Introduction to GLOW: An Open-source Distribution Planning Tool Based on GridLAB-D

Bo Yang, Ph.D.
Panitarn (Joseph) Chongfuangprinya, Ph.D.
Yanzhu Ye, Ph.D.
12/17/2020

GLOW is funded by the California Energy Commission under grant EPC-17-043.

IEEE PES UNIVERSITY

Energy Solutions Lab, R&D,
Hitachi America, Ltd., Santa Clara, CA, USA

IEEE

Presenter Bio

Bo Yang

Senior Director, Hitachi America

- Bo Yang, Ph.D., is a senior director at Hitachi America, Energy Solutions Lab, R&D. She participated in the development of GridLAB-D and has managed multi-million dollar cross-functional research programs for the development of transmission equipment and end-to-end software solutions. Dr. Yang has a PhD in Electrical Engineering and 10+ years of R&D experience on DER studies, data analytics and Energy IoT technologies.

Panitarn (Joseph) Chongfuangprinya

Principal Researcher, Hitachi America

- Panitarn Chongfuangprinya, Ph.D., is a principal researcher at Hitachi America, Energy Solutions Lab, R&D. He has over 10 years of experience working with electric utilities in North America and Asia. His areas of expertise are Smart Grid Strategy, Data Mining and its utility applications, Power System Analysis, Renewable Energy Impact, Load Forecasting, Reliability Analysis, and Asset Management. Prior to joining Hitachi in 2016, he has worked at Energy IT-OT as a senior consultant and Quanta Technology as a principal engineer. He received his Ph.D. in Industrial Engineering from The University of Texas at Arlington.

Agenda

- Introduction (5 Minutes)
- The Current Development of GLOW (5-10 Minutes)
- Potential Use Cases (5-10 minutes)
- Information Architecture and Demo (15 – 20 Minutes)
- Next Step and Conclusion (5-10 Minutes)
- Q&A

Learning Objectives

- Describe the background, drivers, and challenges of rising DER, storage, and EV penetration
- Understand the efforts to support DER modeling and simulation needs
- Identify distribution planning use cases related to these technologies
- Understand high-level aspect of GLOW

INTRODUCTION

Background

- **Challenges, Opportunities, Drivers:**
  - Policy mandates reductions of GHG
  - Rising DER, storage, and EV penetration
    - Increases complexity of grid planning and operations
  - Rising costs of the grid

- **Potential Solutions:**
  - New tools and methodologies for forecasting and planning
  - Transparent grid analytics
  - Making grid conditions openly available

