HiPAS GridLAB-D (EPC-17-046)

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U.S. DEPARTMENT OF ENERGY | Stanford University
SLAC NATIONAL ACCELERATOR LABORATORY

Project status overview

SLAC

New capabilities

1. Weather (historical, real-time and forecasts)
2. Geodata (micro-climate)
3. Data-driven loads (e.g., AMI fit)
4. Pole creation and import (Spidacalc)
5. Resilience metrics analysis (GLMC)
6. Wholesale market model (CAISO, ISONE)

Validation results

1. 2000-feeder performance test
2. Resilience use-case (🔍)

Use-Cases

1. Hosting capacity analysis (👷)
2. Tariff design (🔍)
3. Electrification (🔍)
4. Resilience (🔍)

Technology Transfer

1. 5 updates since Sep 2021
2. User/develop training program (🚧)
3. Commercialization plan (with Hitachi)

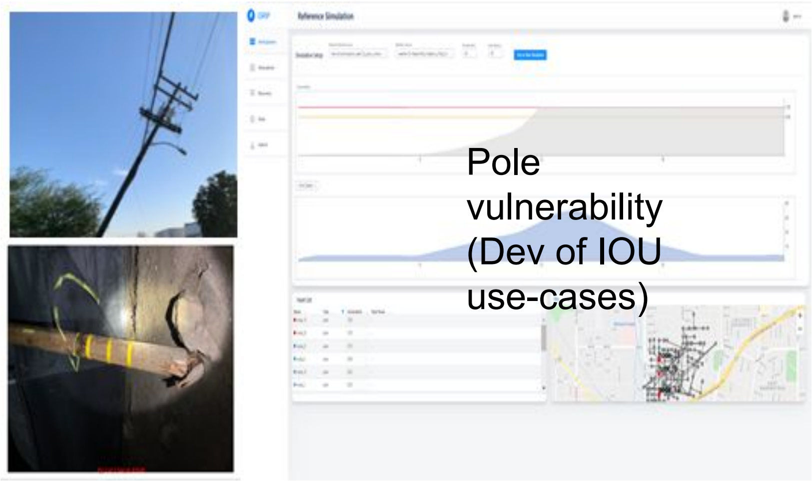
🔍: currently being deployed/validated
👷: available but under active development
🚧: not available to general users at this time

2000-Feeder Performance Validation

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
- Major findings using HiPAS (4.2) vs. (DOE) 4.0
  - Simulation speed up (>99% faster)
  - AWS cost reduction (>99% savings)

Resilience Use-case Validation

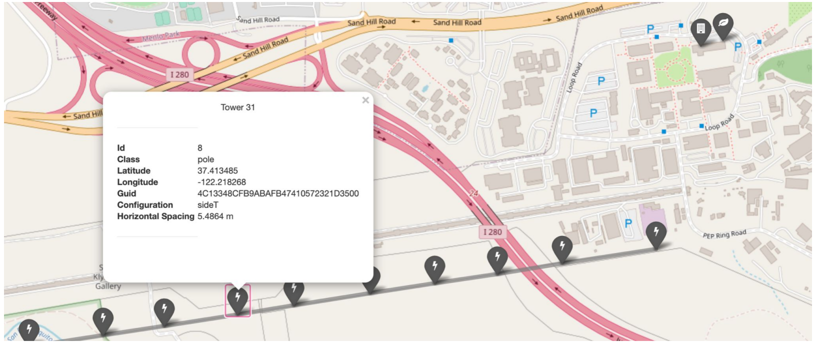


Pole vulnerability (Dev of IOU use-cases)

