Sandia National Laboratories

Maximizing Value of Solar and Energy Storage Installations in NY

PRESENTED BY

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Introduction

NY State has undertaken an ongoing process to change compensation for distributed energy

- Value of Distributed Energy Resources (VDER)
- Replaces net metering
- Assigns value to <u>when</u> and <u>where</u> energy is produced

Multiple values that can stack depending on time and location

- Day Ahead LBMP
- iCap - Value for beneficial production capacity
  - 3 Alternatives that provide value for different production times
- E – Environmental Component
- DRV – Demand reduction value
  - Production during 10 annual peak hours
- LSRV – locational system relief value
  - Extra incentive for generation in certain areas
- MTC – market transition credit
  - Fudge factor to make people happy

iCap Alternative Options

Multiple options can be selected for capacity VDER pricing

Alternative 1

- Fixed monthly $/kWh price for all generation
- Price set monthly
  - Typically higher in summer and fall months
- ES in a DC-tied configuration increases this value by delivering clipped DC power

Alternative 2

- Fixed monthly $/kWh for generation between 2pm and 6pm weekdays
- Only available during summer months (June-August)
- Much higher rate than Alt 1 in most areas
- ES value for AC-tied and DC-tied

Alternative 3

- Monthly $/kW value for generation during coincident peak hours
- Potential ES value as peak hours are typically from 4-8pm

Focus on Alternatives 2 and 3

Projects under consideration

Three candidate Community Distributed Generation (CDG) projects considered
- 3 different locations
- 3 different project sizes (sized for the needs of the area?)

Estimate additional value that could be obtained with energy storage systems
- AC-Tied, separate inverter
- DC-Tied, shared inverter
  - Clipped DC power at the inverter can be used to charge the batteries

Subject to transmission limits, PV potential, etc.

	A	B	C
Service Territory	ConEd Westchester	**National Grid**	Central Hudson
NYISO Zone	H	**A**	G
MW DC	0.75	**7.5**	2.98
MW AC	0.577	**5**	2
ESS Connection	AC	**DC**	DC
Fixed VDER Values (2018)			
E - $/kWh	0.02741	**0.02741**	0.02741
DRV - $/kW	0	**0**	0.5
LSRV - $/kW	0.034	**0**	0
MTC - $/kWh	0.1435	**0.0229**	0

Optimal Battery Dispatch for Peak Revenue

The objective of the optimization is to maximize revenue subject to:

- Battery state-of-charge model – 25% minimum SOC
- PV generation
- Time-variant pricing structure

Battery charging options

- Only clipped DC power
- Full generation range
- AC-tied battery/PV

Optimized battery dispatch schedule using Python/PYOMO

- Open source tools

$$\max_{P_C, P_D, P_{curtail}} \sum_{t=1}^{T} P_{toGrid,t} \cdot \left(iCap_t \cdot \mathbf{iCap_{hour,t}} + E + MTC + LBMP_t \right)$$

$$\text{subject to} \quad \delta E_{sys} \le SOC_{t-1}\eta_s + \Delta t \left(P_{C,t-1}\eta_C - P_{D,t-1} \right) \le \left(1-\delta\right) E_{sys}$$

