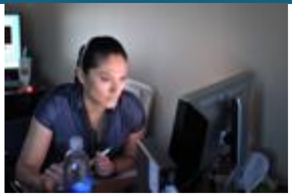
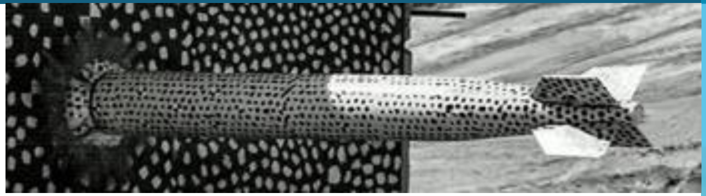
QuESt: Evaluation of Energy Storage





PRESENTED BY

Walker Olis

2023 DOE ENERGY STORAGE FINANCING SUMMIT

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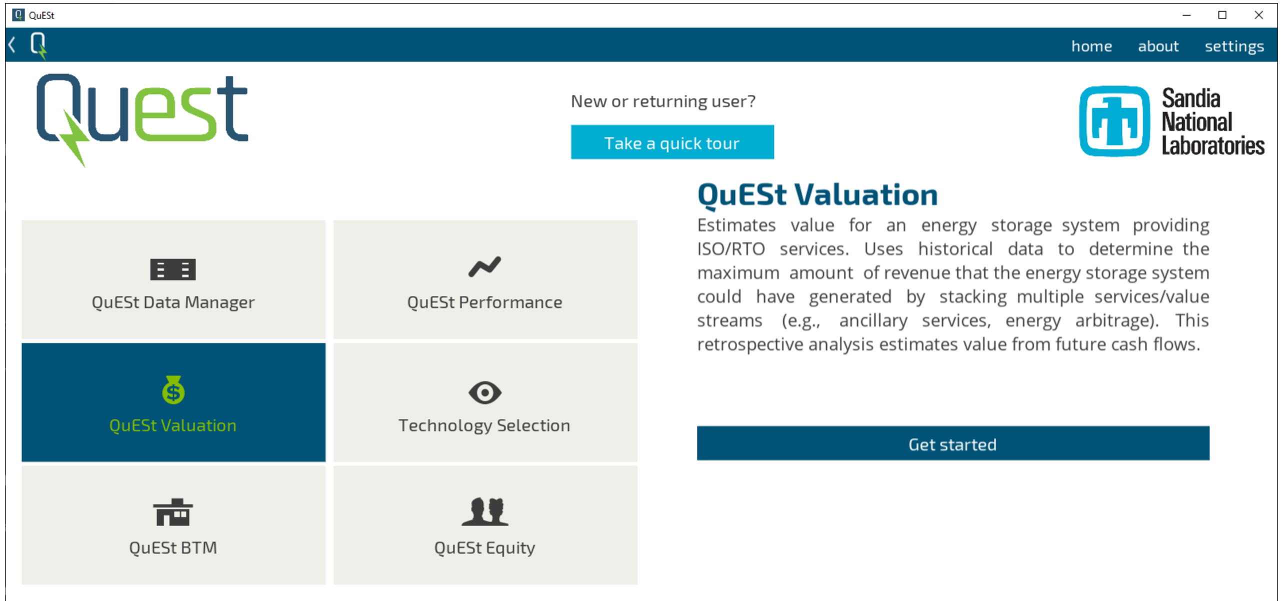
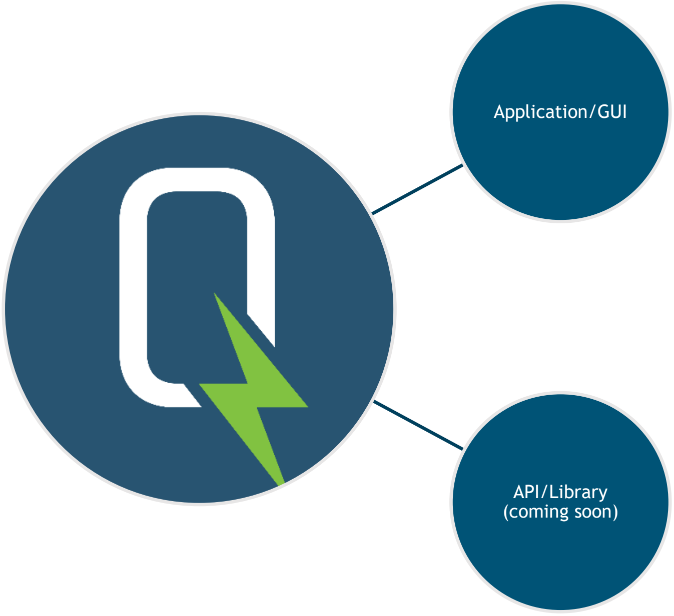
Techno-economic Analysis of Energy Storage

- Identify revenue streams: what are the possible services/applications that an ESS can provide?
- Select the right ES technology to provide those services.
- Evaluate the overall economic gain given the limits in performance of the selected storage technology.
- Optimally size ESS.

QuESt - Overview



Version 1.6 available on GitHub: https://github.com/snl-quest/snl-quest



- Developed for user experience
- No hassle installation

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

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

Current (v1.6):
- QuESt Data Manager
- QuESt Valuation
- QuESt BTM
- QuESt Tech Selection
- QuESt Performance

Alpha Release:
- QuESt Equity

Energy Storage Technology Selection

Goal: given a set of user selections, perform an initial screening to identify and rank feasible energy storage technologies for a given project.

