U.S. DEPARTMENT OF ENERGY
Office of Electricity Delivery and Energy Reliability (OE)

Pacific Northwest NATIONAL LABORATORY
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GridLAB-D™

A Unique Tool to Design the Smart Grid

GridLAB-D™ is a first-of-its-kind time-series 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 latest in end-use load modeling technology. Historically, the inability to effectively model and evaluate smart grid technologies has been a barrier to adoption; **GridLAB-D** is designed to address this problem.

GridLAB-D is developed by Pacific Northwest National Laboratory (PNNL) in collaboration with industry and academia through funding from the U.S. Department of Energy Office of Electricity Delivery and Energy Reliability (DOE/OE). **GridLAB-D** is designed as an open-source tool, freely available to any user, to encourage collaboration with industry and academia. The BSD-style license allows vendors to add or extract their own modules without exposing internal intellectual property.

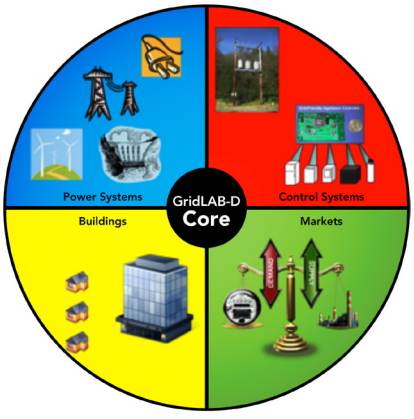
GridLAB-D

"PNNL has a hit on its hands with more than 10,000 downloads of this free, open-source tool. It is (to my knowledge) the only grid simulator that integrates supply and demand and price (power flow and load and market modeling). It even includes models for such things as population growth, C&I buildings, distributed generation and residential appliances."

– **Jesse Berst**
Smart Grid News

About GridLAB-D

GridLAB-D is a flexible, agent-based simulation environment designed to model not only the power system, but the overlying systems that affect the power system. At its simplest, **GridLAB-D** examines the detailed interplay between all elements of a distribution system from the substation to end-use load. **GridLAB-D** provides a valuable test bed for evaluating control strategies and cost-to-benefits ratios. It provides a sand box for studying the effects of smart grid technologies without the cost and complexity of field demonstrations.



GridLAB-D combines multiple domain expertise in a unique simulation environment to more effectively evaluate smart grid technologies.

GridLAB-D is an open-source, modular power system distribution tool that provides first-of-its-kind analysis and simulation of all aspects of grid operations from generation to end use, including markets, in unprecedented detail. Development of GridLAB-D has been supported by the Department of Energy's Office of Electricity Delivery and Energy Reliability.

Who Should Use GridLAB-D?

Most power system tools today do not provide the analysis capabilities required to study the interactions of the future power system. The combined influence of fast-changing information technology, novel and cost-effective resources, multiple and overlapping energy markets, and new business strategies results in very high uncertainty about the success of these important innovations. **GridLAB-D** addresses common concerns expressed by utility engineers, regulators, various stakeholders, and consumers. **GridLAB-D** has been used to perform:

- **Distribution Automation Design/Evaluation:** **GridLAB-D** offers capabilities that support the design and analysis of distribution automation technologies, including volt-var optimization, device coordination and automation, feeder reconfiguration, reliability, and fault detection identification and restoration. **GridLAB-D** provides the user with the technical benefits of these technologies to better guide the selection of best business practices and future investments.

- **Peak Load Management:** Many peak-shaving/shifting-programs and emergency curtailment programs have failed to fully deliver the expected benefits. **GridLAB-D** allows modeling of consumer behavior to better understand and optimize the interaction between various peak-shaving strategies, incorporating advanced mechanisms such as transactive controls, centralized command and control, and distributed solutions. The impact of consumer satisfaction on the availability of peak-shaving resources can be evaluated, and more accurate forecasts of the available resources can be made. **GridLAB-D** even allows the evaluation of consumer rebound effects following one or more curtailment or load-shed events in a single day.

- **Distributed Generation and Storage:** The advent of new distributed energy resources (DER) technologies, such as on-site distributed generation, building combined heating and power (CHP) technologies, distributed storage, and requisite controls creates a number of technology opportunities and challenges. **GridLAB-D** permits utility planners and managers to better evaluate the cost/benefit trade-off between

infrastructure expansion investments and distributed resource investments by including other economic benefits of DER (e.g., increased wholesale purchasing elasticity, improved reliability metrics, and opportunity to sell ancillary services products in wholesale markets). **GridLAB-D** provides a test bed for balancing conflicting economic signals to maximize impact and revenue.

