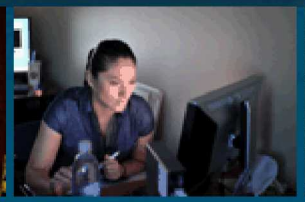
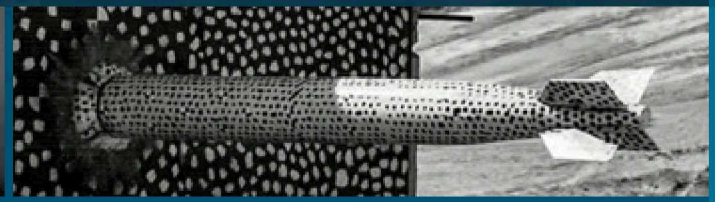
SAND2020-0557PE

An Energy Storage Application Suite





PRESENTED BY

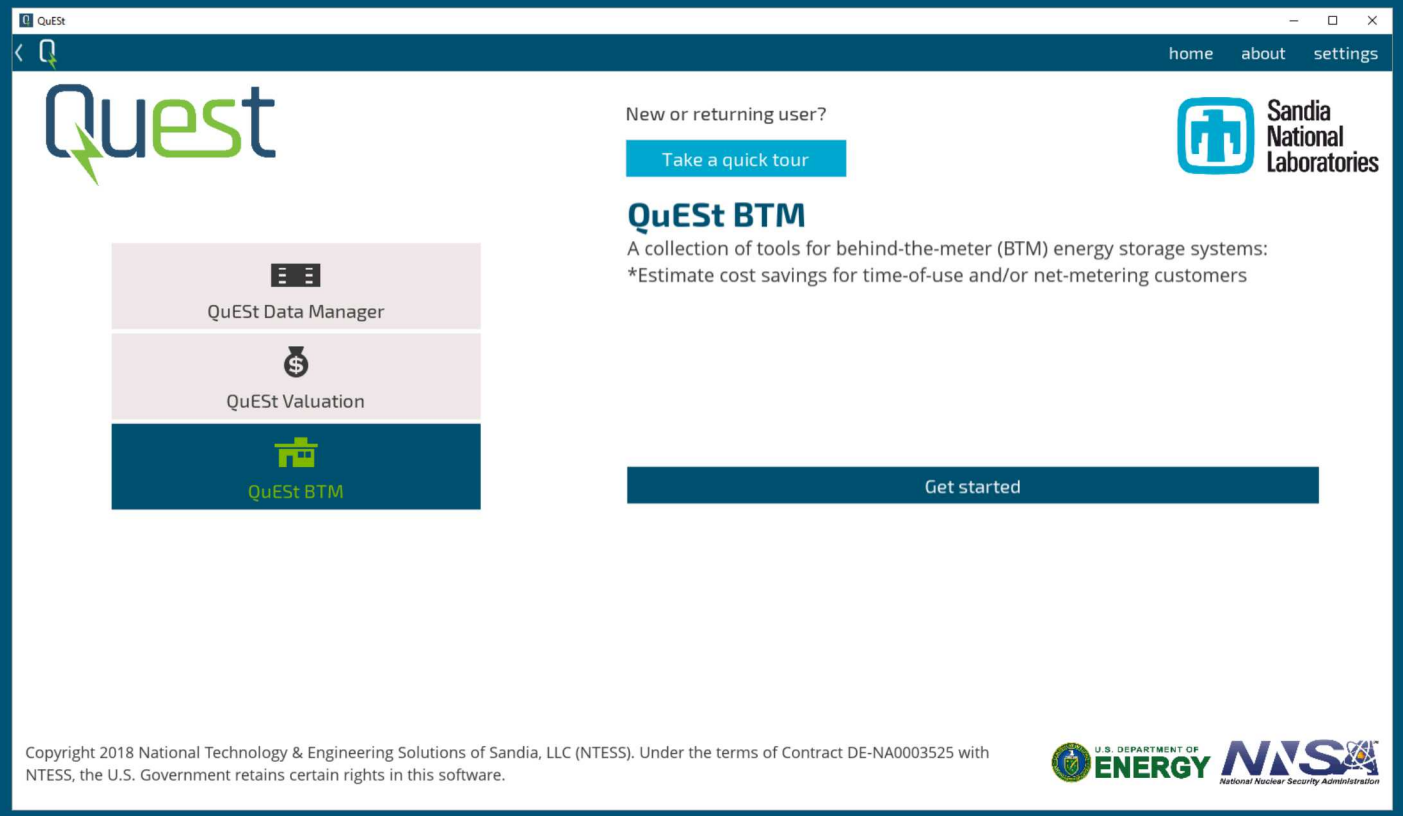
Ricky Concepcion

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

OUTLINE

- QuESt overview
- QuESt applications
  - QuESt Valuation
  - QuESt Data Manager
  - QuESt BTM
- Case study with QuESt
- Wrap-up and conclusions

OVERVIEW



- Energy storage analysis/valuation 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 1.2 available on GitHub
  - github.com/rconcep/snl-quest or sandia.gov/ess (tools)

WHY QUEST?

- For energy storage project stakeholders
  - Accessible and easy-to-use software for energy storage valuation
  - Diverse set of capabilities
- For engineers and software developers
  - Open source software project
  - GUI and application design; Pyomo optimization modeling
- It's free
  - Released under an open source distribution license
- 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.

USING QUEST

Application/GUI

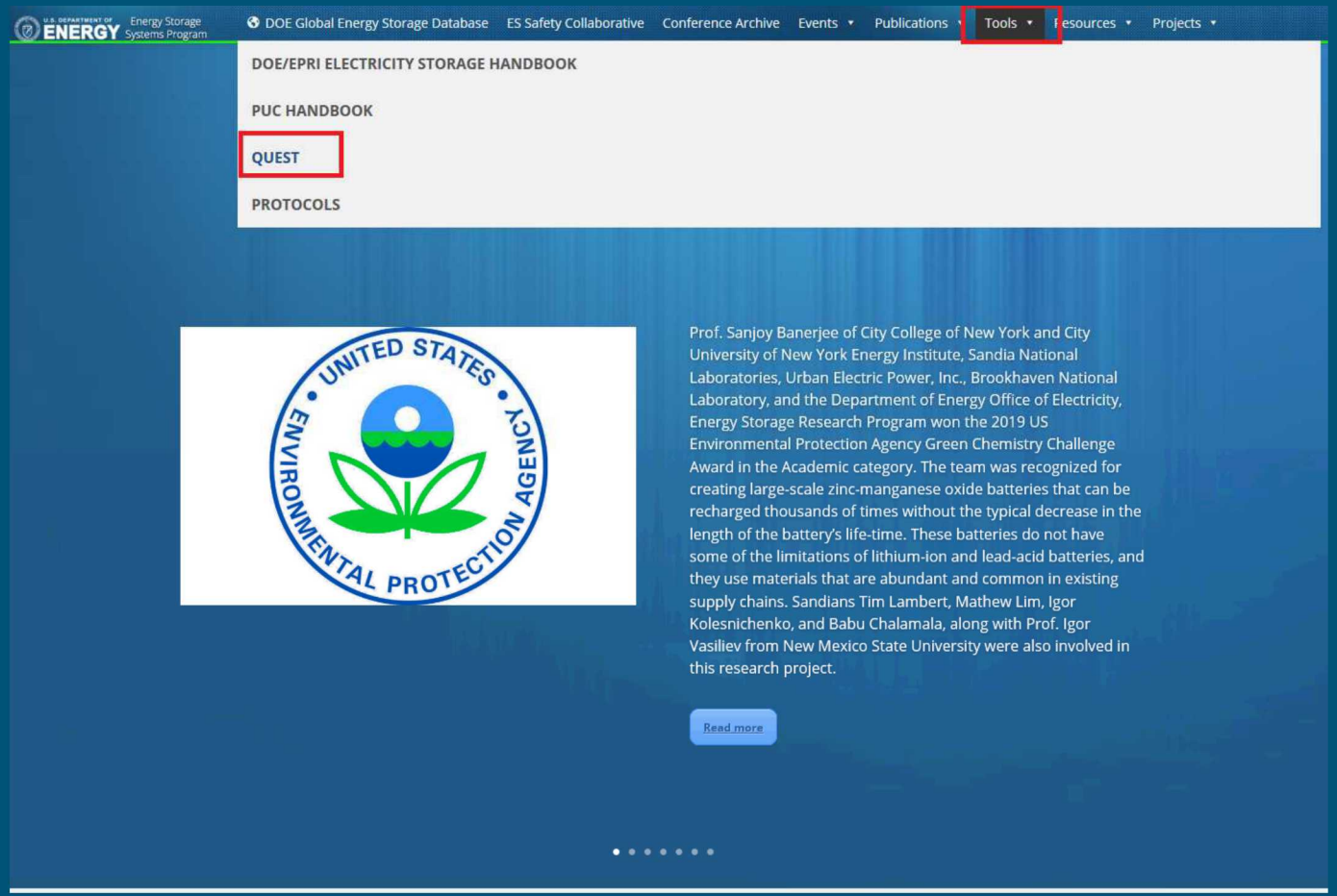
- For most users
- Developed for user experience
- No hassle installation

API/Library
(coming soon)

- For power users
- Use for Python scripting
- More capabilities

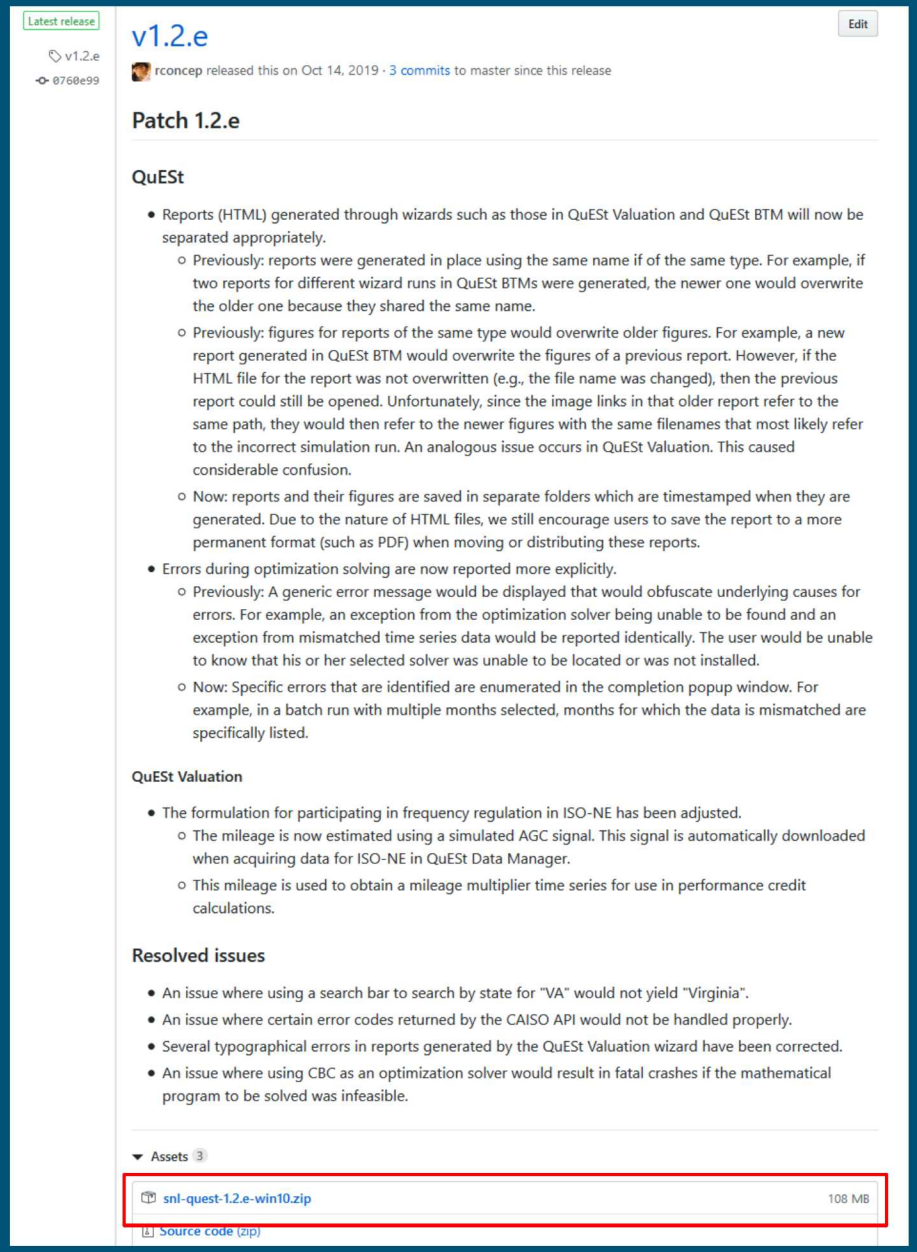
HOW TO OBTAIN QUEST

- Check the ”tools” section of the Sandia ESS website
  - https://www.sandia.gov/ess-ssl/tools/quest/
- The code is hosted on GitHub
  - github.com/rconcep/snl-quest
- General requirements:
  - Windows/OS X/Linux
  - Solver for optimization



HOW TO OBTAIN QUEST

- For Windows 10: we have an executable version of QuESt
  - Fully pre-configured, just run the .exe
  - Still requires an optimization solver
  - Under GitHub releases for each version
- We have portable preview versions of the upcoming Windows 10 release available



Latest release

v1.2.e

0760e99

Edit

v1.2.e

rconcep released this on Oct 14, 2019 · 3 commits to master since this release

Patch 1.2.e

QuESt

- Reports (HTML) generated through wizards such as those in QuESt Valuation and QuESt BTM will now be separated appropriately.
  - Previously: reports were generated in place using the same name if of the same type. For example, if two reports for different wizard runs in QuESt BTMs were generated, the newer one would overwrite the older one because they shared the same name.
  - Previously: figures for reports of the same type would overwrite older figures. For example, a new report generated in QuESt BTM would overwrite the figures of a previous report. However, if the HTML file for the report was not overwritten (e.g., the file name was changed), then the previous report could still be opened. Unfortunately, since the image links in that older report refer to the same path, they would then refer to the newer figures with the same filenames that most likely refer to the incorrect simulation run. An analogous issue occurs in QuESt Valuation. This caused considerable confusion.
  - Now: reports and their figures are saved in separate folders which are timestamped when they are generated. Due to the nature of HTML files, we still encourage users to save the report to a more permanent format (such as PDF) when moving or distributing these reports.
- Errors during optimization solving are now reported more explicitly.
  - Previously: A generic error message would be displayed that would obfuscate underlying causes for errors. For example, an exception from the optimization solver being unable to be found and an exception from mismatched time series data would be reported identically. The user would be unable to know that his or her selected solver was unable to be located or was not installed.
  - Now: Specific errors that are identified are enumerated in the completion popup window. For example, in a batch run with multiple months selected, months for which the data is mismatched are specifically listed.

QuESt Valuation

- The formulation for participating in frequency regulation in ISO-NE has been adjusted.
  - The mileage is now estimated using a simulated AGC signal. This signal is automatically downloaded when acquiring data for ISO-NE in QuESt Data Manager.
  - This mileage is used to obtain a mileage multiplier time series for use in performance credit calculations.

Resolved issues

- An issue where using a search bar to search by state for "VA" would not yield "Virginia".
- An issue where certain error codes returned by the CAISO API would not be handled properly.
- Several typographical errors in reports generated by the QuESt Valuation wizard have been corrected.
- An issue where using CBC as an optimization solver would result in fatal crashes if the mathematical program to be solved was infeasible.

Assets 3

snl-quest-1.2.e-win10.zip 108 MB

Source code (zip)

QUEST APPLICATIONS OVERVIEW

GENERAL WORKFLOW

Decide what type of analysis to do.

- ISO/RTO value stacking => QuESt Valuation
- Behind-the-meter applications => QuESt BTM

Grab the appropriate data from QuESt Data Manager.

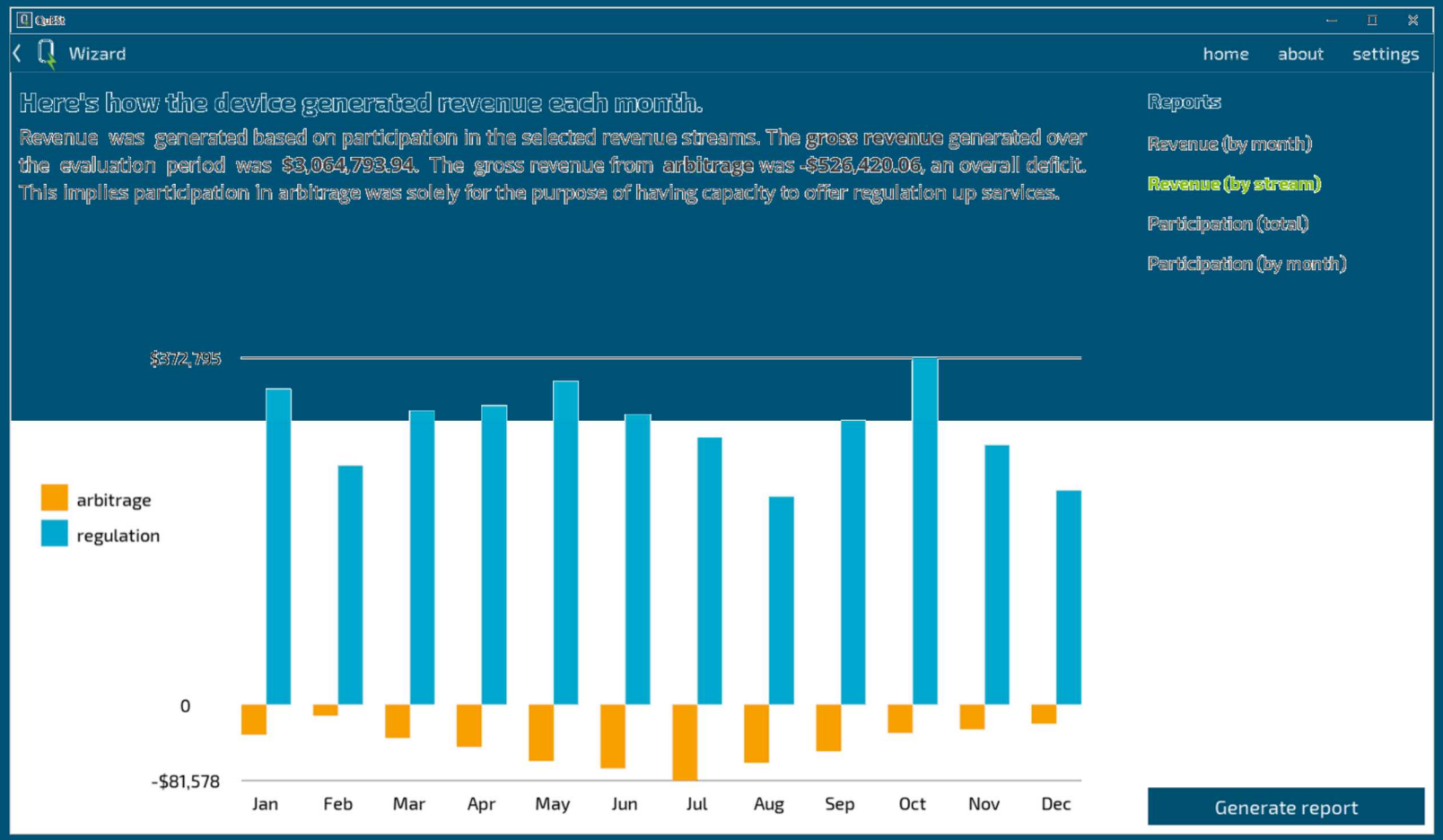
- ISO/RTO market data
- Utility rate structure
- PV profile
- Load profile

Select the appropriate application from the first step.

- Set up the analysis and run it
- View and process results

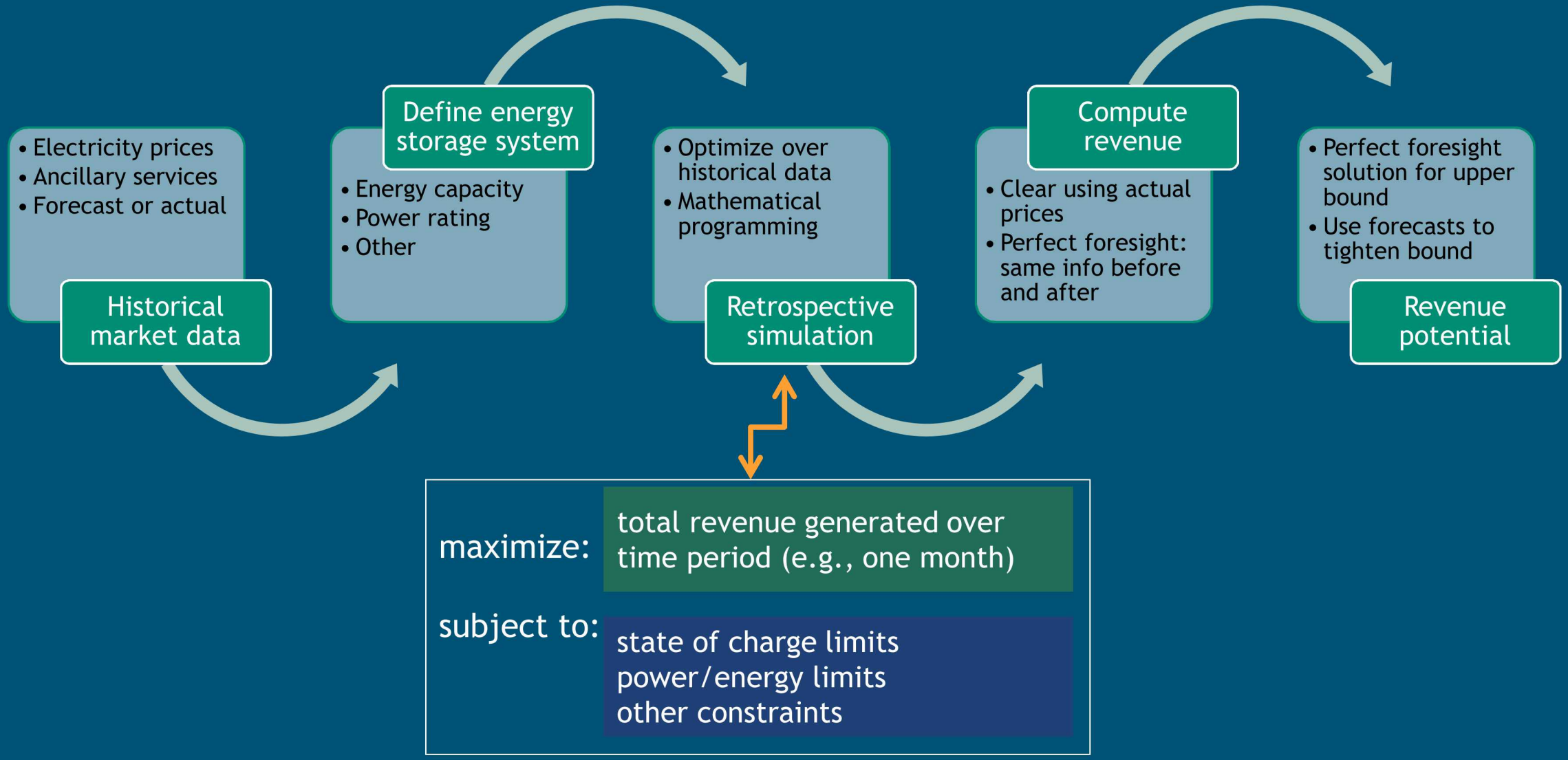
QUEST VALUATION

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?



