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FORCE Output Data Visualization

April 2023

Xingyue Yang, Nathan Woods

Changing the World's Energy Future

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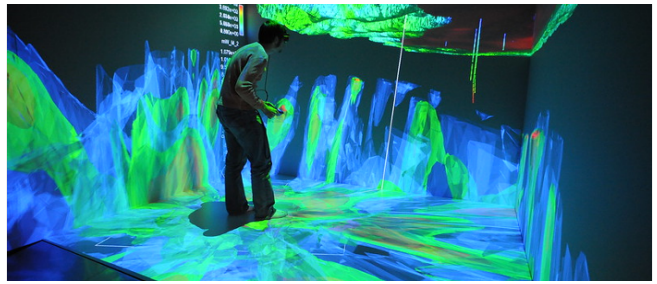
Output Data Visualization

FORCE Overview and Training
April 4-6, 2023

Xingyue Yang
Nathan Woods

Applied Visualization Laboratory (AVL)

- Center for Advanced Energy Studies (CAES), Idaho Falls, ID
- Contains state-of-the-art visualization technologies and 3D environments



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Applied Visualization Laboratory (AVL)

- Cave automatic virtual environment (CAVE)
- Virtual reality (VR) devices
- Augmented reality (AR) devices
- Mixed reality (MR) devices
- LiDAR scanner

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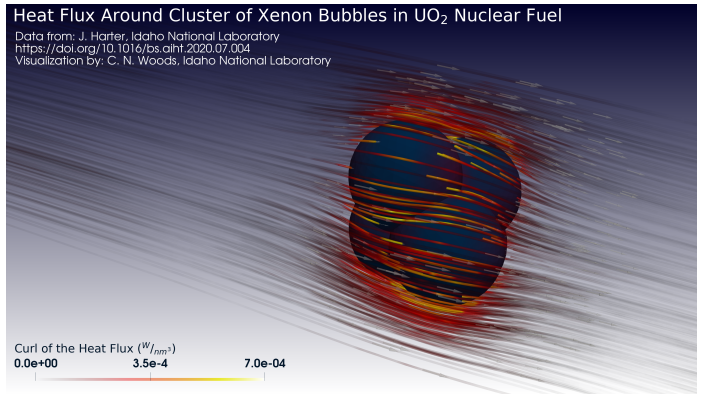
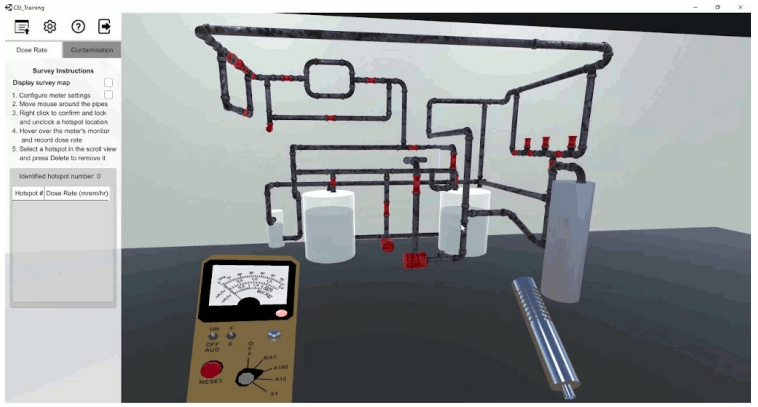
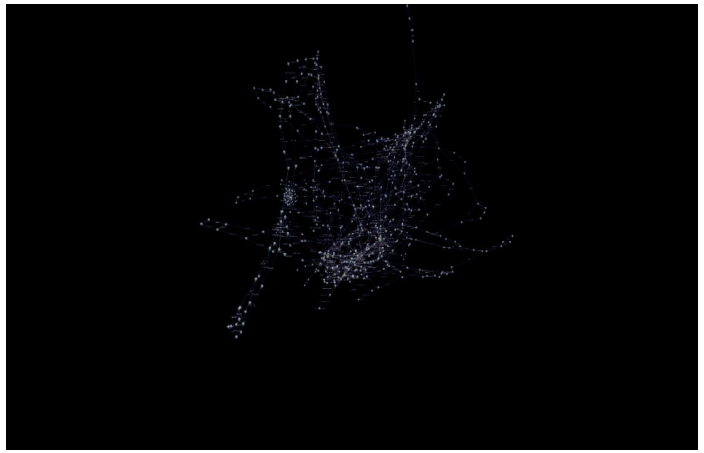
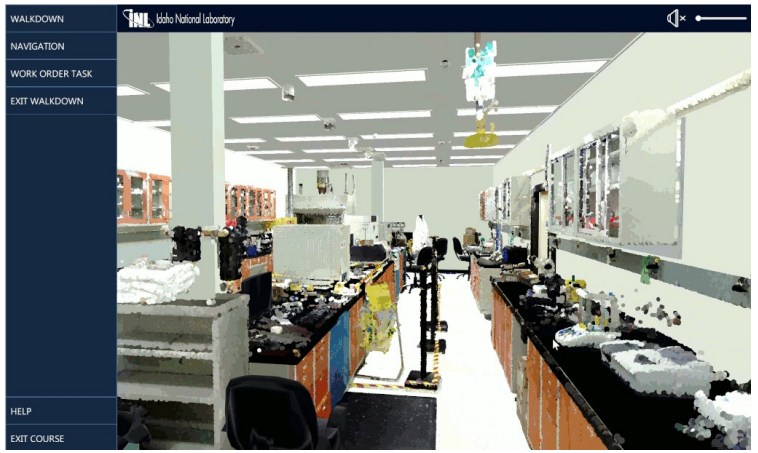
Applied Visualization Laboratory (AVL)

