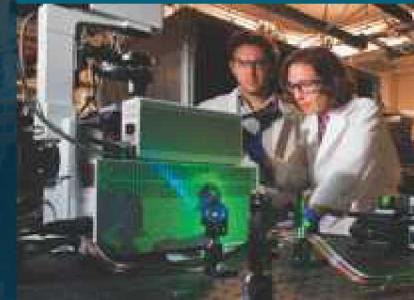




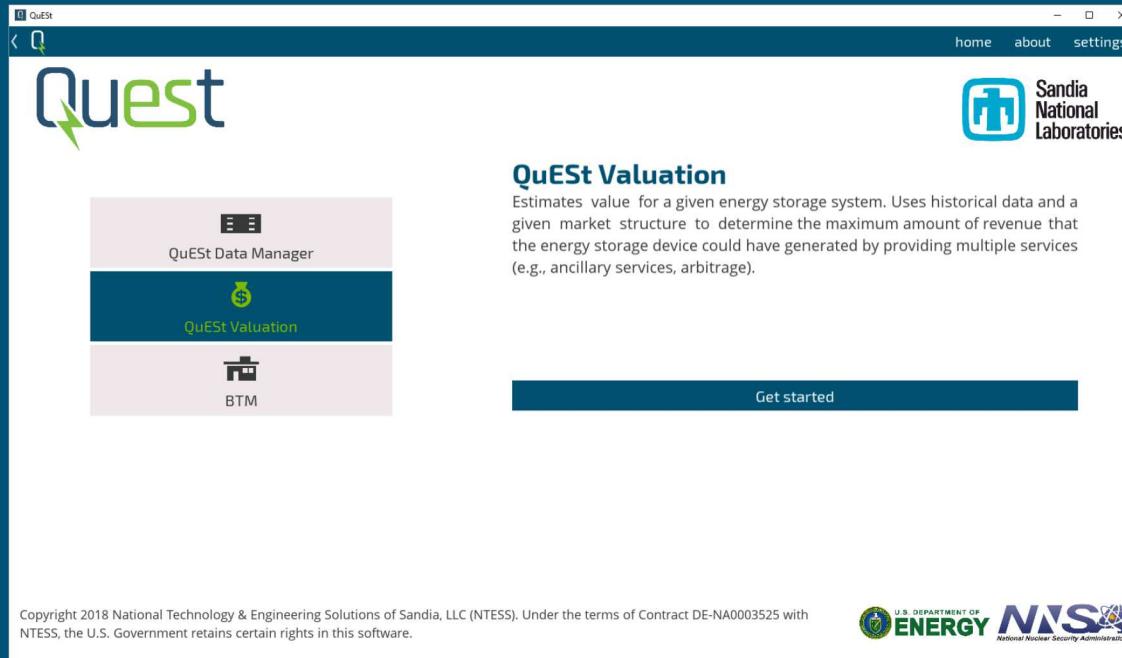
# An Energy Storage Application Suite



PRESENTED BY

Ricky Concepcion

# What is it?



- Open source, Python-based energy storage analysis software application suite
- Developed as a graphical user interface (GUI) for the optimization modeling capabilities of Sandia's energy storage analytics group
- Initial development driven by optimization models for energy storage valuation
- Version 1.0 publicly released in September 2018
- Version 1.1 publicly available on GitHub
  - [github.com/rconcep/snl-quest](https://github.com/rconcep/snl-quest)
  - Or on [sandia.gov/ess](https://sandia.gov/ess)



## Why QuESt?

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

\* For v1.2 release



# QuEST Data Manager

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Search for a utility rate structure.

OpenEI API key: AHKRnsqzqRbhOZ9XU2C63gwFEsPASXtQJl3b1Pd0

pacific

Search

by name by zip by state (abbr.)

Select a utility.

Filter by name

- PUD No 2 of Pacific County
- PacifiCorp
- PacifiCorp
- PacifiCorp
- PacifiCorp
- PacifiCorp
- PacifiCorp
- Pacific Gas & Electric Co.**
- Sierra Pacific Power Co

Select a rate structure.

