Energy Storage Technology Advancement Partnership (ESTAP) Webinar

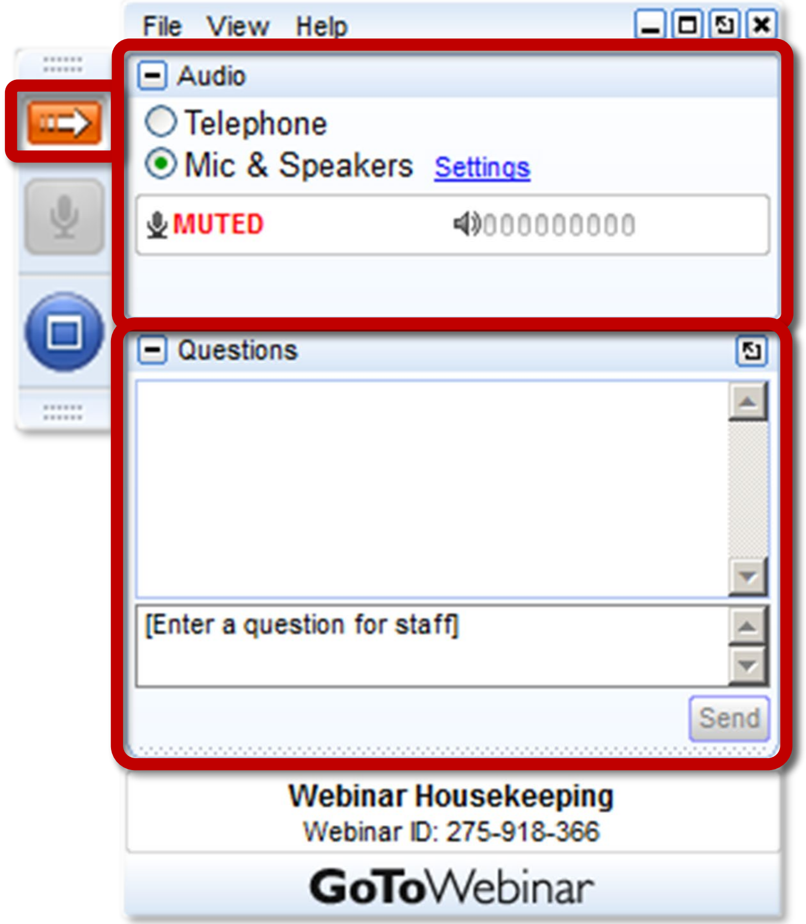
QuEST:
Optimizing Energy Storage Tool

Hosted by
Seth Mullendore
Clean Energy States Alliance

November 6, 2019

U.S. DEPARTMENT OF ENERGY
Clean Energy States Alliance
Sandia National Laboratories

Housekeeping



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Clean Energy States Alliance

Clean Energy States Alliance

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DEPARTMENT OF ENERGY & ENVIRONMENT

Energy Trust of Oregon

IOWA economic development

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IPA ILLINOIS POWER AGENCY

NEW MEXICO emnrd Energy, Minerals and Natural Resources Department

OEI Wisconsin Office of Energy Innovation

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BPU New Jersey's cleanenergy program™ njcleanenergy.com

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Energy Storage Technology Advancement Partnership (ESTAP) (bit.ly/ESTAP)

ESTAP is supported by the U.S. Department of Energy Office of Electricity and Sandia National Laboratories, and is managed by CESA.

ESTAP Key Activities:

1. Disseminate information to stakeholders
    - ESTAP listserv >5,000 members
    - Webinars, conferences, information updates, surveys.
2. Facilitate public/private partnerships to support joint federal/state energy storage demonstration project deployment
3. Support state energy storage efforts with technical, policy and program assistance

U.S. DEPARTMENT OF ENERGY

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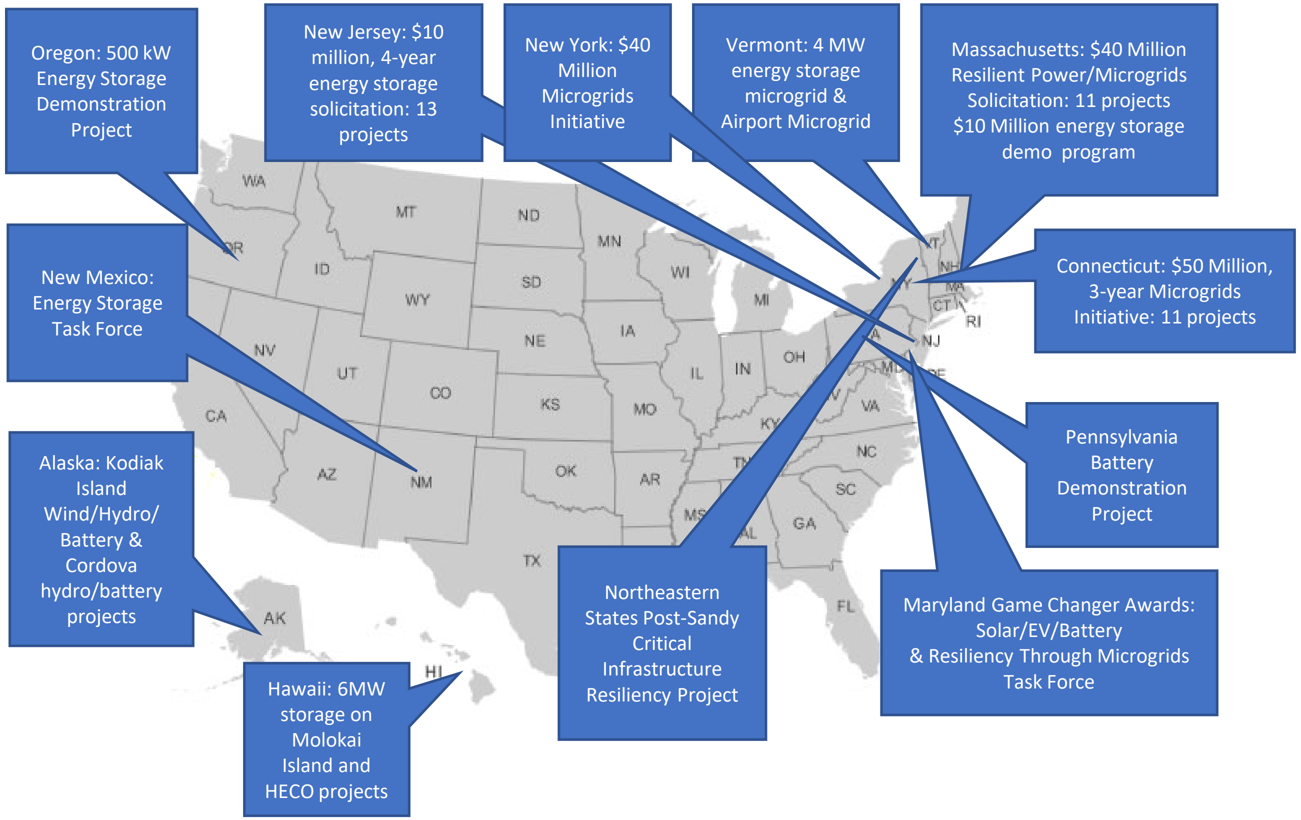
Clean Energy States Alliance

ESTAP Project Locations:



Webinar Speakers

Ricky Concepcion
Sandia National Laboratories

Tu Nguyen
Sandia National Laboratories

Seth Mullendore
Clean Energy States Alliance (moderator)

Thank you for attending our webinar

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Upcoming Webinar

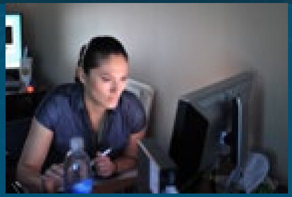
Energy Storage 101: Part 3 – Applications and Economics
Tuesday, November 19, 2019 at 1-2 pm ET

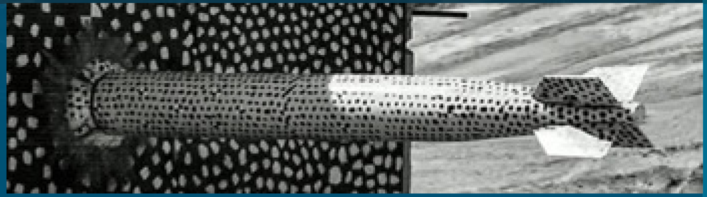
This ESTAP webinar will look at when and where energy storage opportunities exist, which services can be effectively "stacked," how revenue-generating opportunities are sometimes limited due to market rules or utility tariffs, and what future opportunities might arise with changes in market rules and regulations.

Learn more and register at: www.cesa.org/webinars

Quest

An Energy Storage Application Suite





PRESENTED BY

Ricky Concepcion, Tu Nguyen

Sandia National Laboratories

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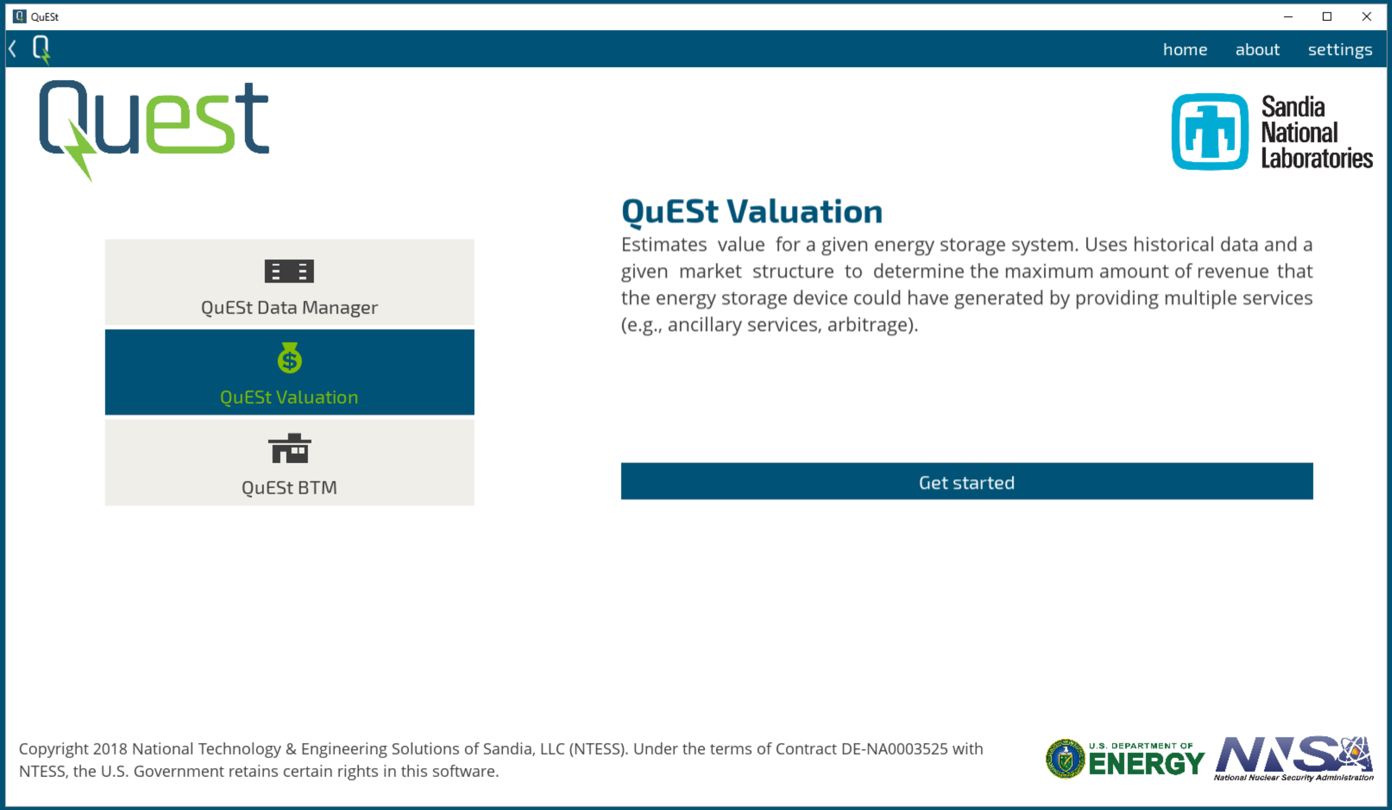
SAND2019-13567 PE

OUTLINE

- QuESt overview
- How to obtain QuESt
- QuESt applications
  - QuESt Valuation
  - QuESt Data Manager
  - QuESt BTM
- Behind-the-meter energy storage systems
- Case study with QuESt: cost savings for large hotel with solar + storage
- Wrap-up and conclusions

OVERVIEW



- 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 1.2 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 tool for energy storage valuation
- For engineers and software developers
  - Open source software project
  - GUI design, application design, Pyomo optimization modeling
  - Pyomo models and other code can be adjusted to fit specific needs
- 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

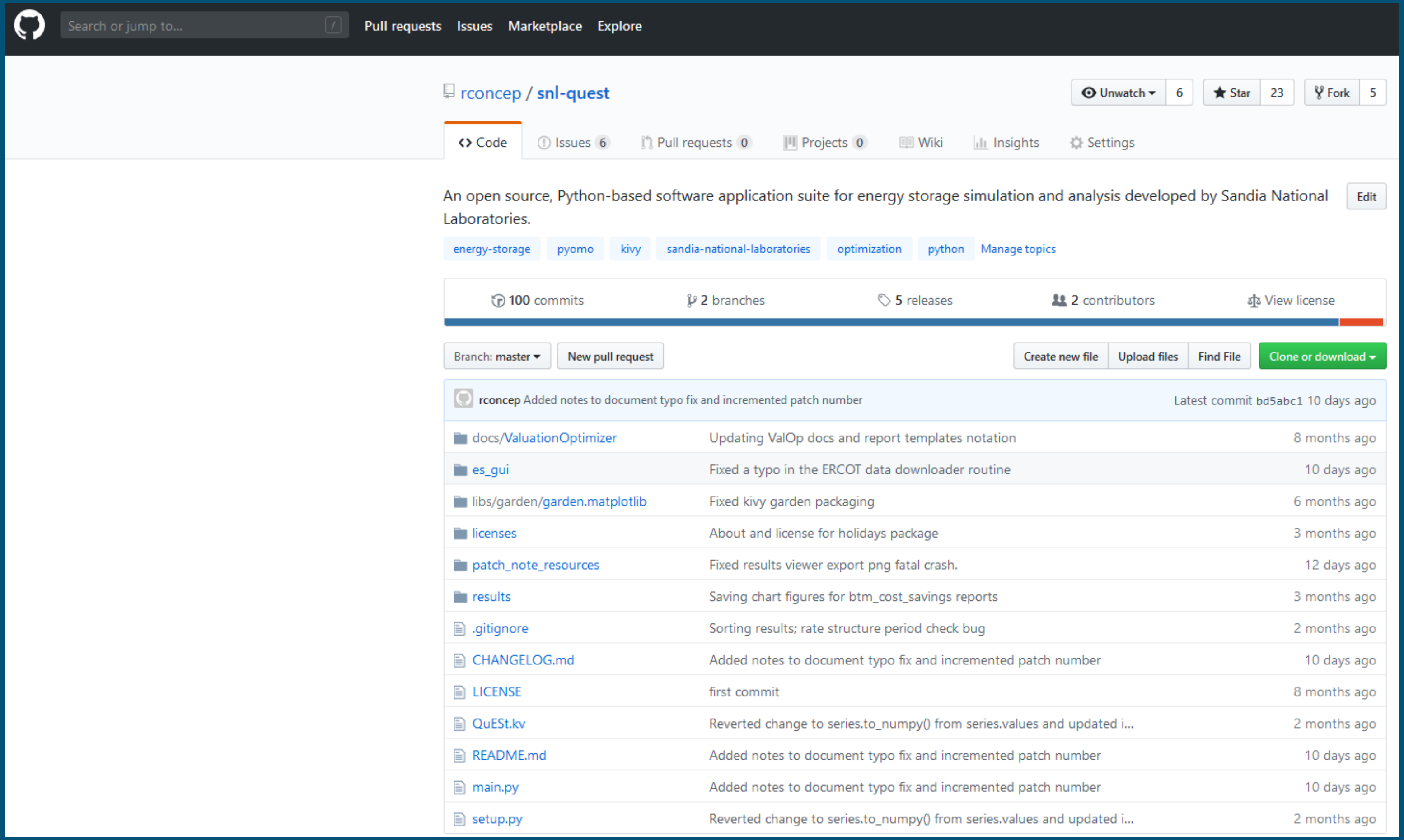
- For most users
- Developed for user experience
- No hassle installation

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

Releases | Tags | Draft a new release

Latest release
1.2.c
bd5abc1

v1.2.c

Edit

rconcep released this 10 days ago

Patch 1.2.c

This patch incorporates a few bug fixes from previous minor revisions. It also introduces an experimental, packaged executable version of QuESt for easier use.

QuESt

- An executable version of QuESt has been released. We are in the process of testing compatibility with a variety of systems and environments, but these executables will allow you to circumvent most of the installation process.
  - No Python installation required; packaged with its own Python environment.
  - Third party solvers for Pyomo still required, but we will look into the possibility of packaging a solver such as GLPK in the archive.
  - Each executable is for a specific operating system. We will start with Windows 10 versions but are looking into OS X (Mojave) versions as well.
  - Packaged using PyInstaller.
  - Once we gather enough feedback that these packages are functional, they will become a staple of each release.
  - The package is available below as `snl-quest-1.2.c-win10.zip` (*not* labeled as source code)
  - To run it, just extract the archive and run the `snl-quest-1.2.c.exe` file. It should launch as if you ran the `python main.py`.

Resolved issues

- An issue where attempting to download ISO/RTO market data for ERCOT resulted in a fatal crash.
- An issue where attempting to export a PNG from a results viewer when solved models were selected but no plot had yet been drawn resulted in a fatal crash.

Assets 3

- snl-quest-1.2.c-win10.zip 61.7 MB
- Source code (zip)
- Source code (tar.gz)

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.

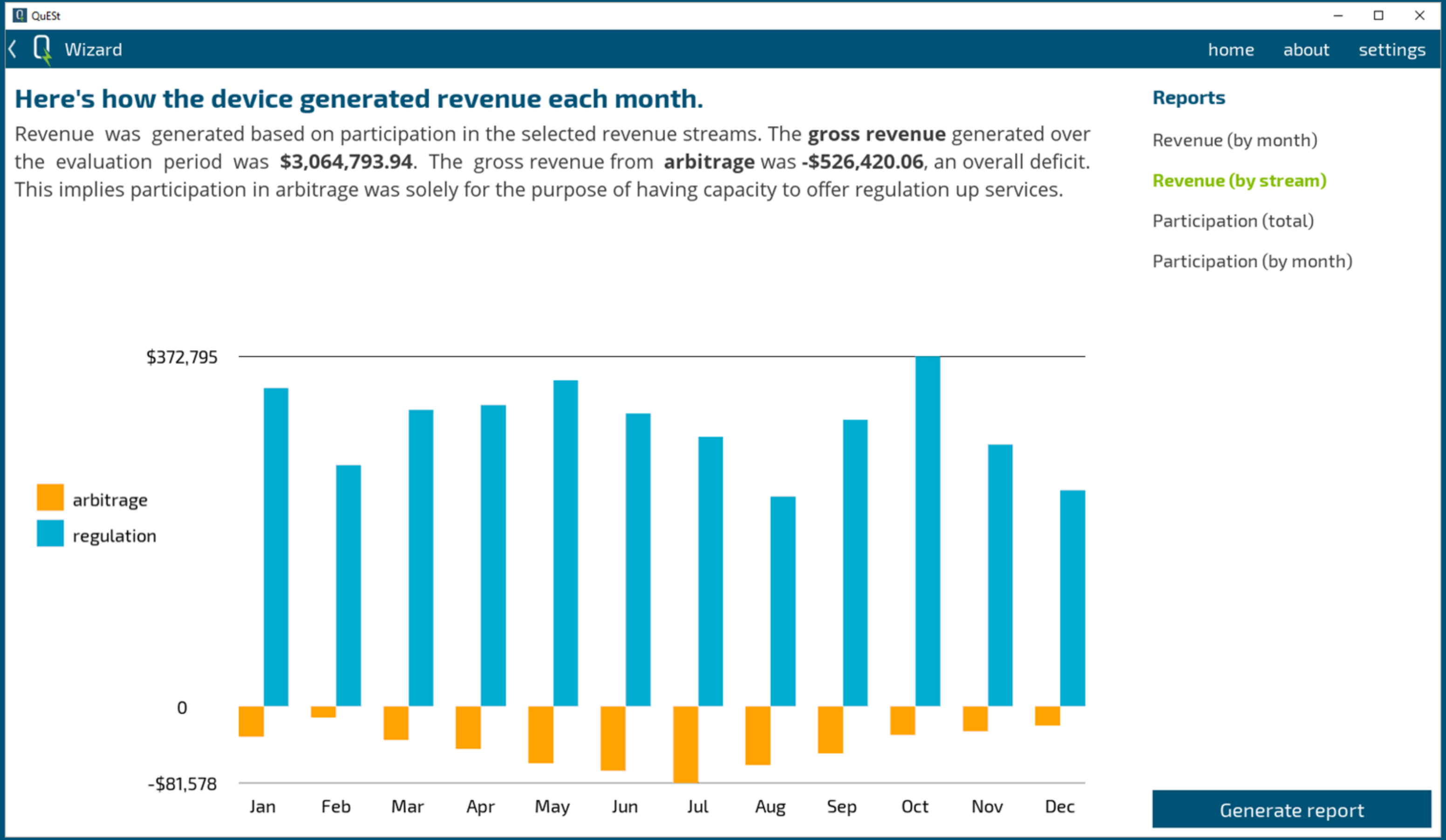
- ISO/RTO market data
- Utility rate structure
- PV profile
- Load profile

Select the appropriate application from the first step.

