Identifying and Estimating Project Development Costs

Energizing Rural Communities Prize: Training #2

National Renewable Energy Laboratory
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AMERICAN MADE
U.S. DEPARTMENT OF ENERGY

OCED
Office of Clean Energy Demonstrations

Agenda

1. Stages of Project Development
2. Potential Project Costs
3. Impact on Ownership Model Choice
4. Tools and Resources for Project Planning, Projecting Costs and Revenues
5. Project Case Study: Solar + Storage Microgrid
6. Q & A

Project Development

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Stages

Potential Costs

Impacts on Ownership Model Choice

Stages of Project Development

1. Project Motivation
2. Site
3. Resource
4. Off-Take
5. Processes and Permits
6. Technology
7. Team
8. Capital
9. Operations and Maintenance
10. Decommissioning

Project Motivation

Pre-development is driven by

- Baseline needs
- Fundamental economics
- Policy environments
- Available technologies and resources
- Consensus

A motivated project is one that has a clear pathway to success and enough opportunity that it simply cannot be ignored.

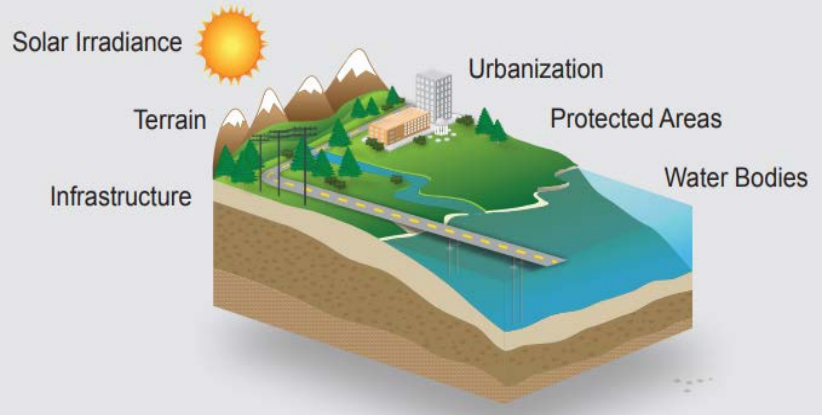
Site

Technical Costs

- Various stakeholders
- Property rights
- Legal definition
- Assignability
- Length of tenure
- Terms/conditions
- Default/cure clauses

Physical Costs

- Slope
- Vegetation
- Soil conditions
- Infrastructure
- Access
- Resource impacts
- Other land uses