E-19

- E-19 (Transmission, Mandatory) (Effective Date : 12/31/2013)
- E-19 (Transmission, Voluntary) (Effective Date : 12/31/2013)
- E-19 -Medium General Demand- TOU (Primary) (Effective Date : 02/28/2015)
- E-19 -Medium General Demand- TOU (Primary) (Effective Date : 09/30/2016)

Continue

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

- Locational marginal prices (LMPs), (frequency) regulation performance/capacity clearing prices, etc. posted by ISOs/RTOs
- U.S. utility rate structures sourced and validated by OpenEI.org (NREL)
- Commercial and residential hourly load profiles for all TMY3 (typical meteorological year) locations in the U.S. by OpenEI.org
  - 16 DOE commercial reference building models

The screenshot shows a web-based application titled "Data Manager: Hourly Commercial/Residential Load". The interface is divided into two main sections: "Commercial" on the left and "Residential" on the right. The Commercial section is represented by a dark blue box with a location pin icon and the word "Commercial". The Residential section is represented by a bright green box with a house icon and the word "Residential". At the top right, there are links for "home", "about", and "settings". The top left corner features a back arrow and a search icon.

< Data Manager: Hourly Commercial/Residential Load

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Commercial

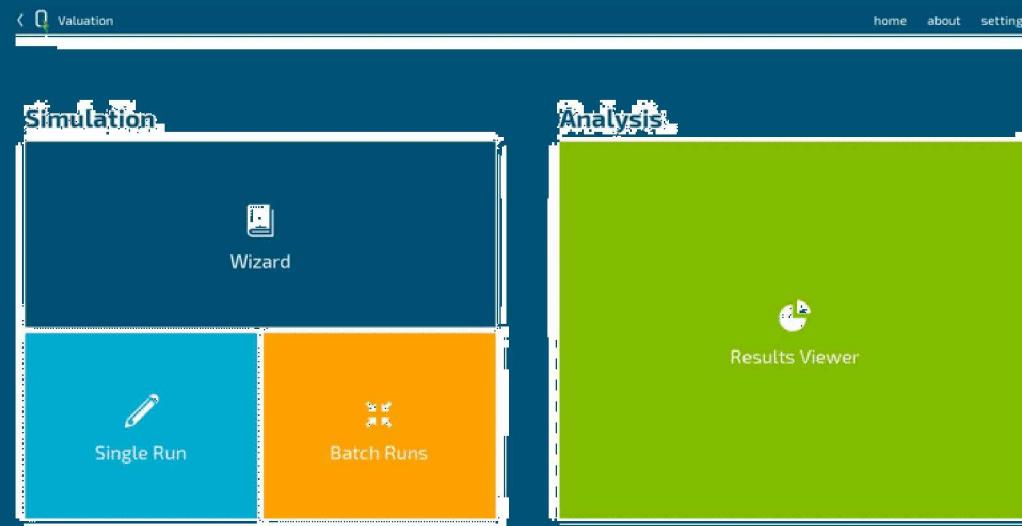
Residential

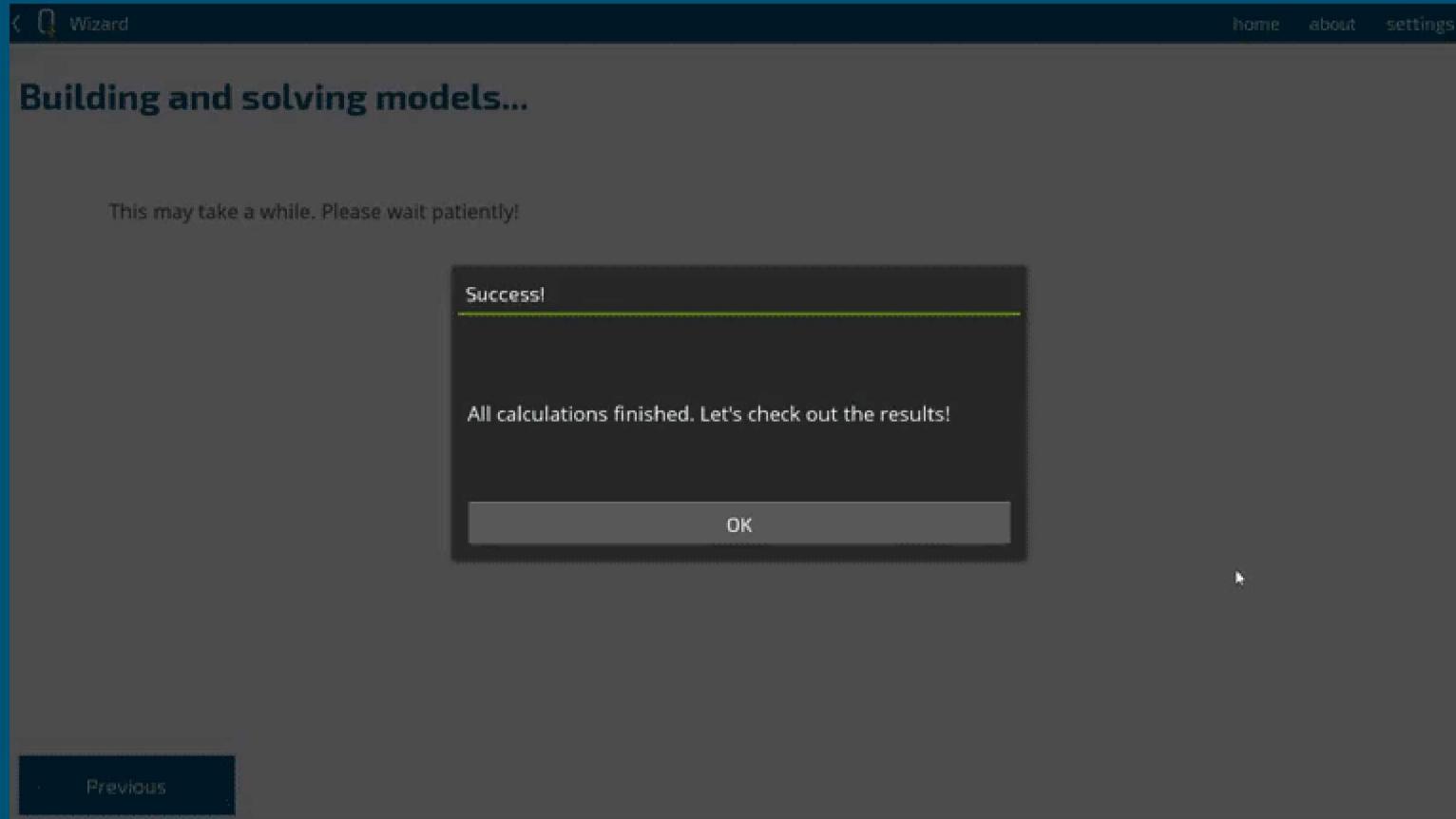
# QuEST Valuation

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?

Examples:

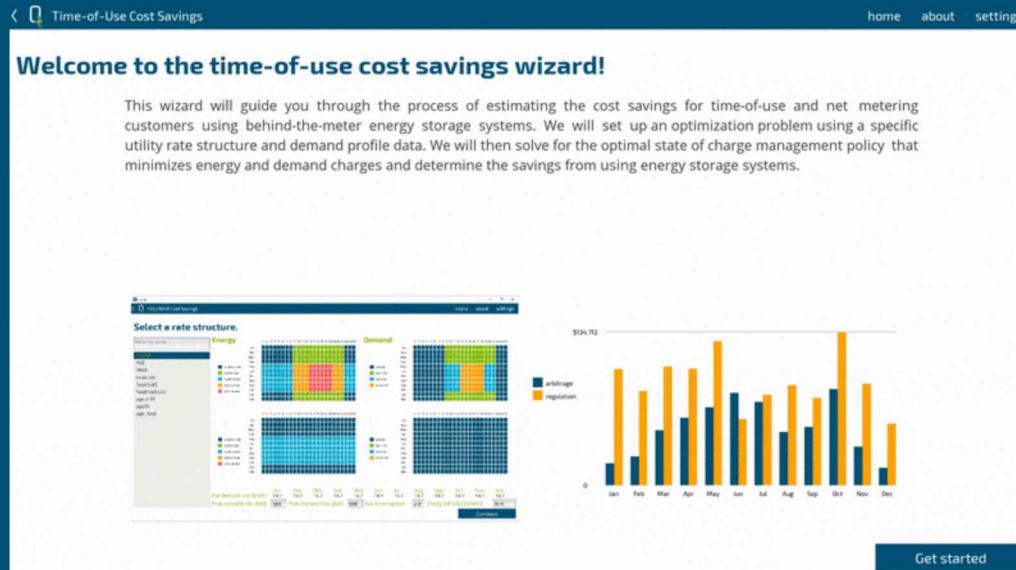
- How much revenue could a flywheel plant located at the Houston pricing node in the ERCOT market have generated in the month of July 2016 by participating in energy arbitrage? What if it also provided frequency regulation services?
- What are the effects of increased size or power rating on revenue potential?





