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Sandia National Laboratories

Storage Sizing and Placement Tool in Distribution Grids

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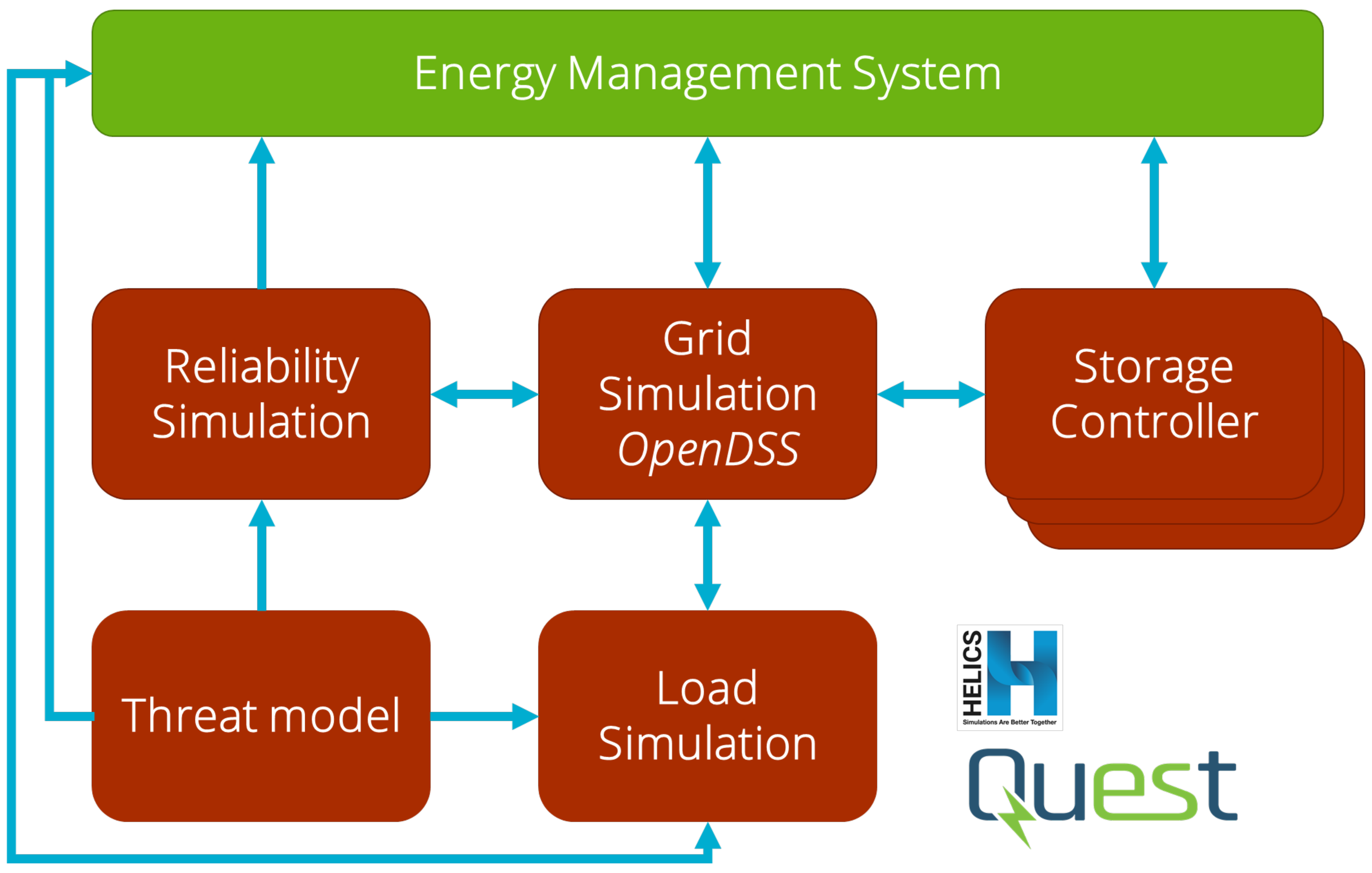
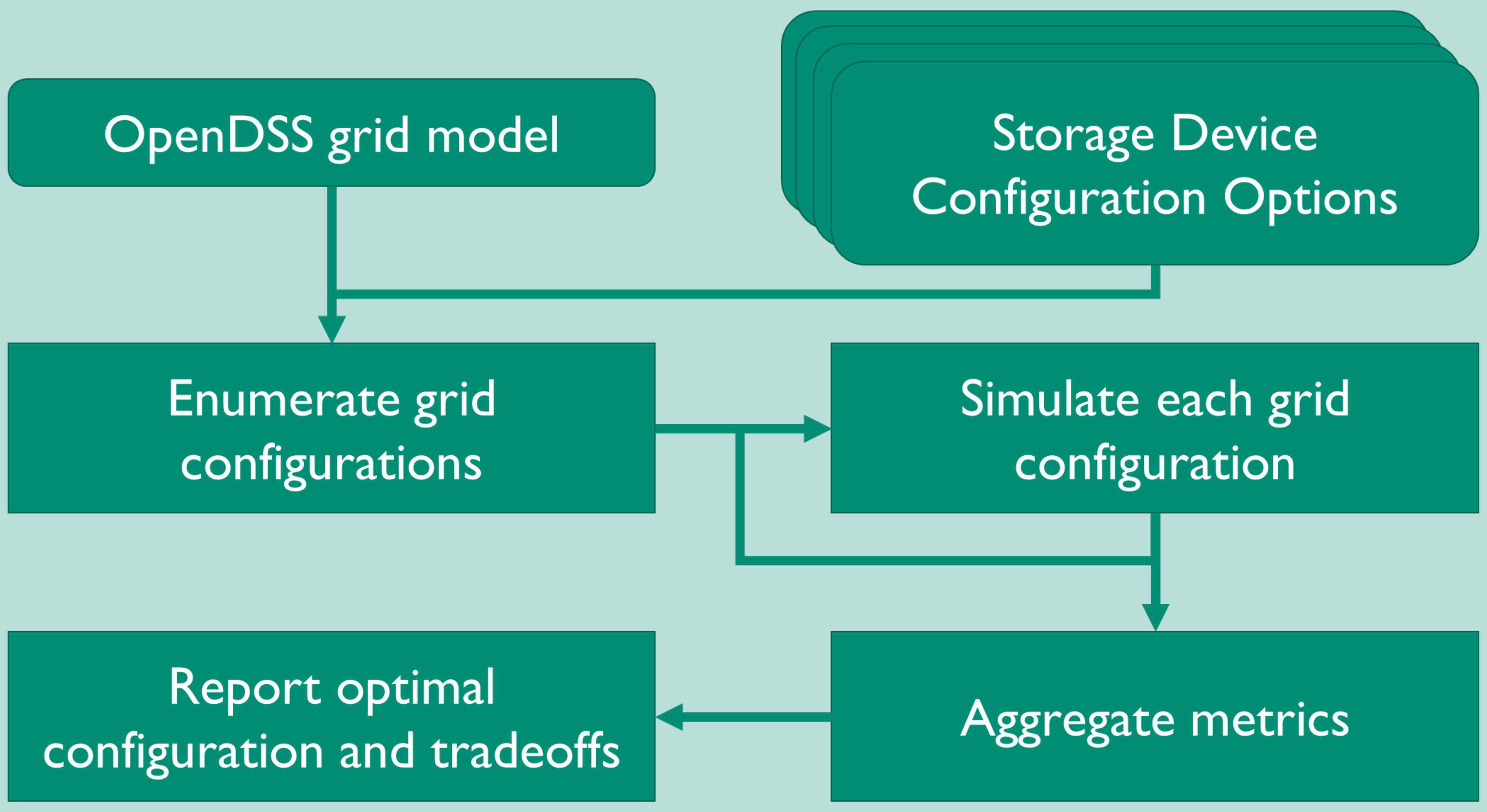
Overview