ES technologies currently in the database:

- Pumped hydro storage (PHS)
- Compressed air energy storage (CAES)
- Sodium (Na)
- Zinc (Zn)
- Flywheel – Long duration (FWLD)
- Flywheel – Short duration (FWSD)
- Flow battery – Vanadium (FBV)
- Flow battery – Iron (FBFe)
- Flow battery – Zinc bromide (FBZnBr)
- Nickel (Ni)
- Lithium-ion – Energy (LiE)
- Lithium-ion – Power (LiP)
- Lead (Pb)
- Lead carbon (PbC)

User inputs:
- Grid location
- Application(s)
- System size (power)
- Discharge duration

ES technologies database
- discharge duration
- round-trip efficiency
- cycle life
- depth of discharge
- response time to full power
- cost
- maturity level
- …

Applications database
- minimum discharge duration
- minimum response time
- power vs. energy application
- deployment location restrictions
- …

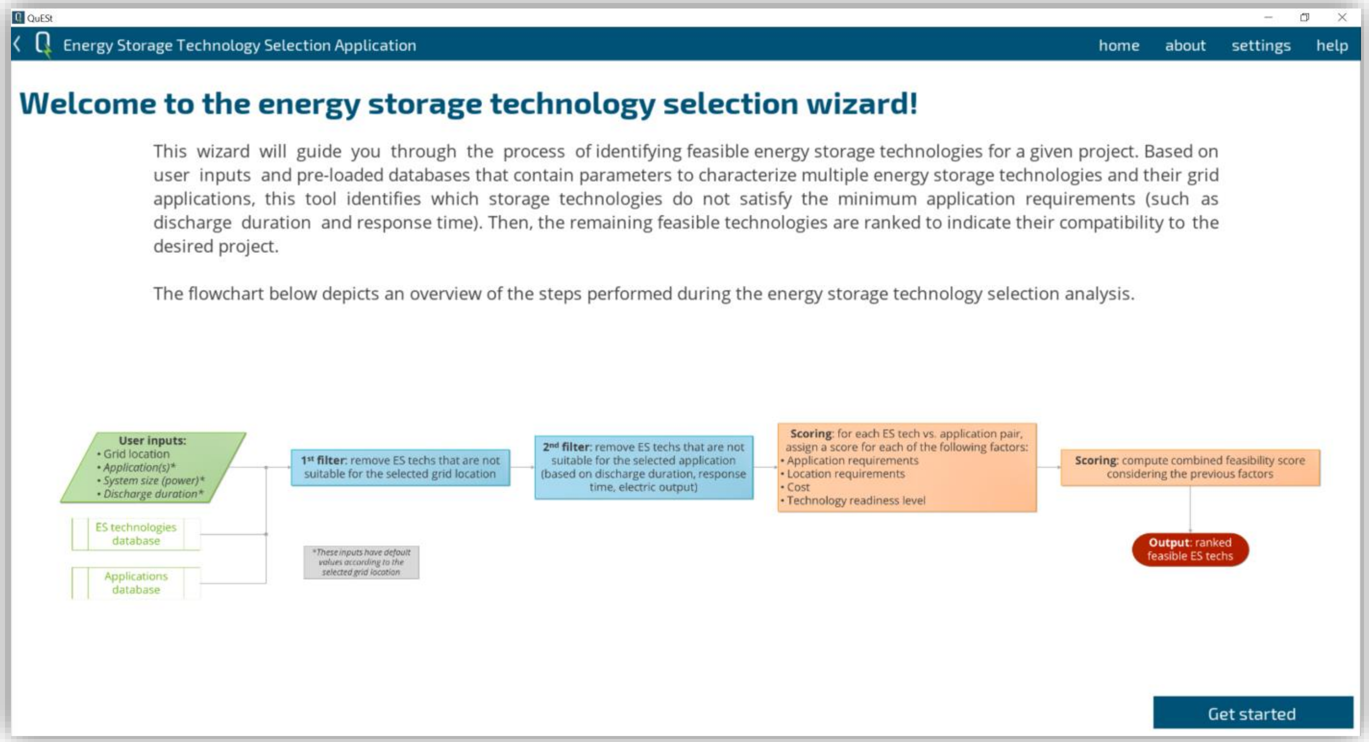
Filter out ES techs that are not suitable for the selected grid location and/or do not meet the minimum application requirements (discharge duration, response time, electric output)

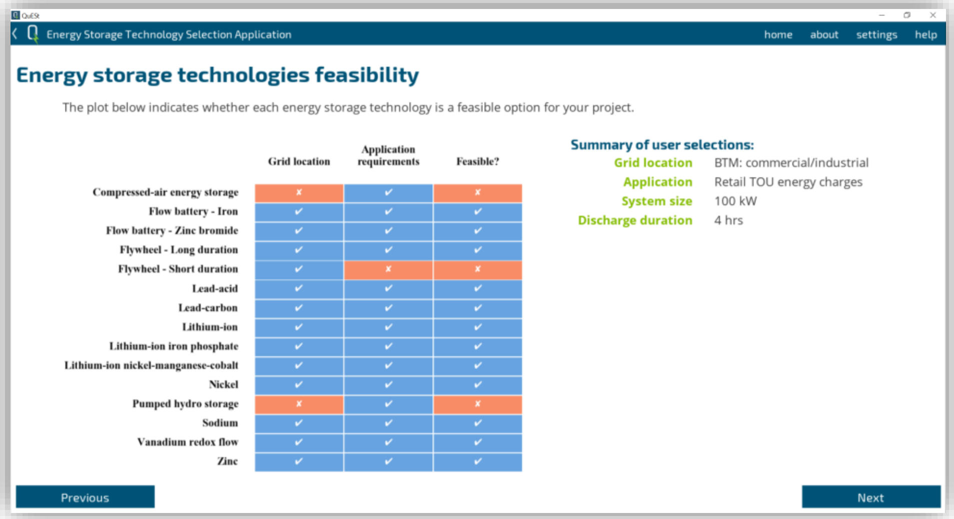
Score each feasible ES tech based on the following factors:
- Application requirements
- Location requirements
- Cost
- Technology readiness level

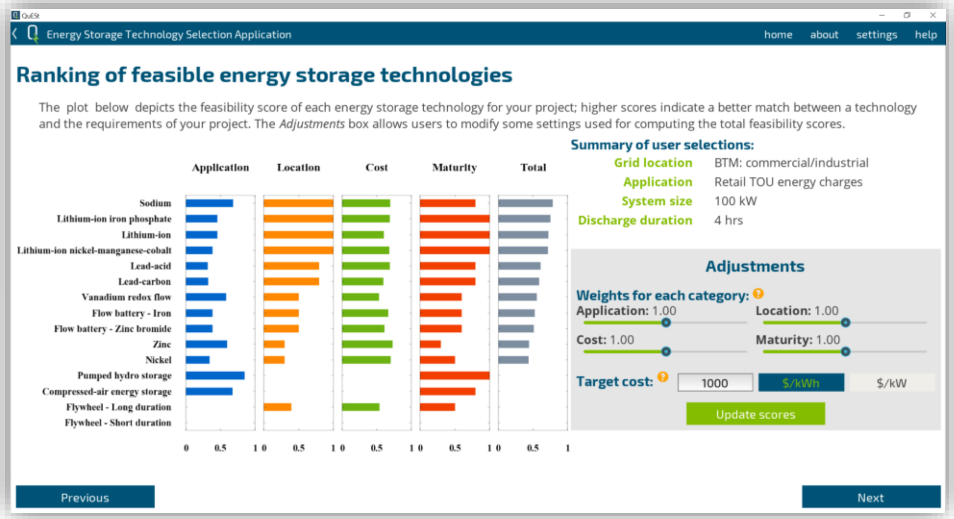
Output: ranked feasible ES techs

The final score for each ES tech is given as the weighted geometric mean of the four individual scores, so that the user can assign higher weights to the factors that they consider more relevant to the intended applications.