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

QUEST VALUATION



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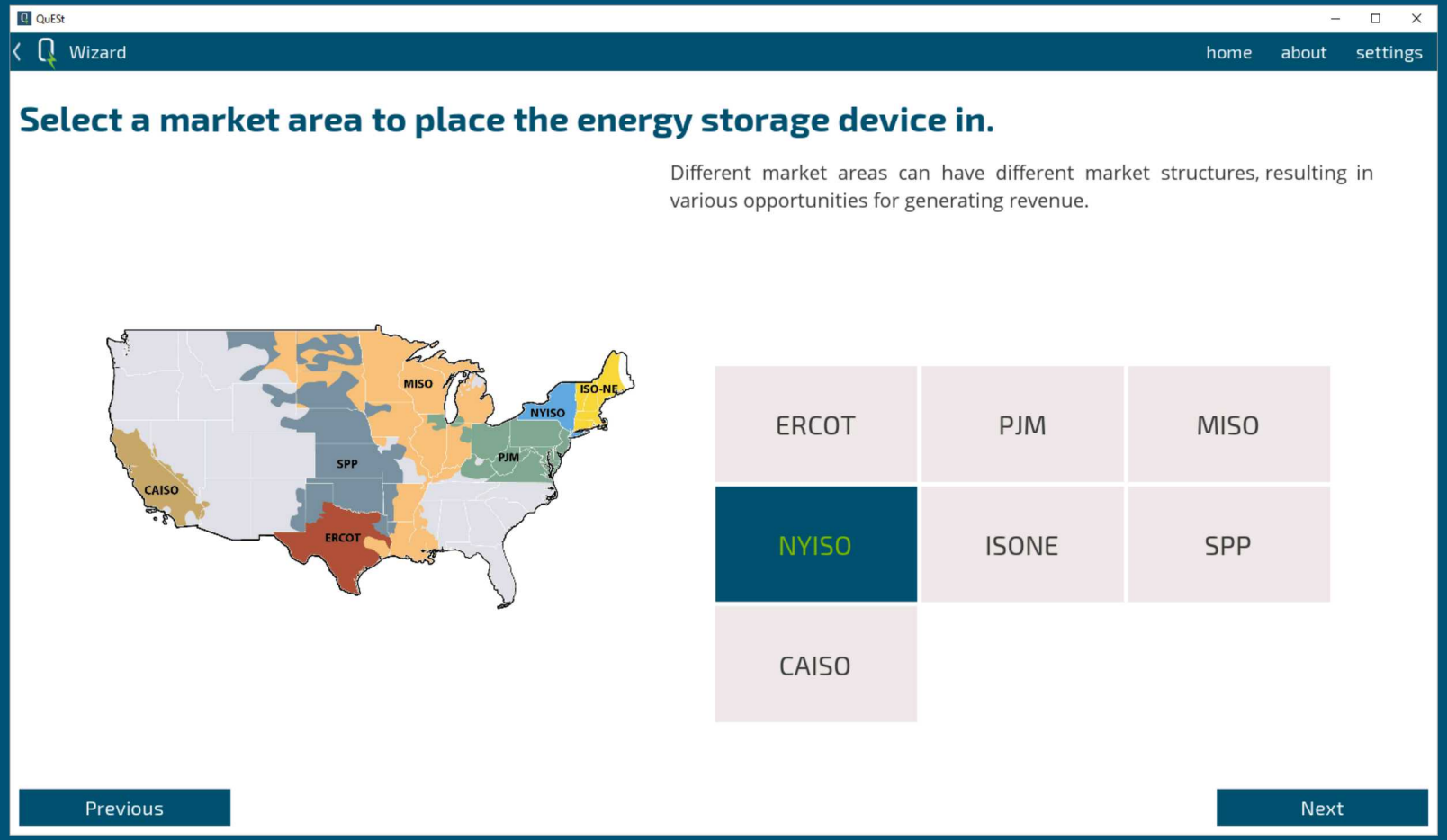

- Market area
- Revenue streams
- Historical dataset to study
- Energy storage model parameters

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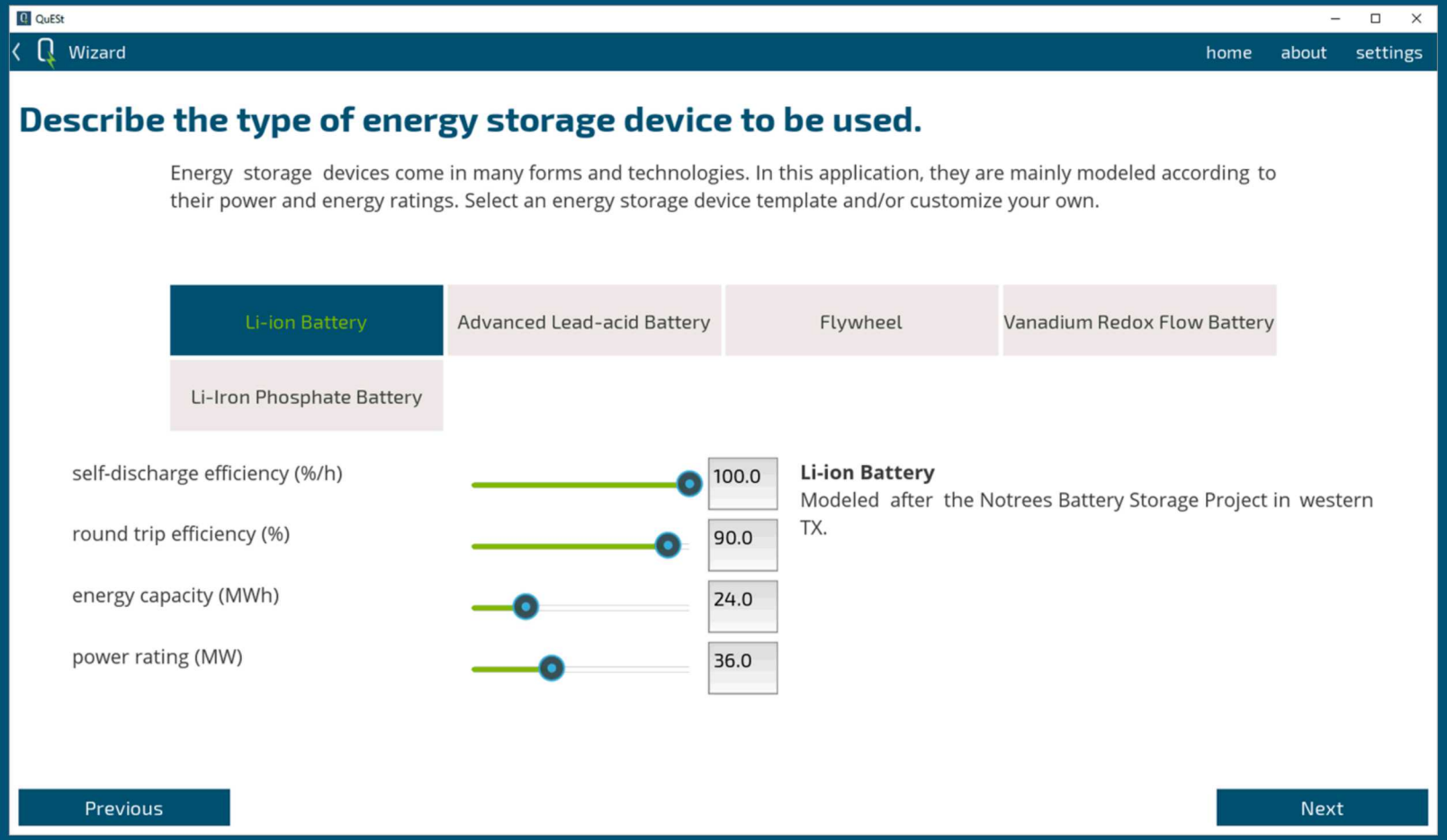

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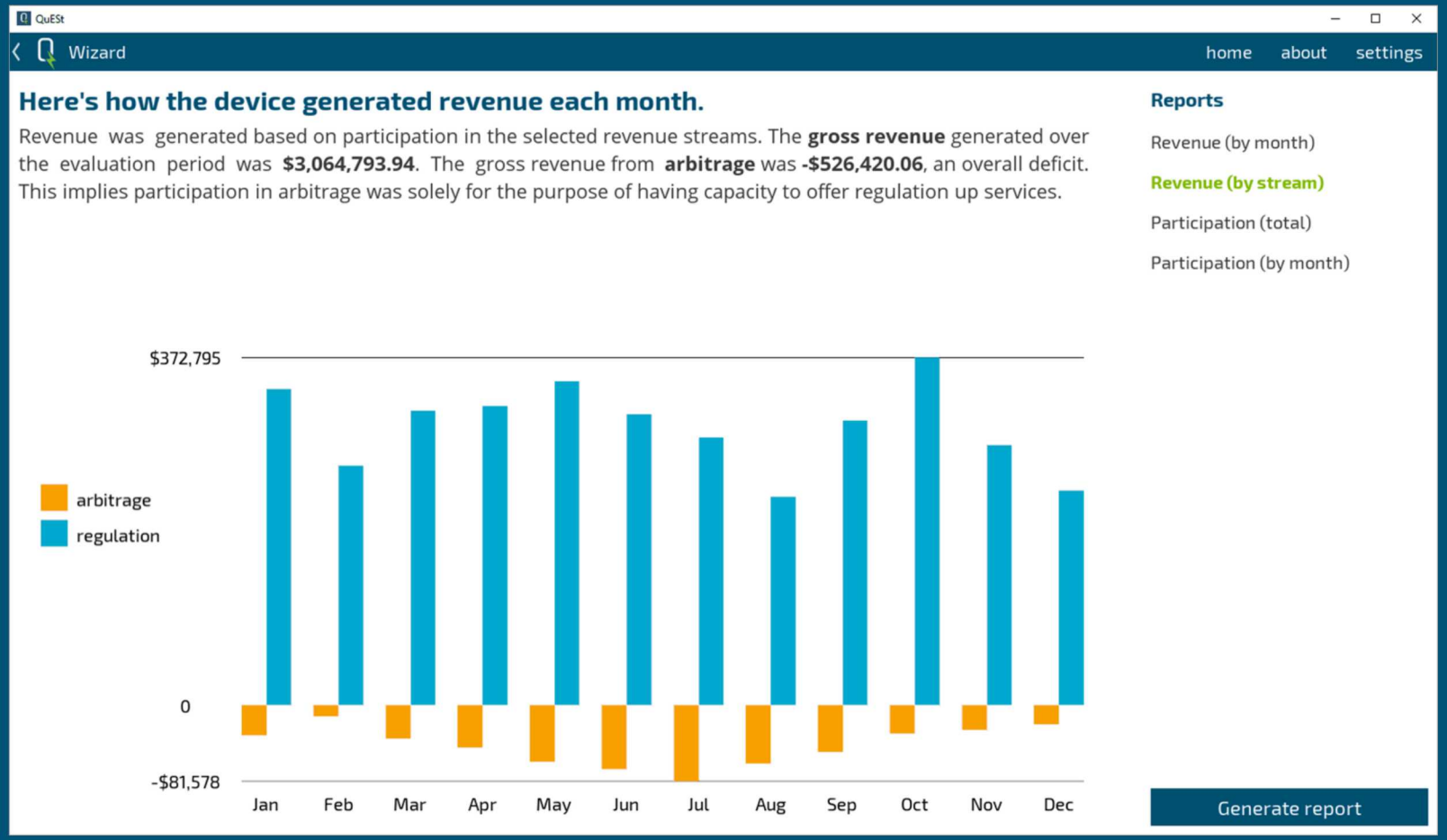
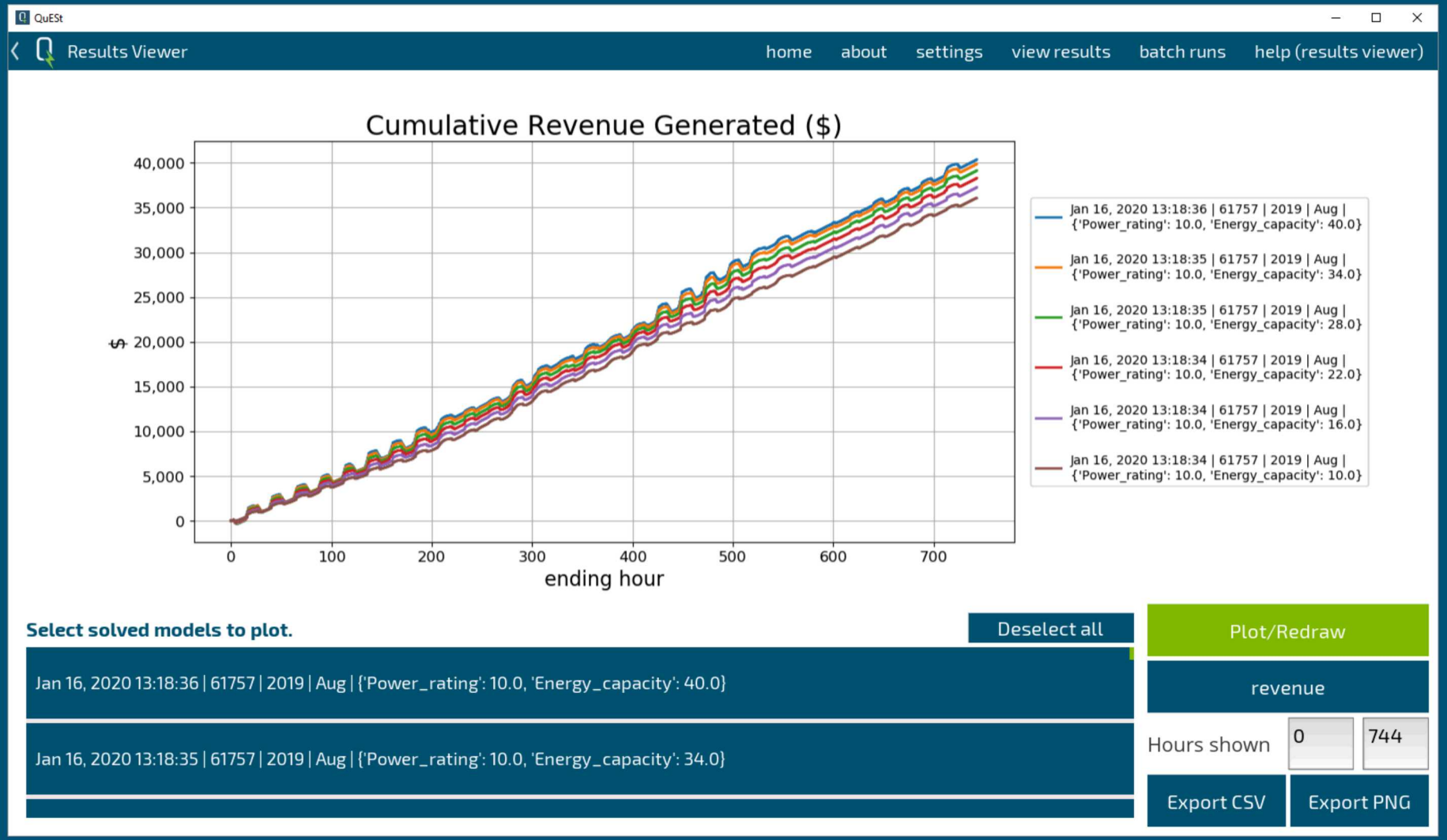


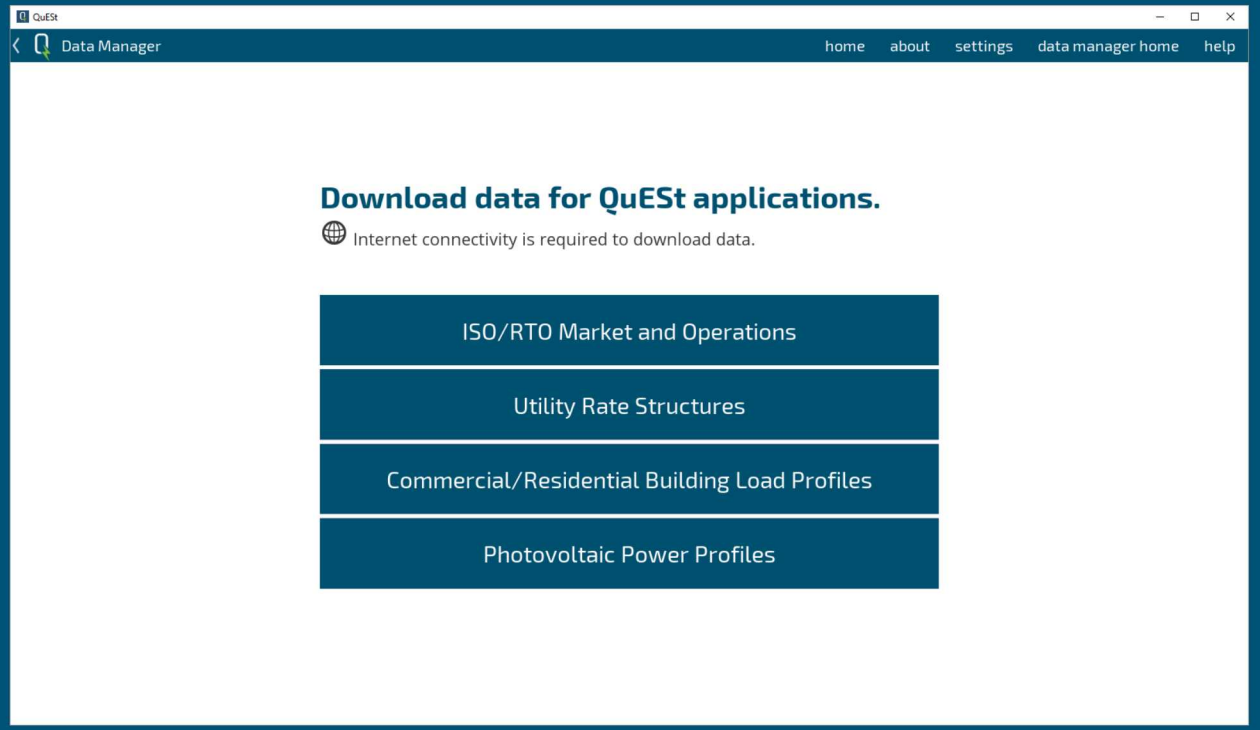
- Revenue by month
- Revenue by revenue stream
- Frequency of participation in each available revenue stream

QUEST VALUATION



- Parameter sensitivity analysis (fixed power rating, varying energy capacity)
- NYISO, CAPITL pricing node, August 2019, arbitrage + regulation