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

- Incorporate specific utility rate structures (energy TOU schedule and rates, etc.)
- Use location-specific simulated load and photovoltaic power data
- Future BTM applications
  - Optimal sizing for power balancing
  - Control applications



\*For v1.2 release; content is under development and subject to change.

Time-of-Use Cost Savings

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## Select a rate structure.

Filter by name

**Energy**

e-19-pge

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

**Demand**

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Flat demand rate [\$/kW]

Jan	14.7
Feb	14.7
Mar	14.7
Apr	14.7
May	14.7
Jun	14.7
Jul	14.7
Aug	14.7
Sep	14.7
Oct	14.7
Nov	14.7
Dec	14.7

Peak demand min. [kW]

500
-----

Peak demand max. [kW]

999
-----

Net metering type

2.0
-----

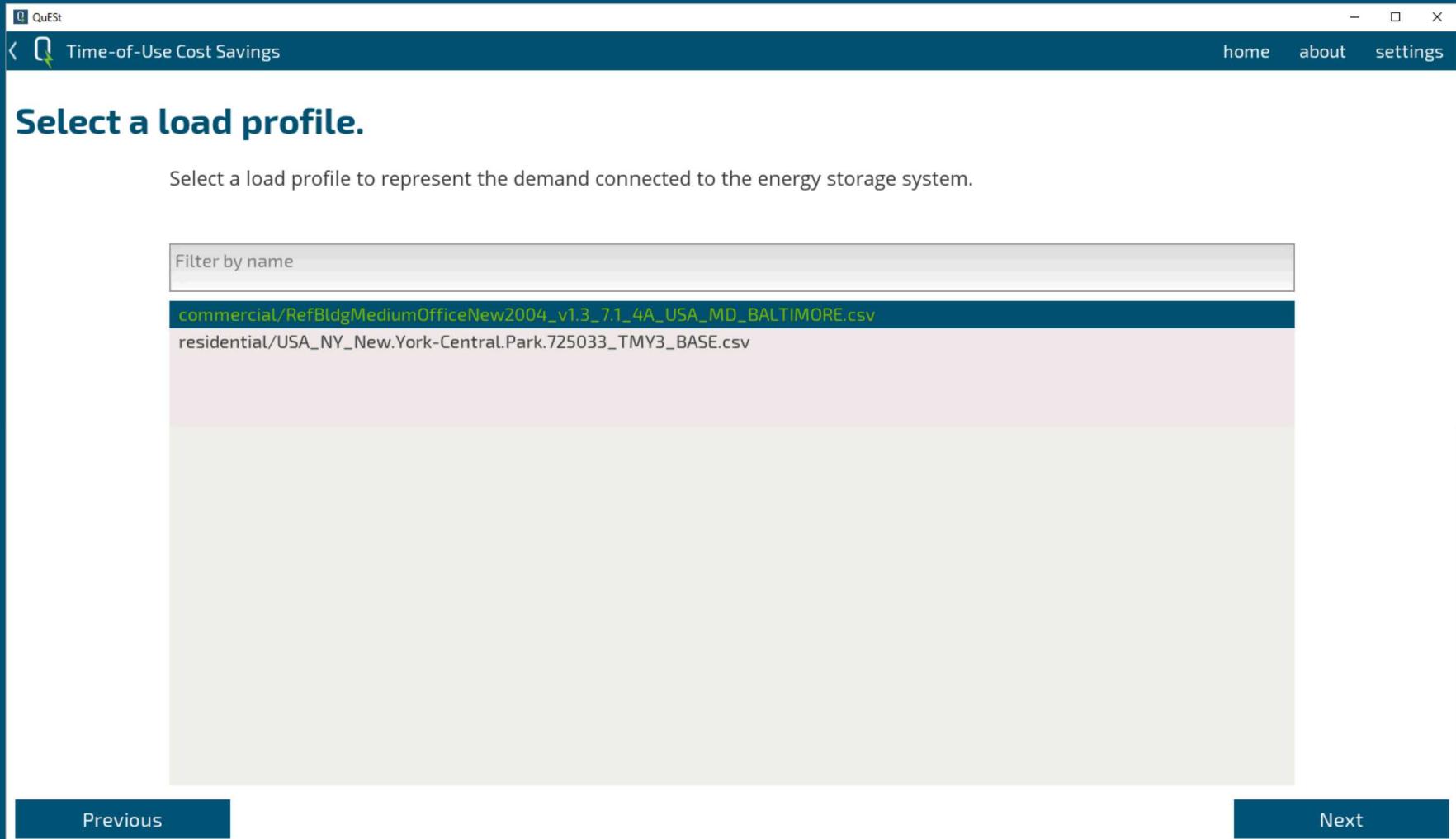
Energy sell price [\$/kWh]