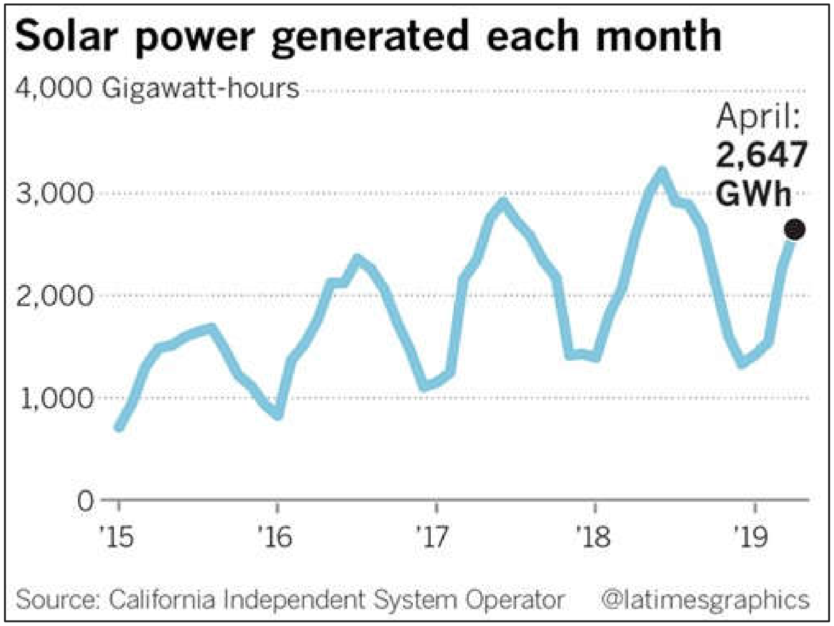
IEEE PES UNIVERSITY IEEE

Key Policy Initiatives

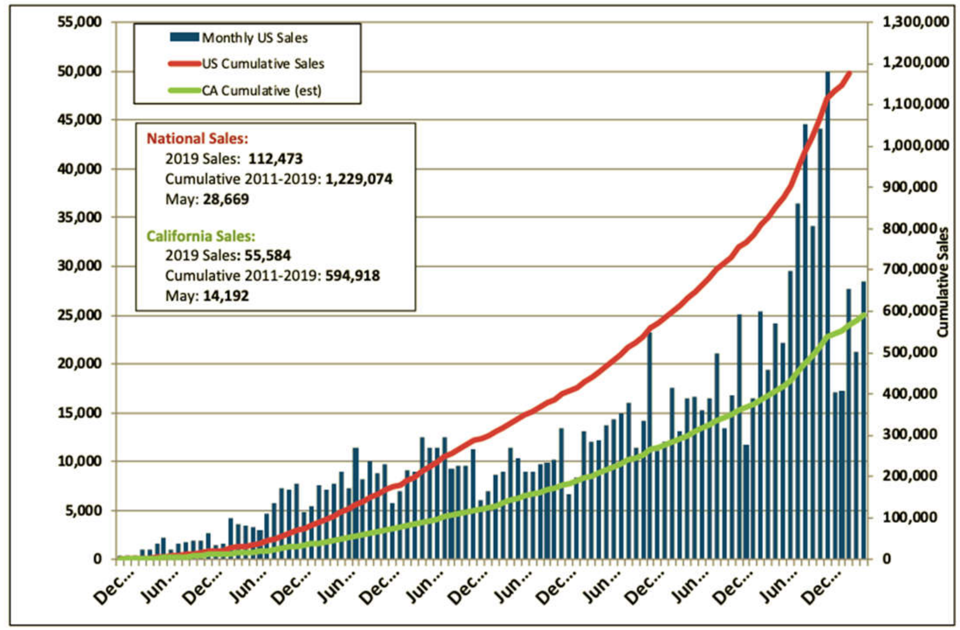
- **California Climate Policies:**
  - Reduce Emissions (AB 32)
    - 40% below 1990 levels by 2030
  - 100% carbon-free electricity by 2045 (Executive Order B-55-18)
    - 50% by 2025

- **California Distributed Energy Policies:**
  - Net Energy Metering (AB 327)
  - 1.3 GW Storage Mandate (AB 2514, CPUC)
  - 5 Million EVs by 2030 (Executive Order B-48-18)
    - 250,000 charging ports
  - Distribution Resource Planning (AB 327)

Rising adoption of PV-DG and EV in CA



https://www.latimes.com/business/la-fi-solar-batteries-renewable-energy-california-20190605-story.html



Note: Approximation assumes CA sales are 49% of national sales.
Reference: www.hybridcars.com and www.insideevs.com

6/7/2019

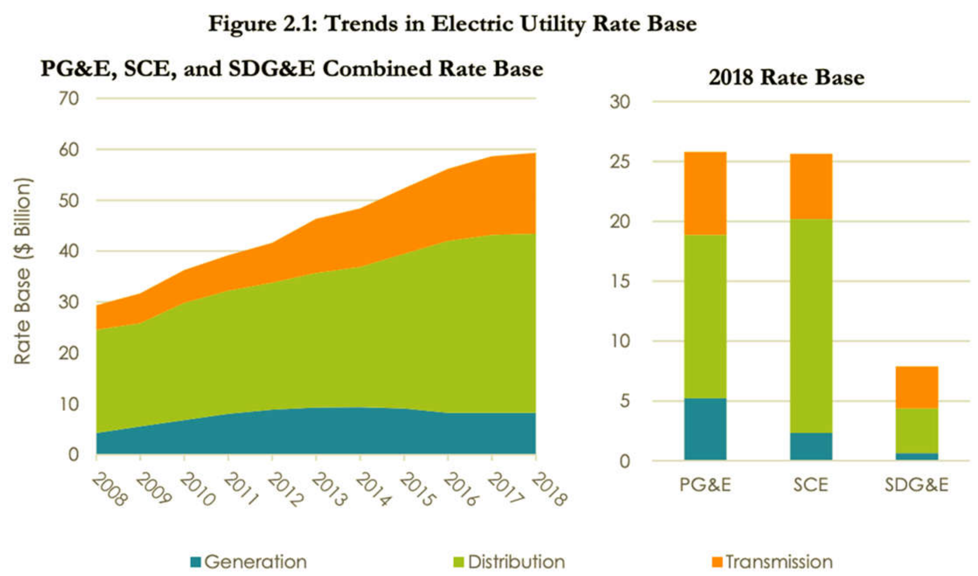
2030 Target
5 million Cars

IEEE PES UNIVERSITY IEEE

Rising Cost of Transmission and Distribution

- Distribution investment has risen 29% since 2008
  - Adjusted for inflation

"Rate Base" is the book value, after depreciation, of utility owned assets.



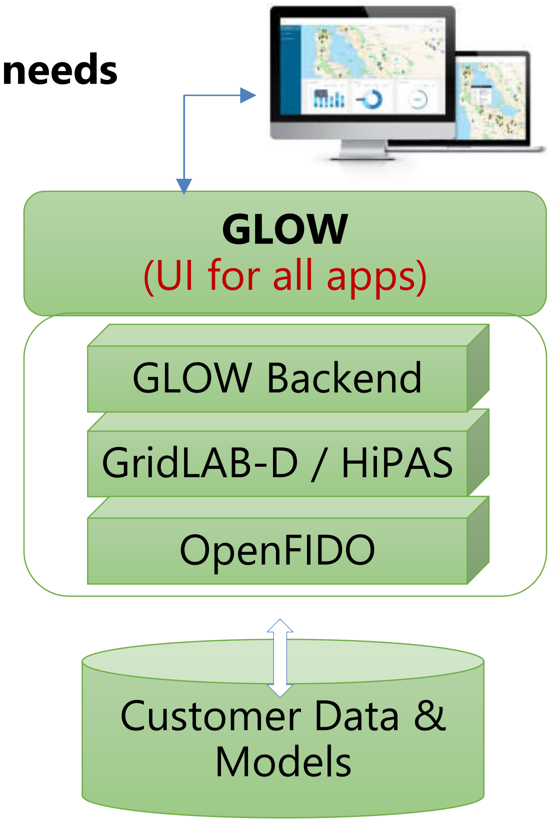
Source: CPUC AB 67 Report, May 2019

THE CURRENT DEVELOPMENT OF GRIDLAB-D OPEN WORKSPACE (GLOW)