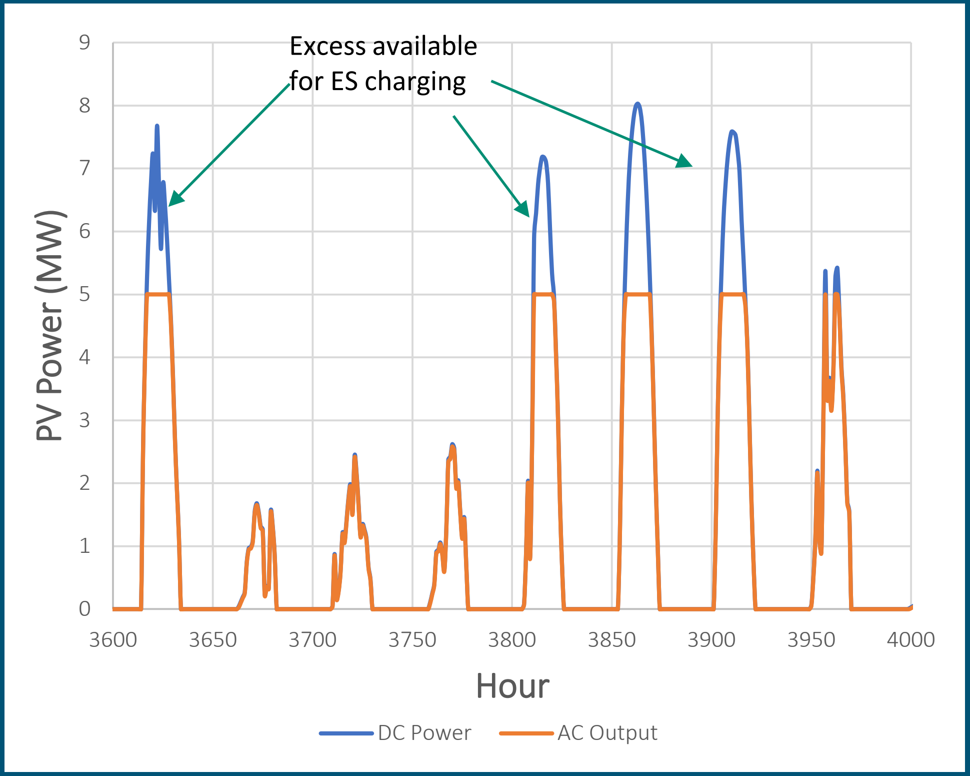
$$P_D \le P_{sys}$$

$$\mathbf{P_{C,t} \le P_{DC,t} - P_{AC,t}}$$

$$P_{toGrid} \le P_{sys}$$

$$P_{toGrid,t} = \eta_{inv} \left(P_{DC,t} + P_{D,t} - P_{C,t} - P_{curtail,t} \right)$$

Modeling PV output



30-min simulation using NSRDB irradiance data

All projects using an DC/AC ratio of ~1.5

- DC-tied systems can store excess power that would be curtailed
- DC connections save on system cost by sharing an AC-DC inverter
- AC-tied systems do not share an inverter

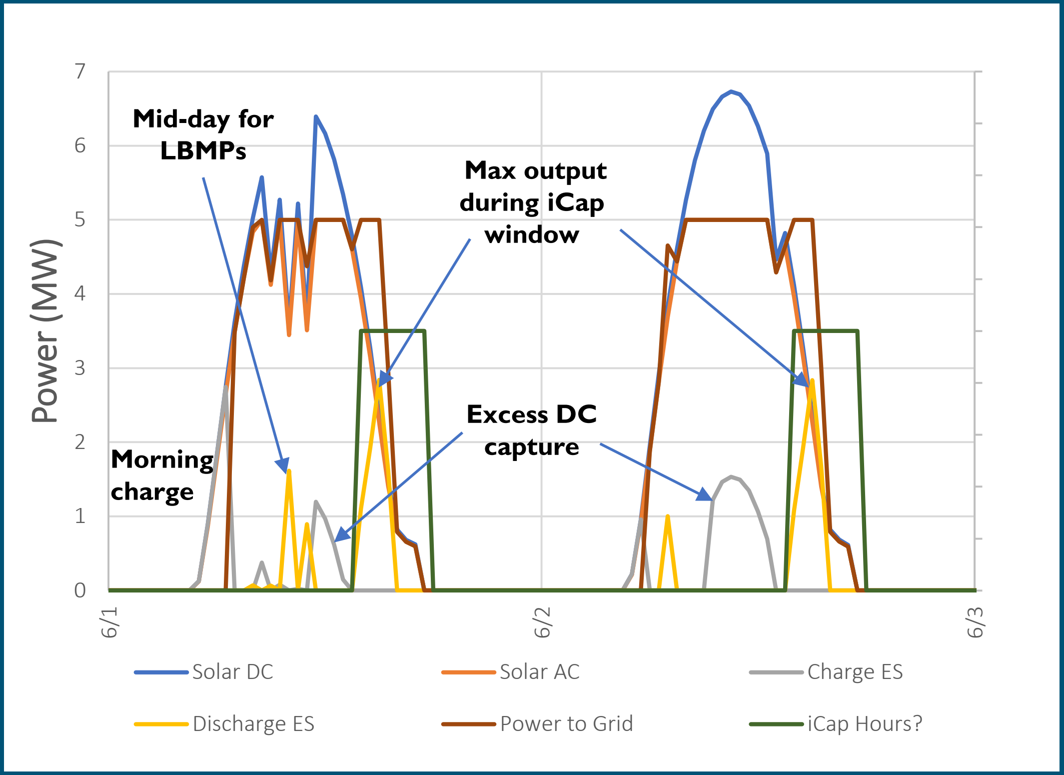
PV output was modeled using the data from the System Advisor Model (SAM)