- Identify optimal sizing and placement of Energy Storage assets on a distribution grid, incorporating considerations of:
  - Grid physics
  - Grid reliability
  - Disruptions caused by extreme events
- A HELICS-based co-simulation couples:
  - OpenDSS grid simulation
  - Grid reliability simulation
  - Energy management system simulation
  - Storage controller simulations
- Beta release: https://github.com/sandialabs/quest-ssim
- Has been integrated with Sandia's QuESt app suite



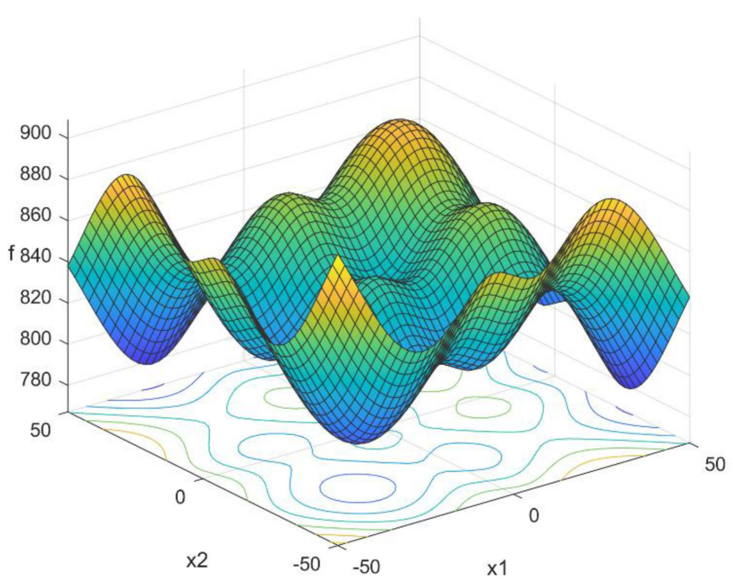
Storage Sizing and Placement Tool



- Metrics are captured and aggregated across the grid to quantify the impact of each storage configuration
- Metrics are normalized in such a way that different quantities of interest can be compared directly.