Distribution Modeling Program as Potential Solutions

Programmatic effort to support DER modeling and simulation needs

- **GridLAB-D Open-source Workspace (GLOW: EPC 18-043)**
    - General user interface for simulation use cases
        - i.e., Power Flow, ICA
    - **GLOW is primary focus of this presentation**
- High-Performance Agent-based Simulation (**HiPAS**: EPC 18-046)
    - High-performance simulation in GridLAB-D
- Open Framework for Integrated Data Operations (**OpenFIDO**: EPC 18-047)
    - Energy data interoperability for California (CPUC, utilities, consultants, etc.)
    - Import and validate model



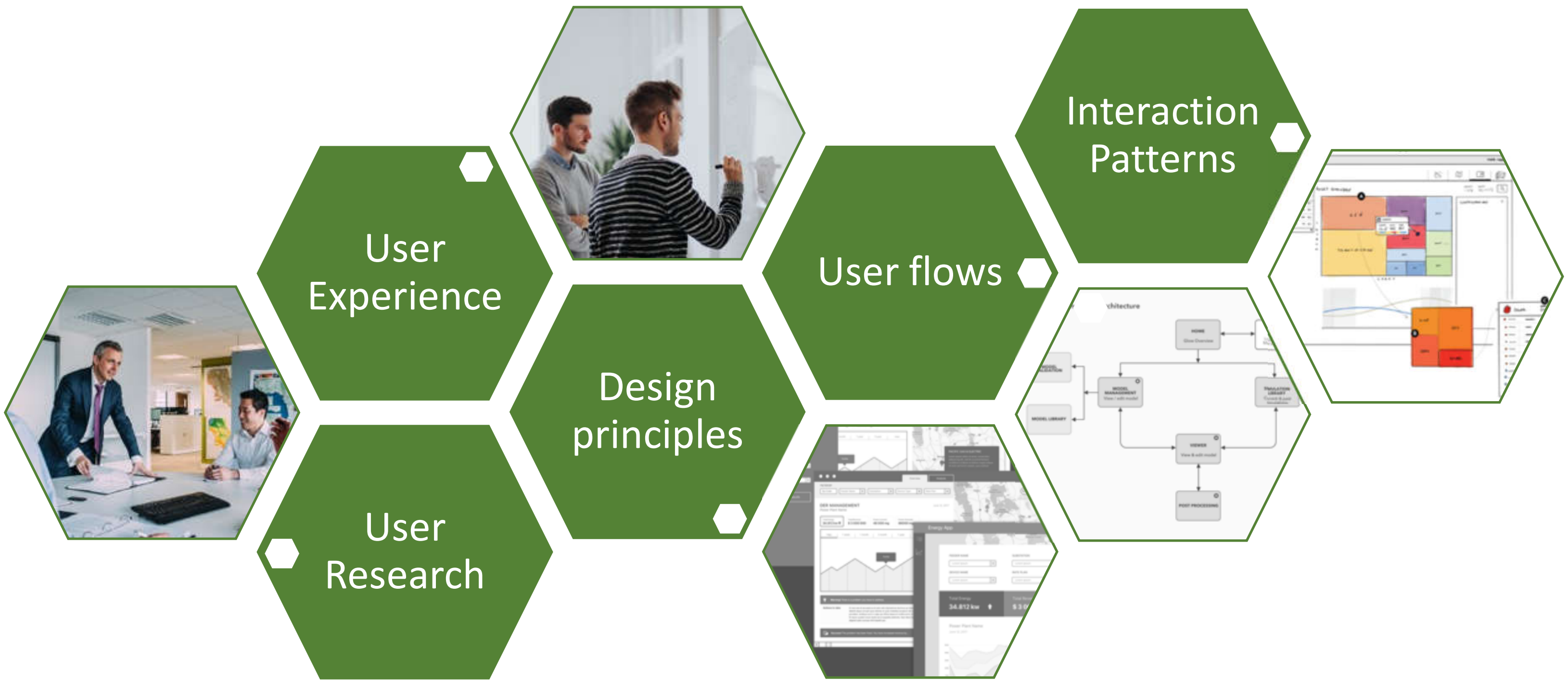
Background of GLOW

- **GridLAB-D**
  - One of the most advanced distribution planning tools
  - Ability to model
    - DERs
    - End-use energy consumption
- **Barriers**
  - Lacking GUI
  - No established method for DERs impact study
  - Extensive training and experiences
- **Goal: GridLAB-D Open Workspace (GLOW)**
  - A user-friendly environment for users
  - A web-based GUI