iCap Alternative 2 Results

Charge early morning and from clipped power

Discharge mid-day to maximize LBMP
- If it can remained fully charge for start of iCap window

Discharge during iCap window to maintain peak power
- Until battery hits lower SOC limit



5 MW / 5 MWh

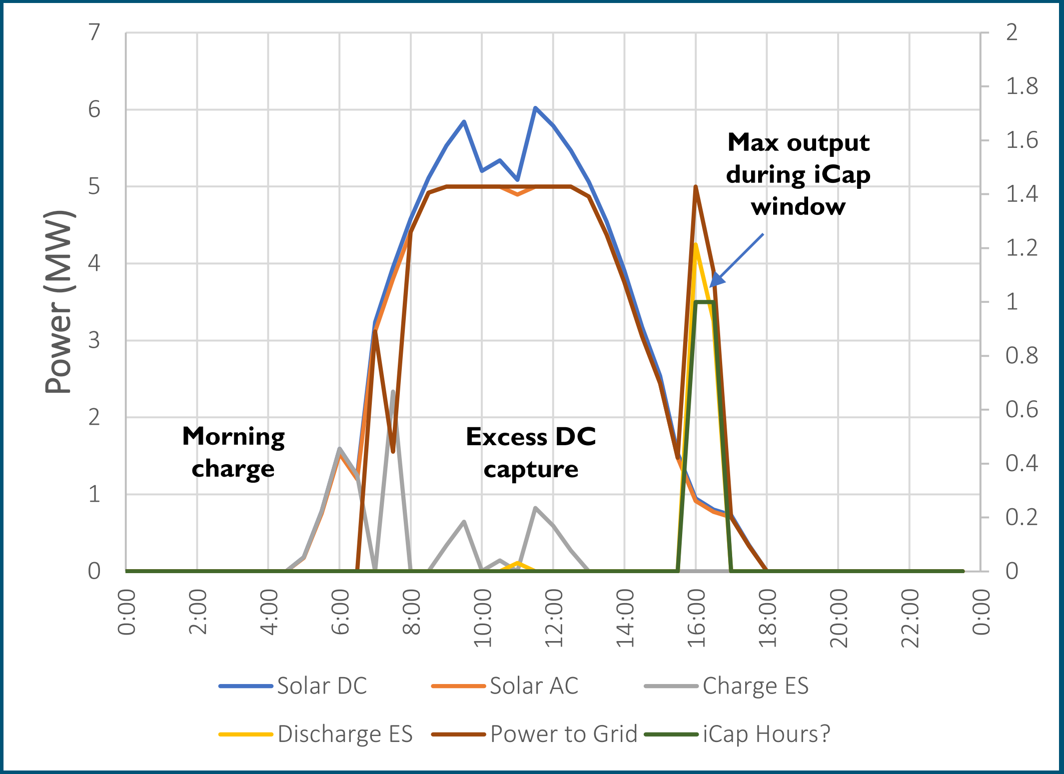
iCap Alternative 3 Results

Charge early morning and from clipped power

Discharge mid-day to maximize LBMP revenue
- If it can remained fully charge for start of iCap window

