NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Overview of Tools to Provide Support for State Energy Programs

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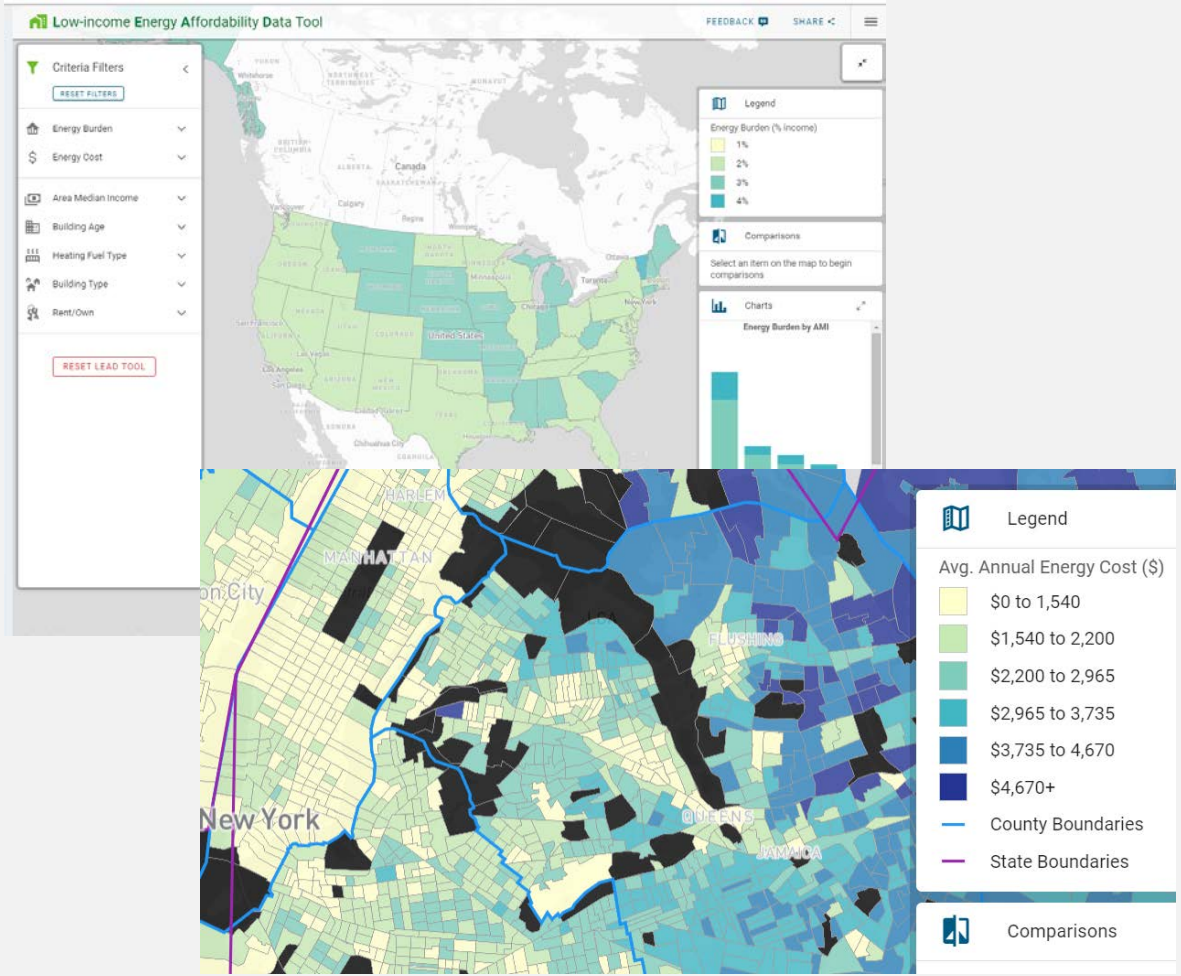
1. LEAD: Low-Income Energy Affordability
2. SLOPE: State and Local Planning for Energy
3. PVwatts
4. REopt®: Renewable Energy Integration and Optimization
5. SAM: System Advisory Model
6. JEDI: Jobs and Economic Development Impact
7. ClimRR: Climate Risk and Resilience Portal

Technical Assistance Tools

Support for State Energy Offices

Low-Income Energy Affordability Data (LEAD)

LEAD
LOW-INCOME ENERGY AFFORDABILITY DATA
TOOL
U.S. DEPARTMENT OF ENERGY



Low-Income Energy Affordability Data (LEAD)

Objective

- To support data-driven decision-making on energy goals and program planning by improving understanding of low- and moderate-income household energy characteristics
- To describe the spatial distribution of energy burden and household characteristics to inform policy and outreach

Data Parameters

No data inputs explicitly required from user.

Tool data for population and utility info from U.S. Census Bureau's American Community Survey and Energy Information Administration

e.g. energy cost, heating fuel type, building type, poverty level, income, education, demographic information

Geographic resolution

Includes interactive map. Data available at national, state, county, city, and census tract levels

Capable of combining geographic areas to produce results for an area at user-customized geographies

Access & Technical requirements

Tool is "ready to use" for new users on a web-based platform; provides information which can be browsed or filtered for specific questions.

Who It's For

Developers, engineers, or planners

State or local policymakers

Economic development officials

Point of Contact

Aaron Vimont, NREL

LEAD.Tool@hq.doe.gov

Low-Income Energy Affordability Data (LEAD)

Example Questions This Tool Can Answer

- What is the energy burden of in my local jurisdiction?
- What is the variation in area median income across my state and how might this impact the state energy budget?
- What neighborhoods are in greatest need of energy investment according to energy burden and indicators of disadvantage?
- How does the fuel for heating compare between two cities?