Optimizing Search Space

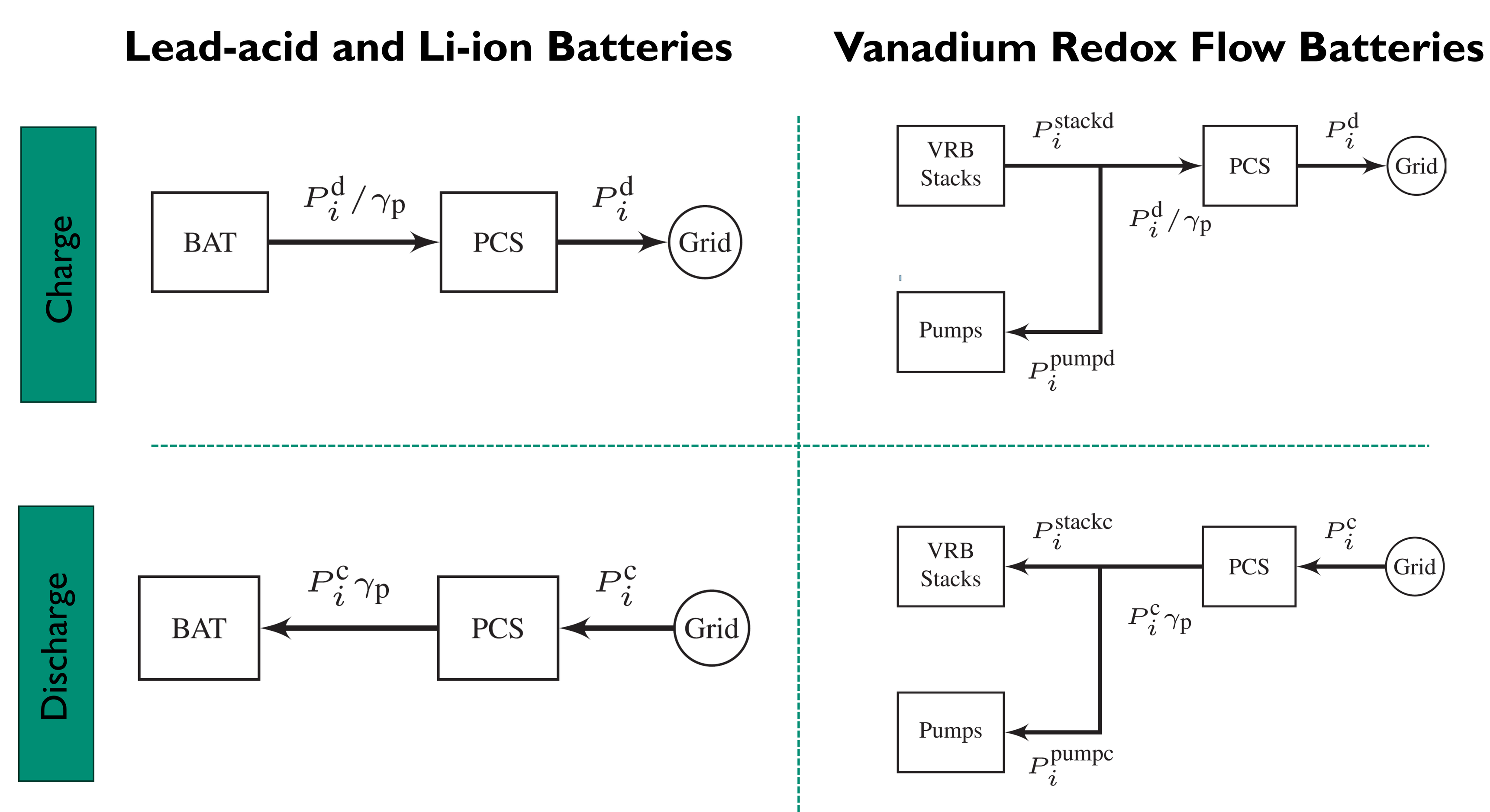
- Currently all possible configurations of energy storage are evaluated.
- Configurations based on:
  - Location
  - Power Rating
  - Storage Duration Rating
- An **evolutionary optimization algorithm** is in the process of being implemented to efficiently navigate the search space.



Source :V. Plevirs, G. Solorzano, "A Collection of 30 Multidimensional Functions for Global Optimization Benchmarking," Data, vol. 7, no.6, 2022.

Improved Energy Storage Models

- Technology-specific modeling capabilities added to the simulator
  - Improves on generic constant-efficiency energy flow model
  - Better captures nonlinearities as the charge/discharge efficiencies of batteries in practice a function of SOC, temperature, and charge/discharge powers
- Lead acid, Li-ion, and Vanadium Redox Flow batteries incorporated
  - Can be parametrized using nameplate or testing data of batteries
  - Capability will be expanded to other technologies
  - Add capabilities for user-defined storage models



Generic Technology Specific Models

$$S_i = \eta_s S_{i-1} + \underbrace{f^{c}(P_i^{c}, S_{i-1})}_{\text{Total charged power}} \tau - \underbrace{f^{d}(P_i^{d}, S_{i-1})}_{\text{Total discharged power}} \tau$$

Ref: T.A. Nguyen, D.A. Copp, R. H. Byrne and 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, Sept. 2019, doi: 10.1109/TPWRS.2019.2909764

Future Work

- Increase simulation speeds by adding parallel computation capabilities.
- Simulate threats to the grid such as extreme weather.
- Develop capability to add PV assets from within the simulator.

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