→ Test using failed pole data

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

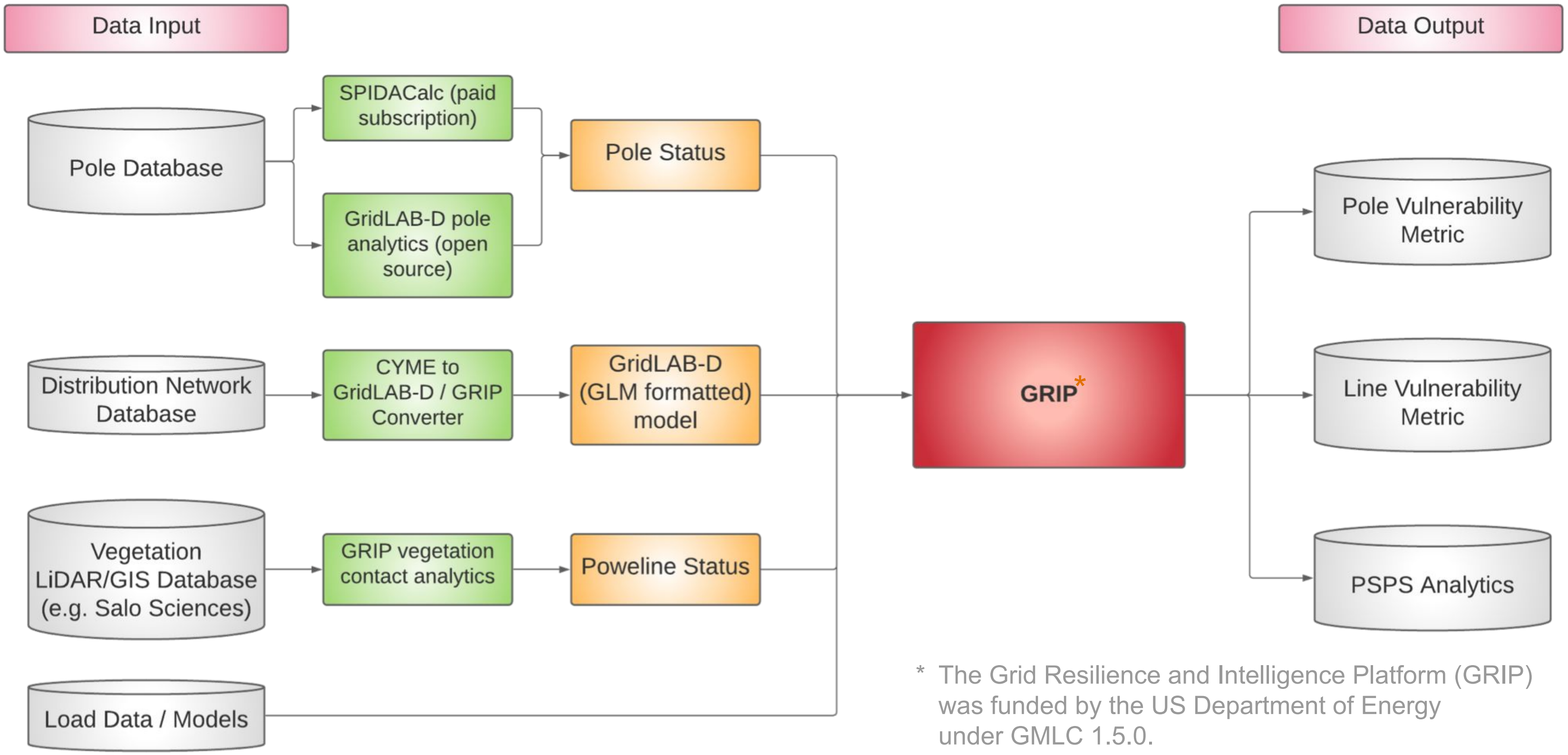
→ Final Test, Integrate and deploy



Features added this year:

- Reformulation of the pole vulnerability assessment in HiPAS GridLAB-D power flow module
  - Line-dependent pole failure vs node-dependent pole failure
  - Ease of integration with IOUs pole databases
- Addition of vegetation geodata module for line vulnerability forecasting