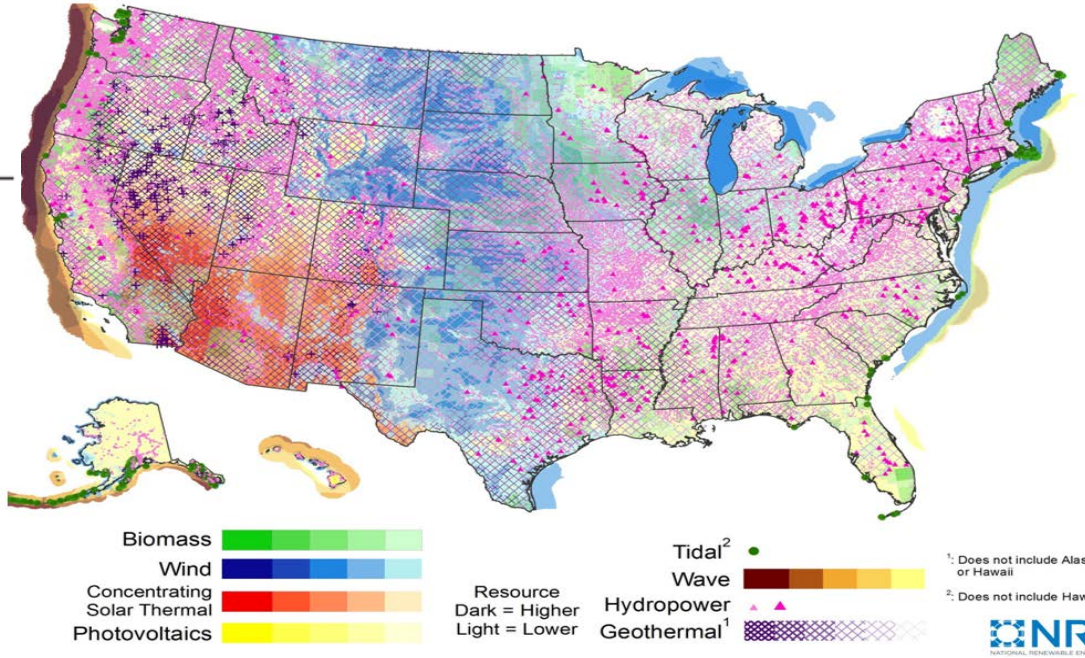


Resource Potential

Resource Potential

Total theoretical potential of a renewable energy resource

- Solar
- Wind
- Biomass
- Hydropower
- Geothermal
- Hydrokinetic



Off-Take

Importance

- Creates value
- Bankability
- Critical project milestone

Key Issues

- Project location
- Project finance
- Transmission
- Interconnection
- Infrastructure
- Regulatory risk
- Agreeing to terms

The term "off-take" implies that there is an economic and executable agreement by the project parties, and that it is ultimately confirmed by written contract.

Processes and Permits

Action	Applicability	Contacts
Interconnection	Grid connected?	Local utility
Net Metering	Availability?	Local utility
Local/State/Tribal Permitting	Project site, Electrical	Applicable agency
Interstate Permitting	Grid connected?	RTO or ISO
Federal Permitting	• Wildlife protection • Air and water protection • Protected land usage	Applicable federal agency

Technology

Technology Costs

- Engineering design
  - Conceptual
  - Design development
  - Construction documents
- Equipment selection
- Procurement activities

All this activity requires investment into the design process and evolves incrementally as further investment is deemed warranted for the project.

Team

Aspects to Address

- Business
- Technical
- Financial
- Legal
- Operational

Assembly of an experienced, capable team is a key element to raising debt, equity, and incentive/grant program capital.

Capital

Source	Availability	Complexity	Providers
Grants	Low	Low-Medium	Government, Private Entities, Development Banks
Equity	Varies	Medium-High	Project Sponsor, Private Investors
Debt	High	High	Governments, Capital Markets, Commercial Lenders
Credit Enhancement	Medium	High	Governments, Development Banks
Third-Party Ownership	Medium	Varies	Energy Service Providers

Operations and Maintenance

O&M Costs

- Fixed costs
- Fixed cost components
- Maintenance costs
- Variable cost components
- Maintenance components
- Replacement costs
- Planning and budgeting for O&M
- Billing and accounting
- Tax preparation and filling
- Enforcement of warranties
- REC certification and trading
- Compliance

An effective O&M program reinforces confidence in the long-term performance and revenue capacity of an asset.

Decommissioning

Alternative	Extend	Refurbish	Repower	Decommission
Advantage	Defers disposal costs No capital investment Leverages existing arrangements	Restores some lost performance Leverages existing plant and arrangements	Enhances performance with new technology Leverages existing infrastructure and arrangements Low maintenance costs	Frees land and other assets for subsequent use Discontinues expenses
Disadvantage	Degraded performance High maintenance costs	Some capital investment High maintenance costs	Higher capital investment	Incurs decommission costs Forfeits existing arrangements

Other Cost Considerations

- Standards
- Regulatory
- Tax
- Challenges
- Best practices

Impacts on Ownership Model Choice

Complexity

Low
Medium
High

Stage of Development	Community Shared Partnership	Direct Utility Owned	Third-Party PPA
Project Motivation			
Site			
Resource			
Off-Take			
Processes and Permits			
Technology			
Team			
Capital			
O&M			
Decommissioning			

