

GridChat: Leveraging GenAI for Smarter Power Distribution Modeling with Arras Energy

Pedram Jahangiri, PhD, AWS

David Chassin, PhD, Eudoxys Sciences



Welcome and Introductions

Arras Energy and GridLAB-D

Energy Delivery Systems Simulation

Arras Energy is a commercial release of HiPAS GridLAB-D developed by the California Energy Commission

- Make the US Department of Energy's agent-based electricity delivery system simulator available to California utilities
- Support emerging use-cases in California
 - Hosting capacity analysis
 - Extreme event resilience
 - Deep electrification
 - Modern tariff design.



Timeline of Arras Energy development

2002 - PNNL creates PDSS, an agent-based solver technology demonstration

2007 - DOE funds development of [GridLAB-D](#) based on PDSS

2008 - First version of GridLAB-D released as free open-source software

2018 - CEC funds SLAC to develop [HiPAS GridLAB-D](#)

2022 - LF Energy adopts HiPAS GridLAB-D and renames it [Arras Energy](#)

Available Solvers

Distribution Systems

3-phase unbalanced solvers

- Newton-Raphson current injection
- Kersting's method
- Transient dynamics (experimental)
- CYME converter available

Detailed asset models

- Cable geometry/configuration
- Transformers, relays, switches, etc.
- Pole failure due wind, ice, vegetations
- Distribution generation and storage

Load models by sector (R/C/I/A)

- Physics based (residential w/appliances)
- Data-driven (all)

Transmission Systems

Positive sequence solver (pypower)

- PSS/E converter available

Aggregate asset models

- Powerline composition
- Transformer, relays
- Generators, including costs for OPF
- Loads

Geodata

- Weather
- Loadshapes
- Other parameters that vary regionally

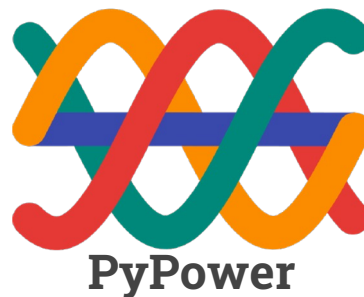
Other Useful Modules

Modeling

- Behavior
- Connection
- Powernet
- Reliability
- Resilience
- Revenue
- Tariff
- Transactive

Support

- Assert
- Influxdb
- Mysql
- Tape
- Optimize



GridLAB-D Subcommands

Building - generate load models from data

Convert - file format converters (to/from)