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

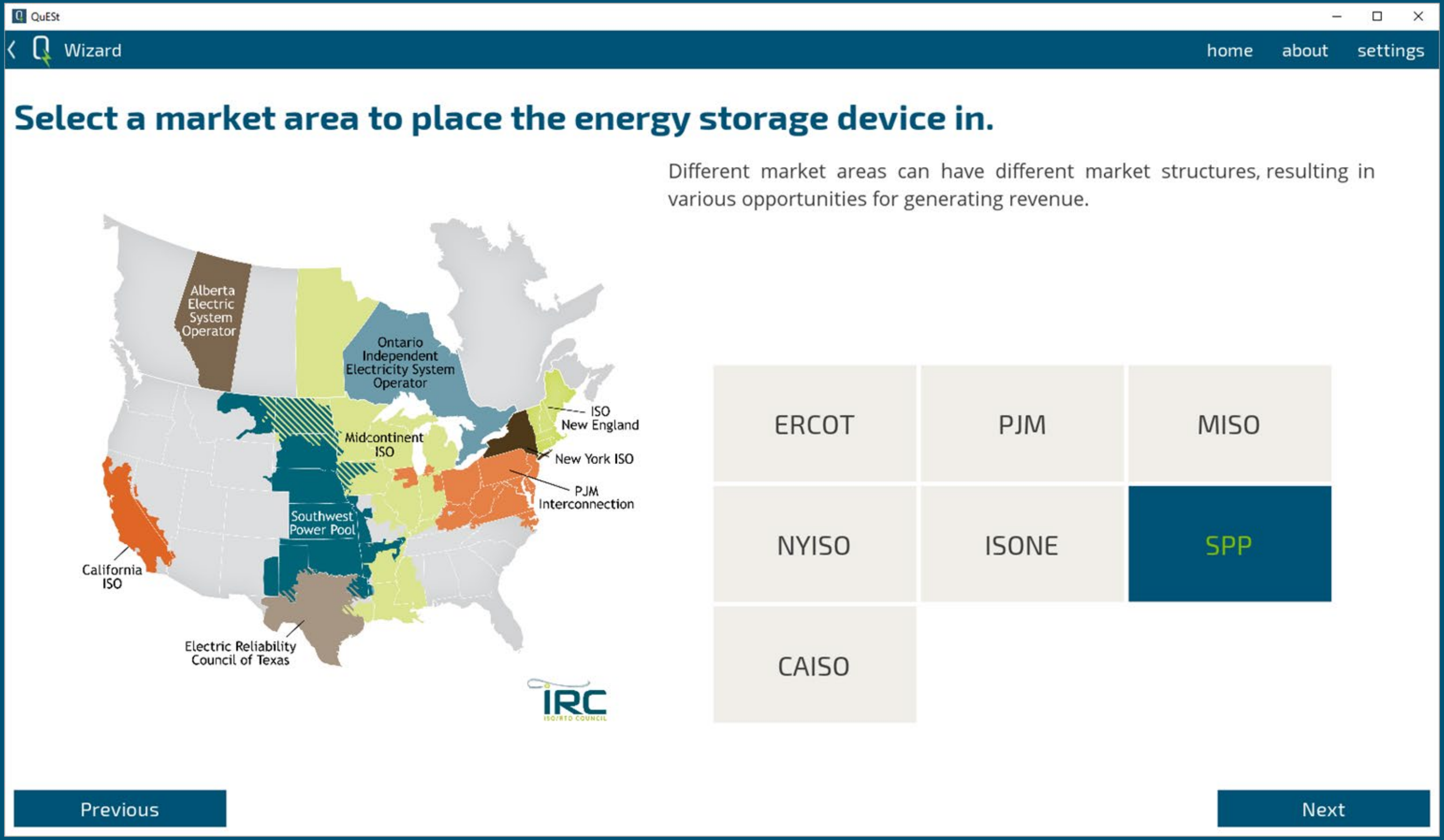
QUEST VALUATION

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?



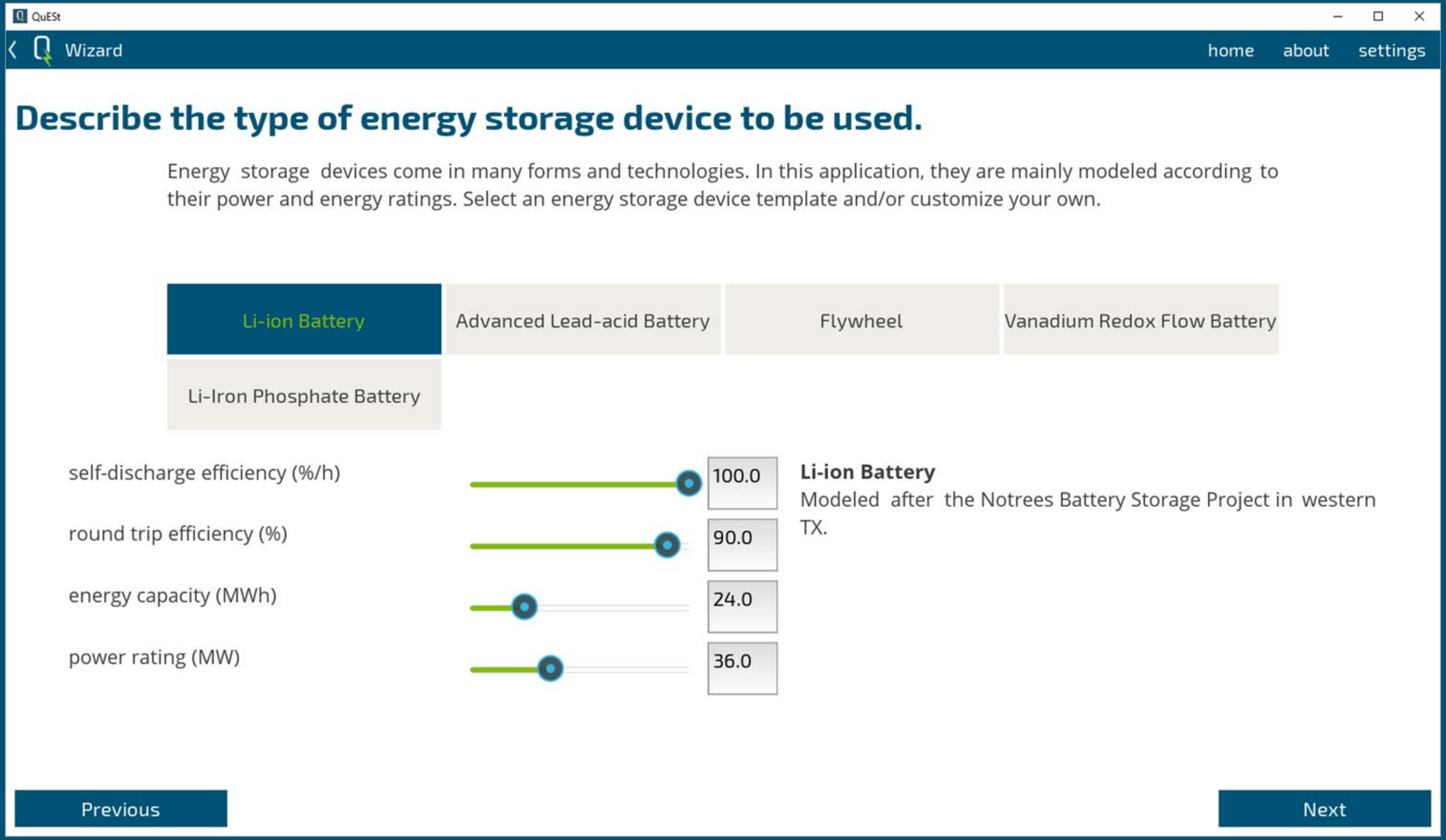
Byrne, Raymond H., et al. "Energy management and optimization methods for grid energy storage systems." *IEEE Access* 6 (2018): 13231-13260.

QUEST VALUATION



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

QUEST VALUATION



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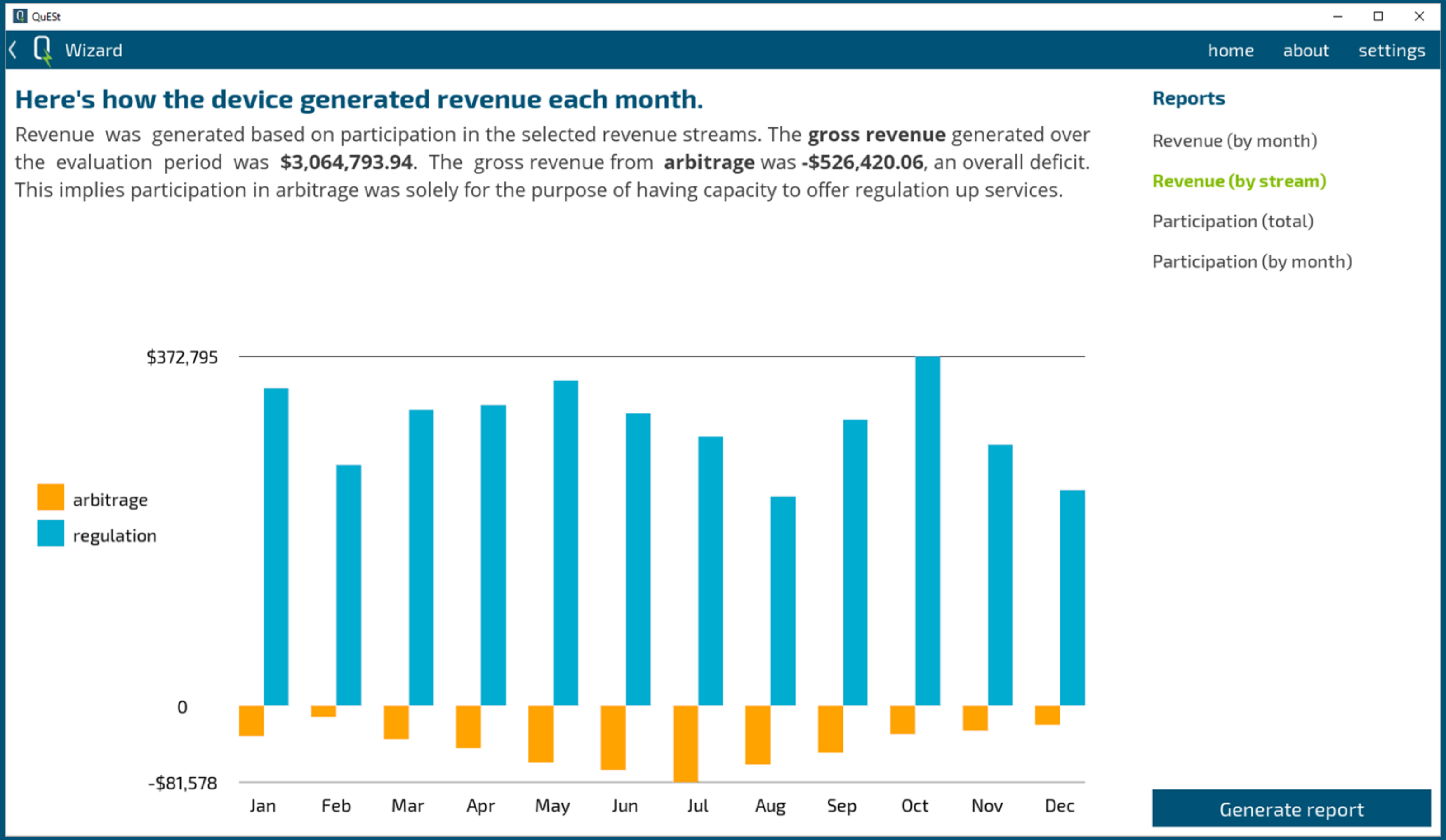
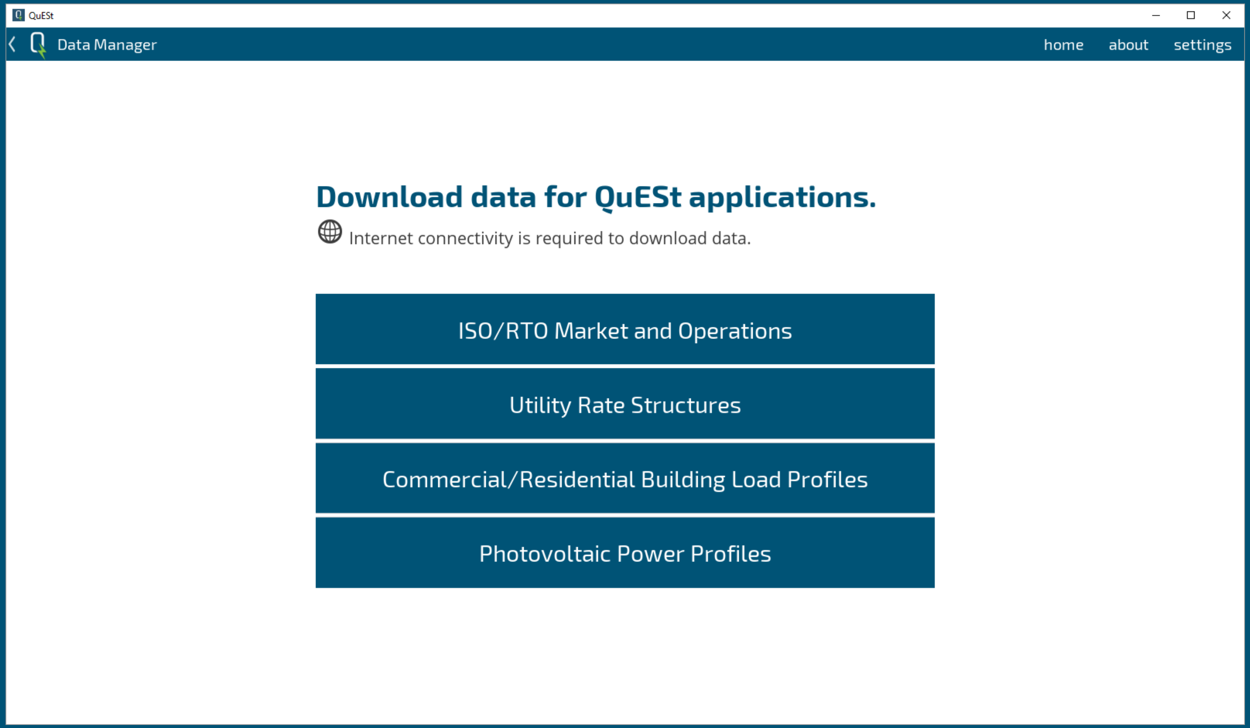
QUEST VALUATION



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

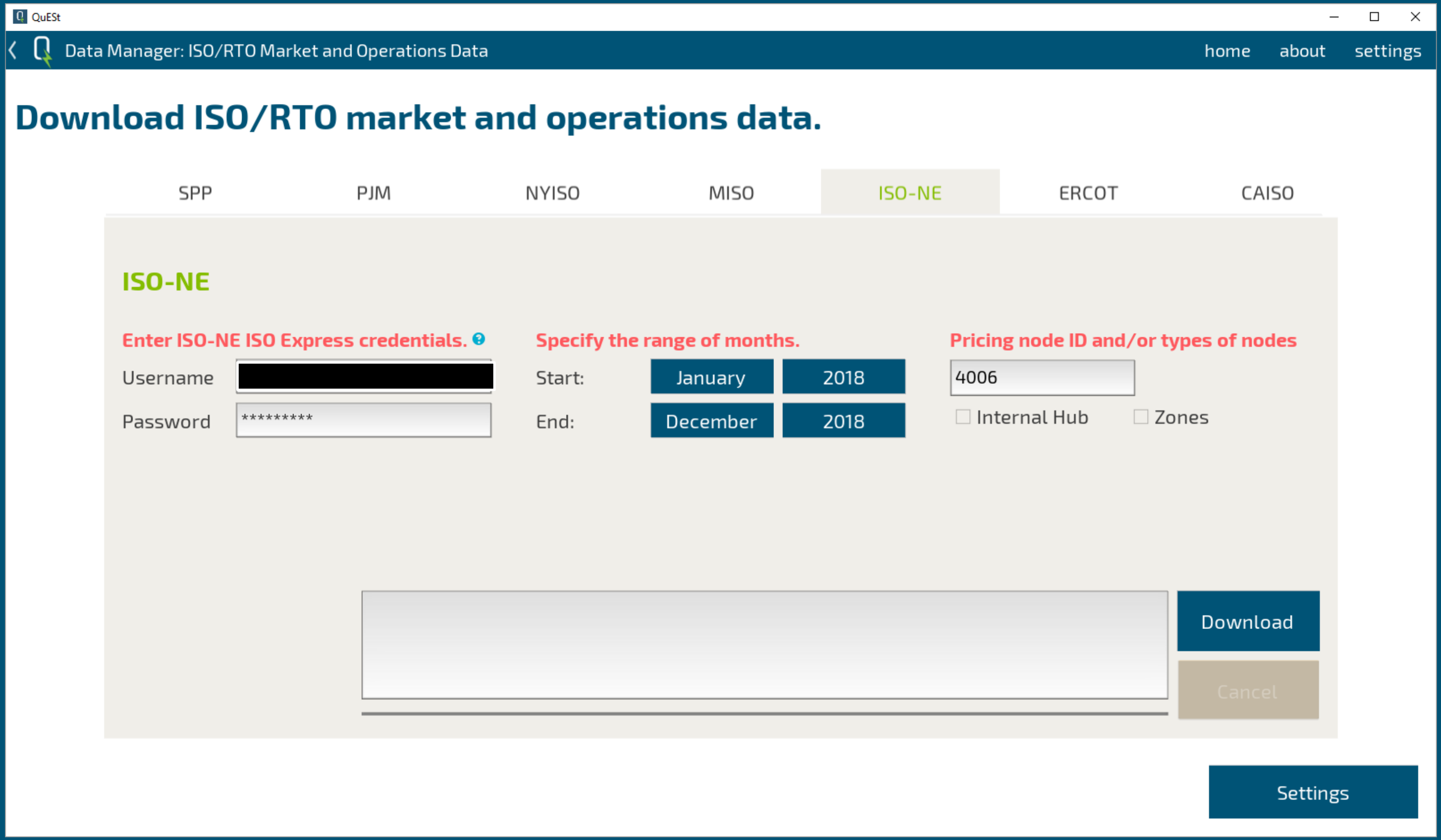
QUEST DATA MANAGER



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

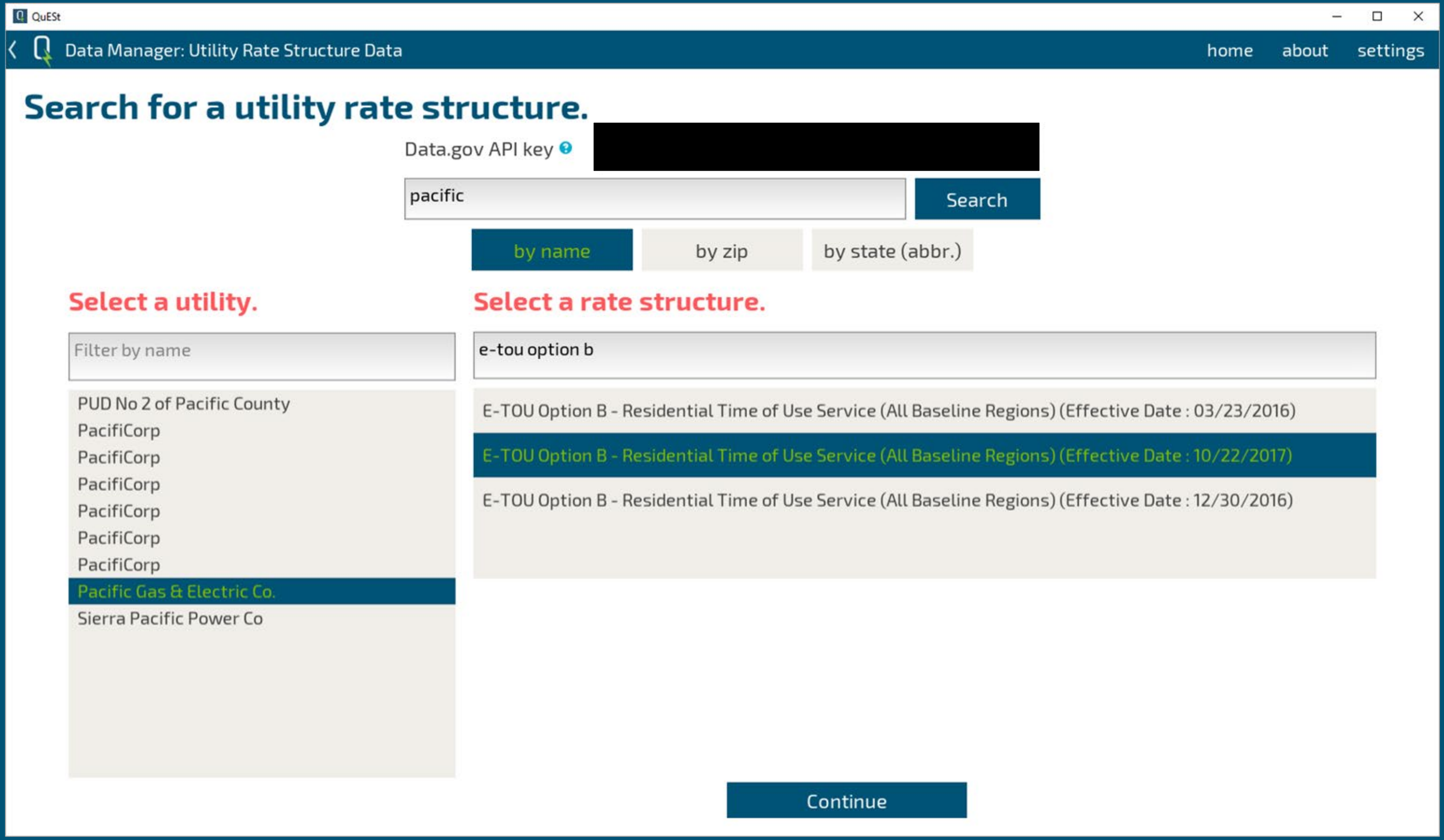
- LMPs, frequency regulation performance/capacity clearing prices, etc. posted by ISOs/RTOs
- U.S. utility rate structures sourced and validated by OpenEI.org
- Commercial and residential hourly load profiles for all TMY3 (typical meteorological year) locations in the U.S. by OpenEI.org
- Hourly photovoltaic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

QUEST DATA MANAGER



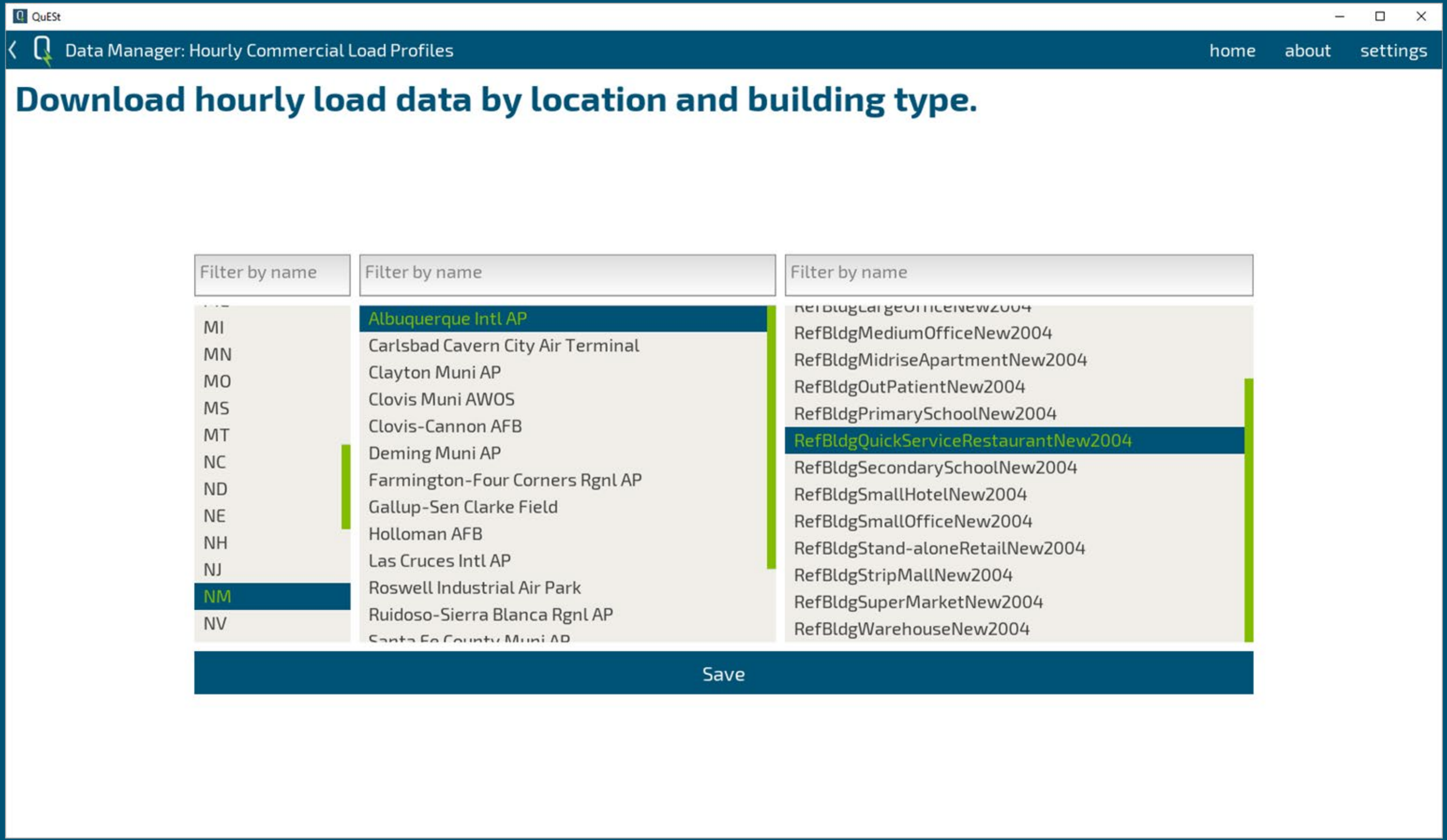
- LMPs, frequency regulation performance/capacity clearing prices, etc. posted by ISOs/RTOs
- Use operator-provided APIs
- Use web crawling libraries to parse marketplace data portals