Project Planning

Tools and Resources

Costs and Revenue Projections

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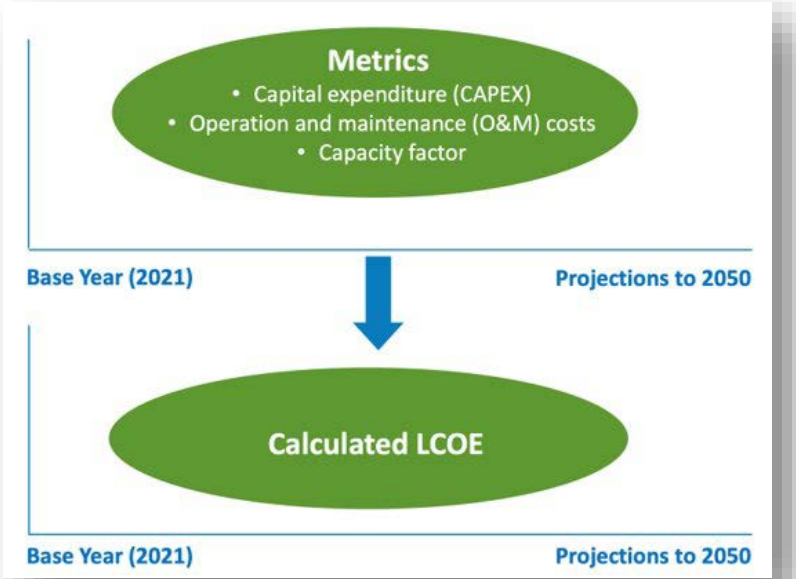
Annual Technology Baseline (ATB)

"Provides consistent technology-specific cost and performance parameters across a range of R&D advancements scenarios, resource characteristics, and sites for electricity-generating technologies"

- For current year and projections through 2050
- Includes the following performance parameters:
  - Capital expenditures (CAPEX)
  - Operation and maintenance (O&M) expenditures
  - Capacity factors
  - Levelized cost of energy (LCOE)
- Updated annually



Sources: https://atb.nrel.gov/electricity/2023/index; https://www.nrel.gov/docs/fy23osti/86419.pdf

ATB Outputs

- Include capital expenditure, operations expenditures, capacity factors for three tech advancement scenarios and two policy scenarios
- Levelized cost of energy (LCOE) is a summary metric that combines all of these metrics into an average price of energy over the selected period
- Details on capital cost components (equipment, permitting, interconnection, overhead, etc) also provided

Summary of Minimum and Maximum Values of CAPEX, Capacity Factor, O&M and LCOE

		LCOE ($/MWh)		CAPEX ($/kW)		Capacity Factor		Variable O&M ($/MWh)		Fixed O&M ($/kW-yr)		Heat Rate (MMBtu/MWh)		OCC ($/kW)	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Land-Based Wind	R&D	26	66	1,363	1,961	0.26	0.5			29	38			1,284	1,847
Offshore Wind	R&D	73	136	3,150	3,901	0.29	0.46			102	116			2,080	2,769
Commercial DW	R&D	43	279	2,331	4,511	0.11	0.45			36	36			2,248	4,349
Large DW	R&D	43	139	2,331	2,331	0.11	0.48			36	36			2,248	2,248
Midsize DW	R&D	43	215	2,331	2,929	0.11	0.42			36	36			2,248	2,824
Residential DW	R&D	43	247	2,331	6,007	0.11	0.4			36	36			2,248	5,792
Utility PV	R&D	33	52	1,291	1,291	0.21	0.34			23	23			1,246	1,246
Commercial PV	R&D	74	115	1,754	1,754	0.12	0.19			18	18			1,691	1,691
Residential PV	R&D	123	190	2,859	2,859	0.12	0.19			30	30			2,859	2,859
CSP	R&D	94	121	7,254	7,254	0.51	0.67	3.7	3.7	69	69			6,822	6,822
Geothermal	R&D	69	103	6,750	8,971	0.8	0.9			114	151			4,547	6,043
Hydropower	R&D	77	418	3,008	19,947	0.33	0.66			28	189			2,820	18,702
Utility-Scale PV-Plus-Battery	R&D	63	98	2,102	2,102	0.23	0.35			54	62			2,028	2,028
Utility-Scale Battery Storage	R&D									24	88			943	3,520
Commercial Battery Storage	R&D									31	72			1,225	2,868
Residential Battery Storage	R&D									92	119			3,681	4,758
Pumped Storage Hydropower	R&D			2,227	4,434			0.54	0.54	19	19			2,088	4,157
Coal	R&D			3,549	6,215			8.5	15	77	150	8.3	8.5	2,857	5,002
Natural Gas	R&D			1,120	1,283			2.	6.4	24	31	6.2	9.7	1,003	1,148
Biopower	R&D	170	170	5,391	5,391	0.64	0.64	5.	5.	157	157	14	14	4,800	4,800
Nuclear	R&D	107	107	9,440	9,440	0.93	0.93	2.5	2.5	152	152	10	10	7,468	7,468

