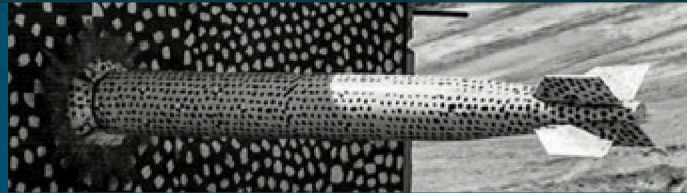




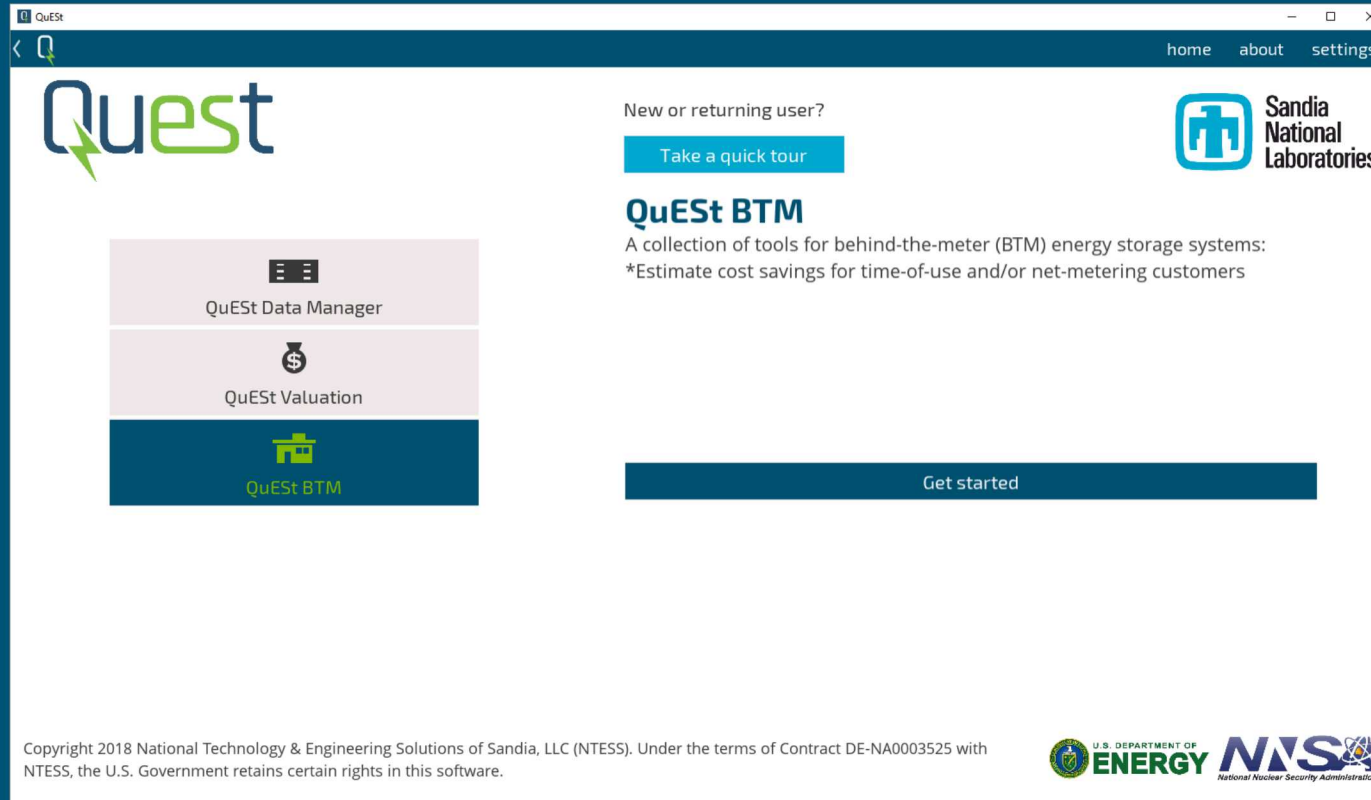
# An Energy Storage Application Suite



PRESENTED BY

Ricky Concepcion

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

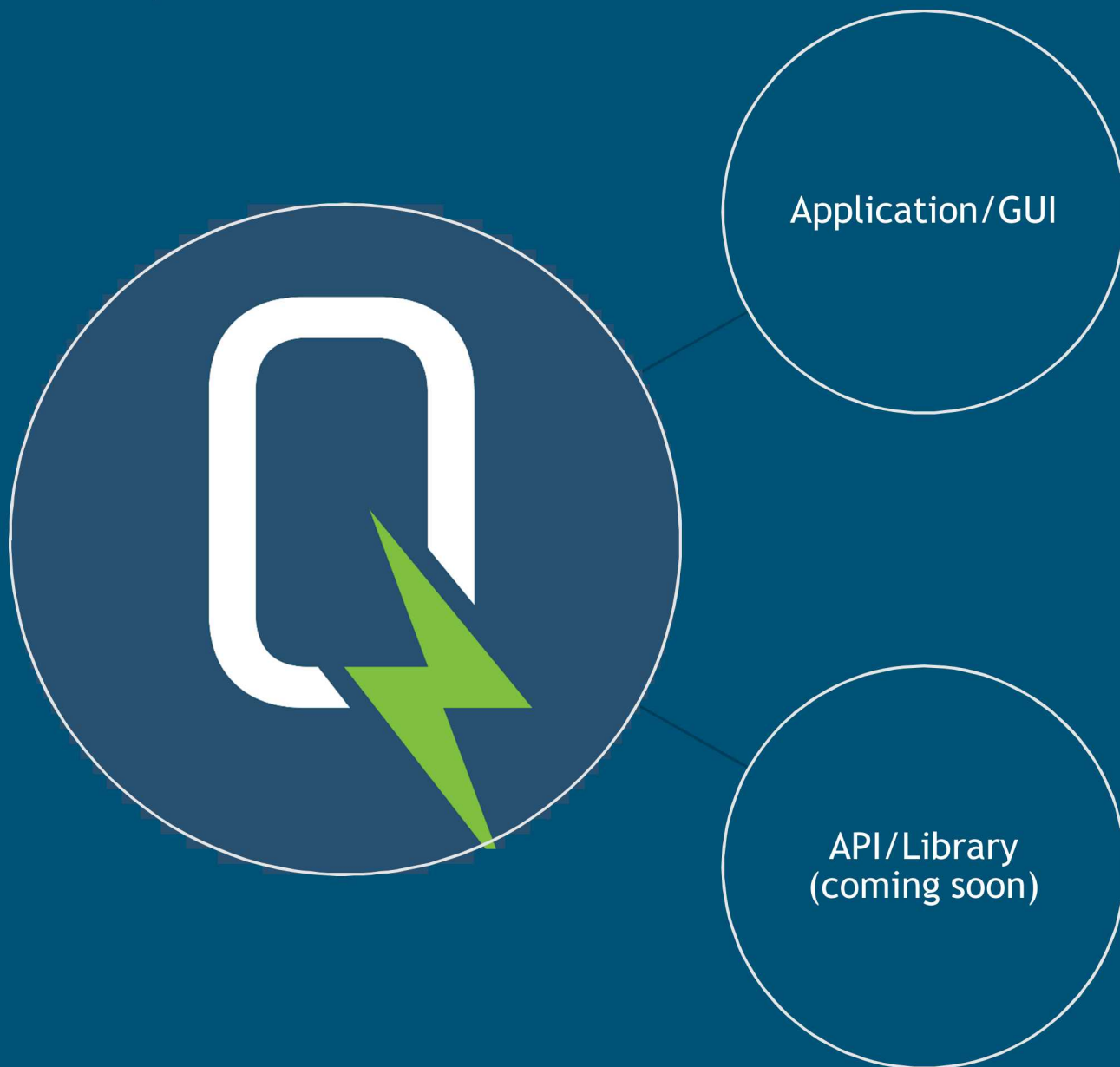


- Energy storage analysis/valuation software application suite
- Developed as a graphical user interface (GUI) for the optimization modeling capabilities of Sandia's energy storage analytics group
- Version 1.0 publicly released in September 2018
- Version 1.2 available on GitHub
  - [github.com/rconcep/snl-quest](https://github.com/rconcep/snl-quest) or [sandia.gov/ess](https://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.



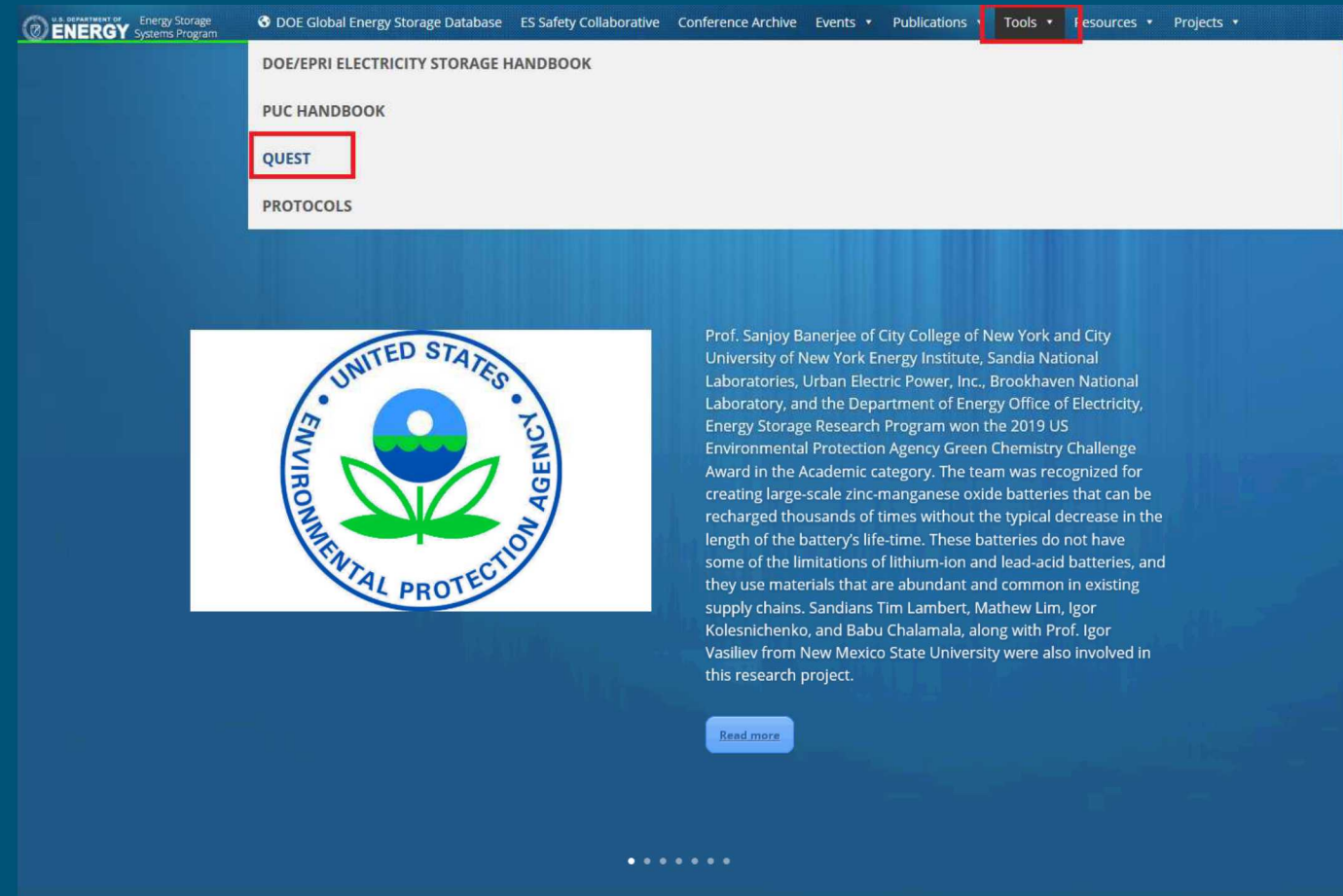


- For most users
- Developed for user experience
- No hassle installation

- 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](https://github.com/rconcep/snl-quest)
- General requirements:
  - Windows/OS X/Linux
  - Solver for optimization



# 7 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

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)	