Geodata - manipulate geographic data

Library - manipulate asset libraries

Loaddata - manipulate load datasets

Model - download example/test models

Plot - generate plots from models

Python - access python environment

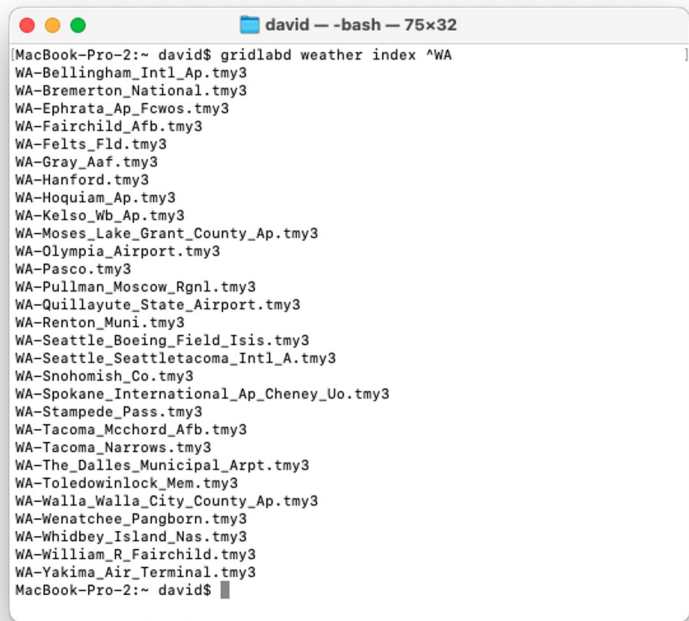
Server - control gridlabd servers

Template - access analysis templates

Timezone - access timezone database

Version - control gridlabd version

Weather - access weather libraries



```
david ~ -- bash -- 75x32
MacBook-Pro-2:~ david$ gridlabd weather index ^WA
WA-Bellingham_Intl_Ap.tmy3
WA-Bremerton_National.tmy3
WA-Ephrata_Ap_Fcwos.tmy3
WA-Fairchild_Afb.tmy3
WA-Felts_Fld.tmy3
WA-Gray_Aaf.tmy3
WA-Hanford.tmy3
WA-Hoquiam_Ap.tmy3
WA-Kelso_Wb_Ap.tmy3
WA-Moses_Lake_Grant_County_Ap.tmy3
WA-Olympia_Airport.tmy3
WA-Pasco.tmy3
WA-Pullman_Moscow_Rgnl.tmy3
WA-Quillayute_State_Airport.tmy3
WA-Renton_Muni.tmy3
WA-Seattle_Boeing_Field_Isis.tmy3
WA-Seattle_Seattletacoma_Intl_A.tmy3
WA-Snohomish_Co.tmy3
WA-Spokane_International_Ap_Cheney_Uo.tmy3
WA-Stampede_Pass.tmy3
WA-Tacoma_Mcchord_Afb.tmy3
WA-Tacoma_Narrows.tmy3
WA-The_Dalles_Municipal_Arpt.tmy3
WA-Toledoinlock_Mem.tmy3
WA-Walla_Walla_City_County_Ap.tmy3
WA-Wenatchee_Pangborn.tmy3
WA-Whidbey_Island_Nas.tmy3
WA-William_R_Fairchild.tmy3
WA-Yakima_Air_Terminal.tmy3
MacBook-Pro-2:~ david$
```


GridLAB-D Tools

create_* - create submodels (ductbanks, filters, meters, poles, schedule, etc.)

fire_* - get fire reports and fire danger for location and date

fit_filter - fit a z -transform to data and generate a gridlabd filter

group - identify potential islands in a gridlabd model

market_* - access market data and generate market models

noaa_forecast - access NOAA weather data (realtime)

nsrdb_weather - access historical weather data from NREL

Python Integration

Module-level

- Full python access
- All global variables
- Model construction (before initialization)
- Model access (after initialization)
- Event handlers
 - Initialization
 - Precommit
 - Presync/sync/postsync
 - Commit
 - Finalize
 - Terminate

Class/Object-level

- Class event handlers
- Object event handlers
- Full object property access
- Automatic unit conversion
- Fast property accessors

Other Python Integrations

- Require tool adds python modules
- Python/shell subcommands access venv
- OpenFIDO access to pipelines/workflows

Online Documentation

The image displays two overlapping browser windows showing the Docs-Browser interface for Arras Energy User Documentation. The interface is titled "Docs-Browser Version 0.1 by SLAC GISMo" and includes a header with logos for the U.S. Department of Energy, Office of Science, Stanford University, SLAC, and the National Accelerator Laboratory (GISM0).

The left window shows the "Getting Started" section, which includes a "Table of Contents" on the left sidebar and a main content area with the heading "Arras Energy" and a subheading "Brought to you by the CEC EPIC Program". Below this is a large blue banner with the text "FUNDING PROVIDED BY CALIFORNIA ENERGY COMMISSION".

The right window shows the "Documentation" section, which includes a "Table of Contents" on the left sidebar and a main content area with the heading "Arras Energy User Documentation". The content area includes a paragraph explaining the GLM file format and a JSON example defining a house object. The JSON example is as follows:

```
{
  "objects": {
    "house0": {
      "id": 0,
      "class": "house",
      "floor_area": 2833.32 sf
    }
  }
}
```

The right window also includes a "Comments" section at the bottom.

