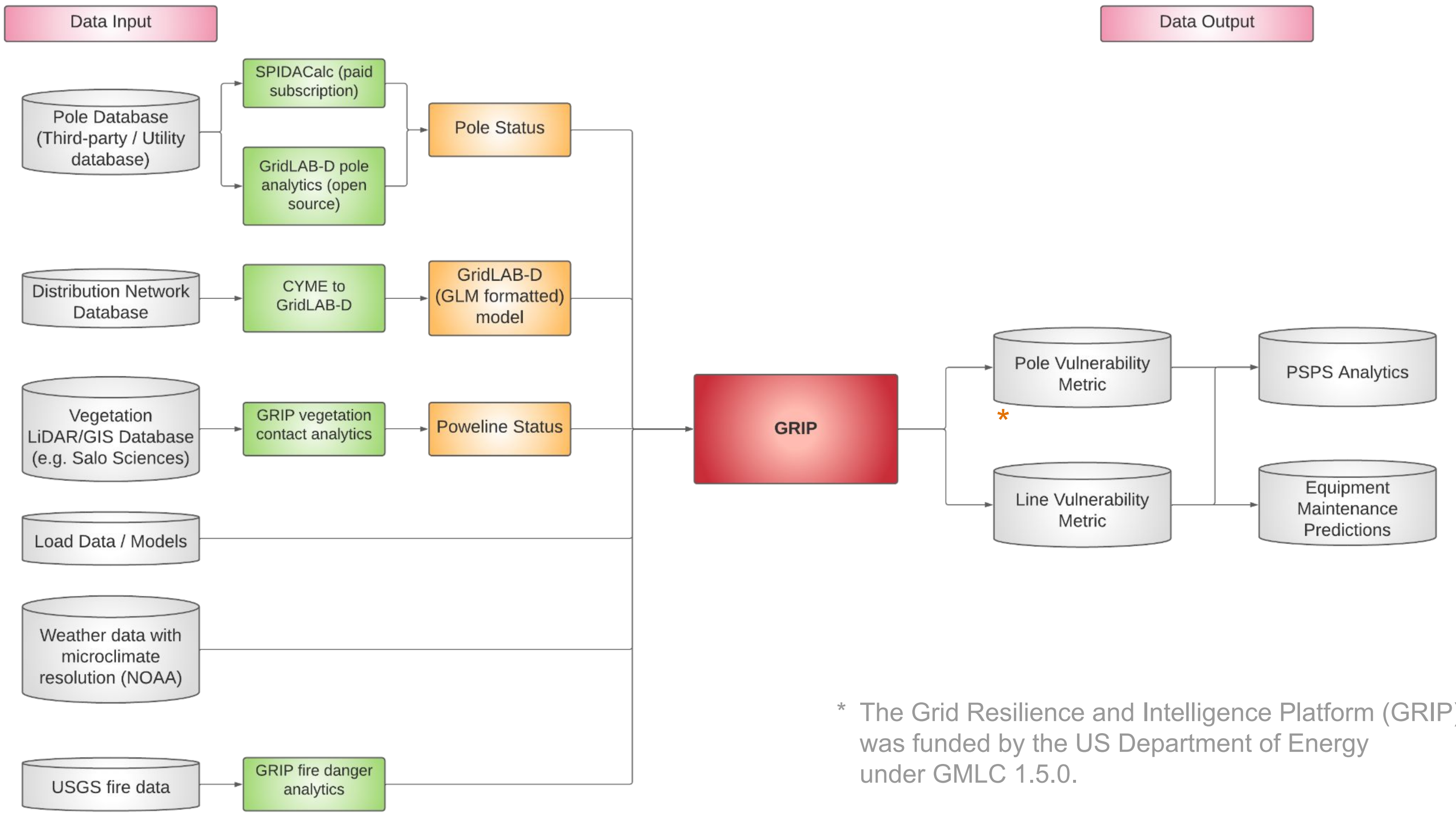
SCE Resilience Use-cases



Identified use-case scenarios:

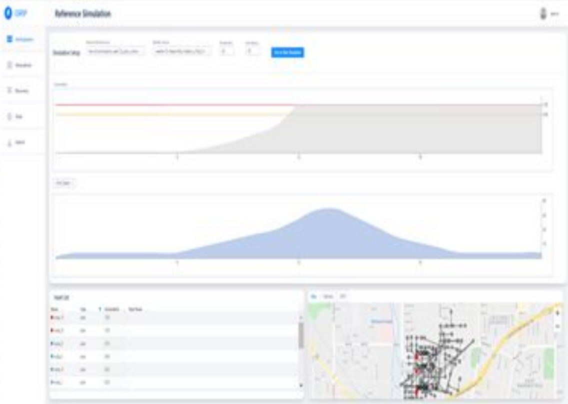
1. Which poles to replace?
2. Assess system stability
3. Identify fire-risk areas where poles may fall
4. Where to stage field crew
5. Where are poles likely to fail - day of events.
6. Maximizing stability during a wind storm

SCE Resilience Analysis Methodology



* The Grid Resilience and Intelligence Platform (GRIP) was funded by the US Department of Energy under GMLC 1.5.0.

SCE Resilience Analysis Evaluation

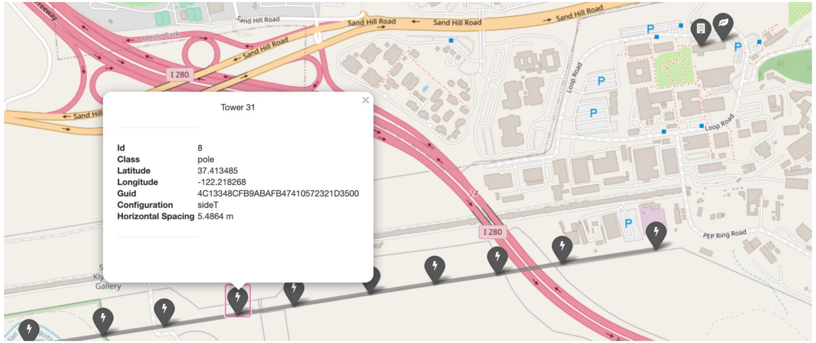


Pole vulnerability (IOU-driven use-case)

Test using failed pole data

Vegetation/ Fire-Risk - Model cables, vegetation (incl. Using lidar), etc.

Final Test, Integrate and deploy



Three use-cases developed for SCE

1. Bulk pole analysis (integration with SPIDACalc for pole database and validation against standards)
2. Pole database integration with network models
3. Vegetation risk use-case

Resilience analytics metrics and results

Included in GridLAB-D powerflow module

- Pole object
- Pole configuration
- Pole mount
- Linked to overhead line object

Uses pole databases with lat/long information

- Moments used to evaluate resilience metrics
- Pole stresses validated with SpidaCALC