NREL

ATB data for technologies on the website: https://atb.nrel.gov/

Technology: (All)

Scenario: Advanced; Conservative; Moderate

Cost Recovery P...: 30 years

Maturity: (All); Mature; Nascent

Case: (All); Market; R&D

Year: 2021

MKT = Market + Policies

Source: https://atb.nrel.gov/electricity/2023/index

Cost Categories and ATB Cost Estimates

1. Engineering (pre-development) and development, including overhead and contingency
2. Equipment: Solar modules, Inverter, "Balance of system" (including structural components)
3. Installation: Labor, Installer margin and overhead
4. Developer/installer profit
5. Sales tax
6. *Land acquisition
7. Permitting and environmental studies
8. Grid interconnection
9. Operations and maintenance

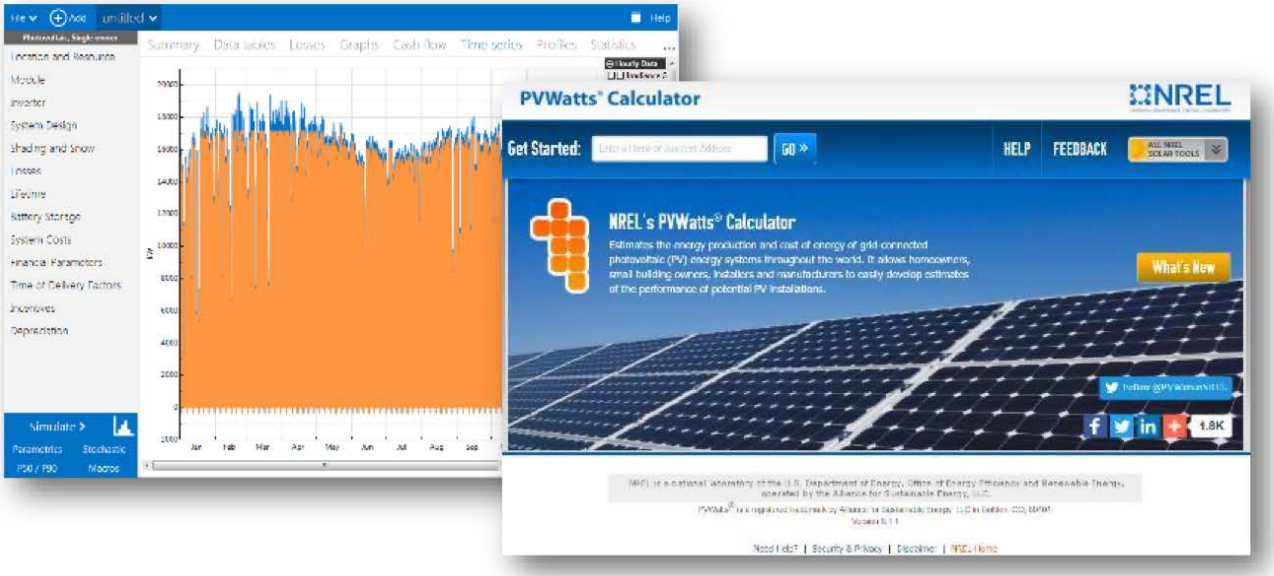
Example Project Cost Estimates

	1,000 kW Solar PV		300 kW Battery Storage		
	per kW	Project	per kW	Project	Total