User Interfaces

- **GitHub Projects**

- Easy setup and management of GridLAB-D models and simulation results
- Ready-to-run template projects with github actions workflows
- Online tutorials/howtos

- **OpenFIDO**

- Developed by SLAC National Accelerator Laboratory
- Funded by CEC as an open grid analysis environment for utilities and regulators

- **Marimo Notebook**

- Developed by Akshay Agrawal, Stanford PhD student of Stephen Boyd
- Funded by GISMo at SLAC and US Department

- **Hitachi GLOW**

- Developed by Energy Solutions Lab, Hitachi America Ltd.
- Funded by CEC as a commercial front-end to HiPAS GridLAB-D

What is GridChat?



GridChat

GridChat is a GenAI chatbot (Powered by [Amazon Bedrock](#)) designed to enhance the user experience for [GridLAB-D](#) users and developers, which is the main engine for [Arras Energy](#), a simulation platform for future electricity distribution power systems.

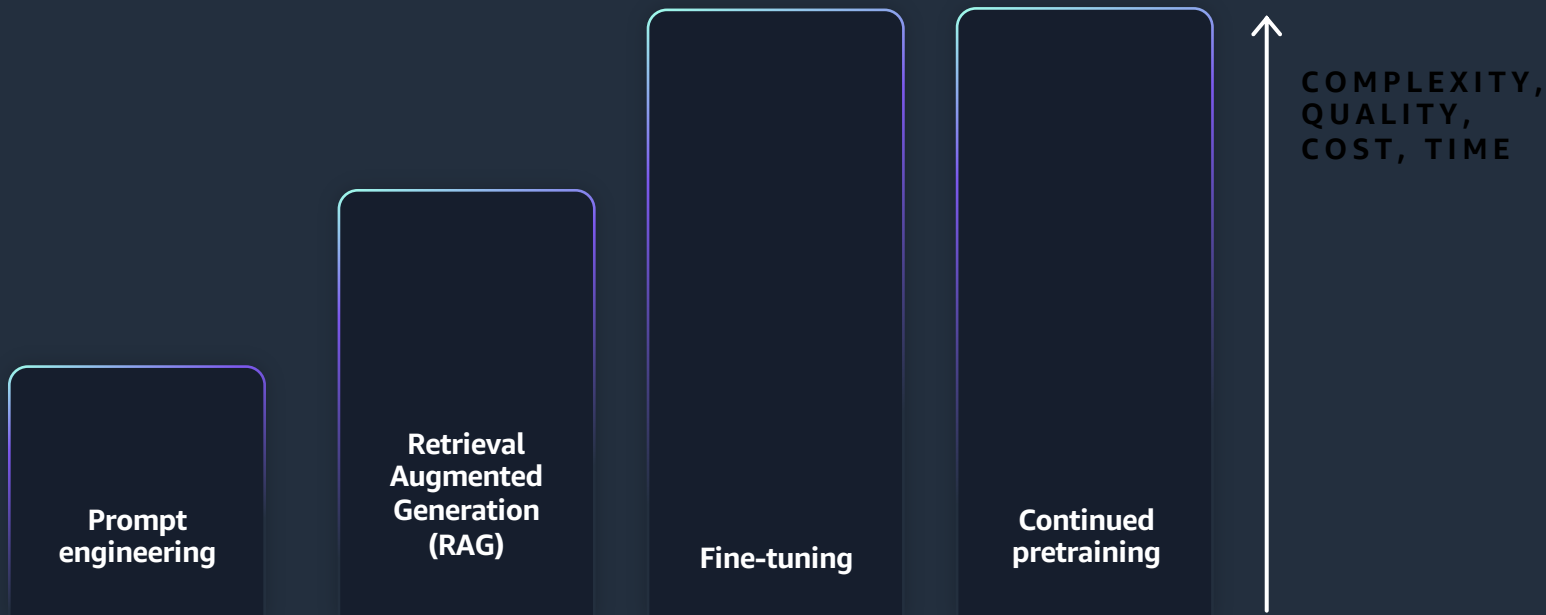
GridLAB-D is a power distribution system simulation and analysis tool that provides valuable information to users who design and operate distribution systems, and to utilities that wish to take advantage of the latest energy technologies. It incorporates advanced modeling techniques with high-performance algorithms to deliver the best in end-use modeling.

