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Sizing and Lessons Learned with Energy Storage

PRESENTED BY

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Outline

- Sandia Energy Storage Program Overview
- Sizing Energy Storage
- Lessons Learned

Energy Storage at Sandia

Energy Storage is a major Crosscut at the lab.

Wide ranging R&D covering energy storage technologies with applications in the grid, transportation, and stationary storage

20+ staff, 10+ post docs, 22 University partners, close industry collaboration

Major R&D Thrust Areas

Materials and Systems Development

- Development of next-generation technologies
- Improving current technology (flow, sodium, Zn-MnO2 batteries, membranes, etc.)

Power Electronics

- Development of power electronics and power conversion systems.

Energy Storage Systems Safety and Reliability

- Fundamental safety R&D, Advanced Modeling
- Laboratory testing and analysis from individual cells to MW size systems

ES Systems Demonstrations and Testing

- Field deployments; State-Initiated Demonstration Project Development

Grid Analytics and Policy

- Systems optimization, wide area controls, modeling and open access tools

Industry Outreach – publications, webinars and conferences to help educate the Grid Energy community

DOE OE Energy Storage Projects and Analysis Team

What We Do and Why

- Work with Utility, Industrial, Commercial, Private, State and International entities to:
  - Provide **third party independent analysis** for cells and systems
  - Support the development and implementation of **grid-tied ES** projects
    - **Application/Economic analysis**
    - **RFI/RFPs**
    - **Design and Procurement Support**
    - **Commissioning Plan Development**
  - Monitor and analyze operational ES Projects
    - Differing applications
    - Optimization
    - Operational performance
  - Develop public information programs
- Goal
  - Inform the Public and encourage investment.

Energy Storage Analytics

Estimating the value of energy storage

- Production cost modeling
  Stochastic unit commitment/planning studies
  Linear Programming Optimization Control strategies for distributed storage
- Wide area control
- Control and architectures for kWh-GWh storage plants

T&D simulation with energy storage (PSLF, OpenDSS, MATLAB)

Supporting Public policy: identifying and mitigating barriers

Standards development and DOE Protocols

Project evaluation

- Technical performance
- Financial performance

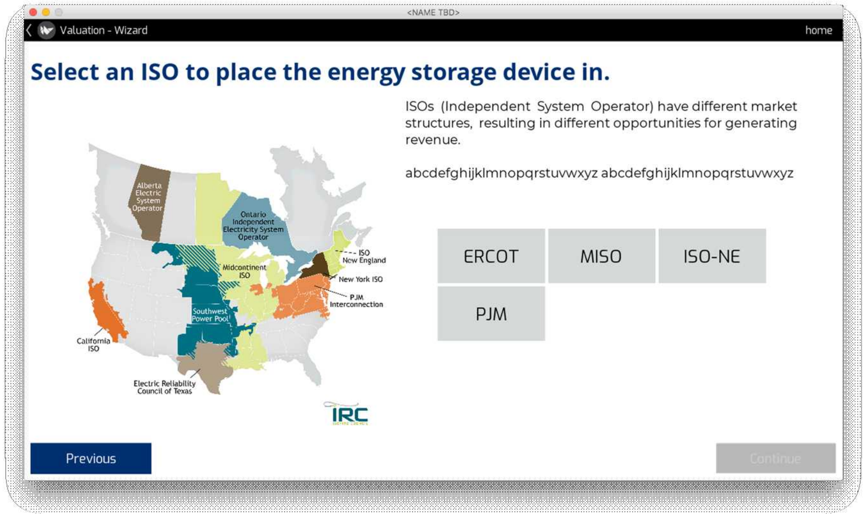
Open Access Energy Storage Tools

Sandia plans to release the internal Python-based software tools that have been employed in-house since ~2012 (July 2018 release)