Resilience analysis



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

Resilience analytics

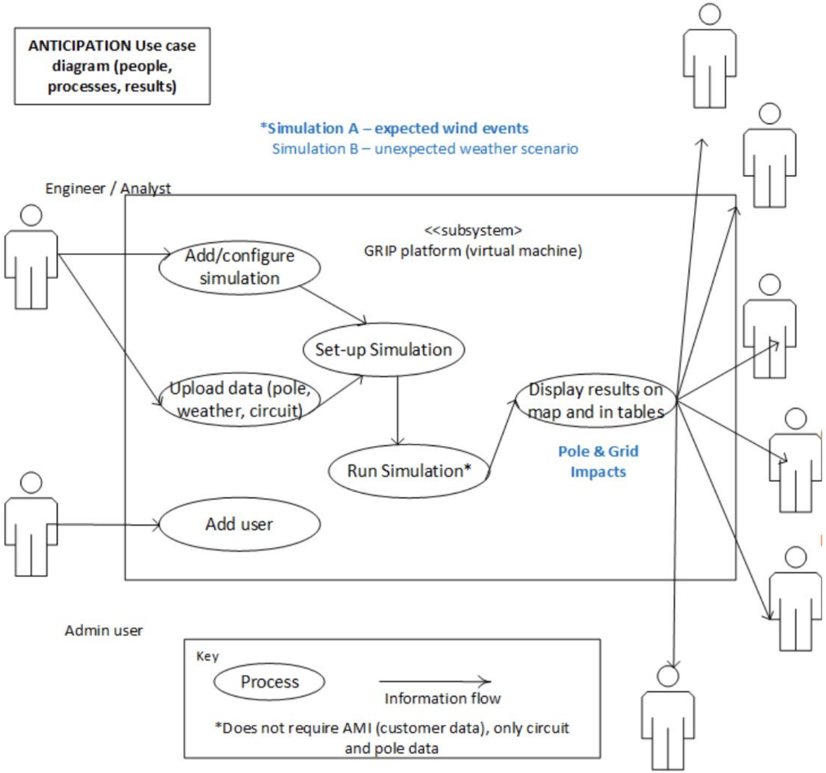
- Built directly into the power flow module within GridLAB-D source code
  - Pole object
  - Pole configuration
  - Pole mount
- Child of the overhead line object
- Allows for integration with pole databases that map lat/long information onto distribution network models.
- Calculates the moments on the pole and translates into the vulnerability metric for resilience.
- Available under an open-source license.
- Alternatively, pole stresses can be populated through other commercially available (paid) software
  - SPIDA - implemented
  - Powerlines Pro - future work
  - Others - future work

```
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;
}
```

SCE Resilience Use-cases

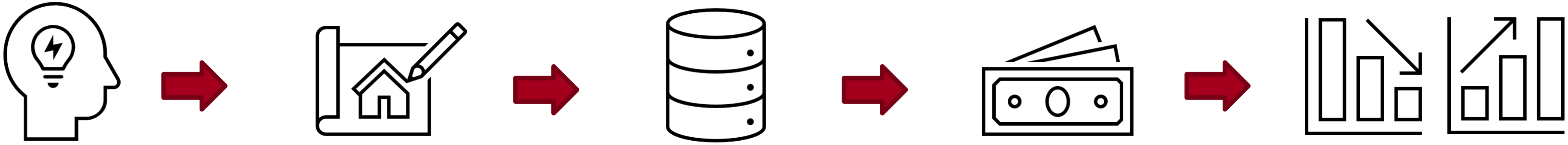


Identified use-cases:

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

Tariff analysis

- Development of electrical tariff simulation **template** for HiPAS GridLAB-D
- Focus on residential tariffs for California IOUs
- Leveraging an open-source world-wide tariff database, OpenEi (NREL)

