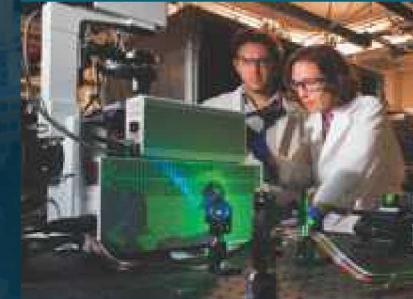




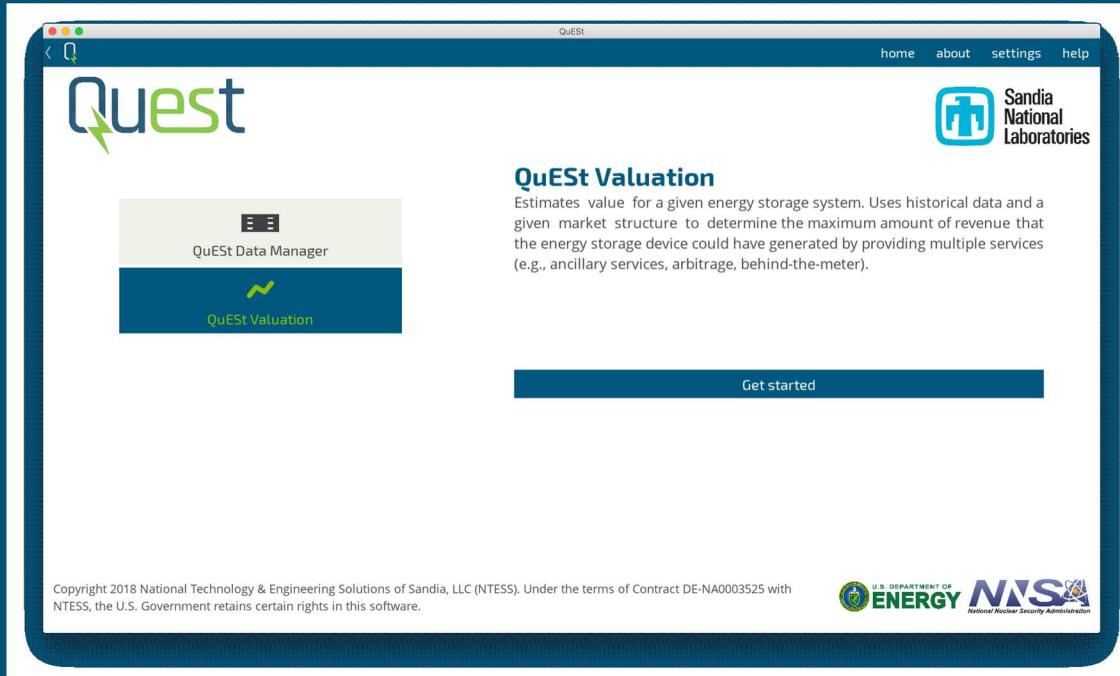
An Energy Storage Application Suite



PRESENTED BY

Ricky Concepcion

What is it?



- Open source, Python-based energy storage analysis software application suite
- Developed as a graphical user interface for the optimization modeling capabilities of SNL's energy storage analytics group
 - Early prototype was presented by David Copp at last year's peer review (2017)
- Initial development driven by Pyomo models for energy storage valuation
- Now publicly available on GitHub
 - github.com/rconcep/snl-quest



Energy storage valuation

Given an energy storage device, an electricity market with a certain payment structure, and market data, how would the device maximize the revenue generated and provide value?

How much revenue could a flywheel plant located at the Houston pricing node in the ERCOT market have generated in the month of July 2016 by participating in energy arbitrage? What if it also provided frequency regulation services?

$$\max \sum_i \left(\begin{array}{l} \text{arbitrage} \\ \text{regulation up} \end{array} \right) + \left(\begin{array}{l} \text{regulation up} \\ \text{regulation down} \end{array} \right) e^{-R_i}$$

subject to:

$$\begin{aligned} s_{i+1} &= \eta_s s_i + \eta_c q_i^r - q_i^d + \eta_c \delta_i^{rd} q_i^{rd} - \delta_i^{ru} q_i^{ru} && \text{state of charge definition} \\ 0 \leq s_i &\leq \bar{S} && \text{state of charge limits} \\ q_i^d + q_i^r + q_i^{ru} + q_i^{rd} &\leq \bar{Q} && \text{power/energy charged limits} \end{aligned}$$

Other constraints, such as requiring the final SoC to equal the initial SoC or reserving energy capacity for resiliency applications can be set.