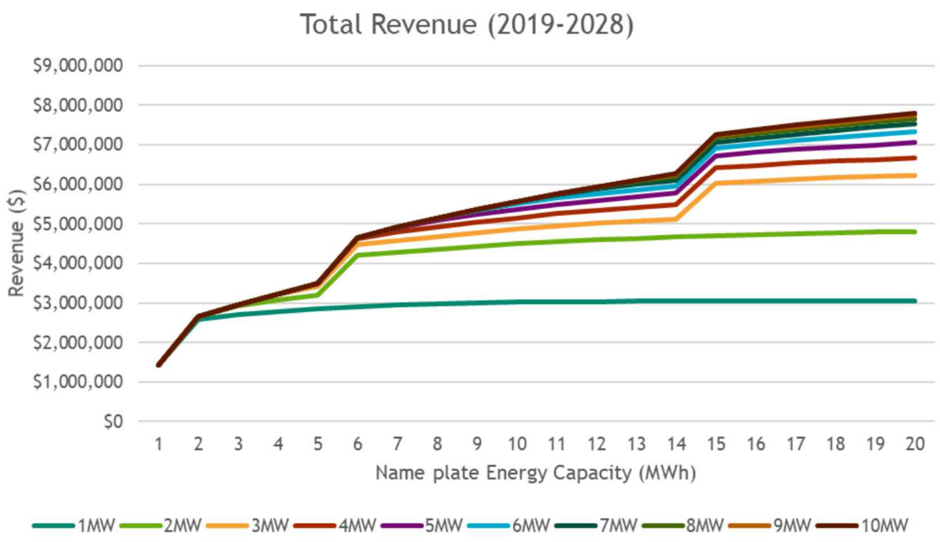
Based on Sandia’s Pyomo optimization framework in Python
- High level object oriented language for formulating optimization problems
- 2016 R&D 100 award winner
- Open source software package with technical support from Sandia

Initial capabilities
- Revenue optimization in ISO market areas
- Arbitrage and frequency regulation

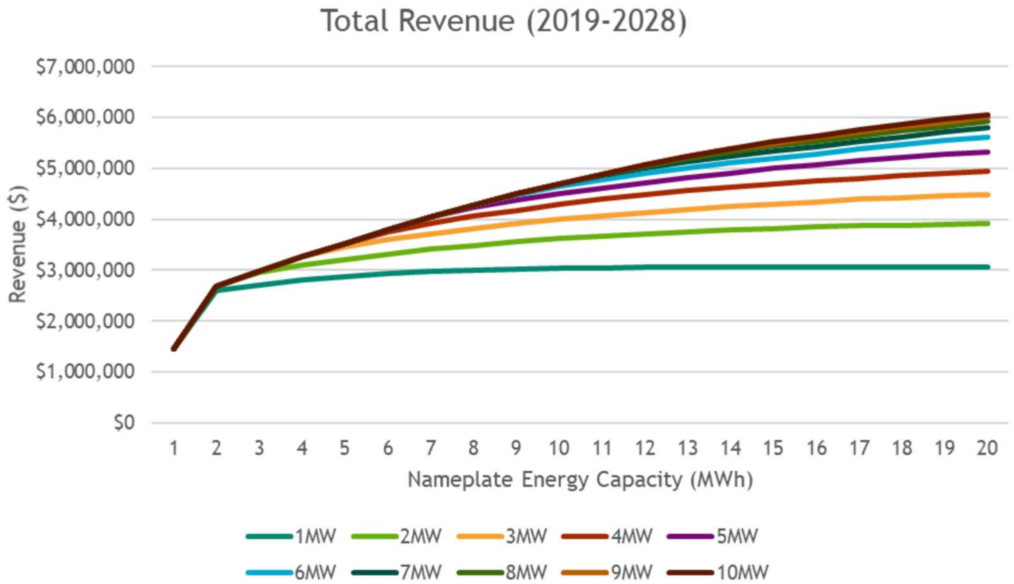
Planned capabilities for subsequent releases
- Microgrid design and operation
- Storage plus solar and wind
- Technology selection guide
- Total cost of ownership calculations using updated data from the Energy Storage Handbook



Result of Cost/Benefit Analysis (Transmission Deferral / Microgrid)



High Load Growth



Low Load Growth

Other Benefits (Cordova Alaska)

- Energy Storage Installation Costs
  - $250k / MW
  - $817.5k / MWh
- Spinning Reserve for Hydro

Power (MW)	Energy (MWh)							
	0.05	0.10	0.25	0.50	0.75	1.00	1.50	2.00
0.75	12.03	11.22	8.00	5.31				
1.00	9.45	9.95	7.54	5.23	4.02	3.26	2.37	1.87
1.50	6.59	7.29	5.95	4.44	3.56	2.97	2.23	1.79
2.00						2.7	2.09	1.71
BENEFIT TO COST RATIO FOR 12 YEARS (>1 is Good)								