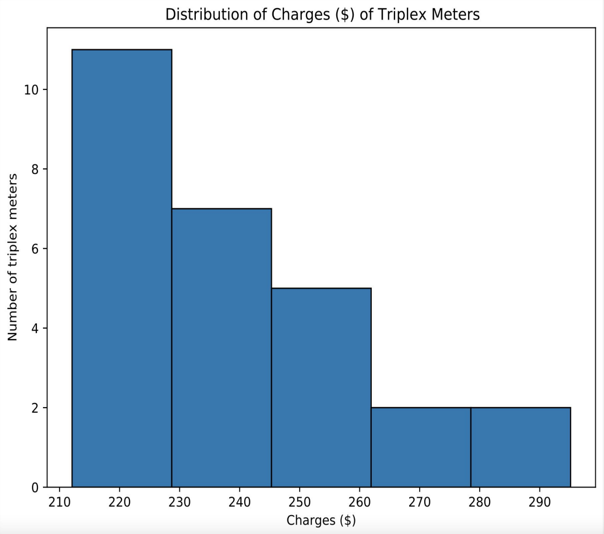


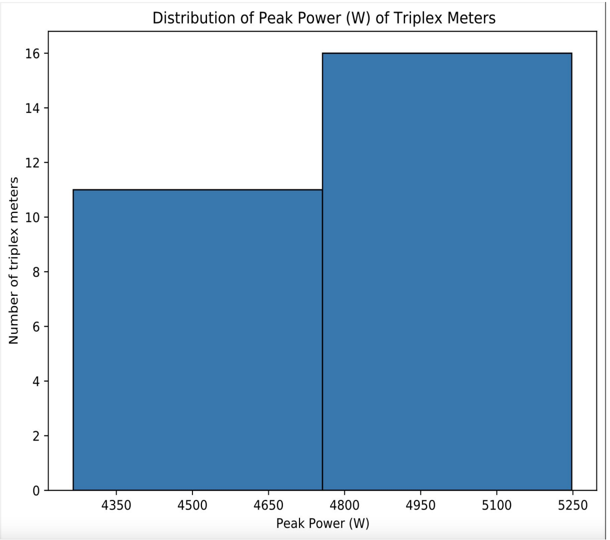
User inputs parameters → Set simulation parameters → Access tariff database → Calculate bill → Optimize desired outputs

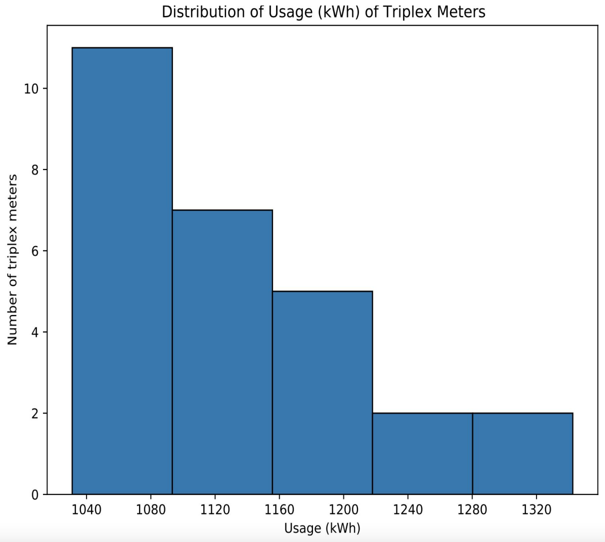
Tariff Design - sample output

Simulation Parameters:

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







Sample output - cont'd

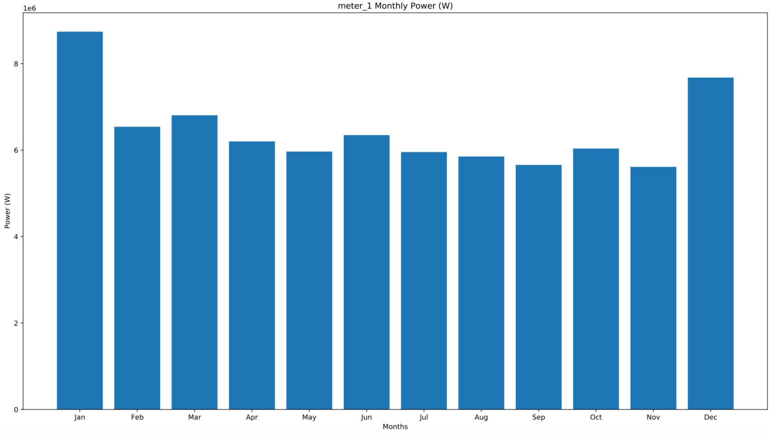
Simulation Parameters:

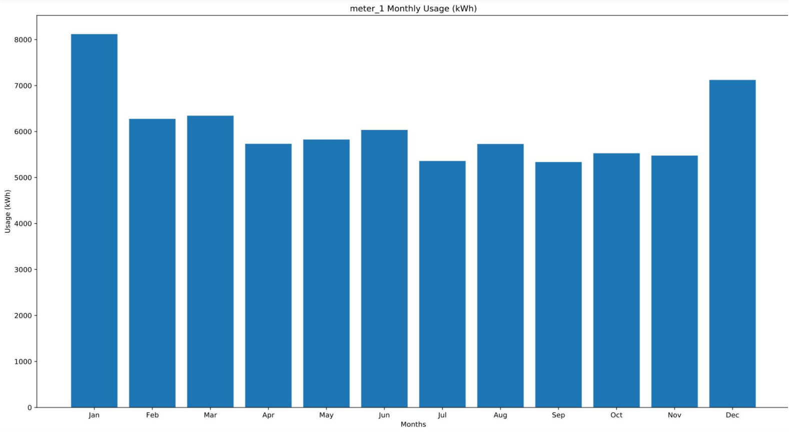
- Jan 1, 2020 – Dec 31, 2020
- 20 houses in San Francisco
- Very good thermal integrity
- Water heater, dryer, and range gas end uses
- Heat pump heating system