Examples of GridLAB-D CLI

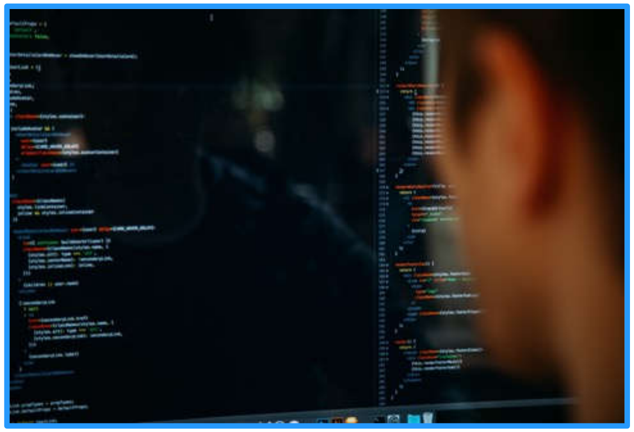
A Different Approach - Human Centered Design

Target: guide technical development to fit the needs of cross-entity collaboration



IEEE PES UNIVERSITY IEEE

Common Challenges



- From our research we found the following shared challenges:
  - Scale, complexity and uncertainty of the **grid**
  - Availability of and access to reliable **data**
  - Access to effective simulation **tools**
  - Lack of transparency over organizational boundaries
    - Difficulty in **communications**
  - An unmet need to **collaborate** and see through to **shared interests** and goals

Implementations – Incorporating Industry Inputs

Challenges

- Manual analysis/process
- Lack of skill resource
- Creating understandable results
- Information validation
- Modeling new type of demand/generation
- Communication between stakeholders
- Data sharing
- Cyber security for data sharing

GLOW Design Advantages

- A software on premise or cloud
- Multi-user simultaneously
- Tiered data access control
- Expandable function modules
  - Modeling
  - Simulation
  - Editing
  - Post processing

Result - GLOW

- **GridLAB-D Open Workspace (GLOW)**
  - A platform for distribution planning method and modelling
  - Designed for distribution resources planning
  - Web-based GUI for GridLAB-D
  - Open-source
  - Support deployment on workstation/cloud
  - Standardized analyses examples:
    - Power flow
    - Integration capacity analysis
  - Post-processing for result realization
  - Generate feeder topology for visualization
  - Designed for cross-organizational collaborations

GLOW Solution Architecture

User Interface
- Model Library/ Viewer
- Simulation Library
- Post-Processing

API
- Data Management
- Analysis
- Configuration

Data Lake
- Input data
- Model data
- Simulation results

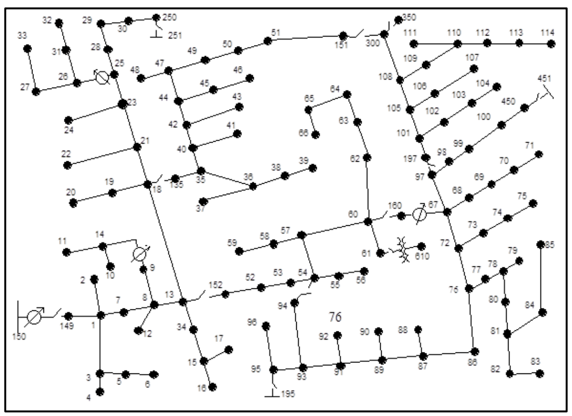
Simulation Engine
- GridLAB-D
- GLOW

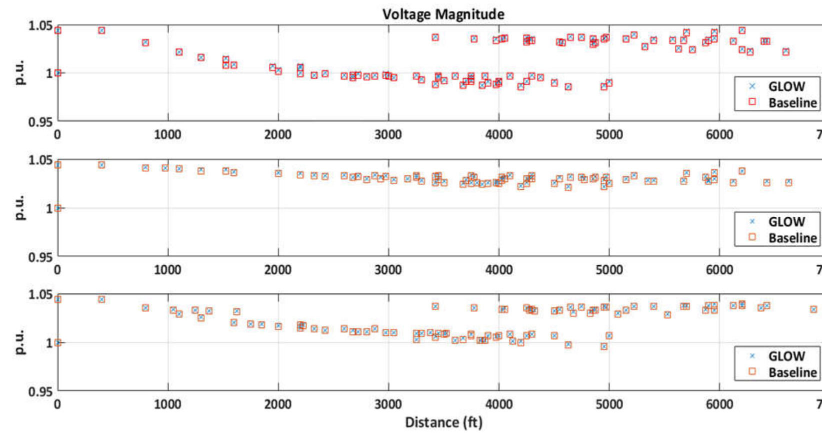
IEEE PES UNIVERSITY IEEE

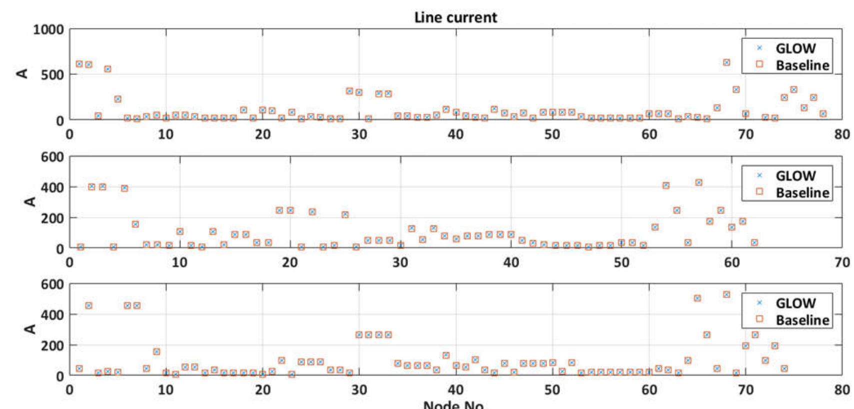
POTENTIAL USE CASES

Use Case #1: Power Flow

- GLOW vs. **IEEE 123** Bus datasheet (published by IEEE PES)
  - Three-phase **node voltage** matches well
  - Three-phase **line current** matches well
  - Total feeder power matches well
- GLOW power flow comparable to industry standards





