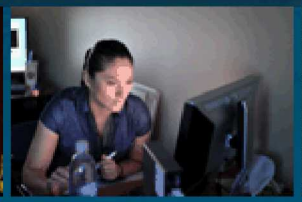
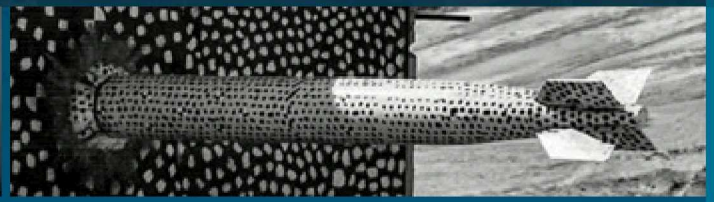
SAND2019-1464C

An Energy Storage Application Suite





PRESENTED BY

Ricky Concepcion

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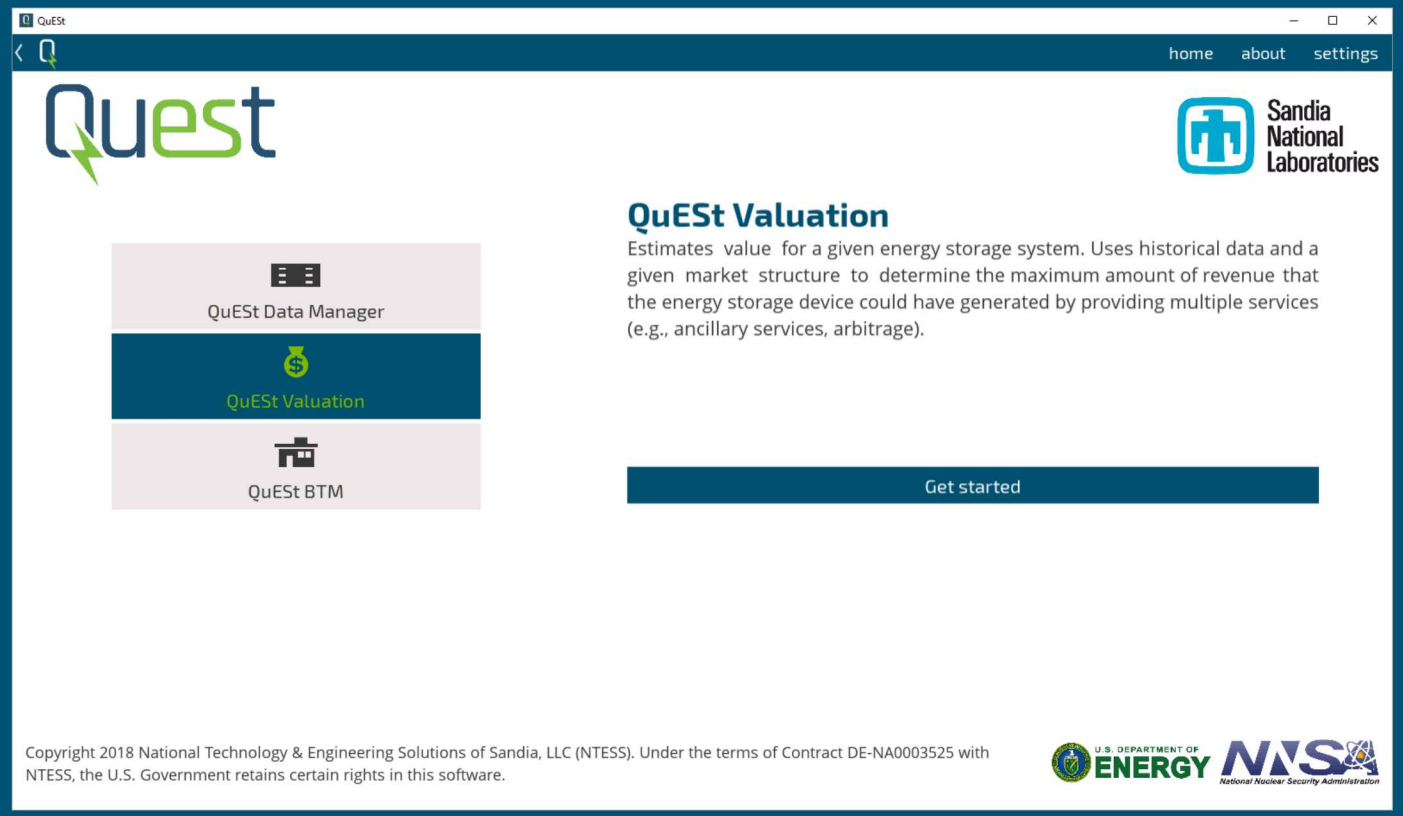
SAND2019-0438 PE

What is it?



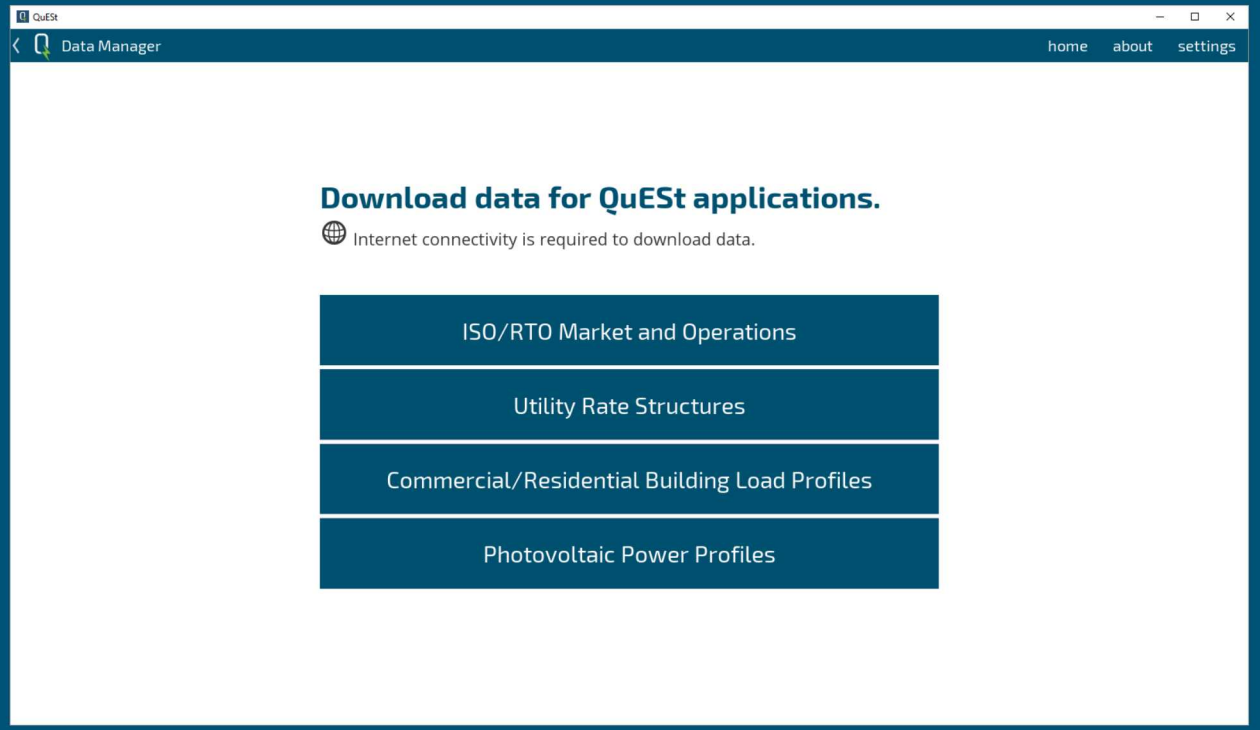
- Open source, Python-based energy storage analysis software application suite
- Developed as a graphical user interface (GUI) for the optimization modeling capabilities of Sandia's energy storage analytics group
- Version 1.0 publicly released in September 2018
- Version 1.1 available on GitHub; Version 1.2 coming soon
  - github.com/rconcep/snl-quest or sandia.gov/ess

Why QuESt?