N/A
-----

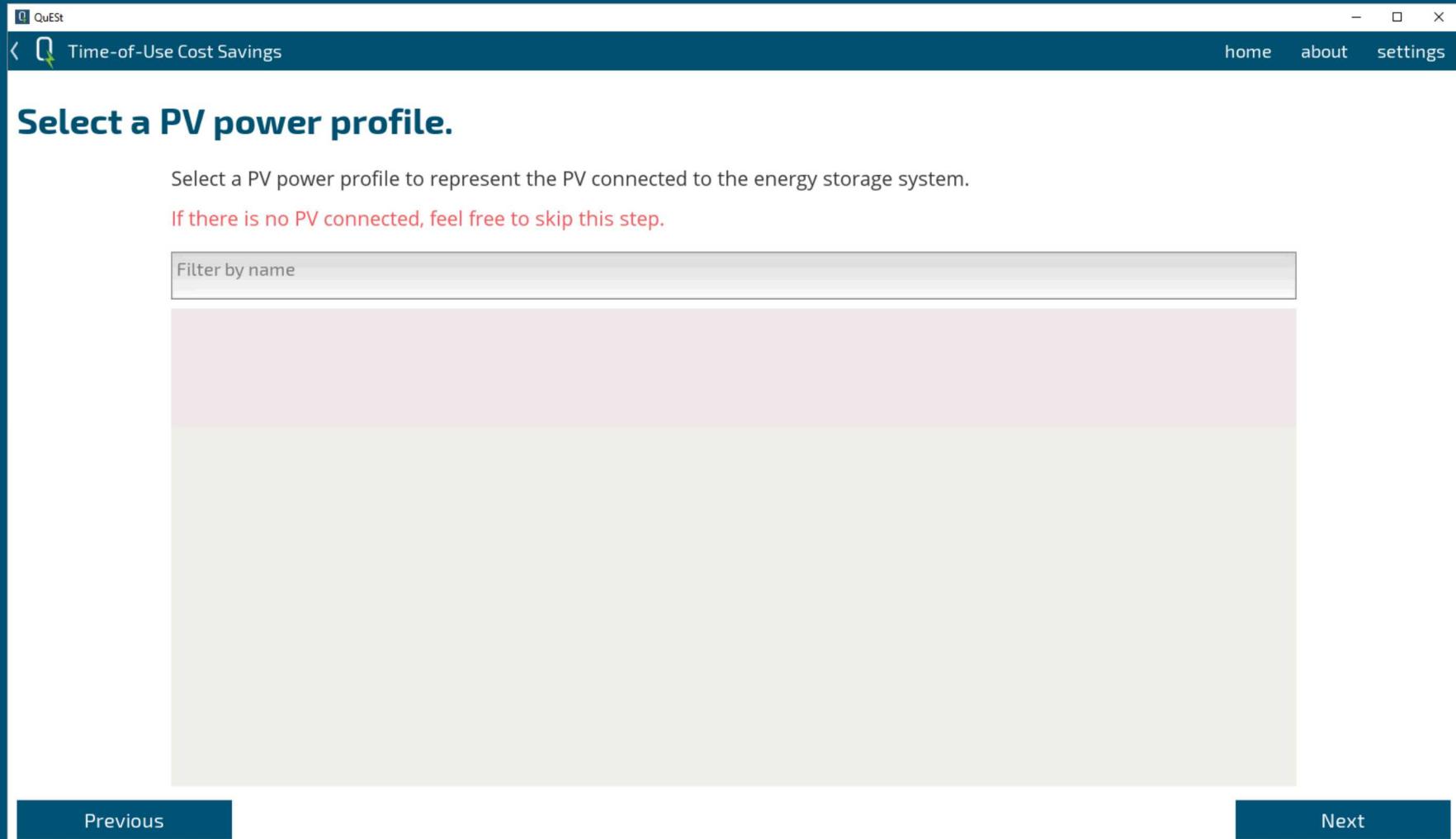
Previous

Next

\*For v1.2 release; content is under development and subject to change.



The screenshot shows a software window titled "QuEST" with a sub-header "Time-of-Use Cost Savings". The main title "Select a load profile." is displayed in a large, bold, teal font. Below it, a sub-instruction reads "Select a load profile to represent the demand connected to the energy storage system." A search bar labeled "Filter by name" is present. A list of load profiles is shown, with the first item highlighted in dark teal: "commercial/RefBldgMediumOfficeNew2004\_v1.3\_7.1\_4A\_USA\_MD\_BALTIMORE.csv". The second item in the list is "residential/USA\_NY\_New.York-Central.Park.725033\_TMY3\_BASE.csv". At the bottom of the list area, there are "Previous" and "Next" buttons. The background of the window is white, and the overall interface has a clean, modern look.





Time-of-Use Cost Savings

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## Specify the energy storage system parameters.

<b>energy capacity</b>	The maximum amount of energy that the ESS can store.	<input type="text" value="100"/> kWh
<b>power rating</b>	The maximum rate at which the ESS can charge or discharge energy.	<input type="text" value="100"/> kW
<b>transformer rating</b>	The maximum amount of power that can be exchanged.	<input type="text" value="100000"/> 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>capacity reserved for discharging</b>	The percentage of energy capacity that the ESS reserves for discharging.	<input type="text" value="0"/> %
<b>capacity reserved for charging</b>	The percentage of energy capacity that the ESS reserves for charging.	<input type="text" value="0"/> %
<b>initial state of charge</b>	The percentage of energy capacity that the ESS starts at.	<input type="text" value="0"/> %

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Time-of-Use Cost Savings

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## Here are the net energy metering (NEM) totals each month.

Net energy metering 2.0 uses the time-of-use energy rate for energy. Negative values represent credits. The total increase in NEM credits with energy storage was \$4,545.52.