Engineering/development			n/a		
Equipment	$850	$850,000	$1,752	$525,660	$1,375,660
Labor	$150	$150,000	$265	$79,380	$229,380
Overhead	$660	$660,000	$333	$99,780	$759,780
Contingency	$50	$50,000	$60	$18,084	$68,084
Profit	$56	$56,000	$126	$37,884	$93,884
Sales tax	$50	$50,000	$97	$28,992	$78,992
*Land acquisition	$0	$0	$0	$0	$0
Permitting/environmental	$30	$30,000	$29	$8,664	$38,664
Grid interconnection**	$60	$60,000	$26	$7,692	$67,692
Total development cost	**$1,906**	**$1,906,000**	**$2,687**	**$806,136**	**$2,712,136**
Operations and maintenance	**$19**	**$475,000**	**$59**	**$445,320**	**$920,320**
Total lifetime cost		**$2,381,000**		**$1,251,456**	**$3,632,456**

System Advisor Model (SAM) & PVWatts

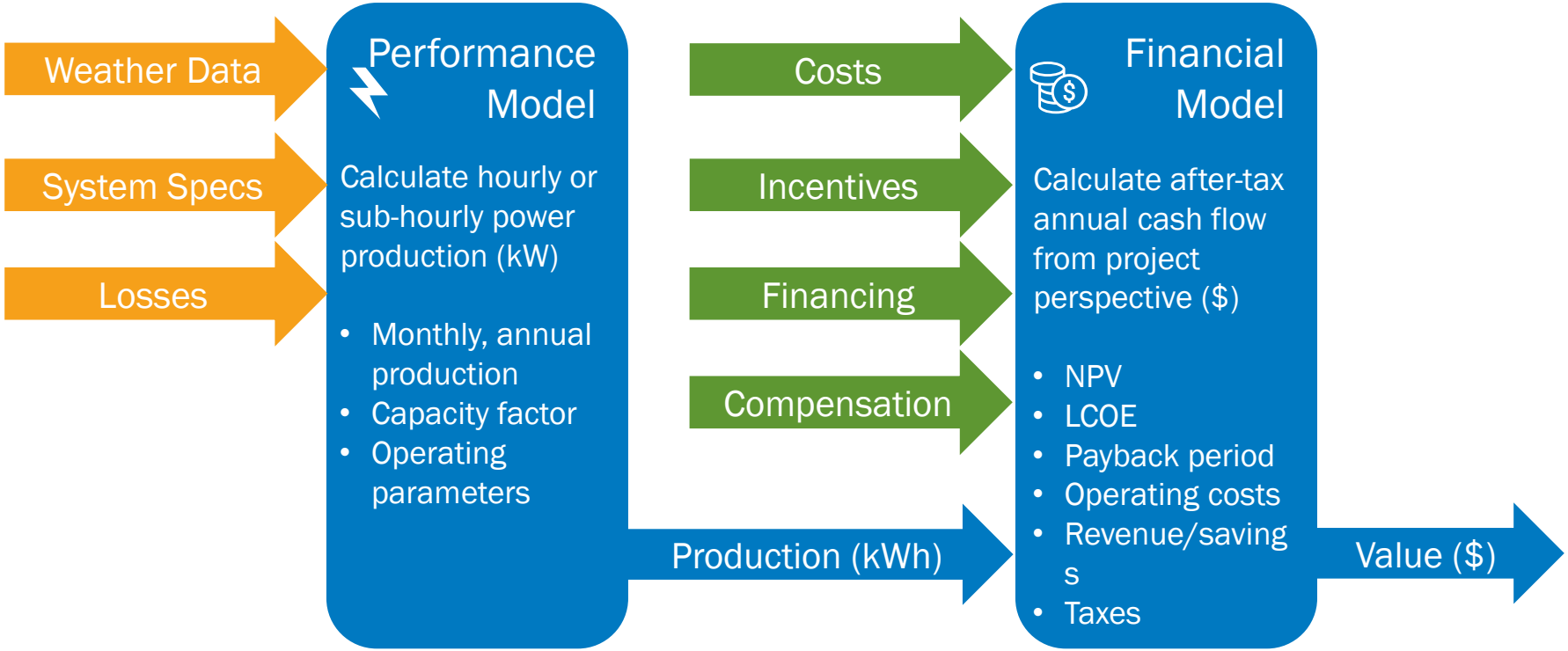
System Advisor Model

Free software that enable detailed performance and financial analysis for renewable energy systems