QUEST DATA MANAGER



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

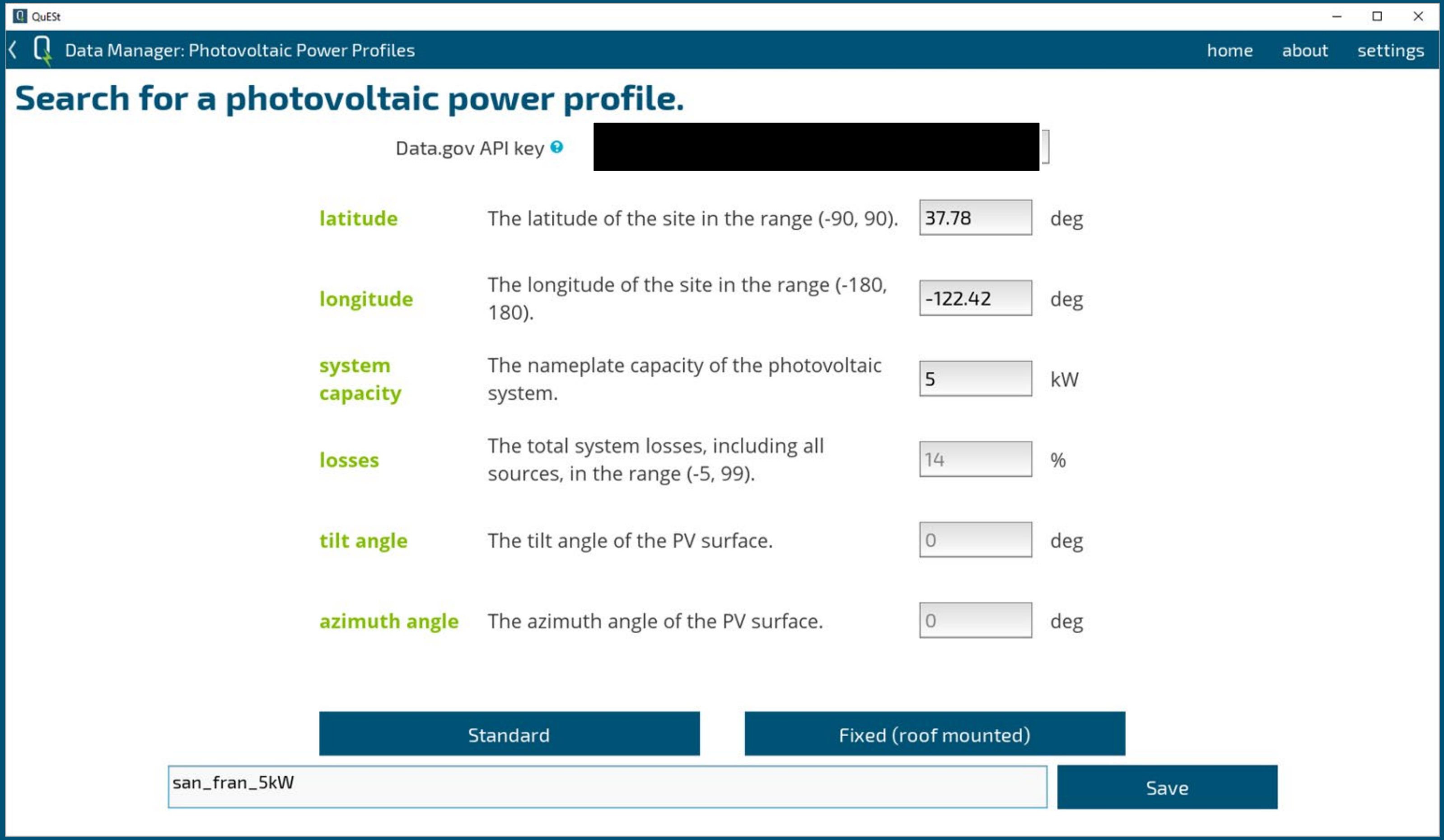
QUEST DATA MANAGER



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

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

QUEST DATA MANAGER



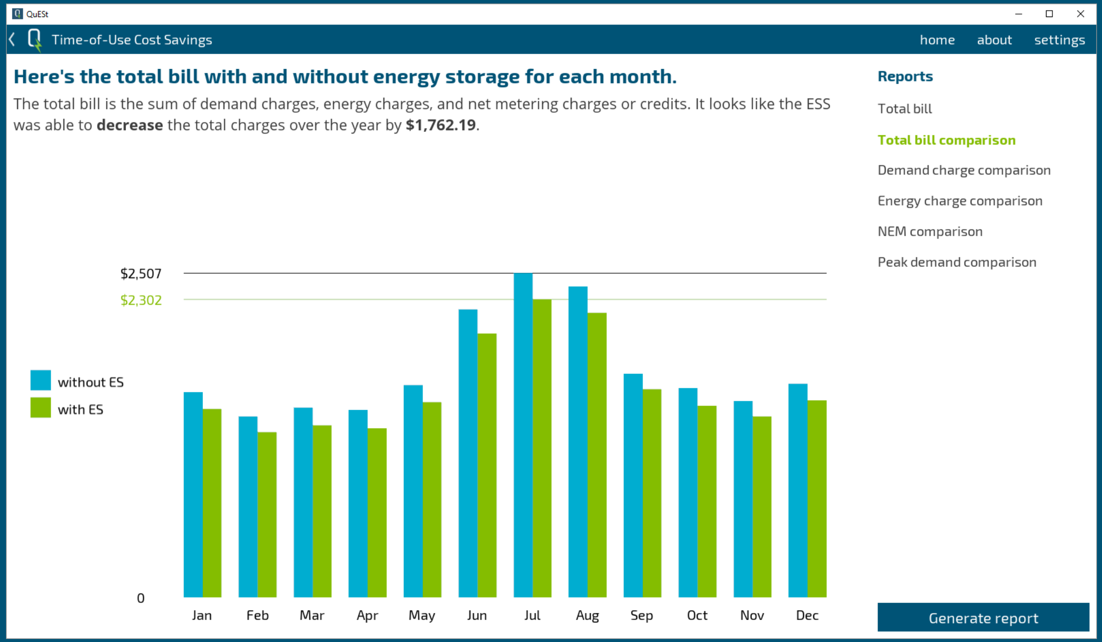
https://pvwatts.nrel.gov/version_6.php

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

QUEST BTM

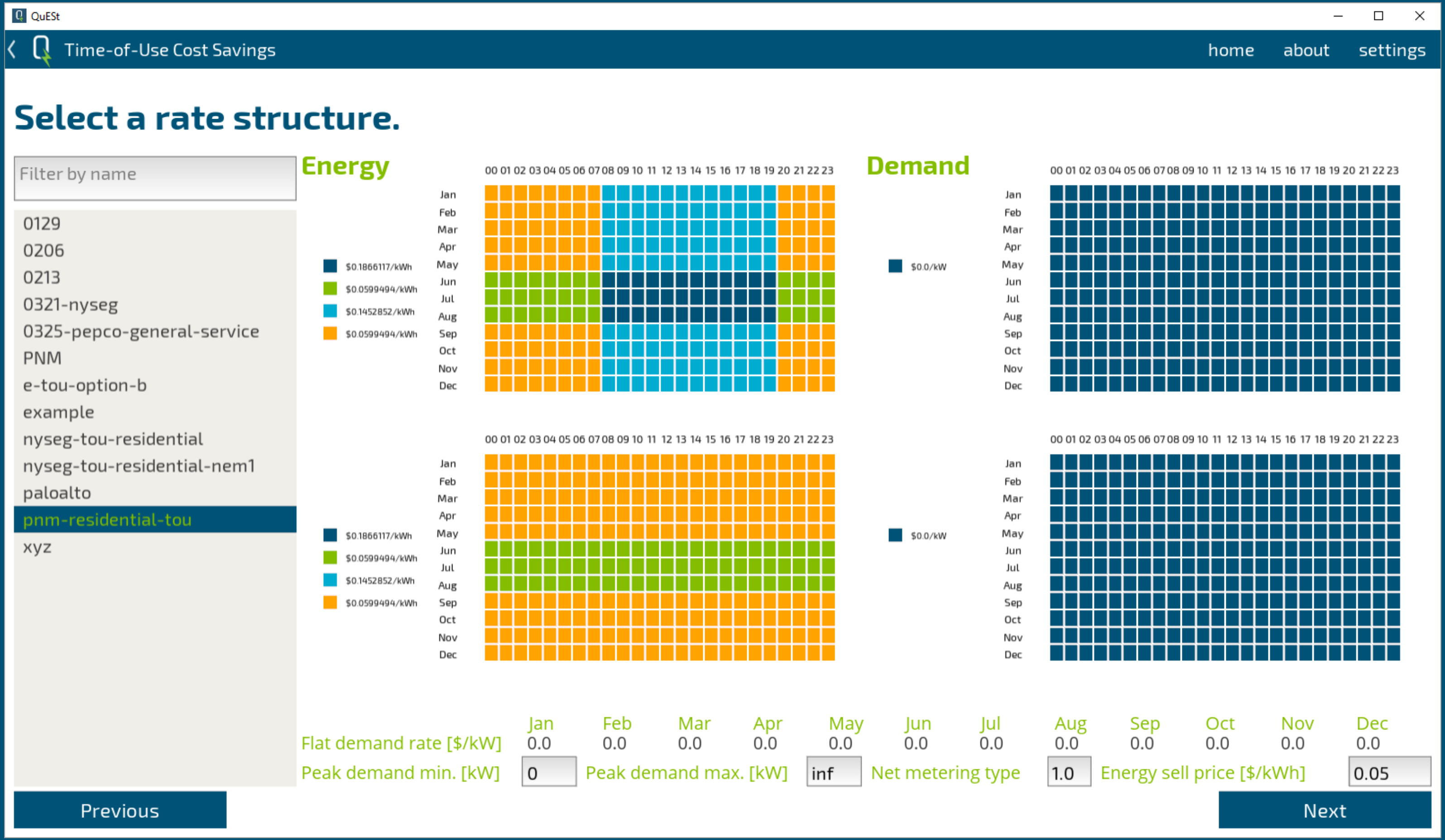
A collection of applications for behind-the-meter energy storage. The first application estimates cost savings for time-of-use and net energy metering customers.

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



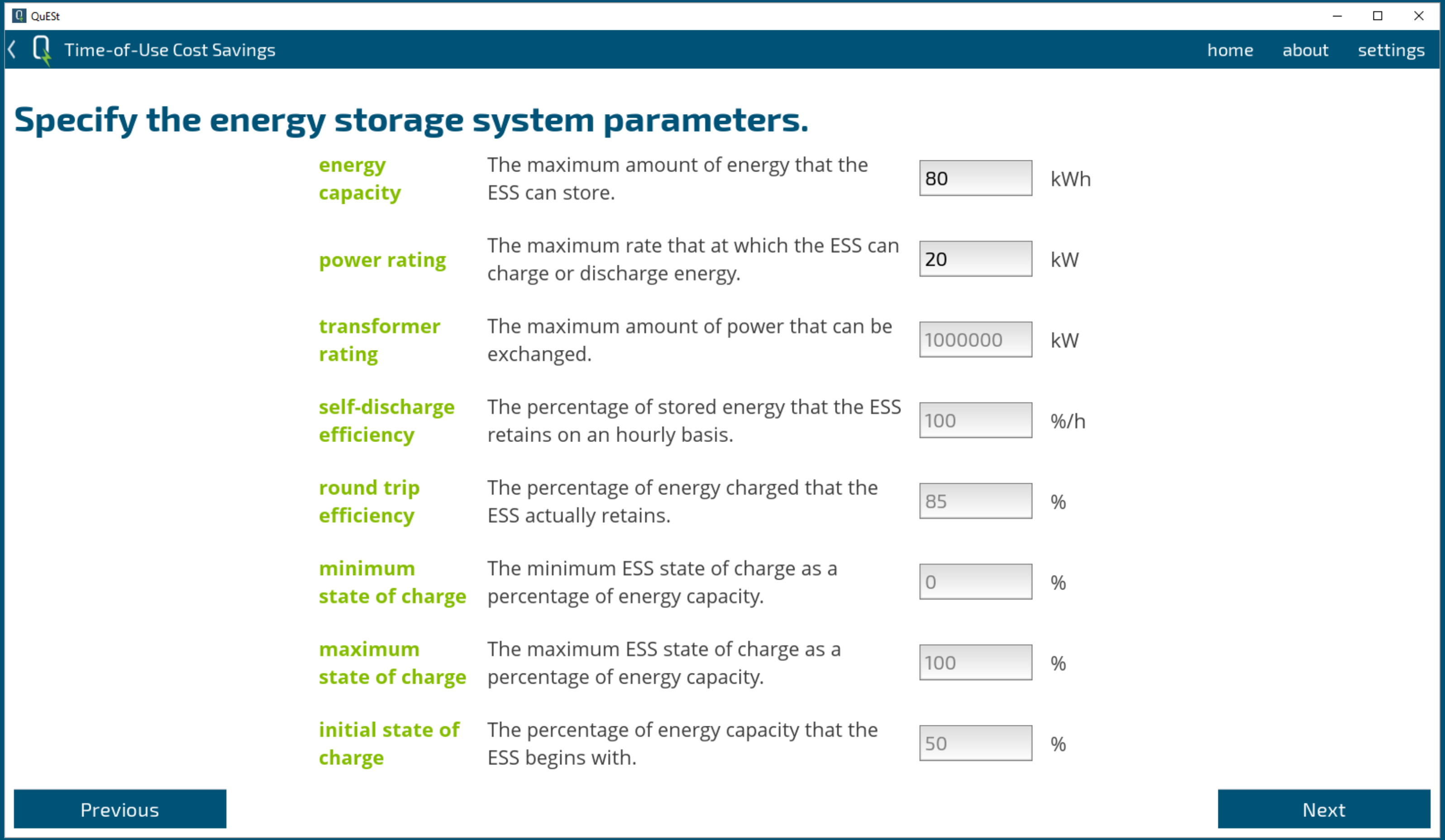
Nguyen, T., and R. Byrne. "Maximizing the cost-savings for time-of-use and net-metering customers using behind-the-meter energy storage systems." *Proceedings of the 2017 North American Power Symposium (NAPS)*. 2017.

QUEST BTM



- 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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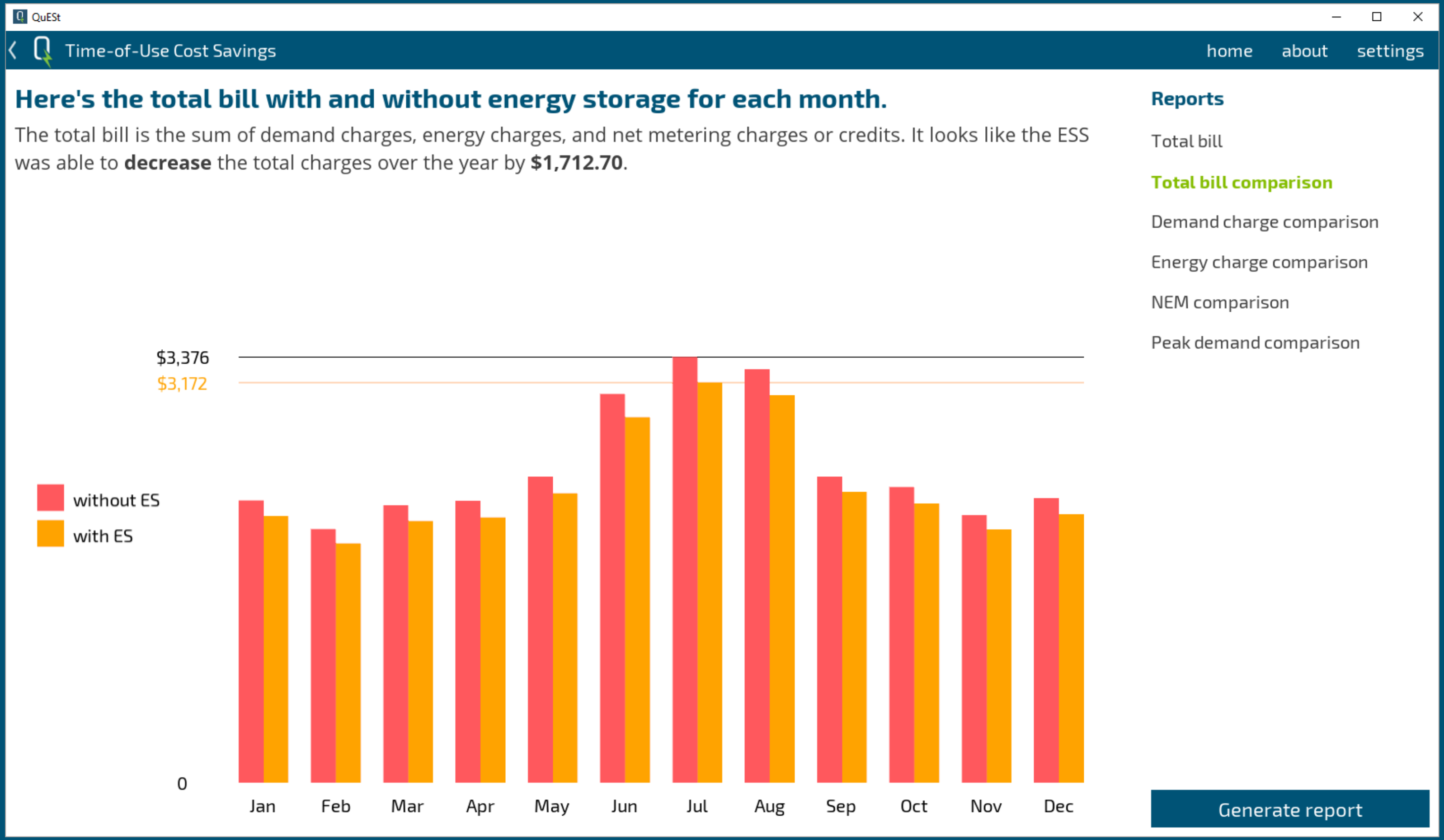
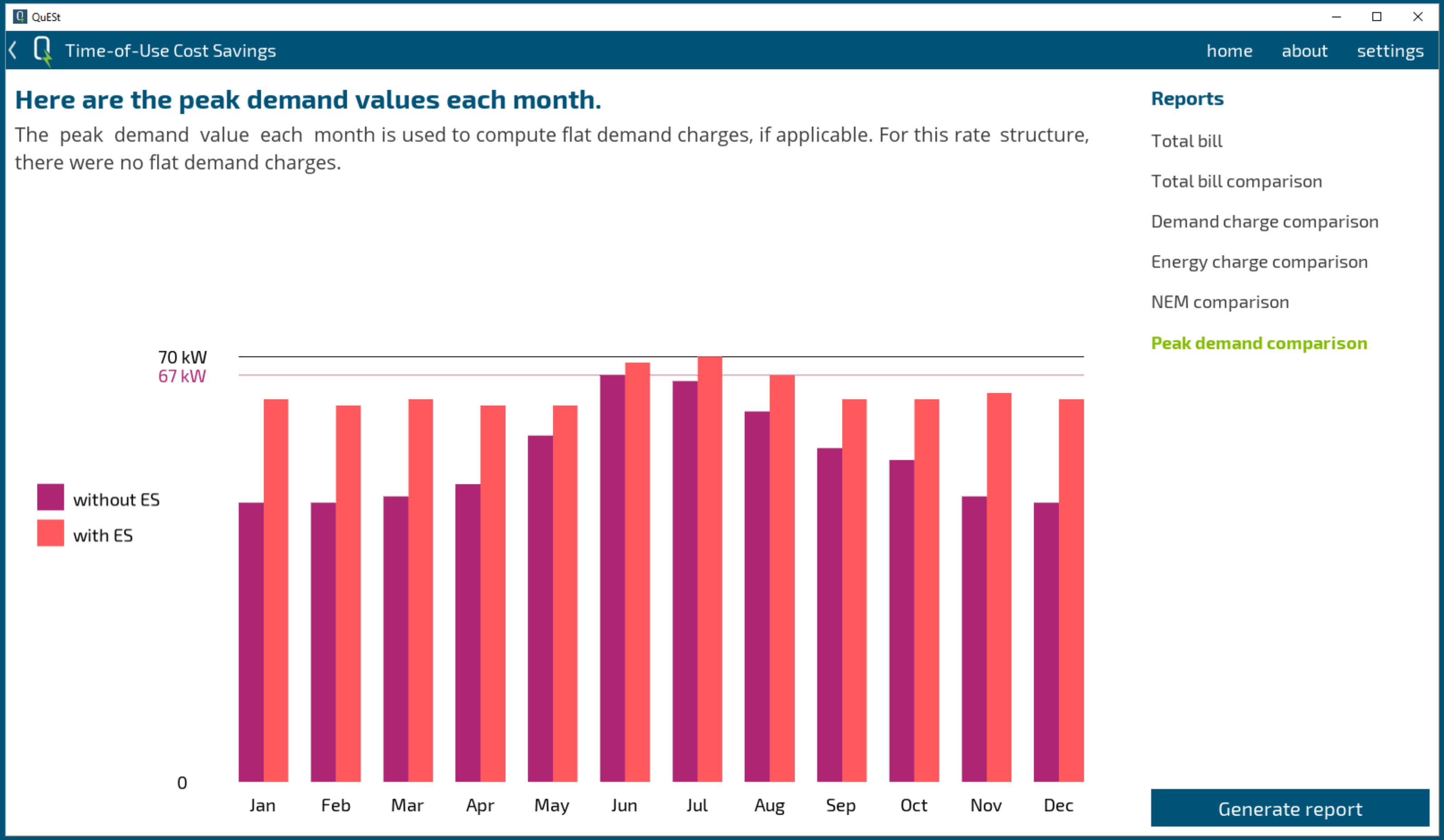