QuESt – Technology Selection







Energy Storage Valuation – Market Problem

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?

$$\max \sum_i \Big(\underbrace{\lambda_i (q_i^d - \eta_c q_i^r)}_{\text{arbitrage}} + \underbrace{q_i^{ru}(\lambda_i^{ru} + \delta_i^{ru}\lambda_i)}_{\text{regulation up}} + \underbrace{q_i^{rd}(\lambda_i^{rd} - \delta_i^{rd}\lambda_i)}_{\text{regulation down}} \Big) e^{-Ri}$$

subject to:

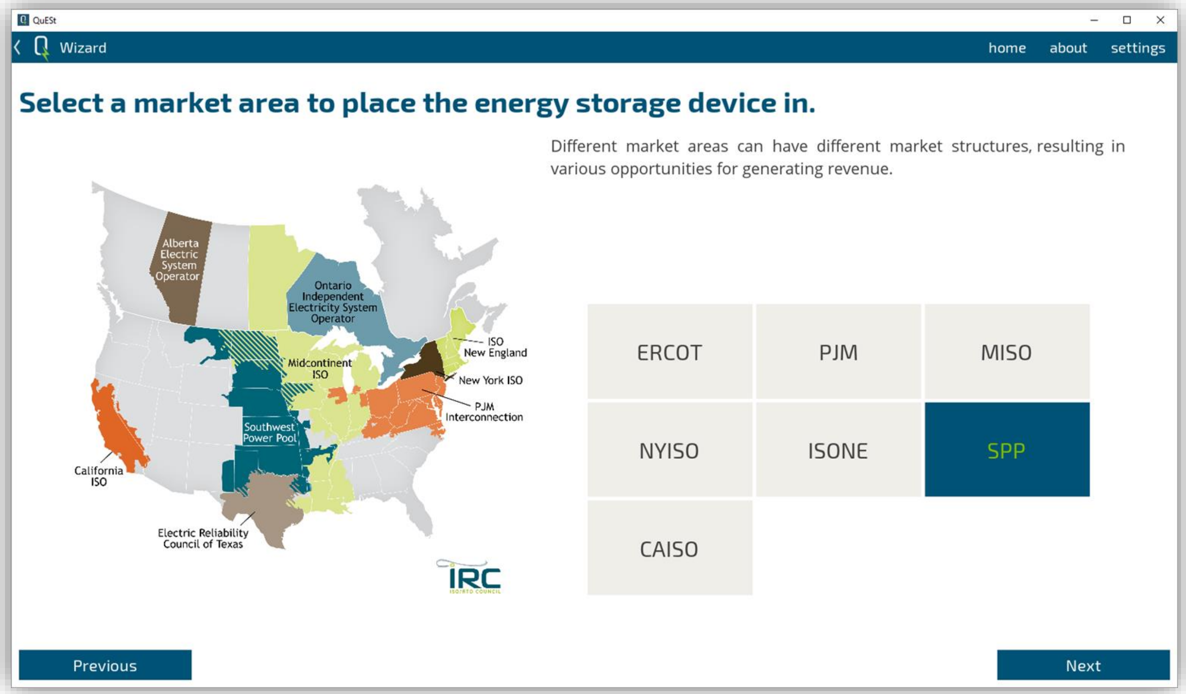
$$s_{i+1} = \eta_s s_i + \eta_c q_i^r - q_i^d + \eta_c \delta_i^{rd} q_i^{rd} - \delta_i^{ru} q_i^{ru} \quad \text{state of charge definition}$$

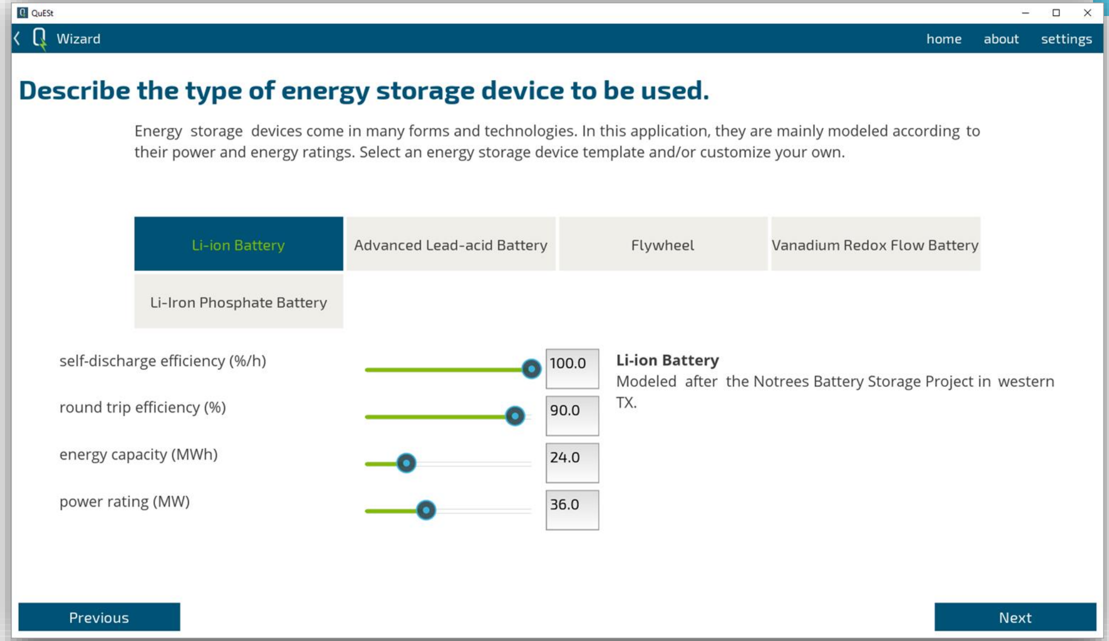
$$0 \leq s_i \leq \bar{S} \quad \text{state of charge limits}$$

