Pacific Northwest
NATIONAL LABORATORY

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Distributed Wind Representation in Modeling and Simulation Tools

An Assessment of Existing Tools

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Summary

Pacific Northwest National Laboratory (PNNL) compiled, characterized, and evaluated the inclusion of distribution wind in a number of modeling and simulation tools for the U.S. Department of Energy (DOE) Microgrids, Infrastructure Resilience, and Advanced Controls Launchpad (MIRACL) project. This work also benefits the international community participating in International Energy Agency (IEA) Wind Task 41: Enabling Wind to Contribute to a Distributed Energy Future. Tools were assessed based on a survey of publicly available and readily accessible information. The evaluation approach, methodology, key takeaways, and next steps are presented below, and the evaluation table is attached to this PDF.

1.0 Background

The objective of the DOE multi-national laboratory MIRACL project is to improve wind's capabilities as a distributed energy resource (DER) in microgrids and distribution networks through improved valuation, cybersecurity, resilience, and controls.

As part of the MIRACL project, PNNL evaluated the inclusion of wind in DER modeling and simulation tools. This evaluation has informed an ongoing effort to modernize existing tools. This modernization will be achieved both directly by working with developers of some tools and indirectly by providing future best practice guides on how different types of tools could enhance certain modeling features to improve distributed wind's representation and valuation.

The assessment of how distributed wind is represented in modeling and simulation tools also supports the IEA Wind Task 41 Work Plan. The focus of Work Package (WP) 3 in the Task 41 Work Plan is to "expand learning and support of the integration of distributed wind into evolving electricity systems." Deliverable 14 in WP3 is "based on initial work completed in the United States, review how distributed wind is modelled in distributed grid and microgrid systems, the availability of design tools and models, and an assessment of the modeling methods used for wind energy." The tool evaluation performed for the MIRACL project represents the initial work completed in the United States.

2.0 Methodology

Many user-facing distribution modeling and simulation tools include wind energy but may not accurately calculate the performance or reflect the temporal, locational, and resilience value of distributed wind. As a first step, PNNL created a comprehensive list of 130 tools used to model or simulate one or multiple DERs. The tool list was created from a power systems analysis software list (Open Electrical 2018), a PNNL report (Anderson et al. 2016), and an electric distribution system planning tool assessment that PNNL is completing as part of the DOE Grid Modernization Laboratory Consortium.

Then, PNNL assessed how distributed wind is represented in each tool compared to other DERs. The ability to model and ease of modeling both distributed wind and non-wind DERs was described using one of four levels of representation: 1) not represented, 2) represented by supplying a time-series generation profile to a generic generator model, 3) represented by supplying device parameters to a DER-technology-specific model, or 4) represented internally without requiring detailed user input. The ability to model and ease of modeling distributed wind was compared to the ability to model and ease of modeling other DERs (using the four levels of representation above). Comparing the level of representation of distributed wind to that of other DERs produces a delta between wind and other DER technologies. When wind is outside the scope of a tool (e.g., a battery modeling tool), the representation of distributed wind relative to other DERs is listed as not applicable (N/A). Otherwise, the magnitude of that delta determines the representation of distributed wind:

- Full: The representation of distributed wind is on par with representation of other DER (i.e., zero delta).
- Partial: The representation of distributed wind compared to other DER is incomplete or out of date (i.e., small delta).
- Minimal: Distributed wind is given significantly less consideration than other DER (i.e., large delta).

This method is intended to identify possible gaps in consideration given to distributed wind relative to other DER technologies while recognizing that different tools intend to model DERs to different levels of detail. Note that tools were assessed based on a survey of publicly available and readily accessible information. While the authors have made a good faith effort to understand these tools, PNNL does not know the intentions of the developers and acknowledges that some tool capabilities or features may not have been accurately captured in this assessment.

PNNL added parameters to further characterize tools that minimally, partially, or fully represent distributed wind. Accessibility to users was characterized by reporting the following for each tool:

- whether the tool is free
- whether a user must be part of the specified organization to gain access
- whether the user must create an account to use the tool
- whether a point of contact for assistance is listed
- whether the tool's source code is available to the user, and
- type of user interface.