QUEST DATA MANAGER



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

- LMPs, frequency regulation performance/capacity clearing prices, etc. 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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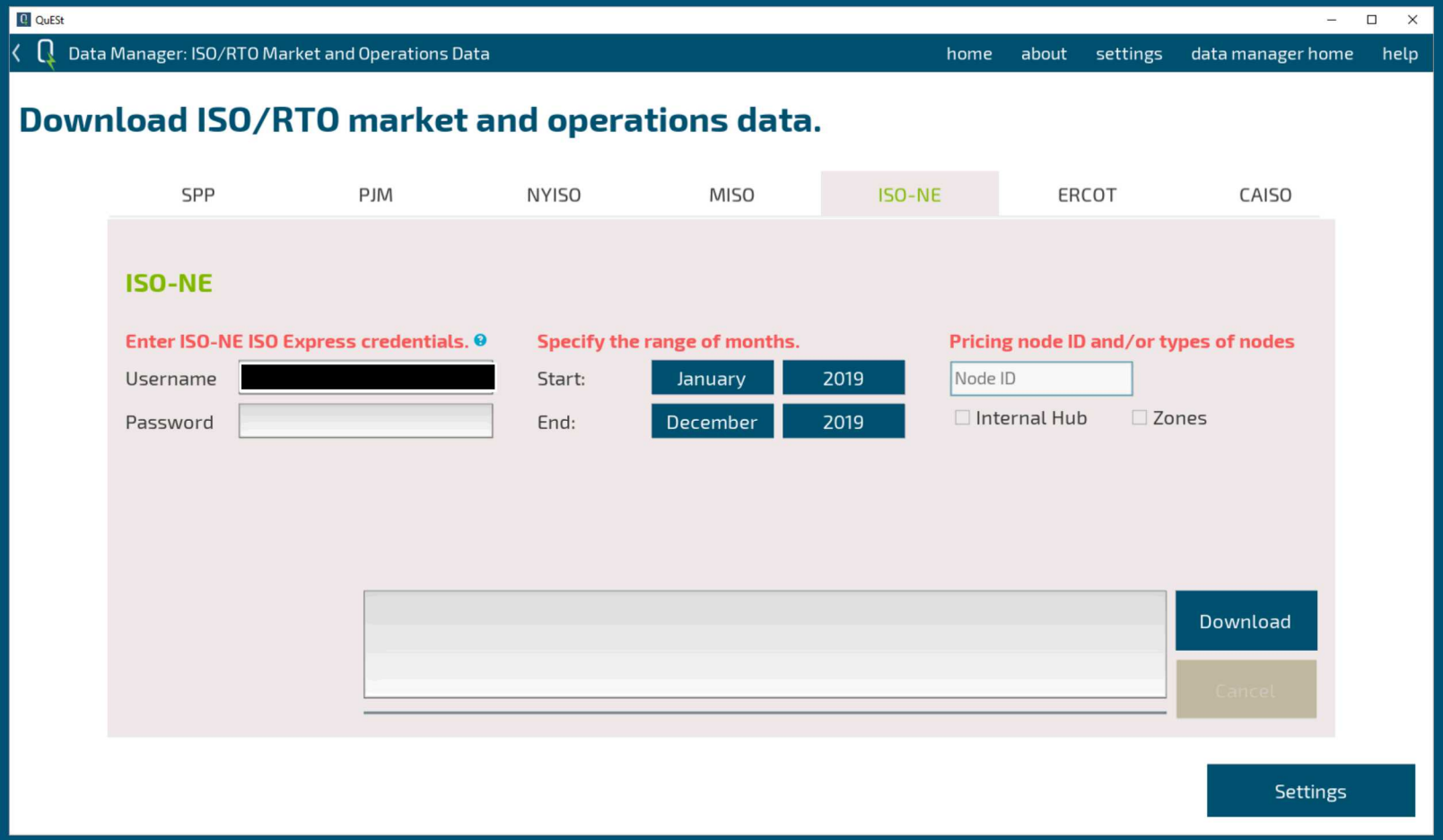

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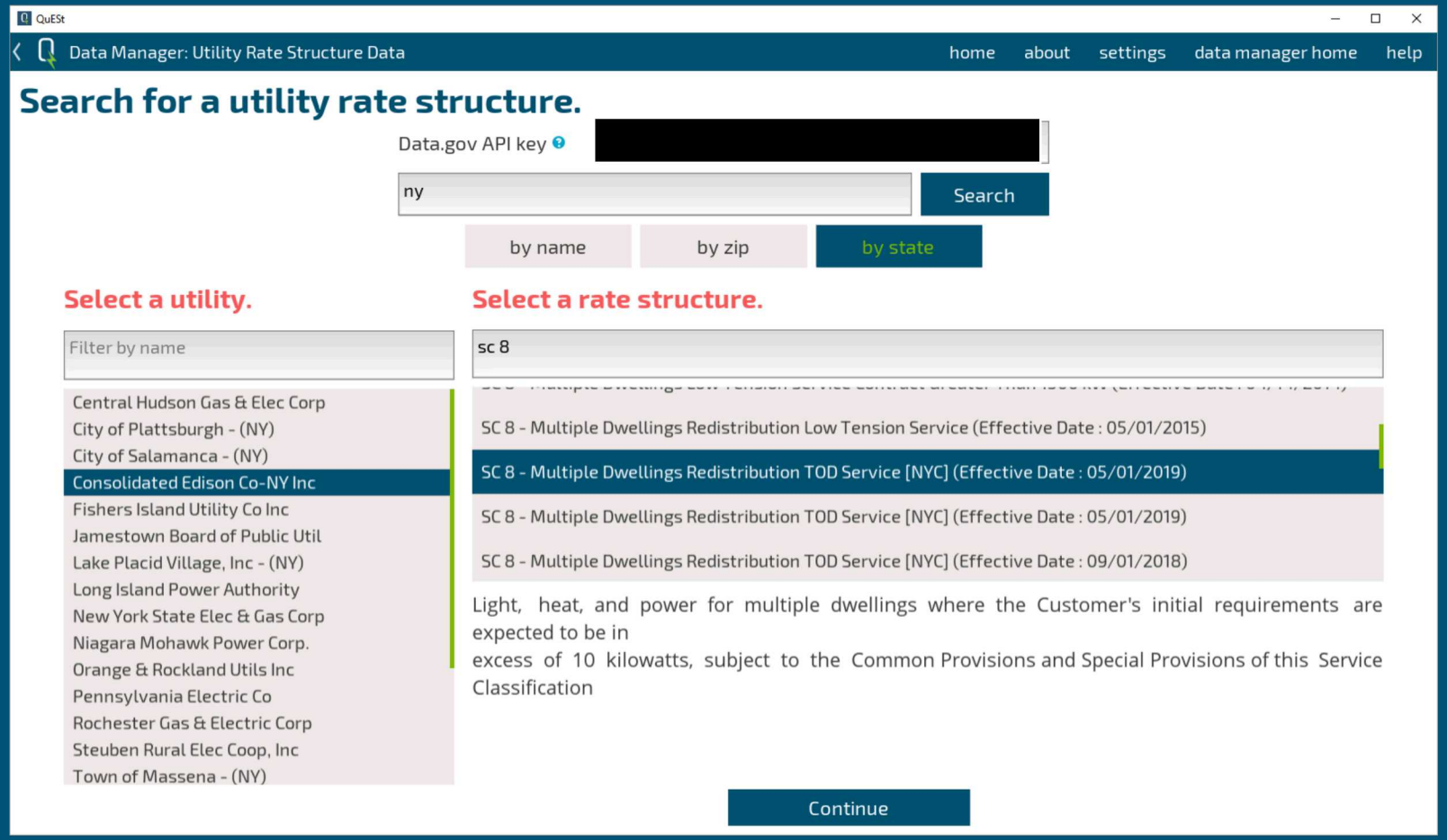
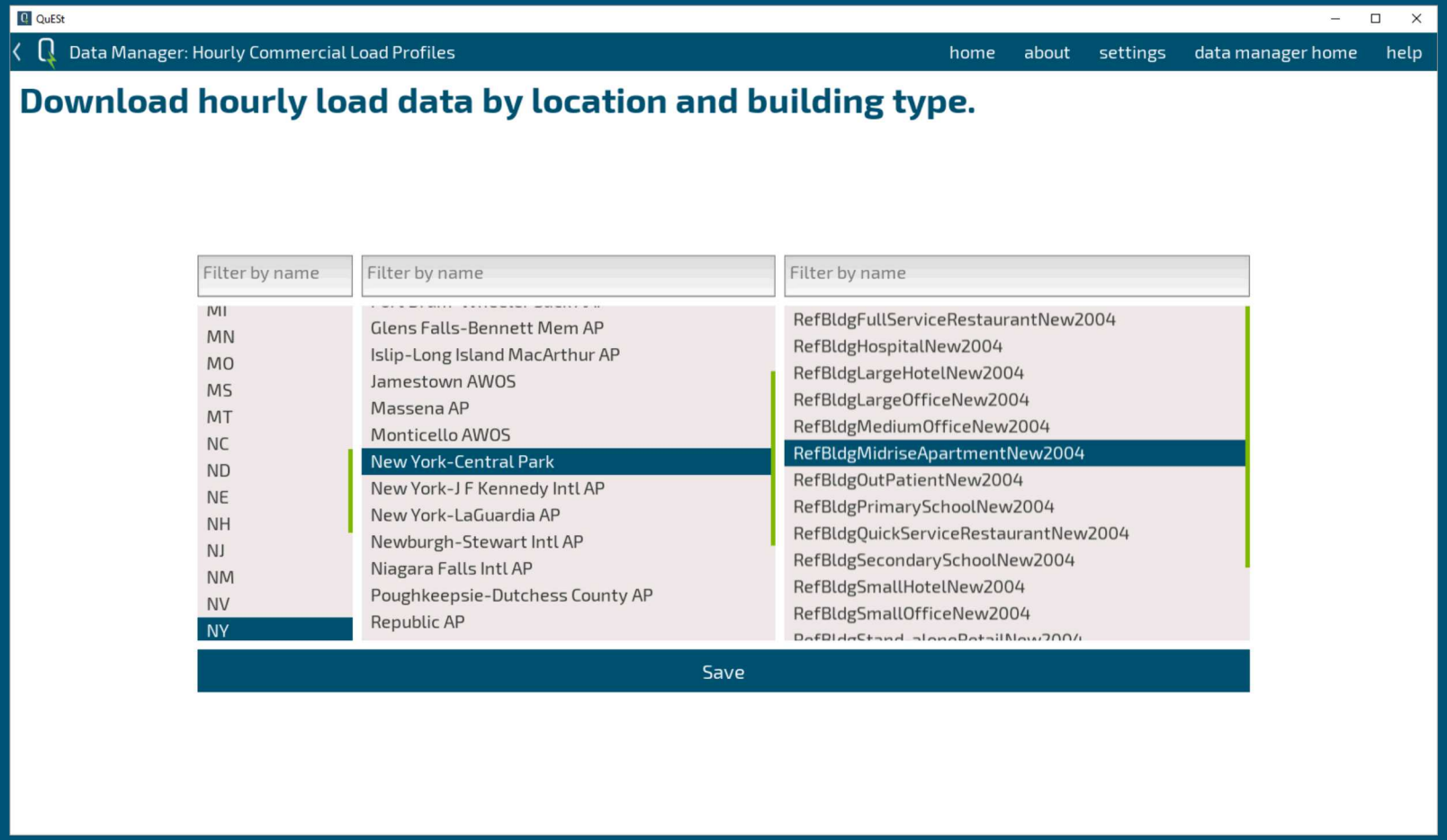


- OpenEI.org hosts a database for U.S. utility rates
- Time-of-use energy rate schedules
- Peak demand and flat demand rate schedules

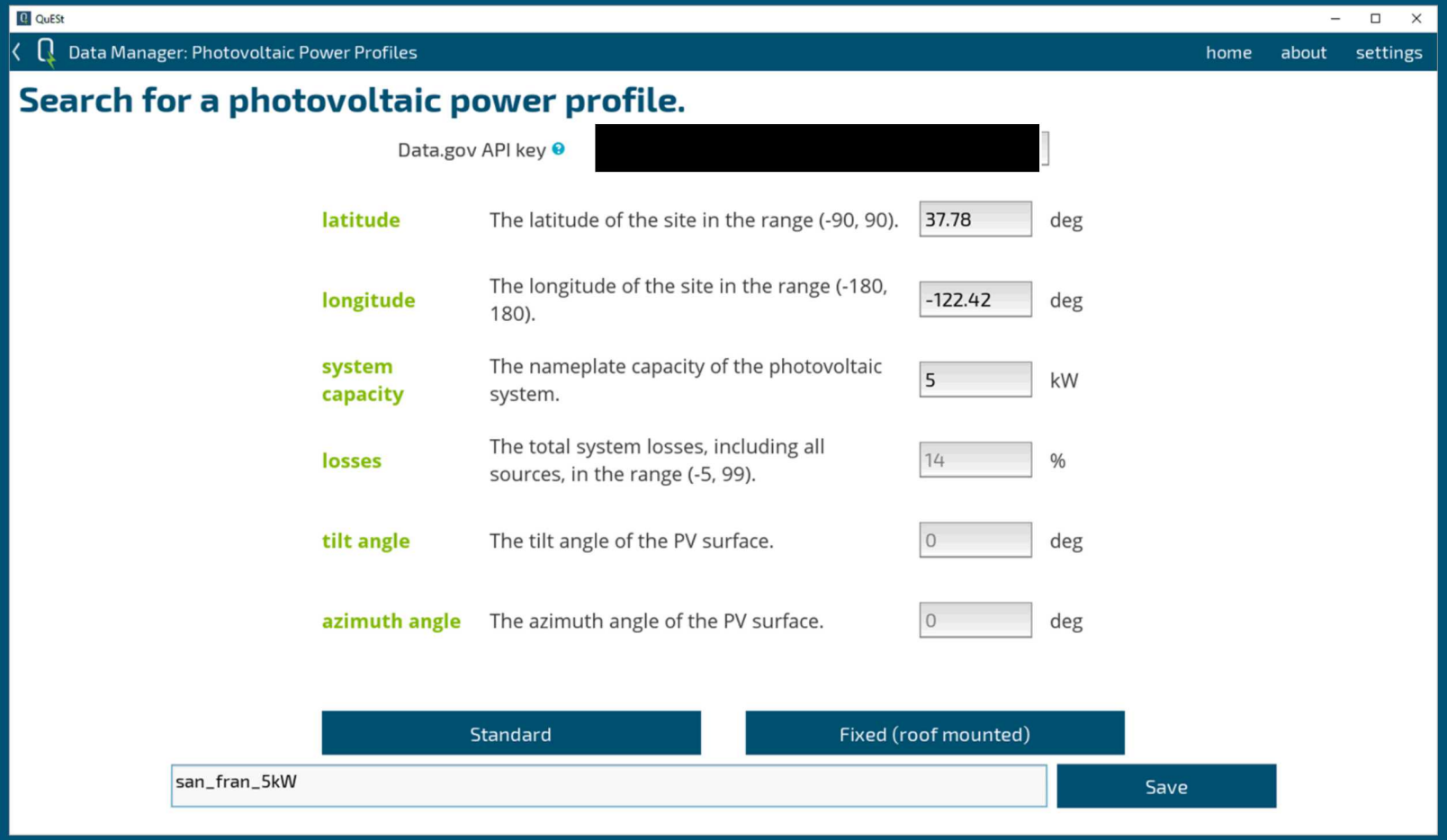
QUEST DATA MANAGER



- OpenEI.org also hosts simulated hourly load profiles for a 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

QUEST DATA MANAGER



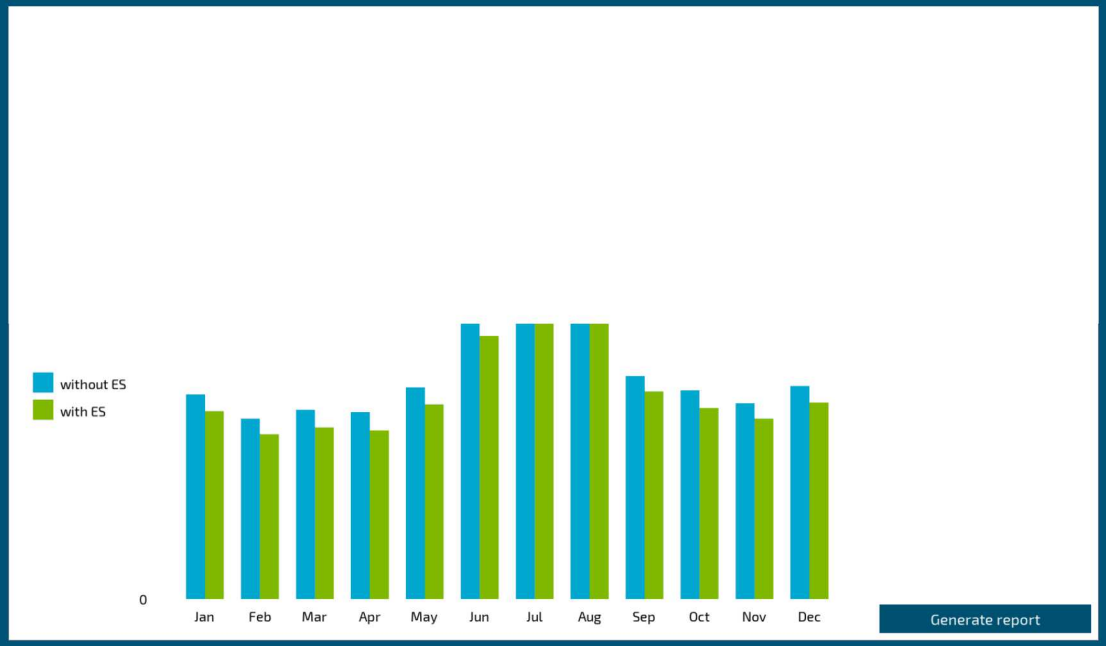
- PVWatts by NREL
  - Uses data from the National Solar Radiation Database and a solar panel system model to simulate hourly power output

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

QUEST BTM

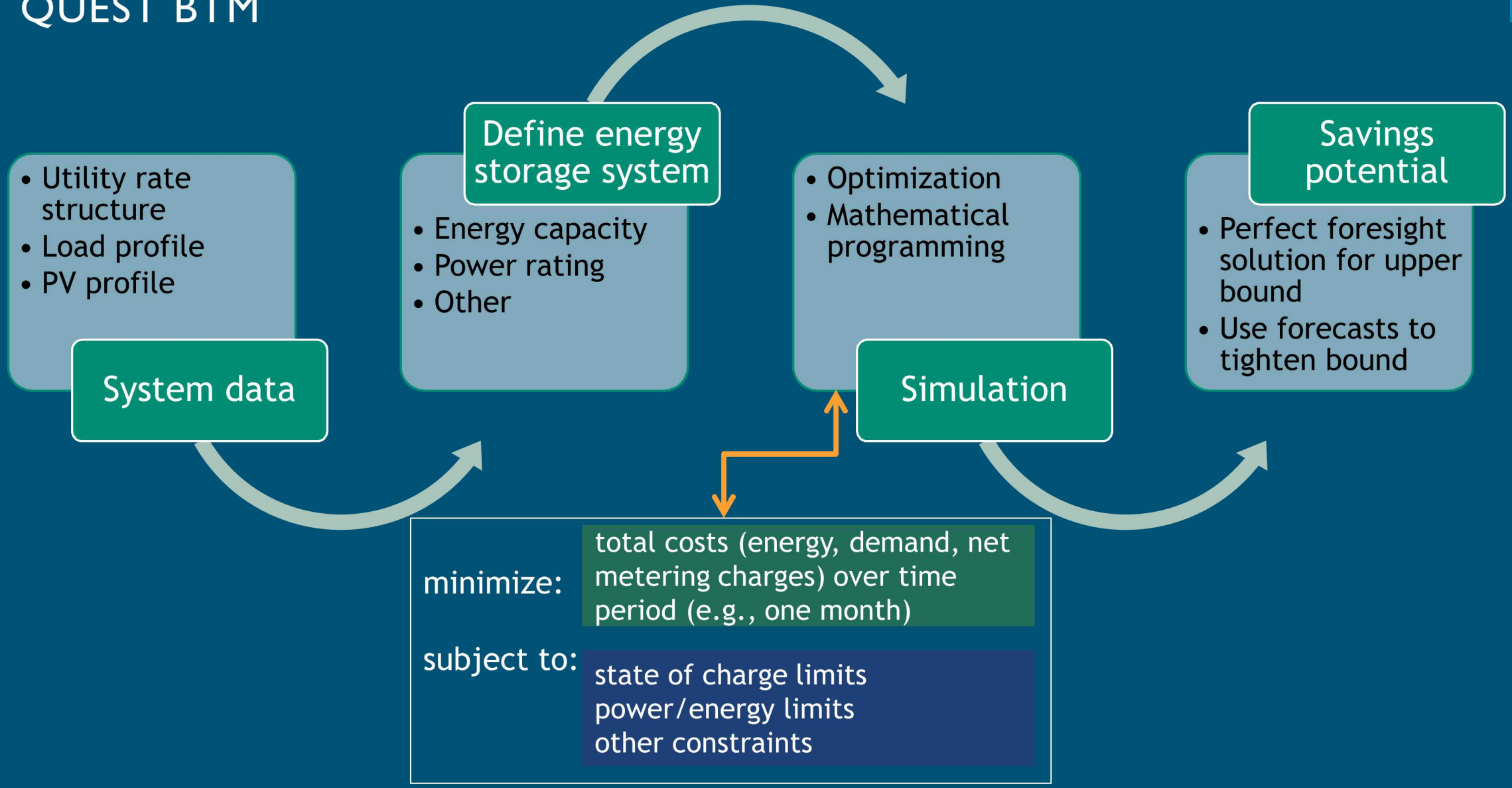
A collection of applications for behind-the-meter energy storage. The first application estimates cost savings for time-of-use and net energy metering customers.