Case studies and example applications

Targeting Energy Affordability Services to Eligible Customers in New York

Achieving Building Efficiencies for Low-Income Households in Carrboro, North Carolina

Funding Energy Efficiency Programs Where Energy Affordability Assistance Is Needed Most in Kentucky

Information to get started

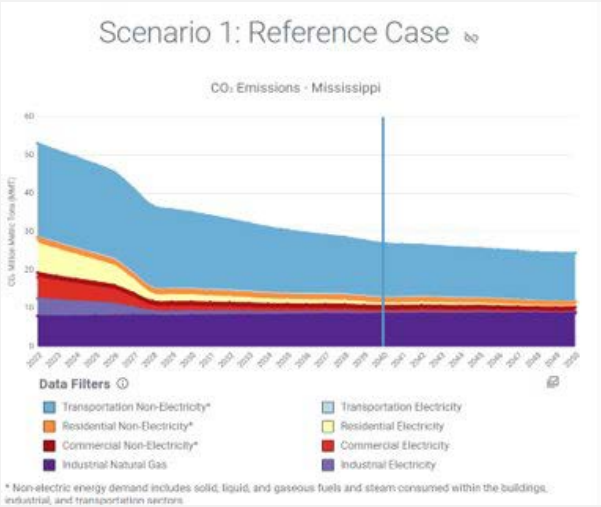
Publicly available; Open-source online platform; Easy-to-use data portal, factsheets, videos, webinars

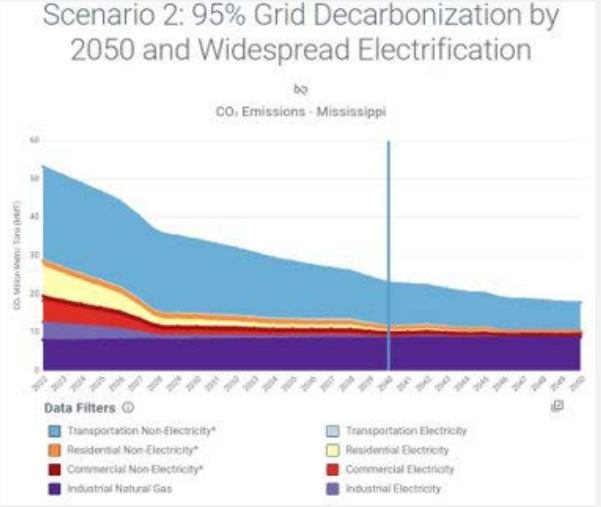
Info: Low-Income Energy Affordability Data (LEAD) Tool and Community Energy Solutions | Department of Energy

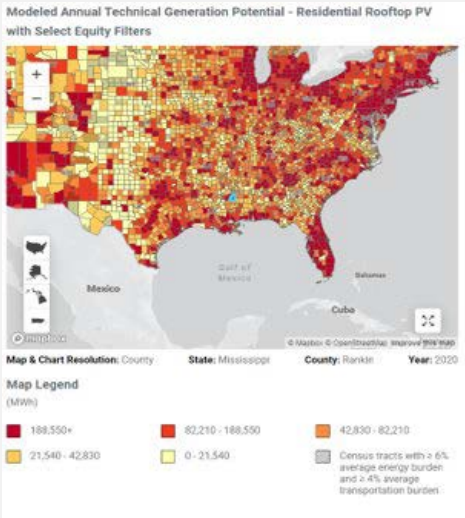
Tool: LEAD Tool | Department of Energy

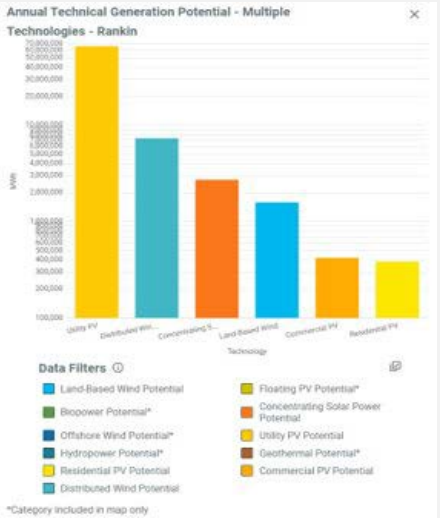
State and Local Planning for Energy (SLOPE)

SLOPE
State and Local Planning for Energy
U.S. DEPARTMENT OF ENERGY









State and Local Planning for Energy (SLOPE) Tool

Objective

- To support data-driven state and local energy and decarbonization planning through two distinct tools:
  - **Scenario Planner**: Compare scenarios for the future of energy, costs, and emissions for counties and states.
  - **Data Viewer**: Explore city, county, and state data on renewables, efficiency, and transportation.

Geographic resolution

Includes interactive map.
Data is available at the state, county, city, and census tract levels.

Data Parameters

No data inputs specifically required from user.

Tool data for each map and chart layer are included in the data descriptions at the bottom of each data layer. Where applicable, links to additional methodologies in extracting data are also provided.

For a current list of SLOPE data sources, see the FAQs section: https://maps.nrel.gov/slope/about

Access & Technical requirements

Tool is "ready to use" for new users on a web-based platform; provides information which can be browsed or filtered for specific questions.

Who It's For

Developers, engineers, or planners; State or local policymakers

Point of Contact

Katie Richardson, NREL
slope@nrel.gov

State and Local Planning for Energy (SLOPE) Tool

Example Questions This Tool Can Answer

- How are emissions impacted if my county focuses on grid decarbonization compared to building and transportation electrification?
- What is the generation potential and cost of renewable energy by technology across the counties in my state?
- What is the potential for bill savings from energy efficiency for low-income households in counties across my state?
- How many electric vehicles could be registered in each county in my state by 2030 in a high electrification scenario compared to a business-as-usual scenario?