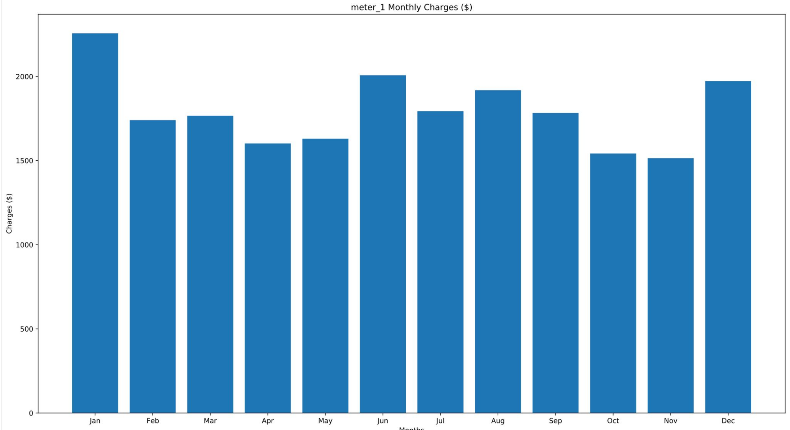
output

Meter_ID	Charges ($)	Usage (kWh)	Peak Power (W)
meter_1_Total	21528.1	72882	NaN
meter_1_Jan	2256.96	8119.23	NaN
meter_1_Feb	1740.39	6275.17	NaN
meter_1_Mar	1766.65	6344.4	NaN
meter_1_Apr	1601.83	5733	NaN
meter_1_May	1629.83	5825.3	NaN
meter_1_Jun	2007.44	6033.6	NaN
meter_1_Jul	1793.9	5358.7	NaN
meter_1_Aug	1918.8	5728.9	NaN
meter_1_Sep	1783	5336.4	NaN
meter_1_Oct	1542	5527.4	NaN
meter_1_Nov	1514.6	5476.7	NaN
meter_1_Dec	1972.7	7123.2	NaN
submeter_1	860.782	3852.89	5307.72
submeter_2	765.234	3452.38	4440.77
submeter_3	763.177	3443.73	4440.77
submeter_4	868.961	3884.75	5406.85
submeter_5	809.21	3640.39	5406.85
submeter_6	867.187	3877.97	5406.85