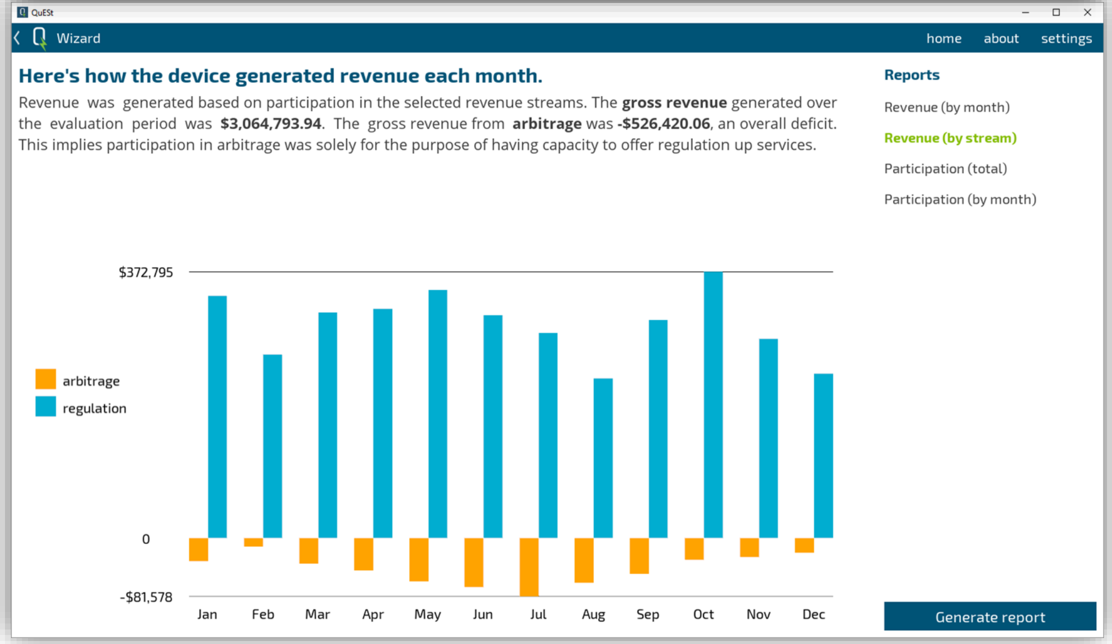
$$q_i^d + q_i^r + q_i^{ru} + q_i^{rd} \leq \bar{Q} \quad \text{power/energy charged limits}$$

- Other constraints, such as requiring the final SoC to equal the initial SoC or reserving energy capacity for resiliency applications can be set.
- Varies based on market and available value streams

QuESt – Valuation Application







Energy Storage Valuation – BTM Problem

Given an energy storage device, a utility tariff structure, how would the device minimize the electricity bills for the customers?