- Compare monthly bill with and without energy storage
- Peak demand reduction to decrease demand charges
- Time-shifting to reduce time-of-use energy charges
- Net metering credits

QUEST BTM



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BEHIND-THE-METER ENERGY STORAGE SYSTEMS OVERVIEW AND CASE STUDY

FRONT-OF-METER VS. BEHIND-THE-METER

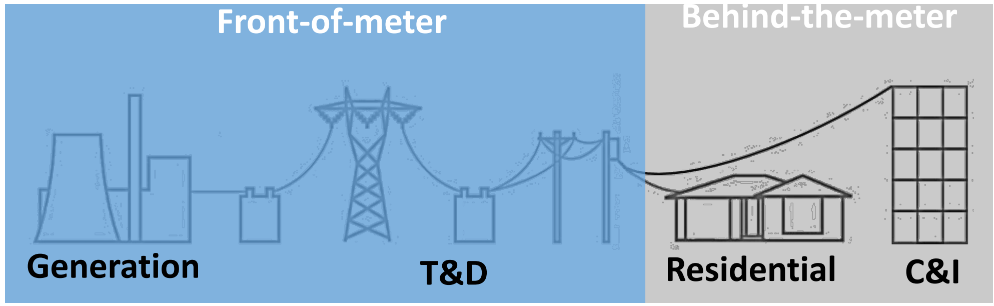
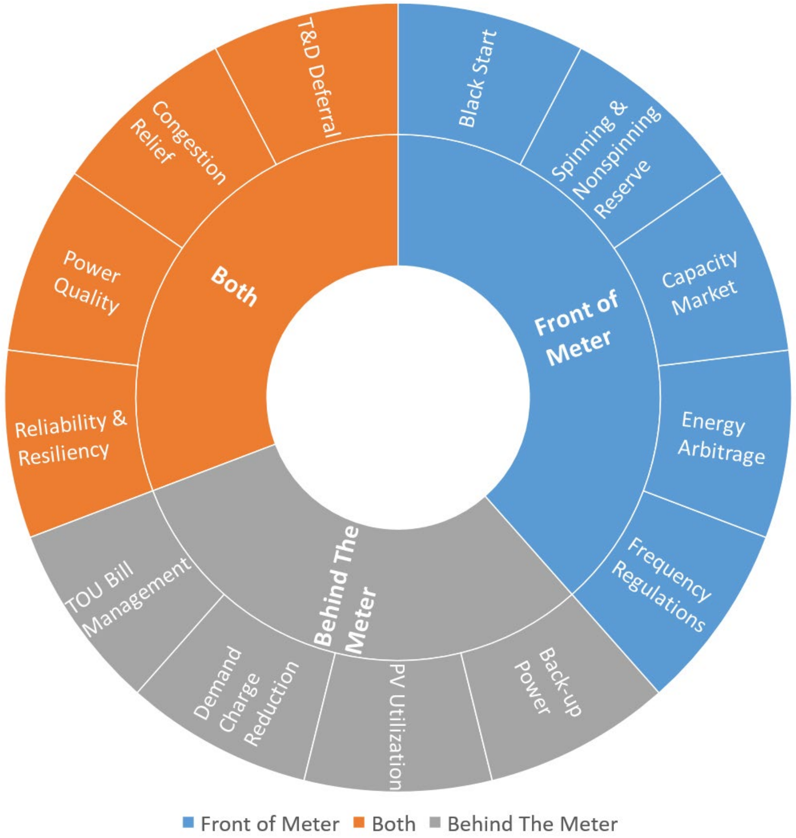


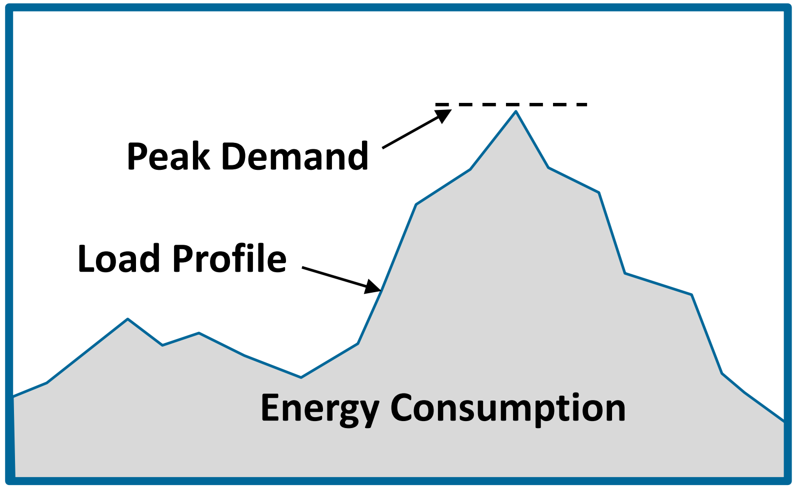
Image Credit: Navigant

- **Behind-the-meter** refers to the systems that are located at the customers' sites (homes, commercial and industrial facilities). BTM systems are usually owned by customers and intended for customers' use.



UTILITY RETAIL RATES

- **Energy Charge**: a charge to customers for the amount of energy consumed, $/kWh.
- **Demand Charge**: a charge to customers for their peak power, $/kW.
- **Other Charges:** meter and basic customer fees are independent of consumption, $/month.



	Energy Charge	Demand Charge	Other Charges
Residential Customers	Yes	Yes/No*	Yes
Commercial Customers	Yes	Yes/No*	Yes
Industrial Customers	Yes	Yes	Yes

* Demand charge is often applied to large commercial customers

UTILITY RATE STRUCTURES – FIXED RATE

Example – PG&E's Tier Rate

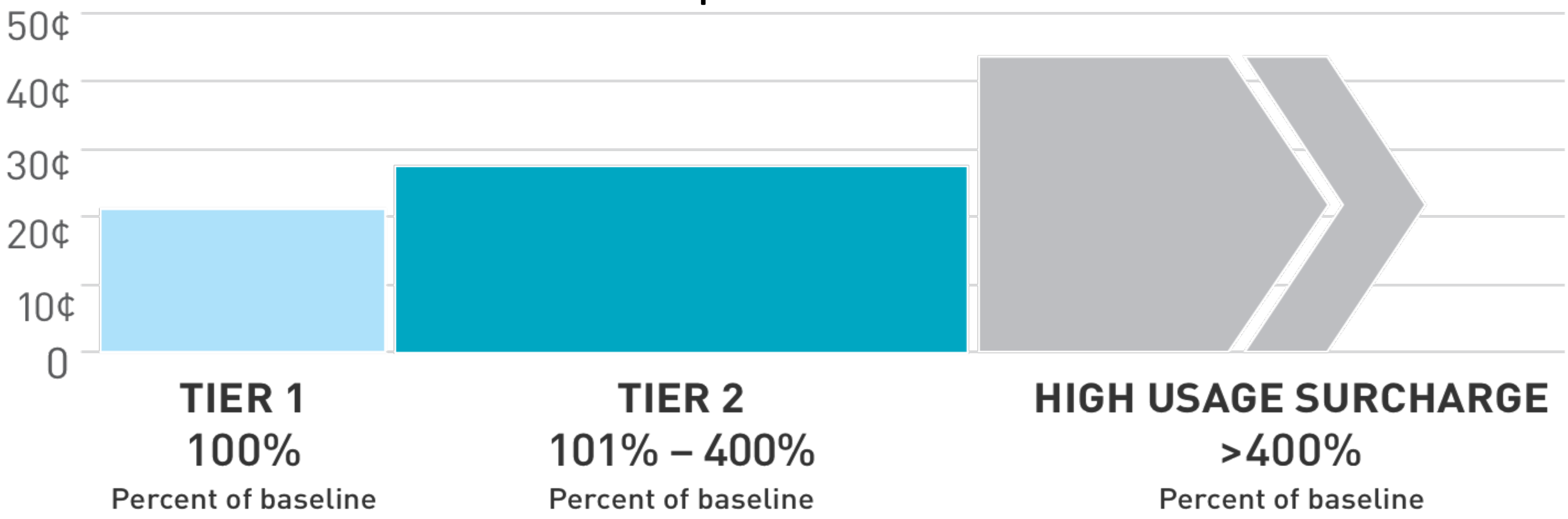


Image Credit: PG&E

- **Fixed rate:** or often called tiered rate is the rate structure where a constant price is applied to each tier of energy consumption.

UTILITY RATE STRUCTURES – DYNAMIC RATE

- **Dynamic rate:** includes the rate structures where energy and demand prices are time dependent.

- **Utilities' motivations for dynamic-price rate:**
  - Increase customer satisfaction with options to reduce energy bill.
  - Encourage load growth.
  - Reduce peak demand by load shifting.
  - Comply with statutory or regulatory mandate

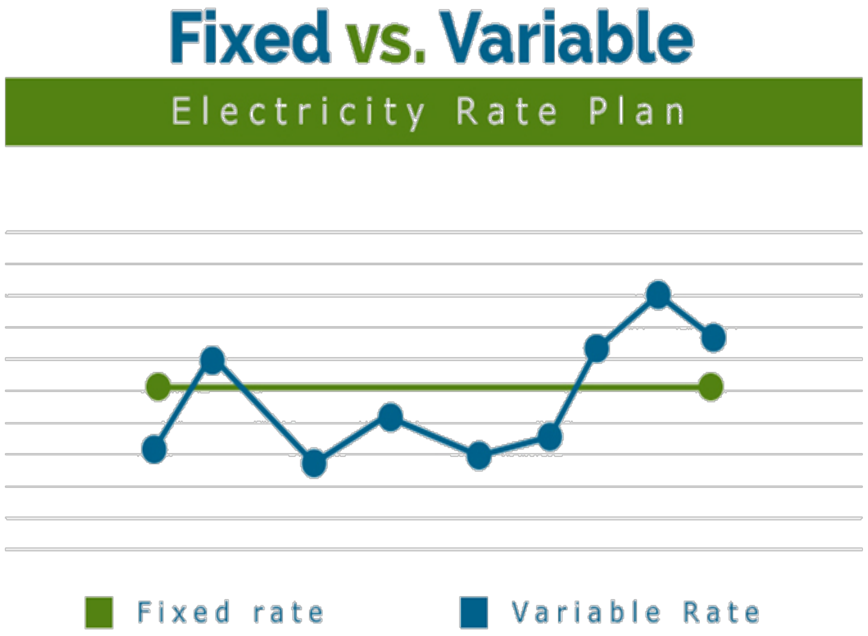
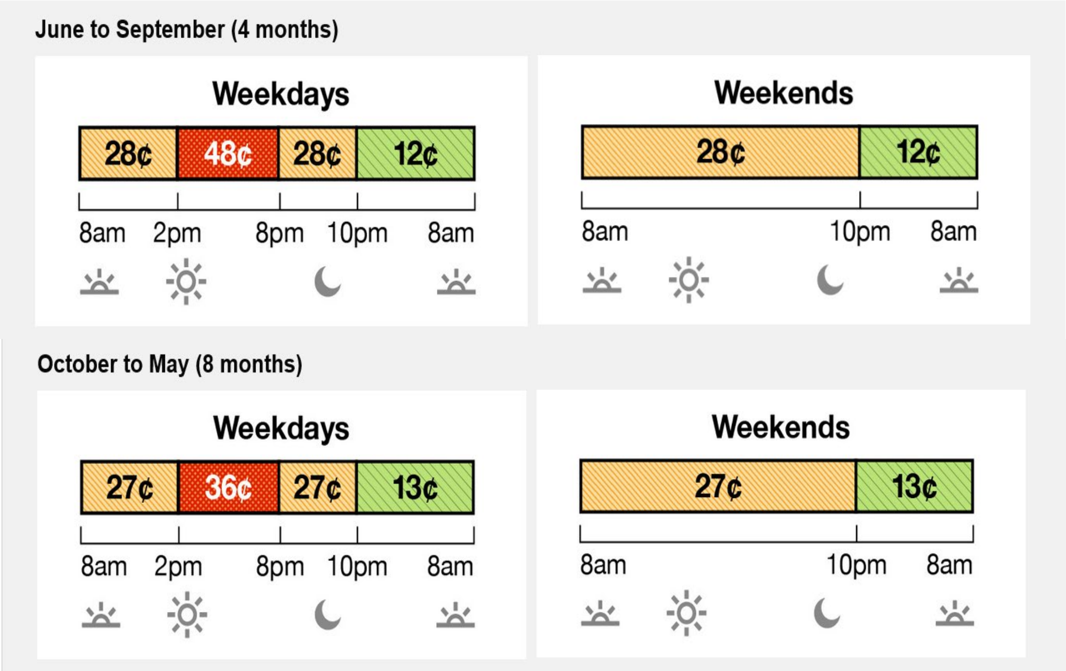


Image Credit: smartenergy.com

UTILITY RATE STRUCTURES – DYNAMIC RATE – TIME-OF-USE

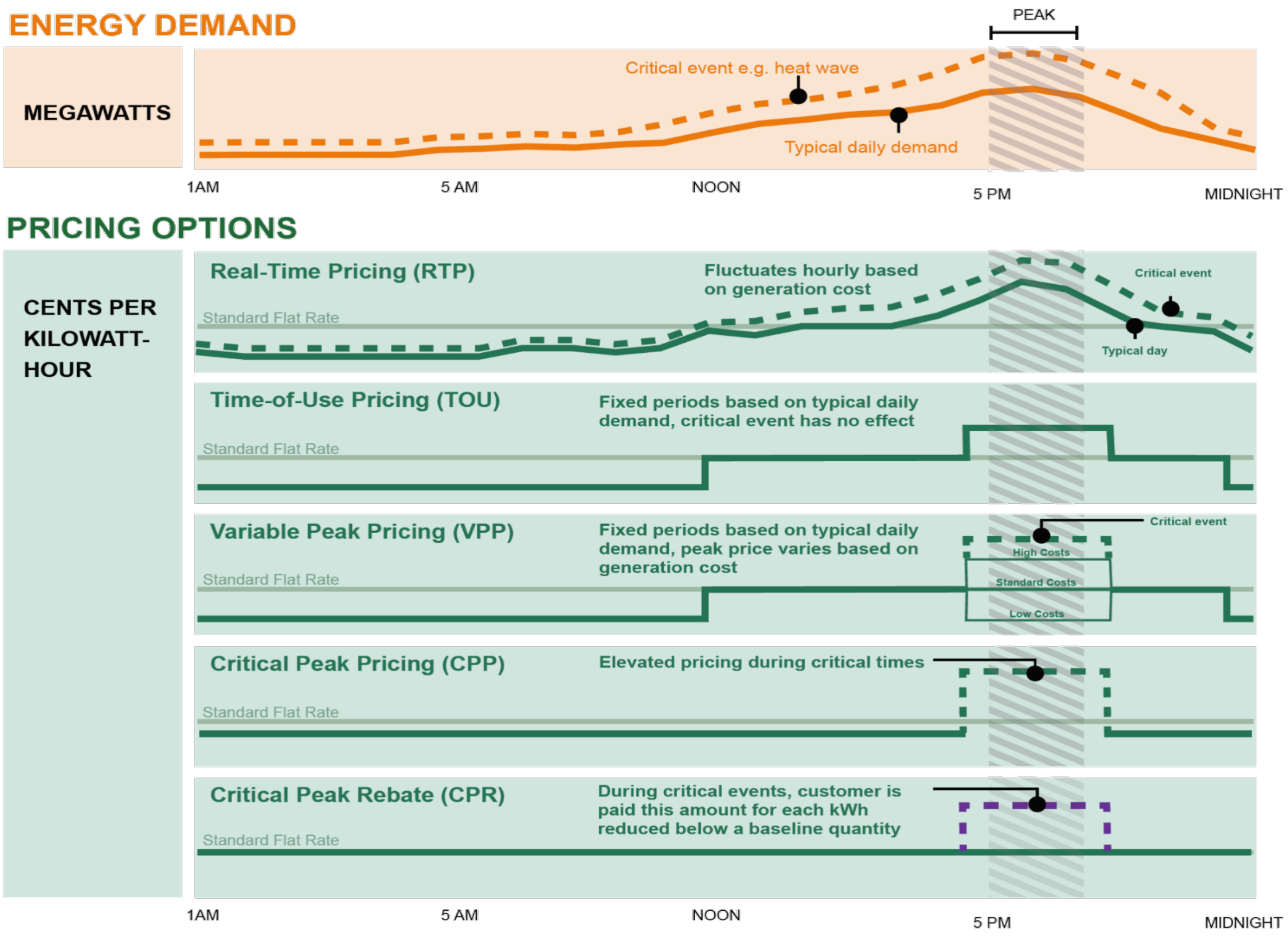
- In TOU pricing, energy and demand prices are set in advance for different time periods.

- Time schedules for TOU:
  - Hour: peak, part-peak, and off- peak hours.
  - Day: weekdays, weekends, and holidays.
  - Month: summer and winter



Southern California Edison – Schedule TOU-D-A

UTILITY RATE STRUCTURES – DYNAMIC RATE



Source: Environmental Defense Fund (EDF)

UTILITY RATE STRUCTURES – NET METERING PROGRAM

- Net metering (NEM) programs allow customers who own renewable energy systems to export their excess energy to the grid.
- The net energy exported to the grid will be used to offset the customers' consumption. At the end of the true-up period, the customers will be charged/credited for the net energy usage/surplus.

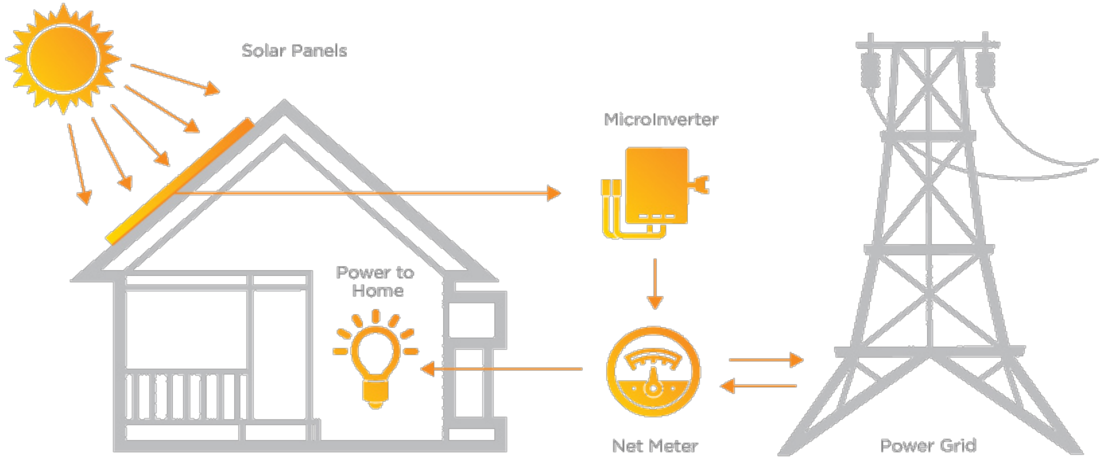
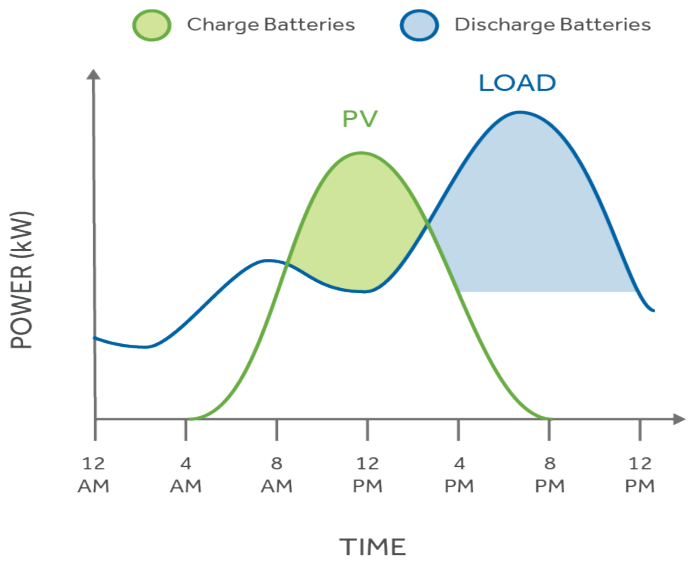


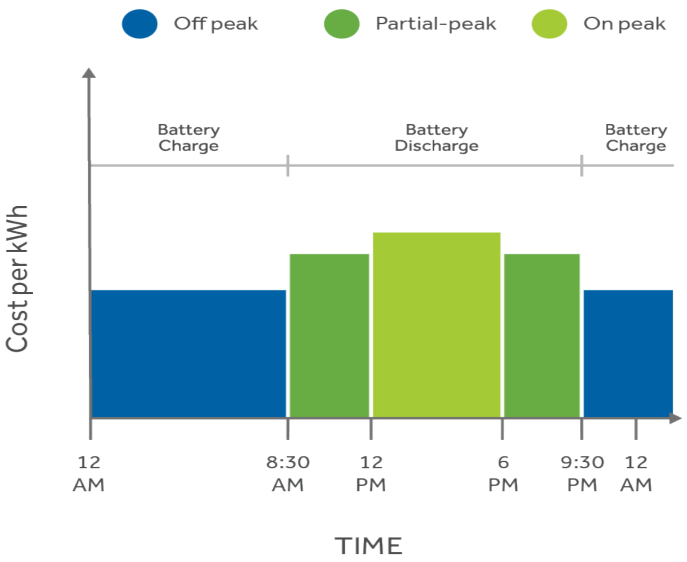
Image Credit - *Lowcountry Solar*

HOW CAN UTILITY CUSTOMERS BENEFIT?

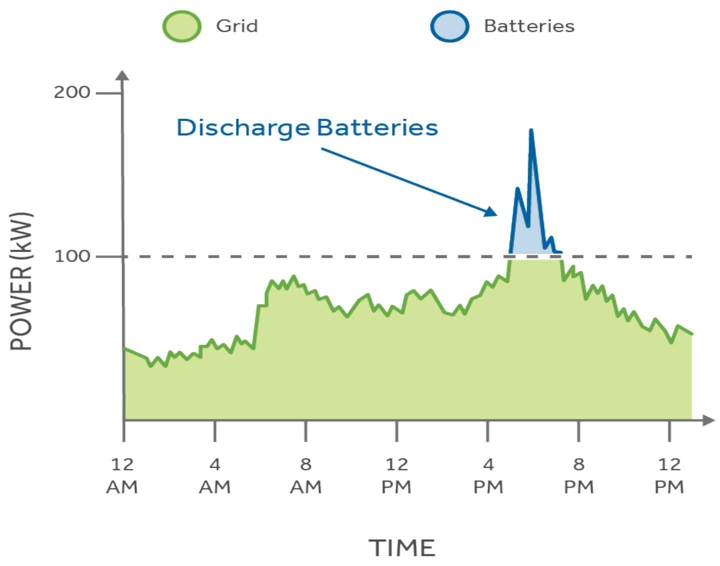
- To benefit from dynamic rate structures, the customers must be able to change their loads in a manner that lowers their electricity bills without interrupting their operations (commercial and industrial customers) or sacrificing their conveniences (residential customers).