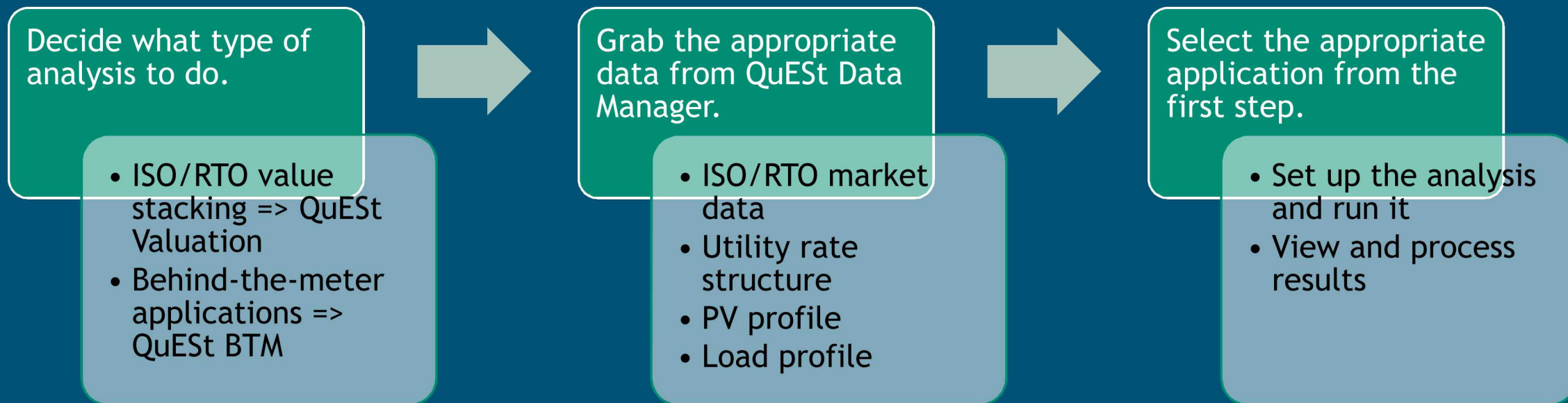




# QUEST APPLICATIONS OVERVIEW

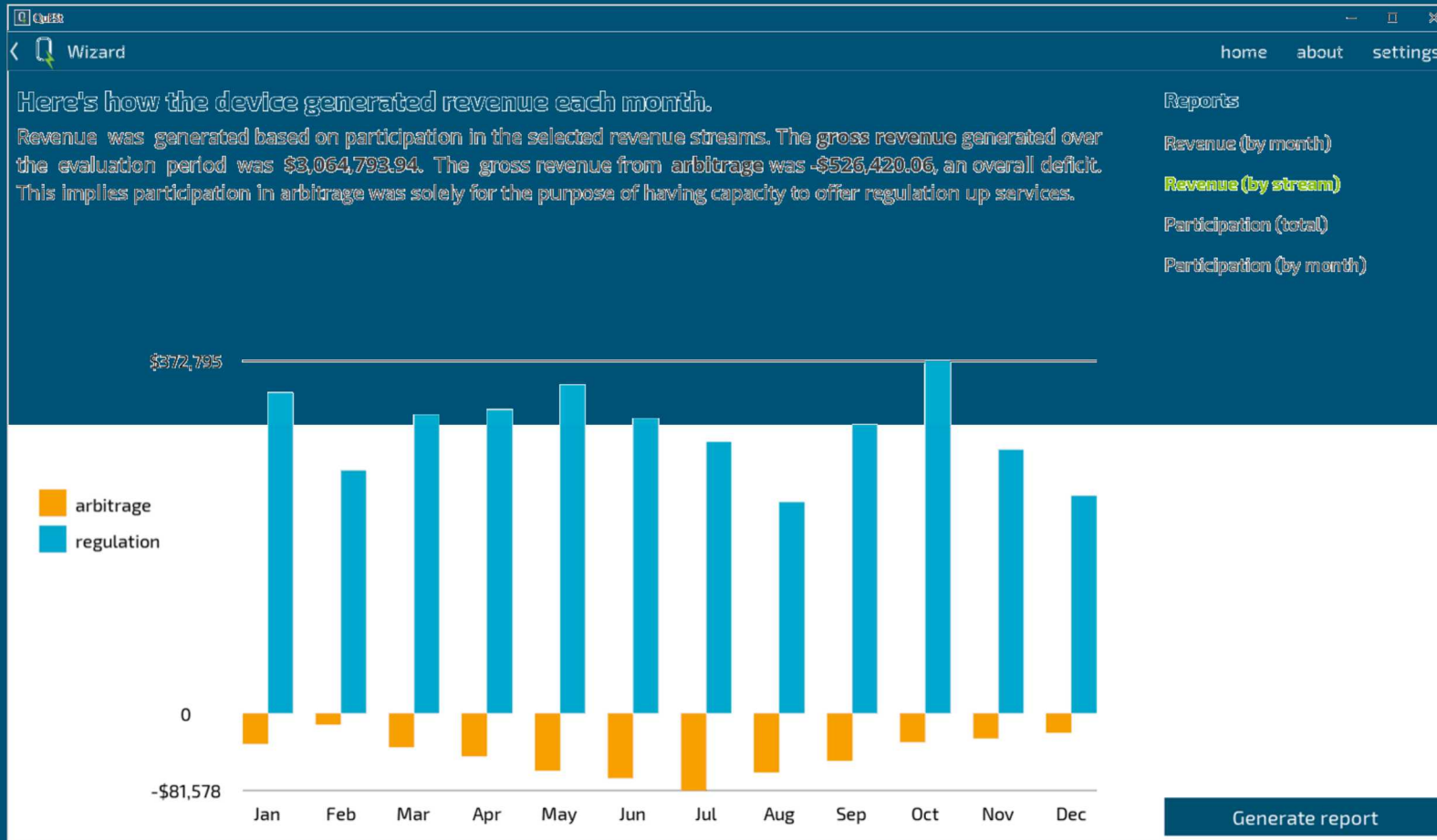
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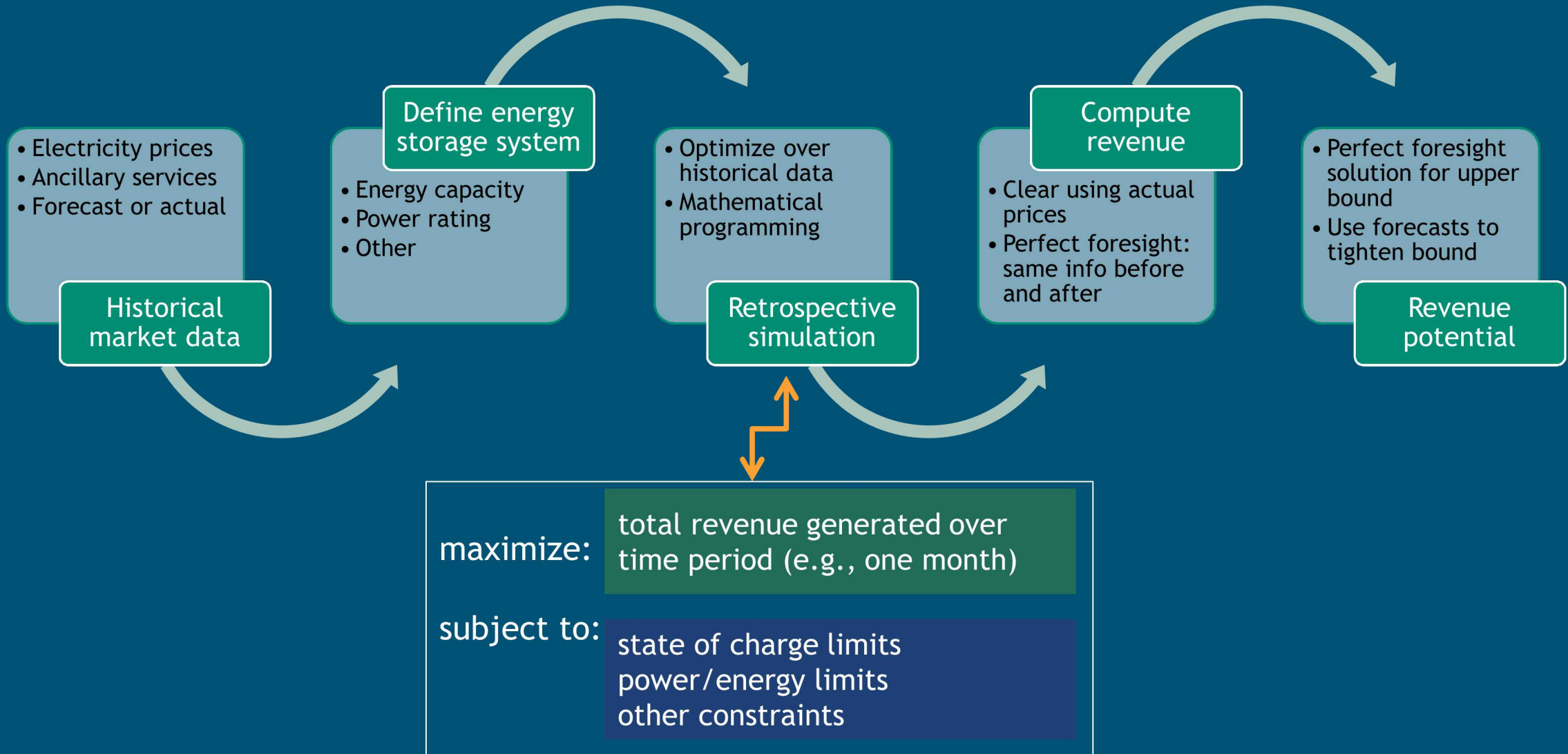


# QUEST VALUATION

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.

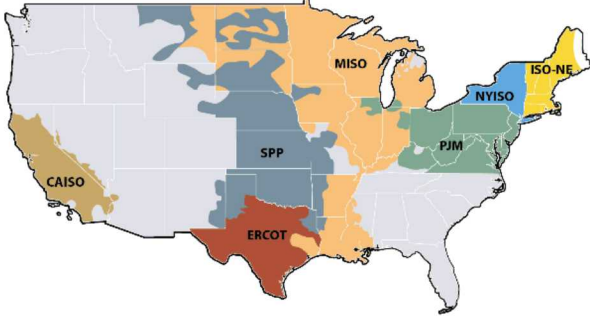


QuEst Wizard

home about settings

### Select a market area to place the energy storage device in.

Different market areas can have different market structures, resulting in various opportunities for generating revenue.



ERCOT	PJM	MISO
<b>NYISO</b>	ISONE	SPP
CAISO		

Previous Next

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



QuEST

Wizard

home about settings

### Describe the type of energy storage device to be used.

Energy storage devices come in many forms and technologies. In this application, they are mainly modeled according to their power and energy ratings. Select an energy storage device template and/or customize your own.

Li-ion Battery

Advanced Lead-acid Battery

Flywheel

Vanadium Redox Flow Battery

Li-Iron Phosphate Battery

self-discharge efficiency (%/h)

100.0

round trip efficiency (%)

90.0

energy capacity (MWh)

24.0

power rating (MW)