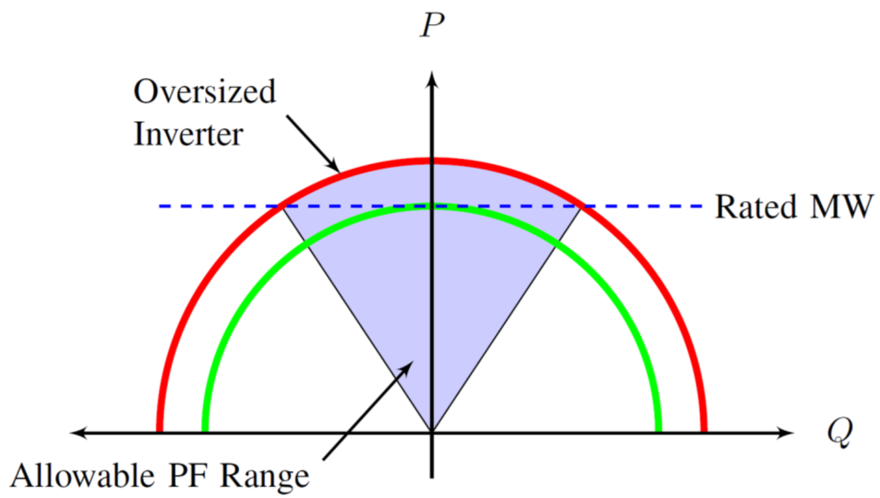
$$\min\{C_E^m + C_N^m + C_D^m\}$$

s.t. energy storage and inverter constraints

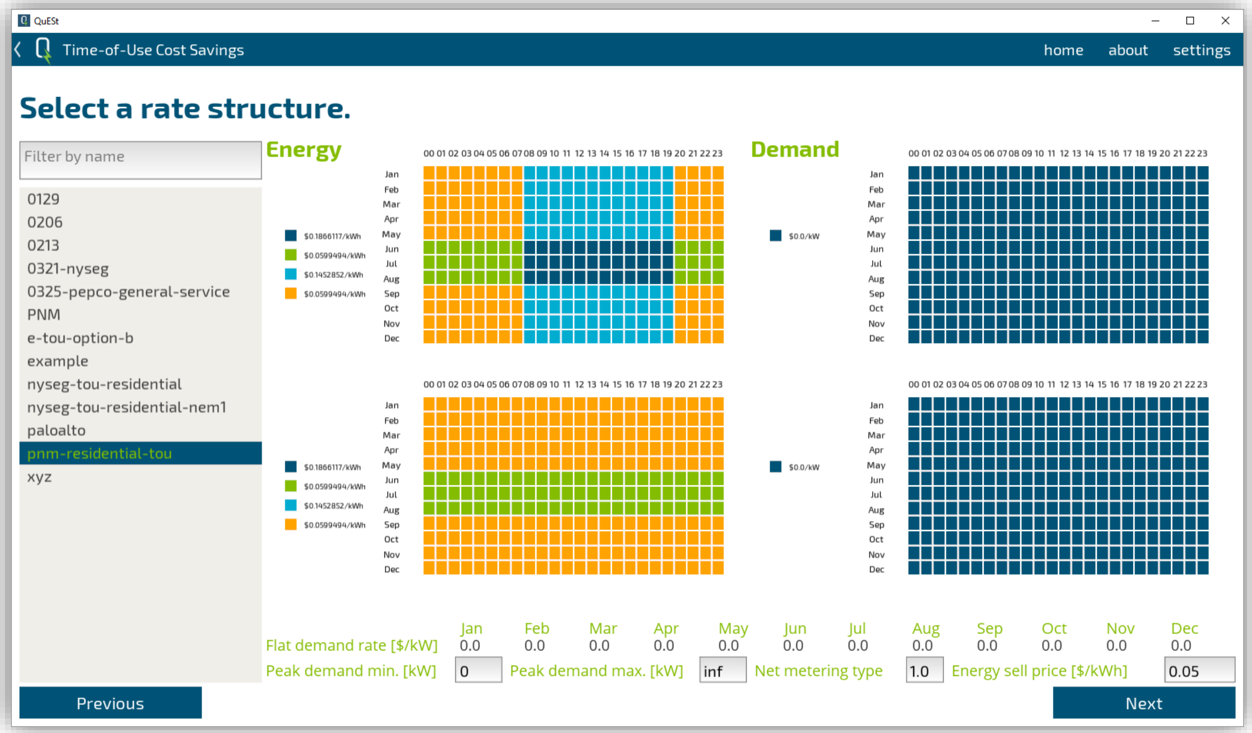
C_E^m is the energy charge of period m

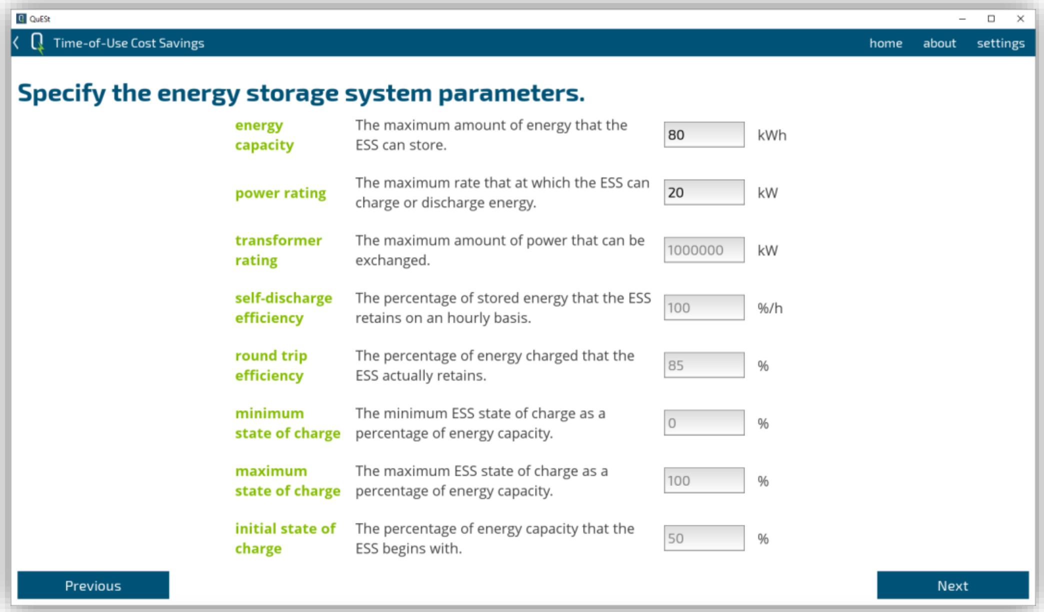
C_D^m is the demand charge of period m

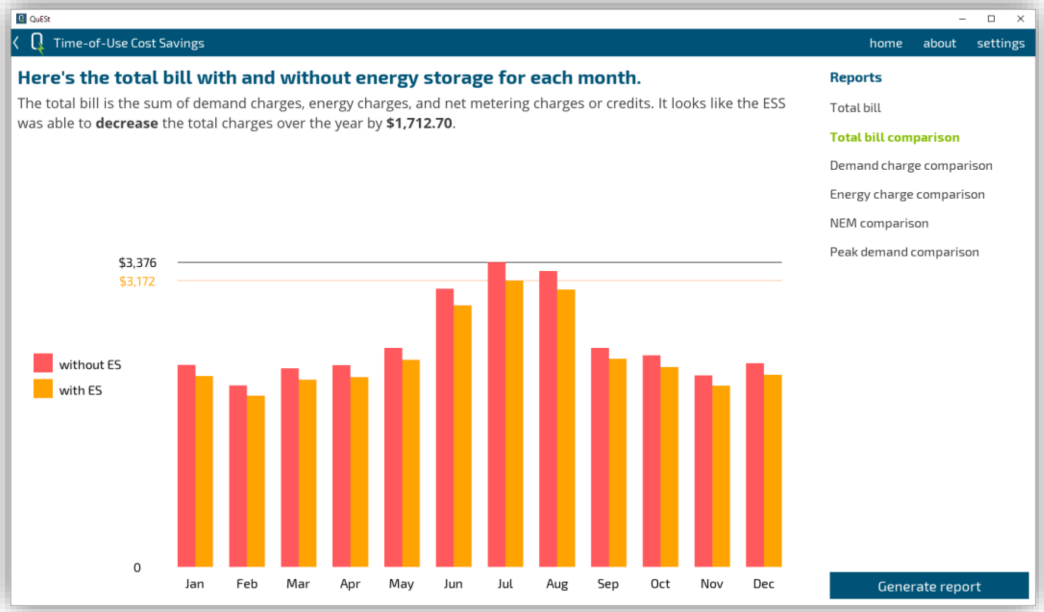
C_N^m (≤ 0) is the net metering charge of period m.



QuESt – BTM Application







QuESt Equity

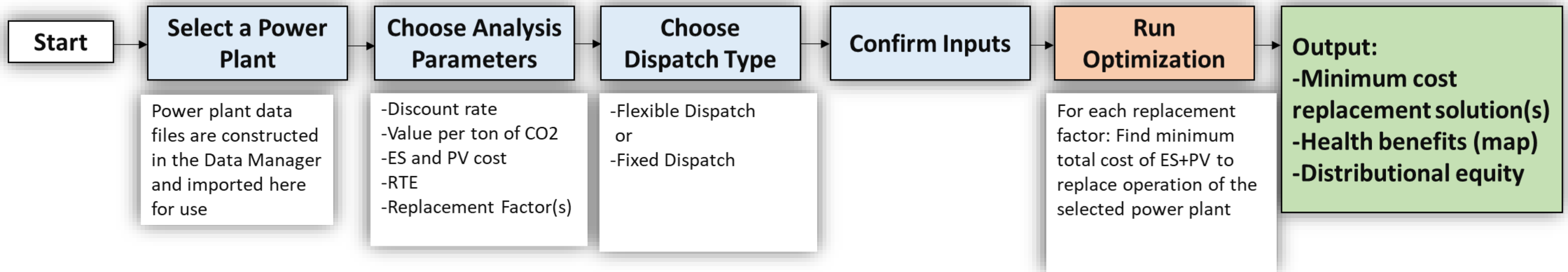
Given a Peaker loading profile, what are the optimal sizes of PV and storage for 1-to-1 replacement of that plant? What are the health and environmental benefits?