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

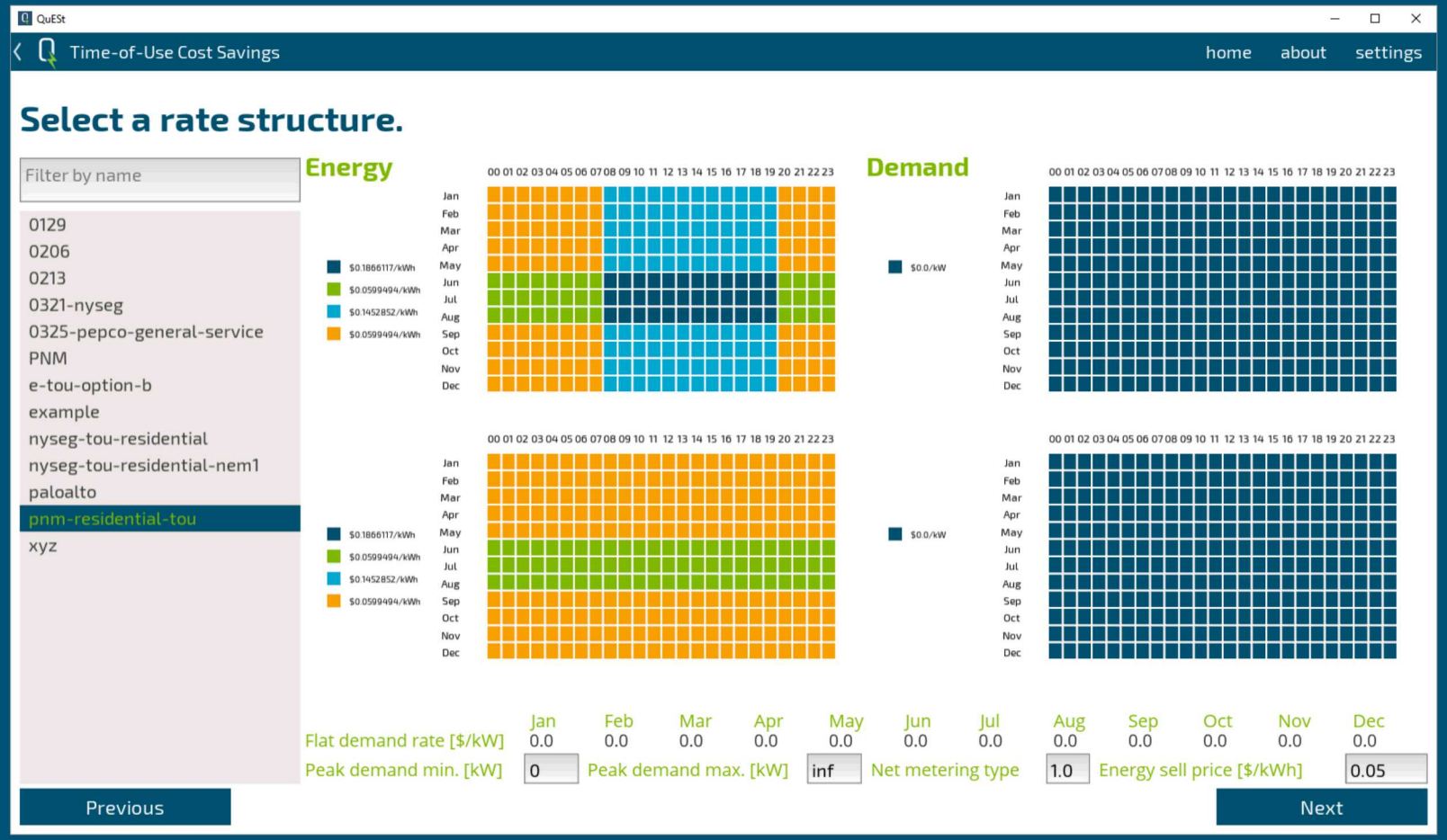


Nguyen, T., and R. Byrne. "Maximizing the cost-savings for time-of-use and net-metering customers using behind-the-meter energy storage systems." *Proceedings of the 2017 North American Power Symposium (NAPS)*. 2017.

QUEST BTM

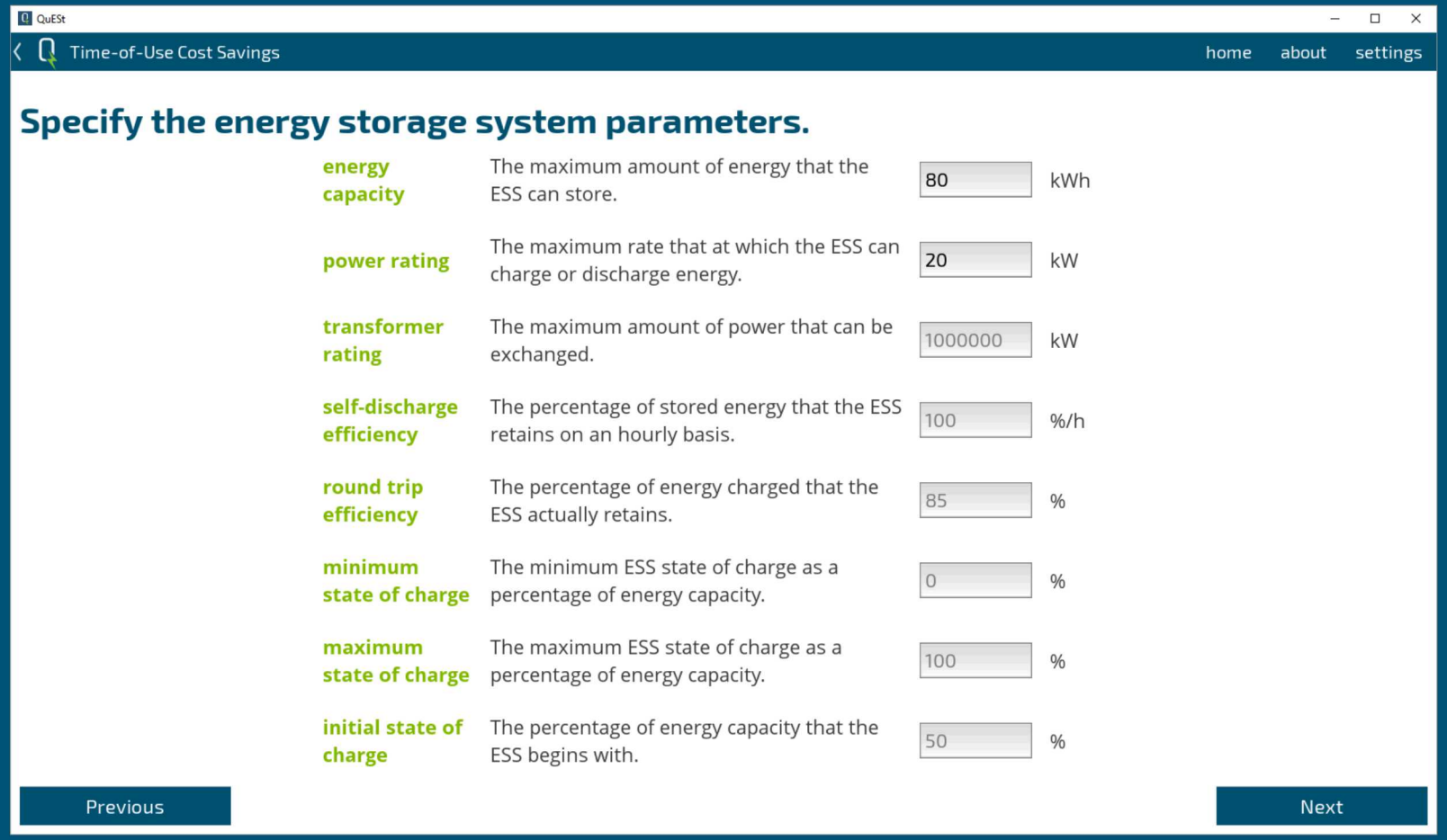

System data
• Utility rate structure
• Load profile
• PV profile
Define energy storage system
• Energy capacity
• Power rating
• Other
Simulation
• Optimization
• Mathematical programming
Savings potential
• Perfect foresight solution for upper bound
• Use forecasts to tighten bound
minimize:
total costs (energy, demand, net metering charges) over time period (e.g., one month)
subject to:
state of charge limits
power/energy limits
other constraints

QUEST BTM



- 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

QUEST BTM



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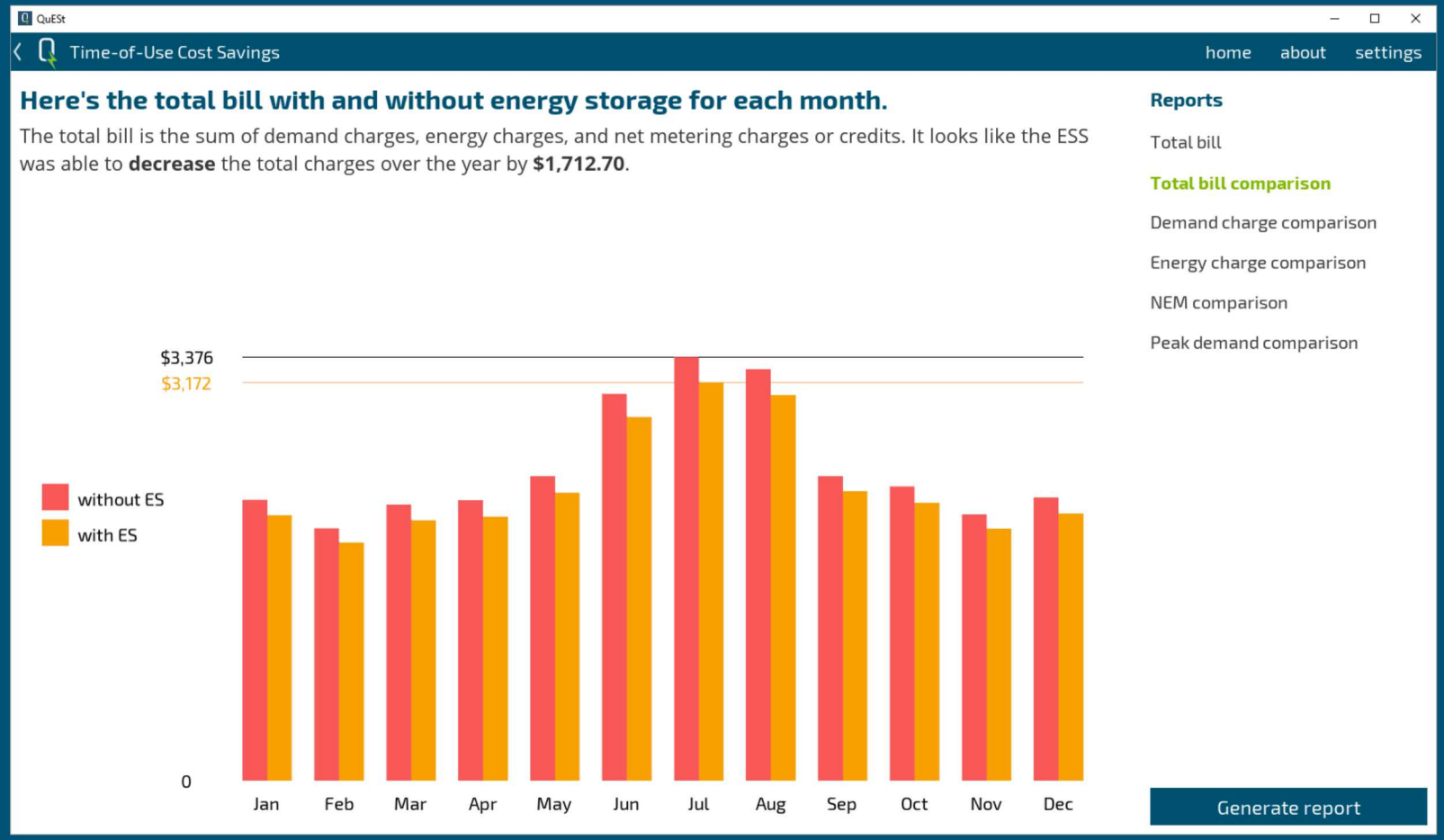
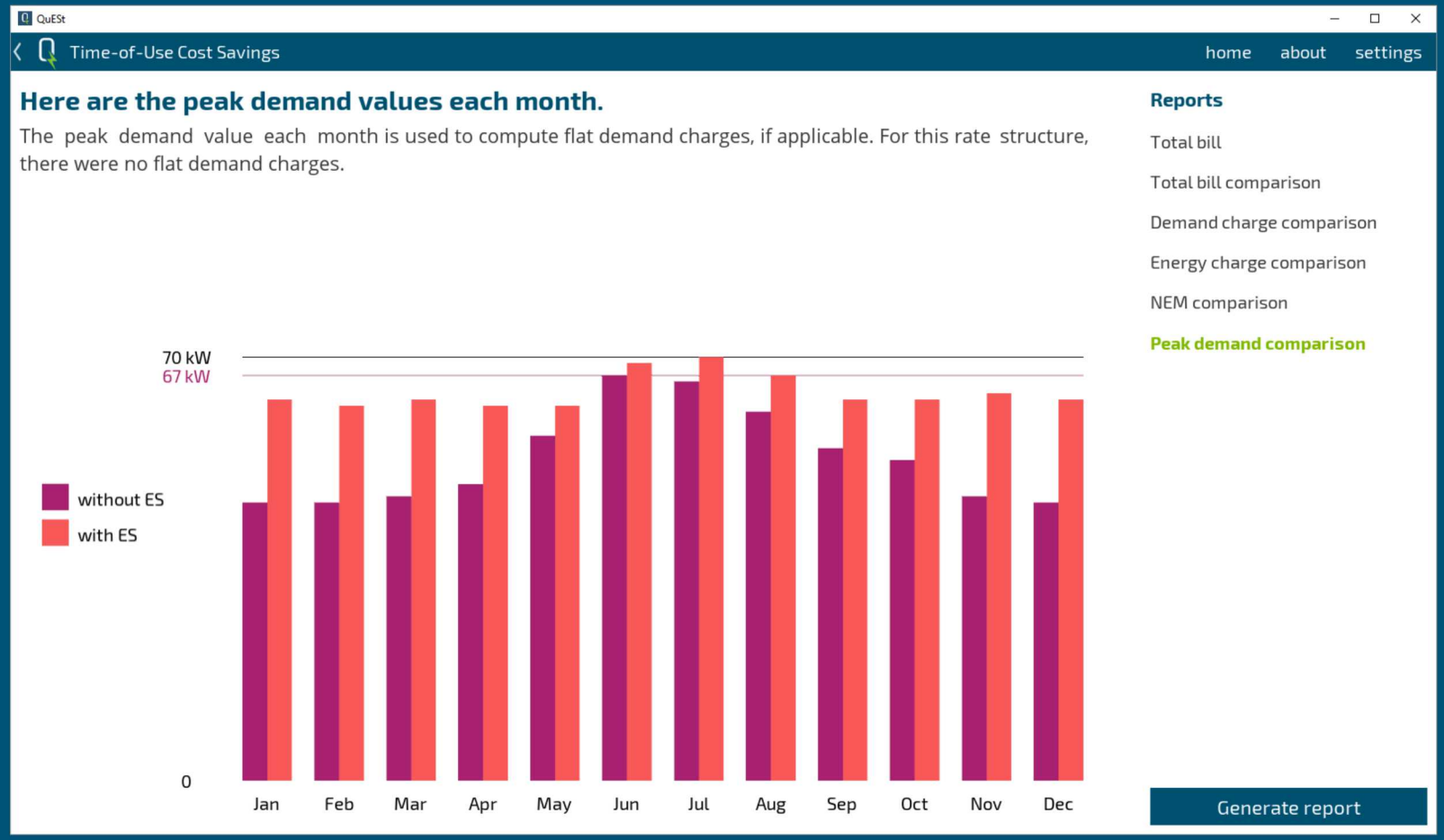


- Compare monthly bill with and without energy storage
- Peak demand reduction to decrease demand charges
- Time-shifting to reduce time-of-use energy charges
- Net metering credits

QUEST BTM



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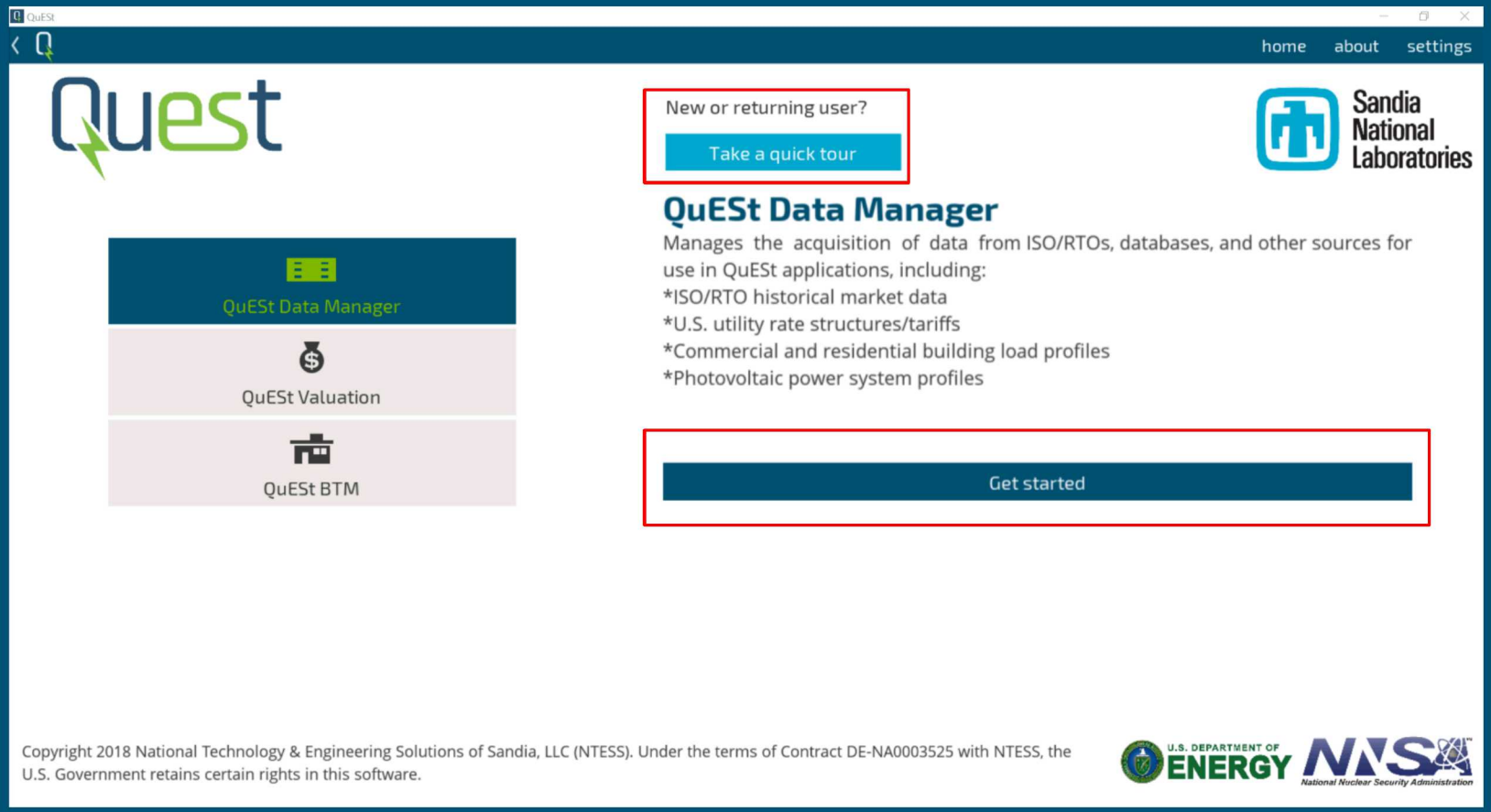
CASE STUDY: A MID-SIZE OFFICE BUILDING WITH SOLAR + STORAGE IN RENO

CASE STUDY: MID-SIZE OFFICE BUILDING WITH PV+STORAGE

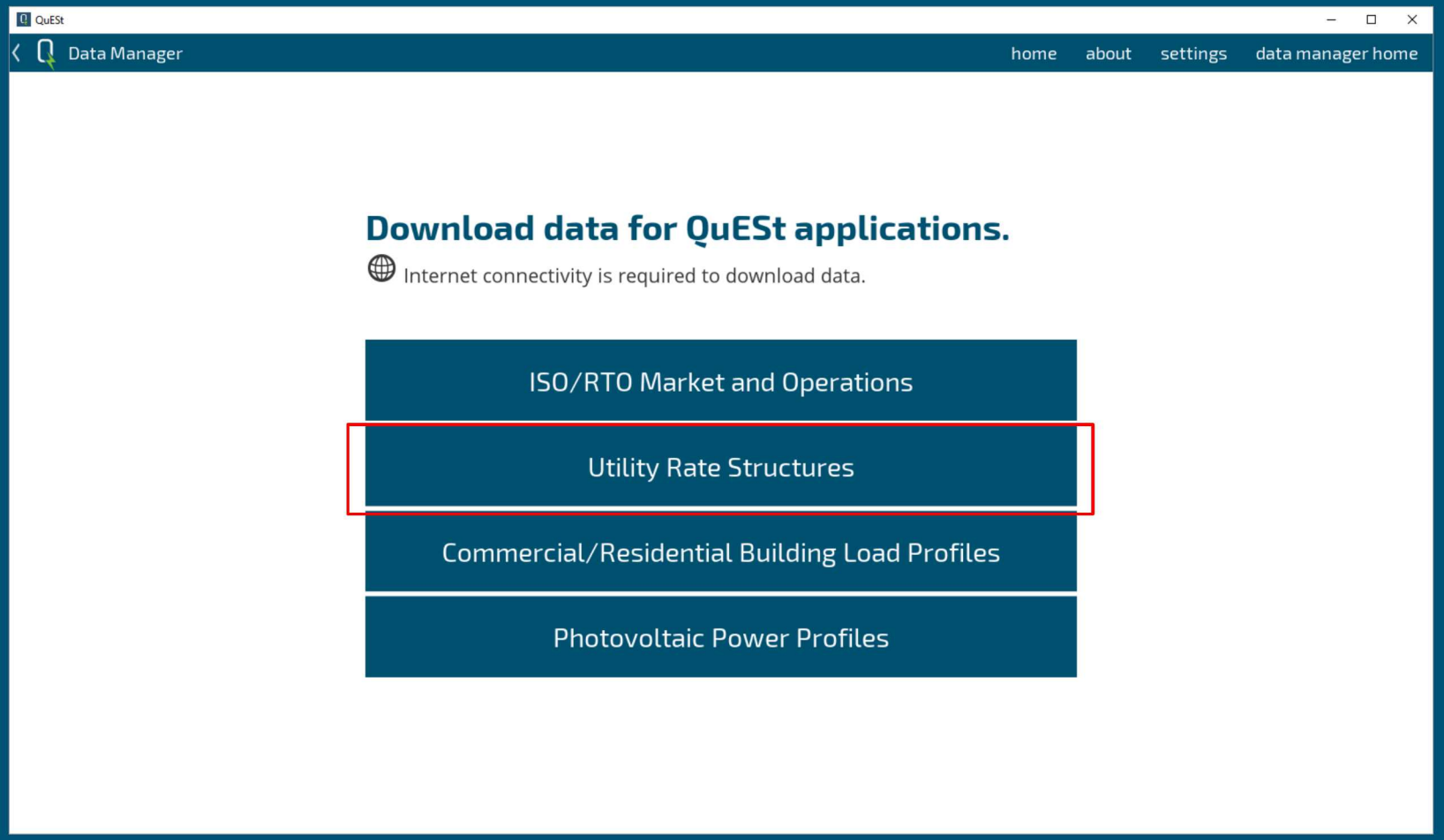
You are the operator of a mid-size office building with a 100 kW rooftop PV system in the Reno area. You're thinking about acquiring an energy storage system to better utilize your PV system and take advantage of time-of-use tariff to reduce the property's electricity bills. Would it be worth it?