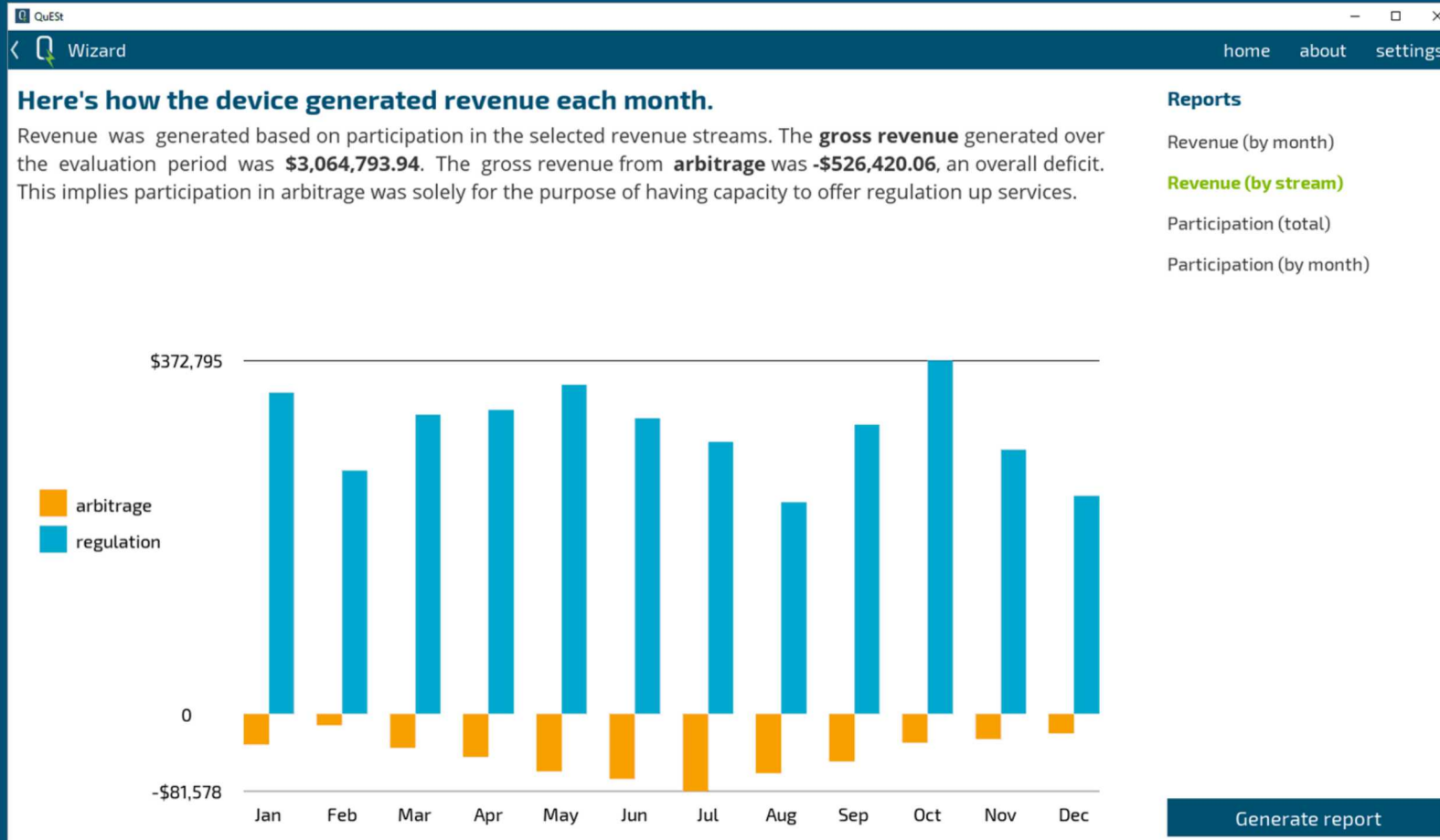
36.0

**Li-ion Battery**

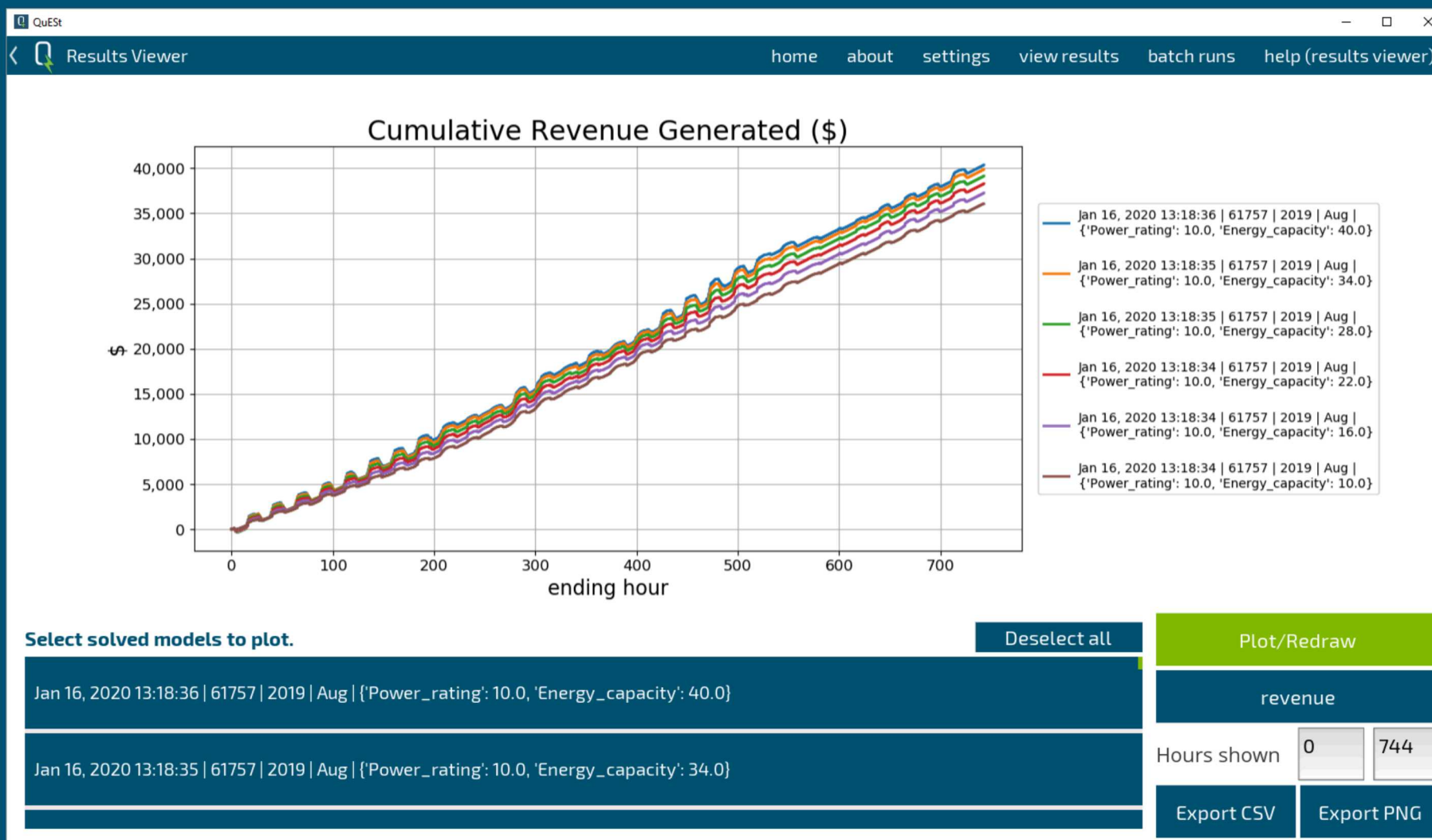
Modeled after the Notrees Battery Storage Project in western TX.

PreviousNext

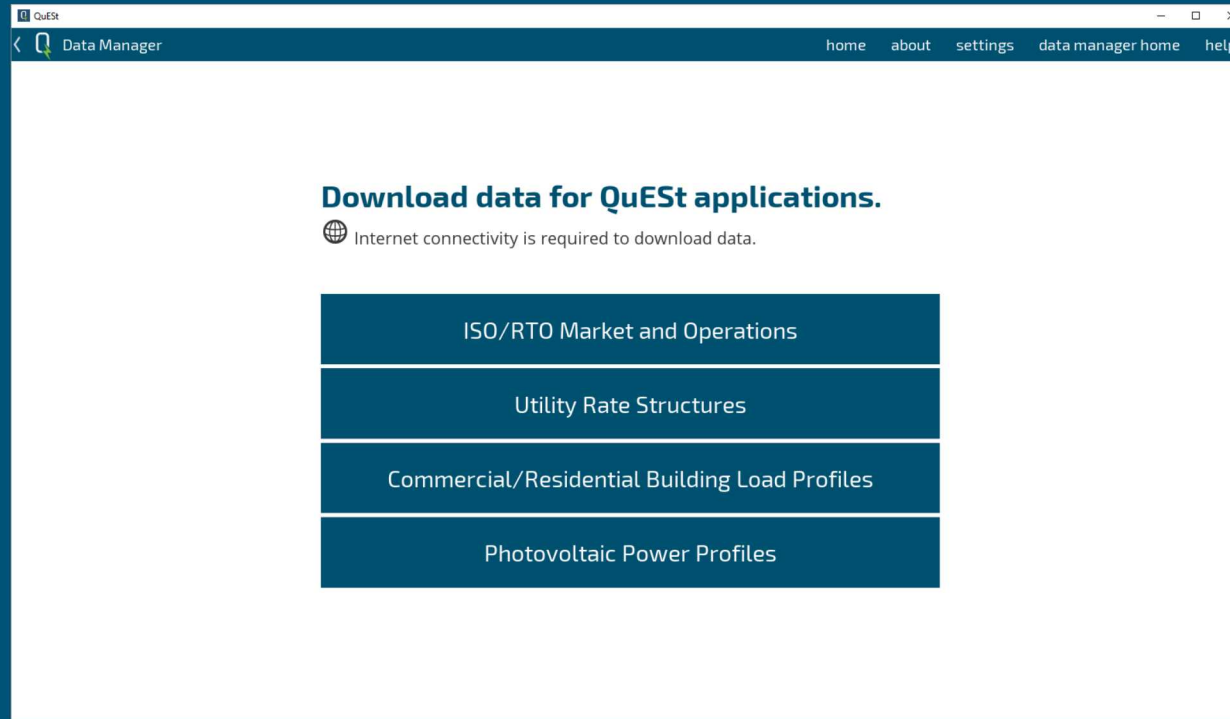
- Market area
- Revenue streams
- Historical dataset to study
- Energy storage model parameters



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



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



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



QuEst

Data Manager: ISO/RTO Market and Operations Data

homeaboutsettingsdata manager homehelp

Download ISO/RTO market and operations data.

SPP

PJM

NYISO

MISO

ISO-NE

ERCOT

CAISO

ISO-NE

Enter ISO-NE ISO Express credentials. ⓘ

Username

Password

Specify the range of months.

Start:

January

2019

End:

December

2019

Pricing node ID and/or types of nodes

Node ID

☐ Internal Hub

☐ Zones

Download

Cancel

Settings


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

QuEST

Data Manager: Utility Rate Structure Data

home about settings data manager home help

### Search for a utility rate structure.

Data.gov API key 

#### Select a utility.

Filter by name

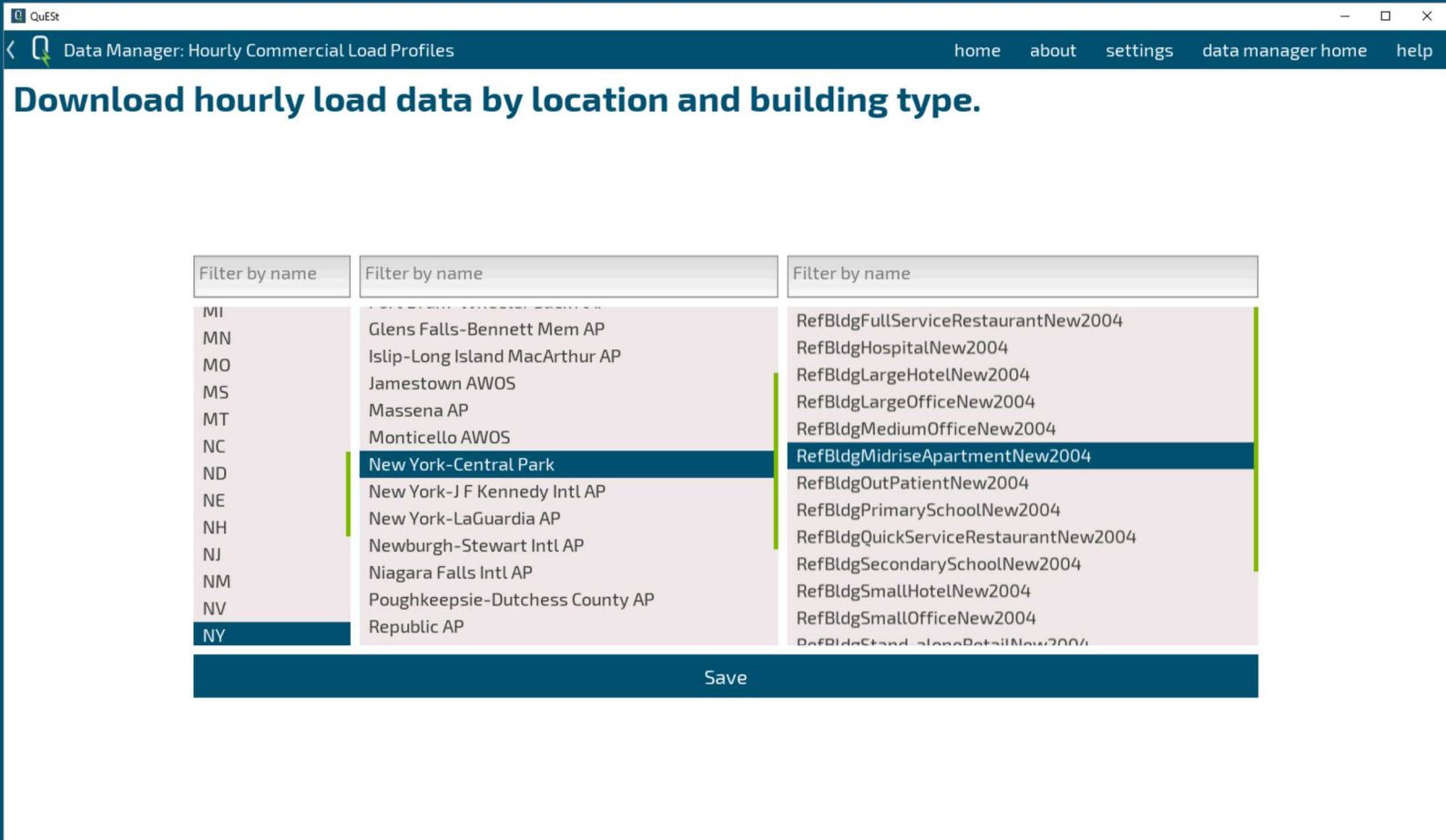
- Central Hudson Gas & Elec Corp
- City of Plattsburgh - (NY)
- City of Salamanca - (NY)
- Consolidated Edison Co-NY Inc**
- Fishers Island Utility Co Inc
- Jamestown Board of Public Util
- Lake Placid Village, Inc - (NY)
- Long Island Power Authority
- New York State Elec & Gas Corp
- Niagara Mohawk Power Corp.
- Orange & Rockland Utils Inc
- Pennsylvania Electric Co
- Rochester Gas & Electric Corp
- Steuben Rural Elec Coop, Inc
- Town of Massena - (NY)

#### Select a rate structure.

- SC 8 - Multiple Dwellings Redistribution Low Tension Service (Effective Date : 05/01/2015)
- SC 8 - Multiple Dwellings Redistribution TOD Service [NYC] (Effective Date : 05/01/2019)**
- SC 8 - Multiple Dwellings Redistribution TOD Service [NYC] (Effective Date : 05/01/2019)
- SC 8 - Multiple Dwellings Redistribution TOD Service [NYC] (Effective Date : 09/01/2018)

Light, heat, and power for multiple dwellings where the Customer's initial requirements are expected to be in excess of 10 kilowatts, subject to the Common Provisions and Special Provisions of this Service Classification

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




- 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: Photovoltaic Power Profiles

home about settings

### Search for a photovoltaic power profile.

Data.gov API key 

latitude	The latitude of the site in the range (-90, 90).	<input type="text" value="37.78"/>	deg
longitude	The longitude of the site in the range (-180, 180).	<input type="text" value="-122.42"/>	deg
system capacity	The nameplate capacity of the photovoltaic system.	<input type="text" value="5"/>	kW
losses	The total system losses, including all sources, in the range (-5, 99).	<input type="text" value="14"/>	%
tilt angle	The tilt angle of the PV surface.	<input type="text" value="0"/>	deg
azimuth angle	The azimuth angle of the PV surface.	<input type="text" value="0"/>	deg

