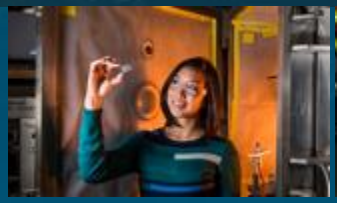
Quest

An Energy Storage Application Suite



PRESENTED BY

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ENERGY NNSA

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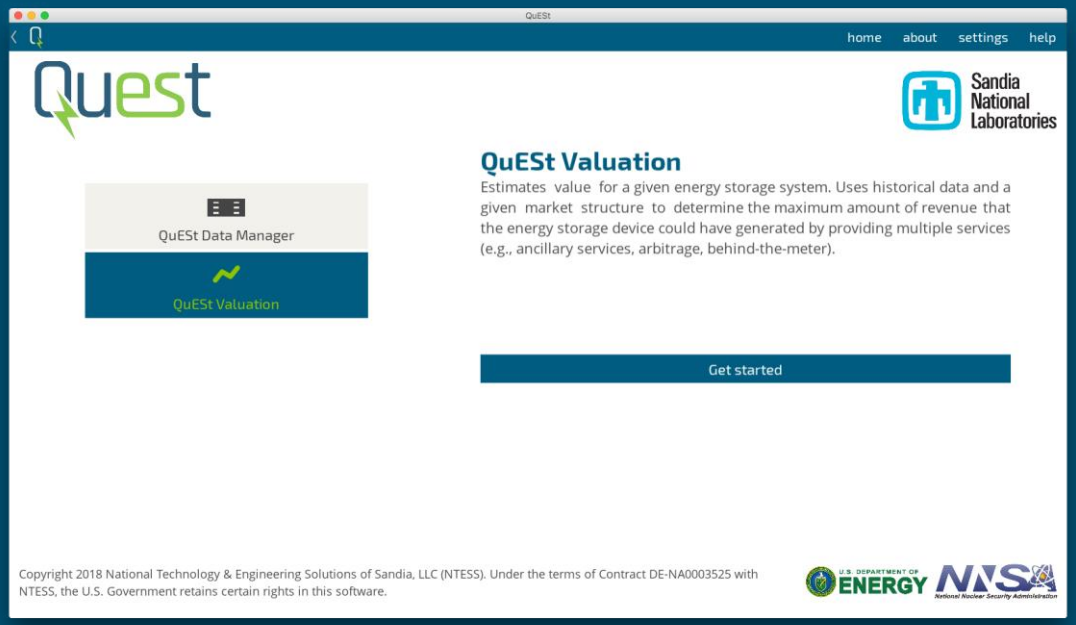
What is it?



- 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?

$$\max \sum_i \Big(\underbrace{\lambda_i (q_i^d - \eta_c q_i^r)}_{\text{arbitrage}} + \underbrace{q_i^{ru}(\lambda_i^{ru} + \delta_i^{ru}\lambda_i)}_{\text{regulation up}} + \underbrace{q_i^{rd}(\lambda_i^{rd} - \delta_i^{rd}\lambda_i)}_{\text{regulation down}} \Big) e^{-Ri}$$

subject to:

$$s_{i+1} = \eta_s s_i + \eta_c q_i^r - q_i^d + \eta_c \delta_i^{rd} q_i^{rd} - \delta_i^{ru} q_i^{ru}$$ state of charge definition