CASE STUDY: MID-SIZE OFFICE BUILDING WITH PV+STORAGE



- This is a behind-the-meter energy storage problem, so we will use QuESt BTM.
- For this analysis, we need:
  - Utility rate structure
  - Load profile for the property
  - PV power profile
- First, we head to QuESt Data Manager to get what we need.

CASE STUDY: MID-SIZE OFFICE BUILDING WITH PV+STORAGE



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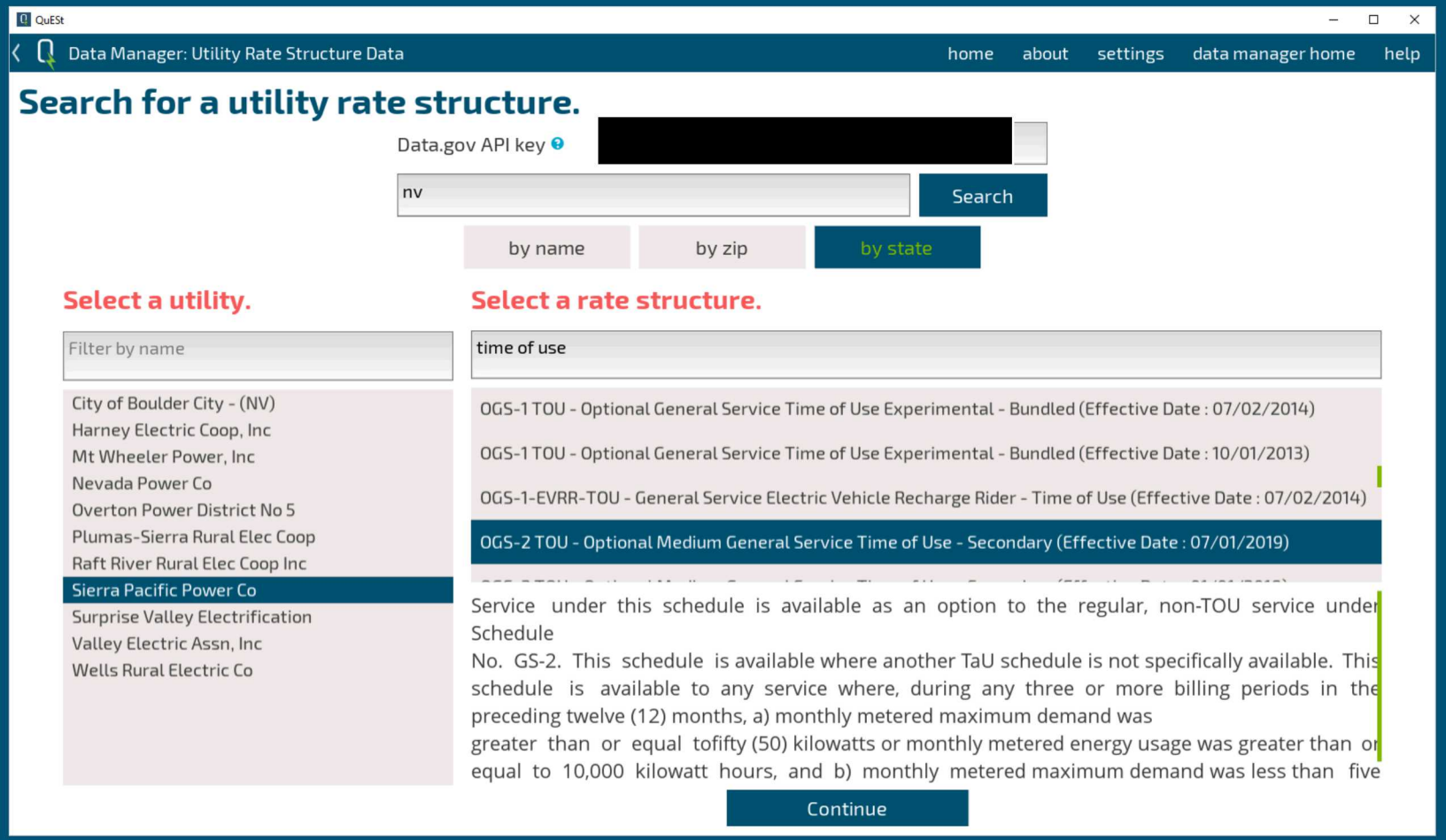
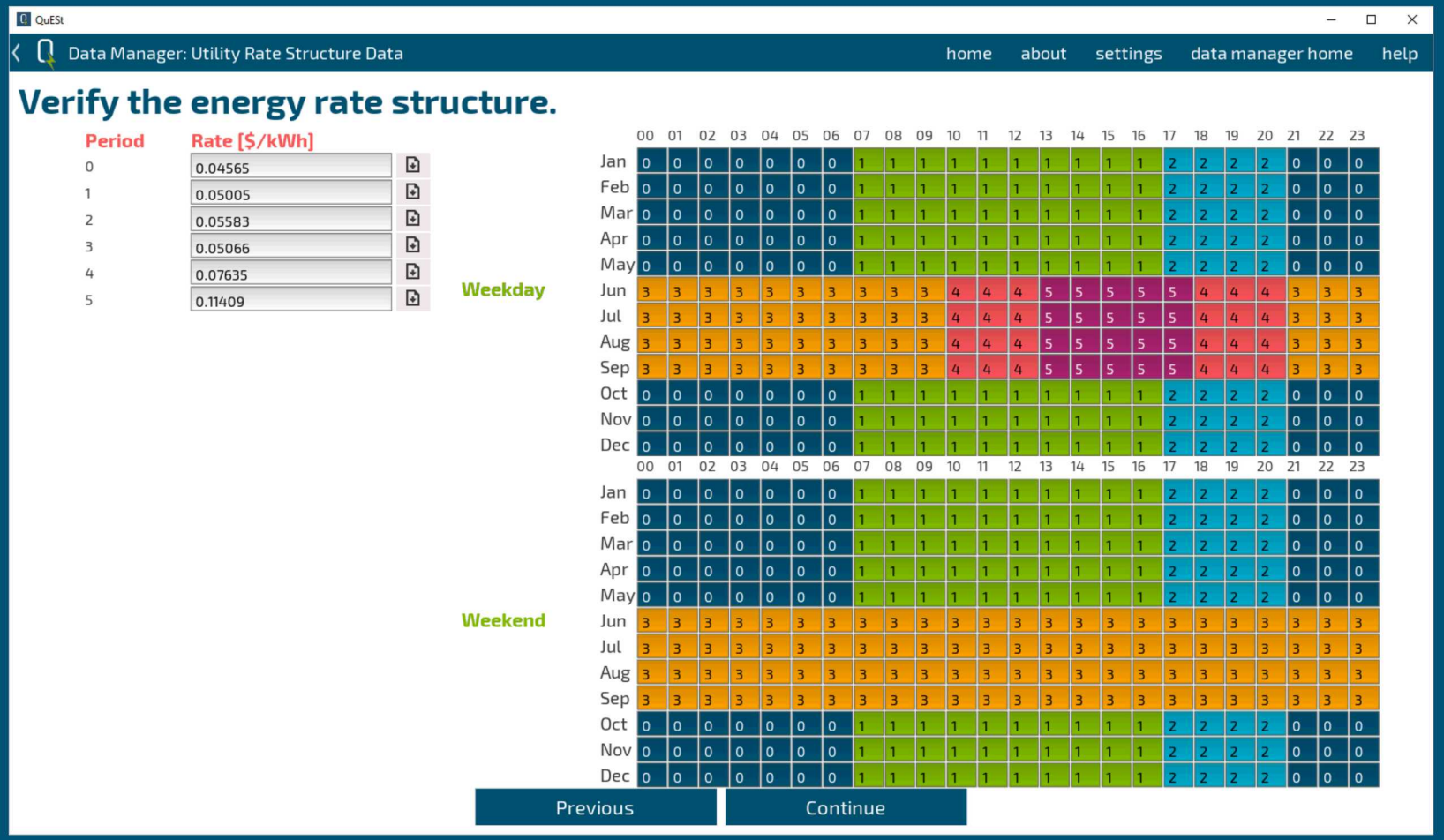


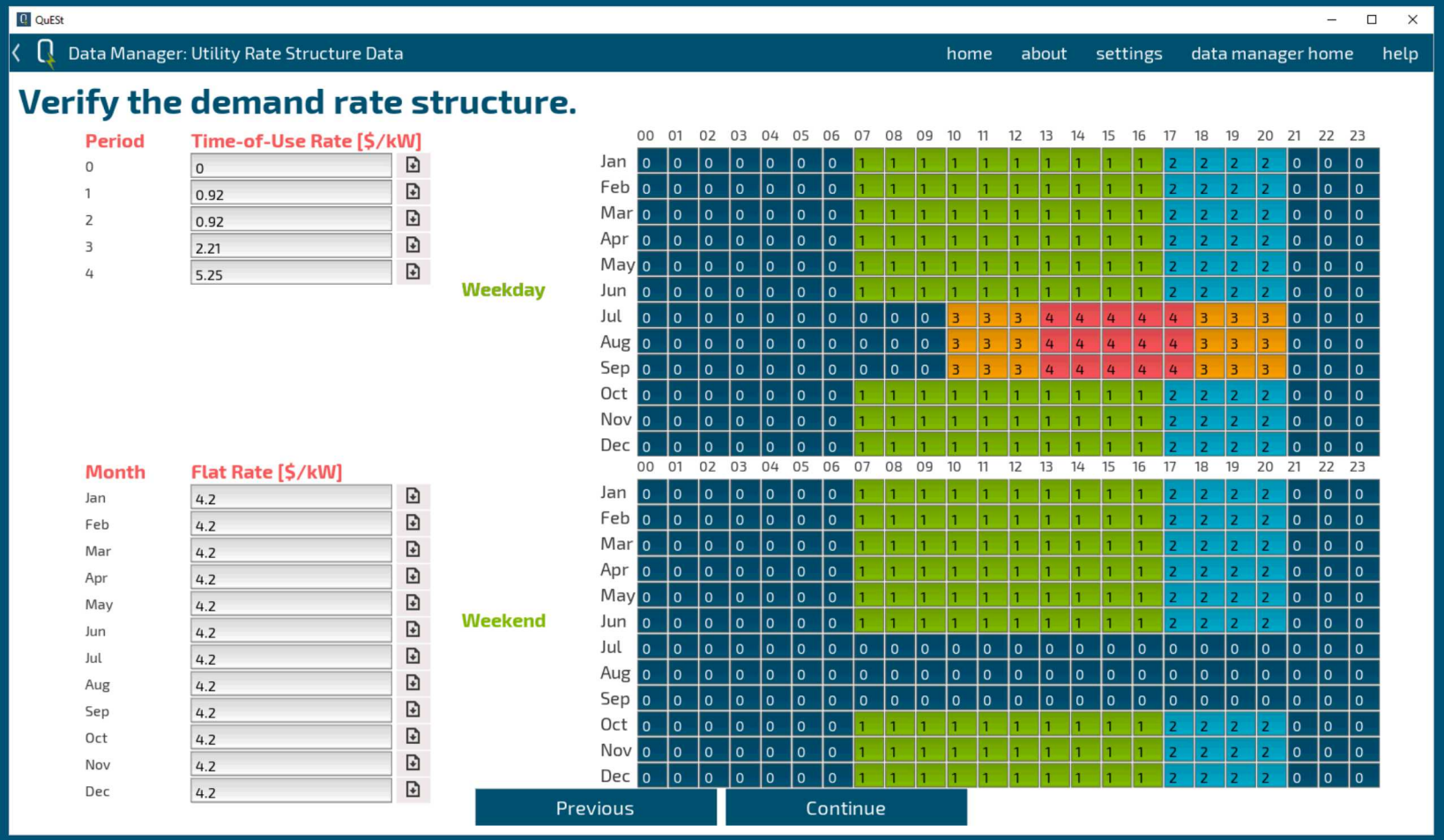
- Our building's utility is Sierra Pacific Power Co (NV Energy).
- The applicable rate structure for our property is "OGS-2 TOU – Optional Medium General Service Time of Use - Secondary".
- We'll need an API key for this tool and the PV profile downloader. There's a help prompt to get you started with that short process.

CASE STUDY: MID-SIZE OFFICE BUILDING WITH PV+STORAGE



- Verify that the energy and demand rate schedules are correct.

CASE STUDY: MID-SIZE OFFICE BUILDING WITH PV+STORAGE



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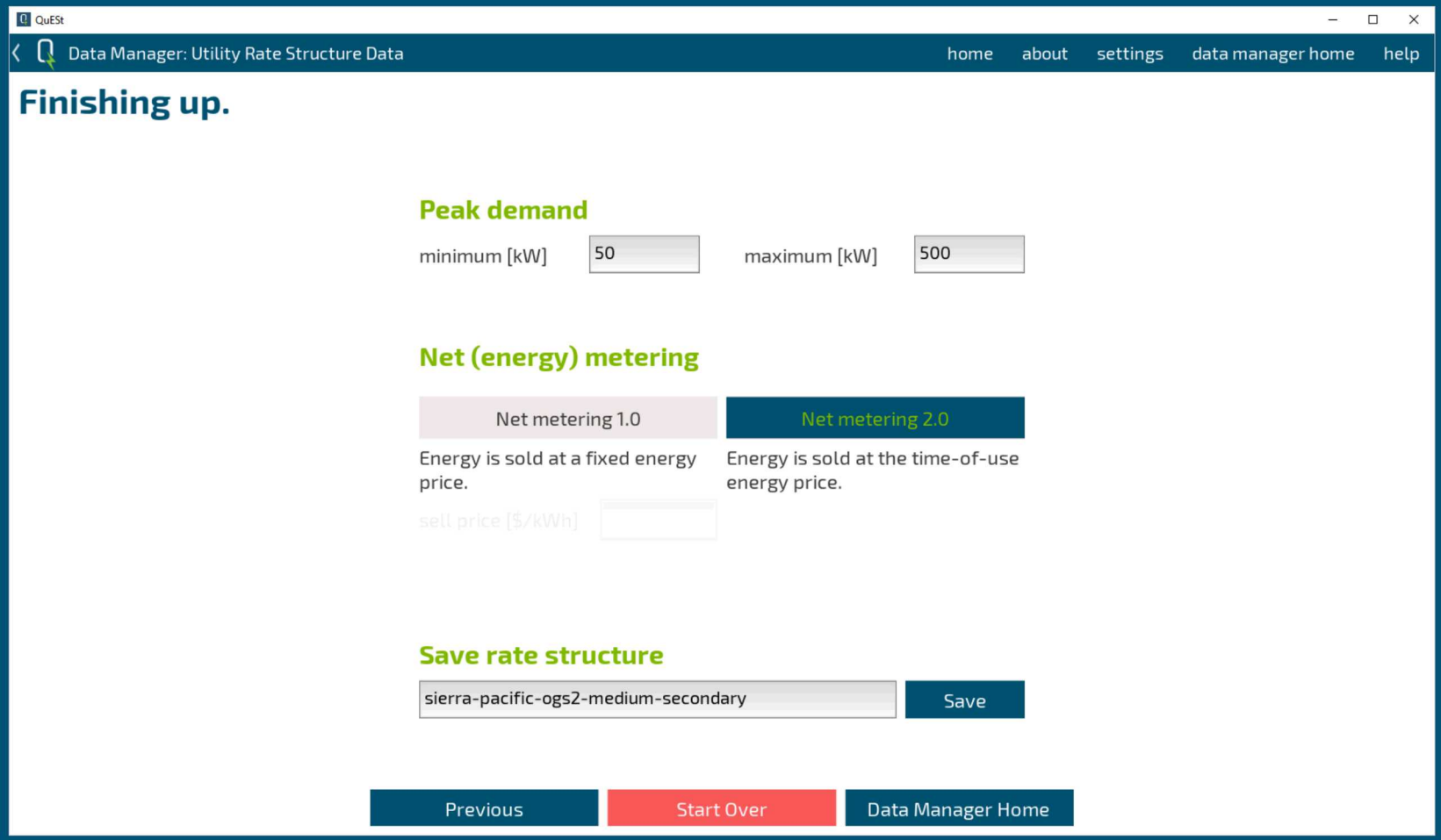
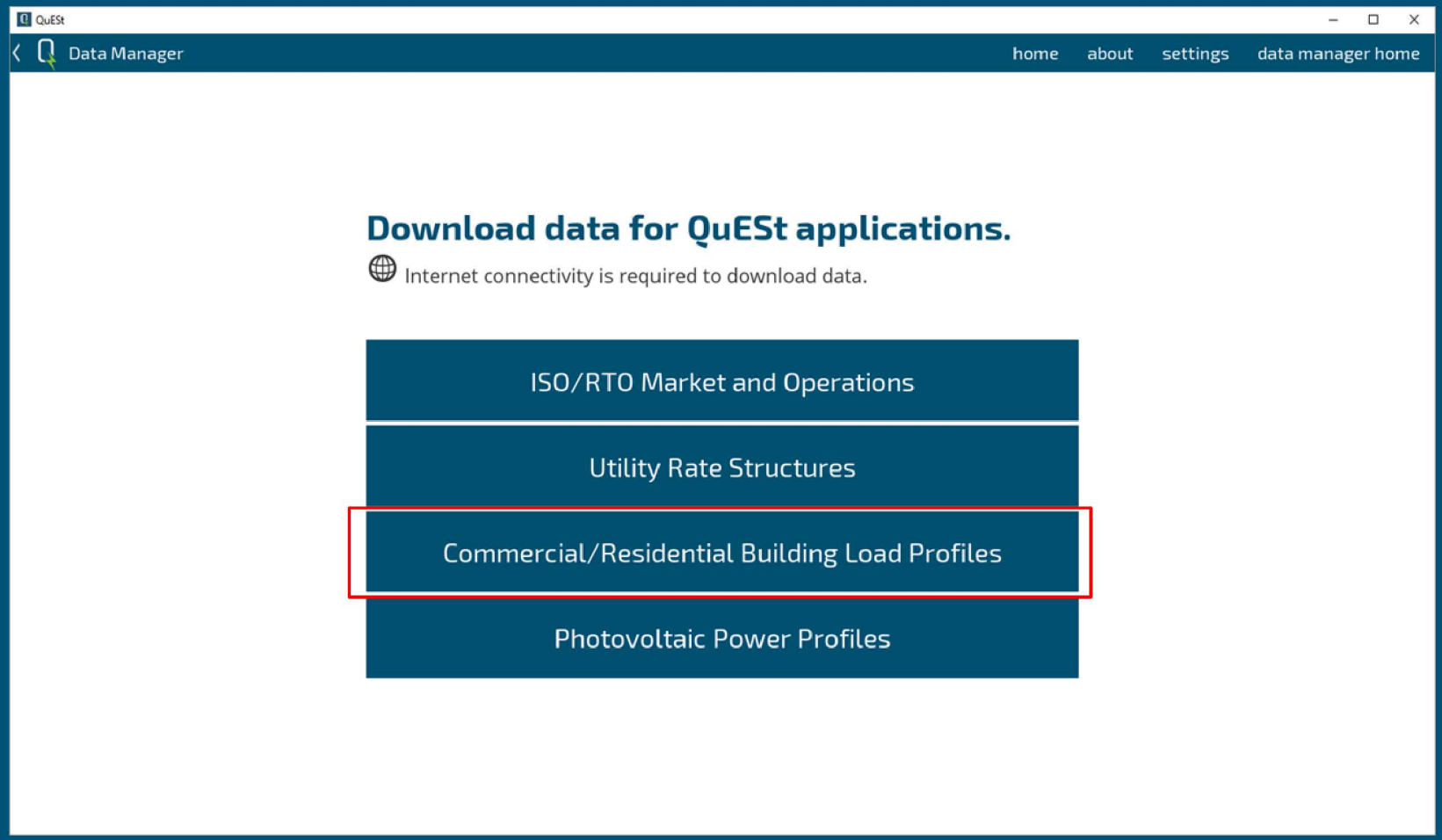


- Save the rate structure for later.

CASE STUDY: MID-SIZE OFFICE BUILDING WITH PV+STORAGE



- Now we'll obtain the load profile for the building.