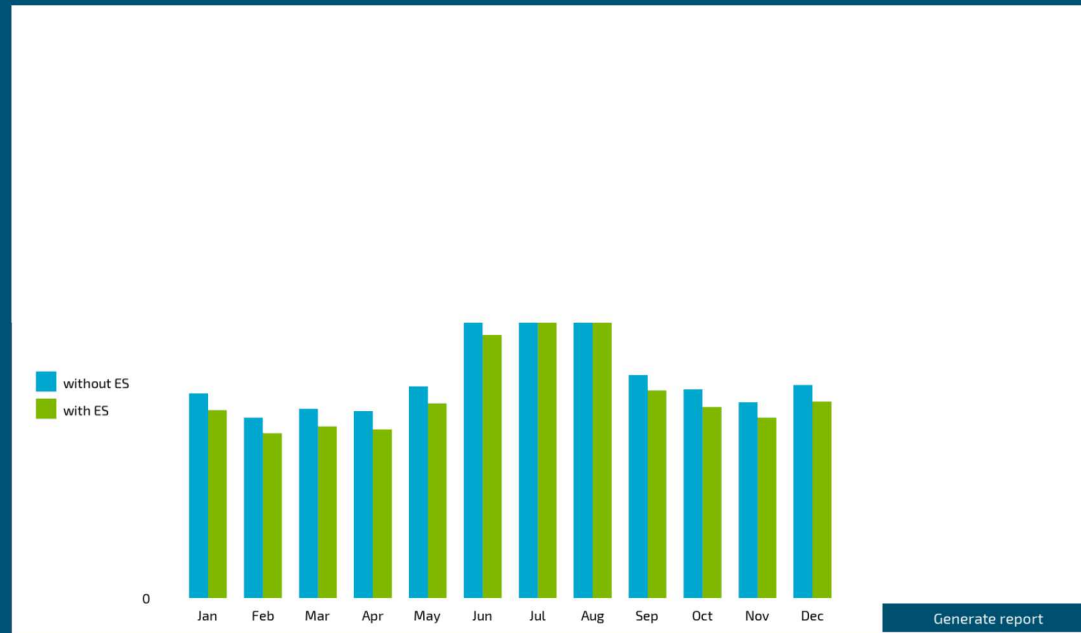
## ■ PVWatts by NREL

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

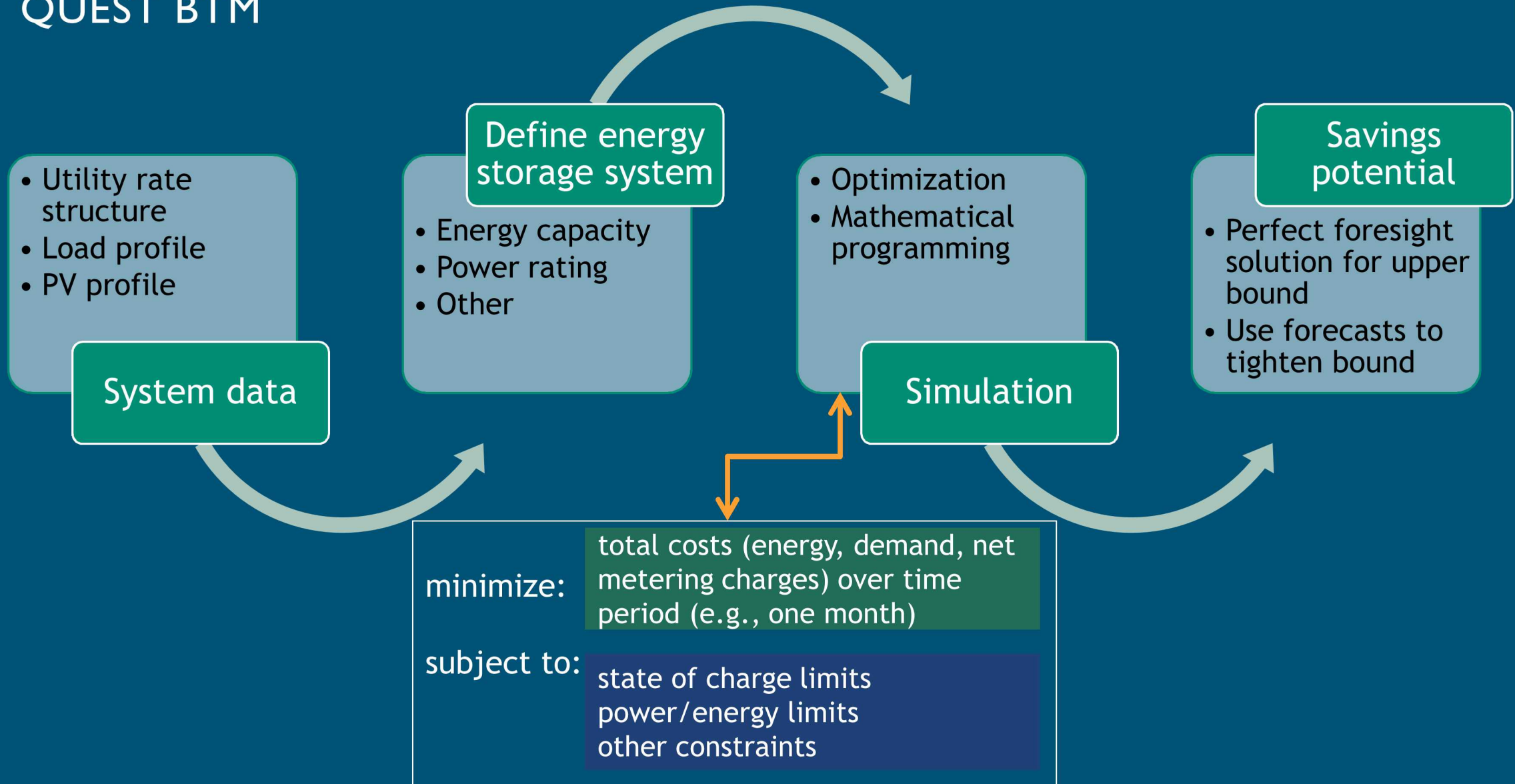


A collection of applications for behind-the-meter energy storage. The first application estimates cost savings for time-of-use and net energy metering customers.

- 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

Time-of-Use Cost Savings

home about settings

### Select a rate structure.

Filter by name

- 0129
- 0206
- 0213
- 0321-nyseg
- 0325-pepco-general-service
- PNM
- e-tou-option-b
- example
- nyseg-tou-residential
- nyseg-tou-residential-nem1
- paloalto
- pnm-residential-tou**
- xyz

**Energy**

\$0.1866117/kWh  
 \$0.0599494/kWh  
 \$0.1452852/kWh  
 \$0.0599494/kWh

**Demand**

\$0.0/kW

Flat demand rate [\$/kW]

Peak demand min. [kW]

Peak demand max. [kW]

Net metering type

Energy sell price [\$/kWh]

Previous Next

- 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

Time-of-Use Cost Savings

home about settings

### Specify the energy storage system parameters.

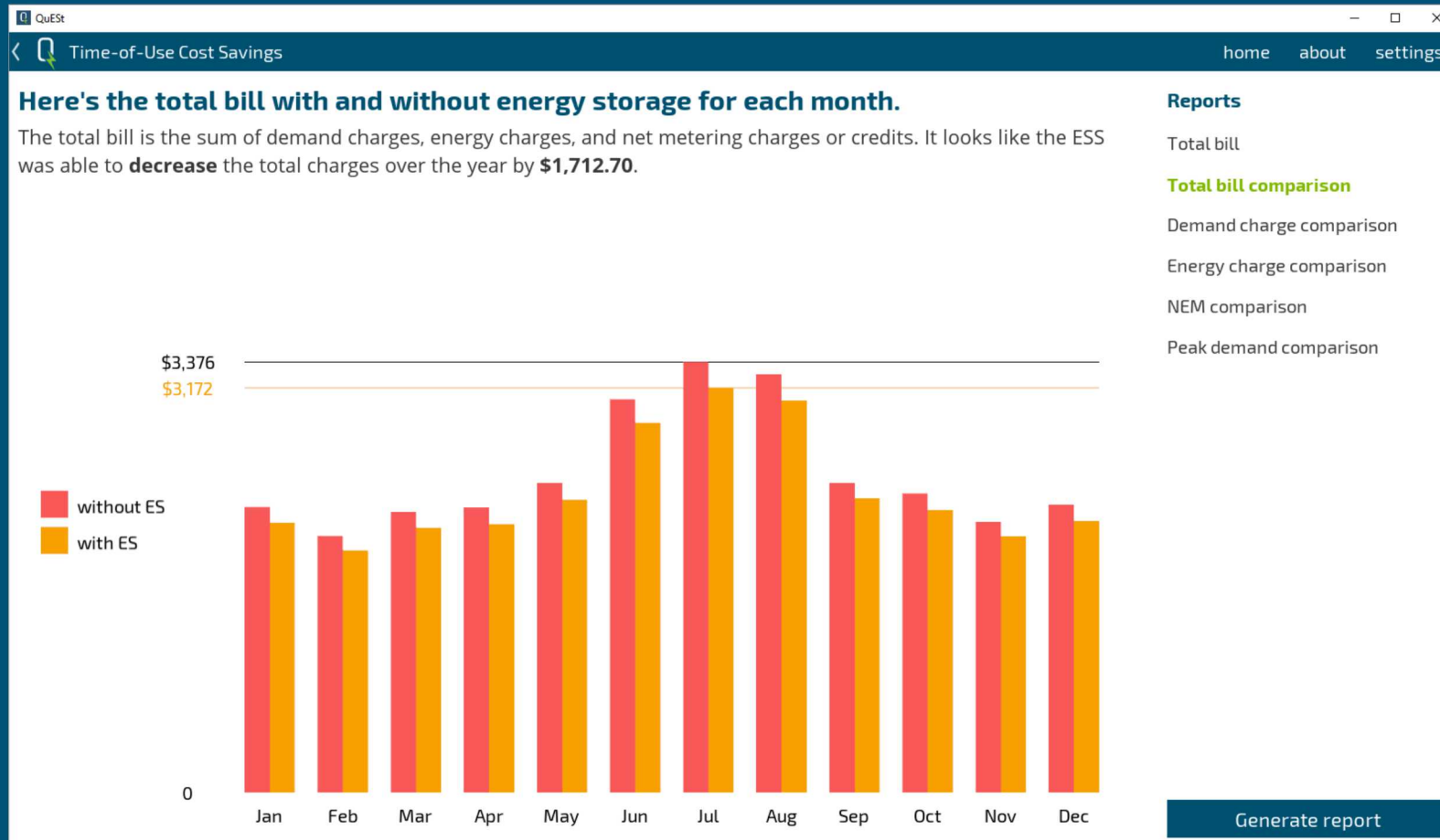
<b>energy capacity</b>	The maximum amount of energy that the ESS can store.	<input type="text" value="80"/>	kWh
<b>power rating</b>	The maximum rate that at which the ESS can charge or discharge energy.	<input type="text" value="20"/>	kW
<b>transformer rating</b>	The maximum amount of power that can be exchanged.	<input type="text" value="1000000"/>	kW
<b>self-discharge efficiency</b>	The percentage of stored energy that the ESS retains on an hourly basis.	<input type="text" value="100"/>	%/h
<b>round trip efficiency</b>	The percentage of energy charged that the ESS actually retains.	<input type="text" value="85"/>	%
<b>minimum state of charge</b>	The minimum ESS state of charge as a percentage of energy capacity.	<input type="text" value="0"/>	%
<b>maximum state of charge</b>	The maximum ESS state of charge as a percentage of energy capacity.	<input type="text" value="100"/>	%
<b>initial state of charge</b>	The percentage of energy capacity that the ESS begins with.	<input type="text" value="50"/>	%

Previous

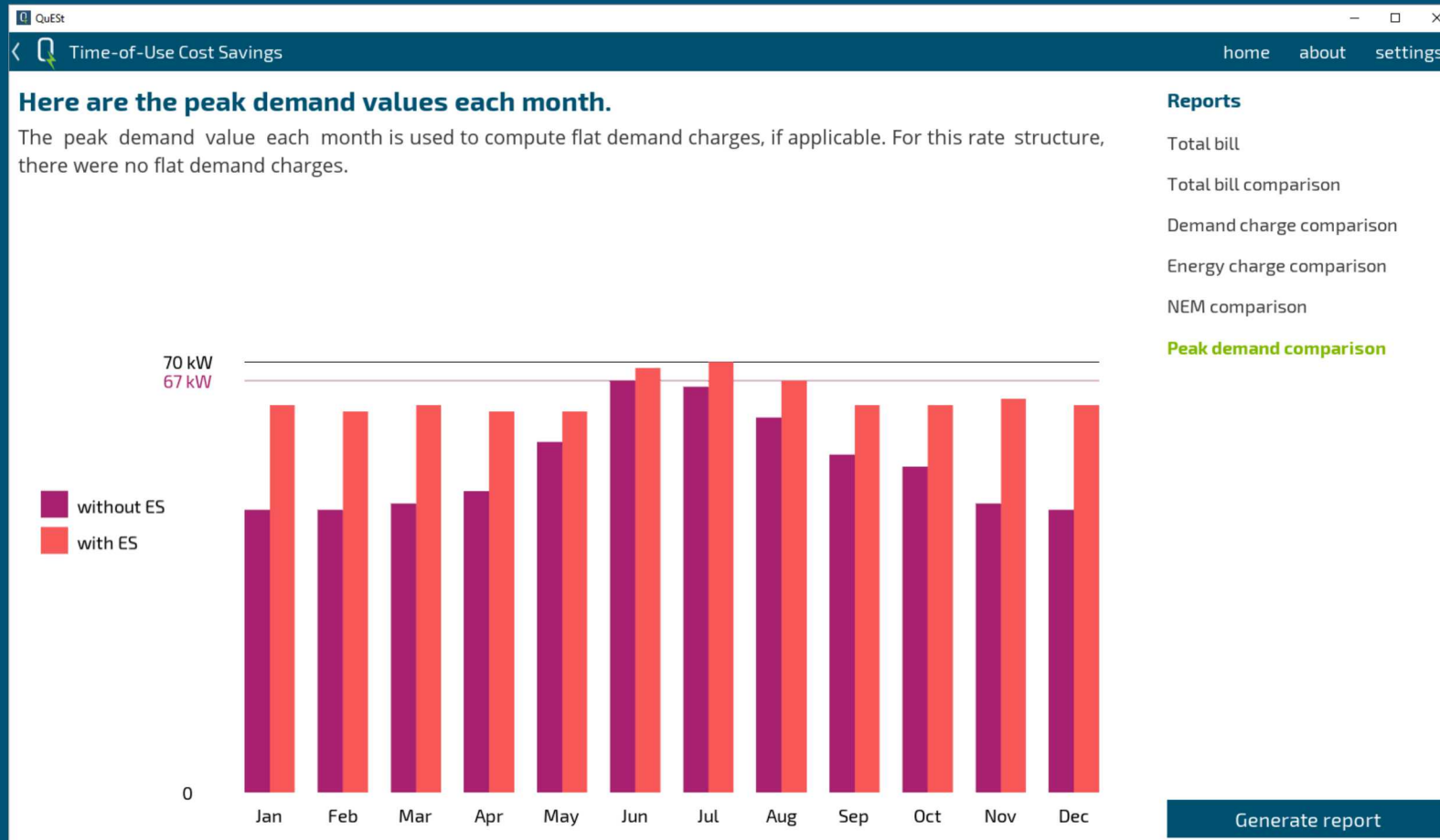
Next

- 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
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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



- 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

An aerial photograph of Reno, Nevada, showing a dense urban area with various buildings and parking lots. In the background, there are prominent mountains under a clear sky. The entire image is overlaid with a semi-transparent blue filter. A vertical orange bar is visible on the far left edge. A horizontal line with a multi-colored segment (orange, green, purple, yellow) is positioned below the text.