Inputs

- Powerplant Data File
- Battery and Analysis Parameters
- Dispatch Type Assumption

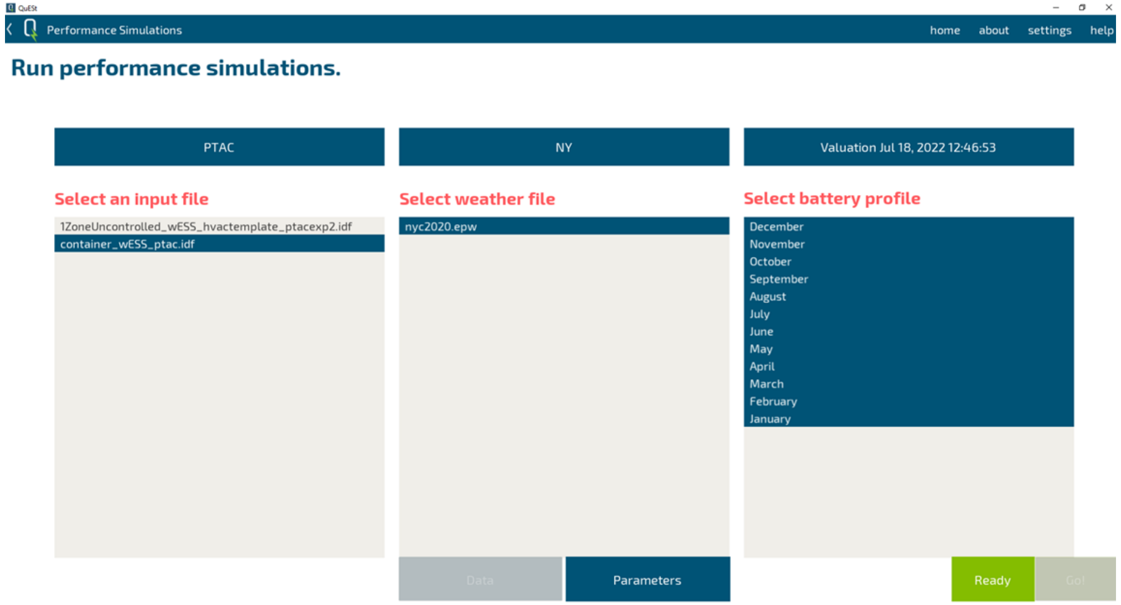
Outputs

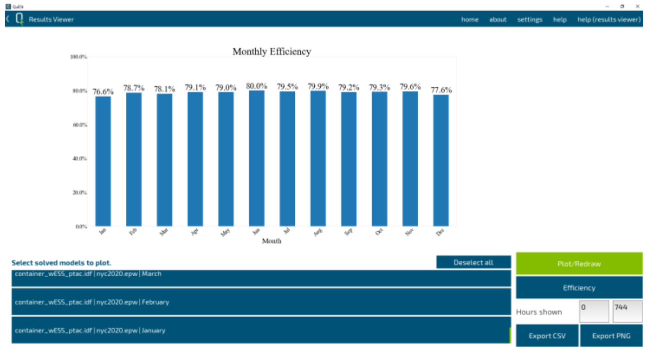
- Minimum capital cost solution(s)
- Health Benefits
- Distributional Impacts



QuESt Performance

Given a charge/discharge profile of a BESS, how much energy is needed to run the HVAC that maintain system temperature within its operating range? How does this affect expected performance and location?





Start
- E+ .idf
- Weather file
- Charge/discharge profile

Simulation parameters
- Battery parameters
- HVAC setpoints
- Insulation

Run simulation
- E+

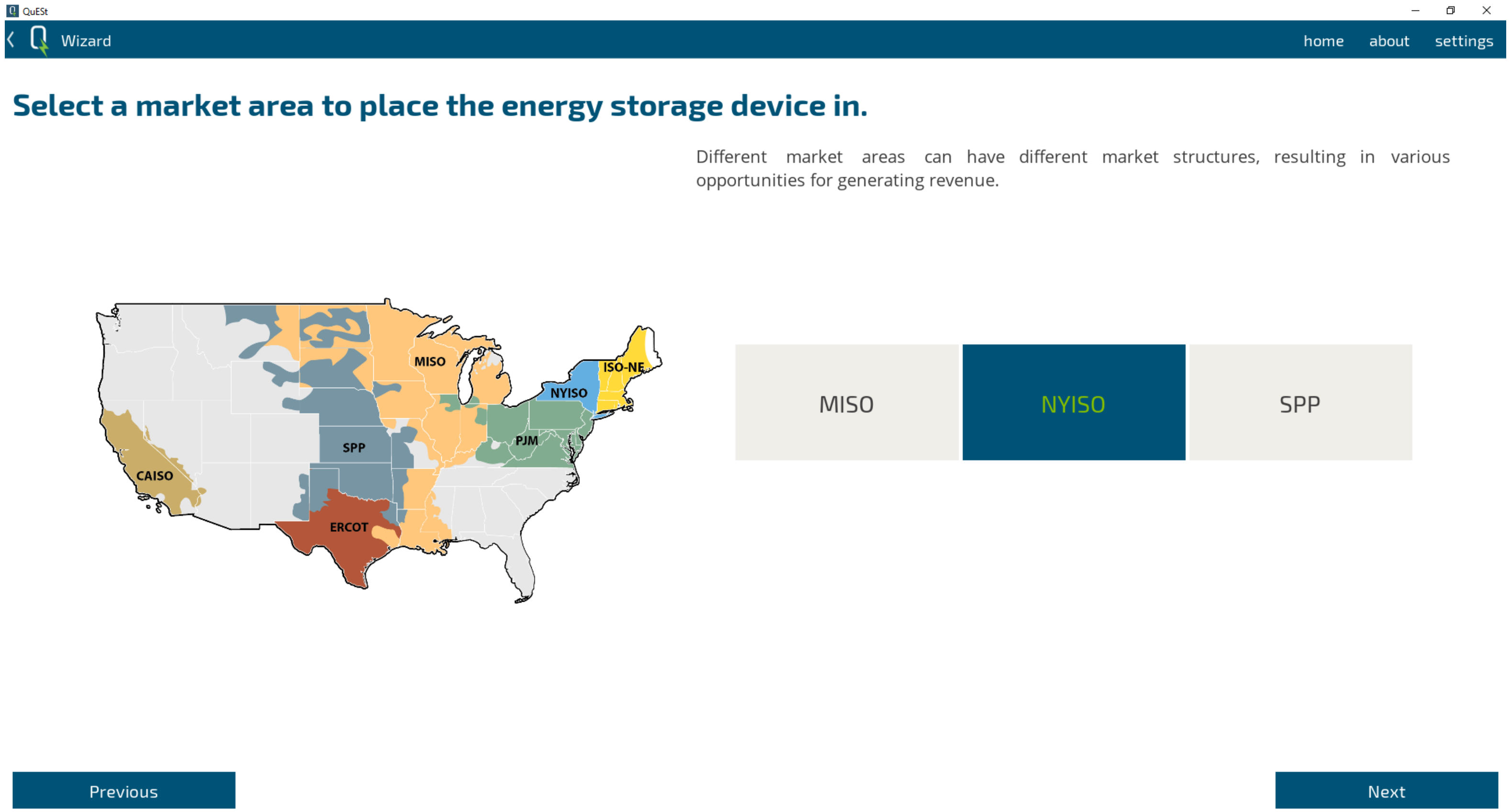
Outputs
- HVAC consumption
- Battery consumption
- System Efficiency