The solution of the mathematical program is the optimal policy of managing state of charge based assuming perfect foresight of market conditions. The corresponding objective value is an upper bound.

The ValuationOptimizer class for wrapping Pyomo models

Idea: Create a Python class that abstracts away the details of Pyomo models (encapsulation) while also supporting an entire family of optimization models, e.g., energy storage valuation for every market area in the US.

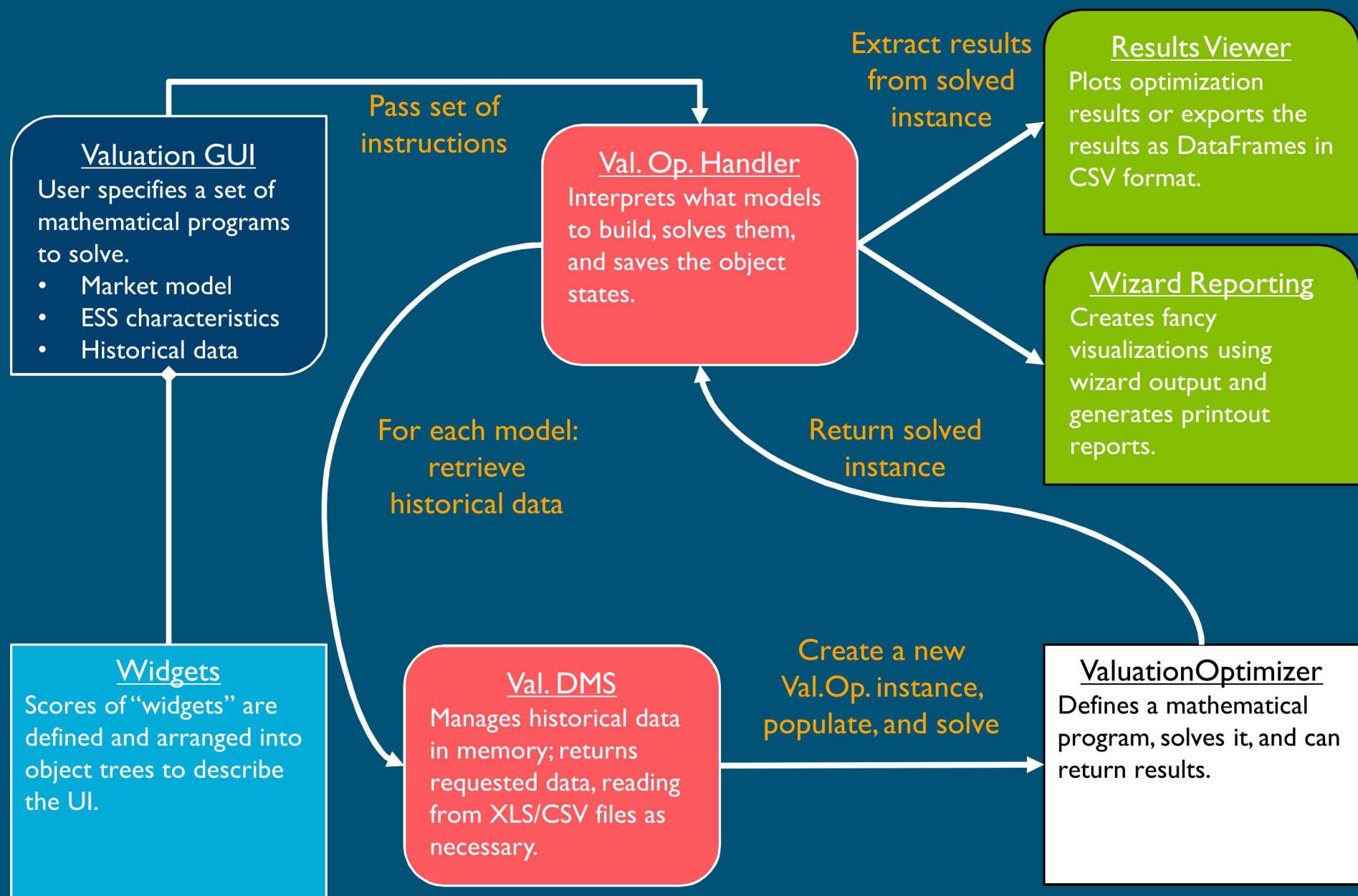


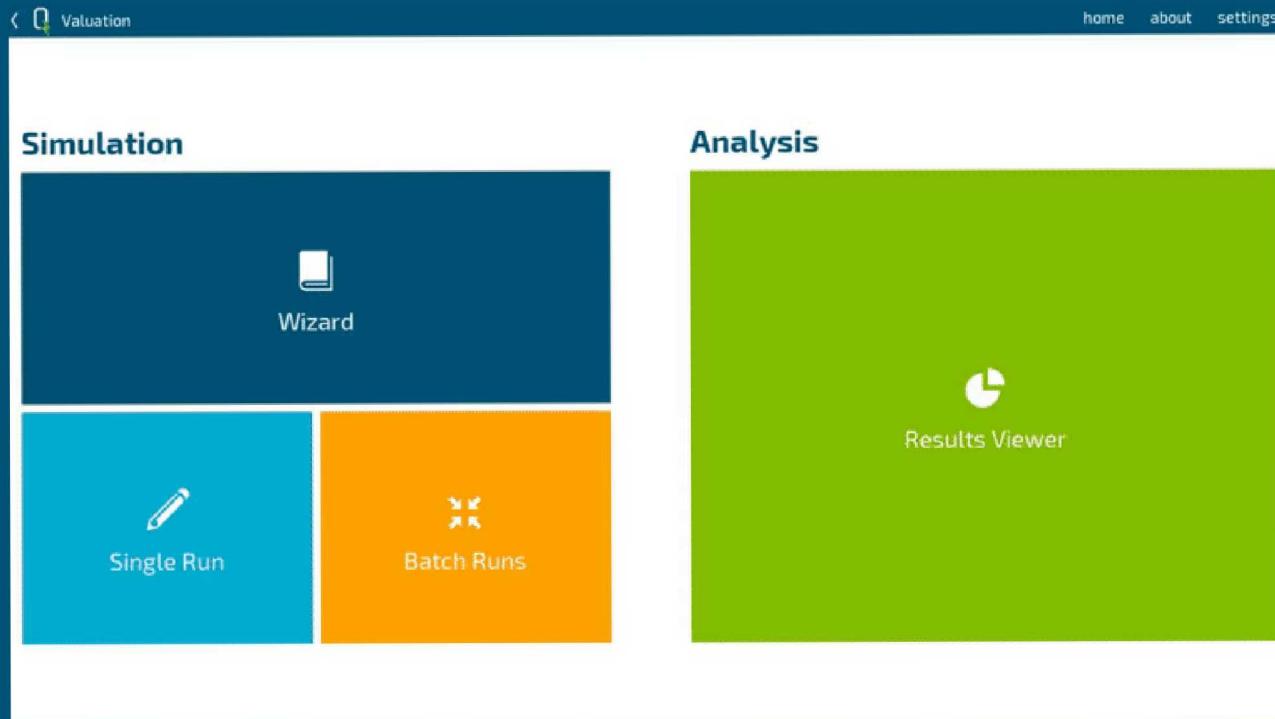
Builds a Pyomo model that you can solve and obtain the results from.