# 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?



The screenshot shows the QuEST web application interface. At the top left is the QuEST logo. To its right is a navigation bar with links for 'home', 'about', and 'settings'. Below the logo is a vertical menu with three options: 'QuEST Data Manager' (highlighted with a green icon), 'QuEST Valuation' (with a dollar sign icon), and 'QuEST BTM' (with a house icon). To the right of the menu, there is a section for 'New or returning user?' with a 'Take a quick tour' button. Below this is the 'QuEST Data Manager' section, which describes its function and lists data sources: ISO/RTO historical market data, U.S. utility rate structures/tariffs, Commercial and residential building load profiles, and Photovoltaic power system profiles. At the bottom of this section is a large 'Get started' button. The footer contains copyright information for National Technology & Engineering Solutions of Sandia, LLC (NTESS) and logos for the U.S. Department of Energy and NASA.

QuEST

home about settings

New or returning user?

Take a quick tour

**QuEST Data Manager**

Manages the acquisition of data from ISO/RTOs, databases, and other sources for use in QuEST applications, including:

- \*ISO/RTO historical market data
- \*U.S. utility rate structures/tariffs
- \*Commercial and residential building load profiles
- \*Photovoltaic power system profiles

QuEST Data Manager

QuEST Valuation

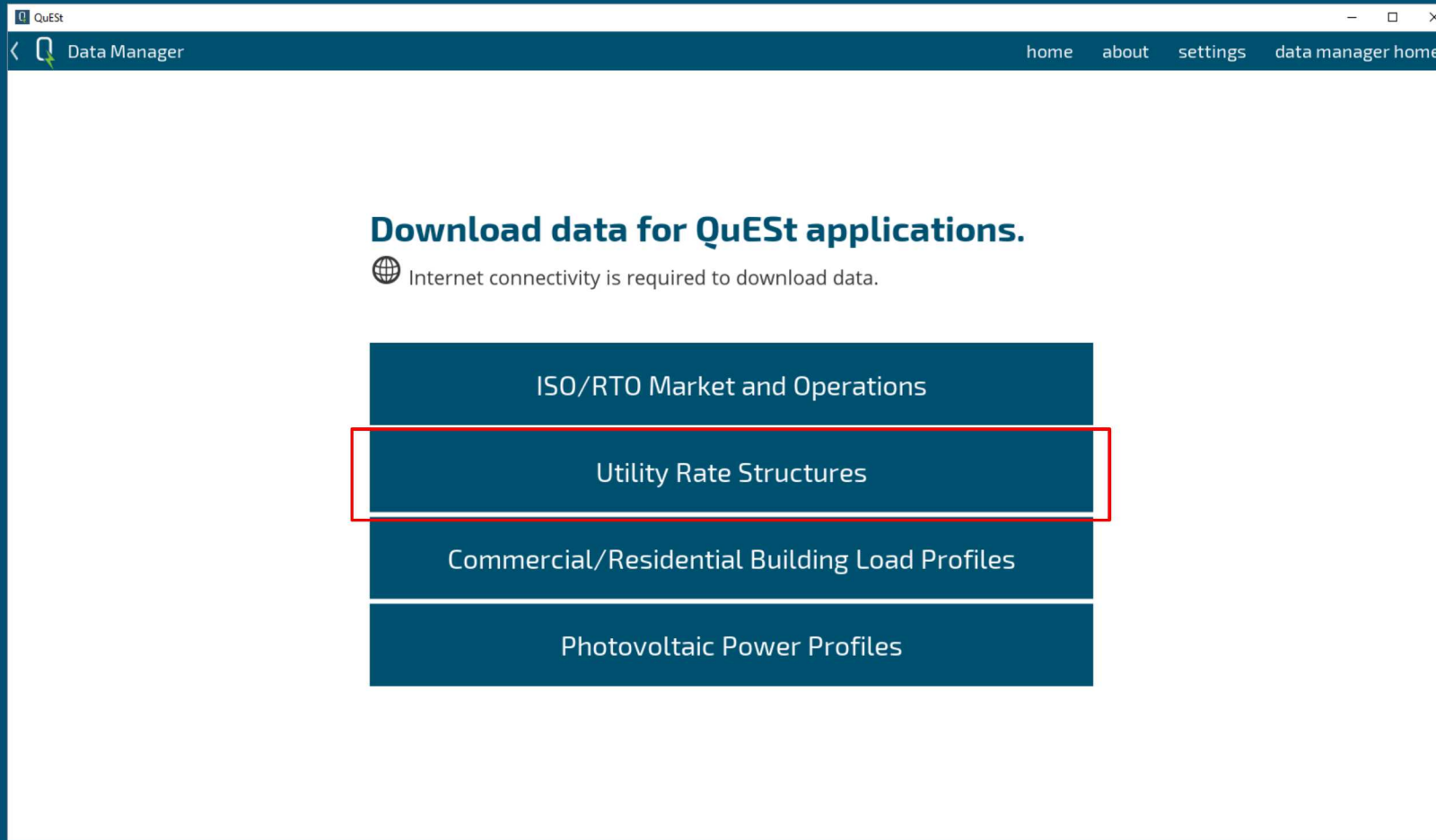
QuEST BTM

Get started

Copyright 2018 National Technology & Engineering Solutions of Sandia, LLC (NTESS). Under the terms of Contract DE-NA0003525 with NTESS, the U.S. Government retains certain rights in this software.

U.S. DEPARTMENT OF ENERGY  
NASA  
National Nuclear Security Administration

- 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.



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

QuEST

Data Manager: Utility Rate Structure Data

home about settings data manager home help

## Search for a utility rate structure.

Data.gov API key 

by name by zip **by state**

### Select a utility.

Filter by name

- City of Boulder City - (NV)
- Harney Electric Coop, Inc
- Mt Wheeler Power, Inc
- Nevada Power Co
- Overton Power District No 5
- Plumas-Sierra Rural Elec Coop
- Raft River Rural Elec Coop Inc
- Sierra Pacific Power Co**
- Surprise Valley Electrification
- Valley Electric Assn, Inc
- Wells Rural Electric Co

### Select a rate structure.

time of use

- OGS-1 TOU - Optional General Service Time of Use Experimental - Bundled (Effective Date : 07/02/2014)
- OGS-1 TOU - Optional General Service Time of Use Experimental - Bundled (Effective Date : 10/01/2013)
- OGS-1-EVRR-TOU - General Service Electric Vehicle Recharge Rider - Time of Use (Effective Date : 07/02/2014)
- OGS-2 TOU - Optional Medium General Service Time of Use - Secondary (Effective Date : 07/01/2019)**

Service under this schedule is available as an option to the regular, non-TOU service under Schedule

No. GS-2. This schedule is available where another TaU schedule is not specifically available. This schedule is available to any service where, during any three or more billing periods in the preceding twelve (12) months, a) monthly metered maximum demand was greater than or equal to fifty (50) kilowatts or monthly metered energy usage was greater than or equal to 10,000 kilowatt hours, and b) monthly metered maximum demand was less than five

- 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

QuEST

Data Manager: Utility Rate Structure Data

home about settings data manager home help

## Verify the energy rate structure.

Period	Rate [\$/kWh]
0	0.04565
1	0.05005
2	0.05583
3	0.05066
4	0.07635
5	0.11409

**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	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Feb	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Mar	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Apr	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
May	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Jun	3	3	3	3	3	3	3	3	3	3	4	4	4	5	5	5	5	5	4	4	4	3	3	3
Jul	3	3	3	3	3	3	3	3	3	3	4	4	4	5	5	5	5	5	4	4	4	3	3	3
Aug	3	3	3	3	3	3	3	3	3	3	4	4	4	5	5	5	5	5	4	4	4	3	3	3
Sep	3	3	3	3	3	3	3	3	3	3	4	4	4	5	5	5	5	5	4	4	4	3	3	3
Oct	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Nov	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Dec	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	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	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Feb	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Mar	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Apr	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
May	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Jun	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Jul	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Aug	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Sep	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Oct	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Nov	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0
Dec	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	0	0	0

Previous Continue

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





QuEST

Data Manager: Utility Rate Structure Data

home about settings data manager home help

### Finishing up.

#### Peak demand

minimum [kW]  maximum [kW]

#### Net (energy) metering

Net metering 1.0

Net metering 2.0

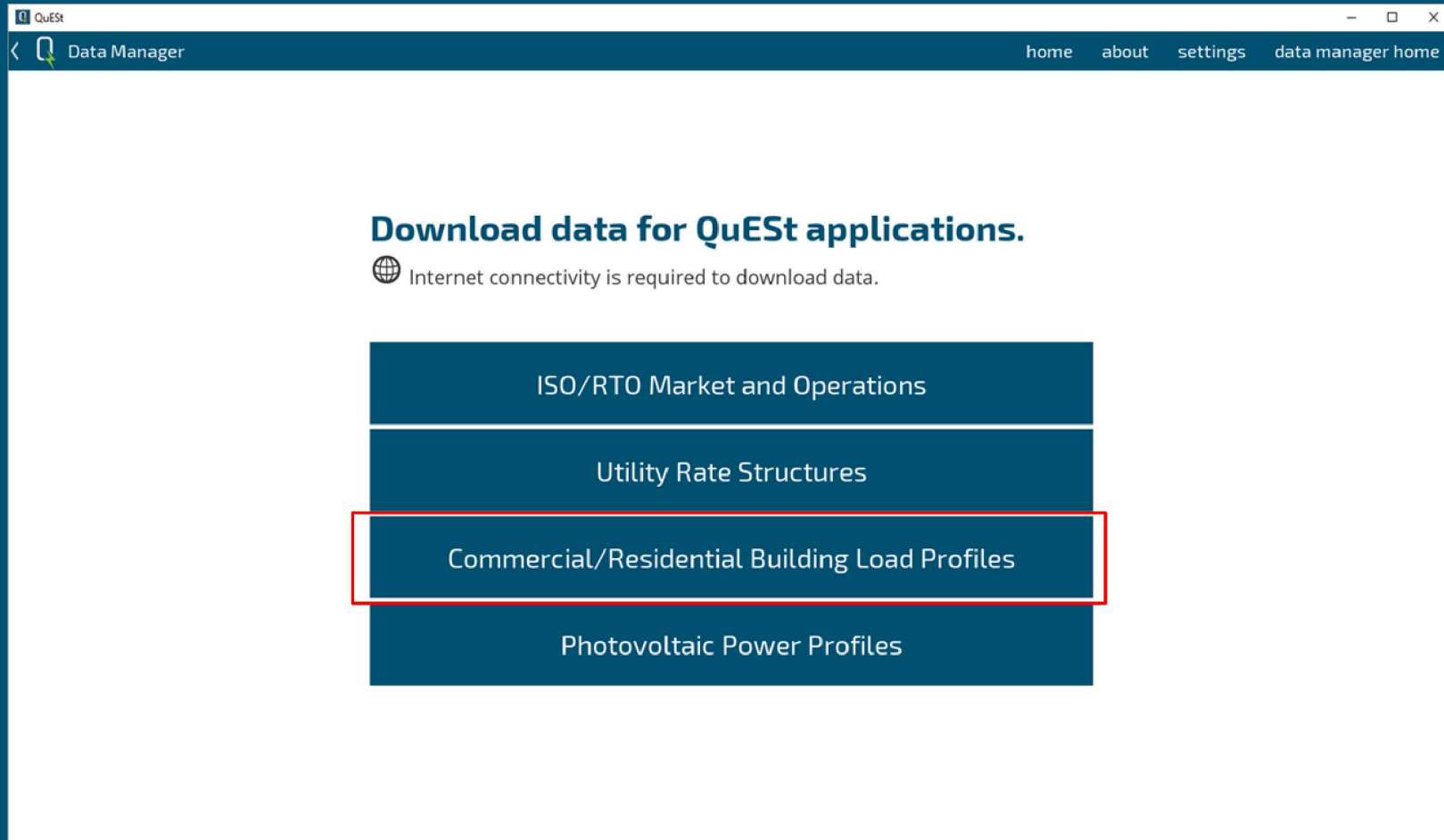
Energy is sold at a fixed energy price.

Energy is sold at the time-of-use energy price.