Renewable Time Shift



Time-of-use Management



Demand Charge Reduction

MINIMIZING ELECTRICITY BILLS FOR UTILITY CUSTOMERS

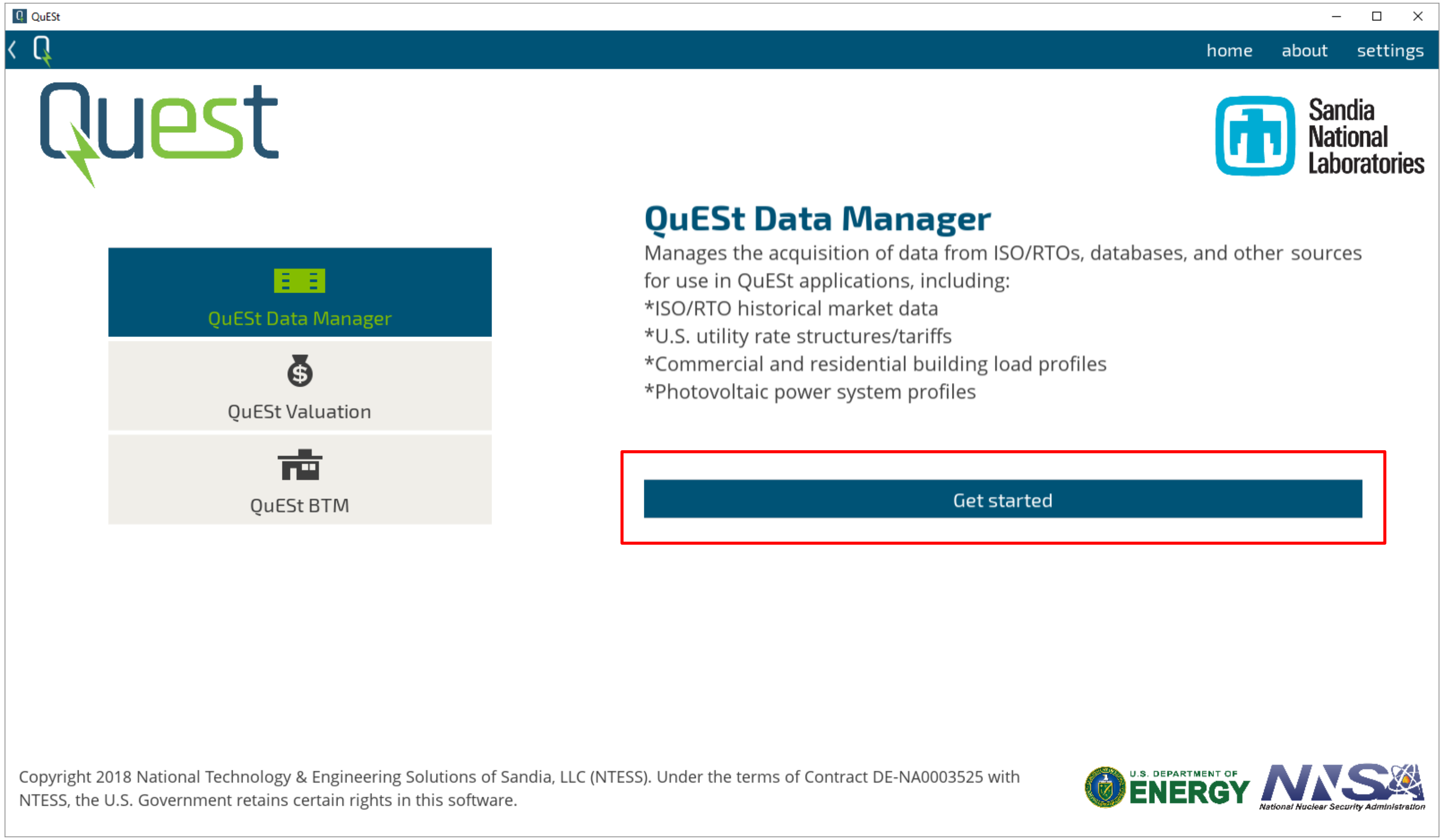
- The objective is to minimize the electricity bill such that the physical limits of energy storage device and the inverter are satisfied.

$$\min\{\mathrm{C}_{\mathrm{E}}^{\mathrm{m}} + \mathrm{C}_{\mathrm{N}}^{\mathrm{m}} + \mathrm{C}_{\mathrm{D}}^{\mathrm{m}}\}$$

$s.t.$ *energy storage and inverter constraints*
$\mathrm{C}_{\mathrm{E}}^{\mathrm{m}}$ is the energy charge of period m
$\mathrm{C}_{\mathrm{D}}^{\mathrm{m}}$ is the demand charge of period m
$\mathrm{C}_{\mathrm{N}}^{\mathrm{m}}$ (≤ 0) is the net metering charge of period m.

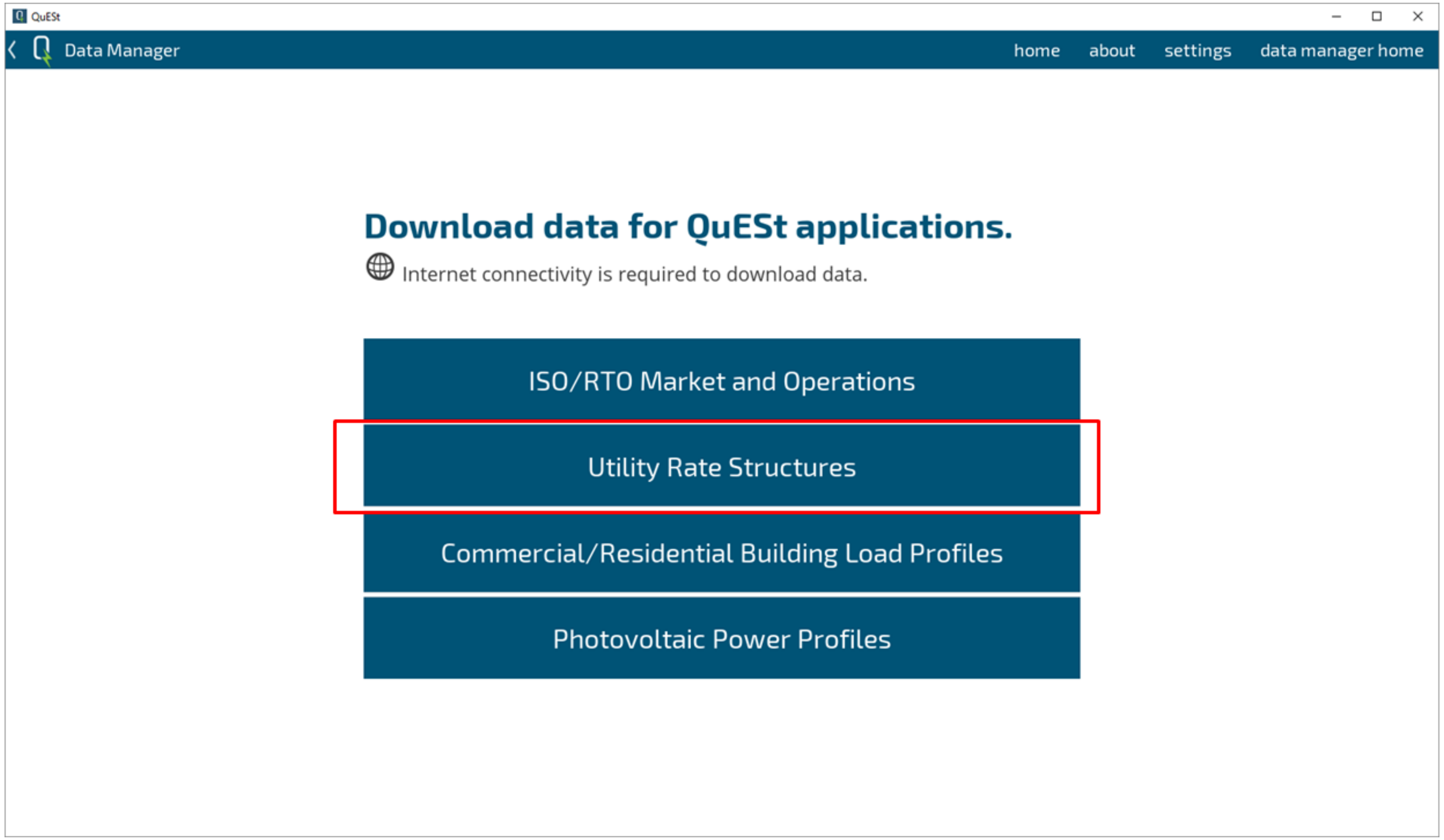
- The decision variables are the charge and discharge power of the energy storage device at each hour

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



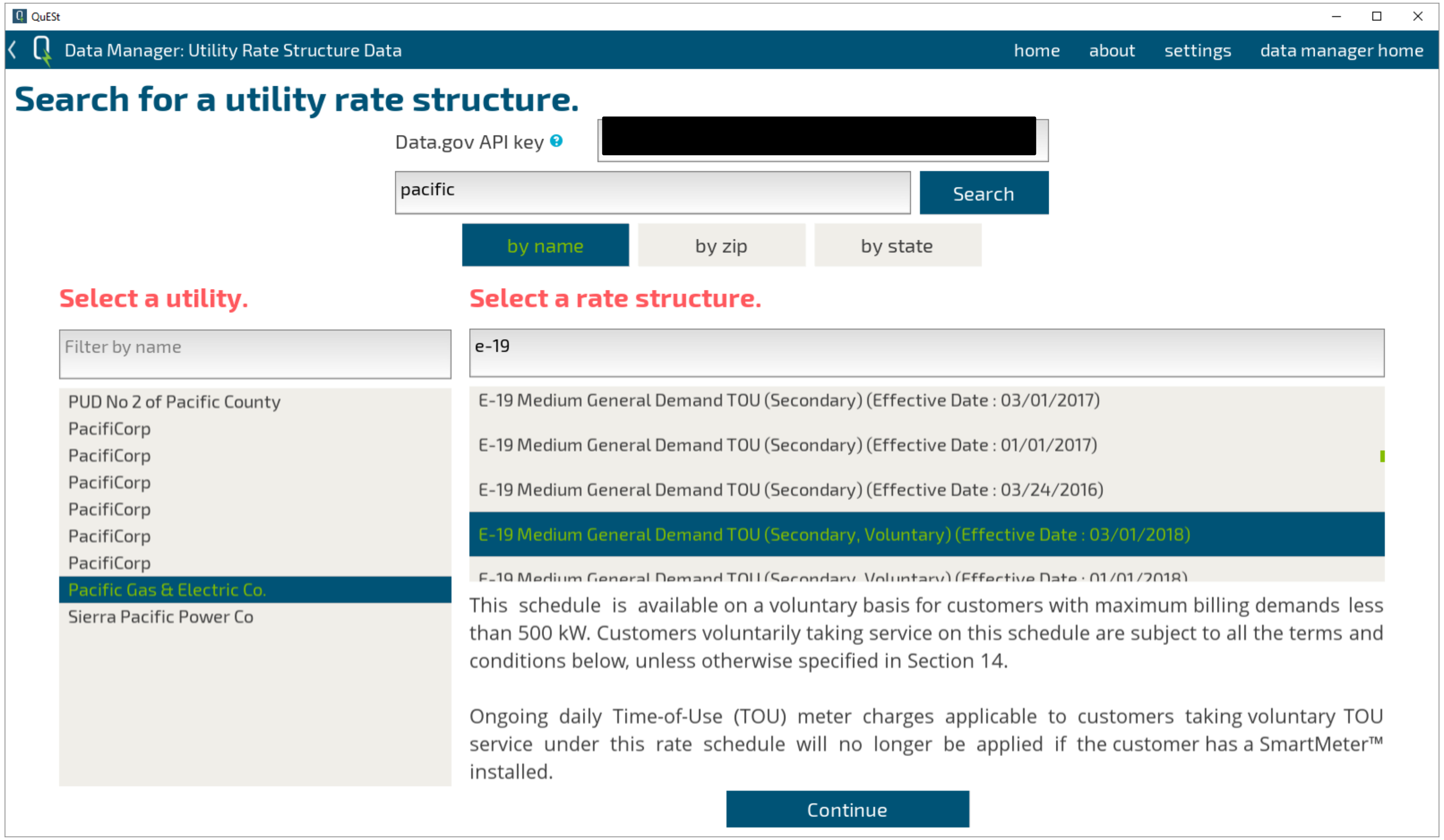
- This is a behind-the-meter energy storage problem, so we will use QuESt BTM.
- First, we head to QuESt Data Manager to get what we need.

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



- For this analysis, we need:
  - Utility rate structure
  - Load profile for the property
  - PV power profile

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



- Our hotel's utility is Pacific Gas & Electric.
- The applicable rate structure for our property is "E-19 Medium General Demand TOU (Secondary, Voluntary)".
- 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: LARGE HOTEL WITH SOLAR + STORAGE

QuESt

Data Manager: Utility Rate Structure Data — home about settings data manager home

Verify the energy rate structure.

Period	Rate [$/kWh]
0	0.09401
1	0.11004
2	0.08671
3	0.11613
4	0.16055

Weekday

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Feb	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Mar	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Apr	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
May	2	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4	4	4	3	3	3	2	2	2
Jun	2	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4	4	4	3	3	3	2	2	2
Jul	2	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4	4	4	3	3	3	2	2	2
Aug	2	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4	4	4	3	3	3	2	2	2
Sep	2	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4	4	4	3	3	3	2	2	2
Oct	2	2	2	2	2	2	2	2	3	3	3	3	4	4	4	4	4	4	3	3	3	2	2	2
Nov	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Dec	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0

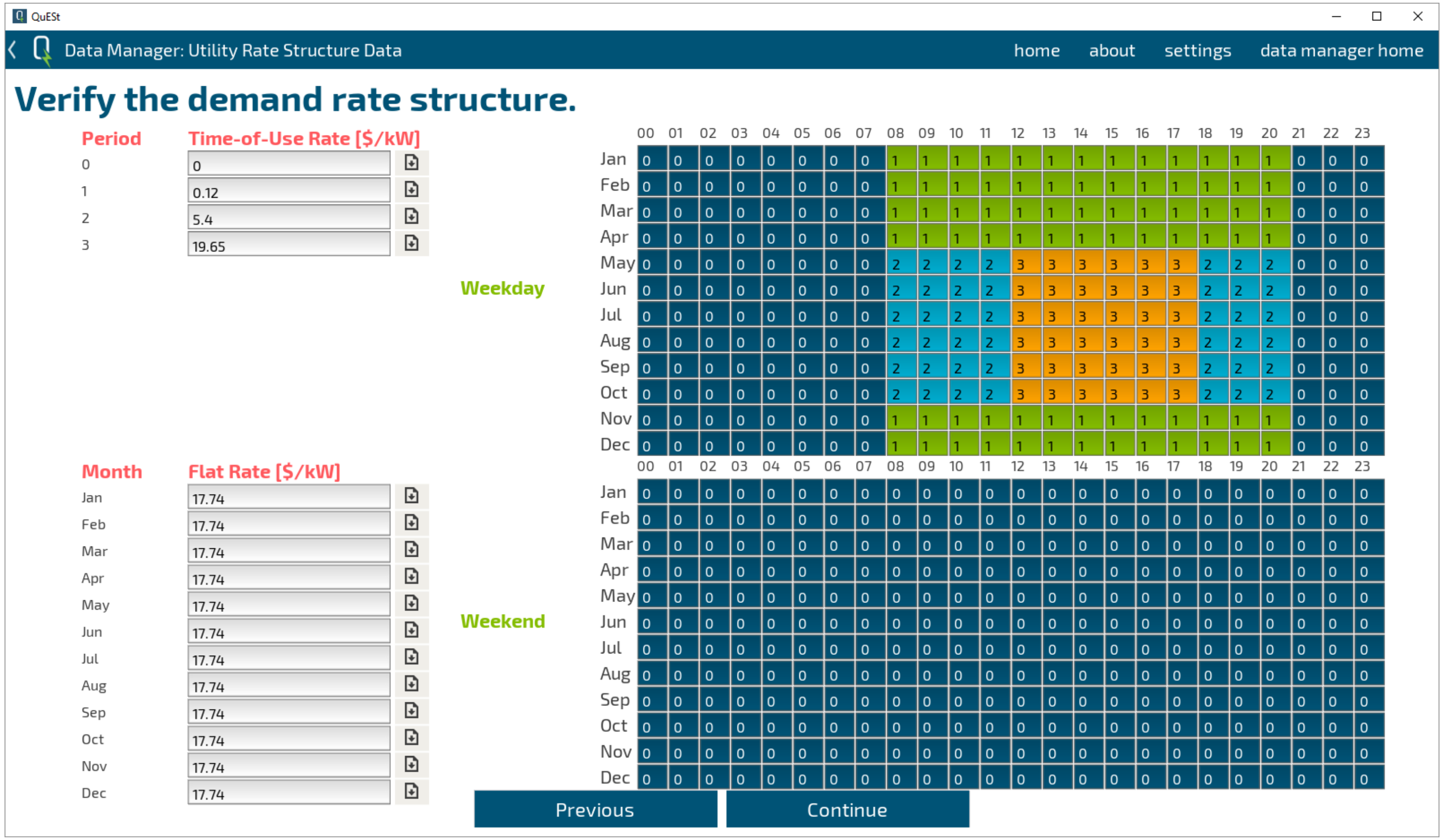
Weekend

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Jun	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Jul	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Aug	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Sep	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Oct	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Previous Continue

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

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



QuESt

Data Manager: Utility Rate Structure Data

home about settings data manager home

Verify the demand rate structure.

Period	Time-of-Use Rate [$/kW]
0	0
1	0.12
2	5.4
3	19.65

Month	Flat Rate [$/kW]
Jan	17.74
Feb	17.74
Mar	17.74
Apr	17.74
May	17.74
Jun	17.74
Jul	17.74
Aug	17.74
Sep	17.74
Oct	17.74
Nov	17.74
Dec	17.74

Weekday

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Feb	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Mar	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Apr	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
May	0	0	0	0	0	0	0	0	2	2	2	2	3	3	3	3	3	3	2	2	2	0	0	0
Jun	0	0	0	0	0	0	0	0	2	2	2	2	3	3	3	3	3	3	2	2	2	0	0	0
Jul	0	0	0	0	0	0	0	0	2	2	2	2	3	3	3	3	3	3	2	2	2	0	0	0
Aug	0	0	0	0	0	0	0	0	2	2	2	2	3	3	3	3	3	3	2	2	2	0	0	0
Sep	0	0	0	0	0	0	0	0	2	2	2	2	3	3	3	3	3	3	2	2	2	0	0	0
Oct	0	0	0	0	0	0	0	0	2	2	2	2	3	3	3	3	3	3	2	2	2	0	0	0
Nov	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0
Dec	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0

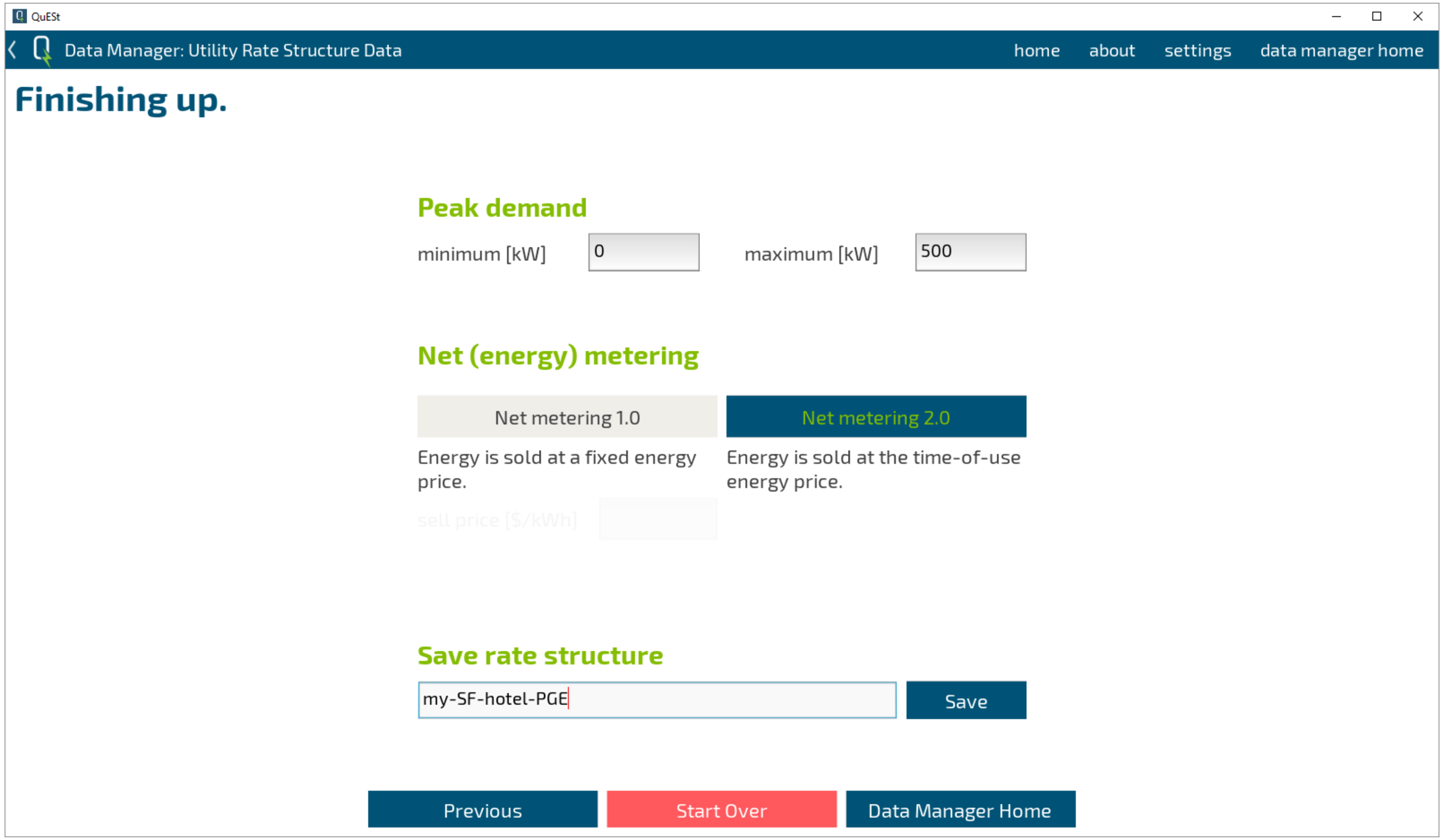
Weekend

	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Jan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jun	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aug	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oct	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nov	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Previous Continue

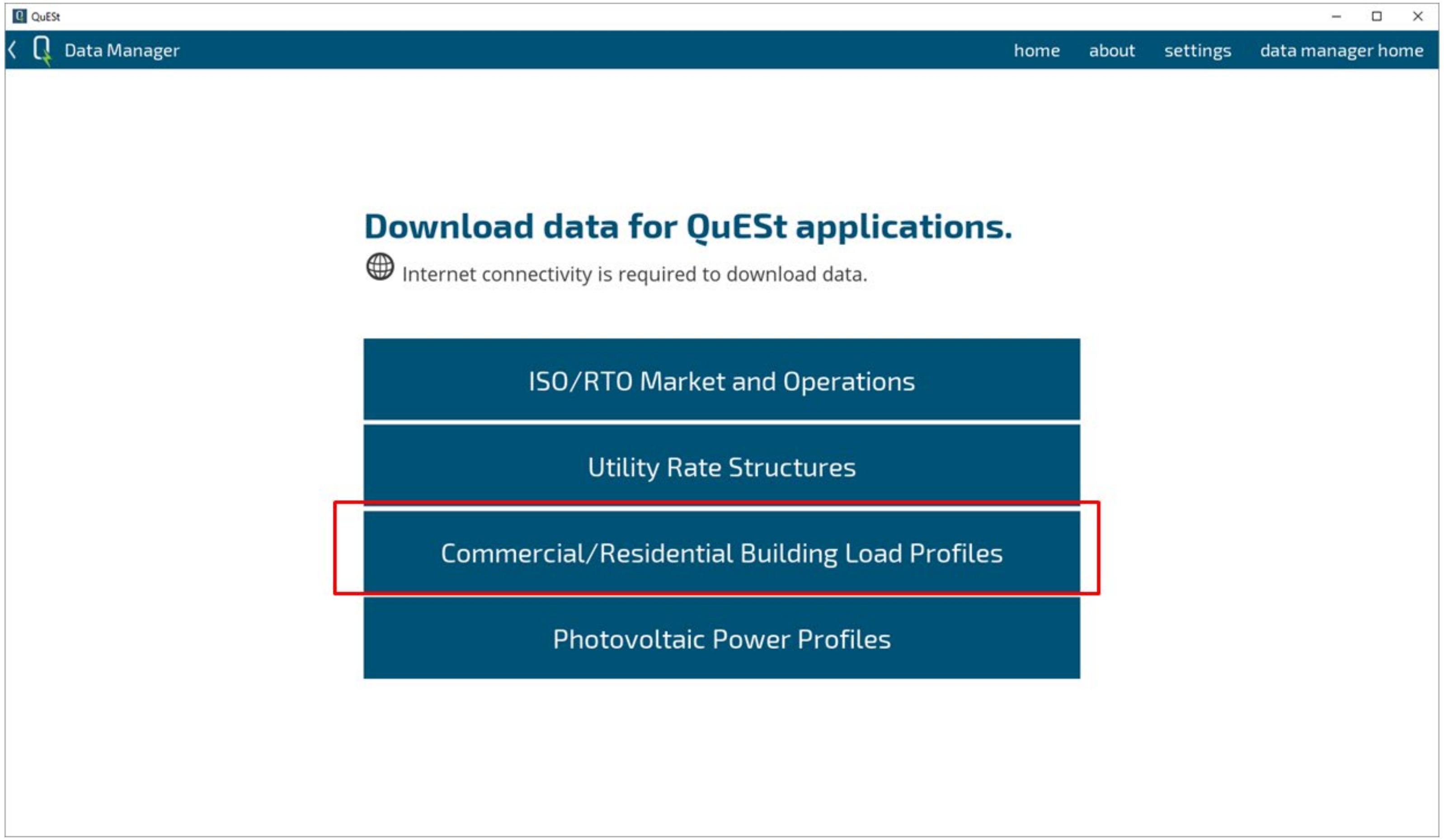
- Verify that the energy and demand rate schedules are correct.