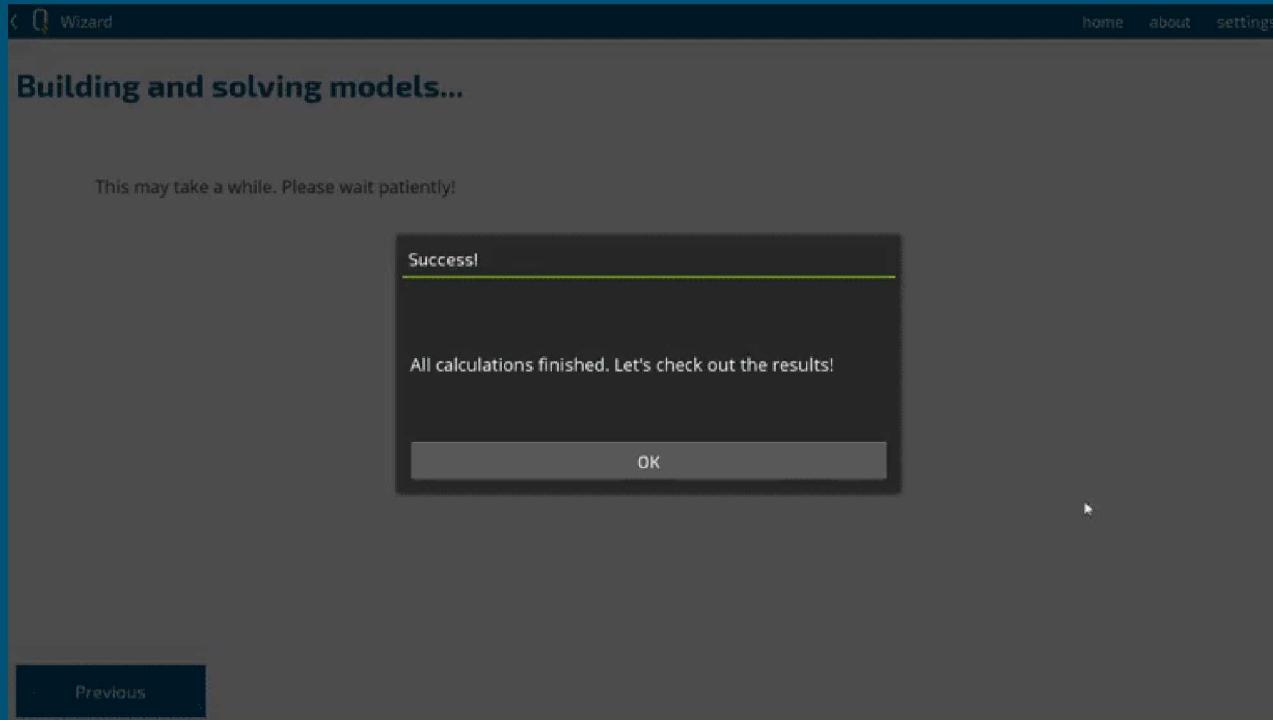
Defines the objective function and constraints that describe the problem.

All a user needs to know is how to interact with ValuationOptimizer object; they do not need to know anything about Pyomo.