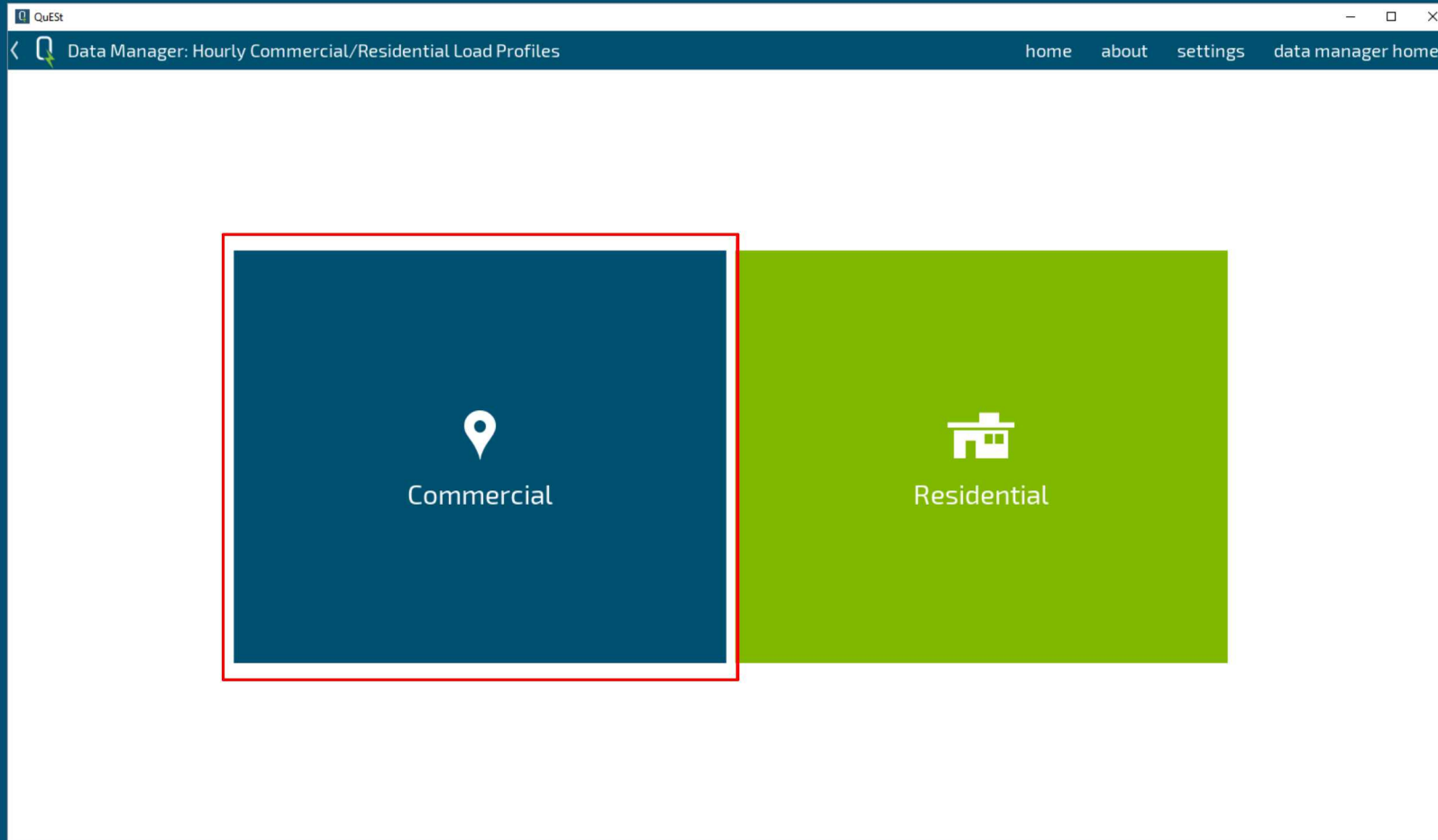
sell price [\$/kWh]

#### Save rate structure

- Save the rate structure for later.



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



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

QuEST

Data Manager: Hourly Commercial Load Profiles

home about settings data manager home help

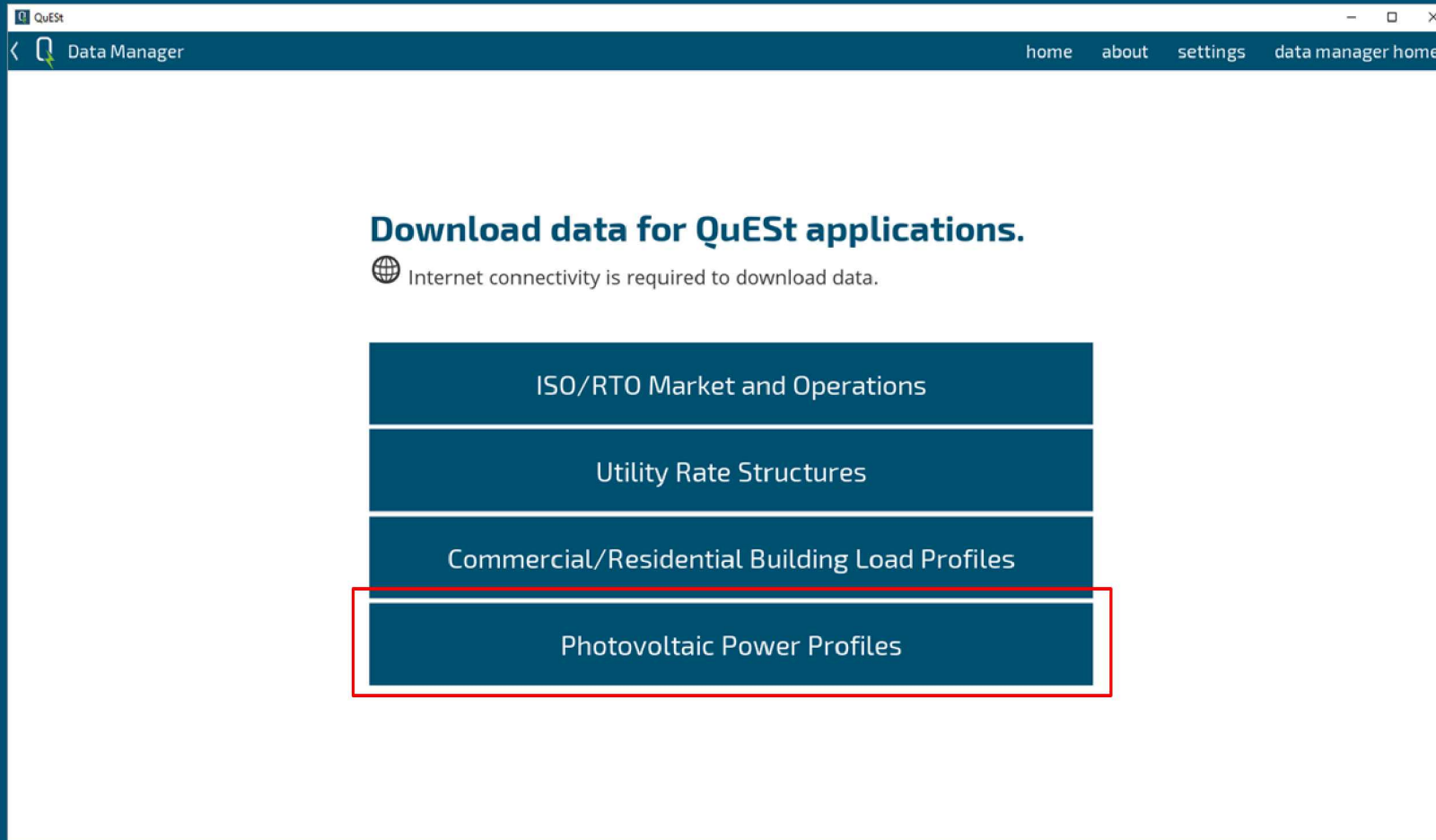
**Download hourly load data by location and building type.**

Filter by name	Filter by name	Filter by name
ND	Elko Muni AP	RefBldgFullServiceRestaurantNew2004
NE	Ely-Yelland Field	RefBldgHospitalNew2004
NH	Fallon NAS	RefBldgLargeHotelNew2004
NJ	Las Vegas-McCarran Intl AP	RefBldgLargeOfficeNew2004
NM	Lovelock-Derby Field	<b>RefBldgMediumOfficeNew2004</b>
<b>NV</b>	Mercury-Desert Rock AP	RefBldgMidriseApartmentNew2004
NY	Nellis AFB	RefBldgOutPatientNew2004
OH	<b>Reno-Tahoe Intl AP</b>	RefBldgPrimarySchoolNew2004
OK	Tonopah AP	RefBldgQuickServiceRestaurantNew2004
OR	Winnemucca Muni AP	RefBldgSecondarySchoolNew2004
PA		RefBldgSmallHotelNew2004
RI		RefBldgSmallOfficeNew2004
		RefBldgStand-aloneRetailNew2004

Save

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






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

QuEST

Data Manager: Photovoltaic Power Profiles

home about settings data manager home help

### Search for a photovoltaic power profile.

Data.gov API key 

<b>latitude</b>	The latitude of the site in the range (-90, 90).	<input type="text" value="39.527"/>	deg
<b>longitude</b>	The longitude of the site in the range (-180, 180).	<input type="text" value="-119.822"/>	deg
<b>system capacity</b>	The nameplate capacity of the photovoltaic system.	<input type="text" value="100"/>	kW
<b>losses</b>	The total system losses, including all sources, in the range (-5, 99).	<input type="text" value="14"/>	%
<b>tilt angle</b>	The tilt angle of the PV surface. Defaults to site latitude.	<input type="text"/>	deg
<b>azimuth angle</b>	The azimuth angle of the PV surface.	<input type="text" value="180"/>	deg

Standard

Fixed (roof mounted)

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

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

The screenshot shows the QuEST web application interface. At the top, there is a navigation bar with the QuEST logo on the left and links for 'home', 'about', and 'settings' on the right. Below the navigation bar, the main content area is divided into two columns. The left column contains three buttons: 'QuEST Data Manager' (with a list icon), 'QuEST Valuation' (with a dollar sign icon), and 'QuEST BTM' (with a house icon). The right column contains a 'New or returning user?' section with a 'Take a quick tour' button. Below this is the 'QuEST BTM' section, which describes it as a collection of tools for behind-the-meter (BTM) energy storage systems and includes a note about estimating cost savings. A large 'Get started' button is highlighted with a red rectangle. At the bottom of the page, there is a copyright notice and logos for the U.S. Department of Energy and the National Nuclear Security Administration.

QuEST

home about settings

New or returning user?

Take a quick tour

**QuEST BTM**

A collection of tools for behind-the-meter (BTM) energy storage systems:  
\*Estimate cost savings for time-of-use and/or net-metering customers

QuEST Data Manager

QuEST Valuation

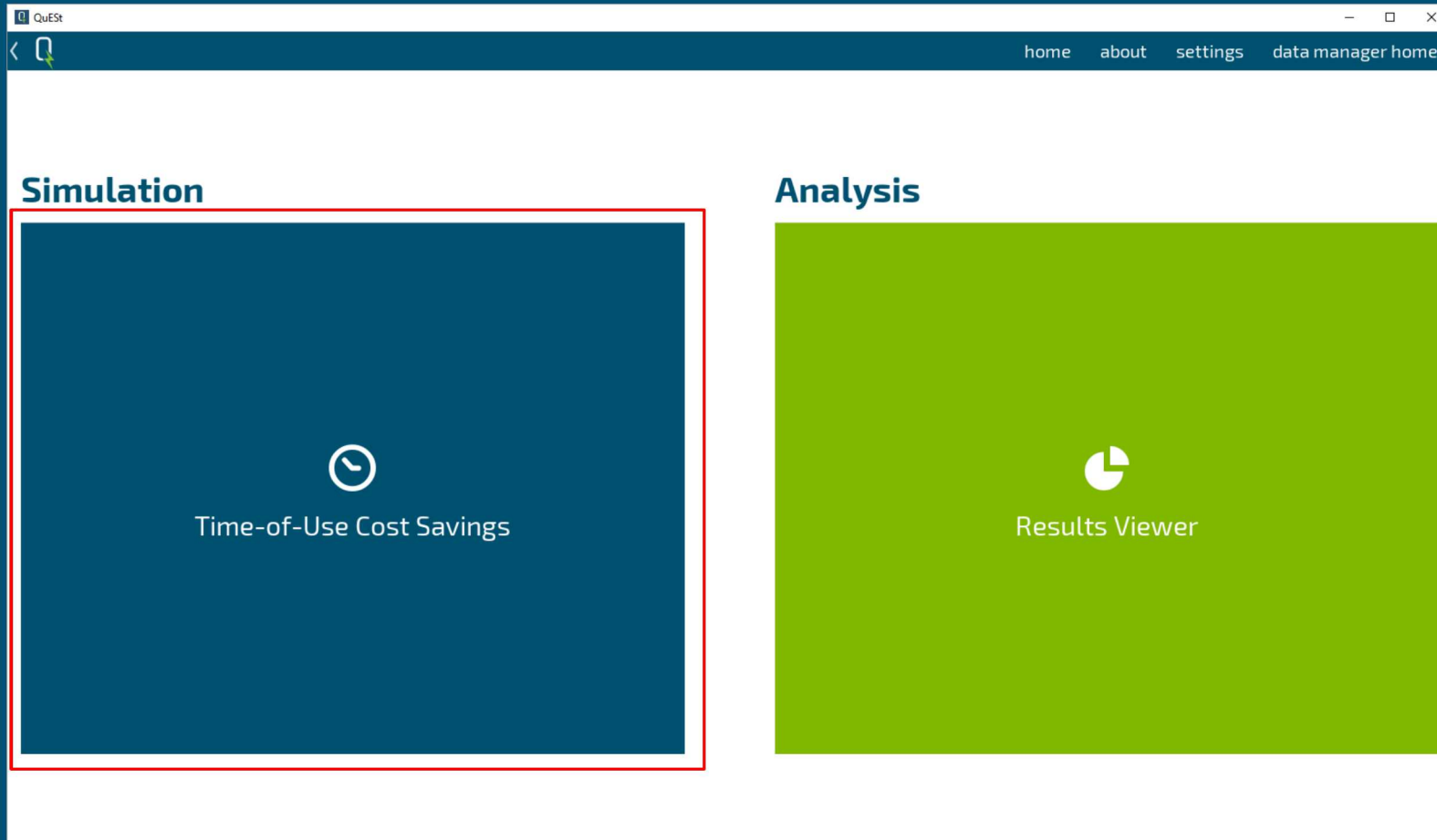
QuEST BTM

Get started

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U.S. DEPARTMENT OF ENERGY  
NNSA  
National Nuclear Security Administration

- 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.