Discharge during monthly

Major difference here is the iCap window
- 1 hour long
- Only once a month
- MUST be properly forecast or NO value

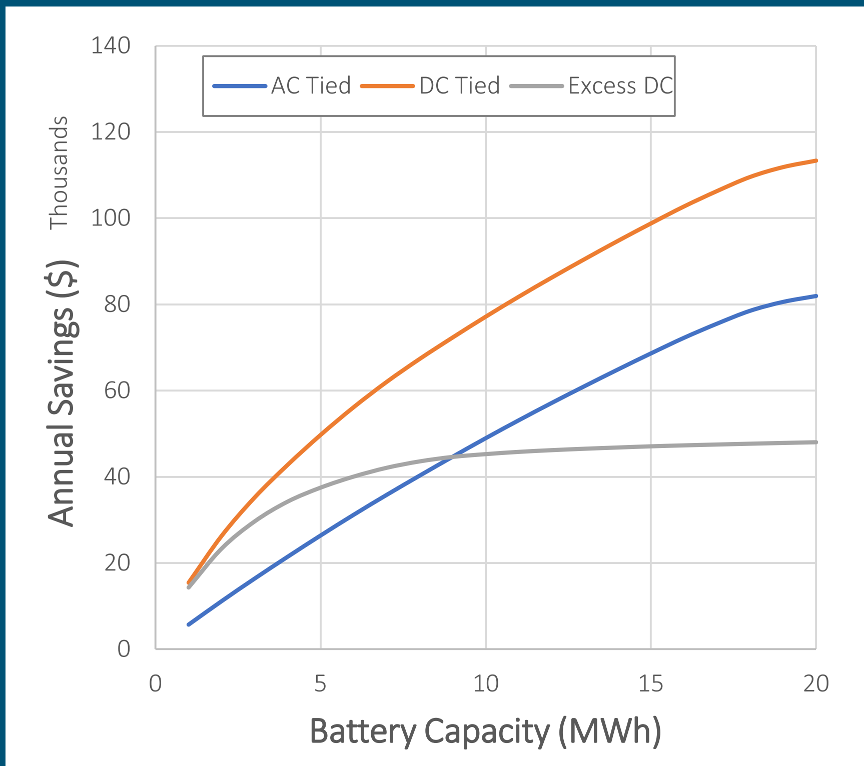


5 MW / 5 MWh

Maximum Project Values

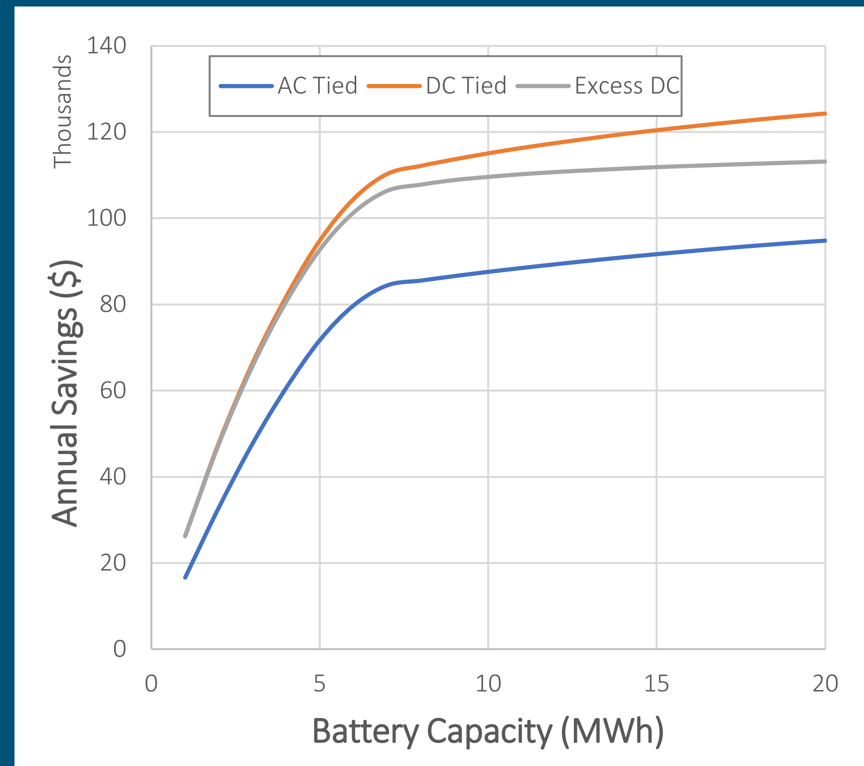
Alternative 2

2-6PM June-August



Alternative 3

Monthly Coincident Peak



Connecting PV and battery DC has advantages over AC connections

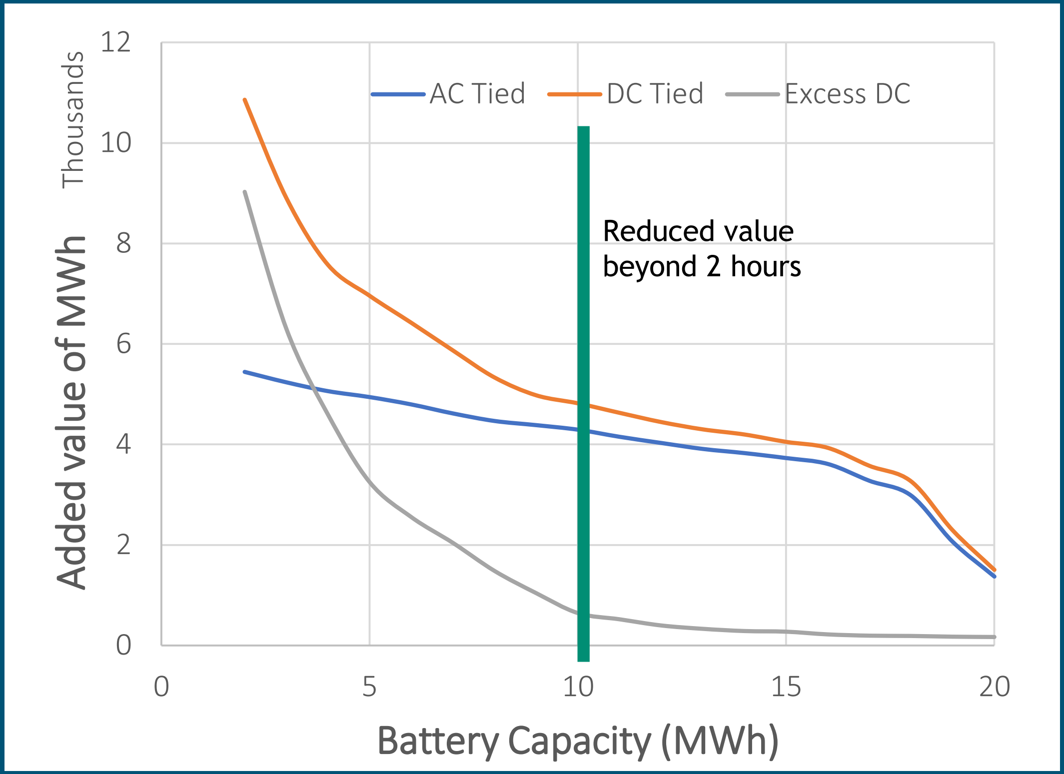
In higher energy applications (iCap 2), charging from all available energy is essential

Low energy applications (iCap 3) yield the most value per MWh

- Of course depending on the pricing at the node

Initial Battery Selection

- For revenue, bigger is better
- Maximizing net benefits comes down to system cost
  - How do you determine batteries sizes for RFPs?
- Diminishing returns indicate upper limits
  - Calculate additional savings from next smallest capacity
  - Similar calculation is useful for varying power ratings
- iCap 2 application, 10 MWh hour battery good center point for search
  - 7.5 MWh for iCap 3