http://sam.nrel.gov/download
https://pvwatts.nrel.gov

Model Structure



Technologies

- Photovoltaics
  - Detailed & PVWatts
- Battery Storage
- Concentrating solar power
- Fuel cell-PV-battery
- Wind
- Marine Energy
- Geothermal
- Solar water heating
- Biomass

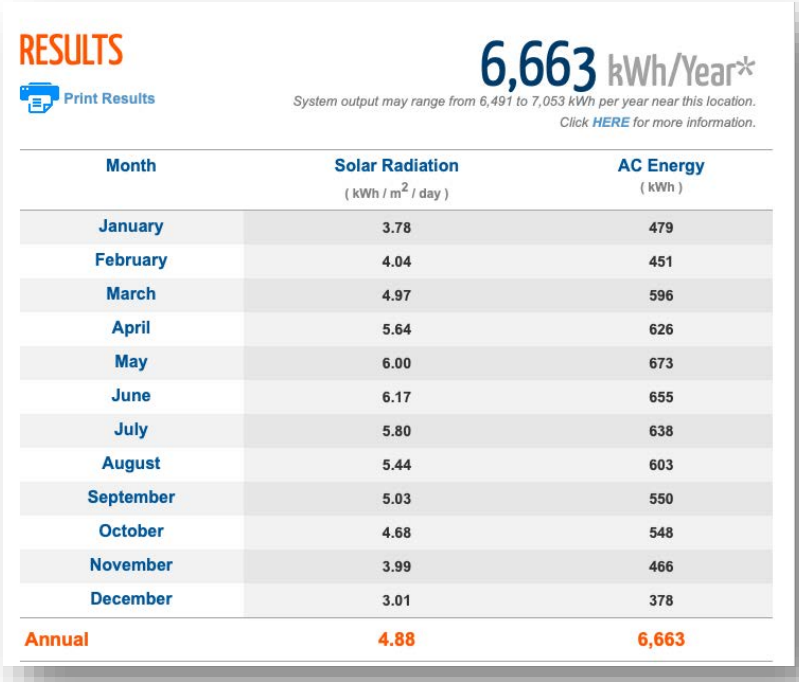
Financial

- Behind-the-meter
  - residential
  - commercial
  - third-party owned
- Power purchase agreements
  - single owner
  - equity flips
  - sale-leaseback
- Host/developer
- Merchant plant
- Simple LCOE calculator

PVWatts Calculator

- Estimates the energy production of grid-connected photovoltaic (PV) energy systems
- Allows users to easily develop estimates of the performance of potential PV installations at any location
- Outputs: monthly solar irradiation and system output*, capacity factor, system losses, etc for selected/calculated system size