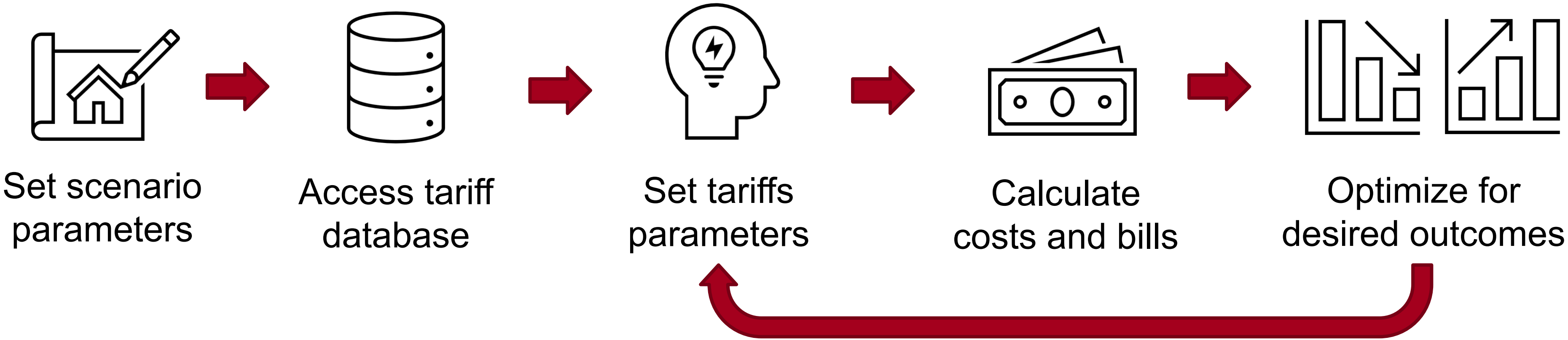
```
object pole
{
    pole_status "OK";
    tilt_angle "0 deg";
    tilt_direction 0 deg";
    weather "<climate-object>";
    configuration "<pole-configuration-object>";
    install_year "1970";
    repair_time "24 h";
    wind_speed 0.0 m/s;
    wind_direction 0.0 deg;
    wind_gusts 0.0 m/s;
    pole_stress "0 pu";
    pole_stress_polynomial_a "0 ft*lb";
    pole_stress_polynomial_b "0 ft*lb";
    pole_stress_polynomial_c "0 ft*lb";
    susceptibility "0 pu*s/m";
    total_moment "0 ft*lb";
    resisting_moment "0 ft*lb";
    pole_moment "0 ft*lb";
    pole_moment_nowind "0 ft*lb";
    equipment_moment "0 ft*lb";
    equipment_moment_nowind "0 ft*
    critical_wind_speed "0 m/s";
    guy_height "0 ft";
}
```

```
object pole_configuration {
  pole type "WOOD";
  design_ice_thickness 0.25;
  desing_wind_loading 4.0;
  design_temperature 15.0;
  overload_factor_vertical 1.9;
  overload_factor_transverse_general 1.75;
  overload_factor_transverse_crossing 2.2;
  overload_factor_transverse_wire 1.65;
  overload_factor_longitudinal_general 1.0;
  overload_factor_longitudinal_deadend 1.3;
  strength_factor_250b_wood 0.85;
  strength_factor_250b_support 1.0;
  pole_length 45.0;
  pole_depth 4.5;
  ground_diameter 32.5/3.14;
  top_diameter 19/3.14;
  fiber_strength 8000;
  treatment_method "CRESOTE";
}
```

```
object pole_mount
{
    equipment link_id;
    height 0.0 ft;
    offset 0.0 ft;
    direction 0.0 deg;
    weight 0.0 lbs;
    area 0.0 ft;
}
```

Tariff analysis use-case

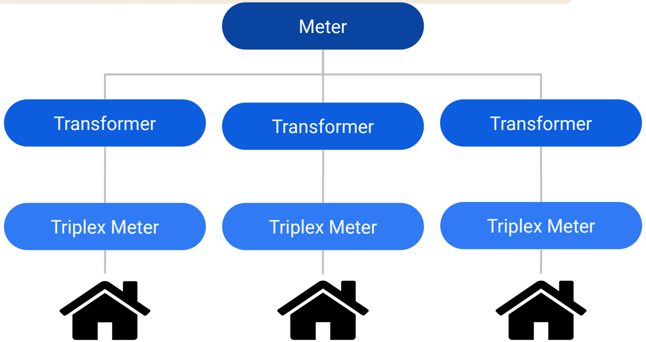
- Electric energy tariff analysis template available for HiPAS GridLAB-D
- Focus on residential tariffs for California IOUs
- Leveraging an open-source world-wide tariff database, OpenEi (NREL)