- For energy storage project stakeholders
  - Accessible and easy-to-use software tool for energy storage valuation and related applications
- For engineers/developers
  - Open source software project
  - GUI design, application design, Pyomo optimization modeling
  - Pyomo models and other optimization code can be adjusted to fit specific needs
- It's free
  - Written in Python; no software licenses required
- Current application list
  - QuESt Data Manager – Manages acquisition of ISO market data, US utility rate data, commercial and residential load profiles, etc.
  - QuESt Valuation – Estimate potential revenue generated by energy storage systems providing multiple services in the electricity markets of ISOs/RTOs.
  - QuESt BTM* - Estimate the cost savings for time-of-use/net energy metering customers using behind-the-meter energy storage systems.

* For v1.2 release

QuESt Data Manager



We use publicly available APIs, posted market data, and crowd-sourced data.

- LMPs, frequency regulation performance/capacity clearing prices, etc. posted by ISOs/RTOs
- U.S. utility rate structures sourced and validated by OpenEI.org
- Commercial and residential hourly load profiles for all TMY3 (typical meteorological year) locations in the U.S. by OpenEI.org
- Hourly photovoltaic power profiles by PVWatts

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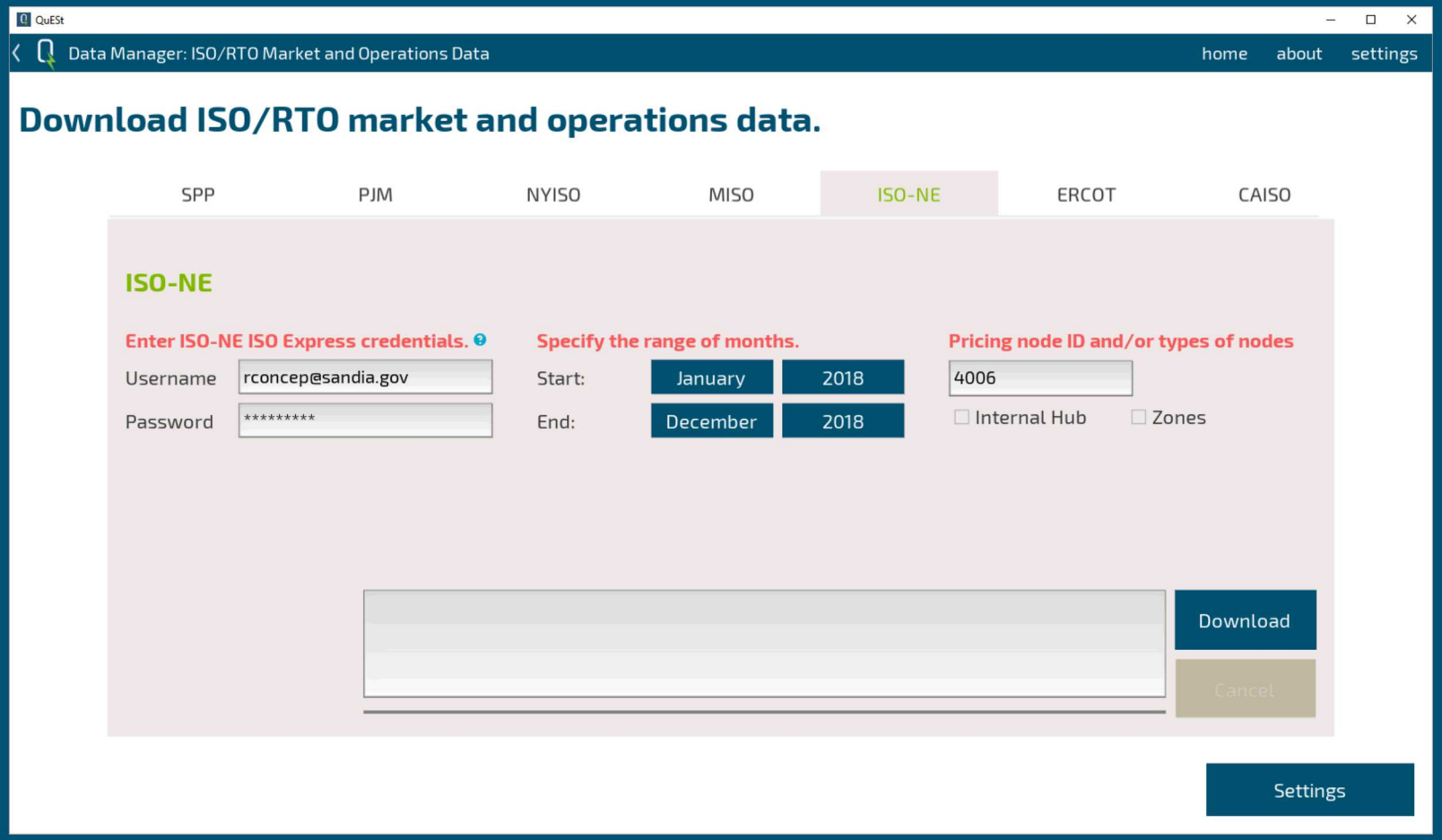

- LMPs, frequency regulation performance/capacity clearing prices, etc. posted by ISOs/RTOs
- Use operator-provided APIs, some requiring a short registration for an API key
  - ISONE, PJM
- Use web crawling libraries like BeautifulSoup to parse marketplace data portals to find data files

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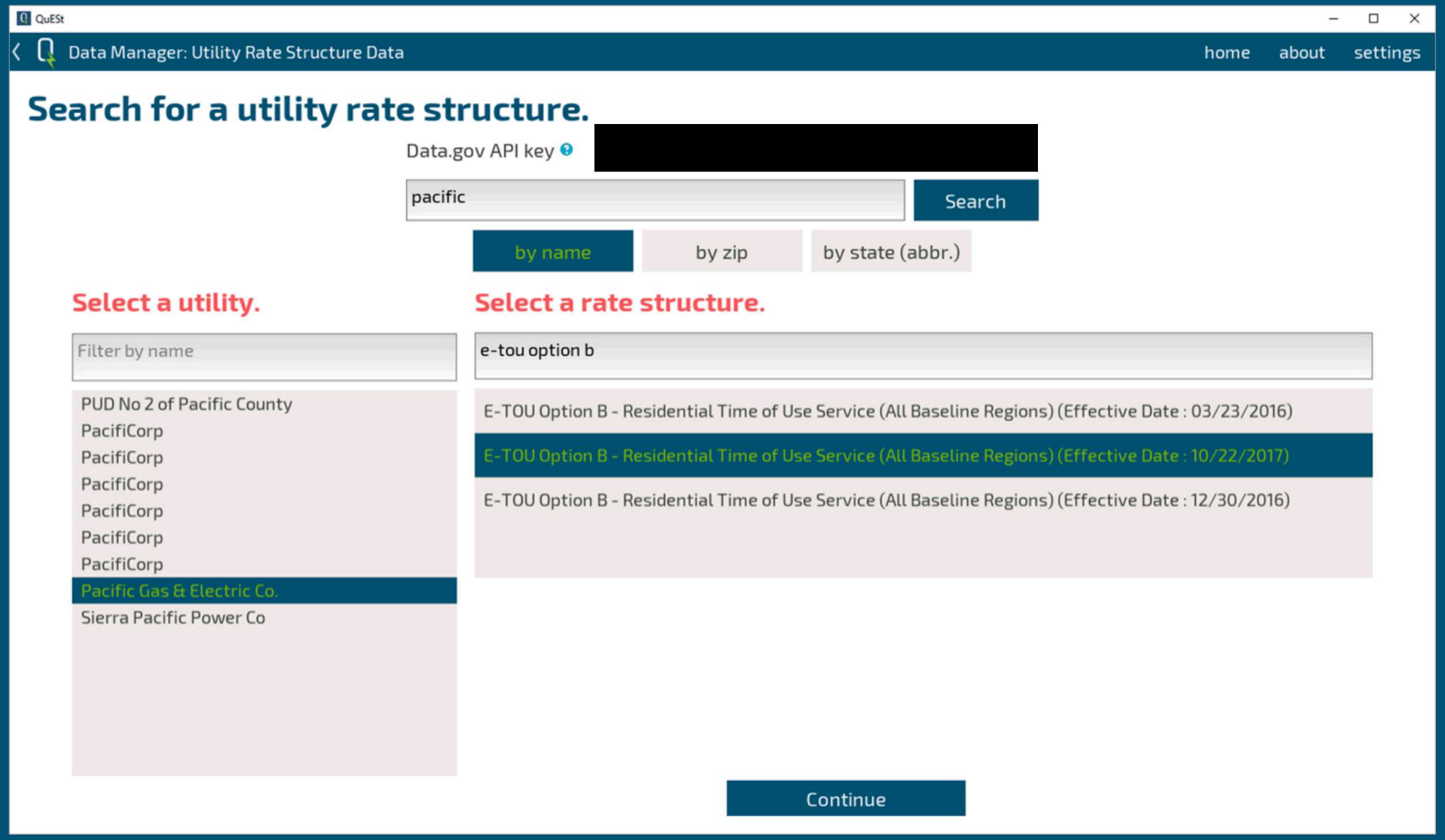