Source: https://pvwatts.nrel.gov/



RESULTS

Print Results

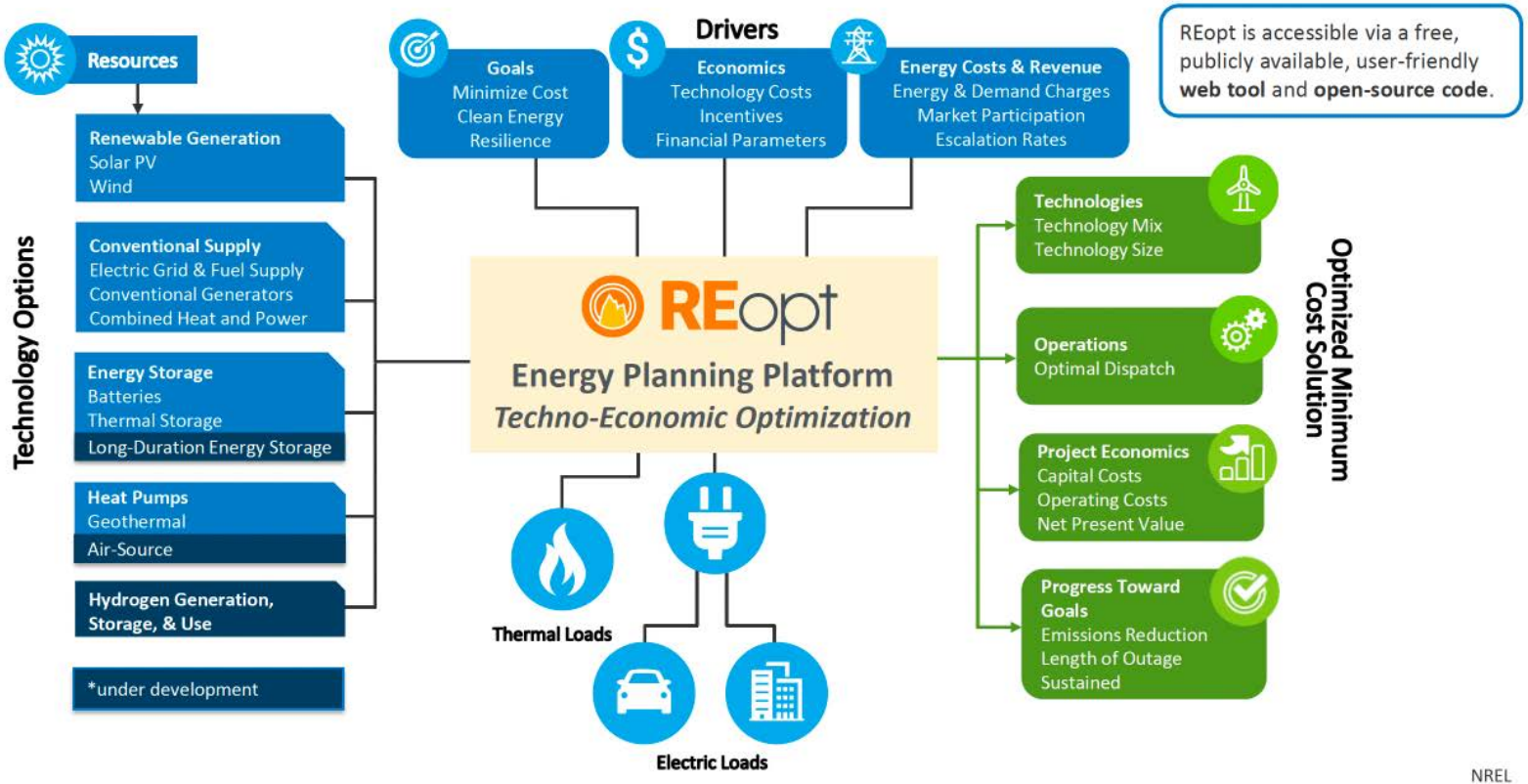
6,663 kWh/Year*

System output may range from 6,491 to 7,053 kWh per year near this location.
Click HERE for more information.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)
January	3.78	479
February	4.04	451
March	4.97	596
April	5.64	626
May	6.00	673
June	6.17	655
July	5.80	638
August	5.44	603
September	5.03	550
October	4.68	548
November	3.99	466
December	3.01	378
Annual	4.88	6,663