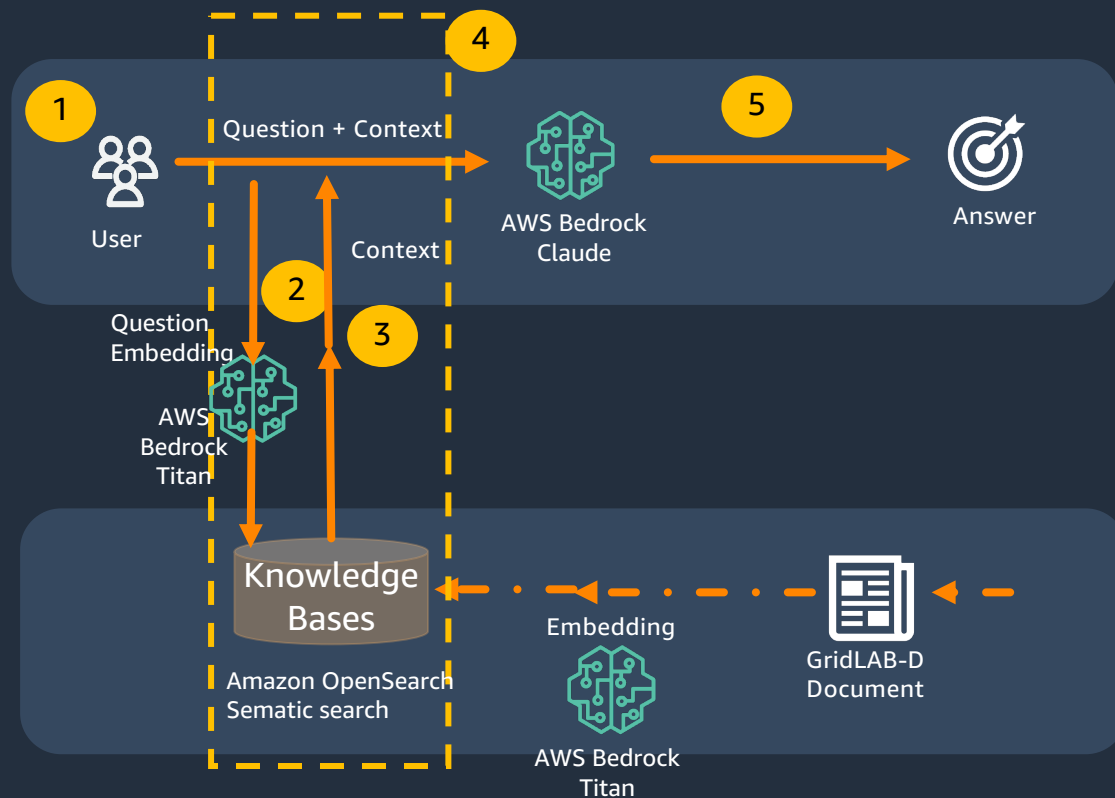
GridLAB-D has its own syntax for input called GLM, which can be challenging for new users. GridChat helps users better understand the GLM model, allowing them to ask questions to debug their models. It is connected to the latest documentation, answering based only on the most recent knowledge.

GridChat is built by the [Arras Energy Technical Steering Committee](#), part of the [LF Energy](#) initiative launched by the [Linux Foundation](#) to improve the power grid through open-source software and practices.