Sample Output - cont'd

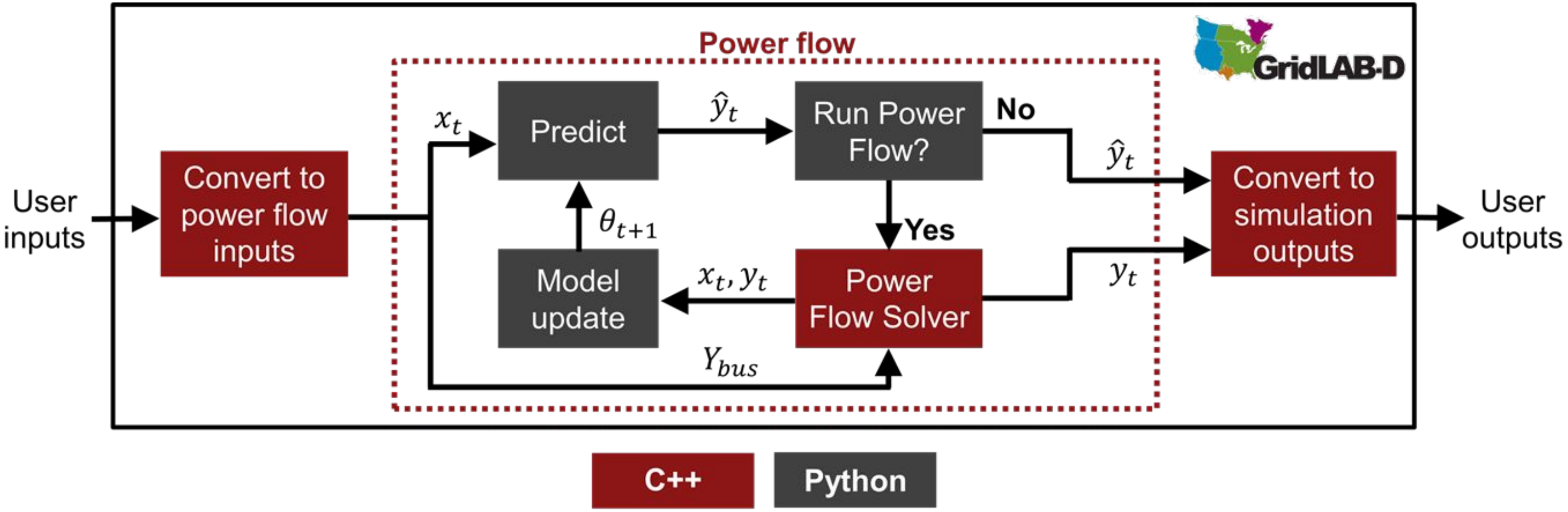






Learning-accelerated powerflow

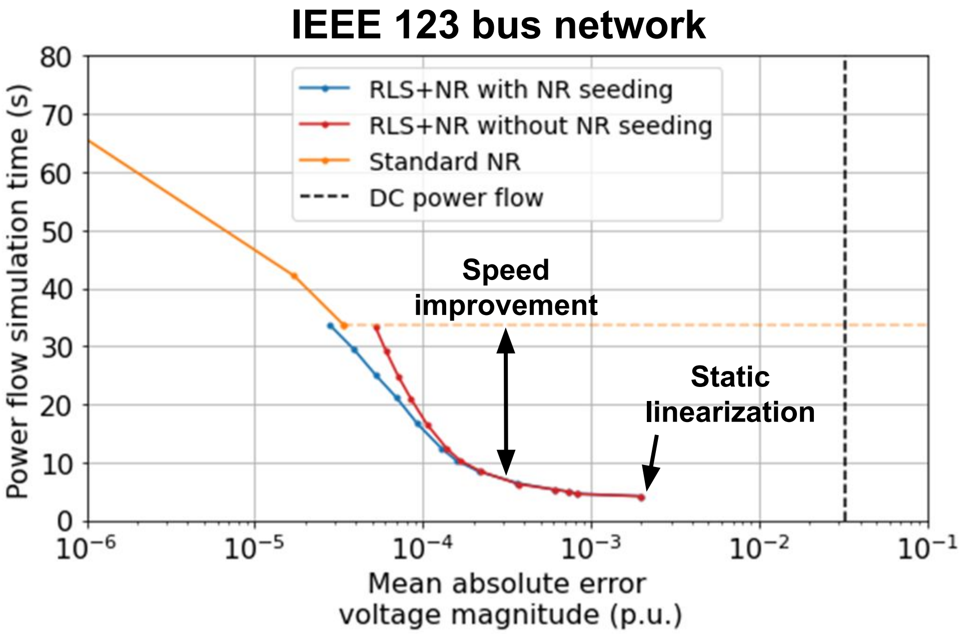
- Train data-driven linear model in-the-loop with powerflow solver and use it to bypass solver when possible
- Update data-driven model recursively whenever standard power flow solver is used



Learning-accelerated powerflow

Recent and current work:

- Improved speed by moving some of the implementation from python to C++
- Improved metrics for comparing performance to baseline methods
- Currently improving methods for dealing with topology change, capacitors, and regulators in the learning algorithm



HiPAS GridLAB-D final production release series

- **Monthly "chiba" releases of 4.3 for final builds**
  - First release in May: 4.3.1 (chiba-1)
  - Move GitHub repo from "slacgismo" to "hipas" organization
  - AWS AMI named "hipas-gridlabd-4.3.##-YYMMDD-master-ec2"
  - Dockerhub images named "hipas/gridlabd:YYMMDD"
- **Final release of "chiba" series planned for September 2022**
  - Only bug fixes will be applied after final release
  - Functional changes deferred to next versions (e.g., 4.4, 5.0)
- **Focus of production work**
  - User and developer manuals
  - Tutorials, video, and training materials

HiPAS GridLAB-D training program roll-out

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.

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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 or use the following link: https://tinyurl.com/2mk56vn3

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/