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



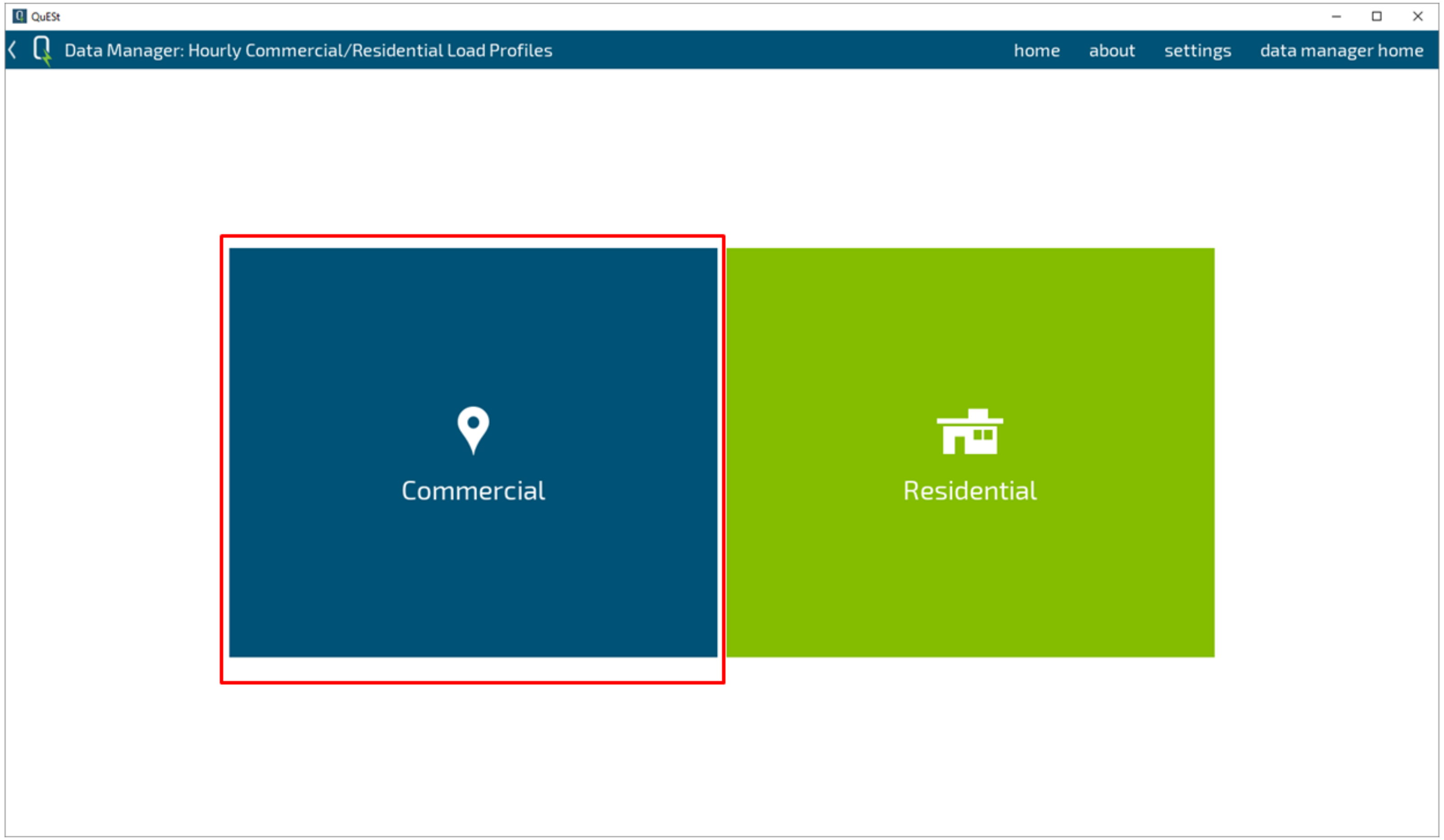
- Save the rate structure for later.

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



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

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



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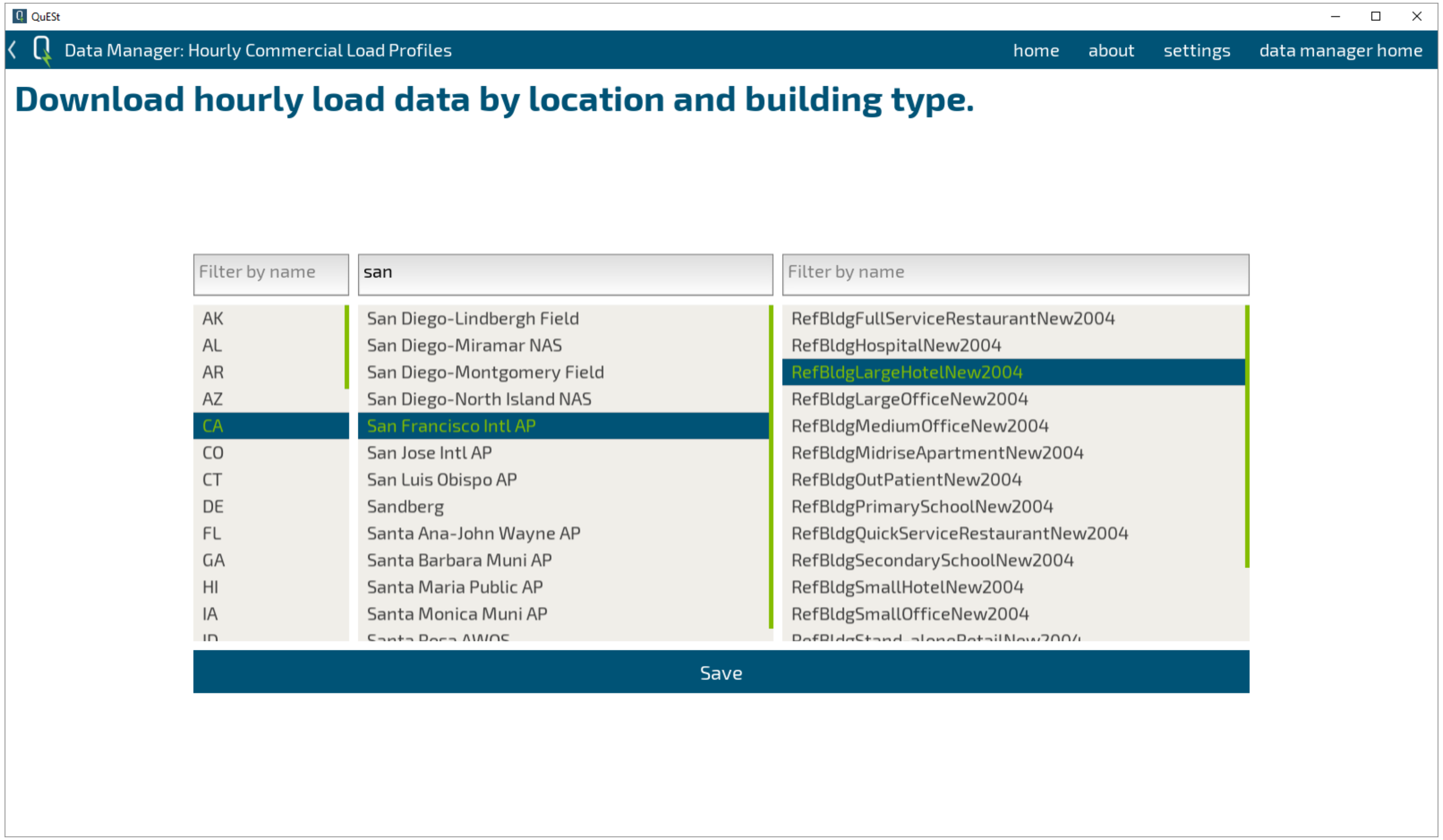
CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



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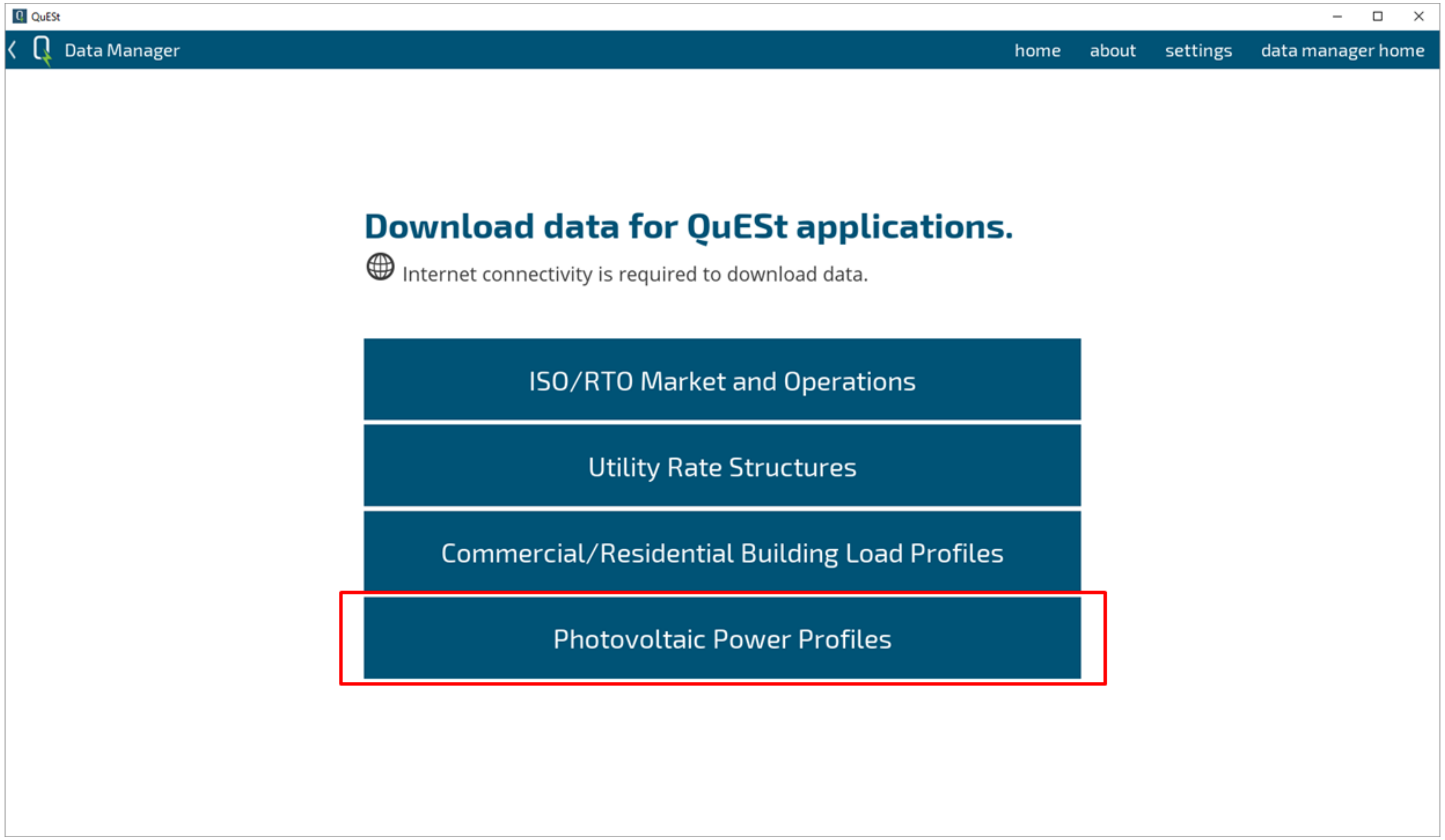
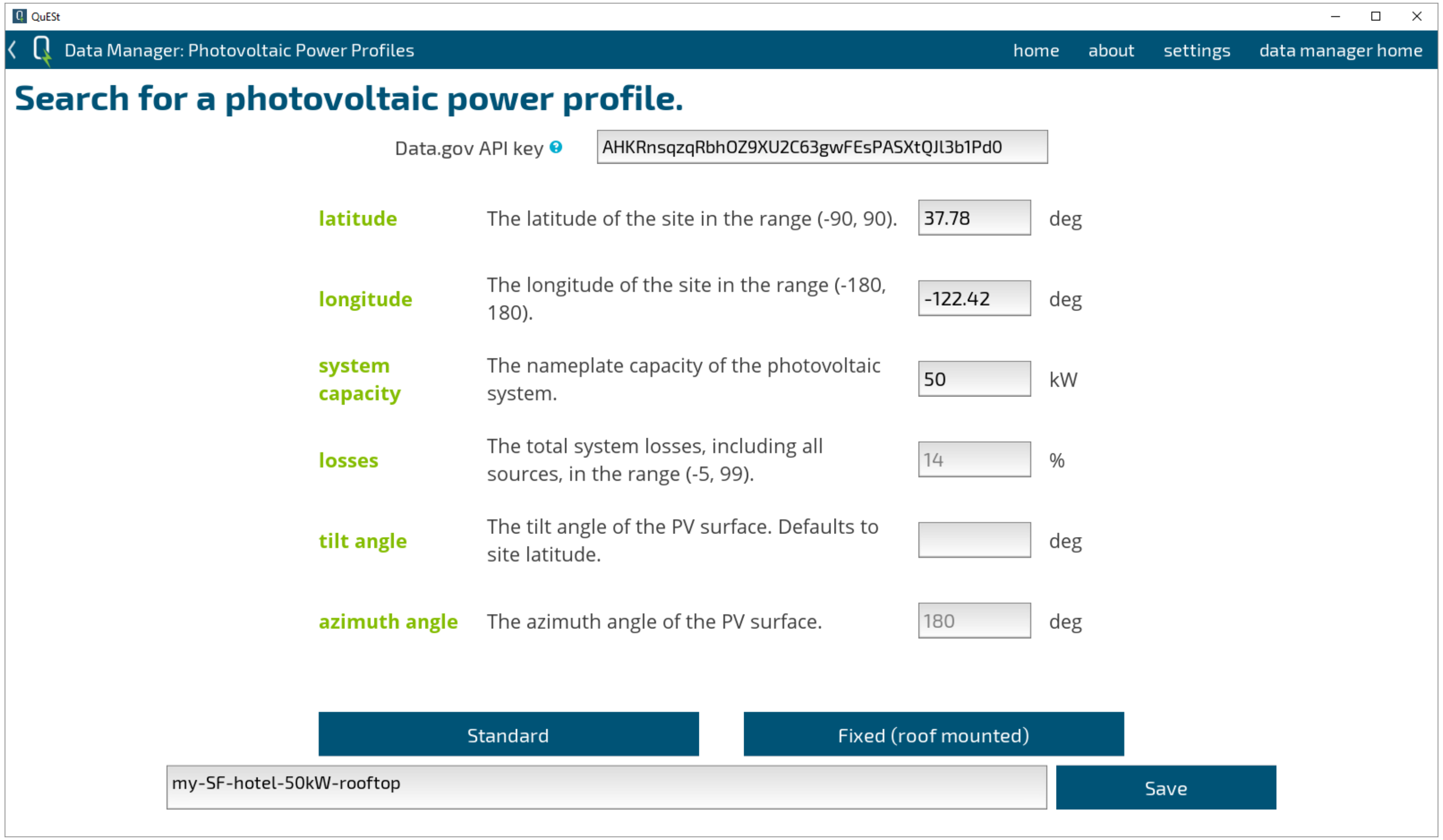
CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



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

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



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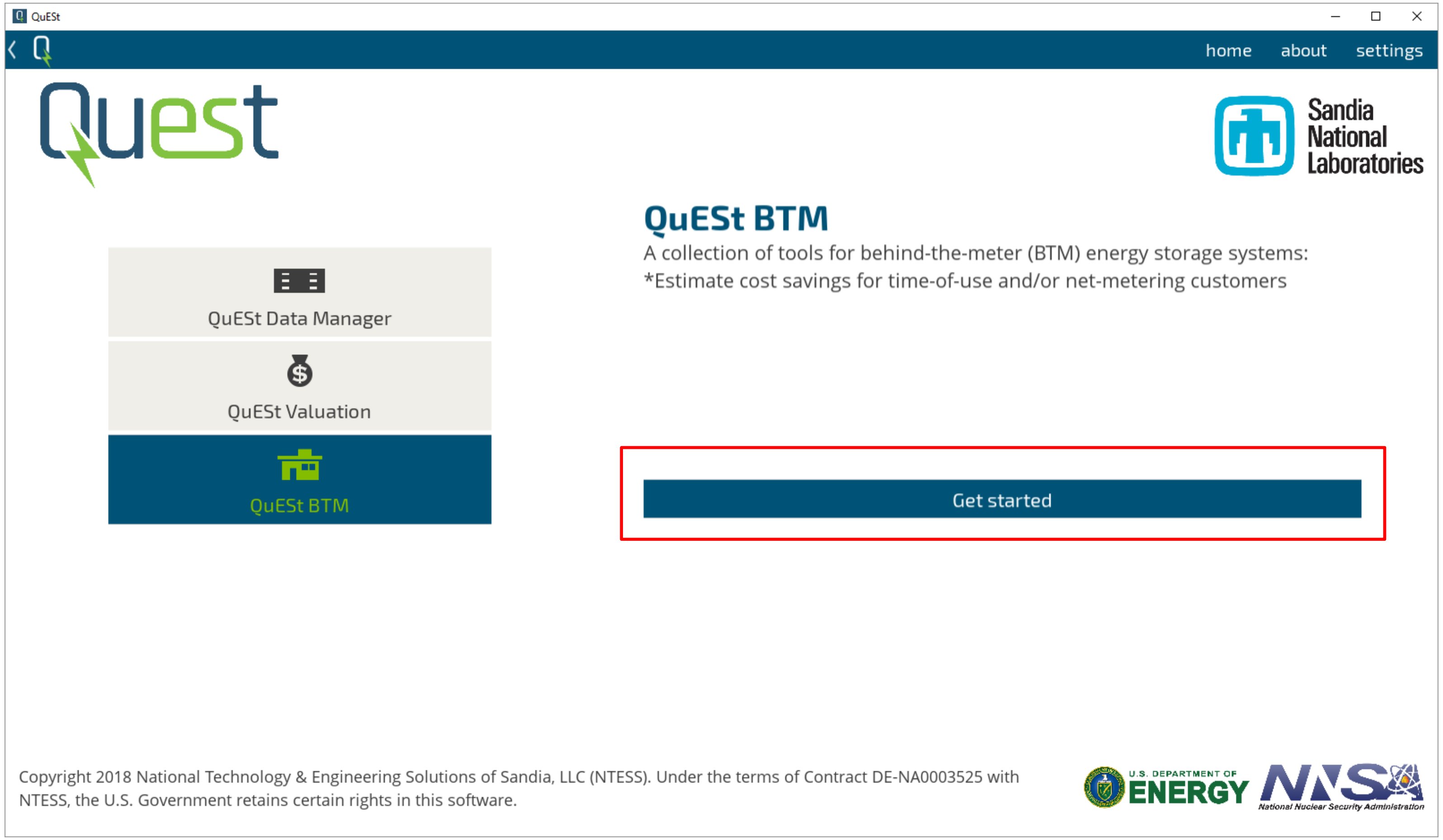
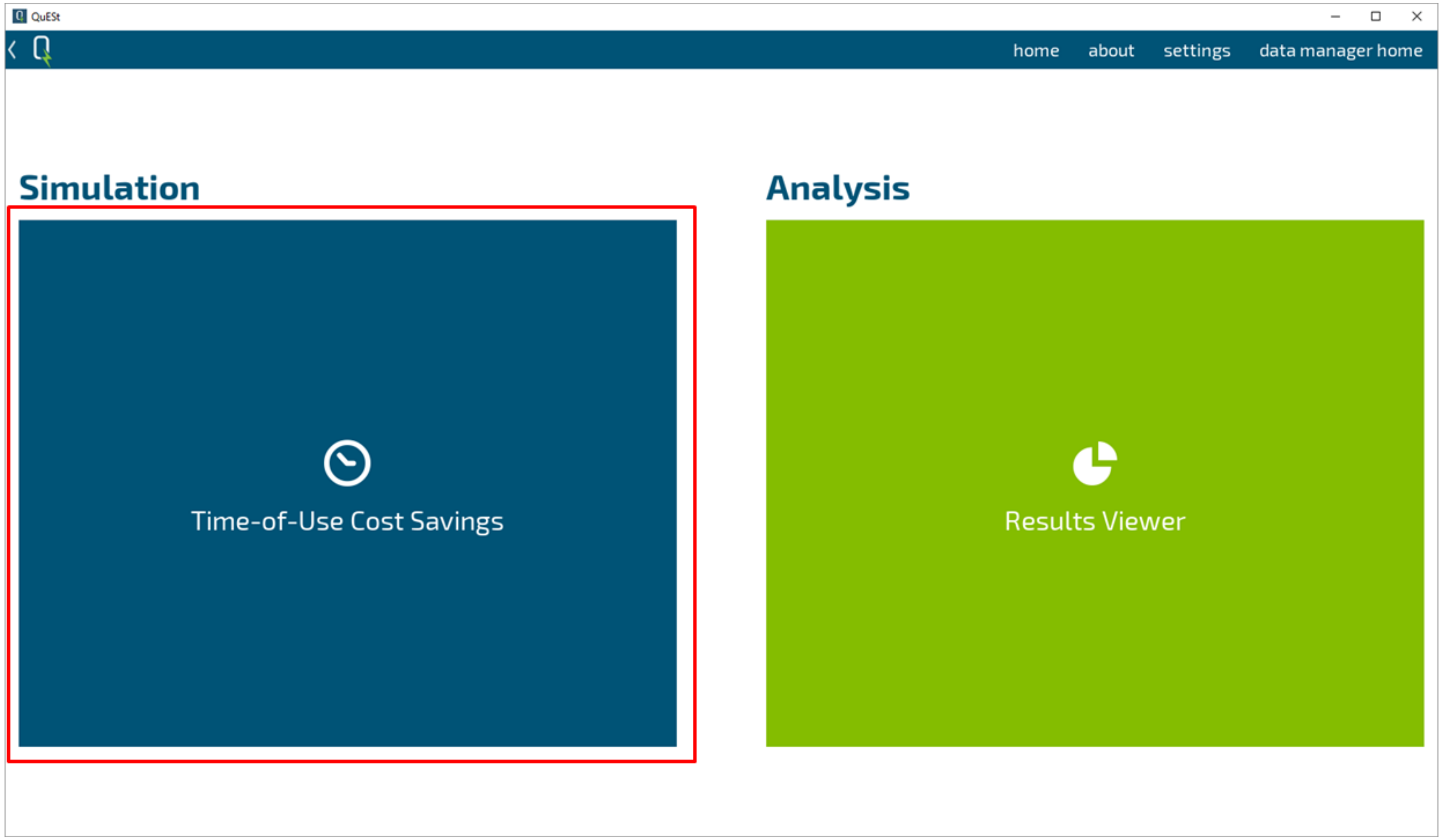


- Now that we have all the data that we need, we can return home and start using QuESt BTM for the analysis.
- We'll use the Time-of-Use Cost Savings wizard.