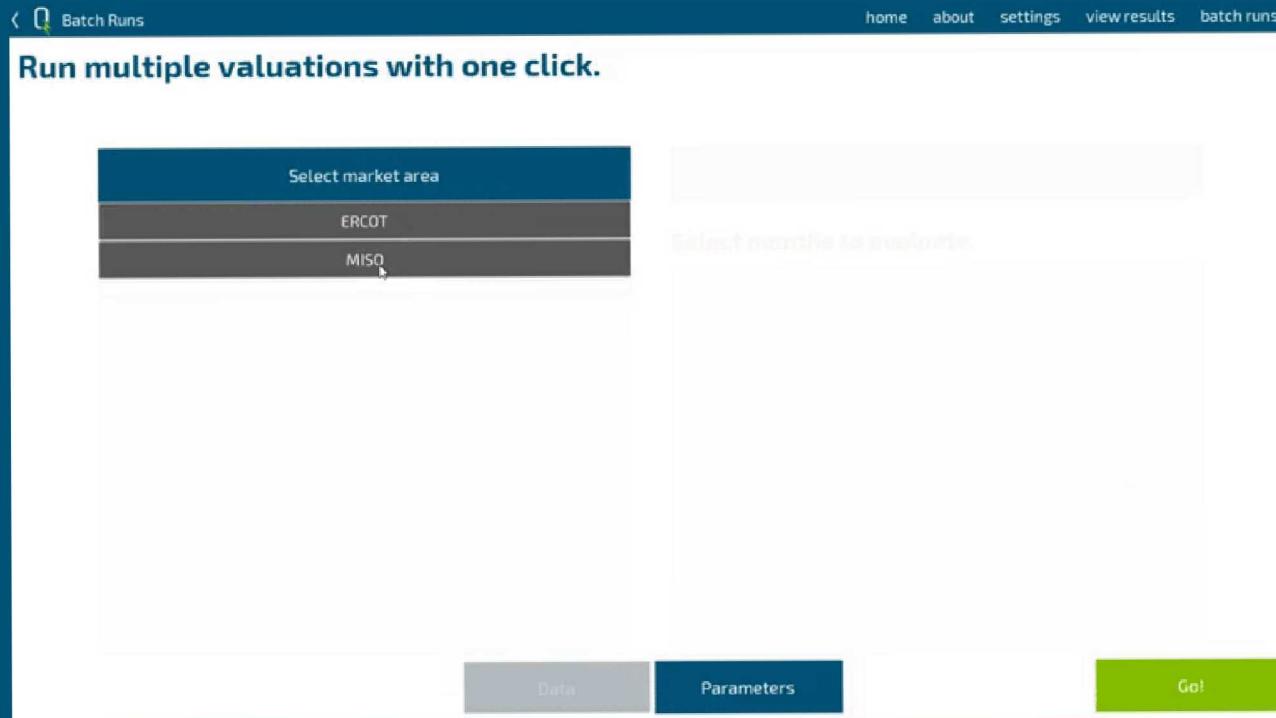
QuEST Valuation software architecture





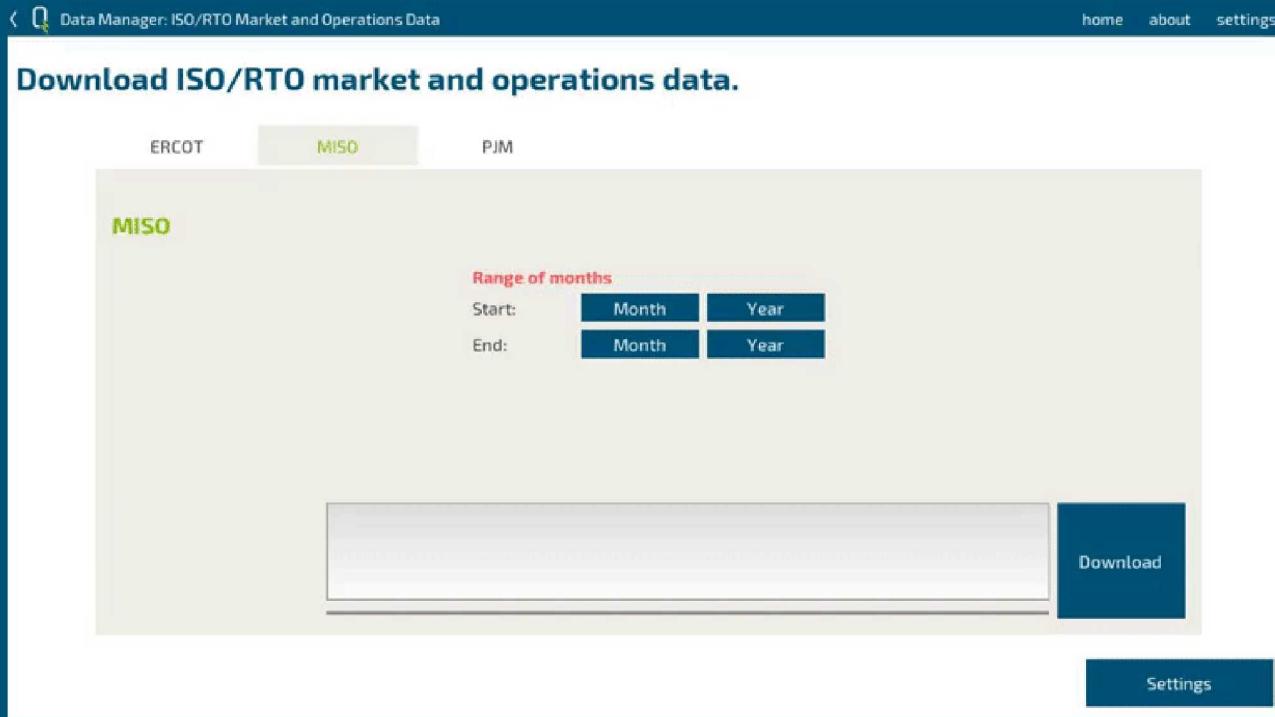


8 QuEST Valuation Batch Runs



The screenshot shows a web-based application for running batch valuation runs. At the top, there is a navigation bar with links: home, about, settings, view results, and batch runs. Below the navigation bar, a sub-header reads "Run multiple valuations with one click." On the left, a dropdown menu titled "Select market area" is open, showing two options: "ERCOT" and "MISO". To the right of the dropdown, a placeholder text "Select months to evaluate" is visible. At the bottom of the interface, there are three buttons: "Data" (gray), "Parameters" (dark blue), and a large green "Go!" button.