Other Benefits

- Applications Considered
  - Uninterruptible Power Supply
  - Frequency Regulation
  - Voltage Support
  - Power Quality
  - Ramp Rate Limiting
  - Distribution Deferral

Power (MW)	Energy (MWh)							
	0.05	0.10	0.25	0.50	0.75	1.00	1.50	2.00
0.75	$0.00M	$0.22M	$1.58M	$4.01M				
1.00	$0.75M	$0.69M	$2.04M	$4.48M	$6.91M	$9.36M	$14.25M	$19.15M
1.50	$2.26M	$2.16M	$3.52M	$5.95M	$8.36M	$10.80M	$15.68M	$20.57M
2.00						$12.28M	$17.15M	$22.03M

ADDITIONAL BENEFIT NEEDED OVER 12 YEARS TO EQUAL 0.75MW/0.05MWh BENEFIT TO COST

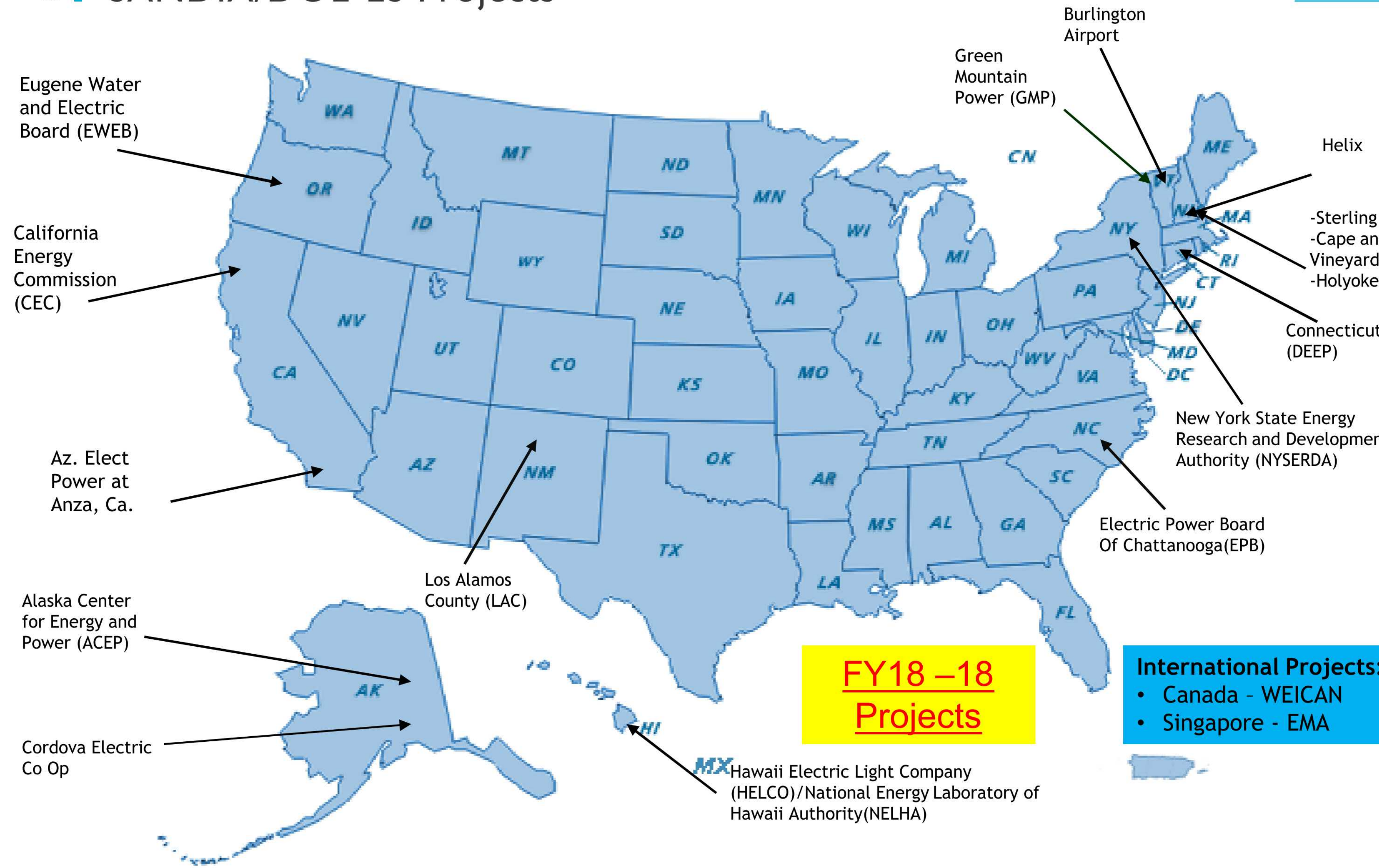
Project Evaluation

Support the demonstration program with data analysis

Recent efforts

- ISO-NE
- Sterling, MA
- Taos, NM
- Cordova, AK
- Anza, CA
- Joint Base Andrews
- Washington Gas & Light
- Los Alamos County (NM)
- Electric Power Board (TN)
- Eugene Water and Electric Board (OR)
- Energy Market Authority (Singapore)

SANDIA/DOE ES Projects



FY18 –18 Projects

International Projects:
- Canada – WEICAN
- Singapore - EMA

Sterling Municipal Light Department

Installed a 2 MW/ 3MWh battery storage system in Sterling Massachusetts

The system can isolate from the grid in the event of an outage

Along with the existing PV array, it can provide 12 days of backup power to the Sterling police station

Saves the town ratepayers $400,000 per year by decreasing the costs associated with capacity and transmission charges

Sterling Municipal Light Department

Issue

- Lack of knowledge and experience regarding procurement of a combined system lead to a difficult and arduous process for vendors

Lessons Learned