$$0 \le s_i \le \bar{S}$$ state of charge limits

$$q_i^d + q_i^r + q_i^{ru} + q_i^{rd} \le \bar{Q}$$ power/energy charged limits

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

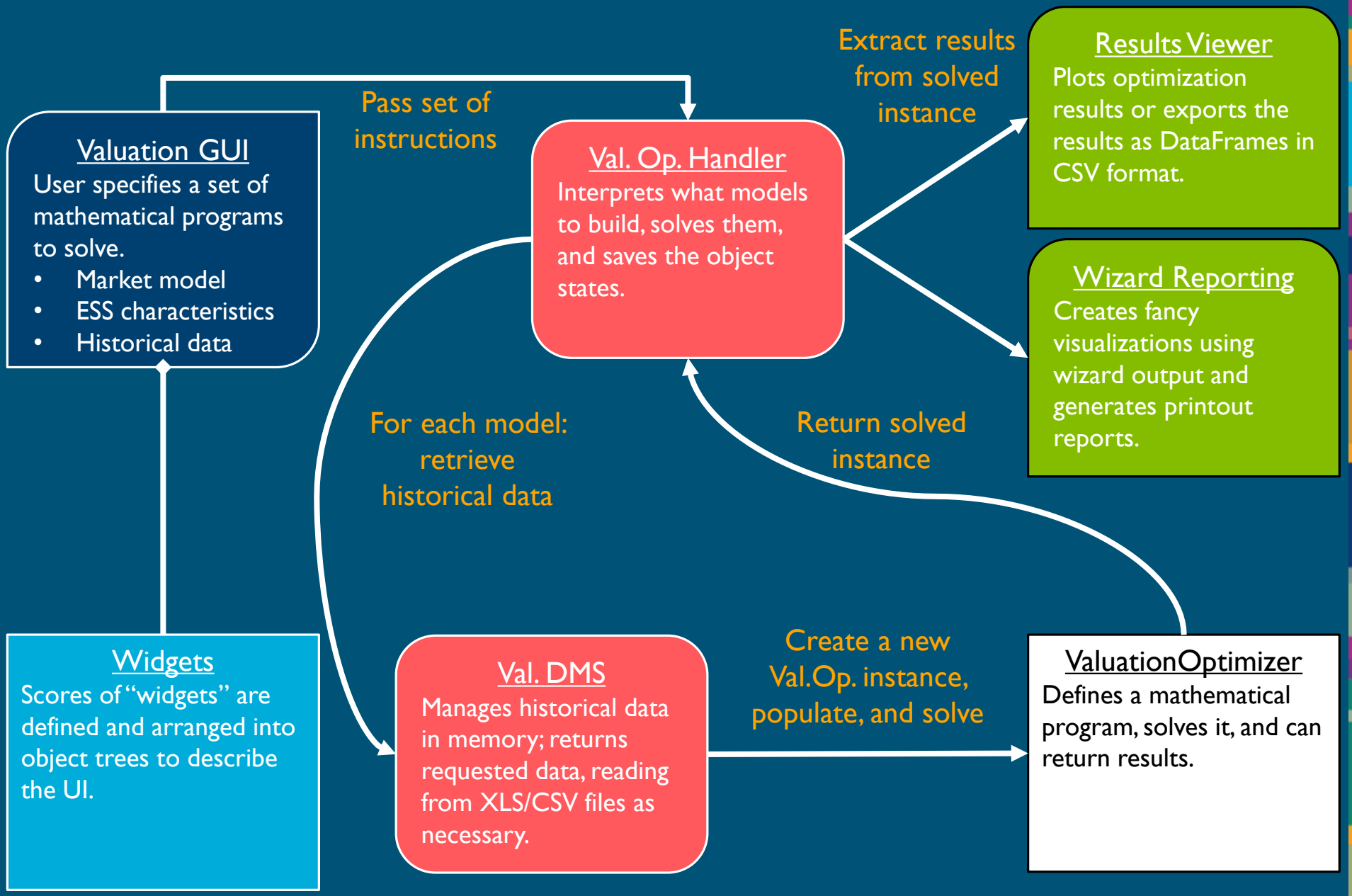
Idea: Create a Python class that abstracts away the details of Pyomo models (encapsulation) while also supporting an entire family of optimization models, e.g., energy storage valuation for every market area in the US.