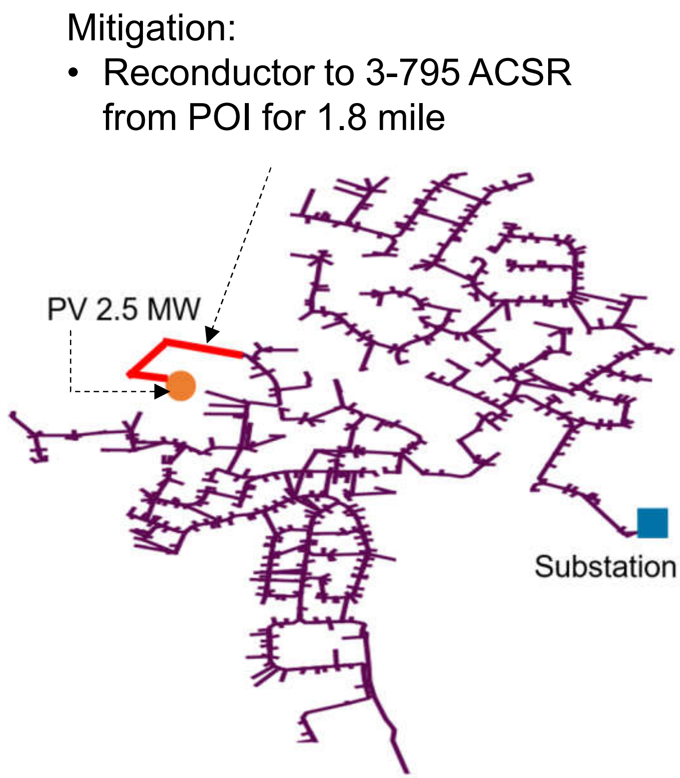


IEEE123-bus feeder: *https://site.ieee.org/pes-testfeeders/resources/*

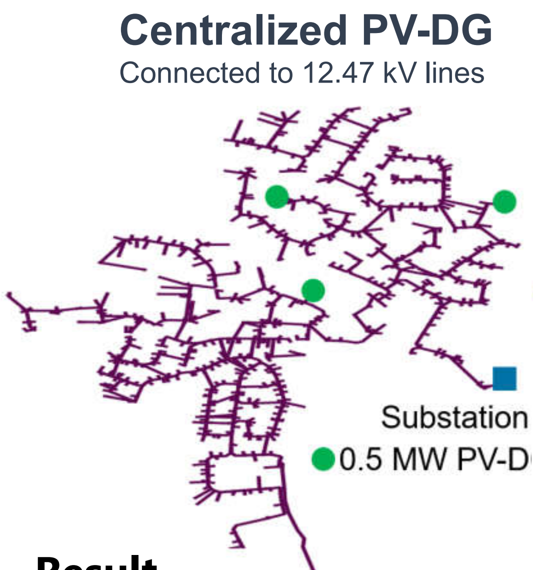
IEEE PES UNIVERSITY IEEE

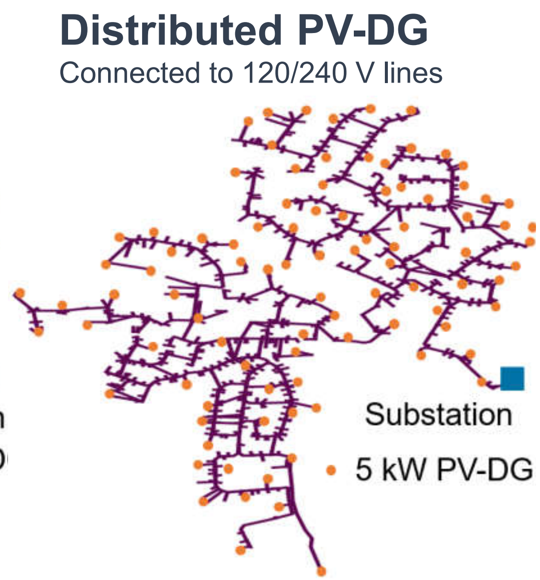
Use Case #2: PV-DG System Impact Study

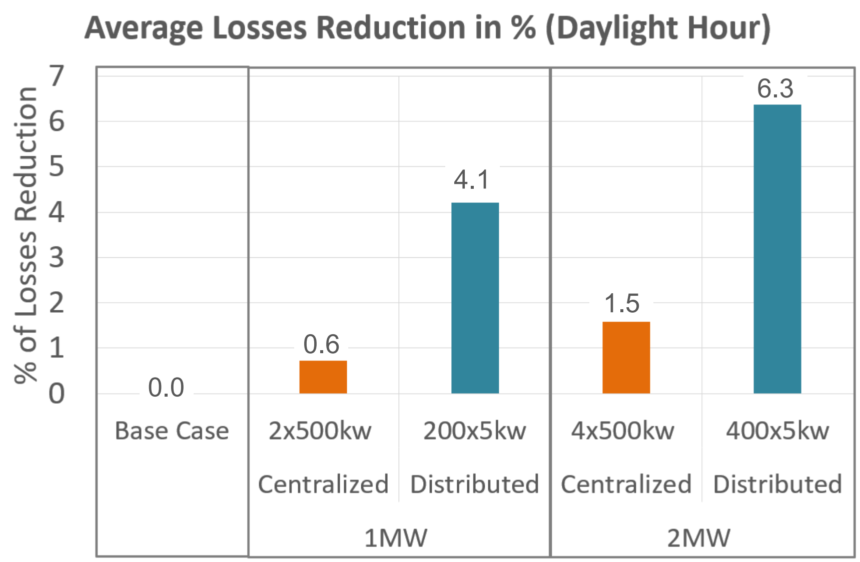
- PV-DG System Impact Study for 2.5 MW Plant
  - Scope
    - Maximum and minimum load day
  - Base Case
    - The largest flicker at POI is 2.5% (limit = 2%)
    - Some area with high voltage condition nearby POI
    - No reverse power flow
  - Proposed Mitigation
    - Reconductor 3/0 AL to 3-477 ACSR from POI to XX St. for 1.8 miles
  - After the mitigation
    - The largest flicker at POI is 1.50%.
    - Steady state voltage is within limit



Use Case #3: Comparison of Centralized vs Distributed Approach







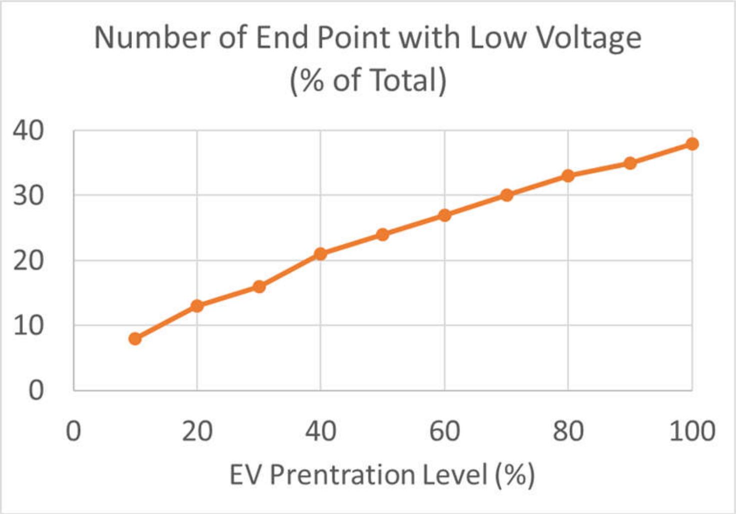
Result

- Highly distributed micro-scale PV-DG may be suitable for losses reduction
- Large-scale PV-DG may be suitable to prevent secondary voltage increase and overall cost

- Losses for the distributed PV-DG are lower than the centralized PV-DG
- The locations of distributed PV-DG are closer to customer loads, thus reduces the power flow through some of the distribution lines and transformers

Use Case #4: Electric Vehicle Impact Study

- Simulation Scenarios
  - 24 Hr. on Maximum load day
- EV Penetration Level
  - 10% to 100 %
  - Number of EV/ house (1 per house = 100%)
- Charger
  - Level 1: 1.4 kW at 120V for 5-30 hours
  - Level 2: 8 kW at 240V for 1-5 hours
- Result:
  - Impacts start from low penetration level
    - Overloaded (Tx, OH conductor, and UG cable)
    - Under voltage to customers
- Potential Mitigation
  - TOU rate designed specifically for EV customer