- OpenEI.org, maintained by NREL, hosts a database for U.S. utility rates
- Time-of-use energy rate schedules
- Peak demand and flat demand rate schedules

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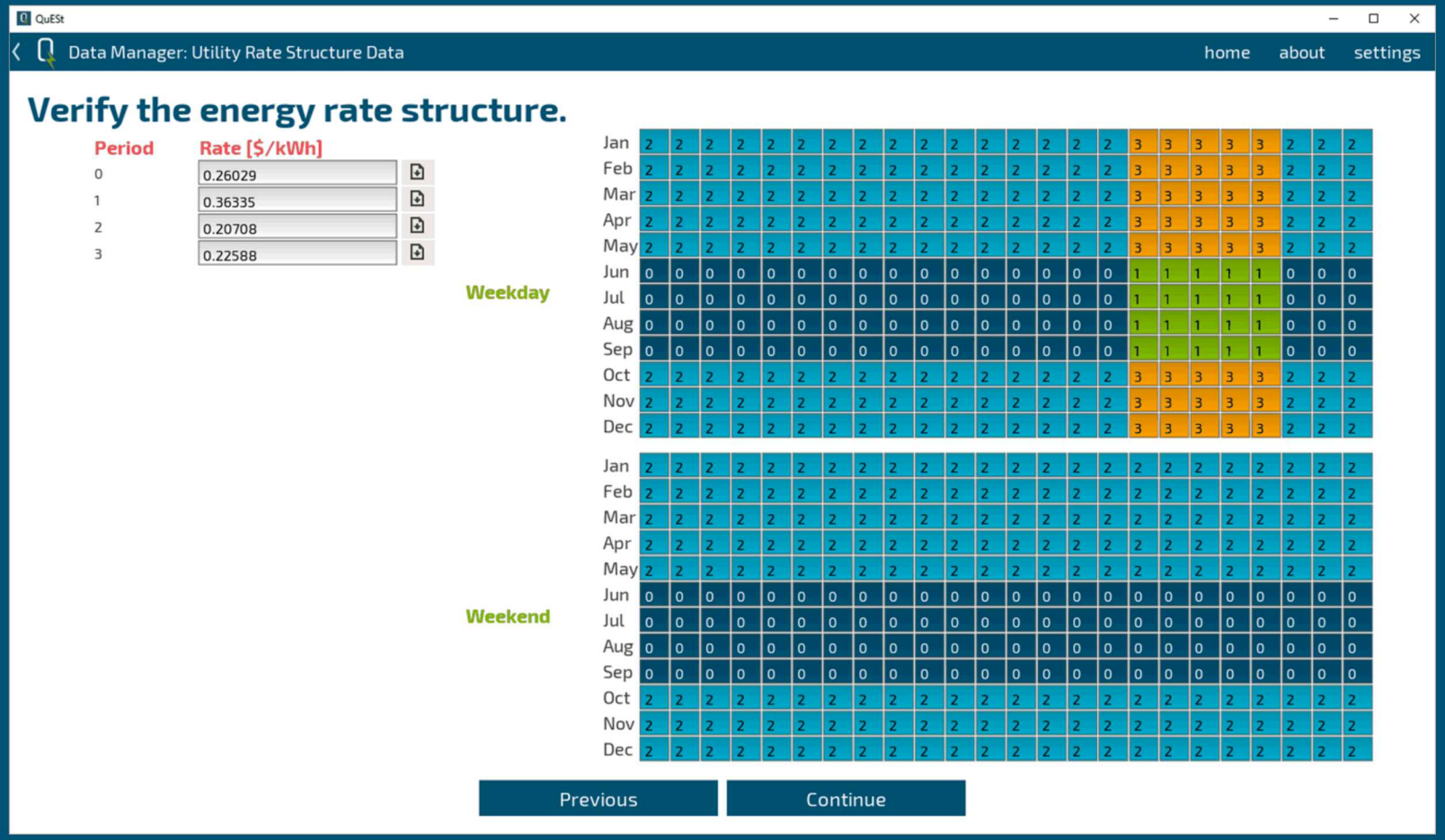

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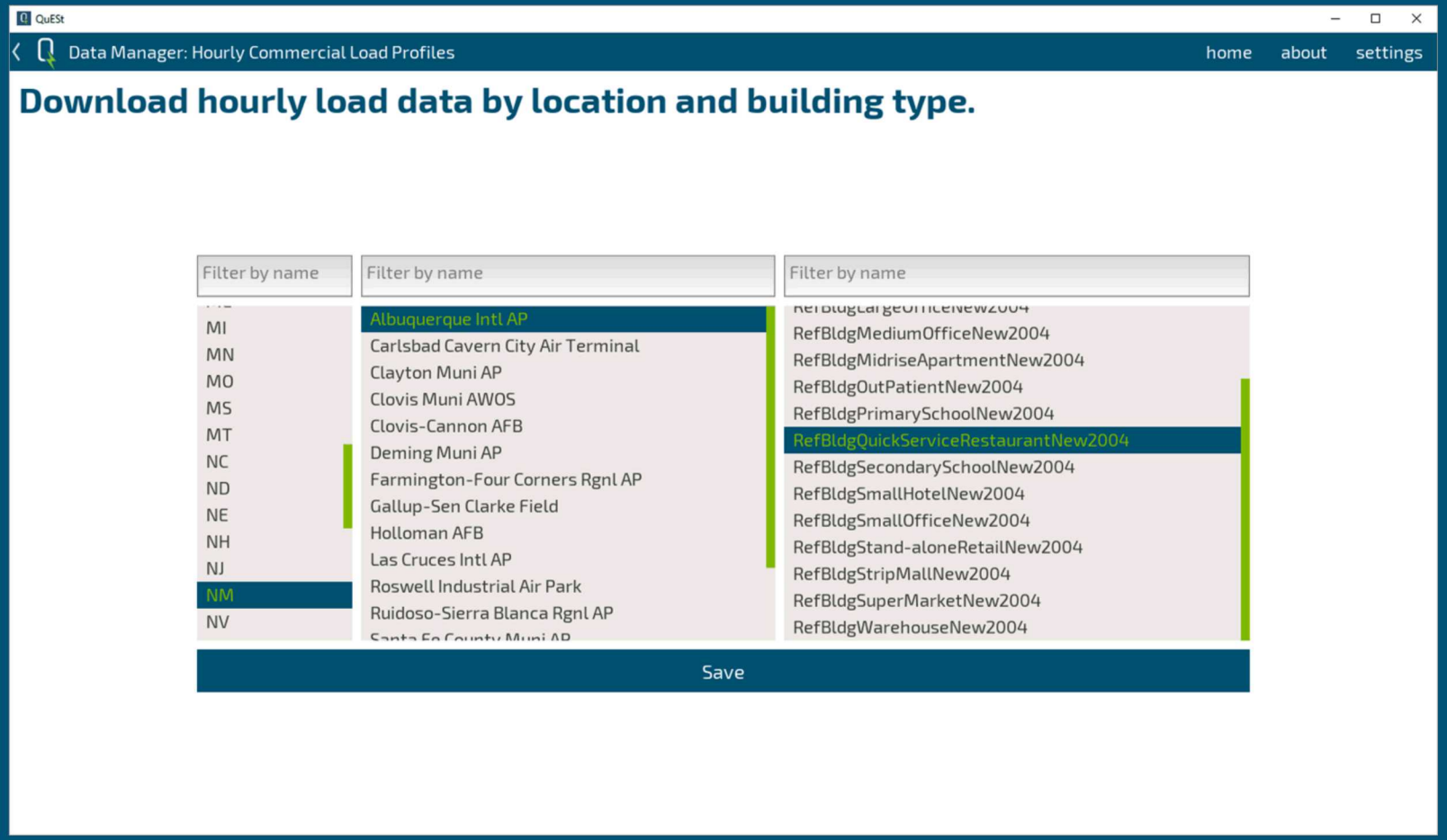