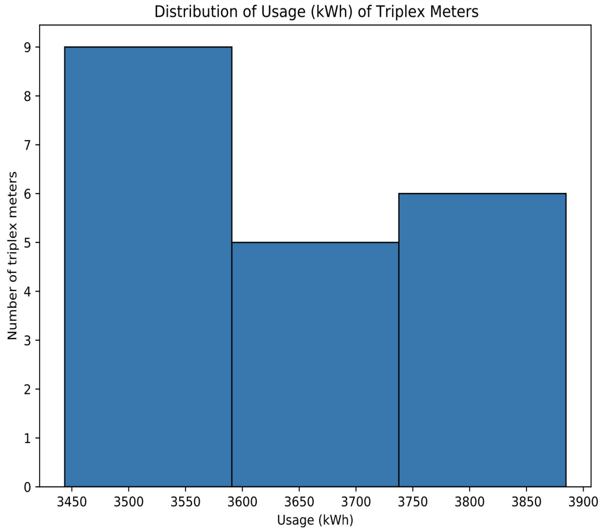


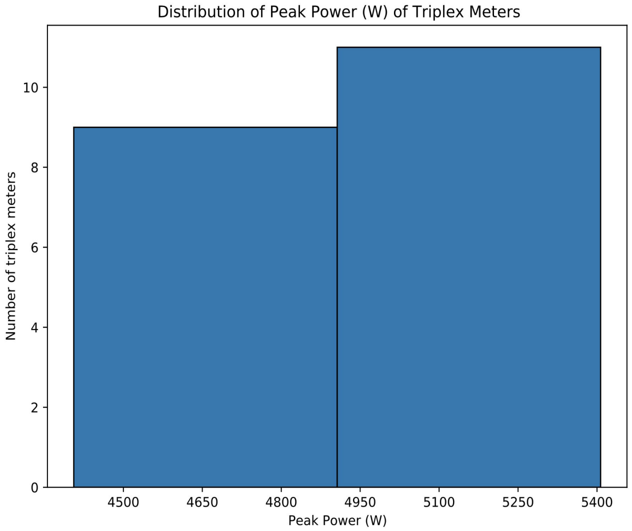
Tariff Design - Example study

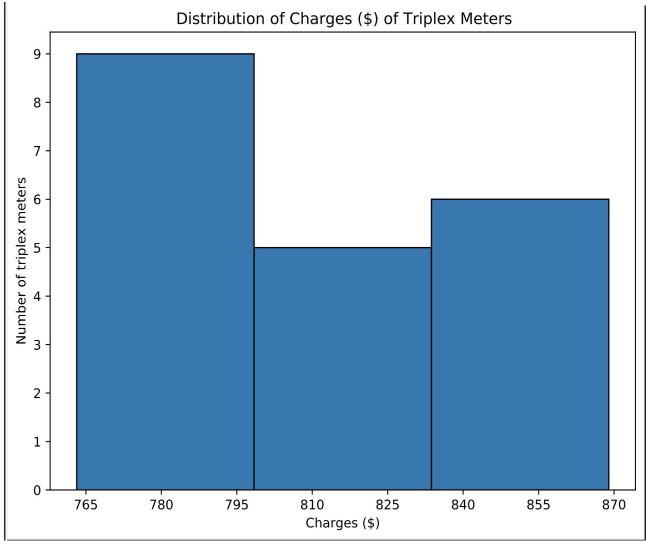
Simulation Parameters:

- Jan 1, 2020 – Dec 31, 2020
- 27 houses in San Francisco
- PG&E E-TOU-C3 Region R









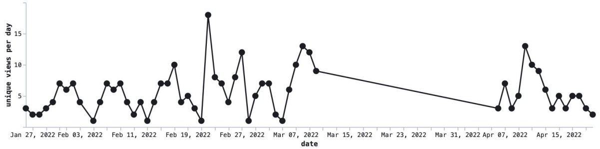
HiPAS GridLAB-D final production release series

- **Continuous releases of 4.3 for CEC builds, niknamed "chiba"**
  - First release in August 2022: 4.3.1 (chiba-1)
  - GitHub repo moving from "slacgismo" to "arras-energy" organization
  - AWS AMI naming: changing to "arras-energy-*"
  - Dockerhub images naming: "arras-energy/gridlabd:YYMMDD"
- **Final release of "chiba" series planned for summer 2023**
  - Only bug patches will be applied after final release
  - Future work planning by LF Energy Arras Energy Technical Steering Committee
- **Focus of current production work**
  - User and developer manuals
  - Tutorials, video, and training materials

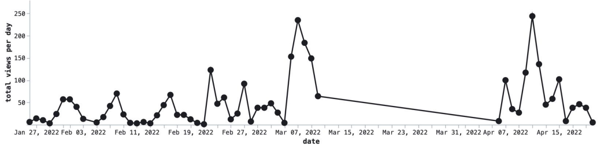
HiPAS GridLAB-D GitHub activity data collection

