Abbreviated Final Technical Report for the Energy Resilience Cost and Performance Tool: The Value of Solar Energy

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National Renewable Energy Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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Technical Report
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NOTICE

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Final Technical Report (FTR)

Cover Page

a. Federal Agency	Department of Energy	
b. Award Number	38427	
c. Project Title	Energy Resilience Cost and Performance Tool: The Value of Solar Energy	
d. Recipient Organization	National Renewable Energy Laboratory	
e. Project Period	*Start:* 10/1/2021	*End:* 9/31/2023
f. Principal Investigator (PI)	Dan Olis Senior Engineer Dan.Olis@nrel.gov 303-384-7398	
g. Business Contact (BC)	Jeff Cook Solar Analysis Program Lead Jeff.Cook@nrel.gov 303-275-3676	
h. Certifying Official (if different from the PI or BC)	Same as PI	

Signature of Certifying Official **Date**

1. **Acknowledgement:** This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Lab Call FY22-24 Award Number(s) 38427.

3. **Project Summary:** Solar photovoltaic systems' ability to provide behind-the-meter resilient backup power is not recognized or correctly valued. The diurnal and intermittent nature of solar power has led facility owners, policy makers, and developers to incorrectly discount the ability of solar PV to provide backup power for critical loads. To begin to address this, this project developed a software tool to assist stakeholders in quantifying the resilience benefits of solar energy when included in backup power systems. This tool was integrated into NREL's existing REopt energy systems technoeconomic screening tool, a free, online web tool. The project team developed requirements, developed resiliency estimation code, designed and developed the web tool user interface, performed validation and user testing, and publicly released the tool.

4. **Project Objectives and Outcomes:** The objective of this project was to develop, validate, and implement a free, publicly available, user-friendly web-based tool that quantifies the resilience value of behind-the-meter solar energy and compares the cost and resilience performance of solar-supplied backup power systems to alternative backup power designs. To ensure the tool met the needs of potential users, the project team convened a group of industry subject matter experts to serve as the project's Technical Advisory Group. NREL staff met with the TAG five times during the period of performance. Some members of the TAG also served as tool beta testers.

The project objectives were met, following the milestone plan:

1. Gather user input for design.
2. Integrate Markovian Matrix reliability calculations into REopt.
3. Develop referenceable default values and assumptions.
4. Develop beta web-based user interface.
5. Complete beta testing.
6. Release final tool.

The project was executed as planned, except for a delay in final completion by one quarter due loss of key staff. At project completion, the team publicly release an energy resilience performance tool that quantifies the resilience value of behind the meter solar energy. The tool performs a reliability analysis of serving critical loads as a post-process of configurations developed first using detailed techno-economic analyses on solar based backup power systems. It allows efficient analysis of cost, resilience, and reliability benefits of alternative system architectures.

The completed tool allows federal agencies, public and private facilities, developers, communities, universities, hospitals, and other critical facilities from a large campus down to an individual building to compare the cost and reliability performance of multiple backup power configurations quickly and accurately. It accounts for realistic component reliability and power variability to calculate the availability and reliability of a backup power system with and without solar power. The research team is unaware of any other software tool, lab-developed or commercially available, that provides this capability.

The tool is available as a free web tool and accessible through an API. The code is also open source to allow others to review the methods and integrate the open-source code into other software platforms and workflows.

5. **Path Forward:** Because the code is open source, the tool can be integrated into commercial software or used by commercial enterprises for development of solar-based backup power systems. As further data is collected on the reliability of deployed PV systems, default values for their reliability metrics should be updated in the tool.

6. **Inventions, Patents, Publications, and Other Results:**
The Energy Resilience webtool is accessible here after completing a resilience analysis in REopt: https://reopt.nrel.gov/tool.
The REopt help manual describes the ERP capability in section 19.5, Resilience. See https://reopt.nrel.gov/tool/reopt-user-manual.pdf#page=111.

The open-source code is accessible here: https://github.com/NREL/REopt.jl.
The REopt API is accessible here: https://github.com/NREL/REopt_API.

7. **Project Team:** All project contributors are current or former NREL staff.

Participant	Role
Dan Olis	PI, technical coordination lead
Jeff Marqusee	Former PI
William Becker	Code integration lead
Linda Casson	Help manual and beta testing
Erika Curry-Elrod	User interface developer
Hallie Dunham	Code development
Sean Ericson	Code development
Indu Manogaran	User interface developer
Katrina Woodhams	Coordination with technical advisory group