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QuEST

Time-of-Use Cost Savings

home about settings help

### Select a rate structure.

Filter by name

- 0129
- 0206
- 0213
- 0321-nyseg
- 0325-pepco-general-service
- 0327-pge-e19-medium
- HELCO-TOU-J
- PNM
- PNM-3B-General-Power-TOU
- e-20-pge
- e-tou-option-b
- example
- my-SF-hotel-PGE
- nyseg-tou-residential
- nyseg-tou-residential-nem1
- paloalto
- pge-1k
- pnm-residential-tou
- sierra-pacific-gs2-tou
- sierra-pacific-ogs2-medium-se
- xyz

**Energy**

- \$0.04565/kWh
- \$0.05005/kWh
- \$0.05583/kWh
- \$0.05066/kWh
- \$0.07635/kWh
- \$0.11409/kWh

**Demand**

- \$0.0/kW
- \$0.92/kW
- \$0.92/kW
- \$2.21/kW
- \$5.25/kW

Flat demand rate [\$/kW]

Peak demand min. [kW]

Peak demand max. [kW]

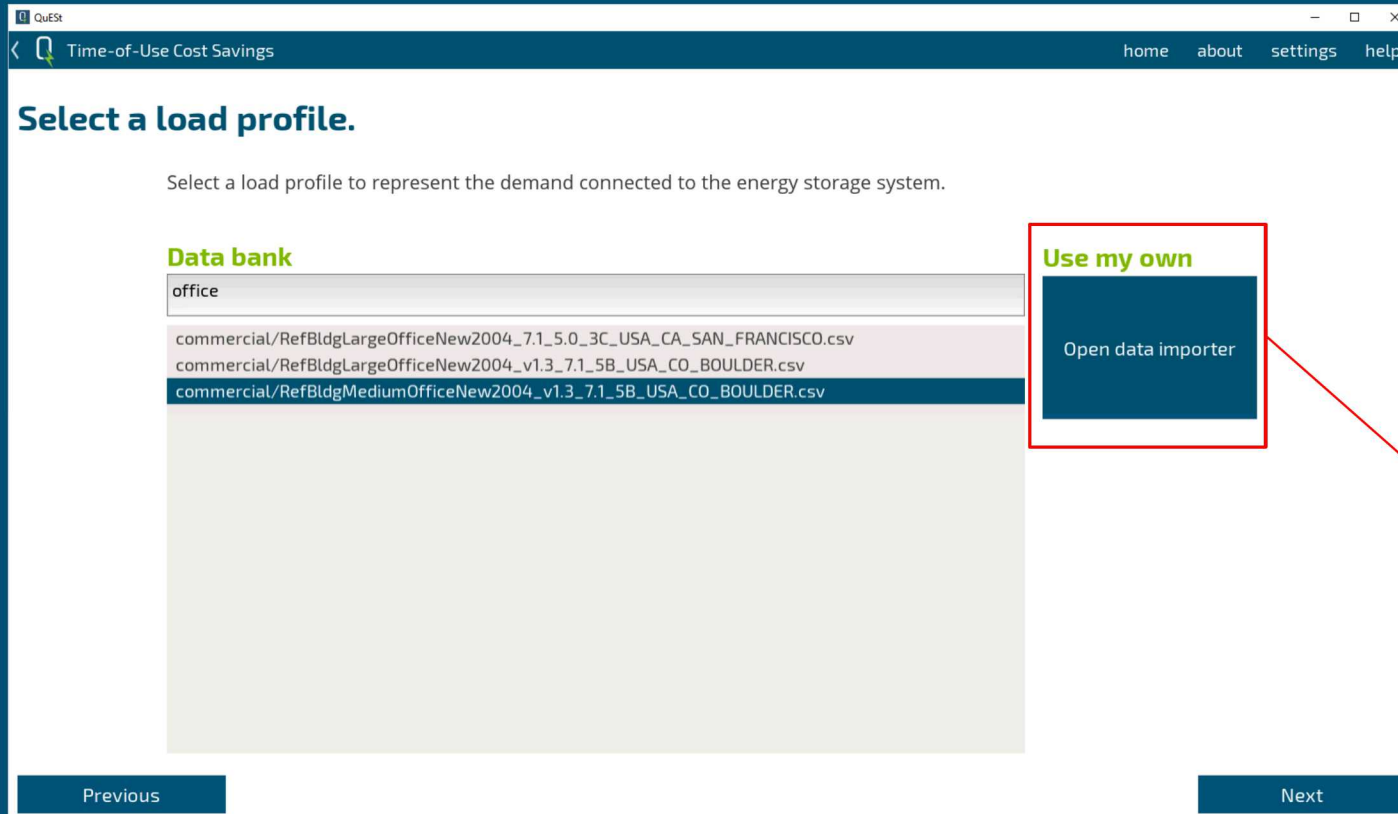
Net metering type

Energy sell price [\$/kWh]

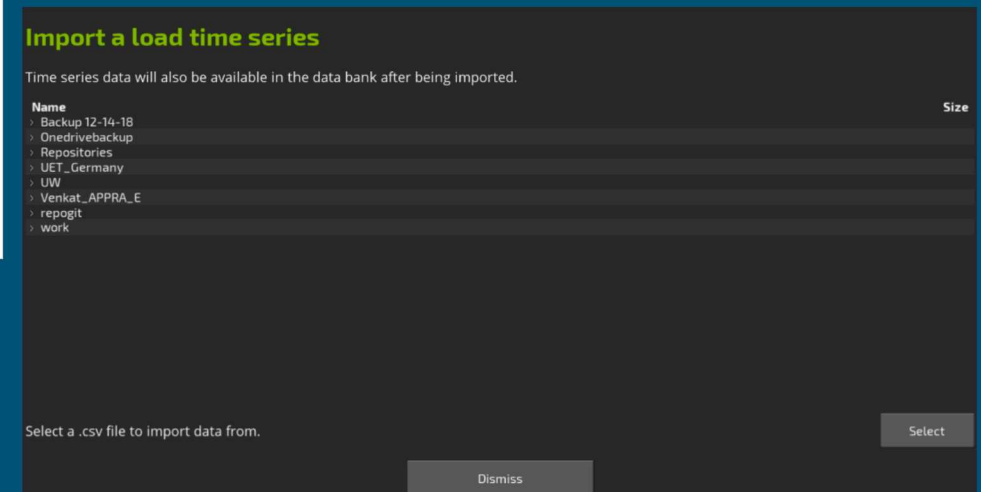
Previous

Next

- 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.



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QuEST

Time-of-Use Cost Savings

home about settings help

### Select a PV power profile.

Select a PV power profile to represent the PV connected to the energy storage system.  
If there is no PV connected, feel free to skip this step.

**Data bank**

Filter by name

- 5kwSFrooftmount
- ABQ1000kW
- NELHA\_research\_campus
- NM
- abqrooftop50kW
- d
- example
- load\_60min\_2006\_for\_2026\_MISO-2
- load\_60min\_2006\_for\_2026\_MISO-7
- load\_60min\_2006\_for\_2026\_Manitoba
- load\_60min\_2006\_for\_2026\_NBSO
- mySFhotel50kWrooftop
- ovvv
- ovvvd
- pvddata
- reno100kWrooftmount

**Use my own**

Open data importer

Previous Next

- Proceeding through the wizard, we select the data that we had just downloaded when prompted.
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QuEST

Time-of-Use Cost Savings

home about settings help

### Specify the energy storage system parameters.

<b>energy capacity</b>	The maximum amount of energy that the ESS can store.	<input type="text" value="320"/>	kWh
<b>power rating</b>	The maximum rate that at which the ESS can charge or discharge energy.	<input type="text" value="80"/>	kW
<b>transformer rating</b>	The maximum amount of power that can be exchanged.	<input type="text" value="1000000"/>	kW
<b>self-discharge efficiency</b>	The percentage of stored energy that the ESS retains on an hourly basis.	<input type="text" value="100"/>	%/h
<b>round trip efficiency</b>	The percentage of energy charged that the ESS actually retains.	<input type="text" value="85"/>	%
<b>minimum state of charge</b>	The minimum ESS state of charge as a percentage of energy capacity.	<input type="text" value="0"/>	%
<b>maximum state of charge</b>	The maximum ESS state of charge as a percentage of energy capacity.	<input type="text" value="100"/>	%
<b>initial state of charge</b>	The percentage of energy capacity that the ESS begins with.	<input type="text" value="50"/>	%

Previous

Next

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QuEST

Time-of-Use Cost Savings

home about settings help

### Summary of selections.

**Rate Structure:**  
sierra-pacific-ogs2-medium-secondary  
Sierra Pacific Power Co  
OGS-2 TOU - Optional Medium General Service Time of Use - Secondary

**Load Profile:**  
commercial/RefBldgMediumOfficeNew2004\_v1.3\_7.1\_5B\_USA\_CO\_BOULDER.csv

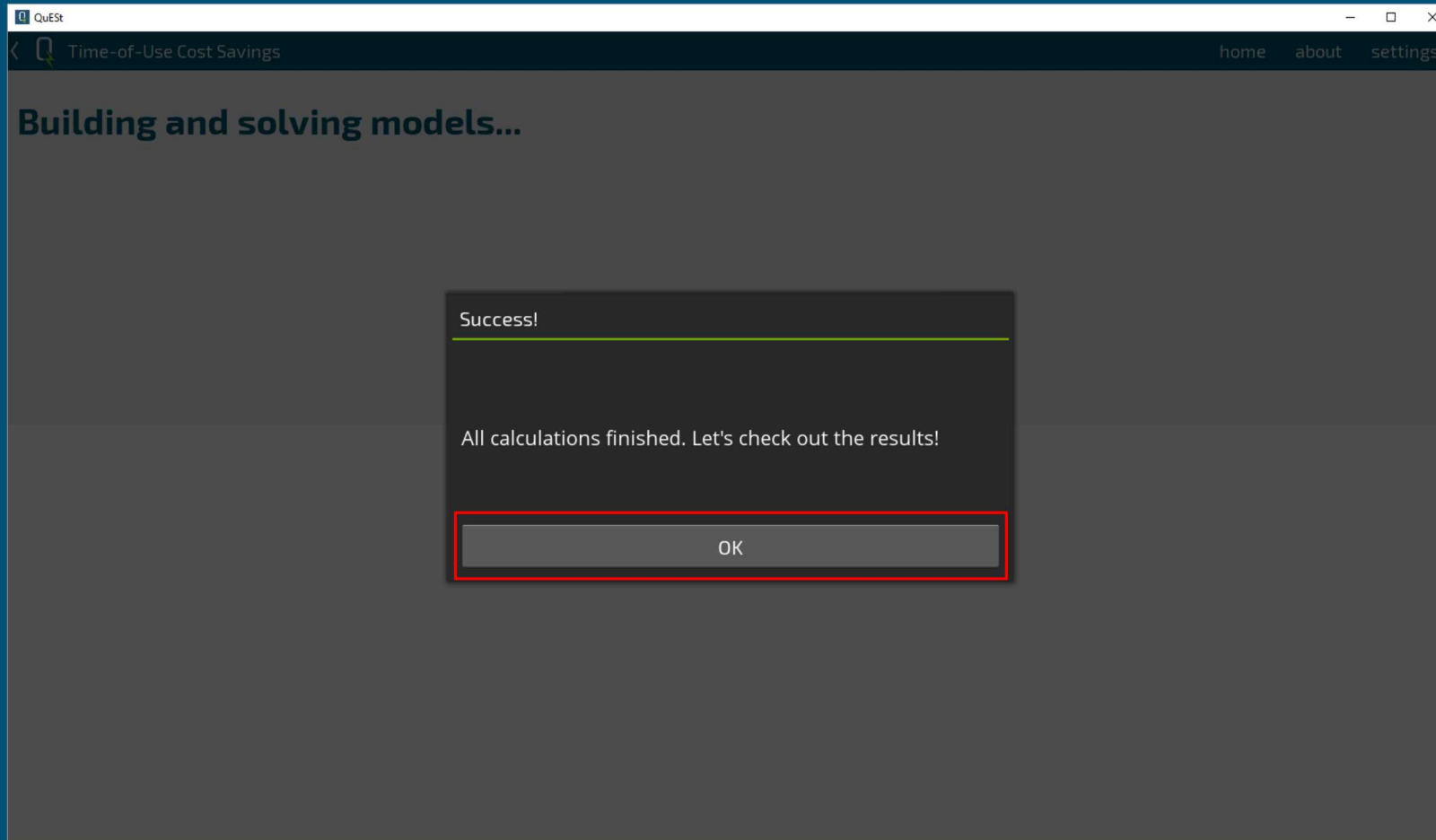
**PV Profile:**  
Location: 39.527, -119.822  
System Capacity: 100 kW  
Azimuth: 180 deg  
Tilt: 39.527 deg  
Array Type: Fixed (roof mounted)  
Module Type: Standard  
System Losses: 14%

**System Parameters:**  
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

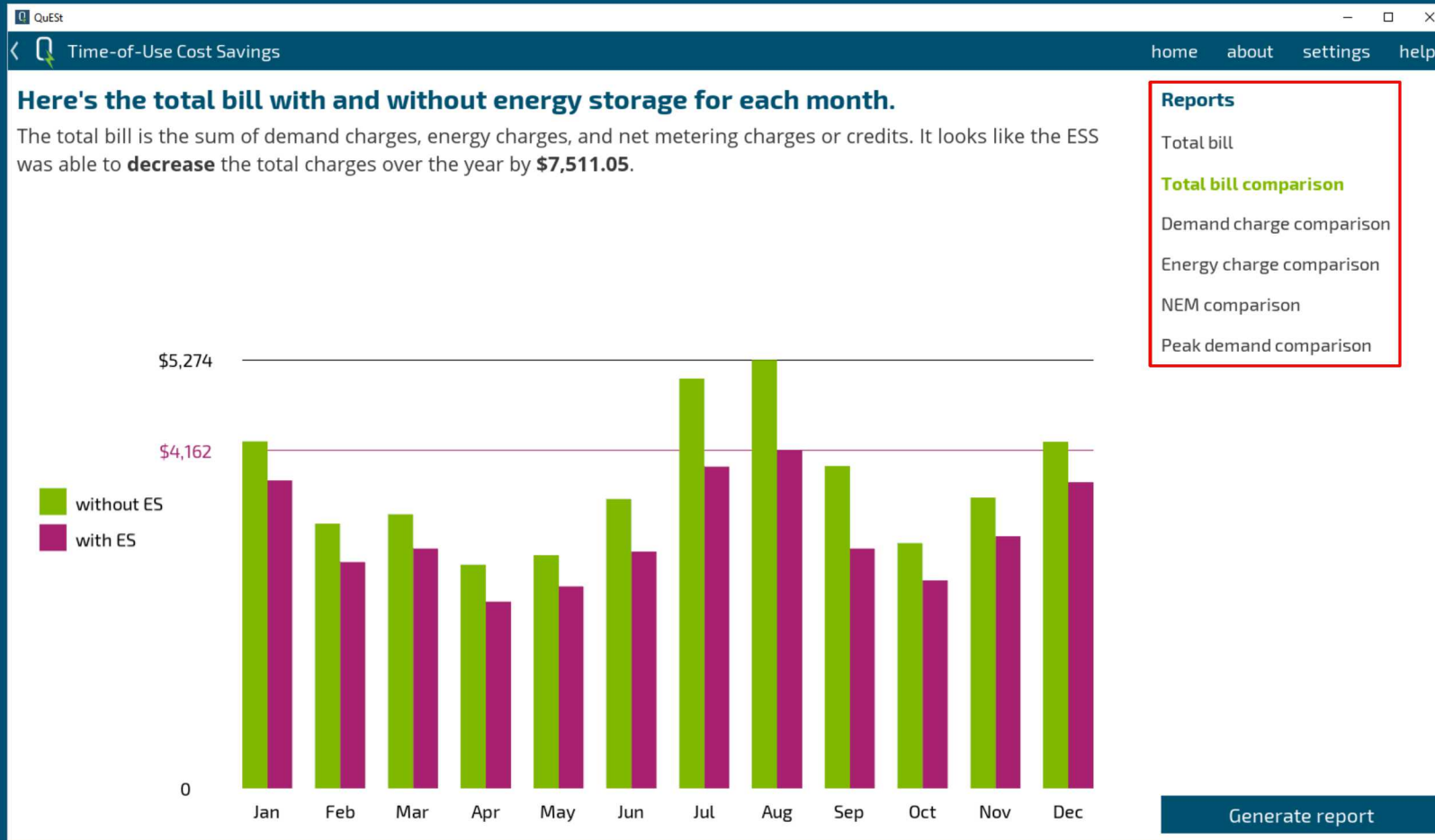
Previous

Next

- 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.