Views

Unique visitors

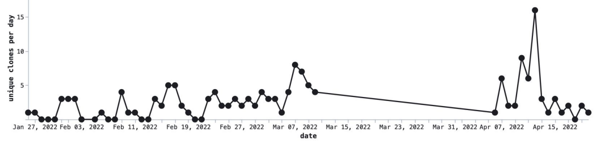


Total views

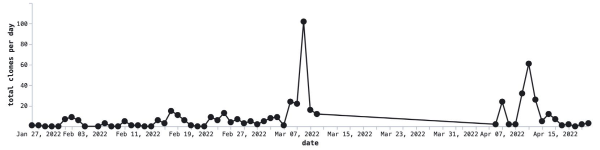


Clones

Unique cloners



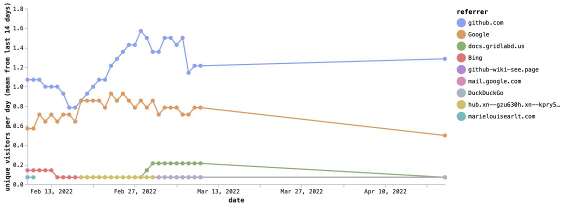
Total clones



Top referrers and paths

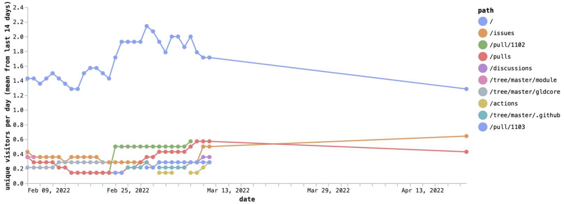
Note: Each data point in the plots shown below is influenced by the 14 days leading up to it. Each data point is the arithmetic mean of the "unique visitors per day" metric, built from a time window of 14 days width, and plotted at the right edge of that very time window. That is, these plots respond slowly to change (narrow peaks are smoothed out).

Top referrers



Top 15 referrers: 01: `github.com` , 02: `Google` , 03: `docs.gridlabd.us` , 04: `Bing` , 05: `github-wiki-see.page` , 06: `mail.google.com` , 07: `DuckDuckGo` , 08: `hub.xn--gzu630h.xn--kpry57d` , 09: `marielouisearlt.com`

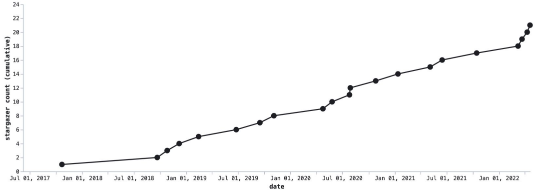
Top paths



Top 15 paths: 01: `/` , 02: `/issues` , 03: `/pull/1102` , 04: `/pulls` , 05: `/discussions` , 06: `/tree/master/module` , 07: `/tree/master/gldcore` , 08: `/actions` , 09: `/tree/master/.github` , 10: `/pull/1103` , 11: `/tree/develop` , 12: `/pull/1090` , 13: `/pull/1143` , 14: `/pull/1047` , 15: `/wiki/AWS-images`

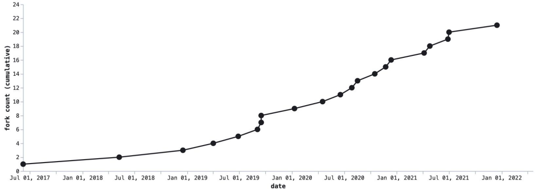
Stargazers

Each data point corresponds to at least one stargazer event. The time resolution is one day.



Forks

Each data point corresponds to at least one fork event. The time resolution is one day.



Other monitored resources:

- Dockerhub
- Amazon AWS

HiPAS GridLAB-D training (IEEE Credentialed CEU/PDH)

SLAC

SLAC NATIONAL ACCELERATOR LABORATORY

APPLIED ENERGY DIVISION

HiPAS GridLAB-D Training

SLAC National Accelerator Laboratory provides training to academic, industry, and vendors that wish to use the High-Performance Agent-based Simulation (HiPAS) version of GridLAB-D in their research, development, and operations. Staff in the Grid Integration Systems and Mobility group are experts on the design, development, and use of GridLAB-D, and related tools.