Each user interface was given one of the following classifications:

- AutoCAD, C++ library
- command line
- MATLAB
- desktop tool
- Excel
- Java Solver
- infrastructure as a service (IaaS)
- platform as a service (PaaS)
- software as a service (SaaS)
- web tool.

If a contact was listed, that email address was recorded. Next, the revision and use statistics of the tools were described by reporting the following for each tool (as of December 2019):

- date of the last tool update
- current version number
- current number of users.

Then, the purpose of the tools was characterized by reporting the following for each tool:

- focus of the tool
- tool outputs and features
- intended users.

Intended users were classified into the following groups:

- industrial (i.e., facilities that draw high power)
- education (i.e., professors, teachers, or students teaching or learning about DERs)
- research (i.e., scientists and engineers testing hypothetical distributed energy resource configurations or scenarios)
- utility (i.e., power engineers for all types of utilities).

Lastly, each tool owner's country and tool webpage address were recorded.

3.0 Discussion

A comprehensive set of 130 power systems modeling and simulation tools were analyzed. Of those, 96 tools include wind and 34 do not (because wind was out of scope for those tools). Of the tools that include wind, at least 31% have been updated as recently as 2019, at least another 18% have been updated as recently as 2015, and for the remaining 51%, no updates in the last five years could be confirmed. Even though many tools are no longer maintained, dozens of useful tools are currently being developed.

Of the 130 tools analyzed, 75 represent wind fully (as defined above), 10 represent wind partially, 11 represent wind minimally, and distributed wind is out of scope for 34 of the tools. Because representation of wind was assessed compared to other DERs, tools with highly detailed models of other DERs (e.g., solar photovoltaics) and basic models of wind scored lower in this metric (i.e., more likely to have a partial or minimal representation) than tools with basic models of all DERs. In fact, some of the most advanced research tools (e.g., OpenDSS and GridLAB-D) fared worse in this metric than tools with simple models of all DERs.

While 96 of the tools evaluated do include wind, a total of 21 of those do not fully represent distributed wind indicating that some tool developers are not focusing on distributed wind. This may be because fluid dynamics and moving parts make wind turbine modeling more complex than solar modeling. And because economics for solar deployment are much more favorable than for distributed wind in many cases, there is less economic imperative to spend the extra time developing the more complex wind modeling capabilities. However, this assessment demonstrates that there is room to improve representation of distributed wind in a number of tools. Improvement can be achieved by reducing the development effort required for detailed modeling of distributed wind.

4.0 Application

This modeling and simulation tool evaluation was performed to inform MIRACL project research and a broader, international audience of tool users and modelers. The list of tools and this evaluation are not intended to recommend any one tool over another; rather, this effort attempts to provide a snapshot of the tool landscape. With the characterization parameters, the list can be used by modelers to more easily find the modeler's intended tool. Other potential users, such as utilities or researchers, can use the list similarly to identify a tool that would meet their planning or design needs.

With respect to the MIRACL project, the list is the first step in identifying which existing tools may benefit from modernizing updates. Next, PNNL is performing deep-dive evaluations on targeted tools—GridLAB-D and REopt Lite initially—to identify and implement specific improvements in their representation of distributed wind. If these deep dives identify enhancements that simplify or streamline distributed wind modeling in general, or within categories of tools, they will also be disseminated to the tool-developing community. PNNL will also pursue opportunities to work with additional developers and modelers identified in this list, where partnerships are available.

5.0 References

Open Electrical. 2018. "Power Systems Analysis Software." Accessed April 26, 2019. https://wiki.openelectrical.org/index.php?title=Power_Systems_Analysis_Software (last updated June 15, 2018).

Anderson, D., N. Samaan, T. Nguyen, M. Kinter-Meyer. 2016. *North America Modeling Compendium and Analysis.* Pacific Northwest National Laboratory, Richland, WA. https://www.energy.gov/sites/prod/files/2017/01/f34/North%20America%20Modeling%20Compendium%20and%20Analysis.pdf.

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