- For successful integration of storage, it can be helpful to have 1 project combining PV and Storage done by 1 company rather than 2 separate projects done by 2 companies
- There is a growing need for companies who can do both

Green Mountain Power

Installed in Rutland, Vermont

4Mw/3.4MWh of a combined lead-acid and li-ion system

Integrated with 2.5 MW of PV

Helps with ancillary services, backup power for an emergency shelter, and demand management

Saved approximately $300,000 by reducing annual and monthly peak

Green Mountain Power Issues and Lessons Learned

Issues

- Project built with 4 - 500KW multi input (DC) inverters
- 500KW ea. of LA and Li-ion, plus ~500KW of PV per inverter
- Inverters limit output
  - Reduced demand reduction capability

Lessons Learned

- Not designing for flexibility of applications limited DR value

Eugene Water and Electric Board

Installed in Eugene, Oregon at the Howard Elementary School

500kW/1MWh Lithium Ion

Integrated with 50kW of PV

Helps backup power for an emergency shelter and demand management

EWEB Issues and Lessons Learned

Issues

- Black Start capability of NEC was designed to start immediately after a power outage. EWEB requires a black start to occur hours to a day after a power outage. UPS battery inside the NEC to allow black start (power for controls) is not large enough.

Lessons Learned

- Design the black start for duration (external larger UPS or use ESS)
- Include this design in the RFP

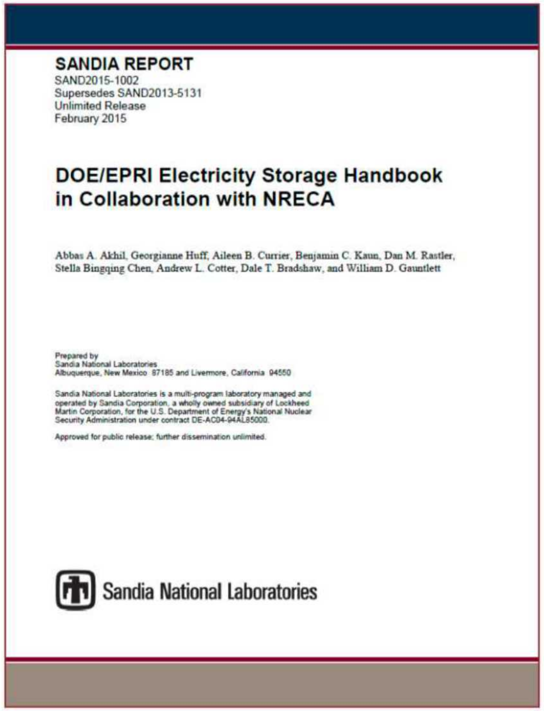
Outreach and Industry Tools

DOE/EPRI Electricity Storage Handbook is a how-to guide for utility and rural cooperative engineers, planners, and decision makers to plan and implement energy storage projects safety in communities