Conclusions and Continual Changes in NY

Low energy demand applications yield the most value per kWh

DC-DC connections take advantage of energy that would be curtailed

- Depends on PV inverter size and transmission limits

Forecasting is important to capture coincident peak benefits

- Peaks generally at the same hour every month

NY made major changes to VDER policies last month

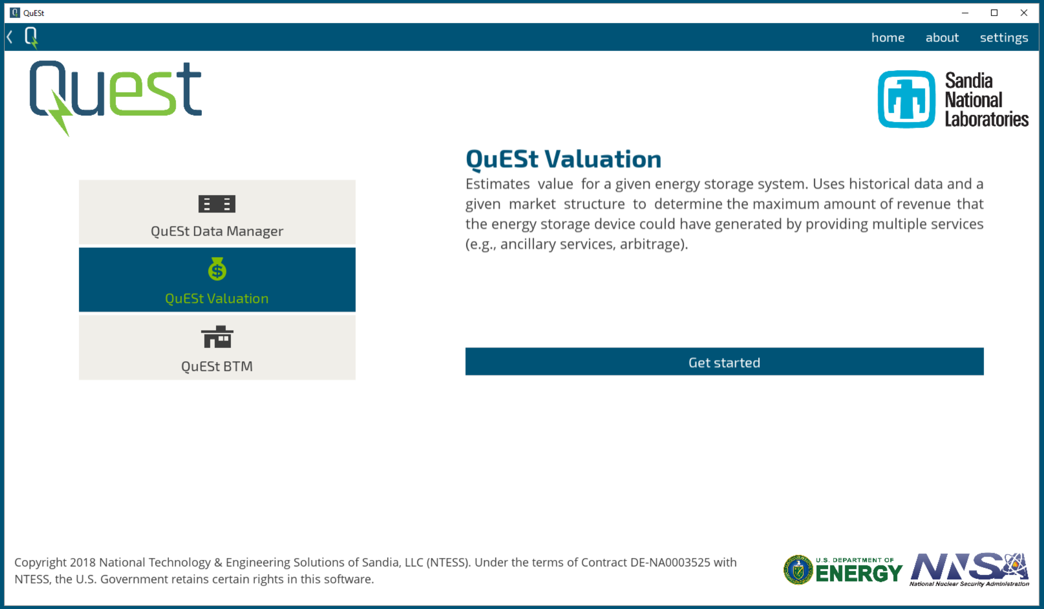
- Retroactive to July 2018
- Capacity value hours shifted later in day
  - Valid dates changing
- Locational System Relief Value to be in response to "utility calls"
  - 21 hours in advance
  - 1 to 4 hour generation requests

Re-assessment would be required to give an accurate revenue potential estimate

Most of these changes will likely increase the value of batteries with solar

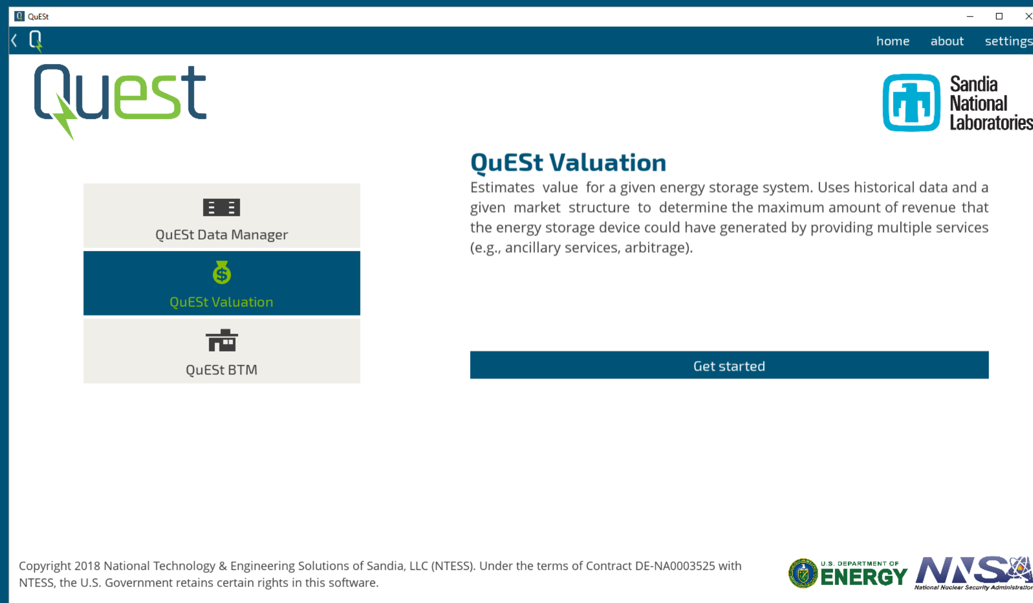
- Value later in the day when PV output is low
- Calls for generation at times when solar alone may not be available
- Values added for standalone batteries