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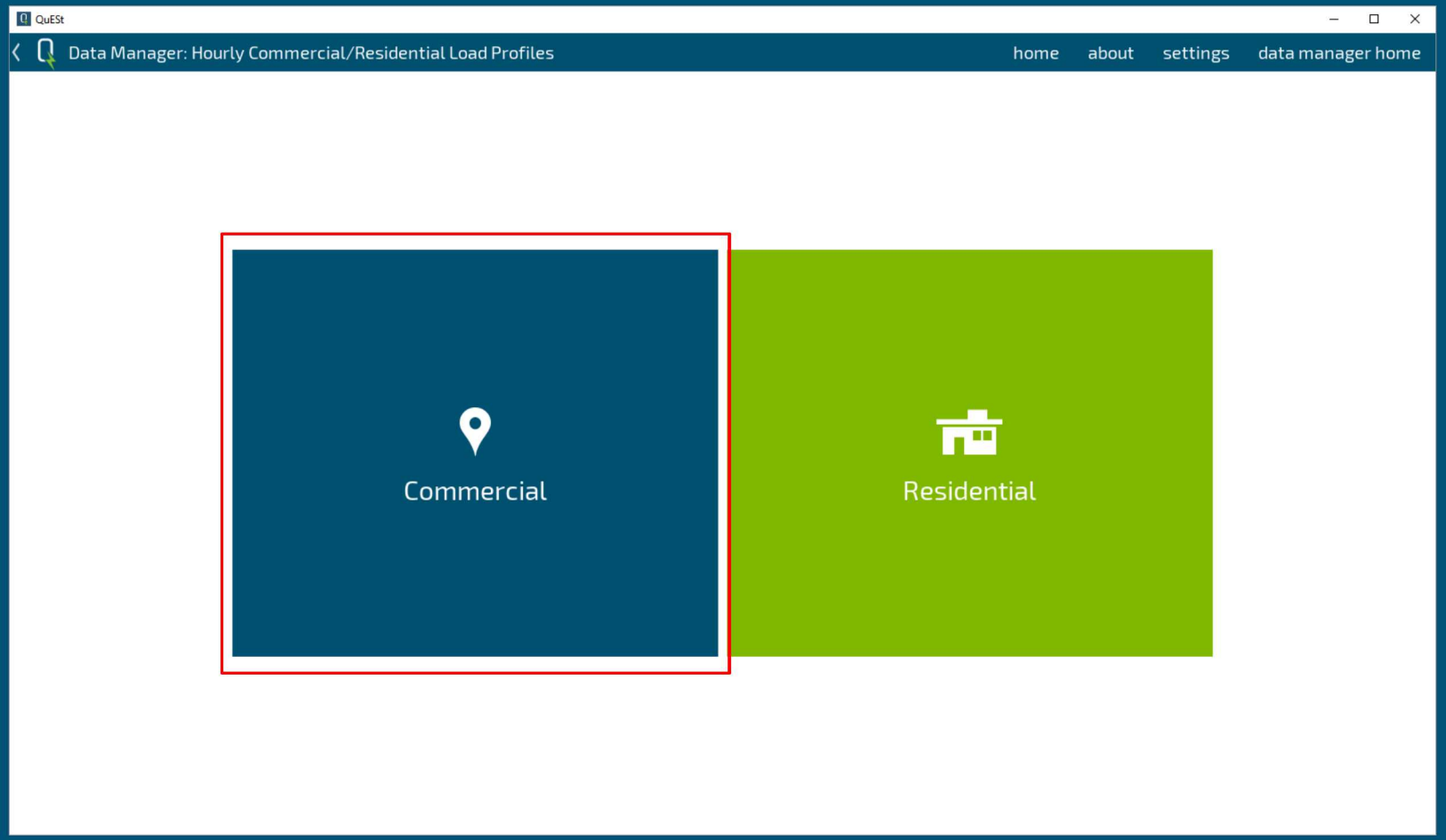

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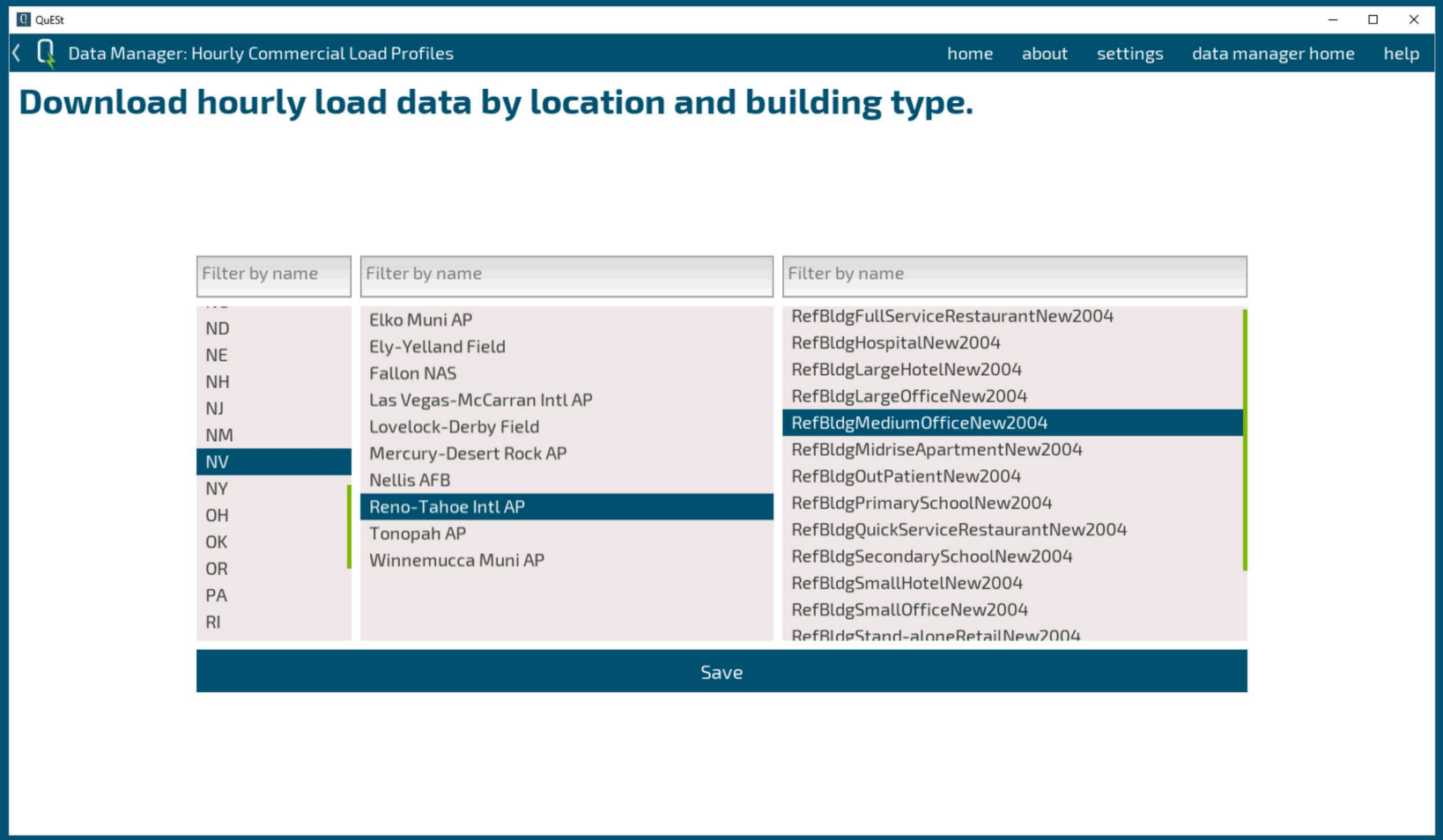

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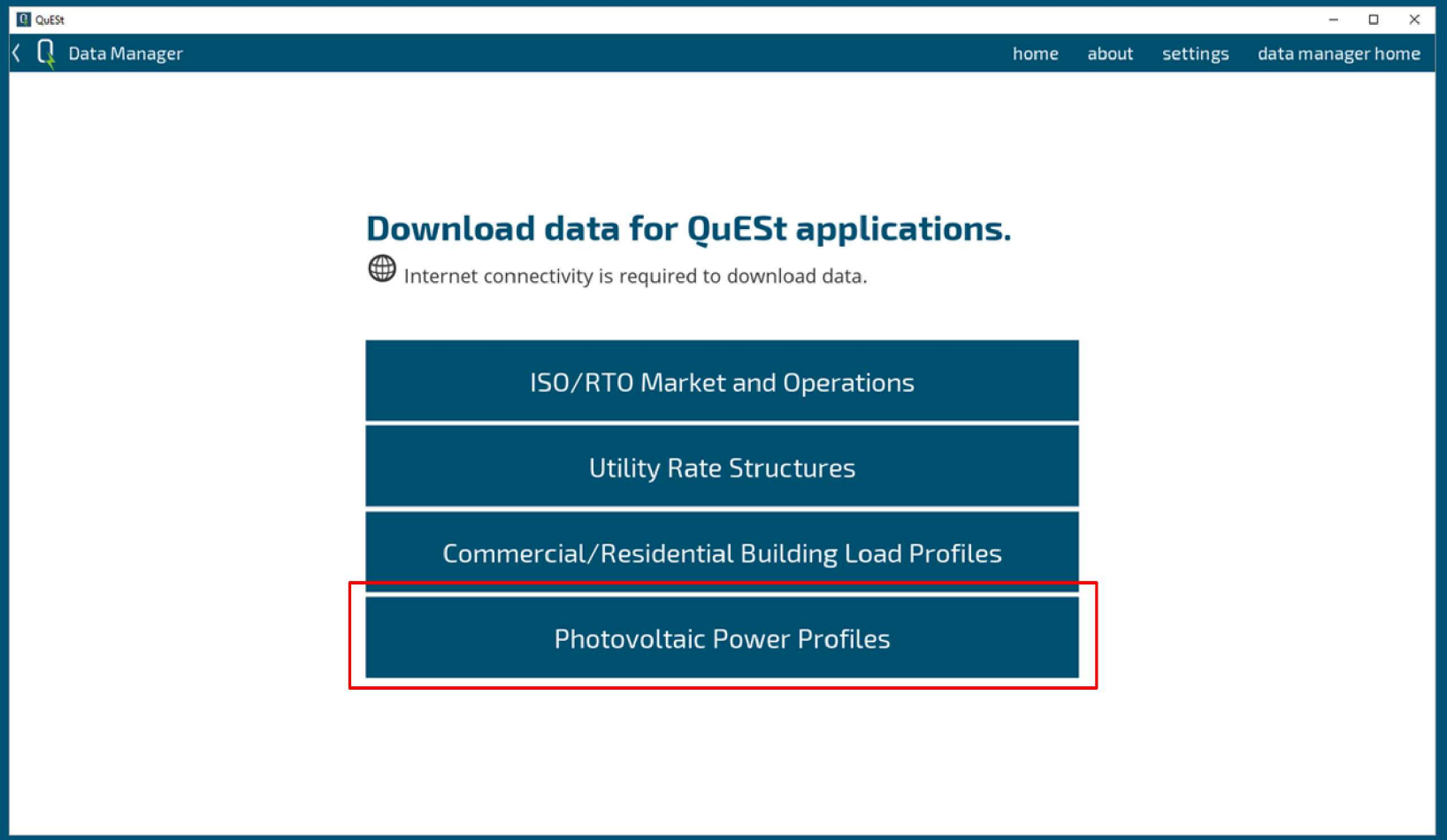

- Finally, we'll grab the PV power profile for our property.

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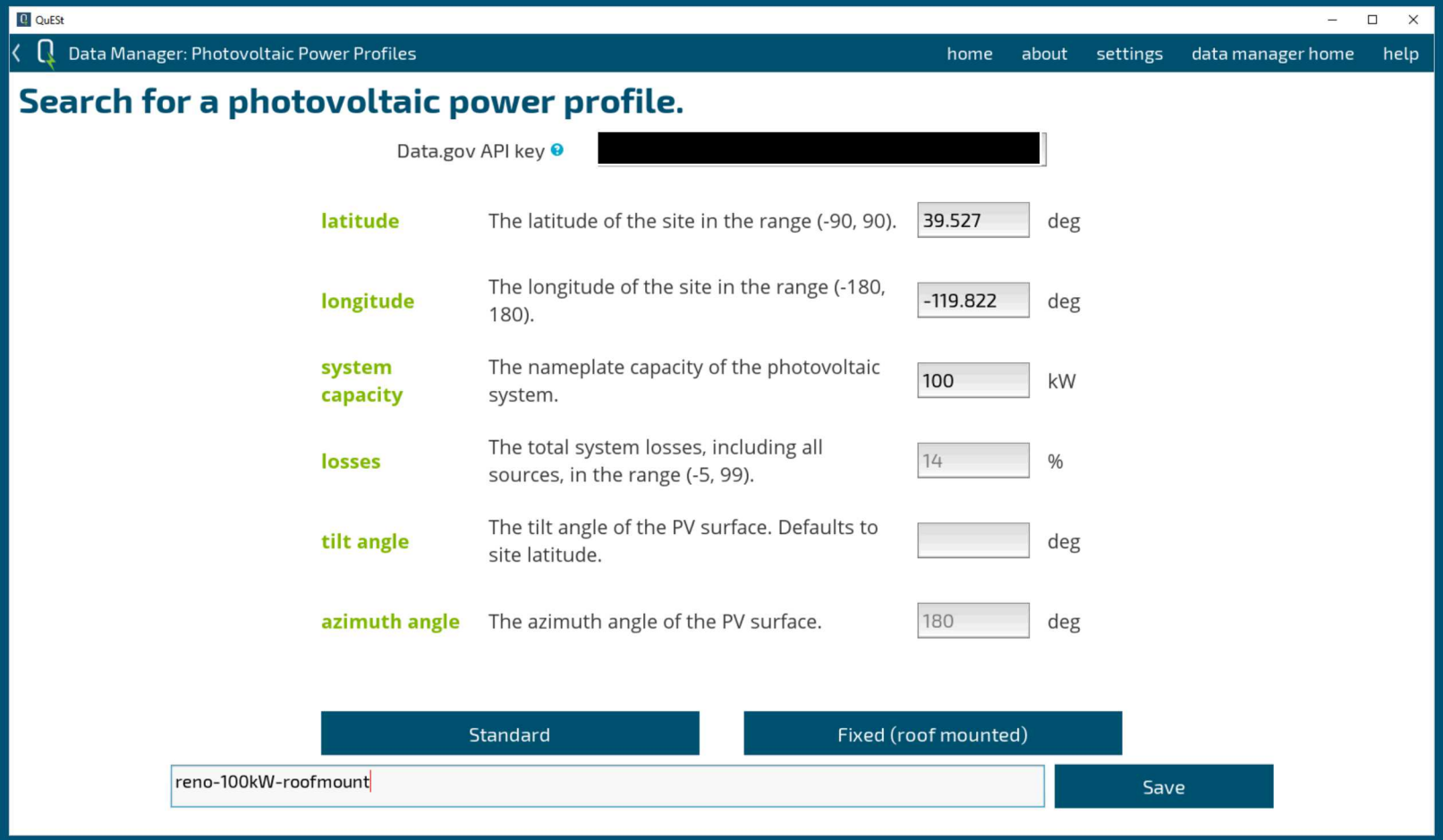

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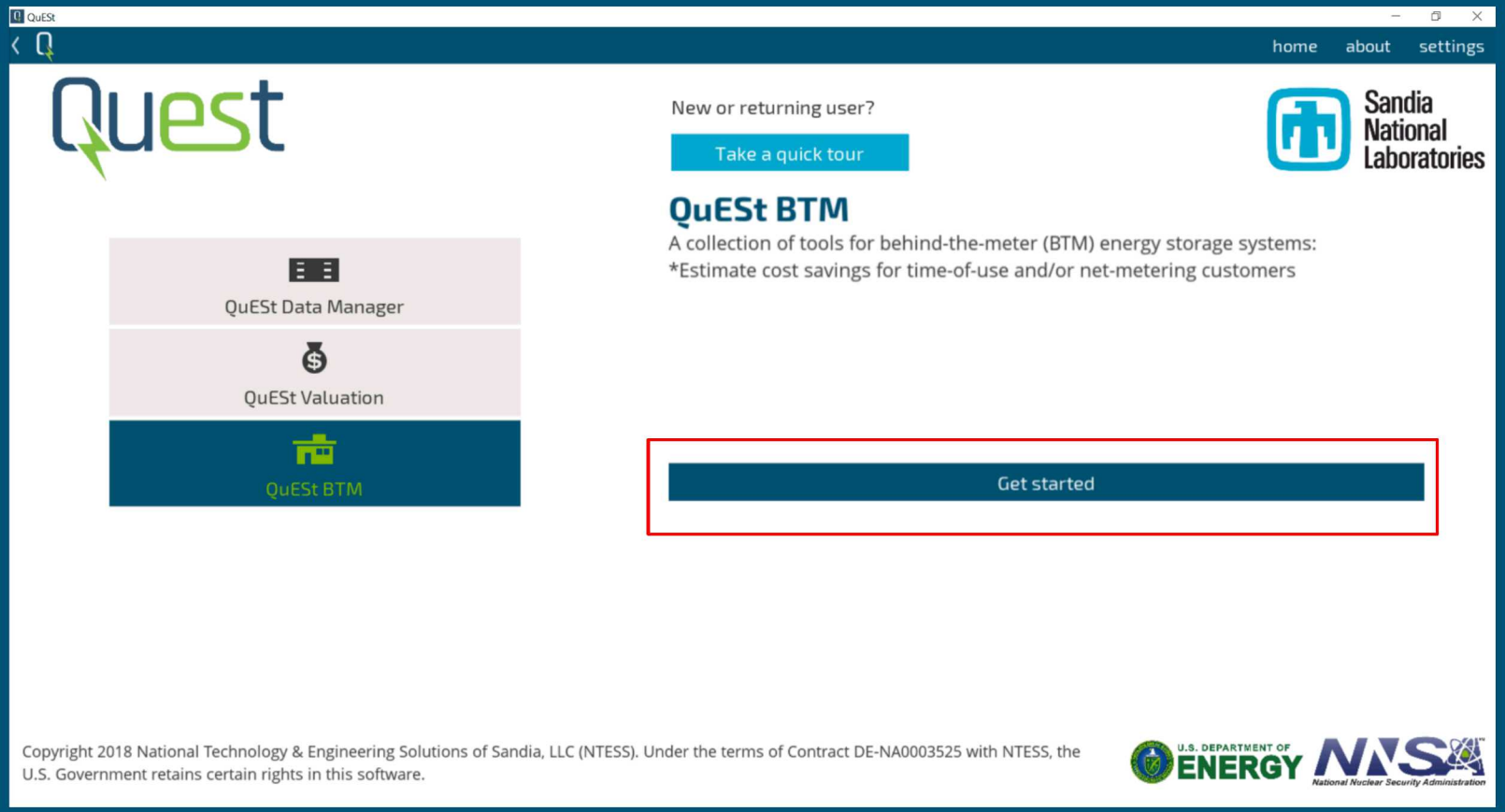
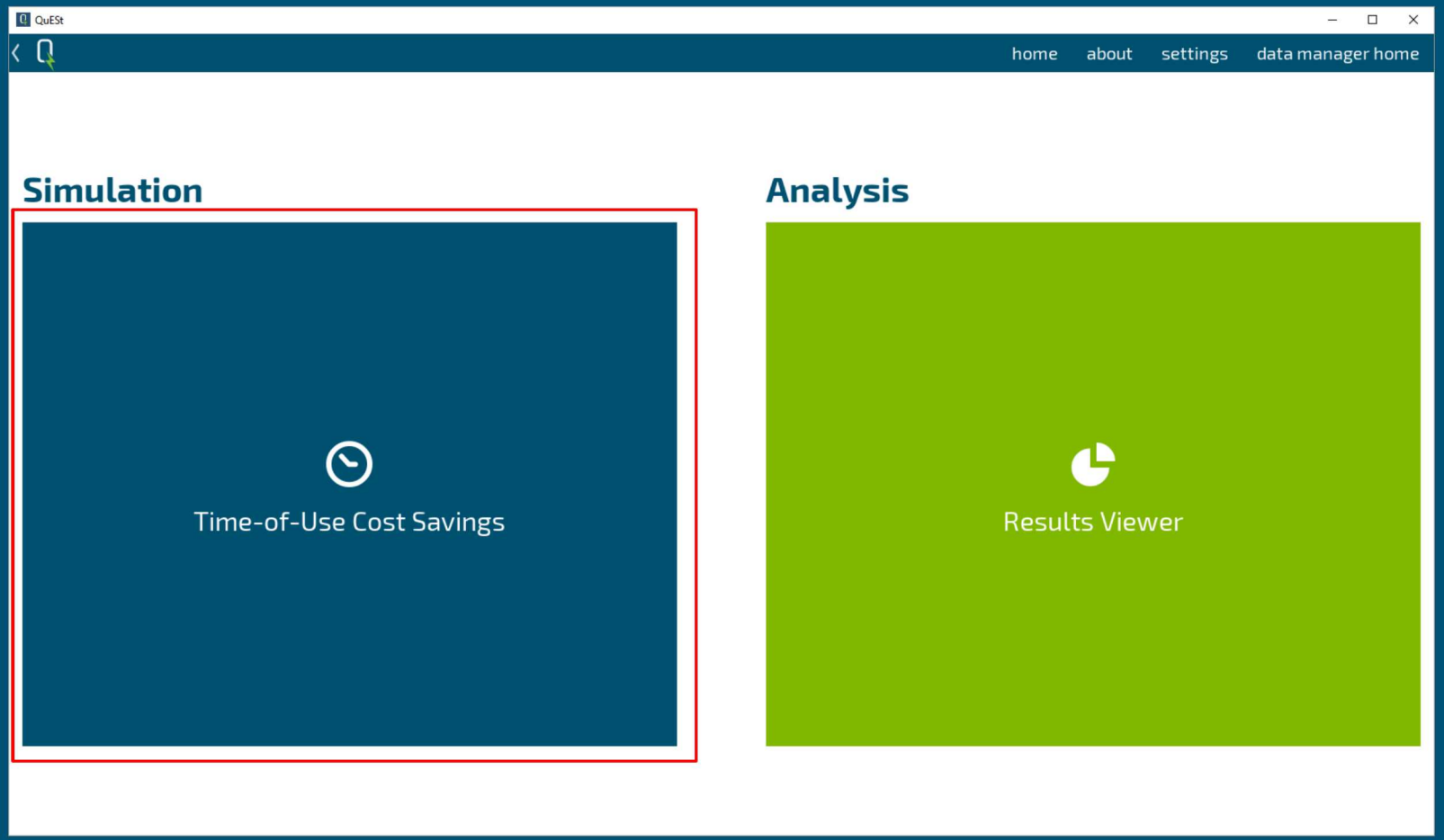


- Now that we have all the data that we need, we can return home and start using QuESt BTM for the analysis.
- We'll use the Time-of-Use Cost Savings wizard.