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



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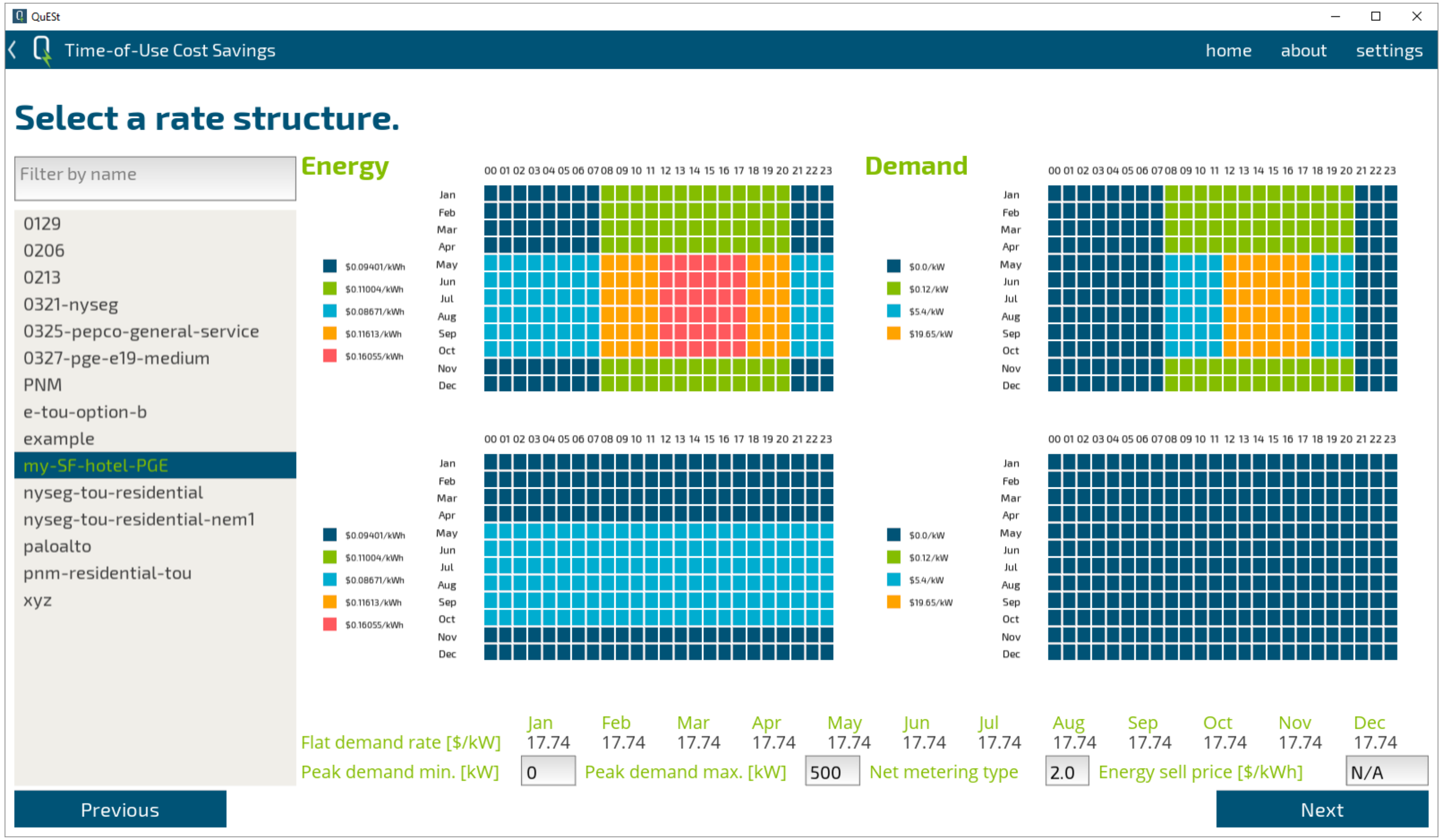
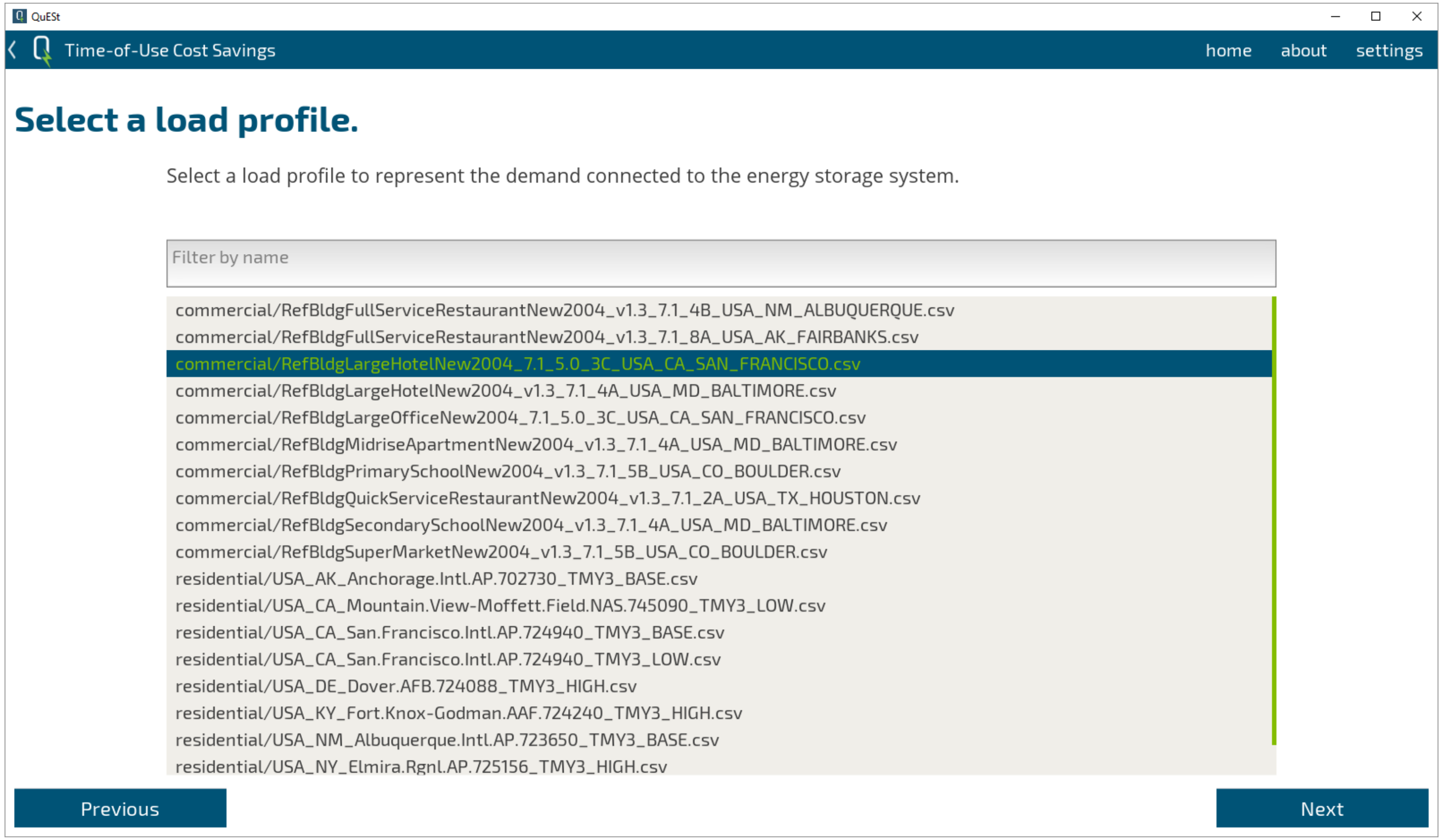
CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



- Proceeding through the wizard, we select the data that we had just downloaded when prompted.
- Our proposed energy storage system is 400 kWh/100 kW, so we'll enter that in.

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



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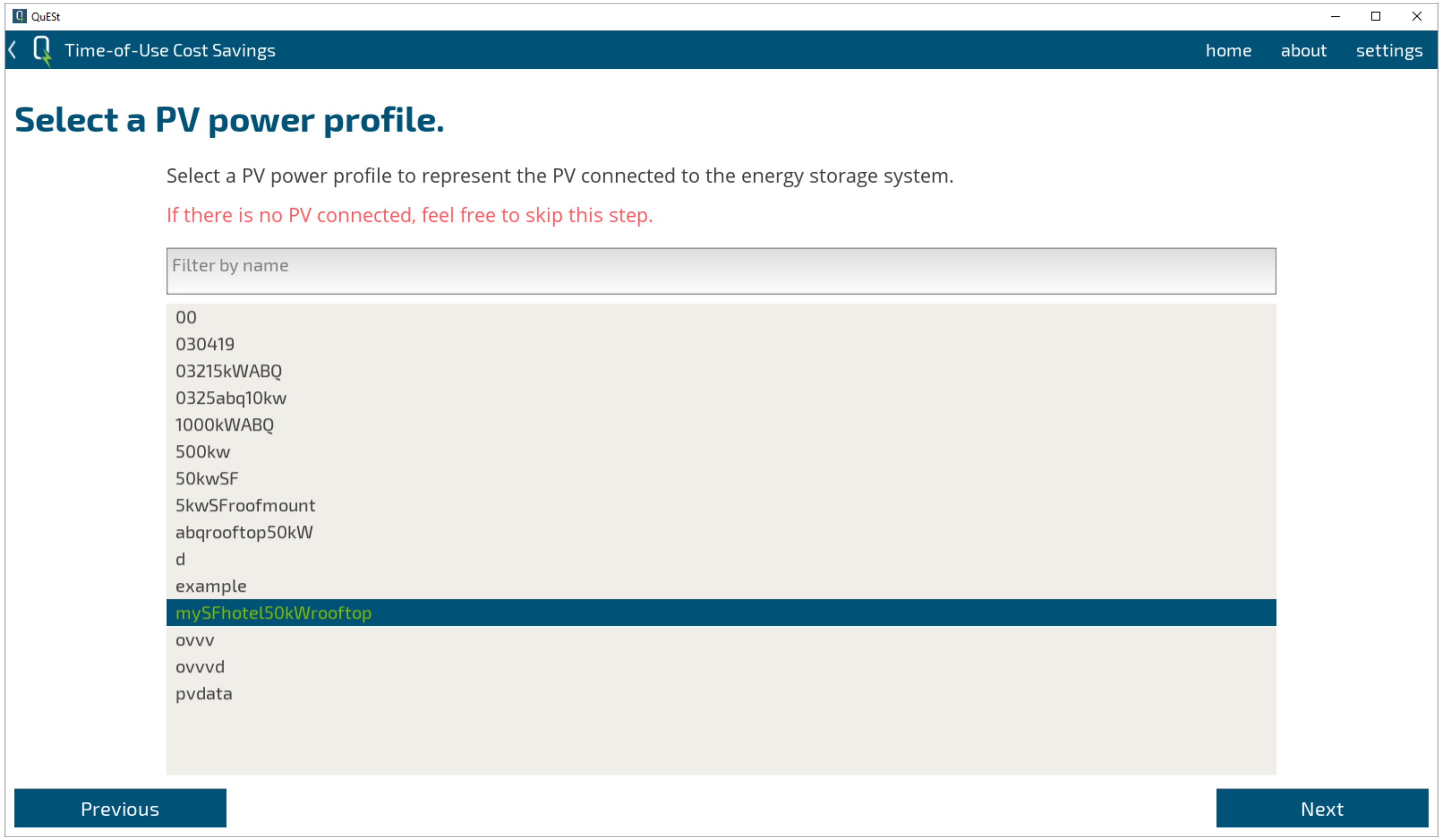

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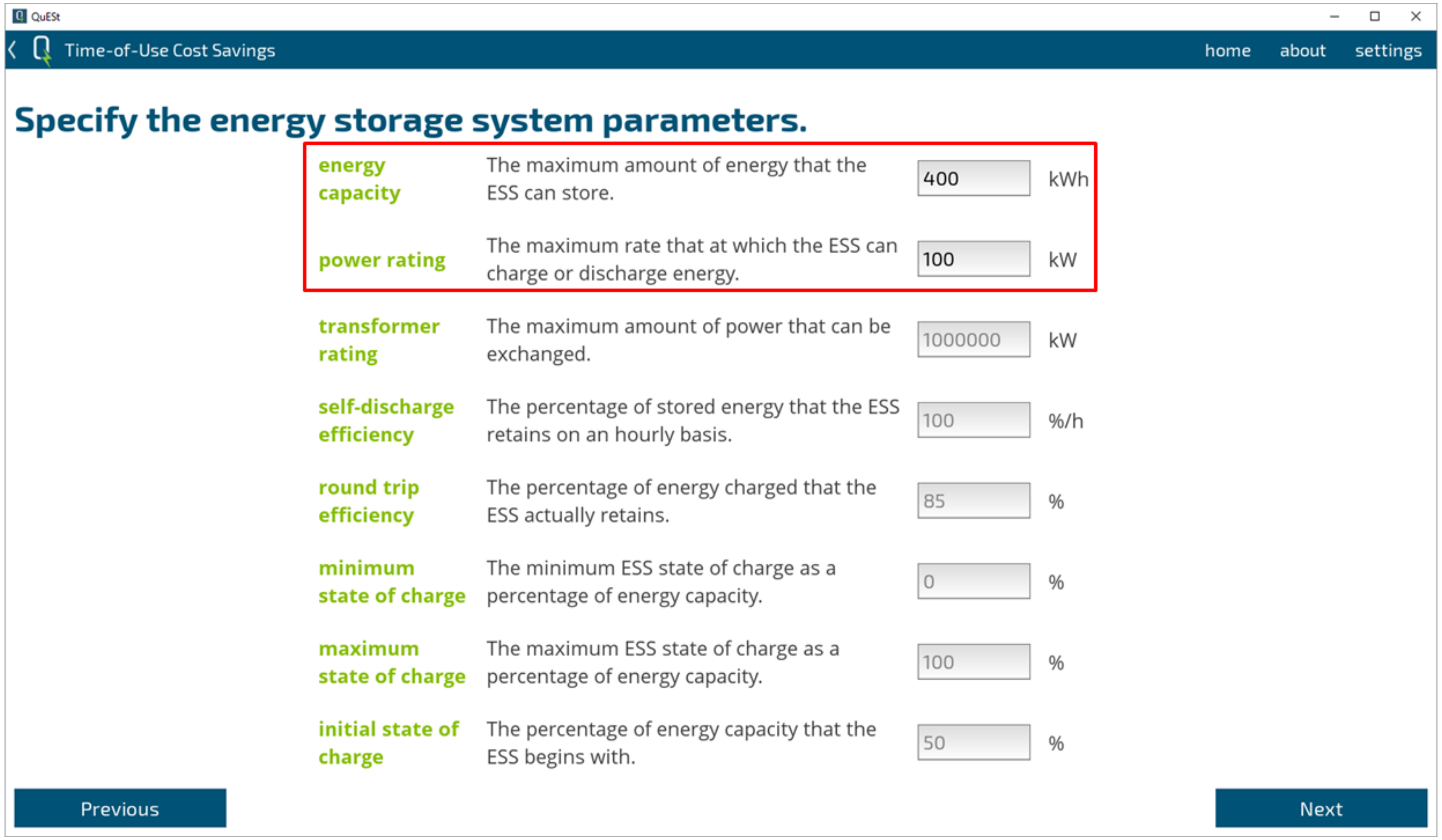

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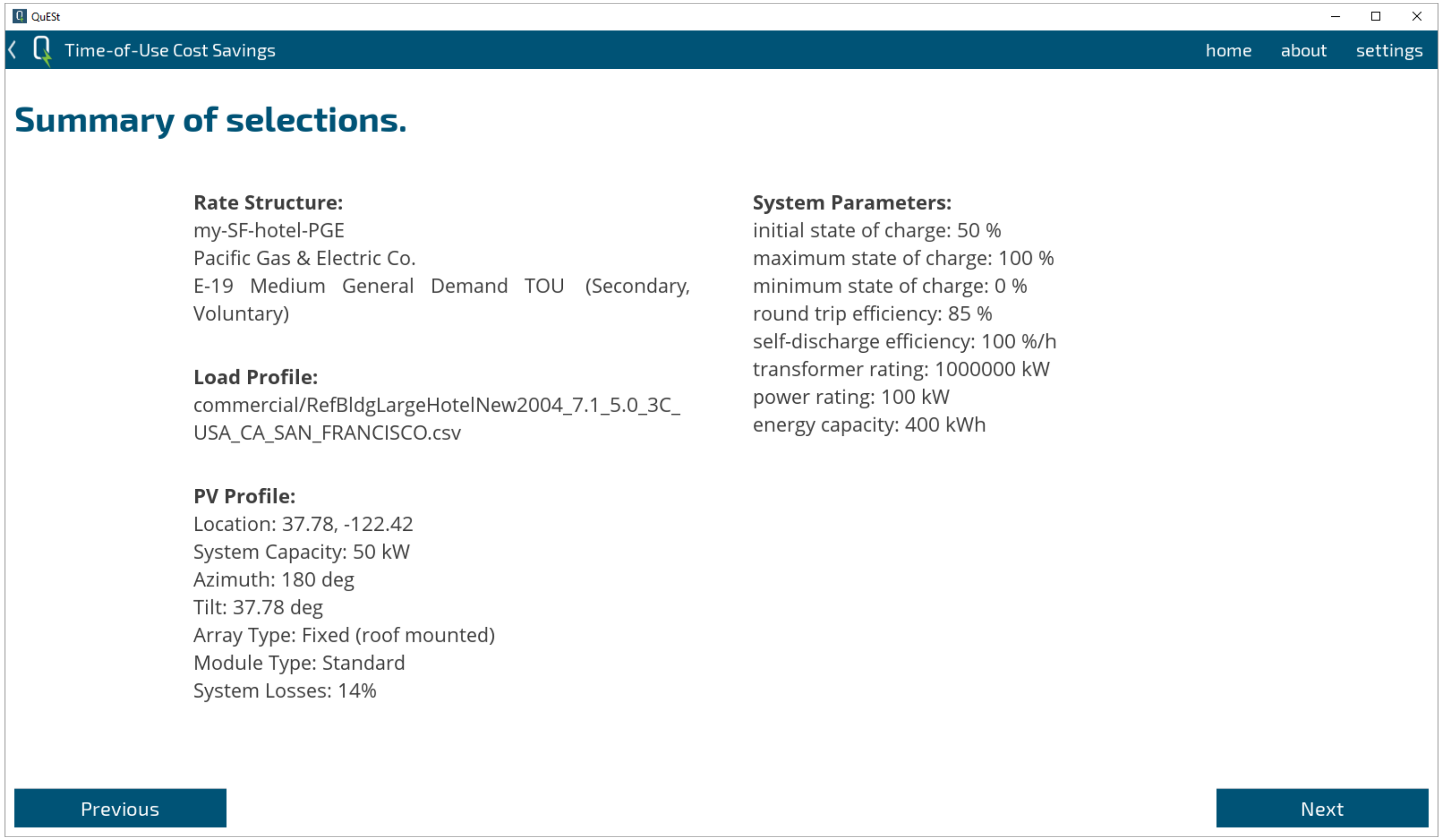
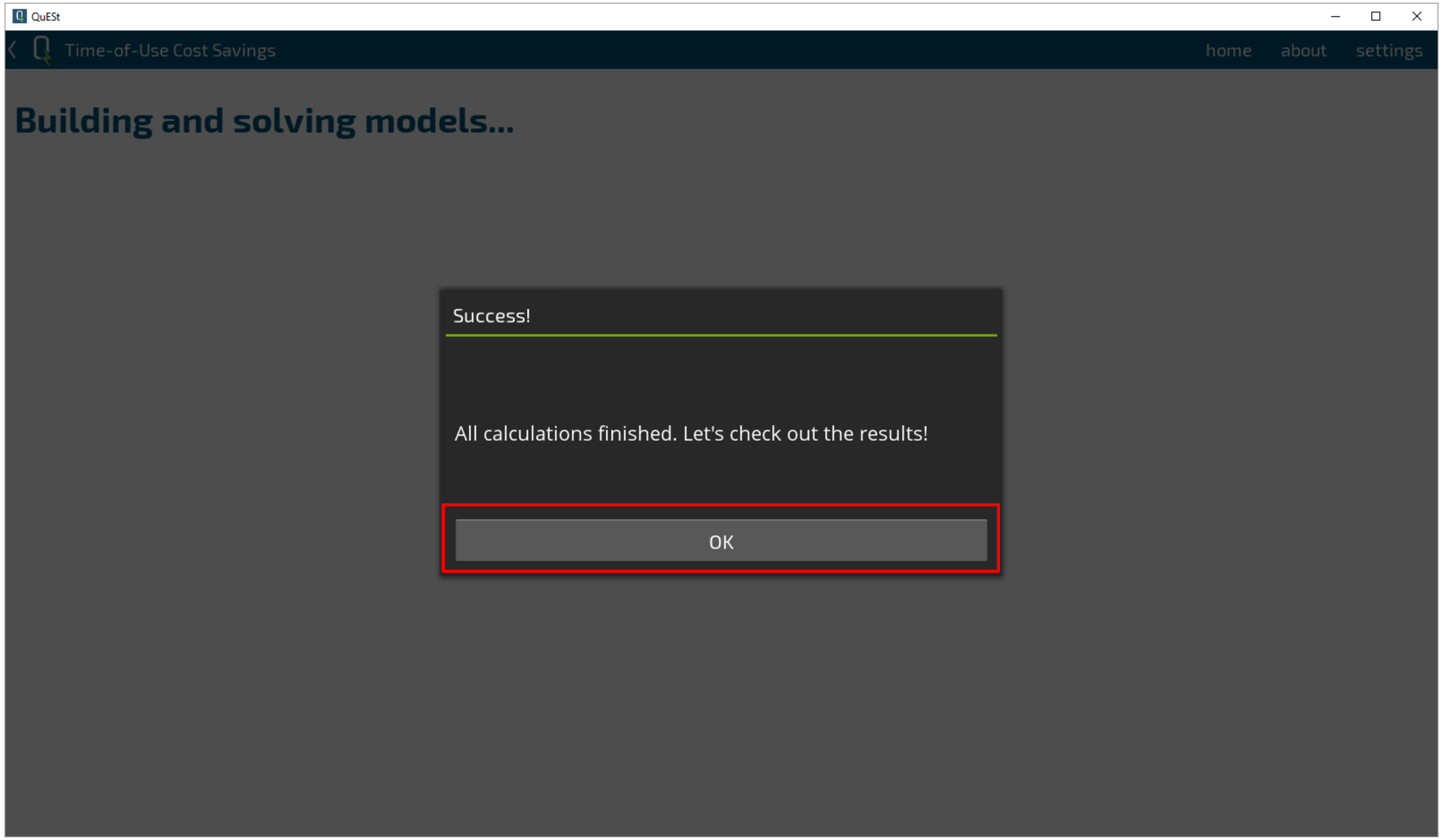