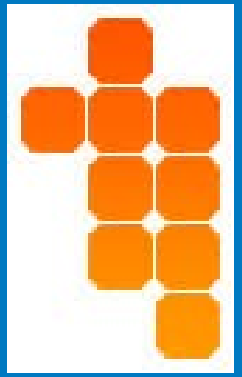
Case studies and example applications

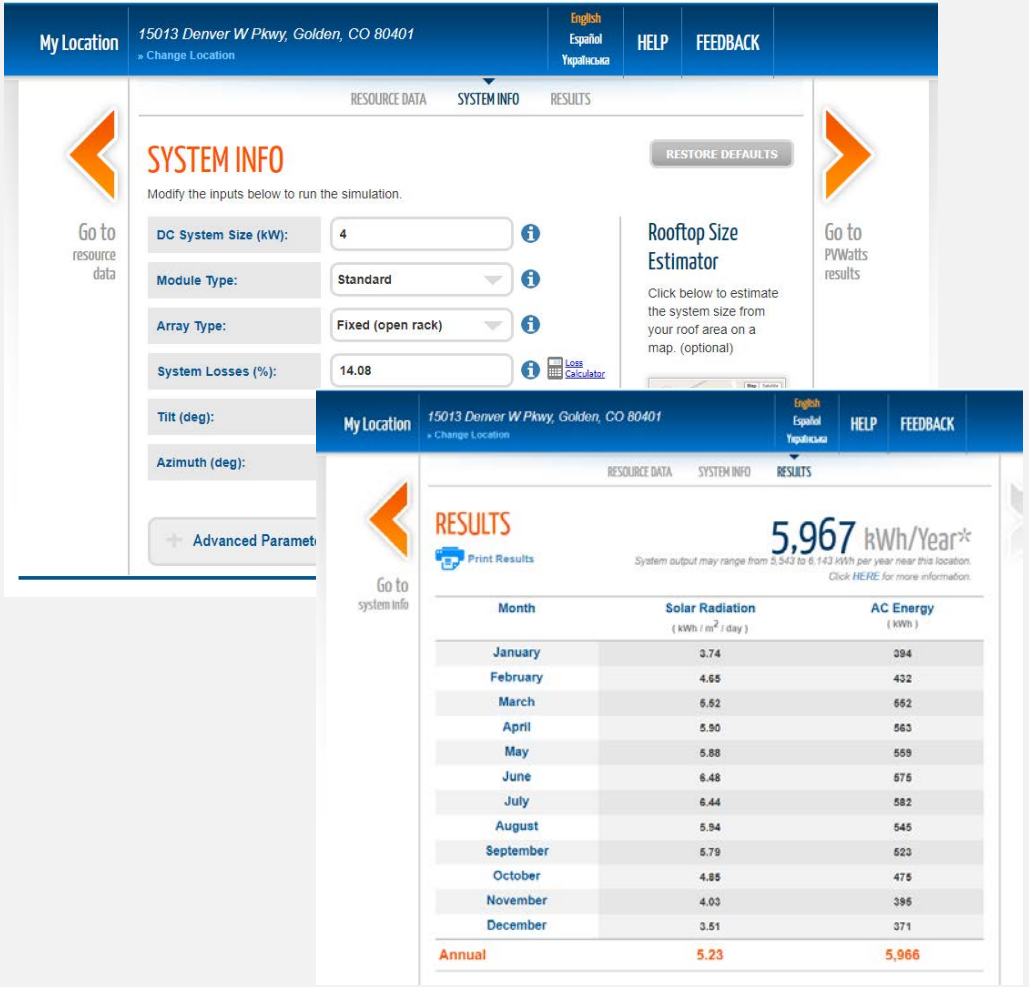
SLOPE Informs Grid Modernization and Transportation Planning in New Mexico
SLOPE Informs Equitable Transition to Electric Vehicles in Atlanta's Metropolitan Area
SLOPE Informs Climate and Equity Planning in Milwaukee, Wisconsin
SLOPE Illustrates Opportunities in Philadelphia's Equitable Carbon Neutrality Quest

Information to get started

Easy-to-use data portal, factsheets, videos, webinars; Open-source online platform
Information and Tool: SLOPE: State and Local Planning for Energy

PVWatts Calculator





PVWatts Calculator

Objective

- To estimate the energy production of grid-connected photovoltaic (PV) energy systems throughout the world.
- To allow homeowners, installers, manufacturers to easily develop estimates of performance of potential PV installations including cost of electricity produced by the system

Geographical Resolution

Site specific – latitude/longitude, street address, or zip code.
Not explicitly mapped in space.

Data parameters

Inputs: PV array location and basic design parameters (size, angle, module, etc.)

Tool data: weather data from NREL National Solar Radiation Database (NSRDB), hourly typical meteorological year (TMY) data, and other international sources to estimate solar resource

Results: hourly electrical output & cost of energy

Access & Technical Requirements

Tool is "ready to use" for new users on a web-based platform to get preliminary estimates.
For software developers, it is available as a web API on the **NREL Developer Network**, or as part of the SAM Simulation Core (SSC) **Software Development Kit**, which includes the **PySAM** Python package.

Who It's For

Developers, engineers, or planners; building owners.