- OpenEI.org also hosts simulated hourly load profiles for TMY3 (typical meteorological year)
  - Residential (base, low, high)
  - Commercial (16 reference building types by DOE)

https://openei.org/datasets/dataset/commercial-and-residential-hourly-load-profiles-for-all-tmy3-locations-in-the-united-states

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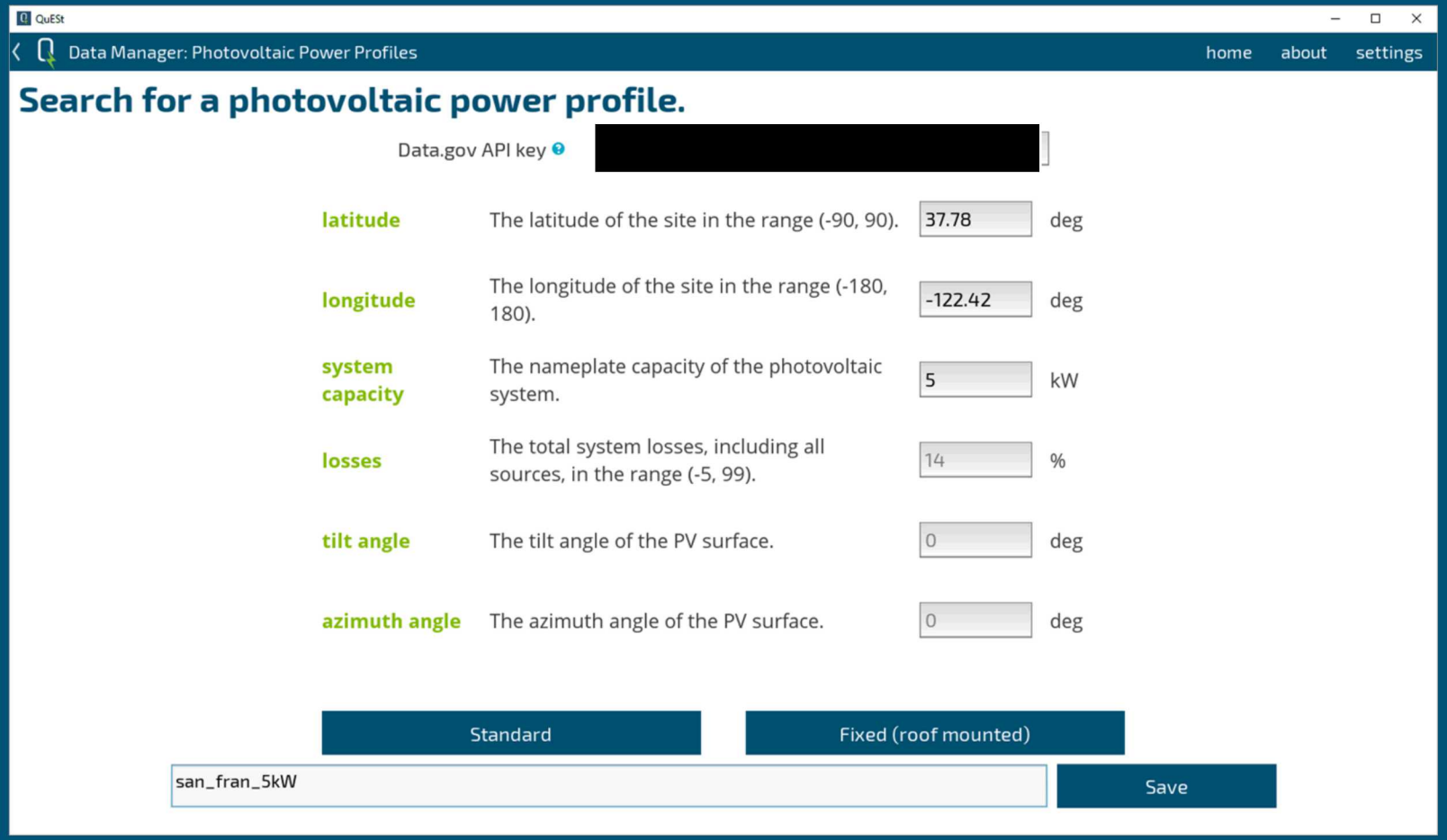


- PVWatts by NREL
  - Uses data from the National Solar Radiation Database and a solar panel system model to simulate hourly power output

https://pvwatts.nrel.gov/version_6.php

QuESt 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?

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

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

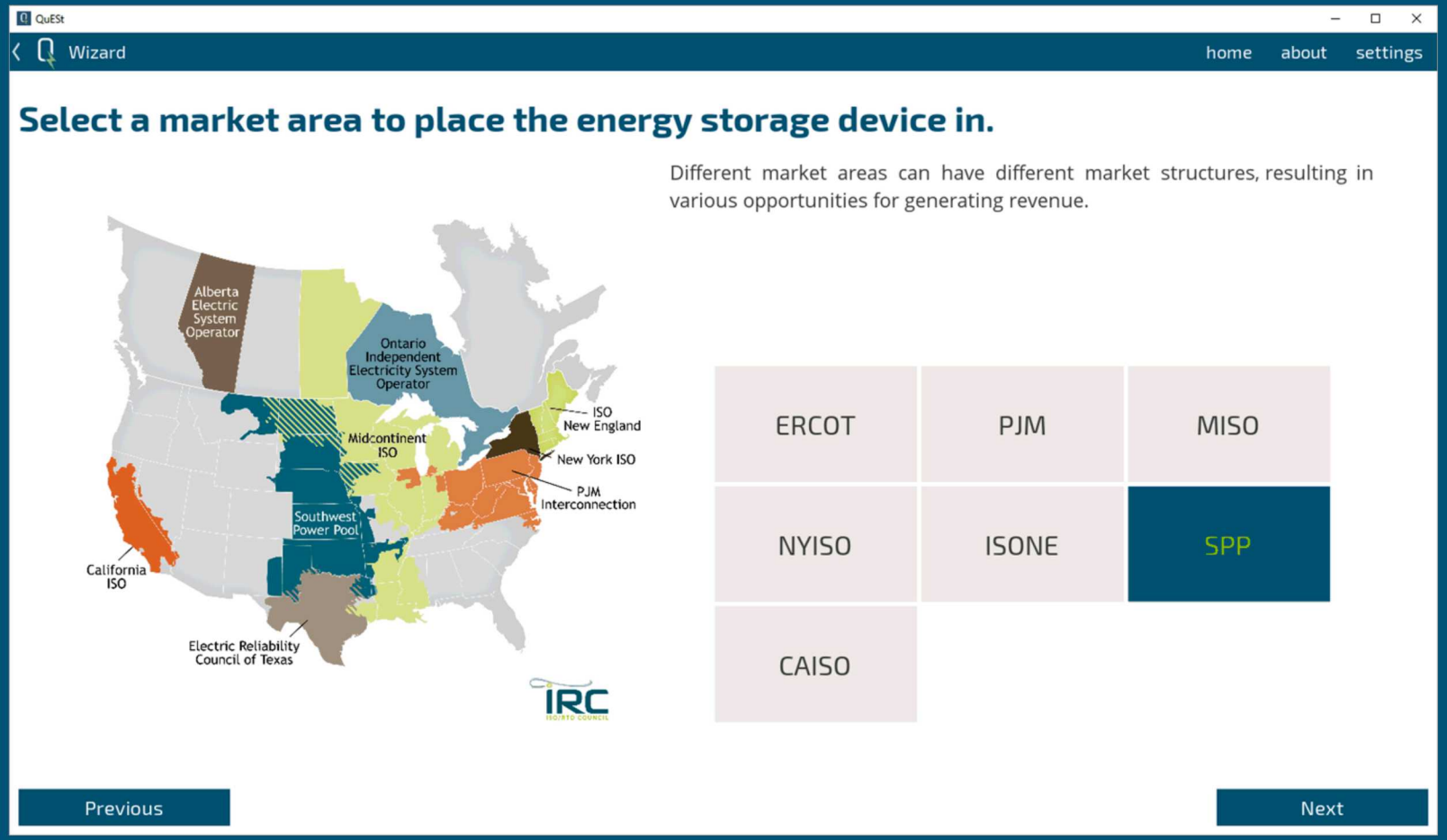
$0 \le s_i \le \bar{S}$ state of charge limits

$q_i^d + q_i^r + q_i^{ru} + q_i^{rd} \le \bar{Q}$ 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.