CASE STUDY: MID-SIZE OFFICE BUILDING WITH PV+STORAGE



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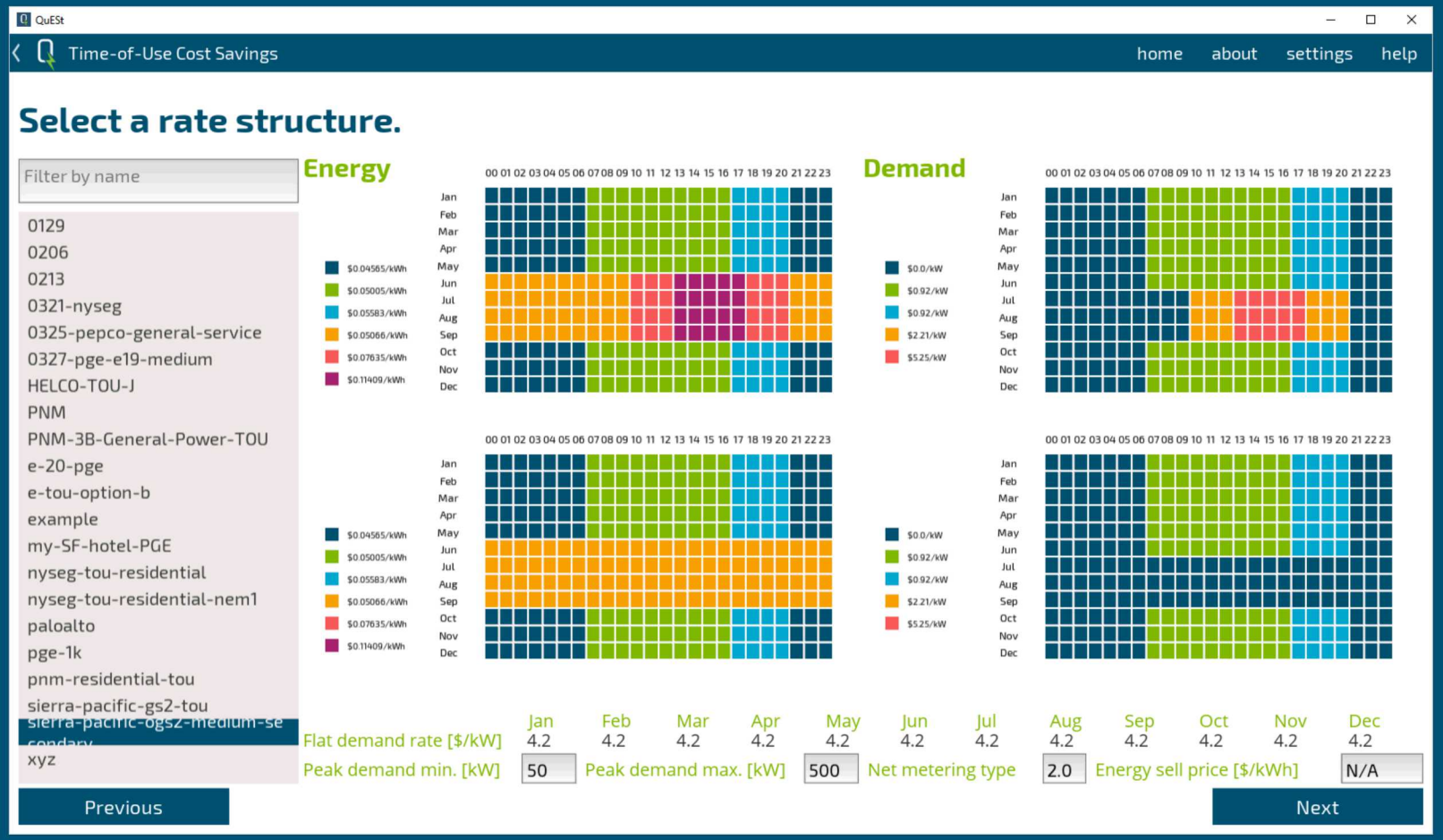
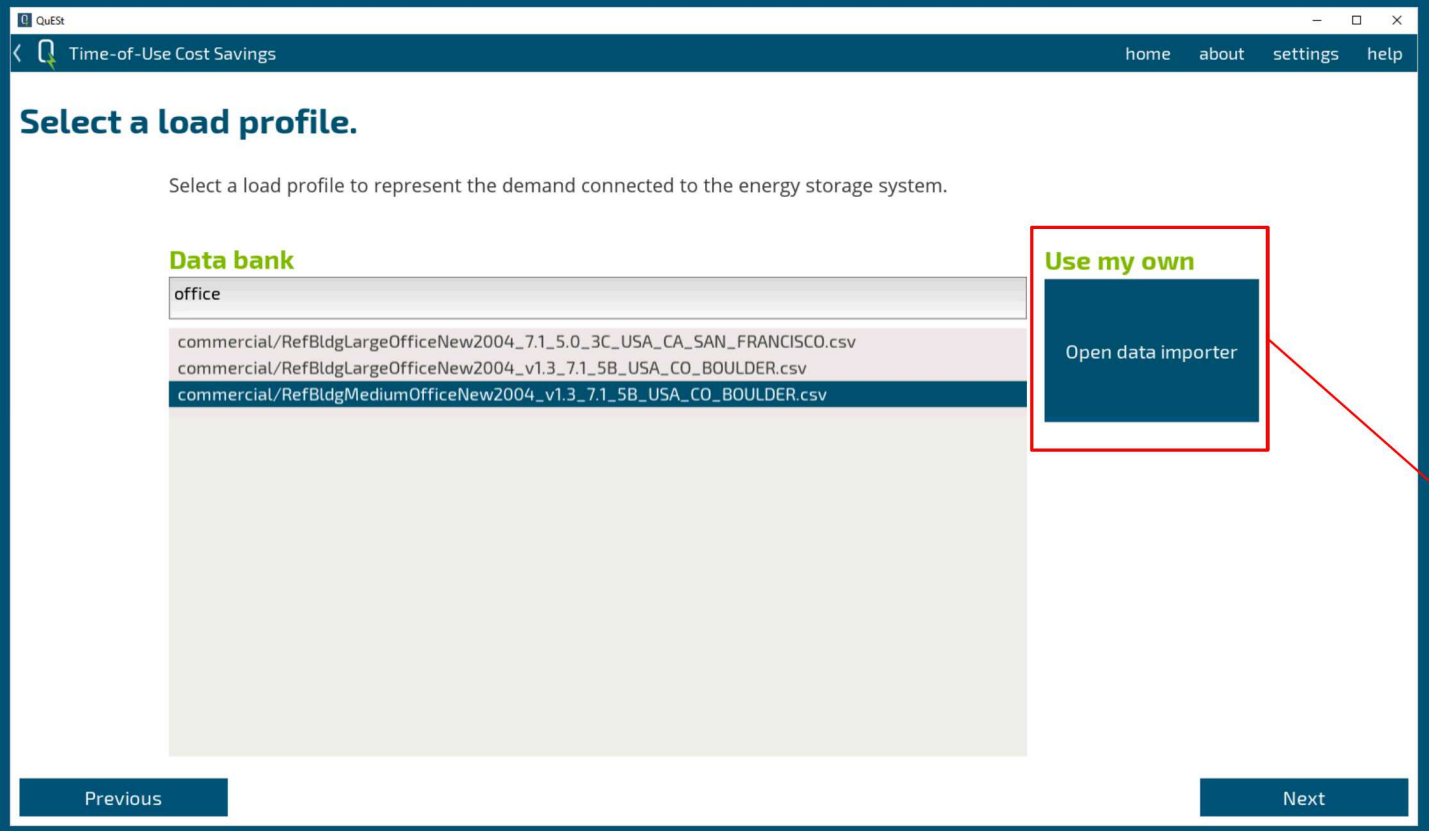


- Proceeding through the wizard, we select the data that we had just downloaded when prompted.
- Our proposed energy storage system is 320 kWh/80 kW, so we'll enter that in.

CASE STUDY: MID-SIZE OFFICE BUILDING WITH PV+STORAGE



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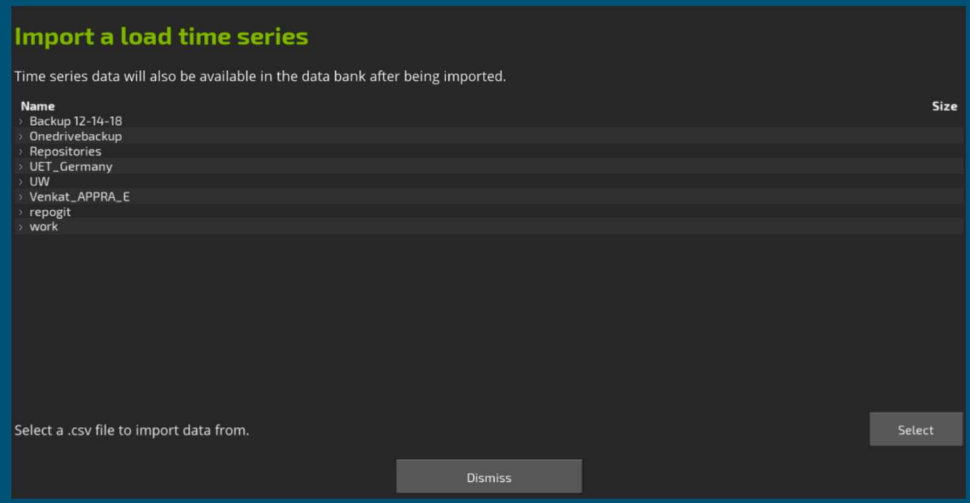

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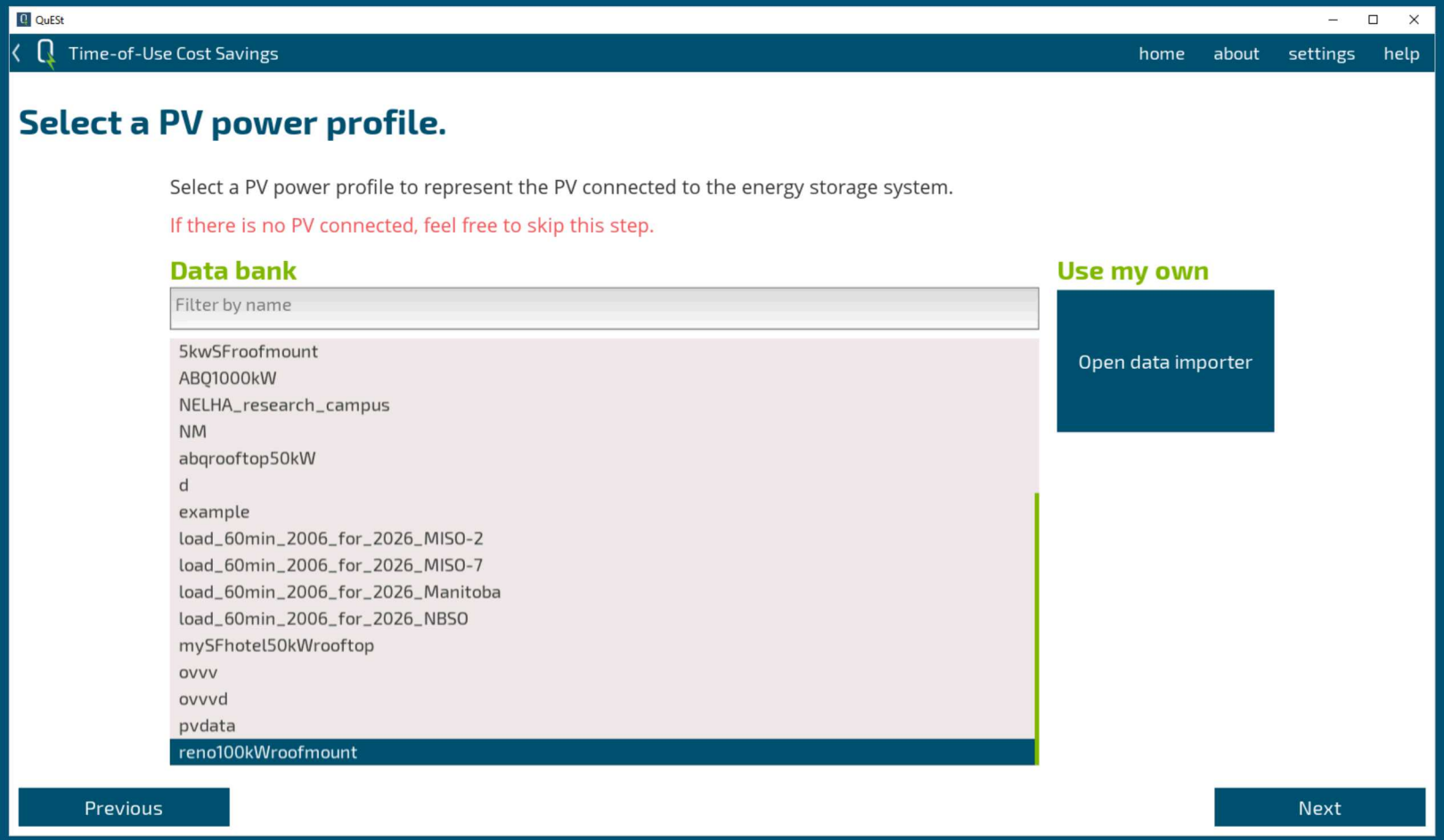

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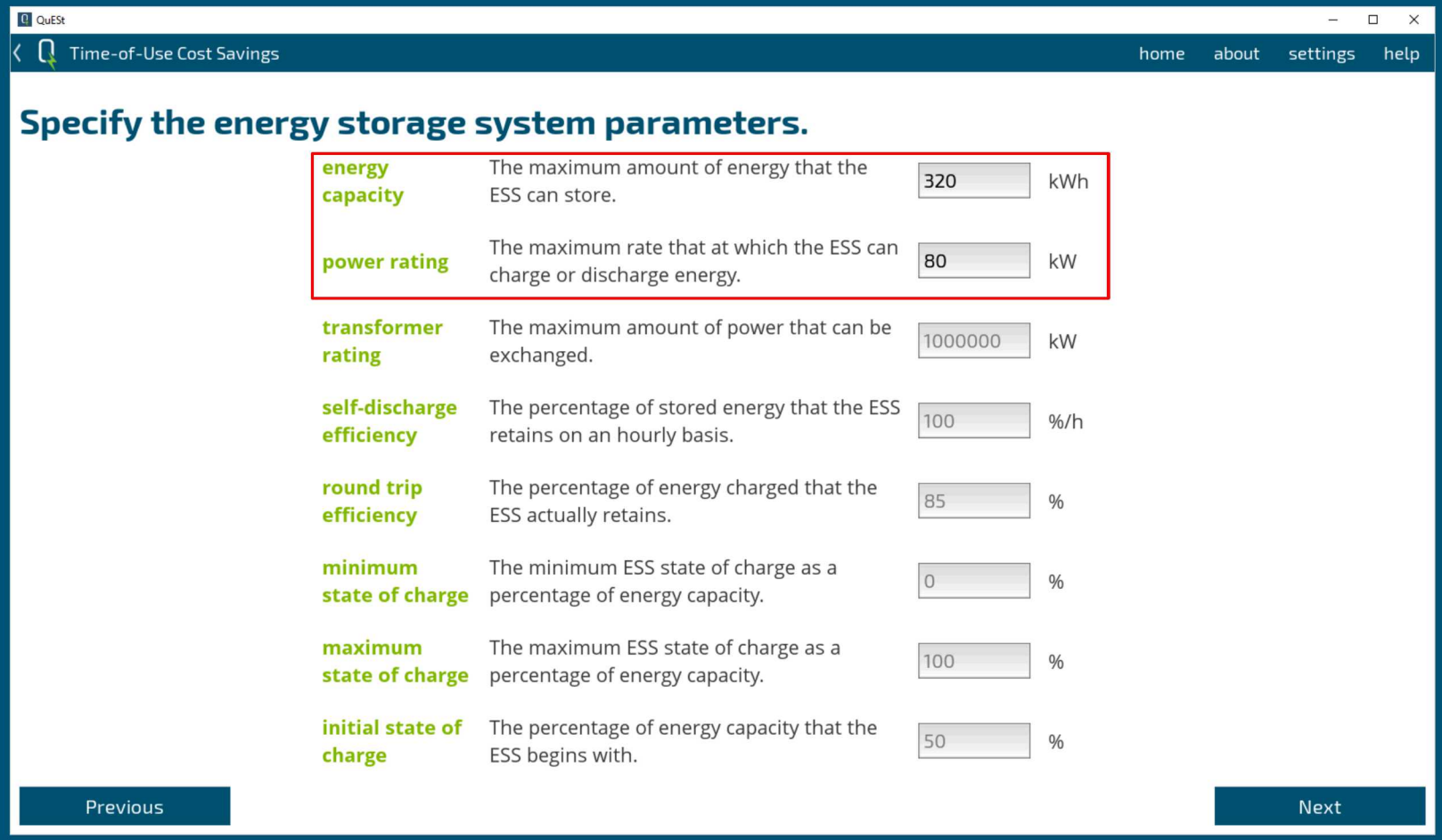