Used in combination with other tools at NREL (SAM)

Point of Contact

Janine Keith, NREL
Nate Blair, NREL
PVWatts@nrel.gov

PVWatts Calculator

Example Questions This Tool Can Answer

- What is the possible performance and annual value of my grid-connected roof- or ground mounted solar project?
- How does potential hourly AC energy output differ for the same system in one location vs another?
- How does expected system output change with different array tilt or orientations?

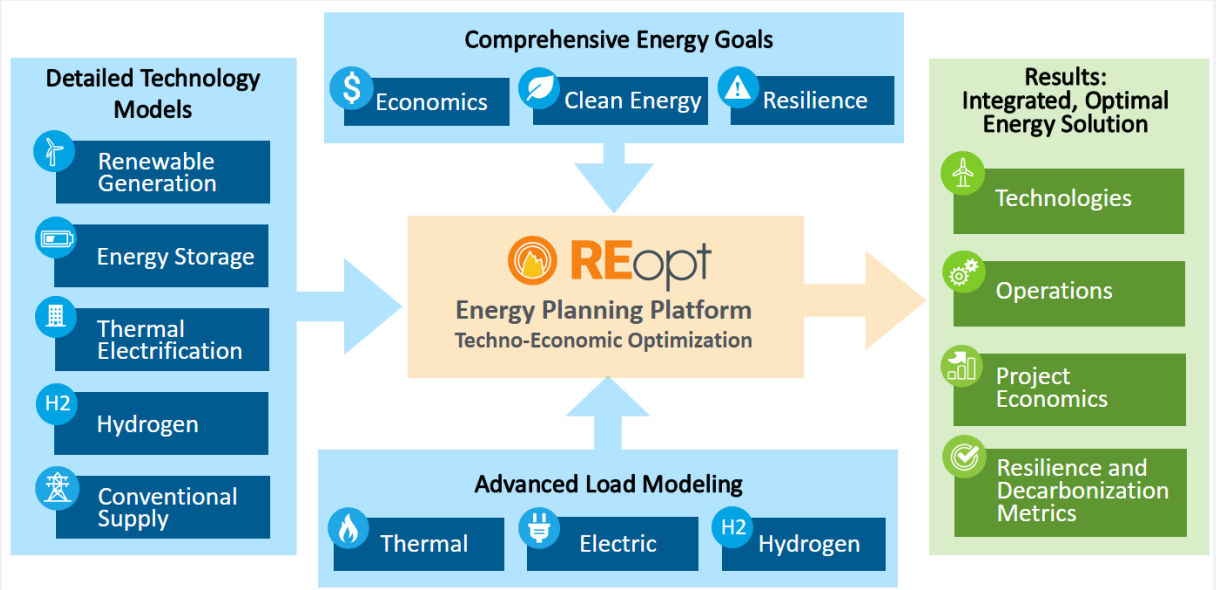
Case studies and example applications

PVWatts Retrospective

Information to get started

Help button on website provides documentation; open source
Introduction video: https://www.youtube.com/watch?v=-NJreCvMiU8
Tool: https://pvwatts.nrel.gov/index.php

REopt Renewable Energy Integration and Optimization



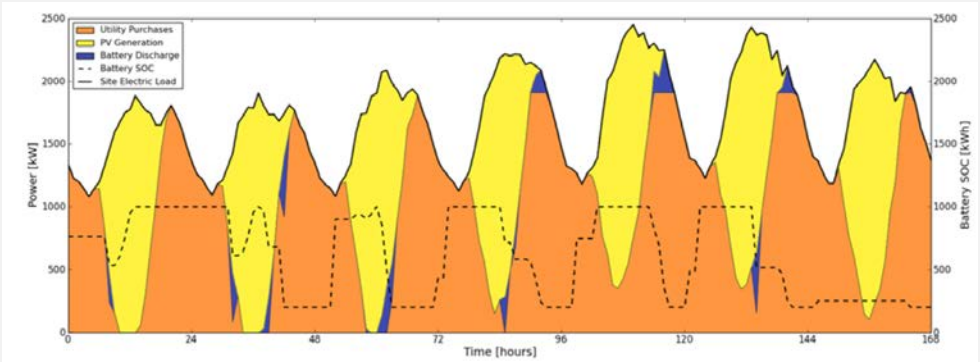


Figure 1. Cost-optimal economic dispatch strategy for a combined PV and battery system

REopt Renewable Energy Integration and Optimization

Objective

- To identify the cost-optimal system sizing and dispatch of integrated distributed energy systems (e.g., on-site generation, storage, electrification) for buildings, campuses, and microgrids towards a site's energy cost savings, decarbonization, and resilience goals.
- To quantify the economic viability, decarbonization impacts, and resilience benefits of these systems.

Geographic resolution

Site-specific, any location

Access & Technical requirements

Tool is accessible to users with basic to advanced computing ability, increasing in complexity from a web-based tool to an application programming interface and open-source code. More advanced skillsets allow for model customization and running REopt programmatically.

- **REopt Web Tool** - accessible web interface that does not require programming skills
- **REopt API** uses Python and Julia, leverages NREL computational resources
- **REopt.jl** uses Julia, offers more speed and flexibility to run locally

Data Parameters

Inputs: Requires only three user inputs- location, energy consumption, and utility costs. Also offers hundreds of customizable inputs with default values, e.g., renewable resource data, technology cost and performance, incentives, and economic assumptions.

Results: Optimal system size and dispatch. Capital costs, O&M costs, net present value, energy bill savings, levelized costs of energy, internal rate of return, simple payback period. Renewable energy and emissions accounting. Resilience metrics, including probability of surviving outages of various durations.

Who It's For

Energy managers and planners; policy analysts; researchers; everyday citizens. Integrated into various NREL and non-NREL (e.g., commercial/industrial) tools.