The Technology Behind GridChat

Common approaches for customizing FMs







Amazon Bedrock

The easiest way to build and scale generative AI applications with powerful tools and foundation models

Choice of leading FMs through a single API

Model customization

Retrieval Augmented Generation (RAG)

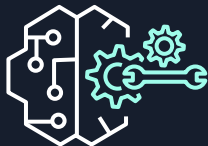
Agents that execute multistep tasks

Security, privacy, and data governance

Amazon Bedrock **simplifies**



Choice



Customization



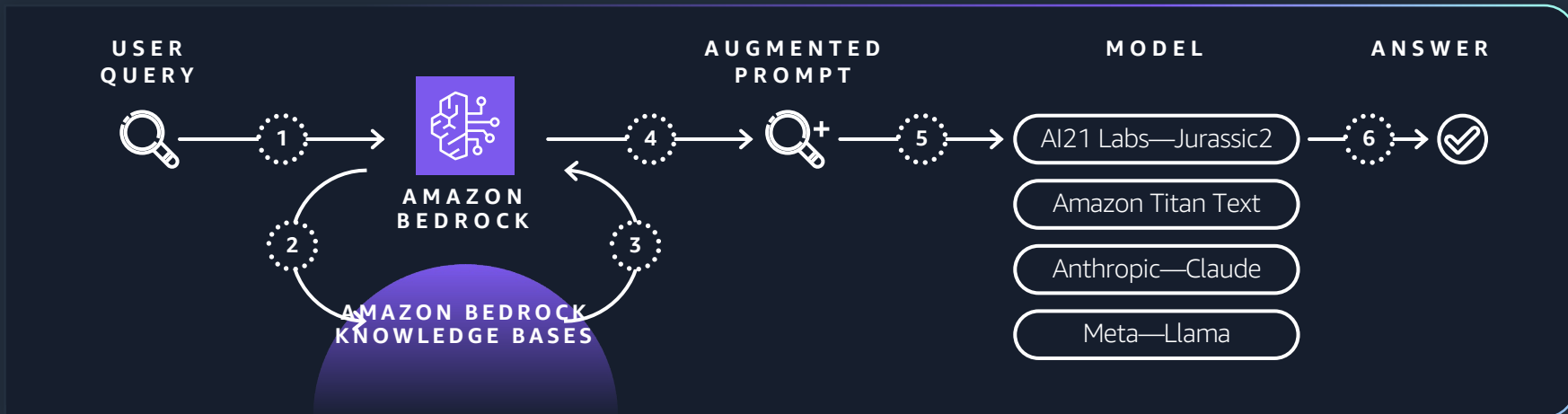
Integration



**Security and
governance**

Amazon Bedrock Knowledge Bases

NATIVE SUPPORT FOR RAG



Securely connect FMs to data sources for RAG to deliver more relevant responses





Fully managed RAG workflow including ingestion, retrieval, and augmentation

Built-in session context management for multiturn conversations

Automatic citations with retrievals to improve transparency

Anthropic Claude Models on Bedrock

CHOOSE THE EXACT COMBINATION OF INTELLIGENCE, SPEED, AND COST TO SUIT YOUR NEEDS

		 Claude 3.5 Sonnet	 Claude 3 Haiku	 Claude 3 Sonnet	 Claude 3 Opus
Use case		Most intelligent, built for high-volume use cases	Fastest performance at the lowest cost	Balance between intelligence, speed, and cost	Second-most intelligent overall; most intelligent in Claude 3 family
Context		200K	200K	200K	200K
Vision		✓	✓	✓	✓
Cost*	Input:	\$0.003	\$0.00025	\$0.003	\$0.015
	Output:	\$0.015	\$0.00125	\$0.015	\$0.075

*Per 1K tokens



Demo

<https://gridchat.gridlabd.us/>

Example: Conversations


Explain the role of the clock object in GridLAB-D. Can you also provide a working example for a simulation starting at 8 AM on January 1st?

Example--Troubleshooting

My simulation results show abnormal voltage swings at node 12. What could be causing this, and how do I debug the issue?