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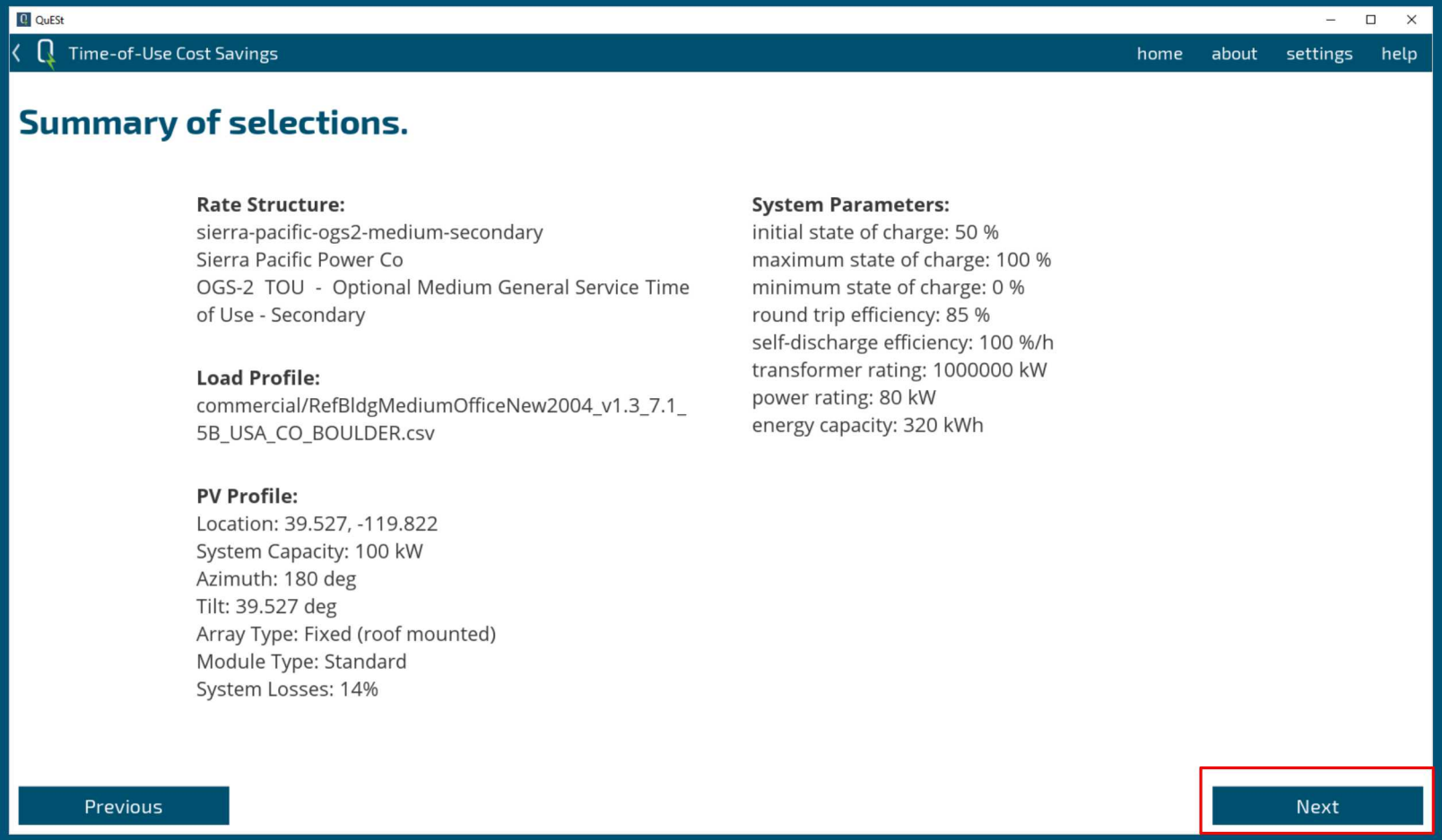
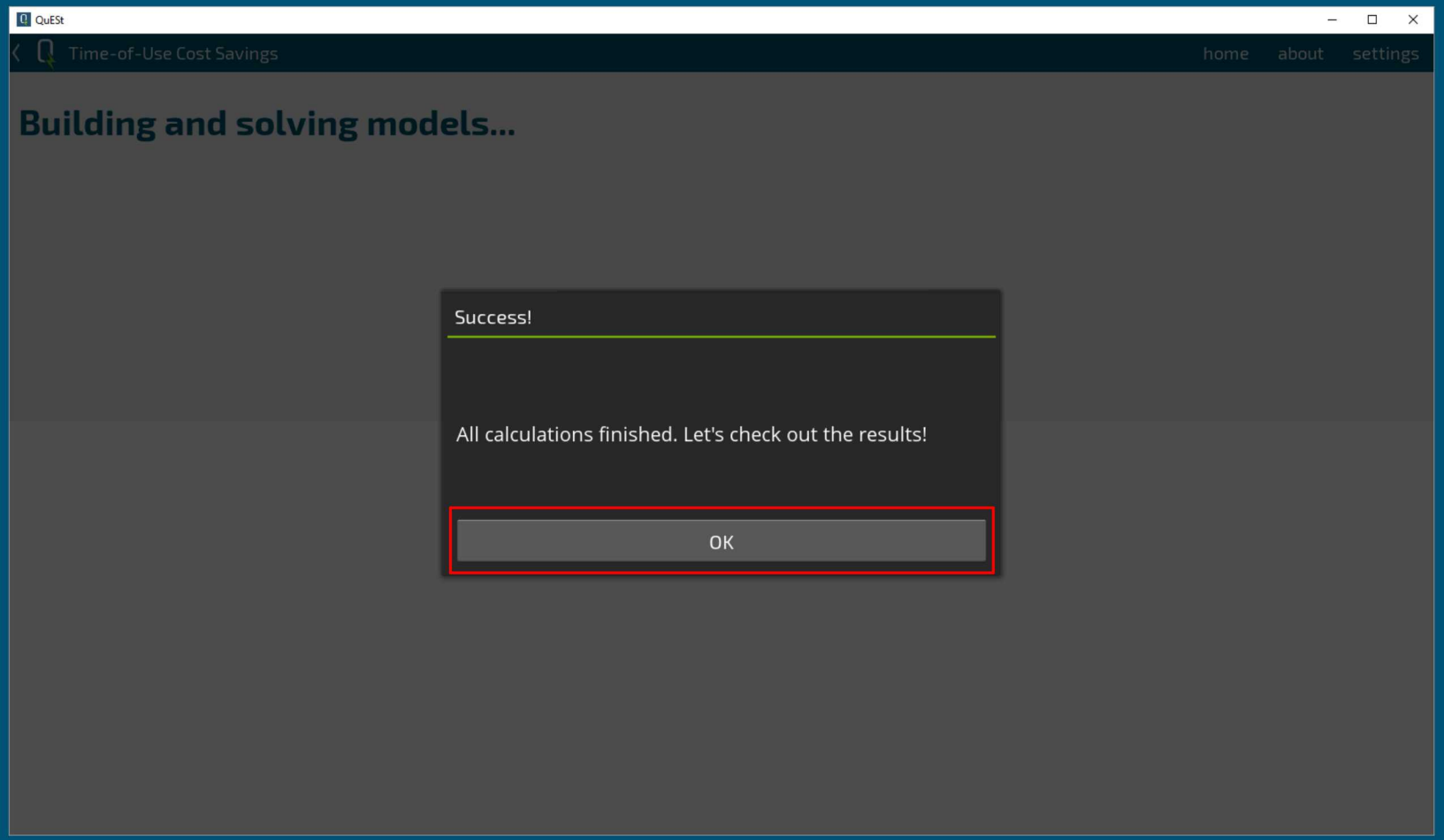


- Once everything's setup, we'll click "Next" to initiate the model building and solution process.
- In the background, the specified data is being loaded, the optimization models are being constructed, and the models are being solved.
- After a brief wait, a prompt will notify you that the computation is complete.

CASE STUDY: MID-SIZE APARTMENT BUILDING WITH PV+STORAGE



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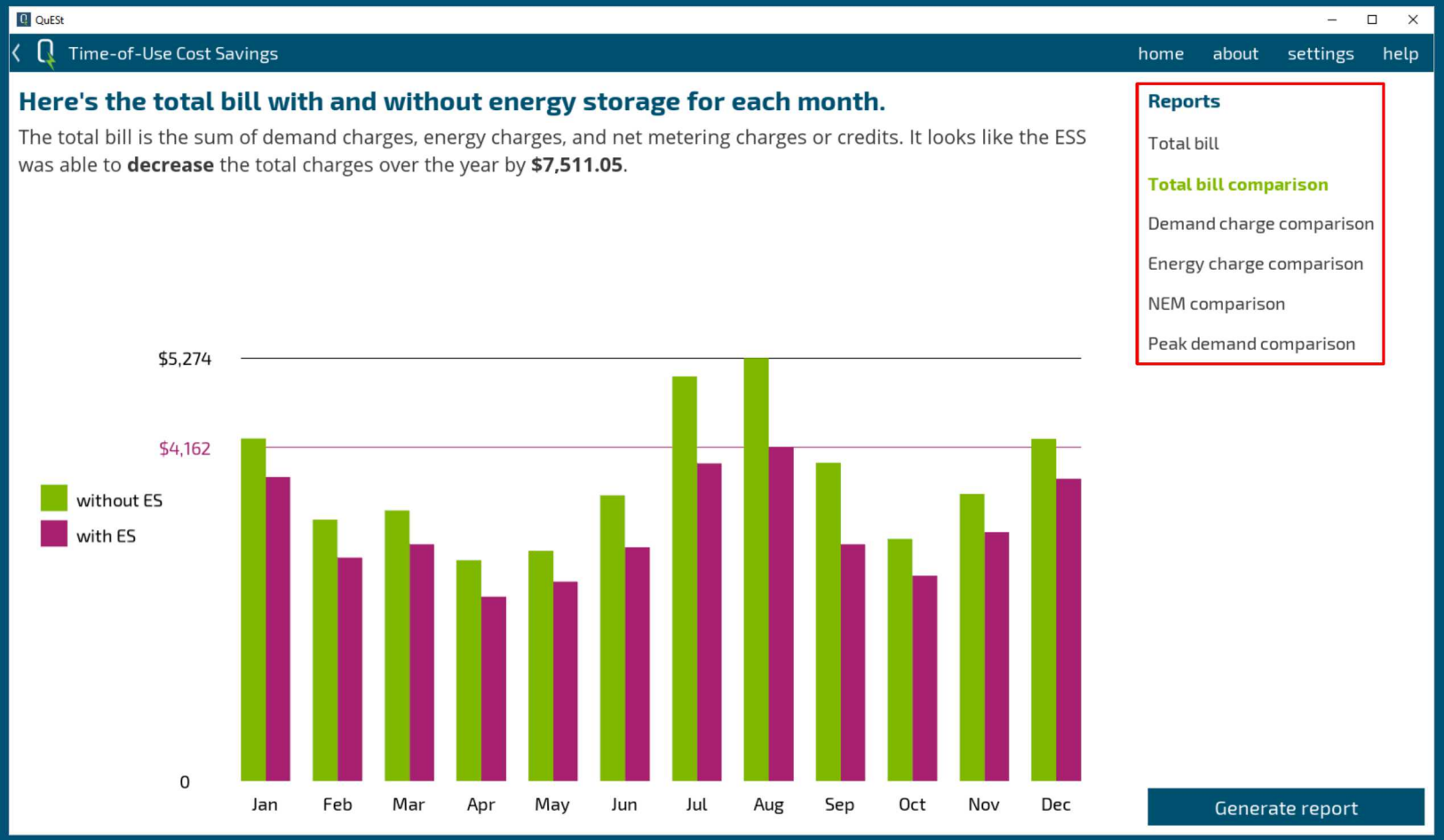

- We can now view the wizard's report of results and view several summary graphics.
- Based on the calculations, the addition of the energy storage system reduced annual charges by about $7,511.
- This was mostly due to demand charge reduction.
- Peak demand each month was reduced by about 80 kW.

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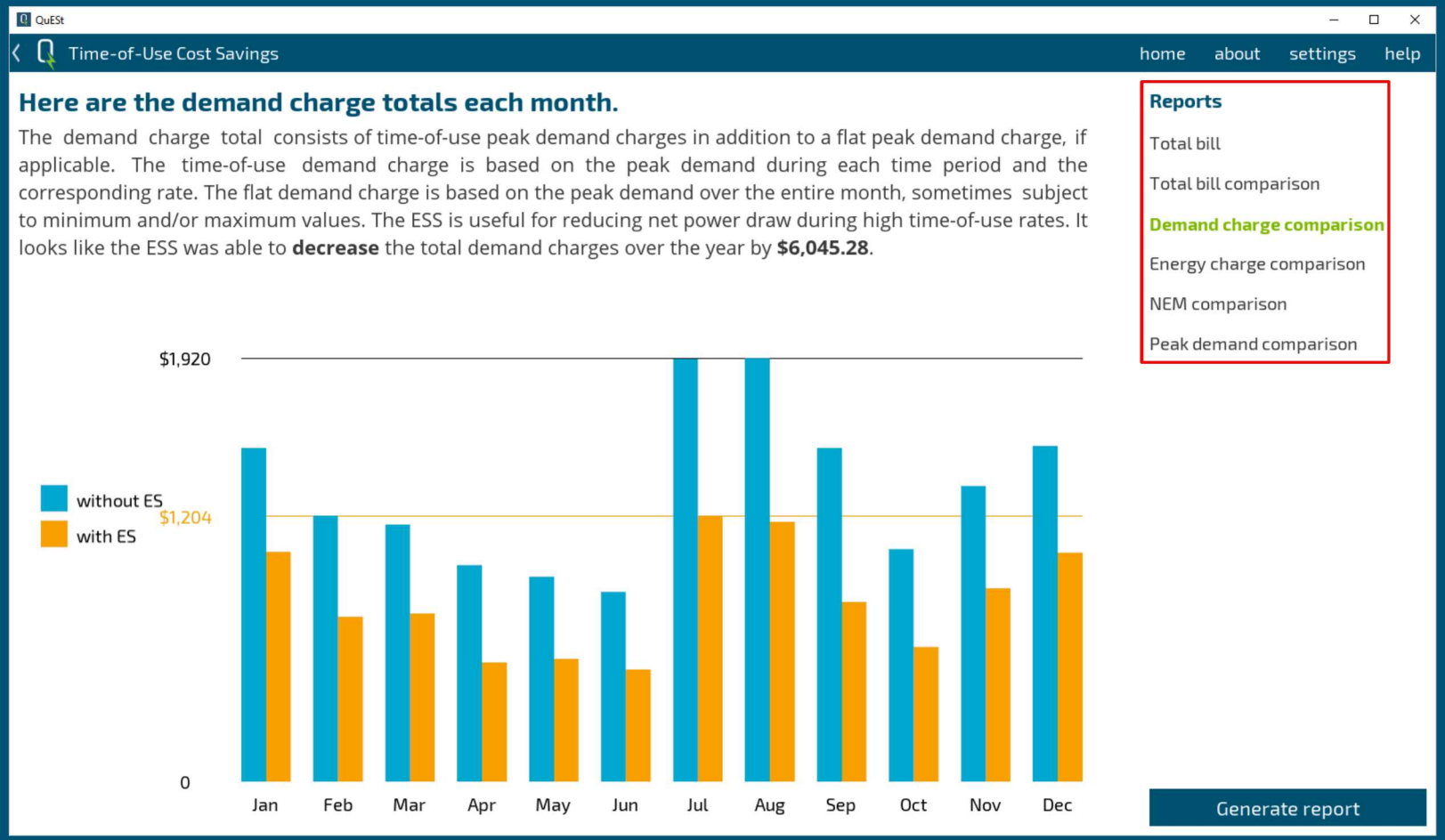

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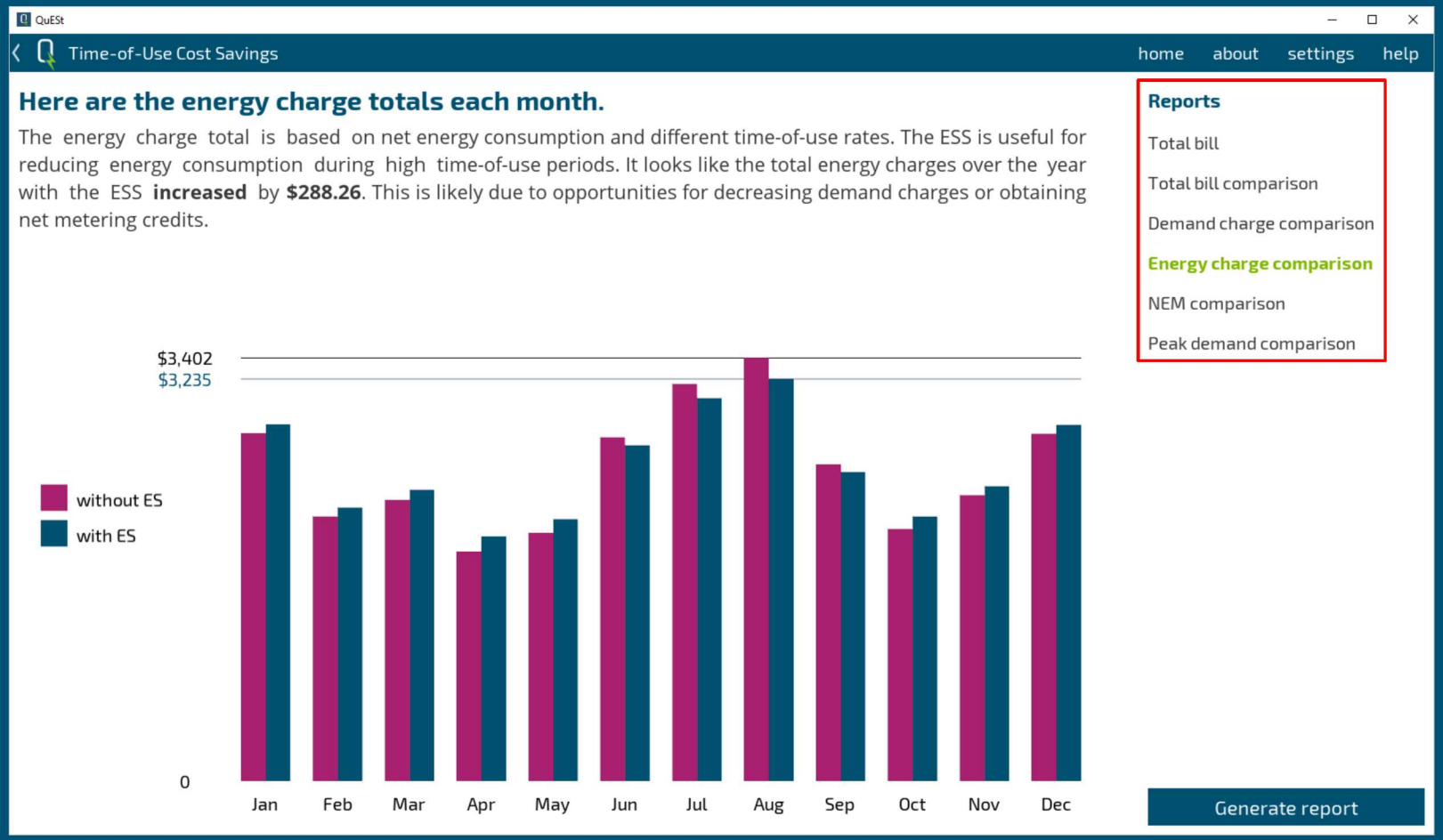

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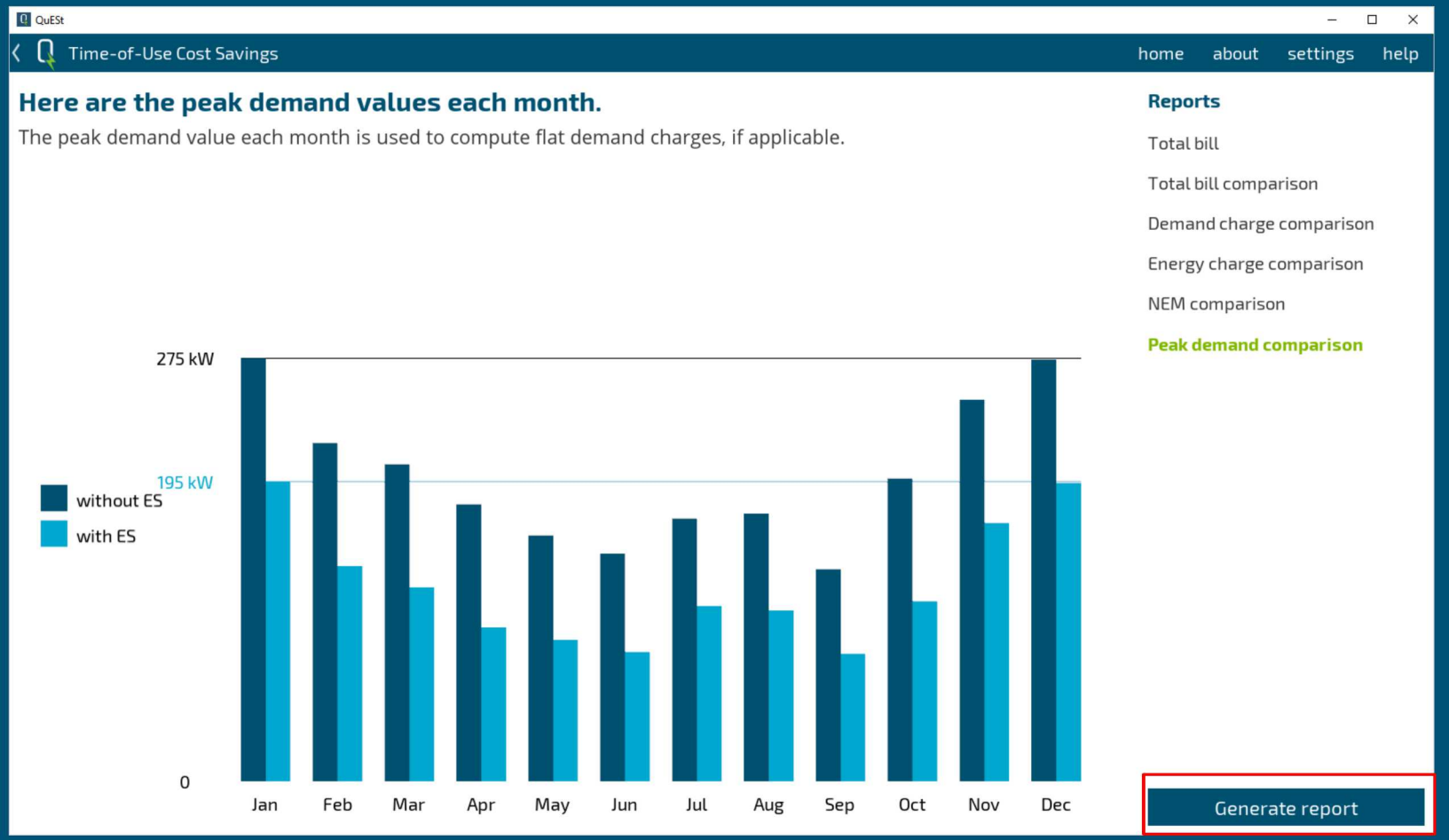

- We can also create a summary report that includes formulation details and the results.

CASE STUDY: MID-SIZE APARTMENT BUILDING WITH PV+STORAGE

Quest

Behind-the-Meter Energy Storage Cost Savings Report

Autogenerated using QuESt BTM

January 16, 2020

This report shows the results from optimizations performed by QuESt BTM.

Scenario Summary

Utility: Sierra Pacific Power Co

Rate Structure: OGS-2 TOU - Optional Medium General Service Time of Use - Secondary

Load Profile: commercial/RefBldgMediumOfficeNew2004_v1.3_7.1_5B_USA_CO_BOULDER.csv

Photovoltaic Power Profile

Location: 39.527, -119.822
System Capacity: 100 kW
Azimuth: 180 deg
Tilt: 39.527 deg
Array Type: Fixed (roof mounted)
Module Type: Standard
System Losses: 14%

Energy Storage System Parameters

Parameter	Value	Units
initial state of charge	50	%
maximum state of charge	100	%
minimum state of charge	0	%
round trip efficiency	85	%
self-discharge efficiency	100	%/h
transformer rating	1000000	kW
power rating	80	kW
energy capacity	320	kWh

Table 1: Energy Storage Device Characteristics

- We can also create a summary report that includes formulation details and the results.

CASE STUDY: MID-SIZE APARTMENT BUILDING WITH PV+STORAGE

We can retry the wizard with different energy storage system parameters. Or we can try different PV/load profiles, rate structures, etc.

Is the energy storage system worth it? It will depend on the financials of acquiring and operating it… but we have an estimate on its performance value potential.

FUTURE PLANS AND WRAP-UP

- Develop new applications and enhance existing ones
  - Integrated resource planning tools to meet RPS
  - Optimizing with costs
  - Implement different charging schemes to satisfy ITC requirements
  - Resilience applications
  - T&D deferral
  - More value streams
  - RFP templates
- Release API/Library
- Webinars, tutorials, workshops
- Integrate user feedback and requests

ACKNOWLEDGMENTS

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.

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Follow us on GitHub:

github.com/rconcep/snl-quest