Point of Contact

Kathleen Krah, NREL

REopt@nrel.gov

Example Questions This Tool Can Answer

- What is the most cost-effective sizing of solar PV and battery storage for my site?
- How can I optimally operate my solar PV and battery to maximize their value and minimize my site's energy costs?
- What is the most cost-effective system to operate as a microgrid for a grid outage spanning two hours? Two days? Two weeks? How much would it cost to install a completely off-grid system?
- What are the renewable energy and emissions reduction impacts of this system?
- How do could I achieve x% emissions reductions or y% renewable energy at least cost?
- Where do market opportunities exist for DERs, now and in the future?

Case studies and example applications

REopt Identifies and Prioritizes Renewable Energy System Potential Across Time Warner Cable Facilities

REopt Optimizes Hawaiian Residential Solar-Plus Technologies

REopt Evaluates Electric Vehicle Charging Stations for the Vehicle Technologies Office

REopt Modeling Informs Design of Off-Grid Water System Under Study for Navajo Nation

Access and support information

Extensive tutorial videos and curriculum for the web tool.

REopt fact sheet, overview slides, and user manual.

Web site: https://www.nrel.gov/reopt/

System Advisor Model (SAM)

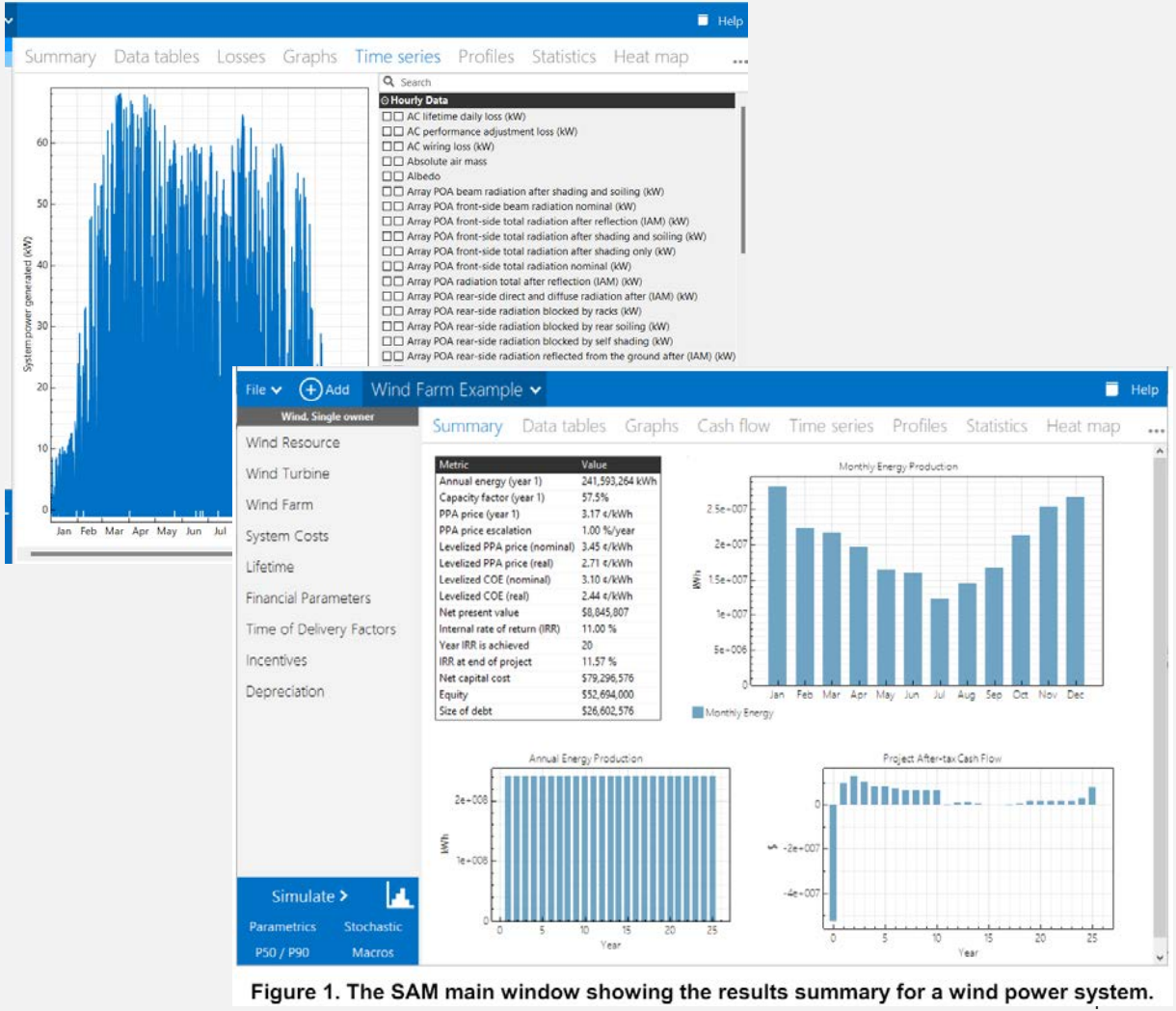


Figure 1. The SAM main window showing the results summary for a wind power system.

System Advisor Model (SAM)

Objective

- To conduct techno-economic analysis of renewable energy technologies to facilitate planning and decision-making.
- To evaluate or compare the energy production or cost of installed systems, various system configurations, or incentive structures

Geographic resolution

Site-specific, state, national. Not explicitly mapped in space.