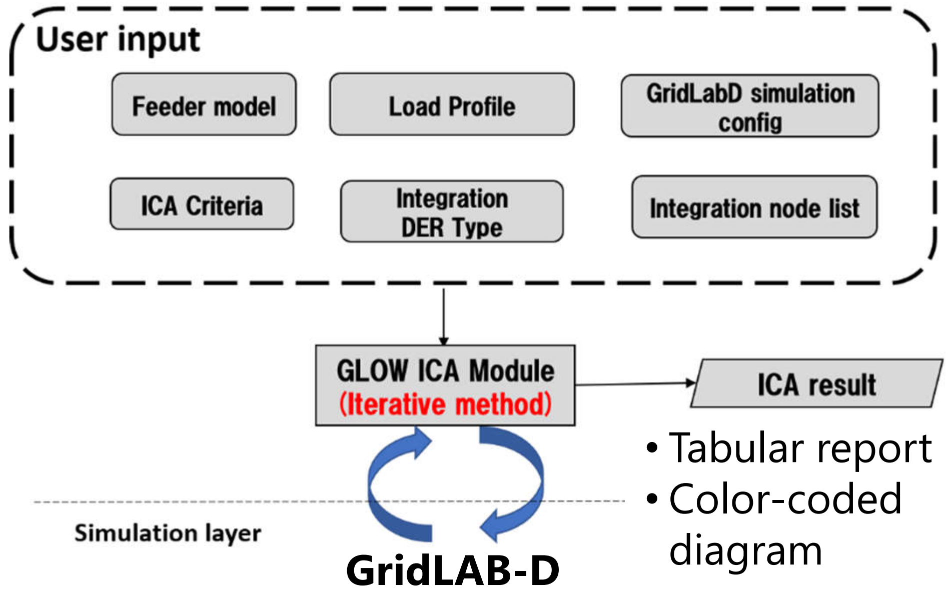


https://ev-database.org/car/1171/Honda-e

Use Case #5: Integration Capacity Analysis (ICA) – Early Phase

- **Objective:**
  - Identify the maximum DER capacity that can be integrated onto distribution system
  - Without compromising its reliability and power quality
- **GLOW ICA implementation**
  - Iterative method
    - Defined in CPUC report
  - Graphical user-friendly simulation set-up wizard

GLOW ICA Workflow

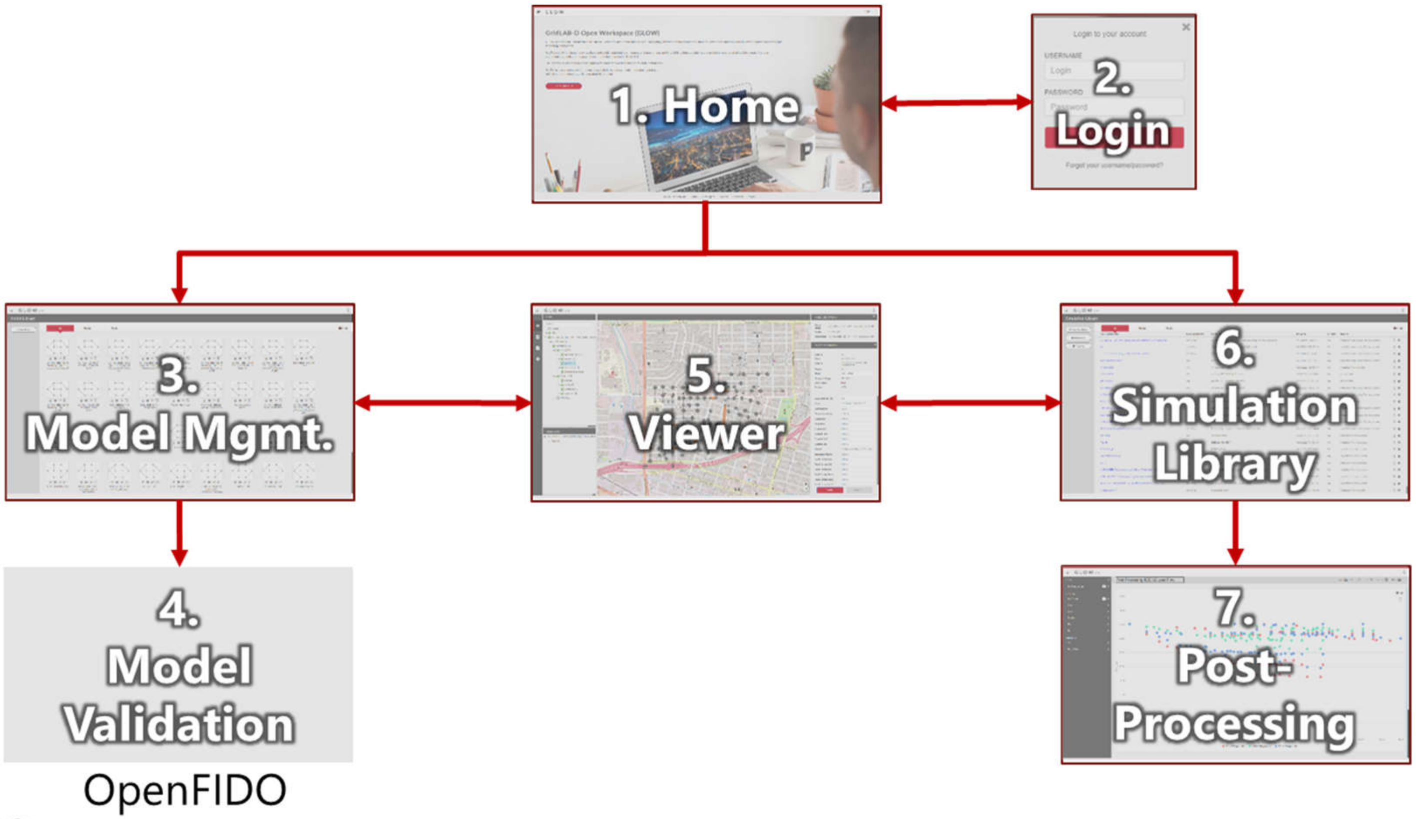


- Tabular report
- Color-coded diagram

* SCE Demonstration Projects A and B Final report, https://drpwg.org/wp-content/uploads/2016/07/R1408013-SCE-Demo-Projects-A-B-Final-Reports.pdf