### Reports

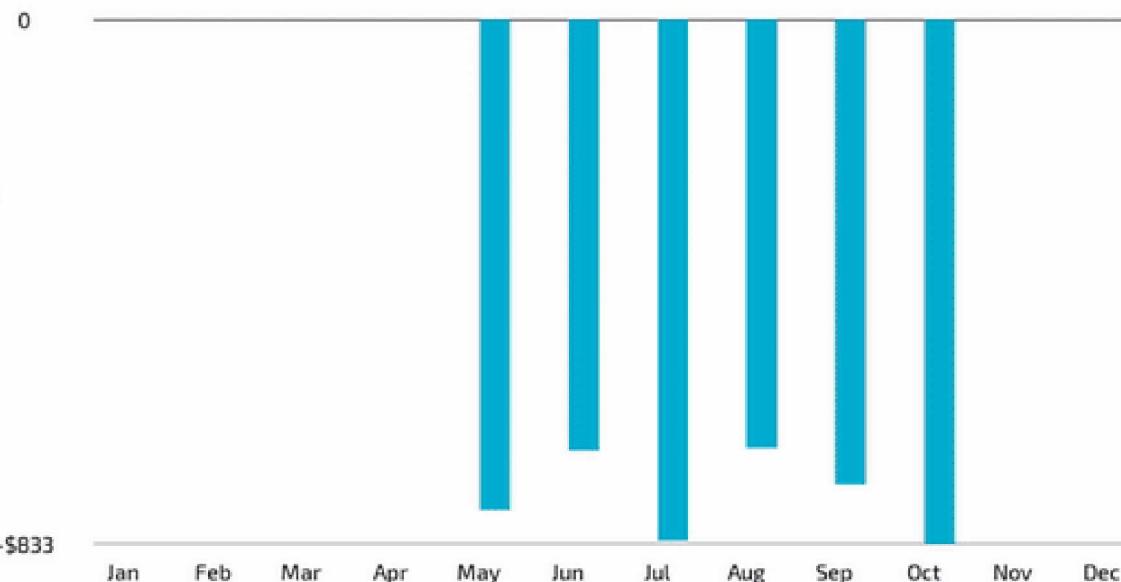
[Total bill \(by month\)](#)

[Total bill comparison](#)

[Demand charge comparison](#)

[Energy charge comparison](#)

[NEM comparison](#)

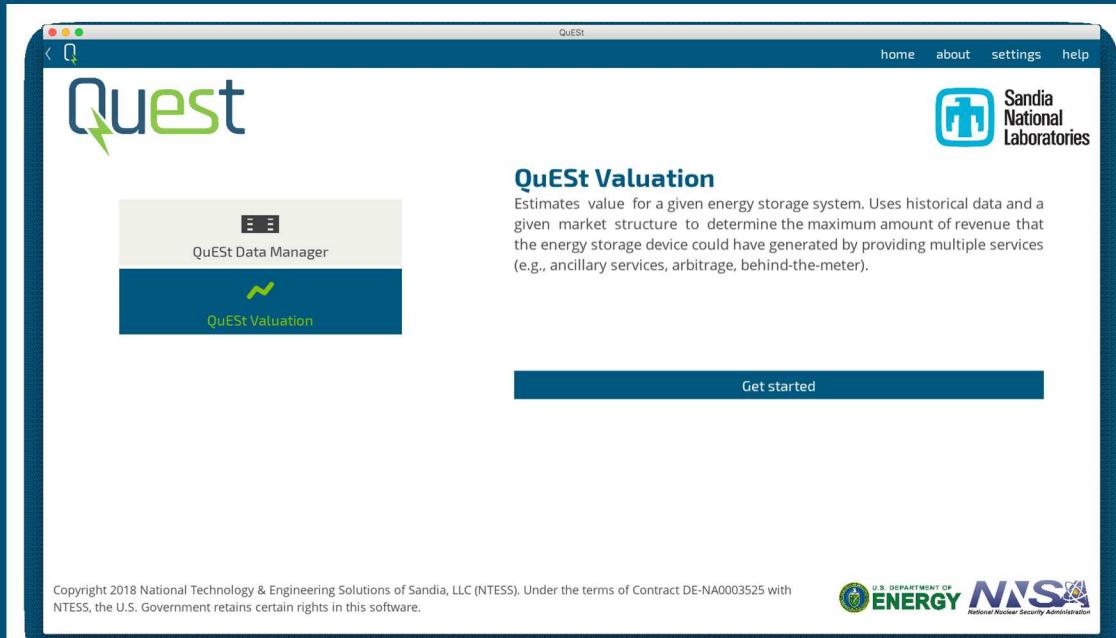


Generate report

## The Future

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

- Consider more complex valuation models, such as modeling degradation
- New applications
  - Technology selection assistant
  - Explorer for energy storage cost data (collected by Mustang Prairie)
  - ?



## Acknowledgements

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### Follow us on GitHub:

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