Data parameters

Inputs: weather data, system specs, system losses (to estimate electricity production) plus costs, compensation, financing, and incentives

Results: system output estimate, capacity factor, levelized cost of energy, payback, revenue, net present value

Access & Technical requirements

Highly tailored analysis requires an experienced analyst. Tool is designed as a desktop application which runs off C++ programming with a python wrapper. Program updates at least each year and is an open-source project (programmers can contribute). It can be accessed a variety of ways (desktop app, Software Development kit, code, etc.), but requires some programming comprehension to do so.

Who It's For

Project managers and researchers; Engineers, developers, and planners; Utilities, manufactures and technology developers; Policy makers

Used within other tools at NREL (dGen, PVWatts, REopt, HOPP, reV, ReEDS, PLEXOS)

Point of Contact

Janine Keith, NREL

sam.support@nrel.gov

System Advisory Model (SAM)

Example Questions This Tool Can Answer

- What system configuration will maximize earnings from electricity sales?
- What incentive structure will be most effective during implementation of new renewable energy systems?
- How will installing a new technology change the cost of energy and system efficiency compared to present?

Case studies and example applications

Modeling Utility-scale Photovoltaic Systems in SAM

Behind-the-meter Battery Dispatch in SAM

Financial Models for Utility-scale Projects in SAM

Information to get started

Introduction and support videos: https://www.youtube.com/watch?v=NhWJ5A2fxZU ; https://www.youtube.com/user/SAMDemoVideos

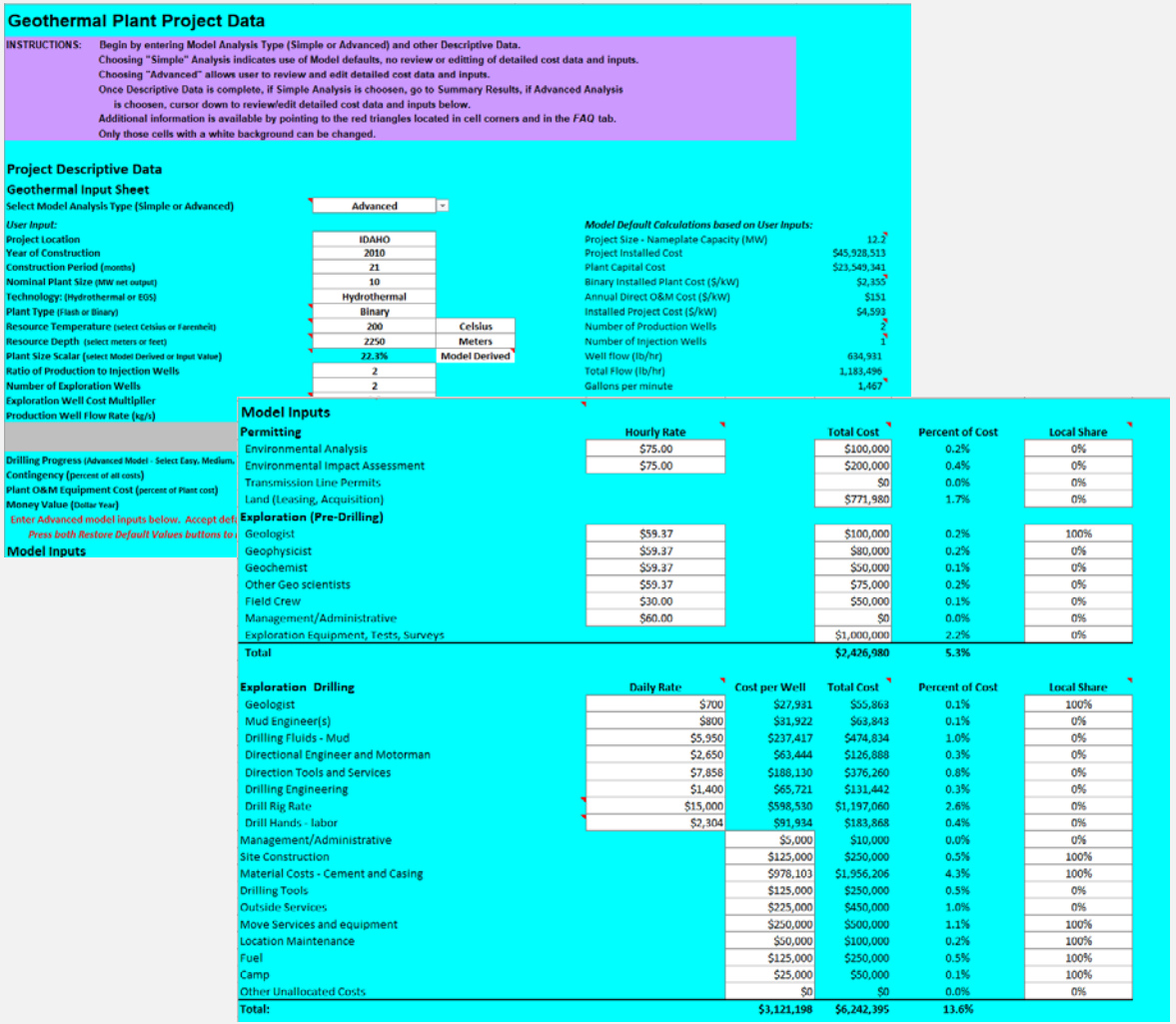
Active forum for questions and engagement https://sam.nrel.gov/forum.html

Monthly 30-minute online round tables for questions about using SAM or feedback on new features

Virtual conferences periodically: https://sam.nrel.gov/events.html

Tool: https://sam.nrel.gov/

Jobs and Economic Development Impact (JEDI) Models



Geothermal Plant Project Data

INSTRUCTIONS: Begin by entering Model Analysis Type (Simple or Advanced) and other Descriptive Data.
Choosing "Simple" Analysis indicates use of Model defaults, no review or editting of detailed cost data and inputs.
Choosing "Advanced" allows user to review and edit detailed cost data and inputs.
Once Descriptive Data is complete, if Simple Analysis is choosen, go to Summary Results, if Advanced Analysis is choosen, cursor down to review/edit detailed cost data and inputs below.
Additional information is available by pointing to the red triangles located in cell corners and in the *FAQ* tab.
Only those cells with a white background can be changed.