DOE Energy storage program website

- Publications
- Project information
- Archive of DOE Peer Review presentations

www.sandia.gov/ess



SANDIA REPORT
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DOE/EPRI Electricity Storage Handbook in Collaboration with NRECA

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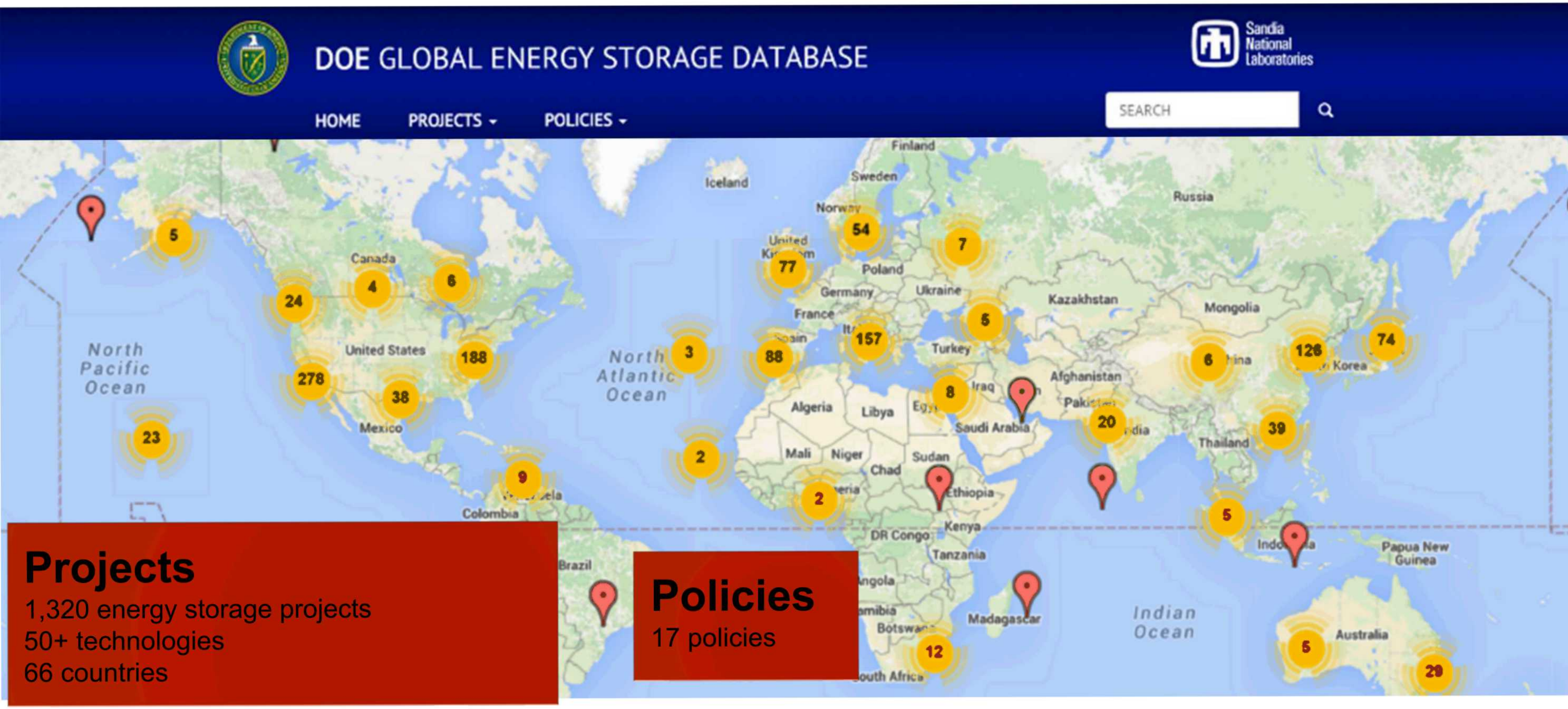
Outreach and Industry Tools

DOE Global Energy Storage Database provides free, up-to-date information on grid-connected energy storage projects and relevant state and federal policies.



Projects

1,320 energy storage projects
50+ technologies
66 countries

Policies

17 policies

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