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

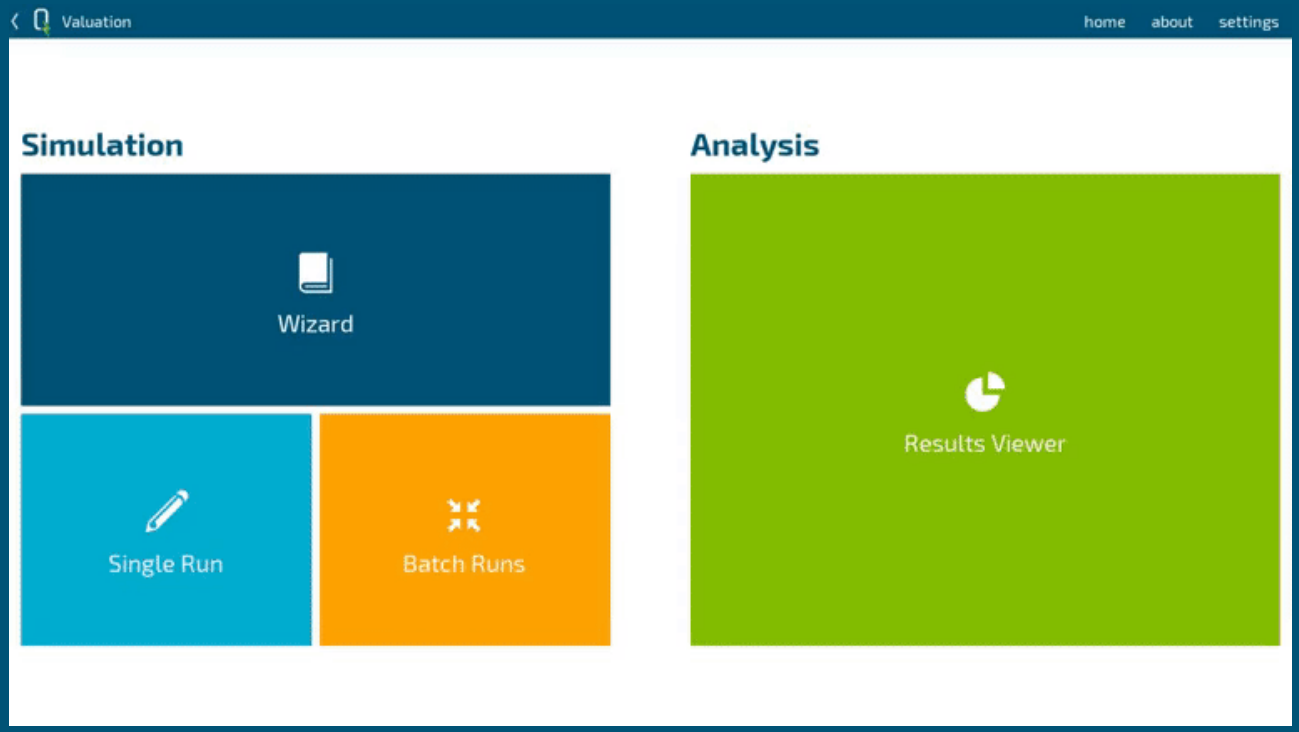
Defines the objective function and constraints that describe the problem.