Example--Advanced Simulation

I want to model a distributed energy system with a photovoltaic array and a battery storage system.
Can you generate the correct GLM syntax for it.



GridChat

GridChat is a GenAI chatbot (Powered by [Amazon Bedrock](#)) designed to enhance the user experience for [GridLAB-D](#) users and developers, which is the main engine for [Arras Energy](#), a simulation platform for future electricity distribution power systems.

GridLAB-D is a power distribution system simulation and analysis tool that provides valuable information to users who design and operate distribution systems, and to utilities that wish to take advantage of the latest energy technologies. It incorporates advanced modeling techniques with high-performance algorithms to deliver the best in end-use modeling.

GridLAB-D has its own syntax for input called GLM, which can be challenging for new users. GridChat helps users better understand the GLM model, allowing them to ask questions to debug their models. It is connected to the latest documentation, answering based only on the most recent knowledge.

GridChat is built by the [Arras Energy Technical Steering Committee](#), part of the [LF Energy](#) initiative launched by the [Linux Foundation](#) to improve the power grid through open-source software and practices.

Logged in email:

gridchat.gridlabd.us

Relaunch to update

I'm GridChat, the GridLAB-D chat assistant. How may I assist you today?

I want to model a distributed energy system with a photovoltaic array and a battery storage system. Can you generate the correct GLM syntax for it.

Certainly! I'll provide you with a GLM syntax example for modeling a distributed energy system with a photovoltaic array and a battery storage system. Here's a concise summary followed by the GLM code:

Summary: This GLM script sets up a distributed energy system with a photovoltaic array and a battery storage system connected to a load through a meter and inverter. It includes necessary modules, defines the simulation timeframe, and adds recorders for data output.

GLM Syntax:

```
// Required modules
module powerflow;
module generators;
module tape;

// Set simulation timeframe
clock {
  timezone EST-5EDT;
  starttime '2023-01-01 00:00:00';
  stoptime '2023-12-31 23:59:59';
}

// Define the load
object load {
  name load_1;
  phases ABCN;
  nominal_voltage 2401.7771;
  constant_power_A 1000+500j;
  constant_power_B 1000+500j;
  constant_power_C 1000+500j;
}

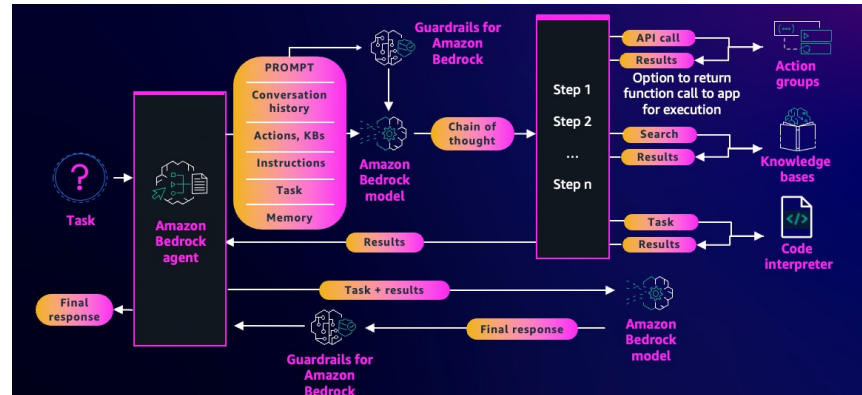
// Add meter
object meter {
  name meter_1;
  parent load_1;
  phases ABCN;
  nominal_voltage 2401.7771;
}

// Add inverter for PV and battery
object inverter {
  name inverter_1;
  parent meter_1;
  phases ABCN;
  rated_power 250 kVA;
}
```

Ask Question from GridChat

Future Plans

- Expanding GridChat's capabilities
- Introducing agentic features for autonomous tool execution



- Collaboration opportunities with the community

Q&A

Pedram Jahangiri, PhD, AWS



David Chassin, PhD, Eudoxys Sciences