Byrne, Raymond H., et al. "Energy management and optimization methods for grid energy storage systems." *IEEE Access* 6 (2018): 13231-13260.

QuESt Valuation



- Market area
- Revenue streams
- Historical dataset to study
- Energy storage model parameters

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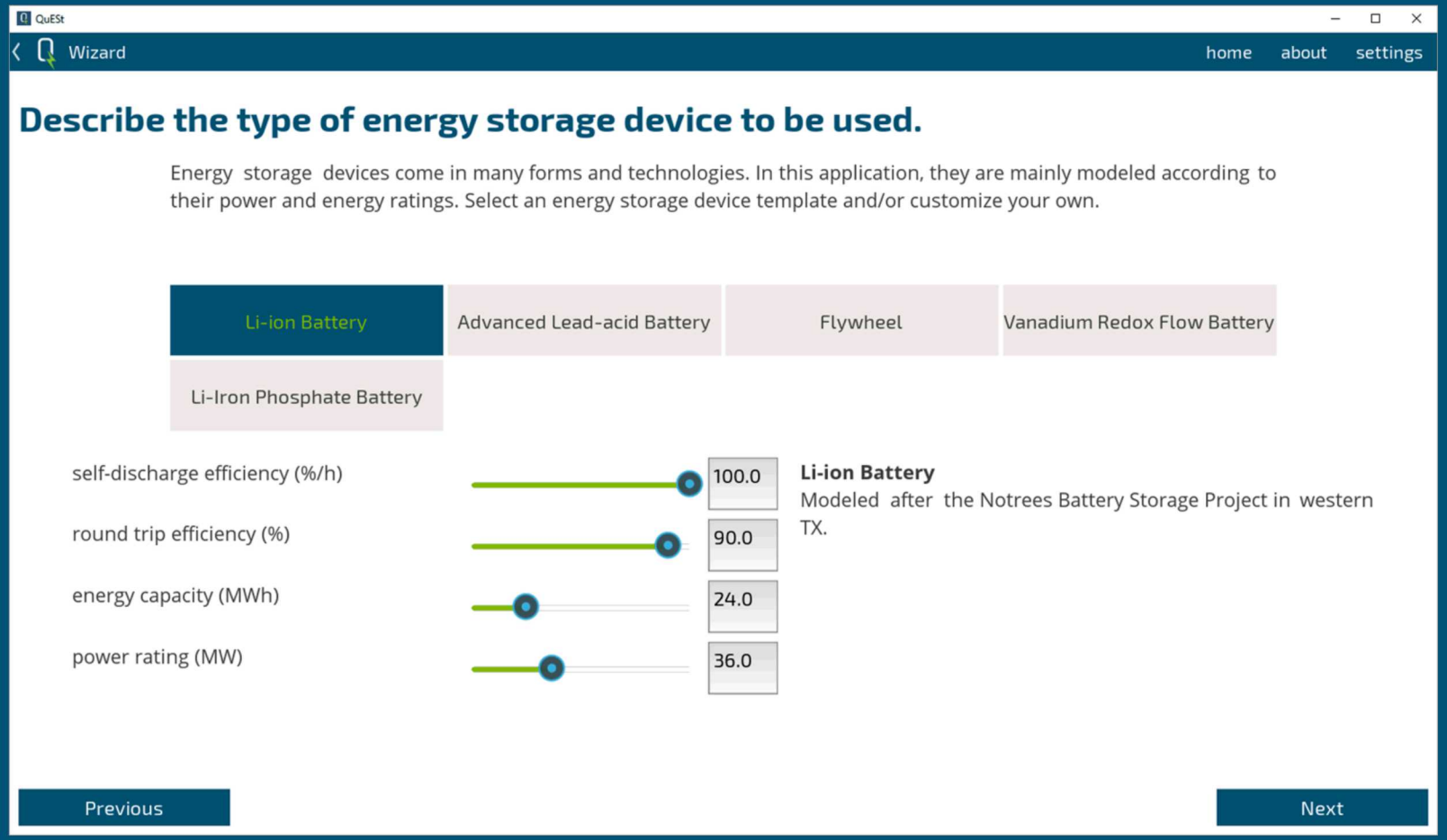

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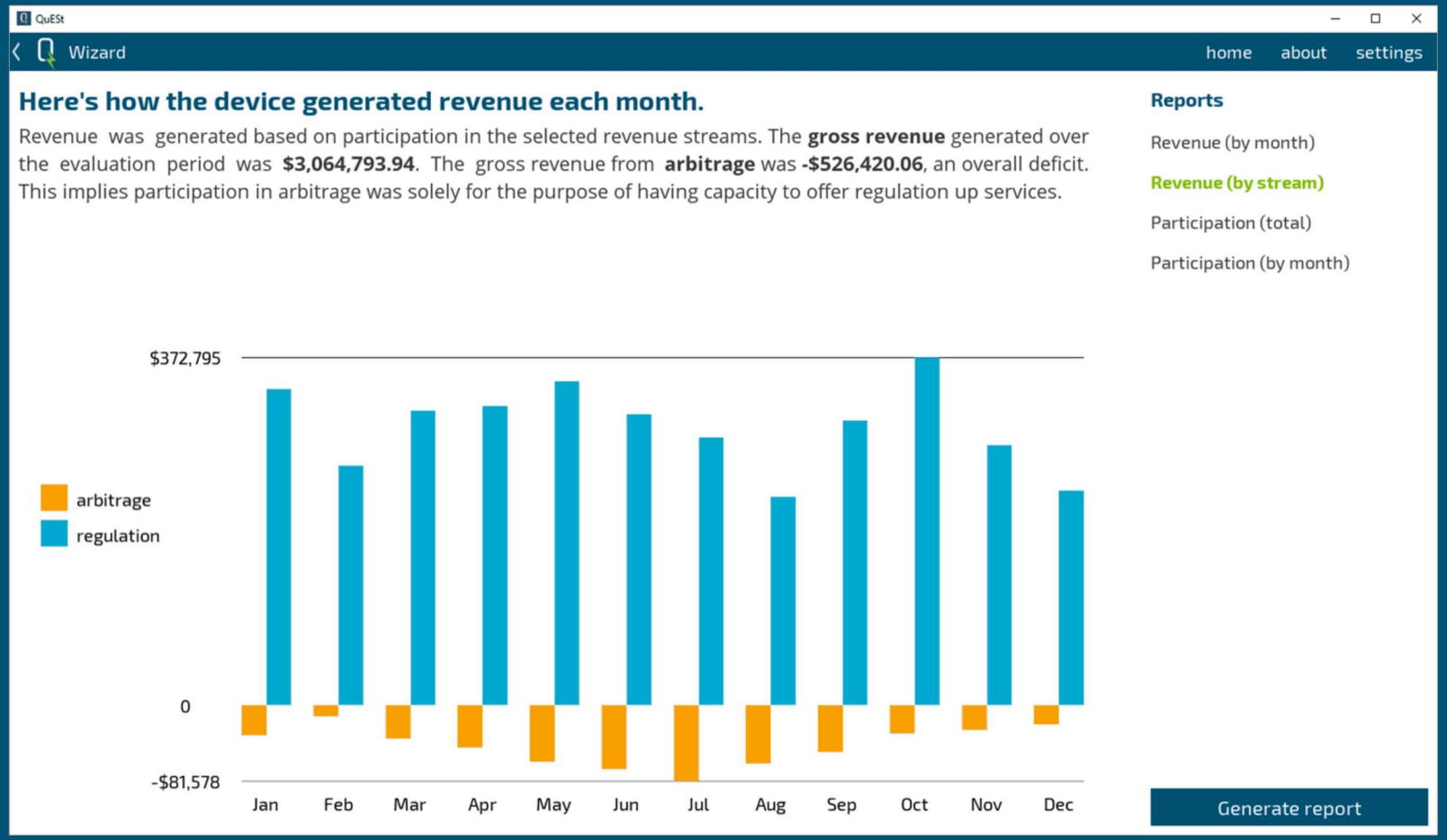