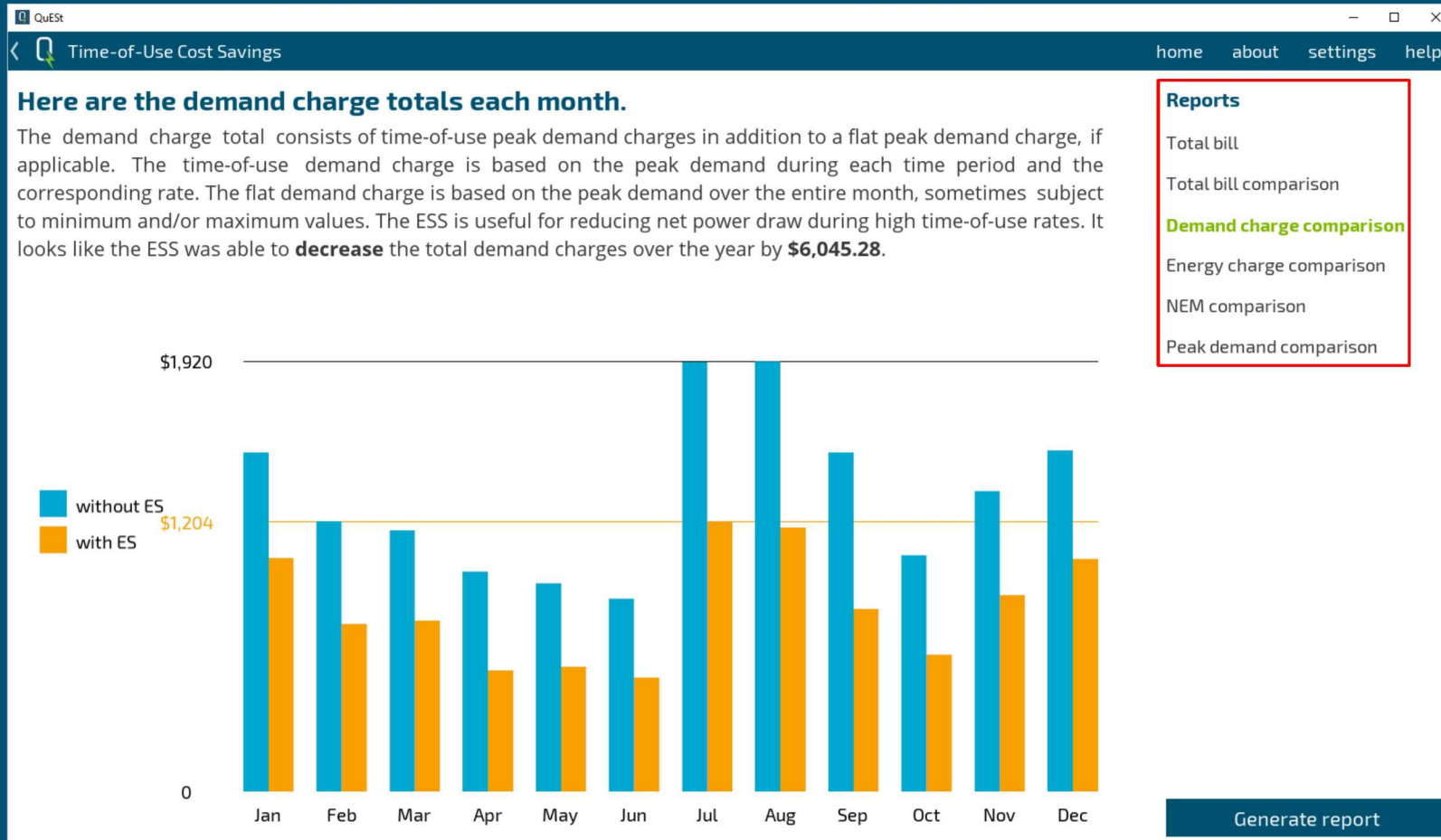


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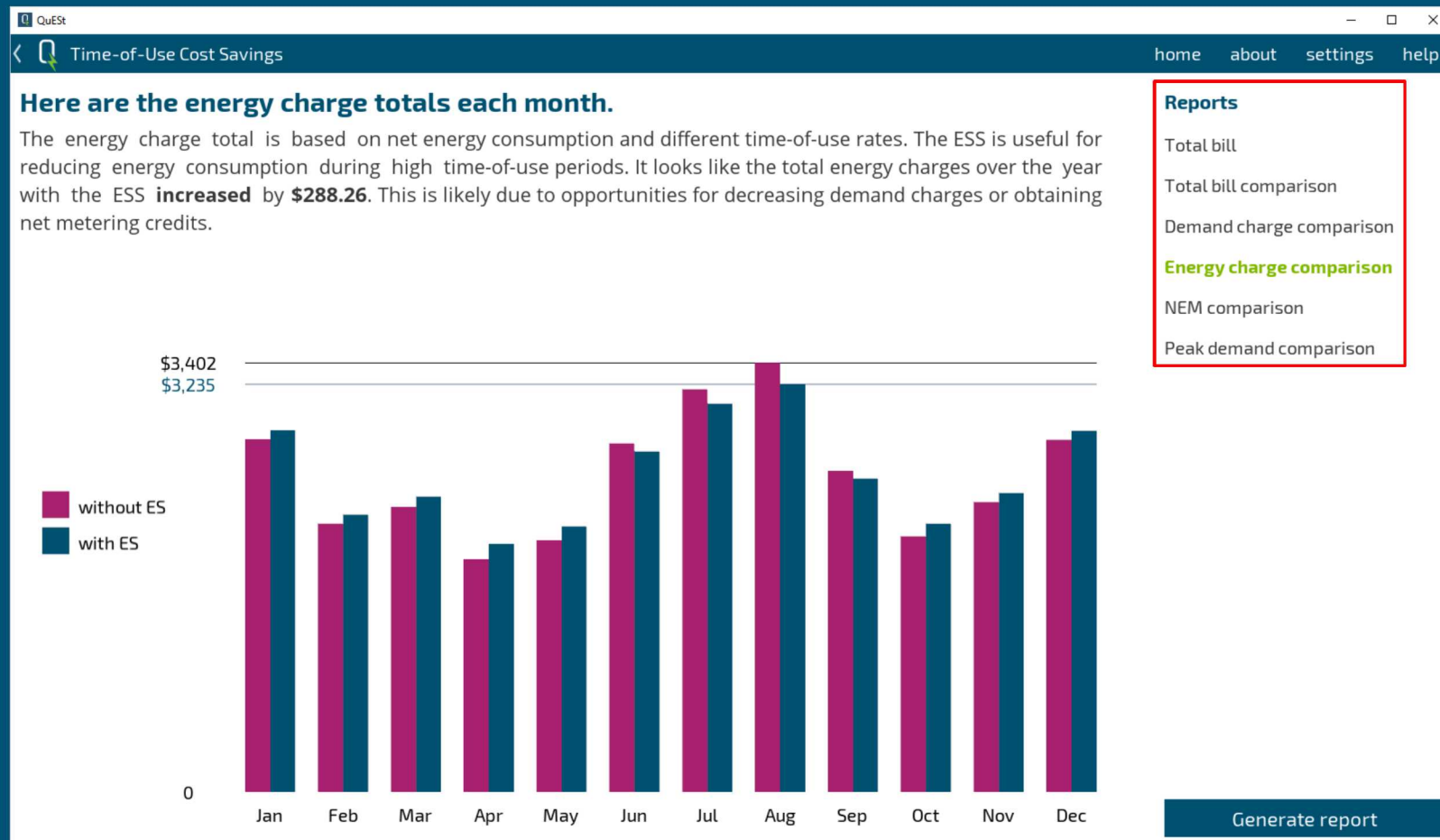
- We can now view the wizard's report of results and view several summary graphics.
- Based on the calculations, the addition of the energy storage system reduced annual charges by about \$7,511.
- This was mostly due to demand charge reduction.
- Peak demand each month was reduced by about 80 kW.

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

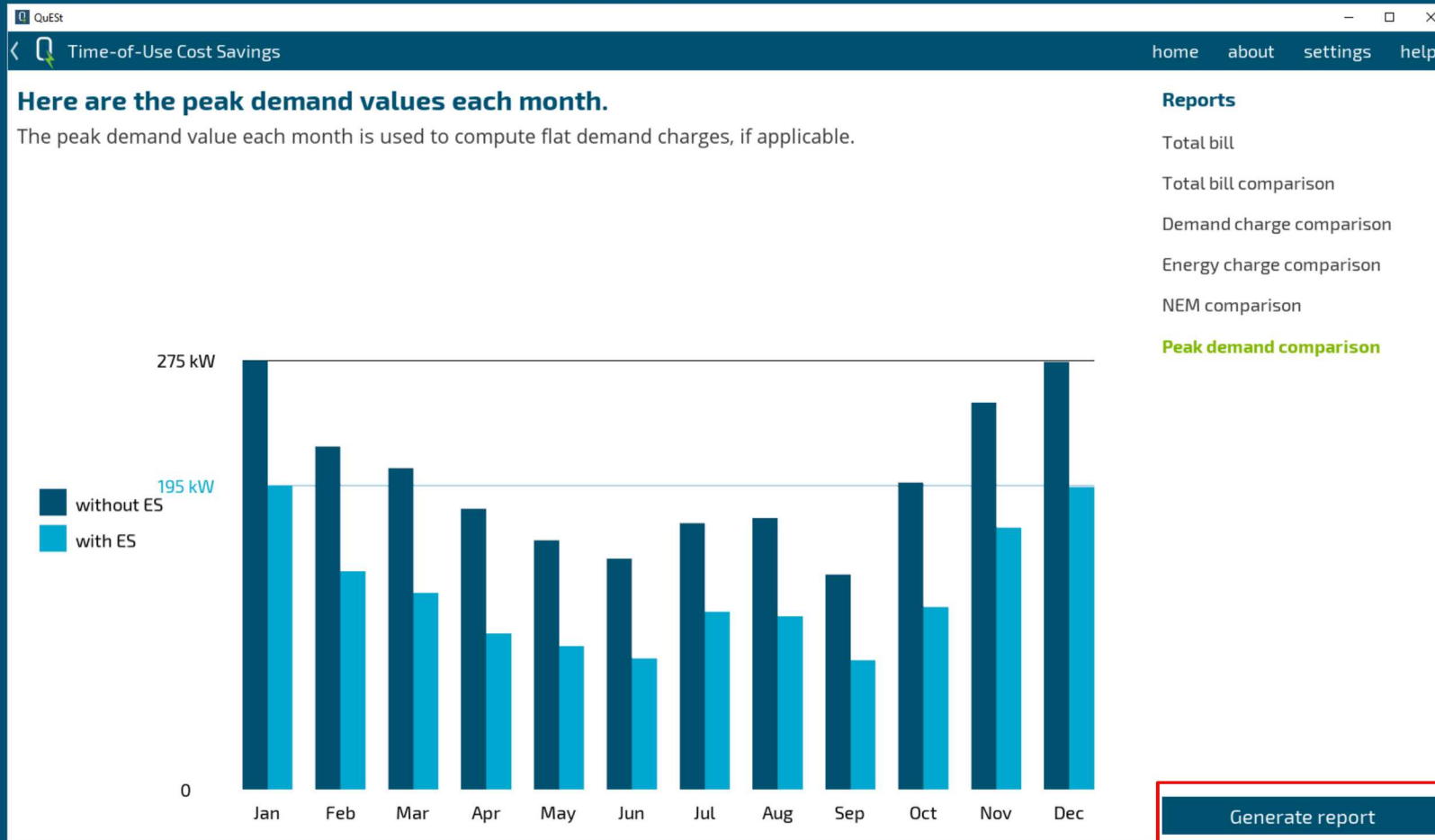


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- We can also create a summary report that includes formulation details and the results.



## 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.

- 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





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

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[github.com/rconcep/snl-quest](https://github.com/rconcep/snl-quest)