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

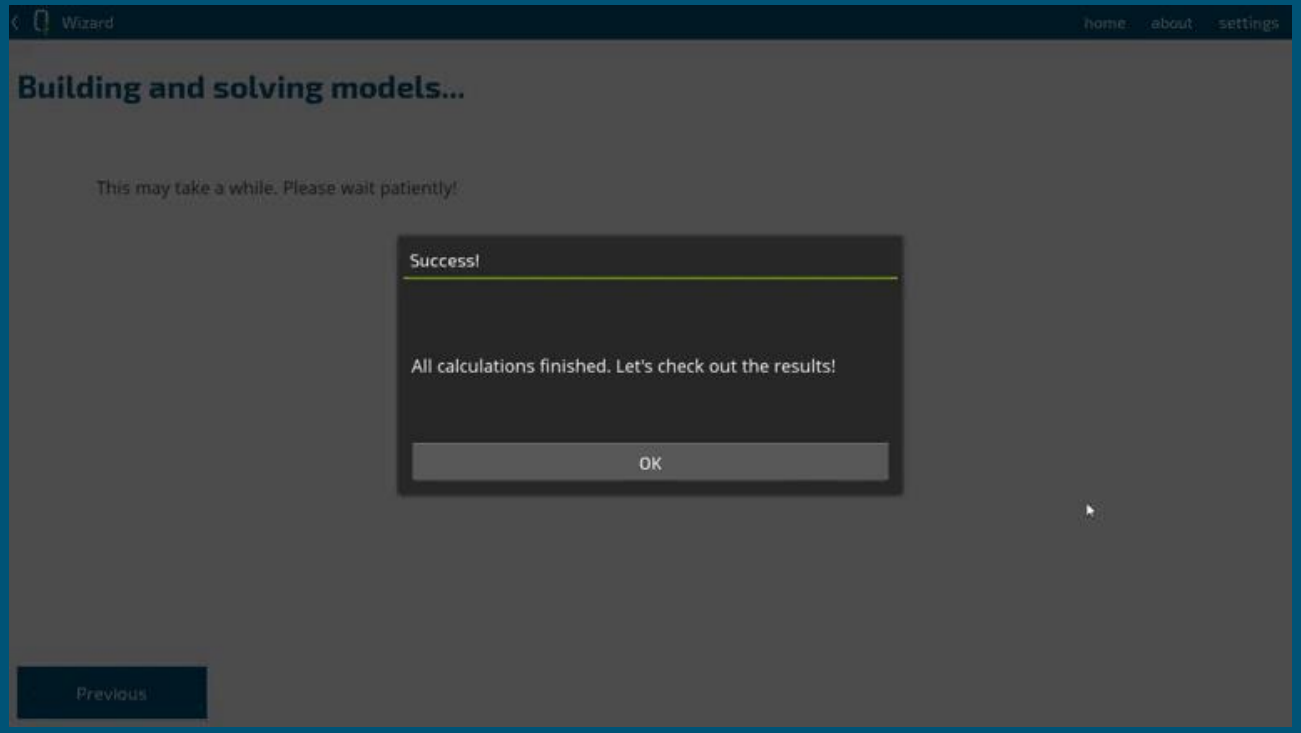
QuESt Valuation software architecture



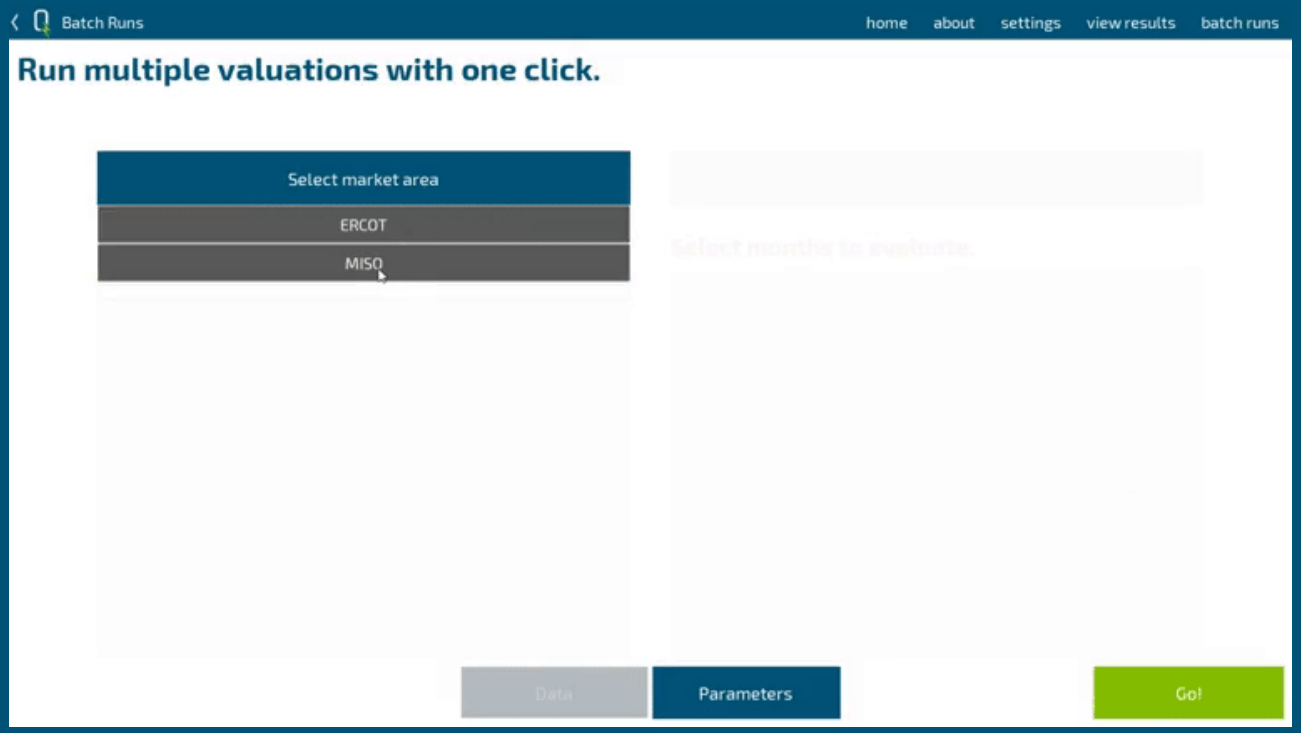
QuESt Valuation Wizard



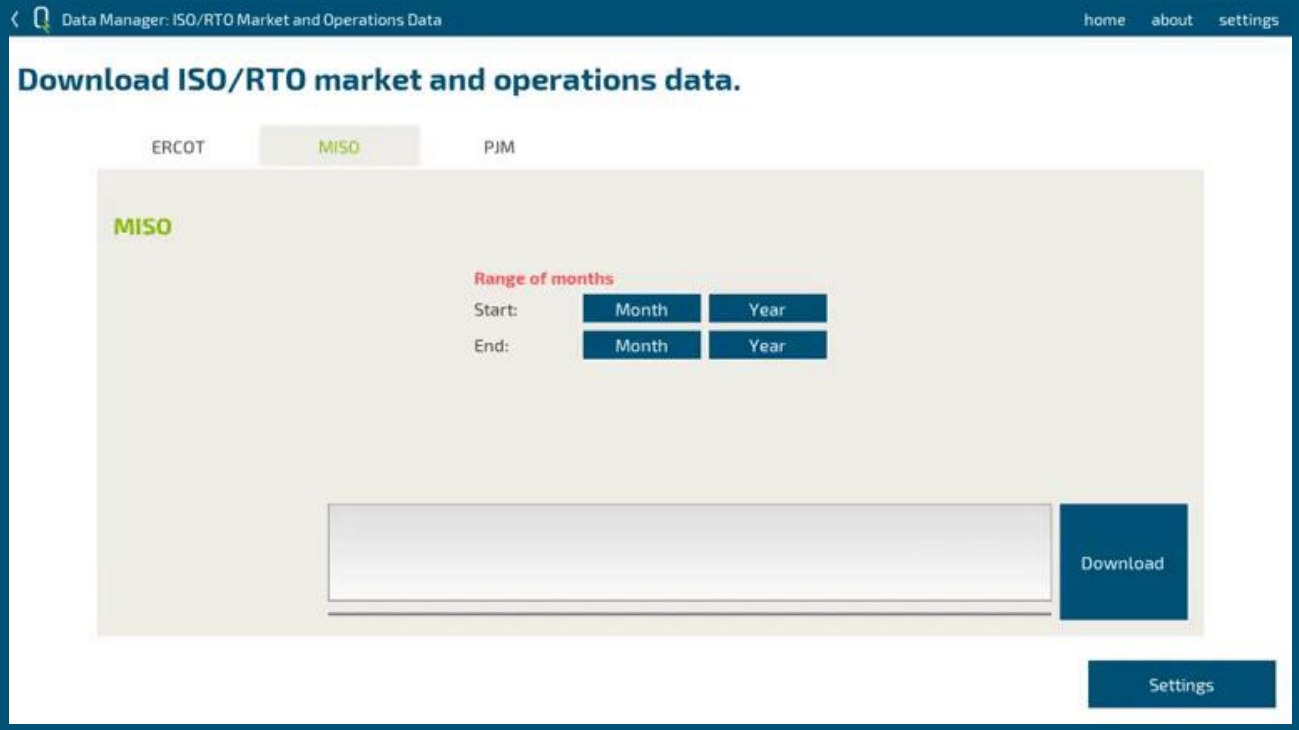
QuESt Valuation Wizard



QuESt Valuation Batch Runs