What is it?



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

What is it?



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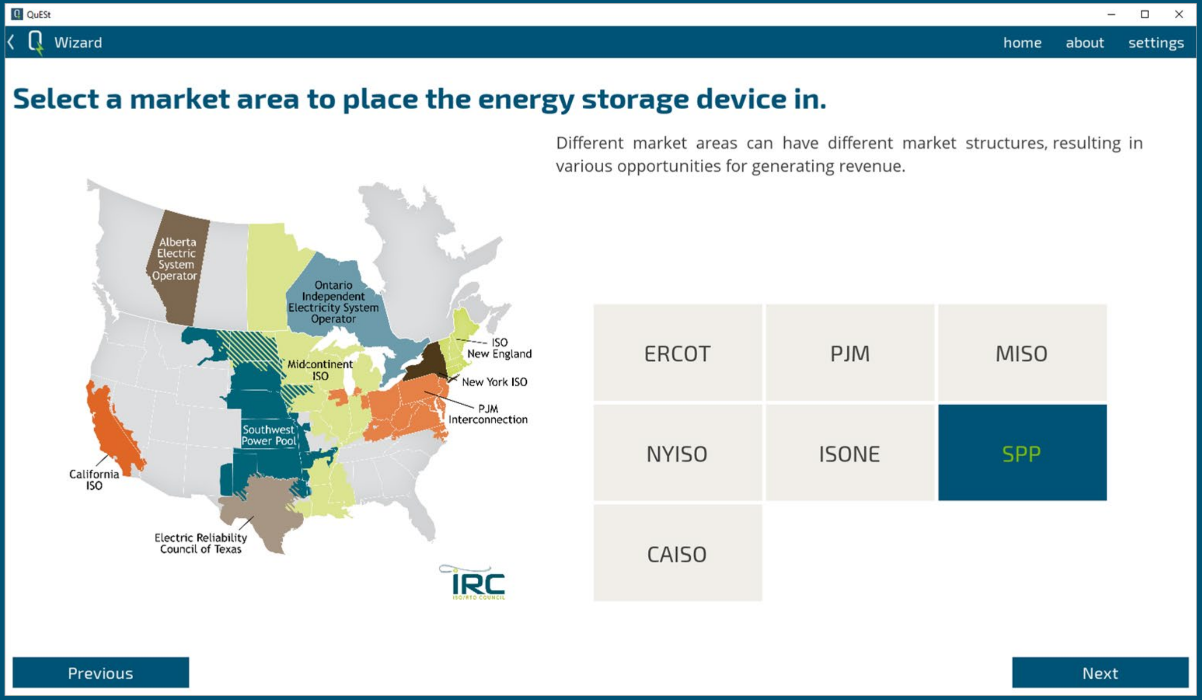
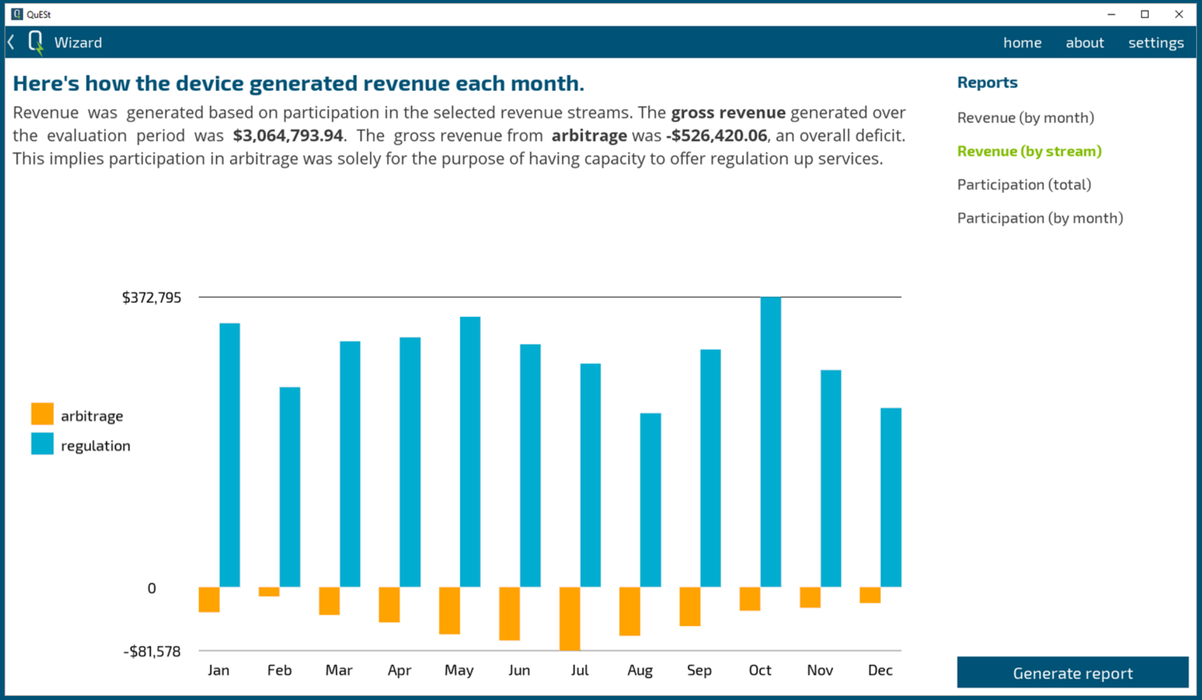
QuESt Valuation