Project Descriptive Data

Geothermal Input Sheet

Select Model Analysis Type (Simple or Advanced)	Advanced	
User Input:		
Project Location	IDAHO	
Year of Construction	2010	
Construction Period (months)	21	
Nominal Plant Size (MW net output)	10	
Technology: (Hydrothermal or EGS)	Hydrothermal	
Plant Type (Flash or Binary)	Binary	
Resource Temperature (select Celsius or Farenheit)	200	Celsius
Resource Depth (select meters or feet)	2250	Meters
Plant Size Scalar (select Model Derived or Input Value)	22.3%	Model Derived
Ratio of Production to Injection Wells	2	
Number of Exploration Wells	2	
Exploration Well Cost Multiplier		
Production Well Flow Rate (kg/s)		
Drilling Progress (Advanced Model - Select Easy, Medium,		
Contingency (percent of all costs)		
Plant O&M Equipment Cost (percent of Plant cost)		
Money Value (Dollar Year)		

Enter Advanced model inputs below. Accept defi
Press both Restore Default Values buttons to

Model Inputs

Model Default Calculations based on User Inputs:	
Project Size - Nameplate Capacity (MW)	12.2
Project Installed Cost	$45,928,513
Plant Capital Cost	$23,549,341
Binary Installed Plant Cost ($/kW)	$2,355
Annual Direct O&M Cost ($/kW)	$151
Installed Project Cost ($/kW)	$4,593
Number of Production Wells	2
Number of Injection Wells	1
Well flow (lb/hr)	634,931
Total Flow (lb/hr)	1,183,496
Gallons per minute	1,467

Model Inputs

Permitting	Hourly Rate	Total Cost	Percent of Cost	Local Share
Environmental Analysis	$75.00	$100,000	0.2%	0%
Environmental Impact Assessment	$75.00	$200,000	0.4%	0%
Transmission Line Permits		$0	0.0%	0%
Land (Leasing, Acquisition)		$771,980	1.7%	0%
Exploration (Pre-Drilling)				
Geologist	$59.37	$100,000	0.2%	100%
Geophysicist	$59.37	$80,000	0.2%	0%
Geochemist	$59.37	$50,000	0.1%	0%
Other Geo scientists	$59.37	$75,000	0.2%	0%
Field Crew	$30.00	$50,000	0.1%	0%
Management/Administrative	$60.00	$0	0.0%	0%
Exploration Equipment, Tests, Surveys		$1,000,000	2.2%	0%
Total		**$2,426,980**	**5.3%**	

Exploration Drilling	Daily Rate	Cost per Well	Total Cost	Percent of Cost	Local Share
Geologist	$700	$27,931	$55,863	0.1%	100%
Mud Engineer(s)	$800	$31,922	$63,843	0.1%	0%
Drilling Fluids - Mud	$5,950	$237,417	$474,834	1.0%	0%
Directional Engineer and Motorman	$2,650	$63,444	$126,888	0.3%	0%
Direction Tools and Services	$7,858	$188,130	$376,260	0.8%	0%
Drilling Engineering	$1,400	$65,721	$131,442	0.3%	0%
Drill Rig Rate	$15,000	$598,530	$1,197,060	2.6%	0%
Drill Hands - labor	$2,304	$91,934	$183,868	0.4%	0%
Management/Administrative		$5,000	$10,000	0.0%	0%
Site Construction		$125,000	$250,000	0.5%	100%
Material Costs - Cement and Casing		$978,103	$1,956,206	4.3%	100%
Drilling Tools		$125,000	$250,000	0.5%	0%
Outside Services		$225,000	$450,000	1.0%	0%
Move Services and equipment		$250,000	$500,000	1.1%	100%
Location Maintenance		$50,000	$100,000	0.2%	100%
Fuel		$125,000	$250,000	0.5%	100%
Camp		$25,000	$50,000	0.1%	100%
Other Unallocated Costs		$0	$0	0.0%	0%
Total:		**$3,121,198**	**$6,242,395**	**13.6%**	

Jobs and Economic Development Impact (JEDI) Models

Objective

- To analyze the local employment and economic benefits of deploying wind, offshore wind, biofuels, concentrating solar power, geothermal, marine and hydrokinetic power, coal, and natural gas.

Geographical Resolution

Local and state levels. Not explicitly mapped in space.

Data parameters

Inputs: user (or default) costs of construction, equipment, operation, maintenance, etc. and financing type for a specific or theoretical project.

Tool data is derived from IMPLAN Professional state data files. IMPLAN data files are updated periodically.