- Once everything's setup, we'll click "Next" to initiate the model building and solution process.
- In the background, the specified data is being loaded, the optimization models are being constructed, and the models are being solved.
- After a brief wait, a prompt will notify you that the computation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

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



- 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.
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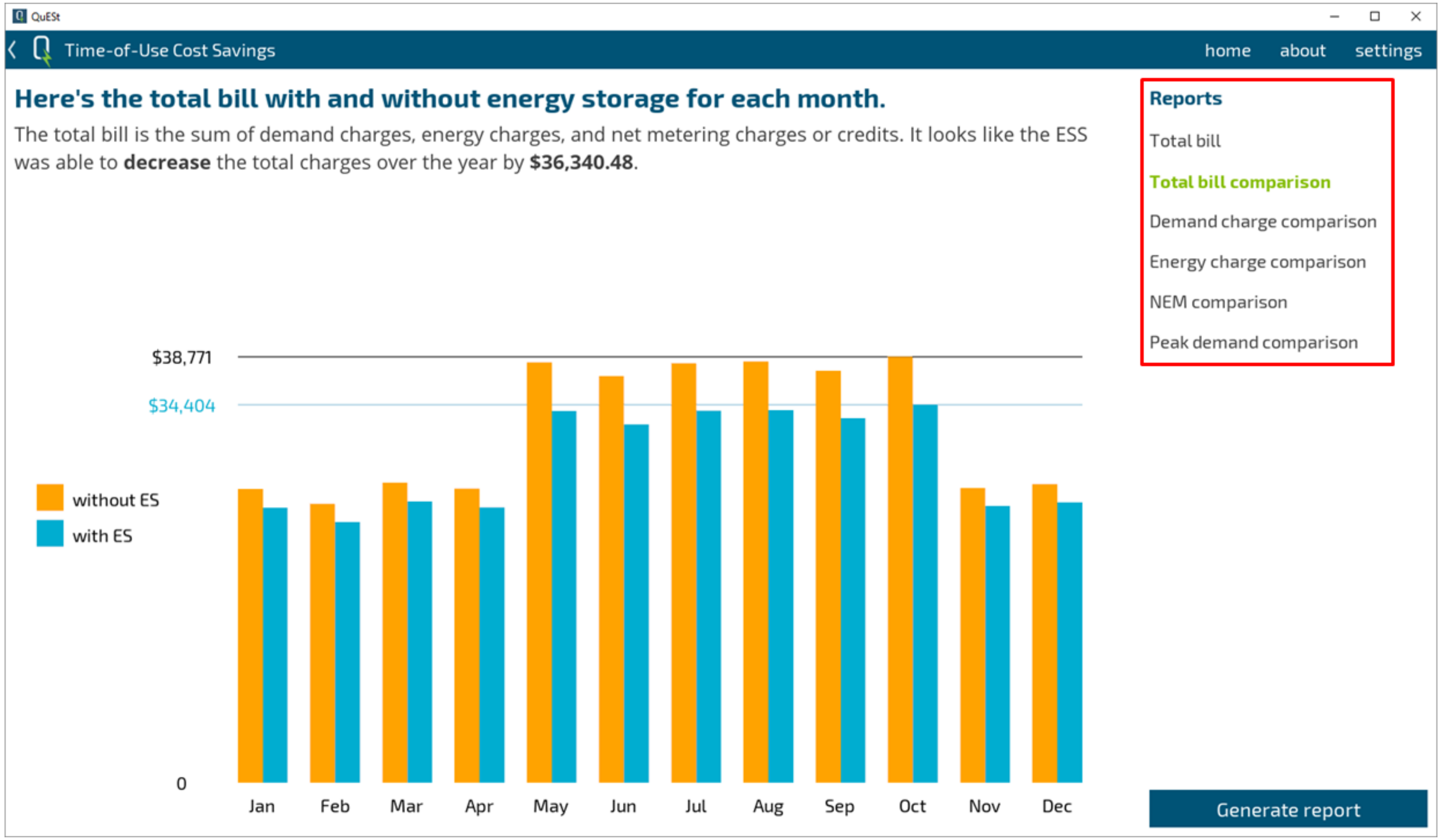
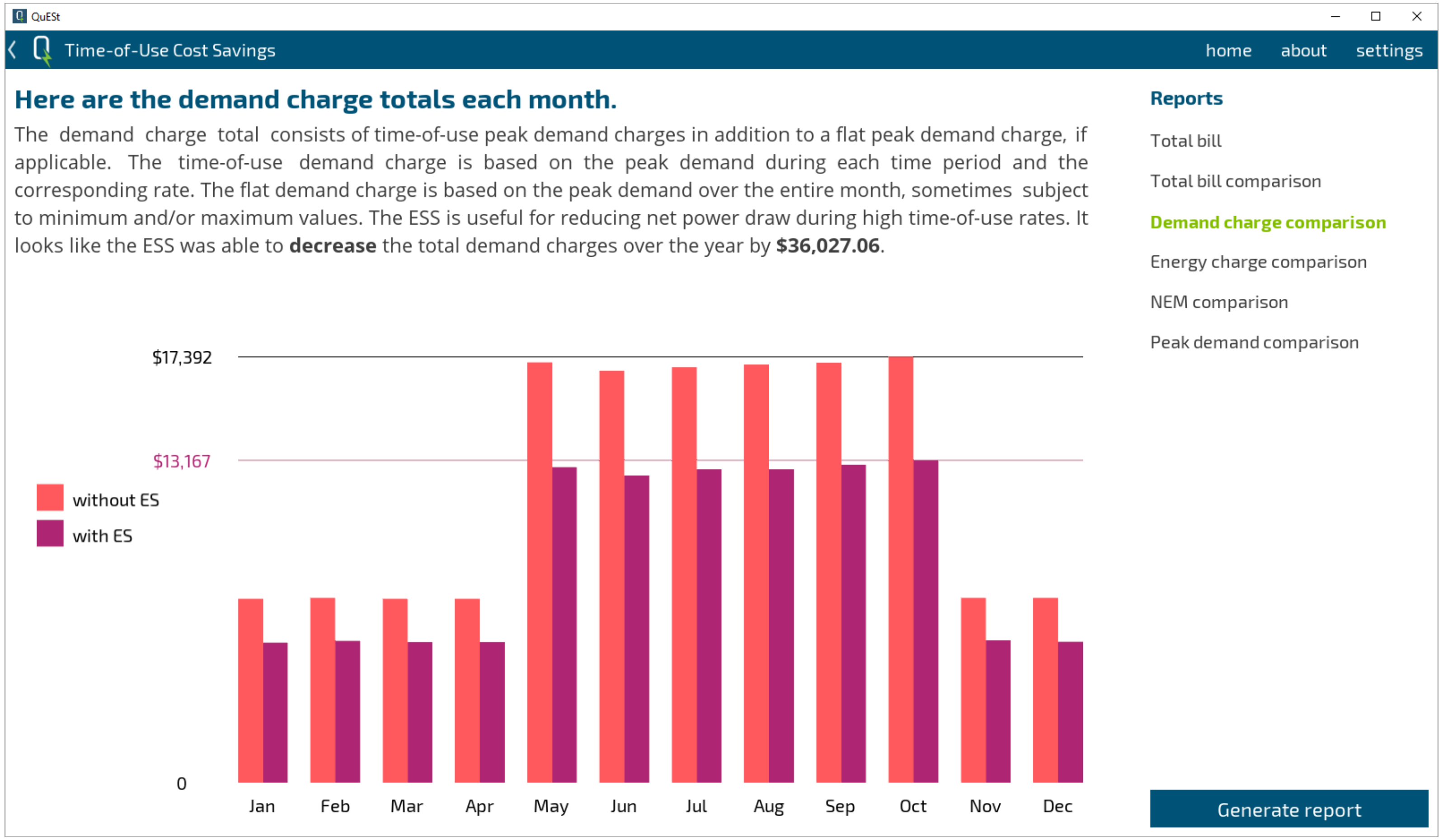


- We can now view the wizard's report of results and view several summary graphics.
- Based on the calculations, the addition of the energy storage system reduced annual charges by about $36k.
- This was mostly due to demand charge reduction.
- Peak demand each month was reduced by about 100 kW.

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE



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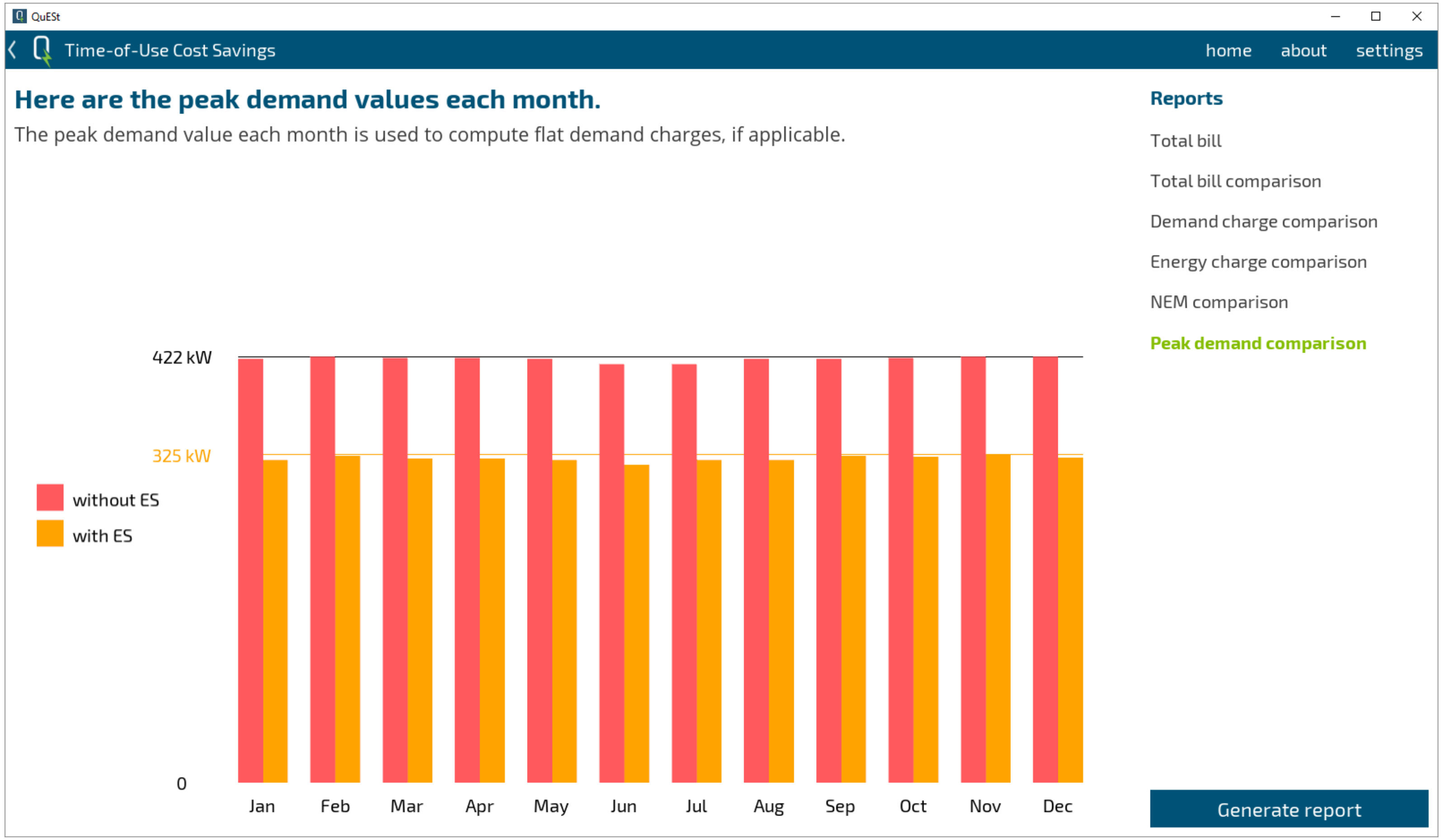

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- Based on the calculations, the addition of the energy storage system reduced annual charges by about $36k.
- This was mostly due to demand charge reduction.
- Peak demand each month was reduced by about 100 kW.
- We can also create a summary report that includes formulation details and the results.

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE

Behind-the-Meter Energy Storage Cost Savings Report

Autogenerated using QuESt BTM

May 13, 2019

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

Scenario Summary

Utility: Pacific Gas & Electric Co.

Rate Structure: E-19 Medium General Demand TOU (Secondary, Voluntary)

Load Profile: commercial/RefBldgLargeHotelNew2004_7.1_5.0_3C_USA_CA_SAN_FRANCISCO.csv

Photovoltaic Power Profile

Location: 37.78, -122.42
System Capacity: 50 kW
Azimuth: 180 deg
Tilt: 37.78 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	100	kW

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

CASE STUDY: LARGE HOTEL WITH SOLAR + STORAGE

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

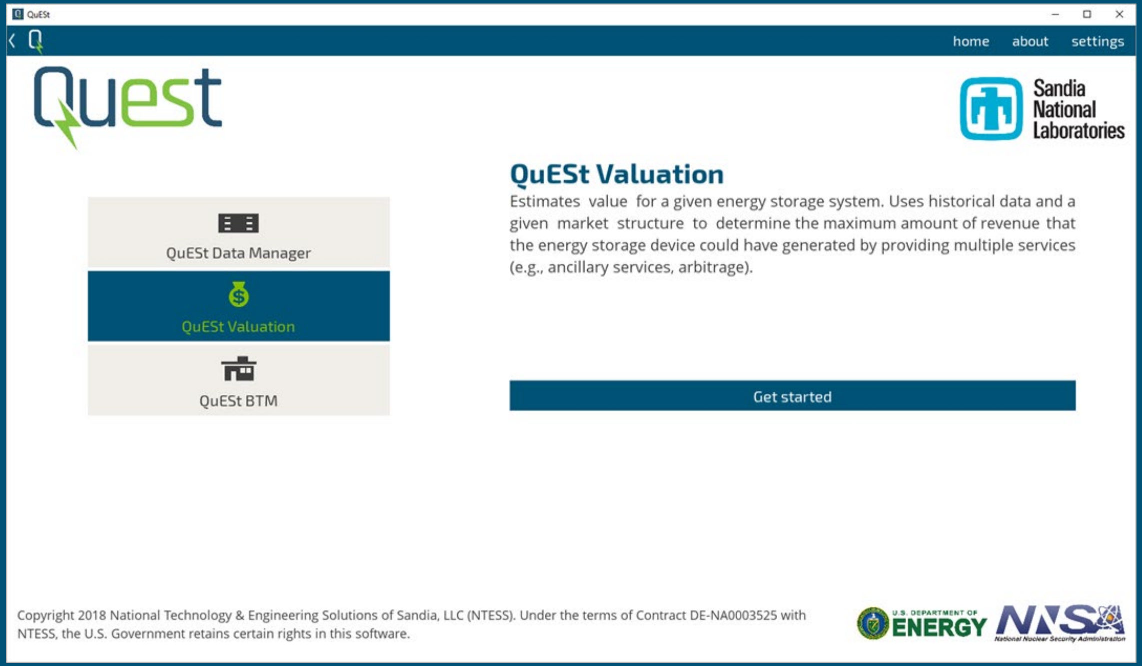
Is the energy storage system worth it? It will depend on the financials of acquiring and operating it… but we have an estimate on its performance value potential.

RELATED WORK

1. Byrne, R. H., Nguyen, T. A., Copp, D. A., Chalamala, B. R., & Gyuk, I, "Energy Management and Optimization Methods for Grid Energy Storage Systems," in IEEE Access, vol. 6, pp. 13231-13260, 2018.
2. T. A. Nguyen, D. A. Copp, R. H. Byrne, B. R. Chalamala, "Market Evaluation of Energy Storage Systems Incorporating Technology-specific Nonlinear Models," in IEEE Transactions on Power Systems, vol. 34, no. 5, pp. 3706 – 3715, April 2019.
3. T. A. Nguyen, D. A. Copp, R. H. Byrne, "Stacking Revenue of Energy Storage System from Resilience, T&D Deferral and Arbitrage," accepted for the 2019 IEEE Power and Energy Society General Meeting, Aug 2019, Atlanta, GA.
4. R. Concepcion, F. Wilches-Bernal, R. H. Byrne, "Revenue Opportunities for Electric Storage Resources in the Southwest Power Pool Integrated Marketplace," accepted for the 2019 IEEE Power and Energy Society General Meeting, Aug 2019, Atlanta, GA.
5. F. Wilches-Bernal, R. Concepcion, R. H. Byrne, "Participation of Electric Storage Resources in the NYISO Electricity and Frequency Regulation Markets," accepted for the 2019 IEEE Power and Energy Society General Meeting, Aug 2019, Atlanta, GA.
6. D. A. Copp, T. A. Nguyen, and R. H. Byrne, "Adaptive Model Predictive Control for Real-time Dispatch of Energy Storage systems," accepted for the 2019 IEEE American Control Conference, Jul 2019, Philadelphia, PA.
7. A. Ingalalli, A. Luna, V. Durvasulu, T. Hansen, R. Tonkoski, D. A. Copp, T. A. Nguyen, "Energy Storage Systems in Emerging Electricity Markets: Frequency Regulation and Resiliency," accepted the 2019 IEEE Power and Energy Society General Meeting, Aug 2019, Atlanta, GA.
8. T. A. Nguyen and R. H. Byrne, "Optimal Time-of-Use Management with Power Factor Correction Using Behind-the-Meter Energy Storage Systems," in the proceedings of the 2018 IEEE Power and Energy Society General Meeting, Aug 2018, Portland, OR. (Selected for Best Paper Session in Power System Planning, Operation, and Electricity Markets.)
9. T. A. Nguyen, R. Rigo-Mariani, M. Ortega-Vazquez, D.S. Kirschen, "Voltage Regulation in Distribution Grid Using PV Smart Inverters," in the proceedings of the 2018 IEEE Power and Energy Society General Meeting, Aug 2018, Portland, OR.
10. R. H. Byrne and T. A. Nguyen, "Opportunities for Energy Storage in CAISO," in the proceedings of the 2018 IEEE Power and Energy Society General Meeting, Aug 2018, Portland, OR.
11. D. A. Copp, T. A. Nguyen and R. H. Byrne, "Optimal Sizing of Behind-the-Meter Energy Storage with Stochastic Load and PV Generation for Islanded Operation," in the proceedings of the 2018 IEEE Power and Energy Society General Meeting, Aug 2018, Portland, OR.
12. T. A. Nguyen, R. H. Byrne, B. R. Chalamala and I. Gyuk, "Maximizing The Revenue of Energy Storage Systems in Market Areas Considering Nonlinear Storage Efficiencies," in the proceedings of the 2018 IEEE Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM 2018), June 2018, Amalfi, Italy.
13. R. H. Byrne, T. A. Nguyen, D. A. Copp and I. Gyuk, "Opportunities for Energy Storage in CAISO: Day-Ahead and Real-Time Market Arbitrage," in the proceedings of the 2018 IEEE Symposium on Power Electronics, Electrical Drives, Automation and Motion (SPEEDAM 2018), June 2018, Amalfi, Italy.
14. Christoph Lackner, T. A. Nguyen, Raymond H. Byrne and Frank Wiegandt, "Energy Storage Participation in the German Secondary Regulation Market," in the proceedings of the 2018 IEEE Transmission and Distribution Conference and Exposition, Apr 2018, Denver, CO.
15. T. A. Nguyen, R. H. Byrne, R. Concepcion, and I. Gyuk, "Maximizing Revenue from Electrical Energy Storage in MISO Energy & Frequency Regulation Markets," in Proceedings of the 2017 IEEE Power Energy Society General Meeting, Chicago, IL, July 2017, pp. 1–5.
16. T. A. Nguyen and R. H. Byrne, " Maximizing the Cost-savings for Time-of-use and Net-metering Customers Using Behind-the-meter Energy Storage Systems," in Proceedings of the 2017 North American Power Symposium, Morgan Town, WV, 2017, pp. 1-7.
17. R. H. Byrne, R. J. Concepcion and C. A. Silva-Monroy, "Estimating potential revenue from electrical energy storage in PJM," 2016 IEEE Power and Energy Society General Meeting (PESGM), Boston, MA, 2016, pp. 1-5.

FUTURE PLANS AND WRAP-UP

- Develop new applications
  - Integrated resource planning tools
  - Optimizing with costs
  - Resilience
  - More value streams
  - RFP templates
- Release API/Library
- Webinars, tutorials, workshops
- Integrate user feedback and requests



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.

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https://www.sandia.gov/ess-ssl/tools/quest/

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Follow us on GitHub:

github.com/rconcep/snl-quest