Example – QuESt Valuation and QuESt Performance

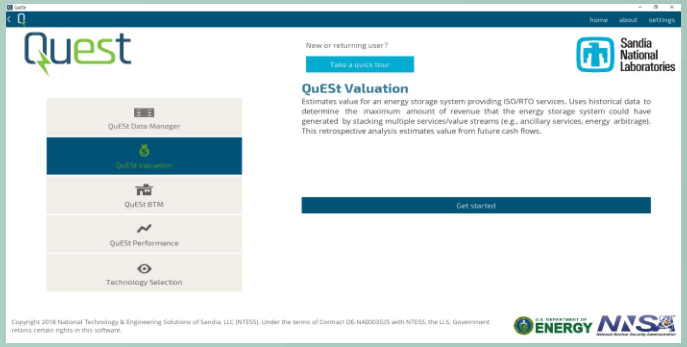
Example: 1MW, 1MWh Li-ion BESS located in NYC

Prerequisites:

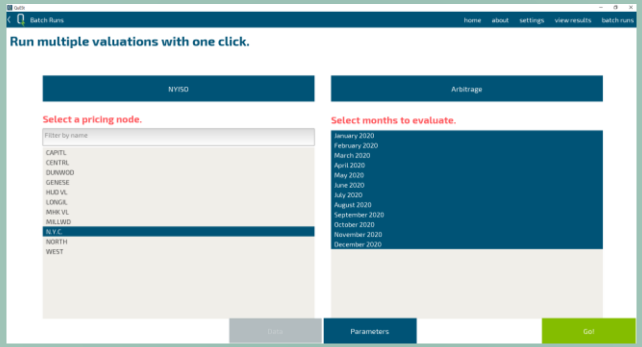
- NYISO NYC zone prices
- NYC weather data
- E+



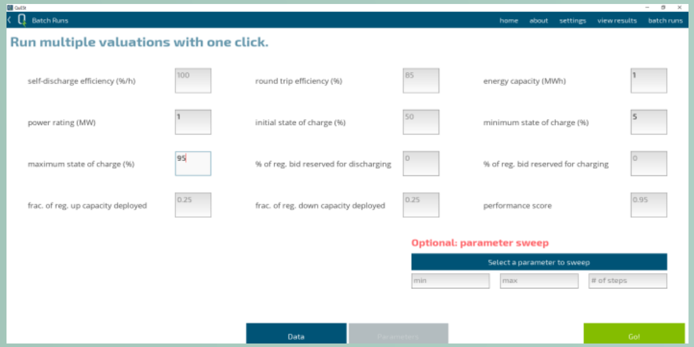
Example – QuESt Valuation and QuESt Performance



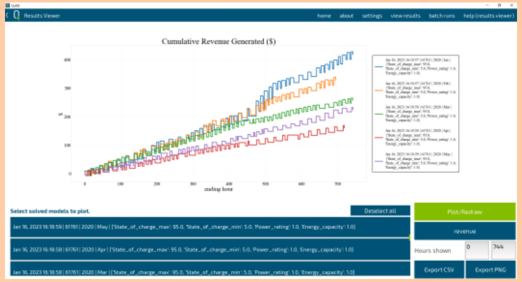
- Navigate to the QuESt Valuation tool.

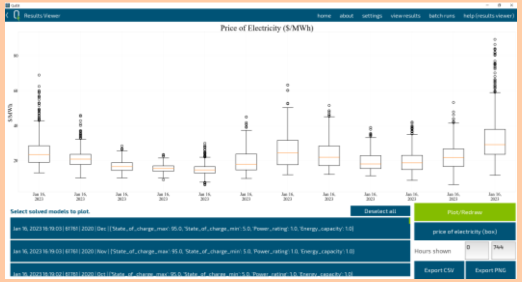


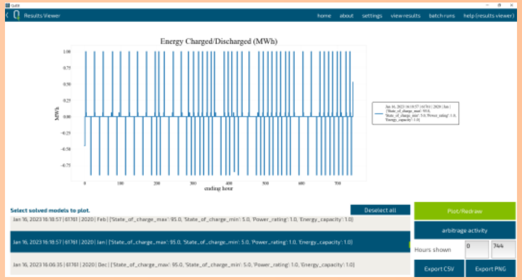
- Click on the Batch Runs Button -> select NYISO from the pull down options -> select N.Y.C. from the node options -> select arbitrage from the pull down options -> select all months of the year.