QuESt Data Manager



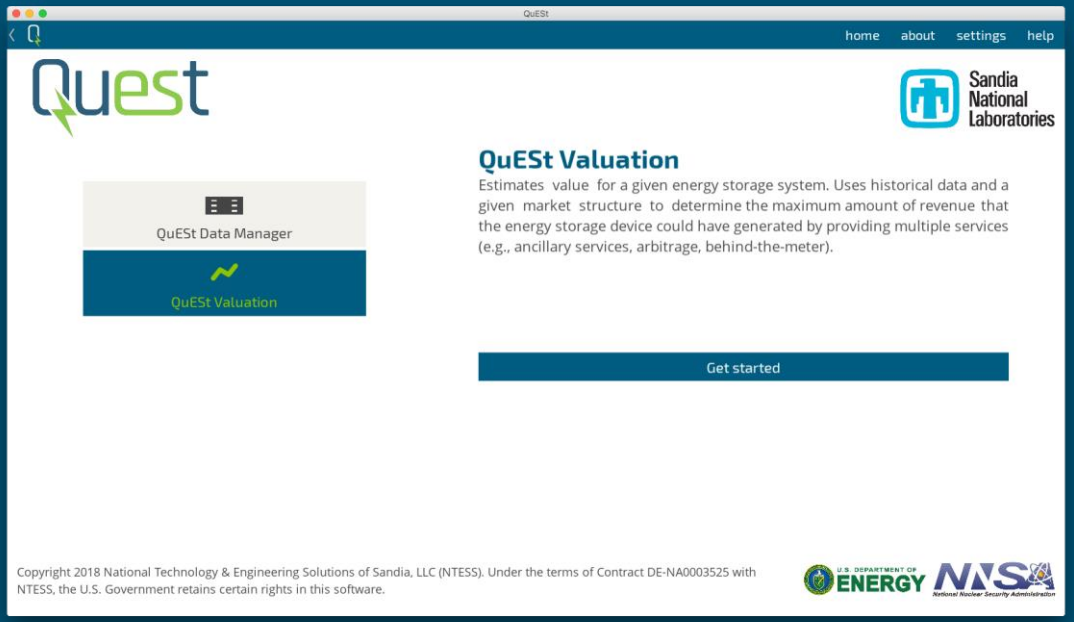
We do not own the historical data that we use, so we cannot distribute any.

- 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

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Follow us on GitHub:

github.com/rconcep/snl-quest