INFORMATION ARCHITECTURE AND DEMO

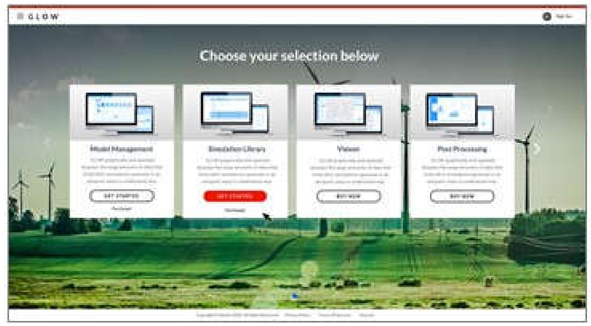
GLOW Information Architecture



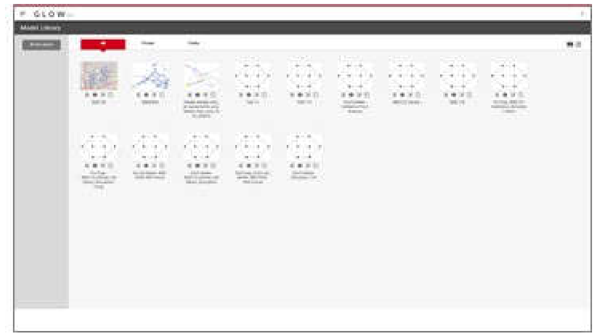
Prototype (Alpha Version)

Landing Page

Module Selection

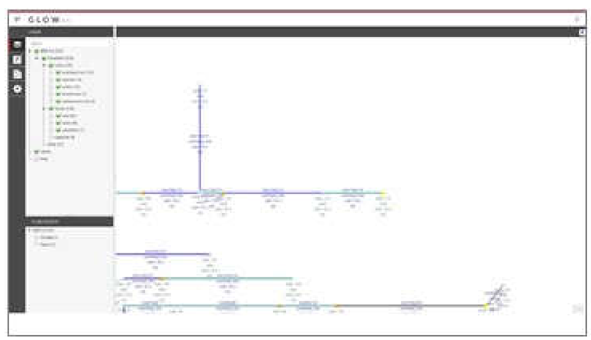


Model Library

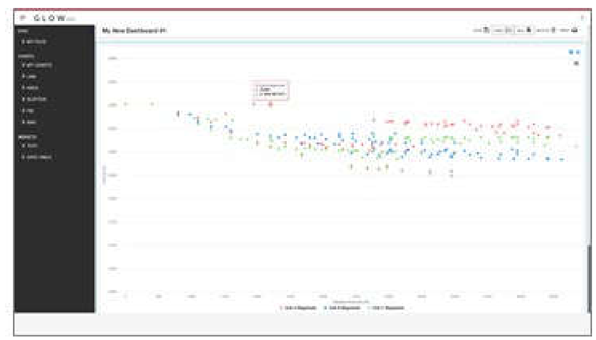


Model Viewer

Simulation Result on Viewer



Post-Processing



Demo Scenarios

- Demo
  - Landing page
  - User Management
  - Scenarios
    - Create a model based on a GridLAB-D
      - Visualize a model in a viewer
      - Create and run power flow simulation
      - Create charts based on result from power flow in Post-Processing

Live Demo

NEXT STEP AND CONCLUSION

IEEE PES UNIVERSITY IEEE

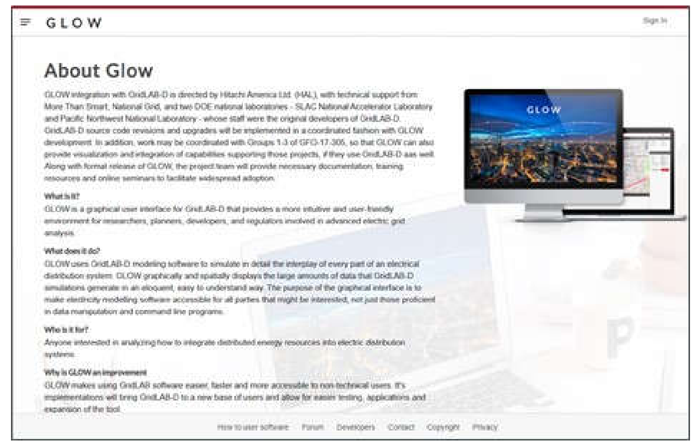
Next Step

- Test and benchmark more **utility feeder** models
- Collaborate with academic teams (NREL, ASU, SLAC) on benchmarking various popular **hosting capacity methodologies**
- Alpha release in 2020 for feature testing
- More distribution system analysis applications are expected to be developed and deployed on this platform
- **Beta release in 2021** for overall system testing
    - Potential features:
        - ML based power flow simulation capability (integration with HiPAS)
        - Use cases
            - Electrification
            - Tariff analysis

**** Welcome utility partners in Alpha and Beta tests**

Conclusion

- **Development of GridLAB-D Open Workspace (GLOW)**
    - An open-source distribution planning method and modelling platform



- **Benefit**
    - Attract more user community
    - Facilitate the adoption of DER integration
    - Facilitate decision-making process
        - Utilities, policy makers, DER developers
    - Indirect benefit for the ratepayer

IEEE PES UNIVERSITY

IEEE

Acknowledgements

- GLOW is supported with funding from the California Energy Commission under grant EPC-17-043.

Thank you

- California Energy Commission
- California Public Utility Commission
- SLAC National Accelerator Laboratory
- Gridworks
- Pacific Northwest National Laboratory
- National Grid

QUESTIONS?