- **Rate Structure Analysis:** Multiple differentiated energy products based on offering new rate structures to consumers are very attractive to utilities because they create the opportunity to reveal demand elasticity and give utilities the ability to balance supplier market power in the wholesale markets. The challenge is designing rate structures that are both cost-effective to utilities and attractive to consumers. **GridLAB-D** provides the ability to accommodate multiple rate offerings (including fixed rates, demand rates, time-of-day rates, and real-time rates) to determine whether a suite of rate offerings is likely to succeed.

How Does GridLAB-D Work?

At its core, **GridLAB-D** has an advanced algorithm to simultaneously determine the state of millions of independent devices, each described by models and equations relevant to the particular domain. **GridLAB-D** does not require the use of reduced-order models to describe the aggregate behavior of the system (but may when appropriate). Rather, it relies on advanced physical models to describe the interdependencies of each of the devices. This helps to avert the danger of erroneous or misapplied assumptions. The advantages of this algorithm over traditional finite difference-based simulators are that it: 1) handles unusual situations much more accurately; 2) handles widely disparate time scales, ranging from sub-seconds to many years; and 3) is very easy to integrate with new models and third-party systems.

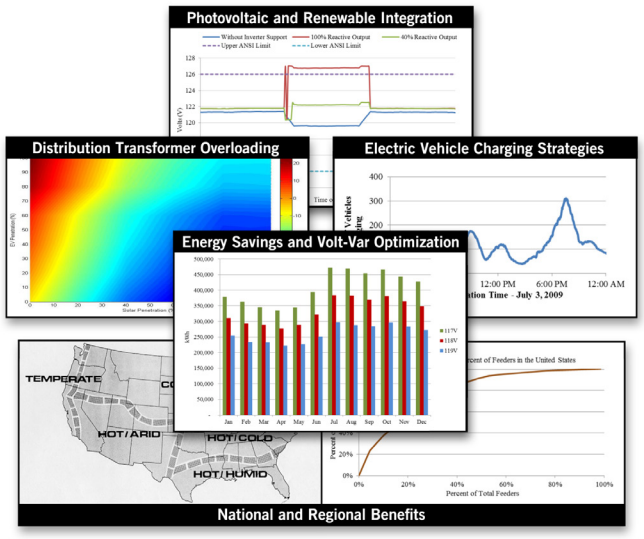
Capabilities

With the ability to study distribution utility system behavior over periods of time that range from seconds to decades, **GridLAB-D** simulates the interactions between physical phenomenon, business systems, markets and regional economics, and customer interactions, and how they each affect the power system. As of version 2.2, released in September 2011, **GridLAB-D** supports the interaction of:

- 3-phase, unbalanced (meshed or radial) power systems,
- end-use load behavior of thousands to millions of homes and appliances,
- retail level markets and transactive controls,
- distributed generation and storage,
- demand response and direct load control,
- distribution automation controls, and
- reliability.

Version 2.3, slated for release in December 2012, also will include:

- microgrid capabilities, including machine dynamics and generator controls,
- advanced control and optimization algorithms and interfaces, and
- development of combined heat and power (CHP) models, to capture the effects of waste heat and offsetting heating requirements in buildings.



Through GridLAB-D, users can predict, evaluate and extrapolate the potential of new technologies and operational strategies to save on capital expansion costs, design more effective and efficient programs and improve system reliability.

Version 3.0, slated for release in summer 2013, also will include:

- a more advanced application programming interface (API) for interfacing with third-party tools,
- co-simulation with a commercial grade transmission tool,
- an advanced high-performance computing engine,
- co-simulation with an open-source telecommunication simulator, and
- internationalization, including time zone and unit support and 50 Hz, low-voltage systems.

Related Papers and Research

Available online at:

http://sourceforge.net/apps/mediawiki/gridlab-d/index.php?title=Related_Papers

Price and Availability

Licensing:

Battelle BSD-style open license.

Download and online support:

http://www.gridlabd.org

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www.pnnl.gov

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Office of Electricity Delivery and Energy Reliability (OE1)

GridLAB-D

GridLAB-D was created for the U.S. Department of Energy Office of Electricity and Energy Reliability (DOE/OE) by Pacific Northwest National Laboratory as part of the GridWise™ Program. DOE/OE has continued the support of this tool and its applications for over five years. For more information on DOE/OE support, please contact:

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GridLAB-D is developed and maintained at PNNL in collaboration with industry and university partners, through long-term support from DOE/OE. PNNL is operated for DOE by Battelle under contract DE-AC05-76RL01830.

For more information on using the tool and training schedules, please contact:

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