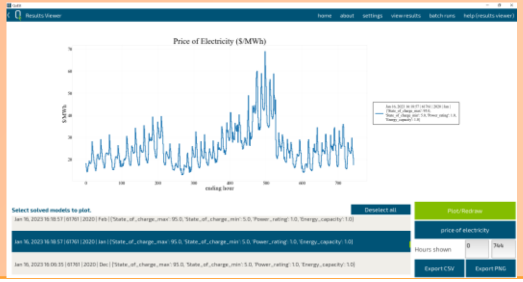


- Click the Parameters tab. Change the energy capacity to 1 MWh and the power rating to 1 MW. Change the minimum state of charge to 5% and the maximum state of charge to 95%.
- Once everything looks correct, click Go! Once the simulations are finished, navigate back to the home page.

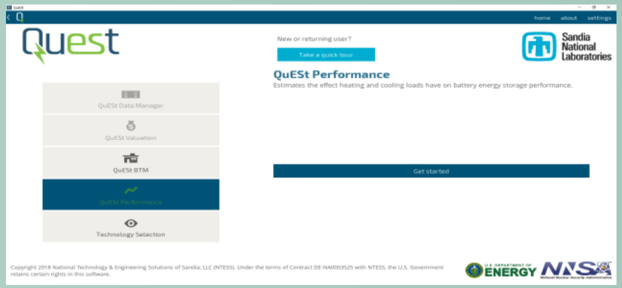




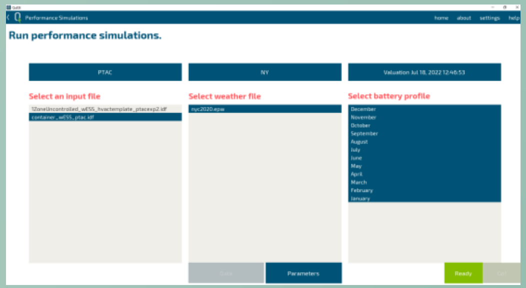




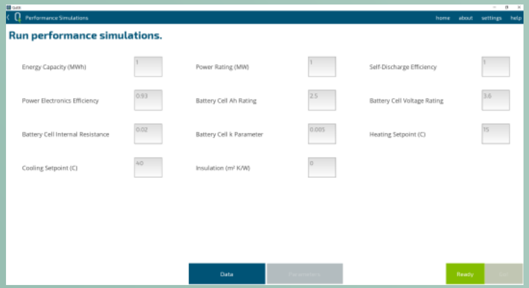
Example – QuESt Valuation and QuESt Performance



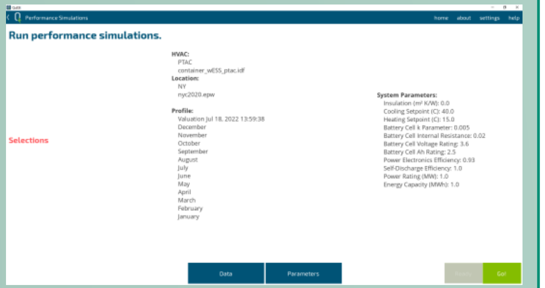
- Navigate to the QuESt Performance tool.



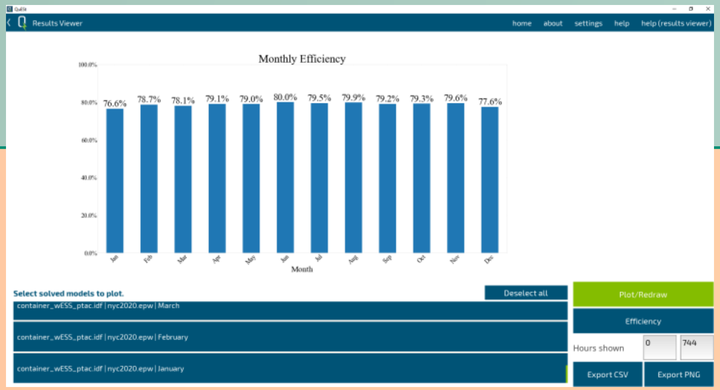
- Enter the Performance Simulations option. Select PTAC from the HVAC options. Select the provided input file describing a BESS in a shipping container. Select NY from the location dropdown. Select the weather file downloaded previously. Select the Valuation run from the Profile dropdown. Select the months available.

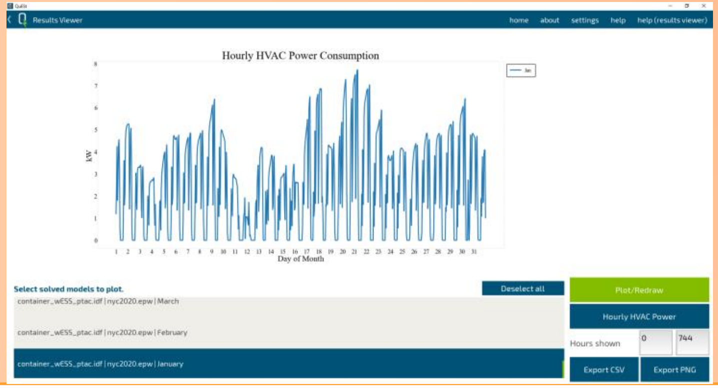


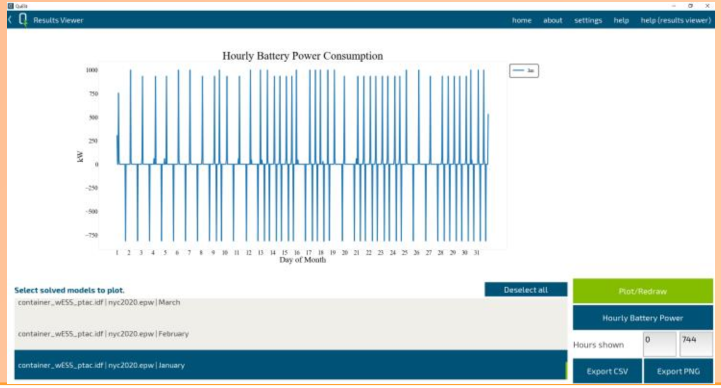
- Click the Parameters tab. Leave the default parameters as is, click the Ready Button.



- The selections made will be displayed. If everything looks correct, press Go!







Acknowledgements

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Thank You!

Tu Nguyen – tunguy@sandia.gov

Walker Olis – wolis@sandia.gov