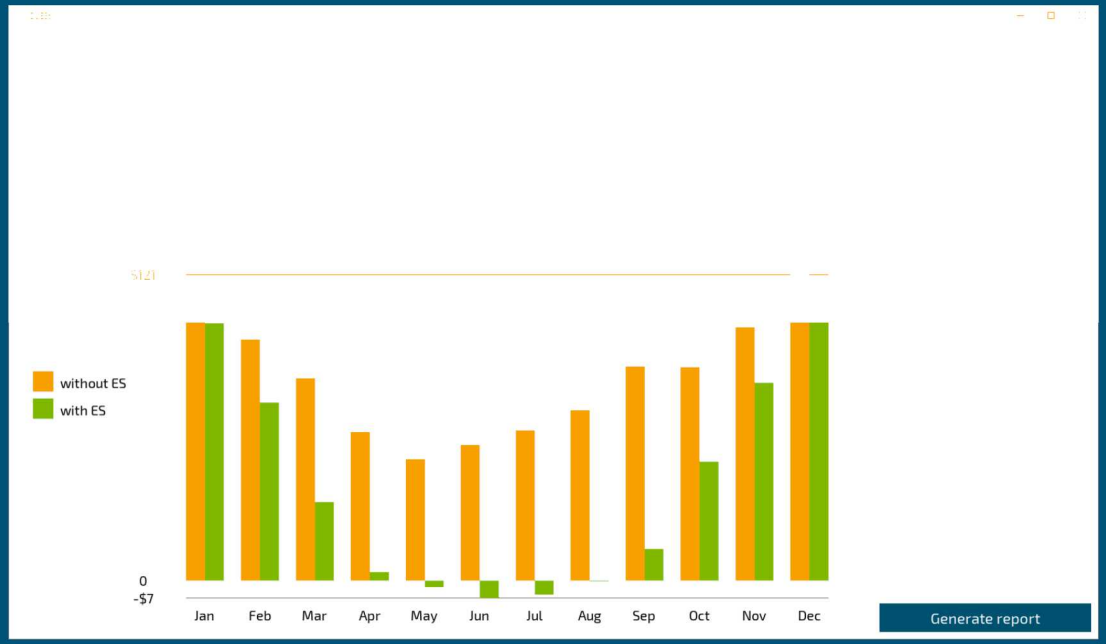
- Revenue by month
- Revenue by revenue stream
- Frequency of participation in each available revenue stream

QuESt BTM*

A collection of applications for behind-the-meter energy storage. The first application will be estimating cost savings for time-of-use and net energy metering customers.

- Incorporate specific utility rate structures (energy TOU schedule and rates, etc.)
- Use location-specific simulated load and photovoltaic power data

Nguyen, T., and R. Byrne. "Maximizing the cost-savings for time-of-use and net-metering customers using behind-the-meter energy storage systems." *Proceedings of the 2017 North American Power Symposium (NAPS)*. 2017.



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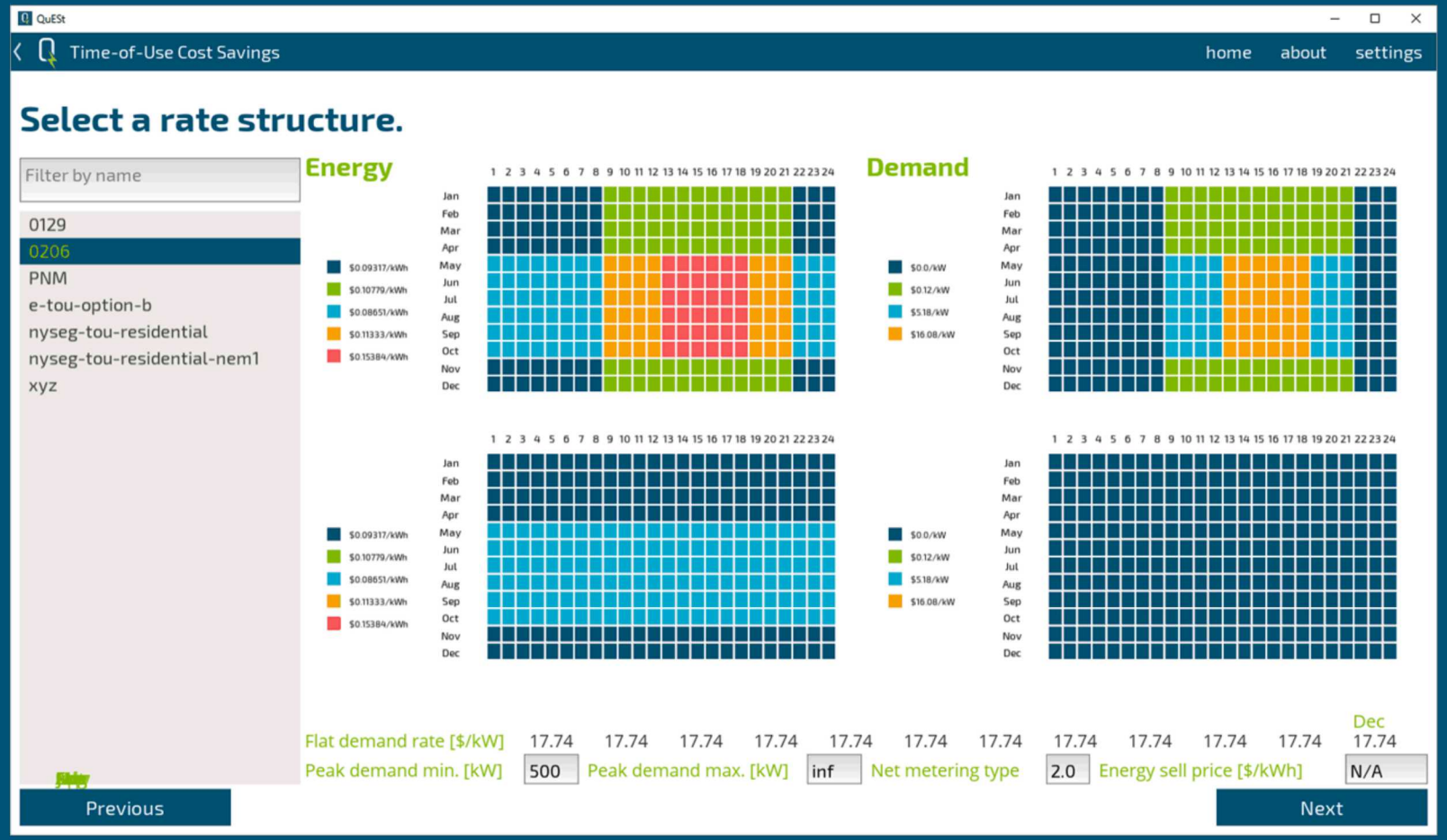

- Utility rate structure for time-of-use energy rate schedules, demand rate schedules, net metering, etc.
- Load profile based on building type
- PV profile if solar + storage configuration
- Energy storage system parameters