QuEST Data Manager



The screenshot shows the QuEST Data Manager interface for downloading ISO/RTO market and operations data. The top navigation bar includes a back arrow, a search icon, and the text 'Data Manager: ISO/RTO Market and Operations Data'. On the right, there are links for 'home', 'about', and 'settings'. Below the navigation is a main title 'Download ISO/RTO market and operations data.' with three tabs: 'ERCOT', 'MISO' (which is selected and highlighted in green), and 'PJM'. A large 'MISO' logo is centered on the page. Below the logo is a 'Range of months' section with two tables for 'Start' and 'End' dates, each with 'Month' and 'Year' columns. A large input field for the download path is followed by a 'Download' button. A 'Settings' button is located at the bottom right of the main content area.

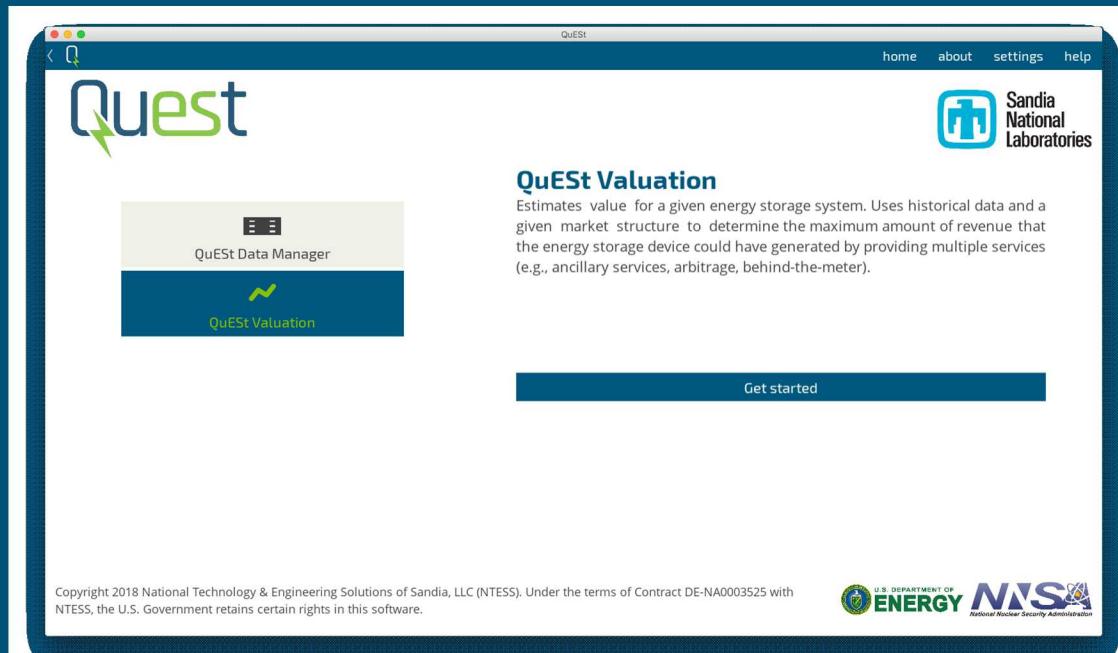
We do not own the historical data that we use, so we cannot distribute any.

- Uses “web crawling” to search ISO/RTO website for download links
- Uses API provided by ISO/RTO to make queries
- Prepares a data bank for use in other applications, e.g., QuEST Valuation
 - Downloads and extracts compressed archives
 - Formats API query results
 - Names files and creates directory structure to keep track of what’s been downloaded

The Future

Mission: Continue adding applications and new capabilities to the suite, building upon the software architecture and GUI foundation that we have established.

- Add support in QuEST Valuation/Data Manager for the remaining US markets
- Consider more complex valuation models, such as modeling degradation
- New applications
 - Behind-the-meter ES valuation
 - Technology selection assistant
 - Data explorer for ES finance information
 - ?



Acknowledgements

The authors would like to acknowledge the support and guidance from Dr. Imre Gyuk, the program manager for the U.S. Department of Energy Office of Electricity Energy Storage program.

Authors

Ricky Concepcion

David Copp

Tu Nguyen

Felipe Wilches-Bernal



Inquiries to:

Ricky Concepcion

rconcep@sandia.gov

Follow us on GitHub:

github.com/rconcep/snl-quest