Training courses cover a range of topics from introductory material for newcomers to the world of agent-based power system simulation, intermediate topics on specific modules, including power systems, buildings loads, transportation infrastructure, and distributed energy resource integration, and advanced topics, include data handling, cloud computing, module development, and core development. Attendees will learn how to use GridLAB-D to simulate grid behaviour under deep electrification, DER integration, and tariff design. In addition, special topics may be addressed by request.

Instructors are highly experienced electrical and mechanical engineers who have worked with and developed tools using GridLAB-D for many years. Training courses are offered in 1/2-day or 1-day modules, depending on the topic and can be delivered on-line using Zoom, on-site at SLAC National Accelerator Laboratory, or off-site at a hosting facility. Off-site courses include GSA per-diem costs, unless instructors' travel, food, and lodging are prepaid.

About the Instructors *

David P. Chassin, PhD

David has more than 30 years experience in energy system modeling and simulation. He manages the Grid Integration Systems and Mobility at SLAC. He is the original developer of GridLAB-D and leads the development of the California Energy Commission EPIC projects to commercialize GridLAB-D for California's investor-owned utilities.

Alyona Teyber, MASc

Alyona has 7 years experience modeling and simulating power systems using GridLAB-D, as well as developing tools and applications based on GridLAB-D technology. Alyona leads research projects in grid resilience, distribution system electrification, and the integration of renewable resources in distribution system operations.

* Please note that instructors may change depending on the course date and location.

SLAC NATIONAL ACCELERATOR LABORATORY

APPLIED ENERGY DIVISION

GridLAB-D Training Course Application

Company name: ______________________ **DUNS:** ______________

Principal address: ______________________ **US Corporation?** [ ] Yes

______________________ (see Note 1) [ ] No

____

Contact name: ______________________

Contact email: ______________________

Contact phone: ______________________

Course dates: ___/___/20___ to ___/___/20___

Send an email request for training and support.

Please choose course topics:

	Topic	*Online Only*	*SLAC Hosts*	*Company Hosts*
[ ]	GridLAB-D Introduction (1/2 day)	$1250	$1750	$1250
[ ]	Distribution system modeling (1/2 day)	$500	$1000	$500
[ ]	Load modeling (1/2 day)	$500	$1000	$500
[ ]	Retail market/tariff design (1/2 day)	$500	$1000	$500
[ ]	Load electrification (1/2 day)	$500	$1000	$500
[ ]	Electric vehicle charger integration (1/2 day)	$500	$1000	$500
[ ]	Solar resource integration (1/2 day)	$500	$1000	$500
[ ]	High-performance simulation (1/2 day)	$500	$1000	$500
[ ]	Database operations (1/2 day)	$500	$1000	$500
[ ]	Cloud operations (1/2 day)	$1250	$1750	$1250
[ ]	Module development (1 day)	$2500	$3000	$2500
[ ]	Core development (1 day)	$2500	$3000	$2500
[ ]	Special topics (1/2 day)		(call for pricing)	
	Course administrative fee	$1000	$1000	$1000
	Subtotal:	$________	$________	$________
	Travel (see Note 2)	$0	$0	$________
	Total:	$________	$________	$________

Notes:

1. Foreign corporations require 60-90 days for US Department of Energy review and approval.
2. Please use GSA per diem rates for training location. Partners may provide travel, food, and lodging.

Please send your application to SLAC (pao@slac.stanford.edu)

Scan this QR code to get a copy of the training application form and access the online tutorial videos, or use the following link:

http://training.gridlabd.us/

Questions

1. How are you using Arras Energy now or in the near term?
2. What future applications do you anticipate long term?
3. What new capabilities do you wish to see?
4. What benefits were made possible by this project?
5. What is necessary to realize those benefits?

Thank you

Contact: dchassin@slac.stanford.edu

HiPAS GridLAB-D source online at https://source.gridlabd.us/

Documentation available online at https://docs.gridlabd.us/