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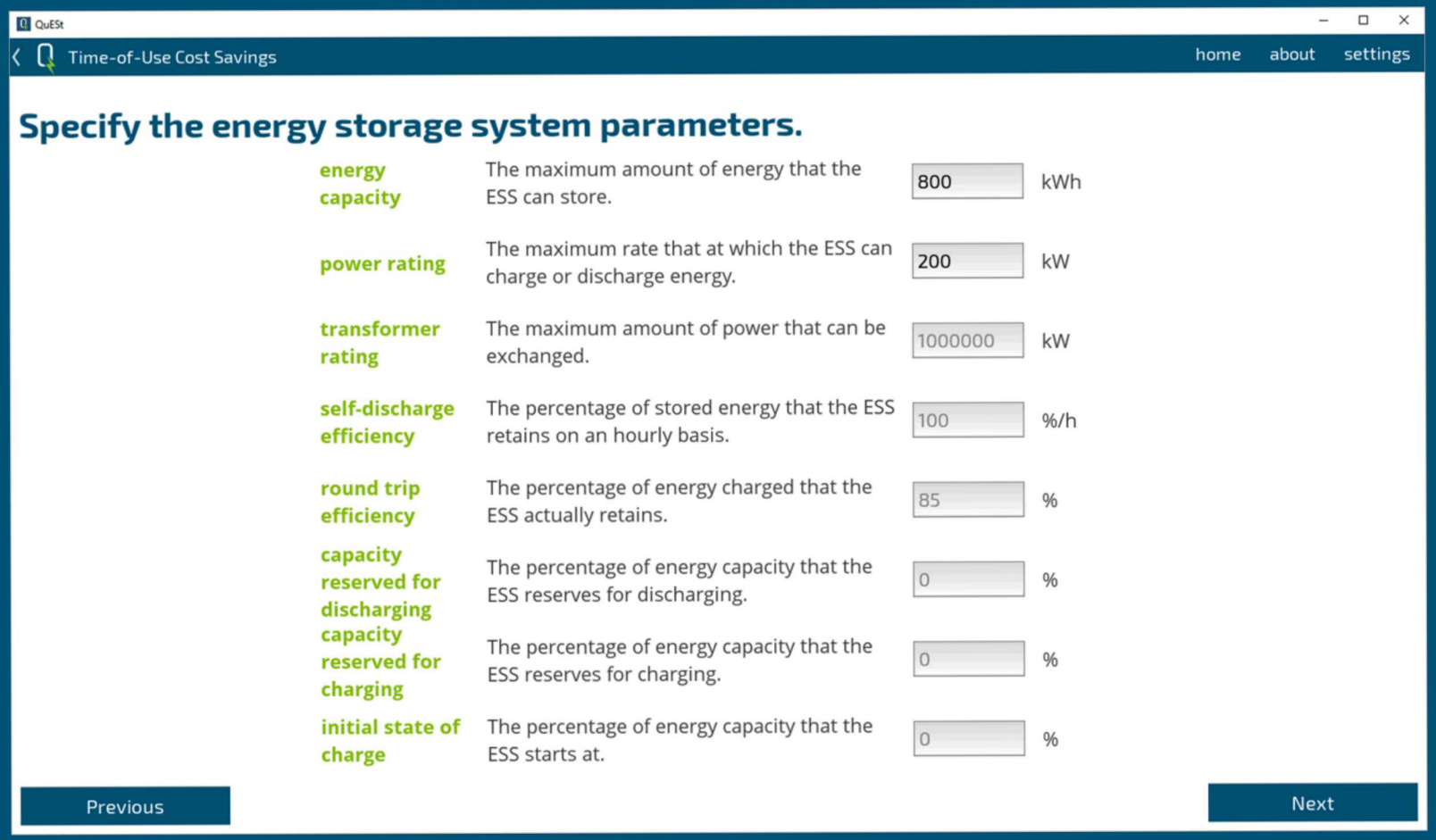

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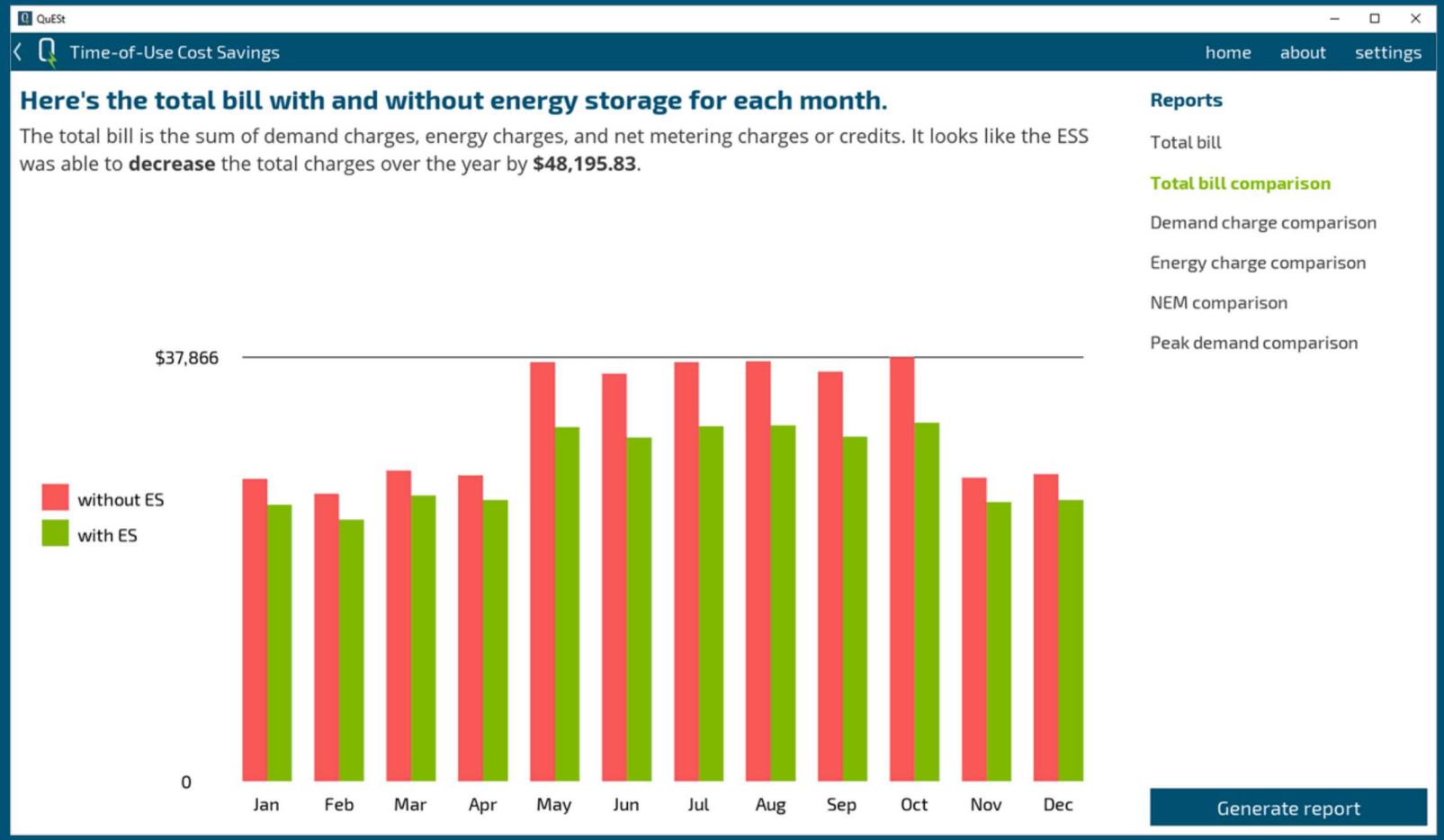

- Compare monthly bill with and without energy storage
- Peak demand reduction to decrease demand charges
- Time-shifting to reduce time-of-use energy charges
- Net metering credits

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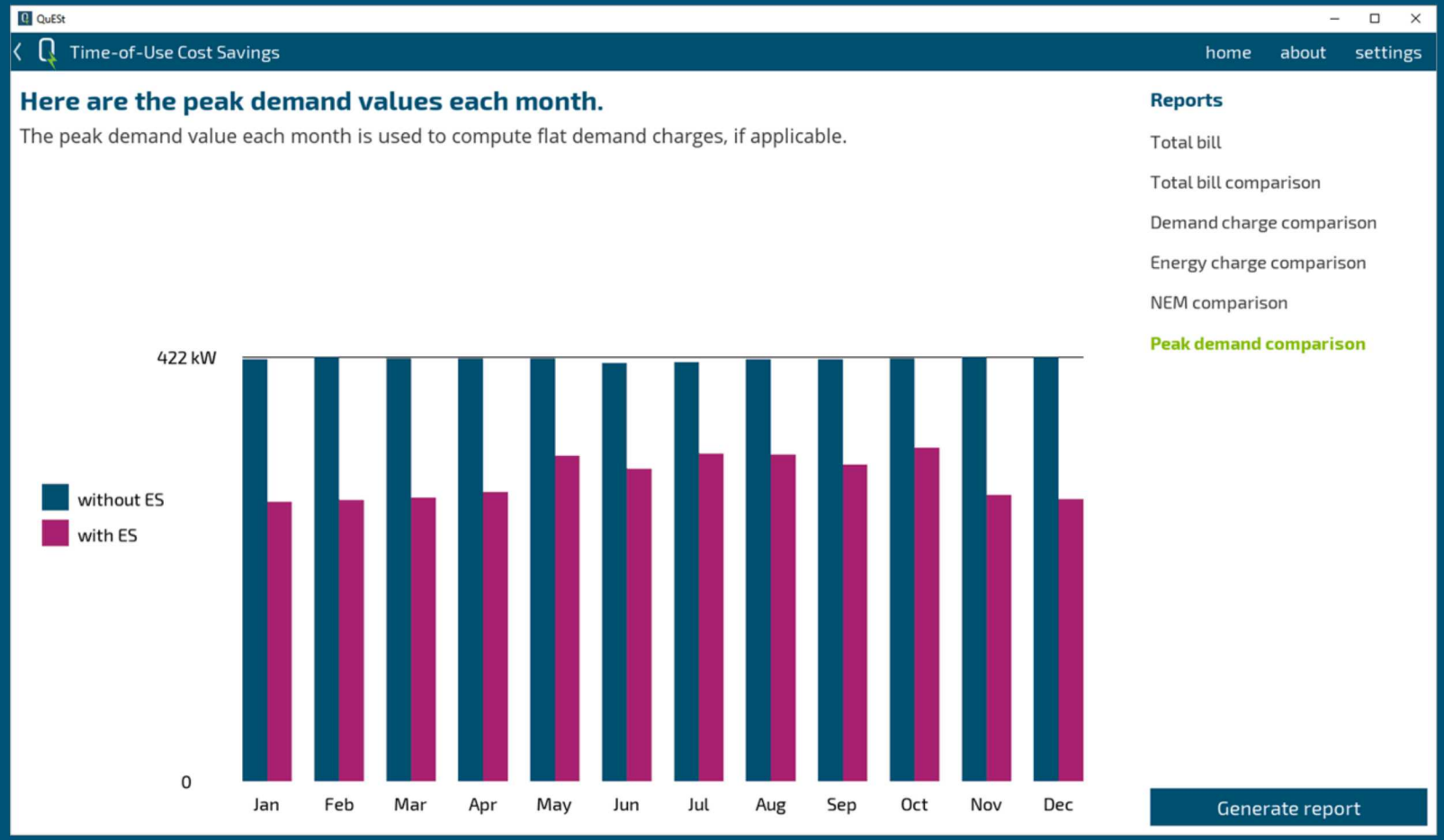