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

QuESt Valuation



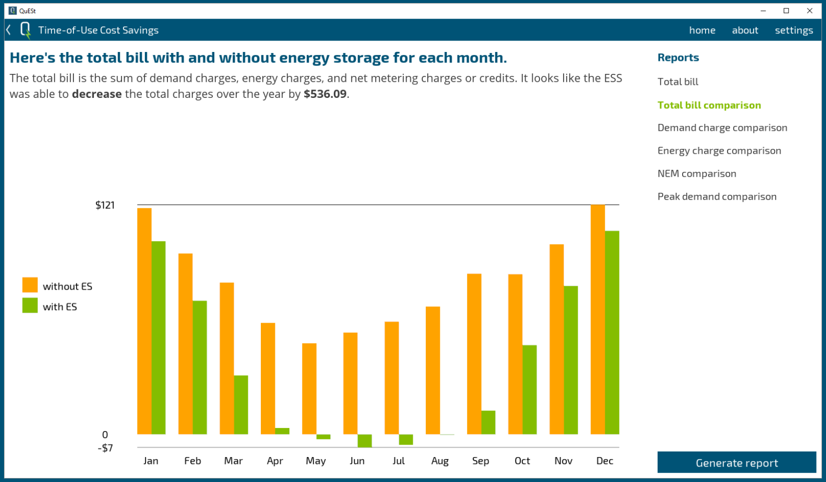
- Revenue by month
- Revenue by revenue stream
- Frequency of participation in each available revenue stream

QuESt BTM*

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

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

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



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

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