Storage Evaluation Tools

Ricky Concepcion, **David Copp**, and Tu Nguyen

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Energy Storage Evaluation Tool

What is it?

- Open-source, easy-to-use, software application
- Unified toolset for straight-forward and transparent evaluation of energy storage
- One stop shop for evaluating multiple ES applications
Energy Storage Evaluation Tool

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Who should use it?

▪ Decision-makers and stakeholders.
▪ Utilities, regulators, policy-makers, vendors, researchers
Energy Storage Evaluation Tool

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Who should use it?
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Why use it?
- Free, open-source, transparent, and easy-to-use.
- No need for development or technical expertise.
- Algorithms and software developed by researchers at Sandia National Laboratories with results validated and published in peer-reviewed articles.
Energy Storage Evaluation Tool

What does it do?

- One stop shop for evaluating energy storage
  - Valuation
  - optimal operation
  - sizing and placement
  - choosing particular technology
  - microgrid management with other energy resources (PV, wind, etc.)

- Interfaces with other open-source tools for even more applications
  - Power system dynamic simulation (how does ES affect dynamics)

- Compare to other applications (not open-source):
  - NREL Battery Lifetime Analysis and Simulation Tool (BLAST)
  - PNNL Energy Storage Optimization Tool
  - EPRI StorageVET
Energy Storage Evaluation Tool

Applications

- Valuation - Estimate value of a given ES system. Use historical data and a given market structure to determine the maximum revenue that ES device could generate by providing multiple services (e.g., ancillary services, arbitrage, behind-the-meter).

- Optimal Operation - Determine optimal charge/discharge schedule for various operational objectives (e.g., maximizing efficiency, lifecycle, revenue).

- Sizing and placement - Determine optimal placement and size of ES for various applications given budget constraints.

- Choosing particular technology - Help users understand and select different ES technologies for various applications.

- Microgrid management - Optimally operate/manage a portfolio of multiple energy resources (e.g., ES, PV, HVAC, fuel cells, etc.)
Energy Storage Evaluation Tool

Compatibility

- OS:
  - Windows
  - Mac
  - Linux
- Solvers:
  - free open-source - GLPK, NOPT, IPOPT
  - commercially licensed - CPLEX, GUROBI
  - See PYOMO (pyomo.org) for more information
- Python 2.7 or 3

Installation

- Scientific distribution of Python (e.g., Anaconda)
- PYOMO (open-source optimization modeling language)
- Solver (e.g., GLPK)
Demonstration

Welcome to the Sandia Energy Storage Application!

Energy Storage Valuation
Discover the maximum revenue an energy storage system of certain specifications may generate in a certain ISO using historical data.

Continue
Welcome to the Sandia Energy Storage Application!

Energy Storage Valuation
Discover the maximum revenue an energy storage system of certain specifications may generate in a certain ISO using historical data.

Click to open the application.

Explore other applications.

Continue
Energy Storage Valuation

Estimates value for a given energy storage system. Uses historical data and a given market structure to determine the maximum amount of revenue that the energy storage device could have generated by providing multiple services (e.g., ancillary services, arbitrage, behind-the-meter).
Application Tabs

Energy Storage Valuation

Estimates value for a given energy storage system. Uses historical data and a given market structure to determine the maximum amount of revenue that the energy storage device could have generated by providing multiple services (e.g., ancillary services, arbitrage, behind-the-meter).
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Sizing and Siting

Determine optimal placement and size of energy storage systems for various applications given budget constraints.
Sizing and Siting

Determine optimal placement and size of energy storage systems for various applications given budget constraints.
Technology Selection

Help users understand and select different energy storage technologies for various applications.
Application Tabs

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Windows
Load Data
Load Data

Select Market Area  Select Data Type  Select Year  Select Month  Select Node  Load Data
Load Data