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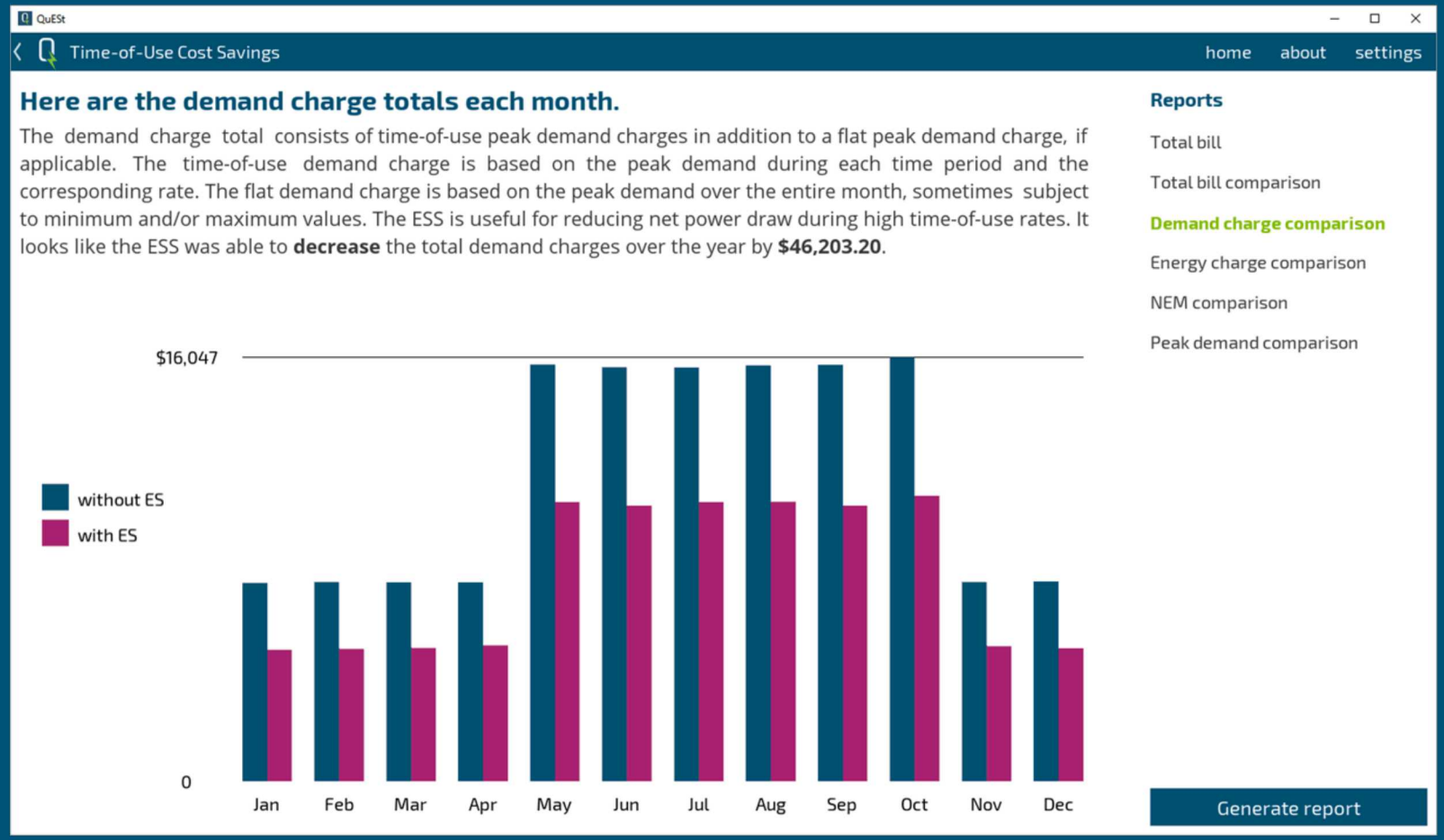

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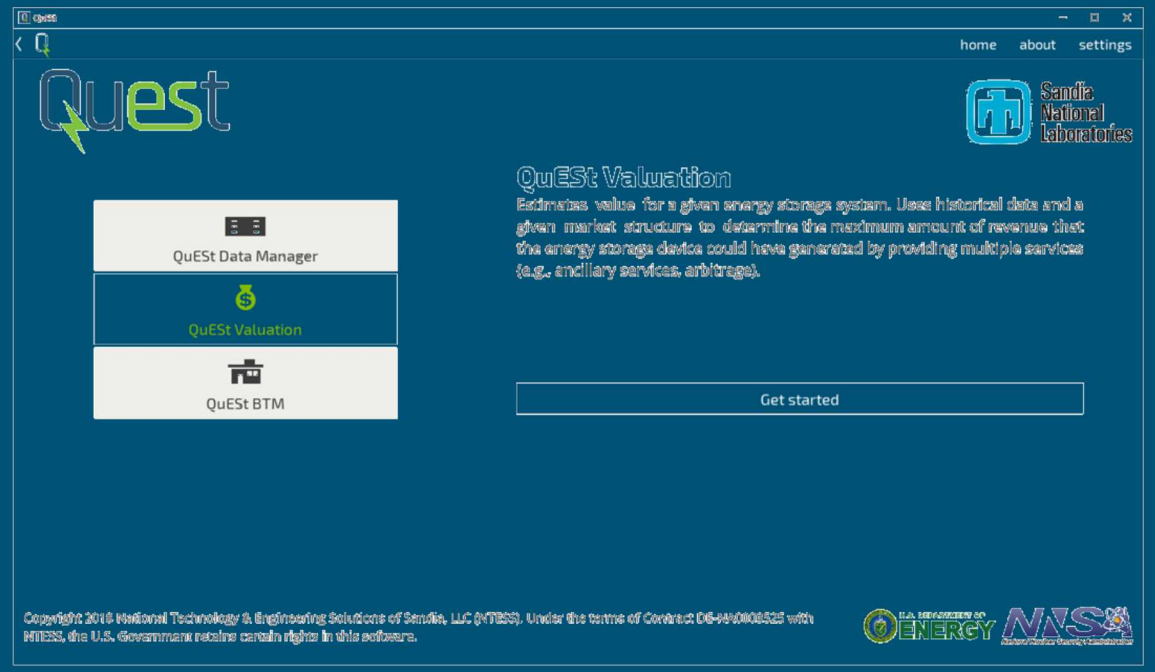
The Future

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

- Consider more complex valuation models, such as modeling degradation
- New applications
  - Technology selection assistant
  - Explorer for energy storage project cost data
  - Optimal sizing of energy storage for solar + storage
  - ?



Acknowledgements

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Follow us on GitHub:

github.com/rconcep/snl-quest