Results: expenditure estimates, economic impacts in terms of jobs, earnings, and project output described as impacts to project development and onsite labor, local revenue and supply chain, or induced impacts

Access & Technical Requirements

Tool is "ready to use" for new users able to download the model of choice; technology-specific models available in adaptable tool within Excel spreadsheet. Detailed project-specific analysis would be enhanced by advanced users

Who It's For

Engineers, developers, and planners; Utilities, manufactures, and developers; Policy makers and regulators

Point of Contact

Jeremy Stefek, NREL, jeremy.stefek@nrel.gov
JEDIsupport@nrel.gov

Jobs and Economic Development Impact (JEDI) Models

Example Questions This Tool Can Answer

- For a given renewable energy project, what are the potential direct, indirect, and induced jobs that will be created throughout the project lifecycle? What sectors will those jobs be created in?
- What are the potential gross economic impacts associated with in-pipeline and planned renewable energy projects?
- How many in-state construction jobs will be generated if a new wind farm is installed?

Limitations: https://www.nrel.gov/analysis/jedi/limitations.html

Case studies and example applications

Guide to Interpreting Results (Incl. Example Scenario)

Information to get started

Informational video: https://www.youtube.com/watch?v=1mePoKFdDB8
Free Models: https://www.nrel.gov/analysis/jedi/models.html

Climate Risk and Resilience Portal (ClimRR)

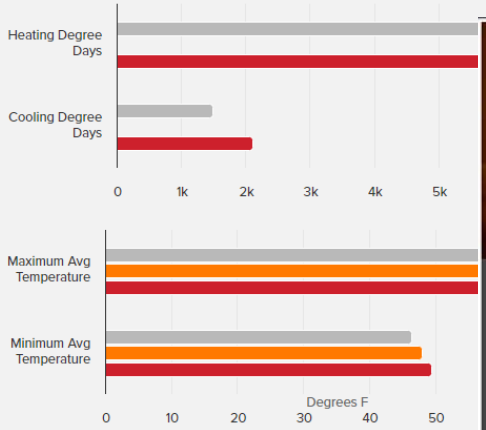
Coordinates: -104.98, 39.74
Located in Denver County, Colorado

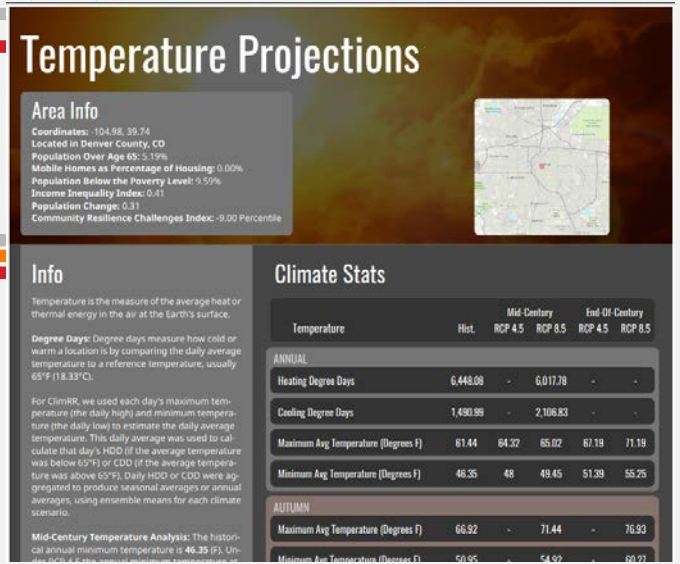
Data Catalog Guide | Tool Guide

Geography Picker | Geometry File Upload

Open Data Filters and Map Layers Menu

Generate Report





Climate Risk and Resilience Portal (ClimRR)

Objective

- To provide future climate data to help plan for and adapt to our changing world.
- To empower individuals, governments, and organizations to examine simulated future climate conditions at mid- and end-of-century for a range of climate perils.

Geographic resolution

Includes interactive maps. Climate models downscaled to 12-km grid cells. Info at point, county, state, nation, or "draw" areas

Access & Technical Requirements

Tool is "ready to use" for new users on a web-based platform; provides info to be browsed or filtered for specific questions.

Who It's For

Non-technical individuals, organizations, planners and decision-makers in state, local, tribal, and territorial governments

Data Parameters

No data inputs explicitly required from user.
Tool data includes community characteristics (census) and resiliency index information from FEMA's Resilience Analysis and Planning Tool (RAPT); carbon emissions scenarios (RCP 4.5 and RCP 8.5) at two time horizons (mid to end of century); maps of extreme temperatures, cooling /heating degree days, heat index, wind, fire weather index, precipitation.
Results: local climate projections for select geographies, data overlays, statistics, and reports.
Data layers and visualizations are available in a variety of formats: https://climrr.anl.gov/datacatalog

Point of Contact

Operated by Argonne National Laboratory
Center for Climate Resilience and Decision Science
CCRDS@anl.gov

Climate Risk and Resilience Portal (ClimRR)

Example Questions This Tool Can Answer

- How can I understand how future climate conditions will impact my community?
- How can my community update our hazard mitigation plan?
- What data can help my community build resilience in the face of multiple possible climate scenarios?
- How might climate risks impact government agencies and businesses?

Case studies and example applications

Public Health Planning for Extreme Heat Emergencies

Climate Risk Awareness for Tribal Communities

Engineering and Business Planning Applications for ClimRR

Information to get started

Local Climate Projections Guide

Data Catalog

Tool: https://climrr.anl.gov/

ClimRR portal is supported with funding from DOE-GDO, FEMA, and AT&T

Continued Learning

- Data and Tools Catalogue
- Maps: Innovative Data Energy Applications
- NREL Learning Tool Tutorials: https://www.youtube.com/@NRELLearn
- LEAD: fact sheet or methodology publication
- SLOPE: fact sheet or intro video and supporting how-to videos
- REopt: fact sheet and user manual
- SAM: Detailed description or high-level explanation
- PVwatts: Manual (v.5)
- JEDI: About the tool
- ClimRR: User Guide, Data Catalogue Guide, or Usage webinar