REopt® Energy Planning Platform

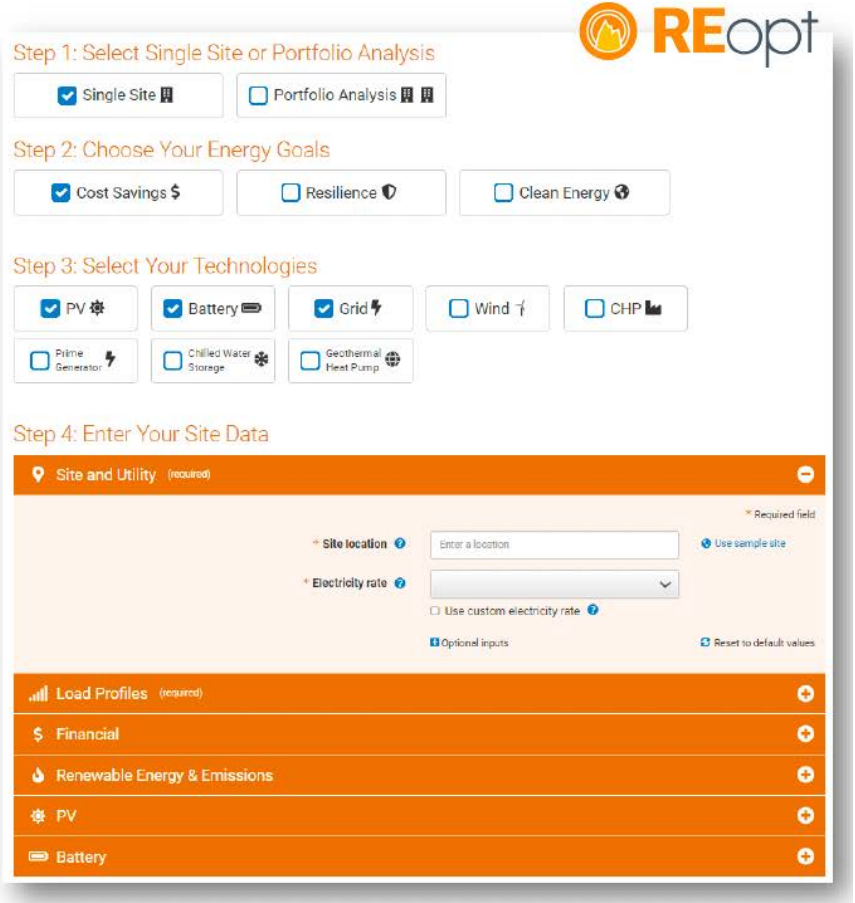
Formulated as a mixed integer linear program, REopt provides an integrated, cost-optimal energy solution.



NREL

REopt Web Tool User Interface

- **REopt web tool** provides free, publicly available, user-friendly capabilities from NREL's comprehensive **open-source REopt model**
- Optimizes **PV, wind, CHP, GHP, and energy storage** system sizes and dispatch strategies to **minimize life cycle cost of energy**
- **Resilience mode** optimizes DER systems, along with backup generators, to sustain critical load during grid outages
- **Clean energy goals** allow users to consider renewable energy targets, emissions reductions targets, and emissions costs in optimization
- Access the REopt web tool at reopt.nrel.gov/tool.



Other tool trainings

1. Introduction to the State and Local Planning for Energy (SLOPE) Platform – **November 14**
2. Introduction to REopt : Renewable Energy Integration & Optimization – **December 5**
3. *Solar Siting and Available Decision-making Tools – **January 9***
4. *Introduction to the System Advisor Model (SAM) Financial Analysis Software for Renewable Energy Systems – **January 16***

All recorded trainings are posted on our American Made Challenges website. You can find completed trainings at the bottom of the website.

https://americanmadechallenges.org/challenges/rural-energy/calendar

- Thank you / Q&A

Email: ruralenergyprize@nrel.gov

American Made: americanmadechallenges.org/challenges/rural-energy

HeroX Forum: www.herox.com/rural-energy

NREL/PR-7A40-88920

Resources

- Database of State Incentives for Renewables and Efficiency: https://www.dsireusa.org
- Institute for Local Self-Reliance Community Power Map: https://ilsr.org/community-power-map/
- NREL Renewable Energy System Interconnection Standards: https://www.nrel.gov/state-local-tribal/basics-interconnection-standards.html
- National Community Solar Partnership: https://www.energy.gov/communitysolar/about-national-community-solar-partnership
- NREL Energy Compensation Mechanisms for Distributed Generation: https://www.nrel.gov/state-local-tribal/energy-compensation-mechanisms.html
- EPA Customer Power Purchase Agreements (Primer): https://www.epa.gov/statelocalenergy/customer-power-purchase-agreements