Select Market Area

Select Data Type

Select Year

Select Month

Select Node

Load Data
Load Data
Load Data
Load Data
### Set Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
<th>Unit</th>
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</thead>
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<tr>
<td>Gamma_s, Storage efficiency in [0, 1]</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Gamma_c, Conversion efficiency in [0, 1]</td>
<td>0.8</td>
<td></td>
<td></td>
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<tr>
<td>Q_c_max, Maximum energy charged per timestep [MW*(DT [Time_unit])]</td>
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<td></td>
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<tr>
<td>Q_d_max, Maximum energy discharged per timestep [MW*(DT [Time_unit])]</td>
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<tr>
<td>S_max, Maximum state of charge (charge capacity) [MW*Time_unit]</td>
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<tr>
<td>S_min, Minimum state of charge [MW*Time_unit]</td>
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<td></td>
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<tr>
<td>R, Discount/interest rate [time^(-1)]</td>
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<tr>
<td>Gamma_ru, Fraction of regulation up offers accepted in [0, 1]</td>
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<td>Gamma_rd, Fraction of regulation down offers accepted in [0, 1]</td>
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<tr>
<td>Q_c_max</td>
<td></td>
<td>8.0</td>
</tr>
<tr>
<td>P_max</td>
<td>Maximum power [MW]</td>
<td>32.0</td>
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<tr>
<td>P_max</td>
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<tr>
<td>SOE_max</td>
<td>State of energy (capacity) [MW*Time_unit]</td>
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<tr>
<td>SOE_max</td>
<td></td>
<td>0.0</td>
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<tr>
<td>SOE_min</td>
<td>State of energy (demand) [MW*Time_unit]</td>
<td>0.0</td>
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<td>SOE_min</td>
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[Run Optimization]
Run Optimization

Run optimization?
This may take a while. The application will be unresponsive during the solve.

Run
View Results
Dismiss
Run Optimization
Run Optimization

Running optimization

This may take a while. The application will be unresponsive during the solve.
Instantiating Pyomo model...
Populating Pyomo model...

Run  View Results  Dismiss
Run Optimization

Running optimization

This may take a while. The application will be unresponsive during the solve.
Instantiating Pyomo model...
Populating Pyomo model...
Solving model...

Run
View Results
Dismiss
Run Optimization

Finished

This may take a while. The application will be unresponsive during the solve.
Instantiating Pyomo model...
Populating Pyomo model...
Solving model...
Processing solve results...
Finished!
View Results

State of Charge [MWh]

0  5  10  15  20  25  30
0  24  48  72  96  120  144

state of charge  Plot  Save results
Summary

Storage Evaluation Tool

- Open-source, easy-to-use, application for evaluation of energy storage
- One stop shop for evaluating multiple ES applications
- Free, open-source, transparent, and easy-to-use.
- No need for development or technical expertise.

Further Development

- Ability to evaluate more applications
- Interface with other open-source and commercial tools
Acknowledgements

- Funding provided by US DOE Energy Storage Program managed by Dr. Imre Gyuk of the DOE Office of Electricity Delivery and Energy Reliability.

Thank you.

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Tu Nguyen – tunguy@sandia.gov
EXTRA SLIDES
Why Do We Need Storage?

- Storage can provide many grid services:
  - Resiliency and reliability
  - Transmission and Distribution (T&D) upgrade deferral
  - More efficient operation of the generation fleet
  - Balance the variability of renewable generation
  - Behind the meter savings for commercial and industrial customers
  - Ancillary services (frequency regulation, spinning reserve, black start, etc.)
  - Peaker plant replacement
  - Voltage support
Energy Storage Analytics

Equitable Regulatory Environment Thrust Area

- Goals: Lower barriers to widespread deployment of energy storage by identifying new and existing value streams, quantifying the impact of policy on deployment, and developing new control strategies

- Objectives:
  - Project case studies
  - Tools for storage valuation
  - Identify new value streams
  - Control strategies to maximize revenue/grid benefit
  - Assess policy impact on storage
  - Develop policy recommendations