- Scientific visualization
- Immersive analytics
- Digital twins
- Remote collaboration
- Virtual training
- Graph visualization
- WebXR
- LiDAR









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Output Visualization Challenges

- Output results from HERON have been in the form of
  - Comma-separated value (CSV) files
  - Rudimentary visualization options
- Current visualization tools mostly used to confirm correct operation of the code for developers
- Sometimes, it takes significant time to piece through the data and comprehend outcomes
- It becomes easy to miss key interpretations when information that interacts is spread across multiple charts

Output Visualization Goals

- Create automate tools for plotting analysis results on HERON
- Transform output data into visually appealing displays
- Improve visualization results for distribution, presentations and reporting
- Provide high-quality data visualization
- Allow users to effectively comprehend and interpret outputs
  - Visualize analysis results generated from complex models
  - Identify patterns, trends, and correlation
  - Understand large amounts of information and complex relationships
- Improve usability of FORCE and HERON
- Help with decision-making
- Improve data storytelling

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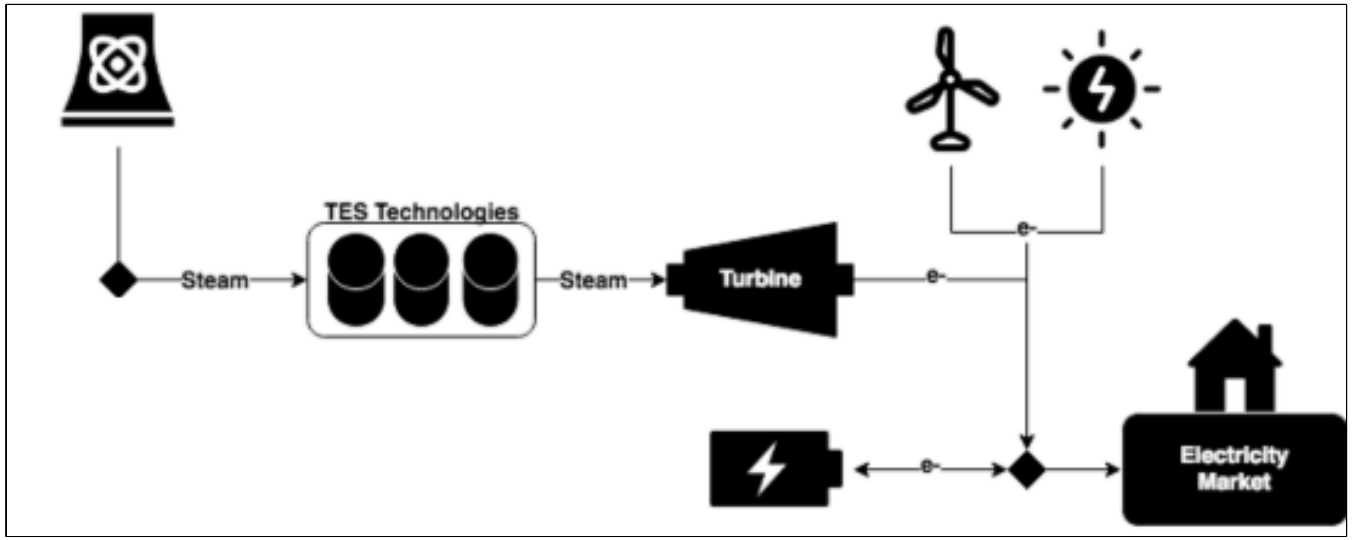
Output Visualization - Dispatching

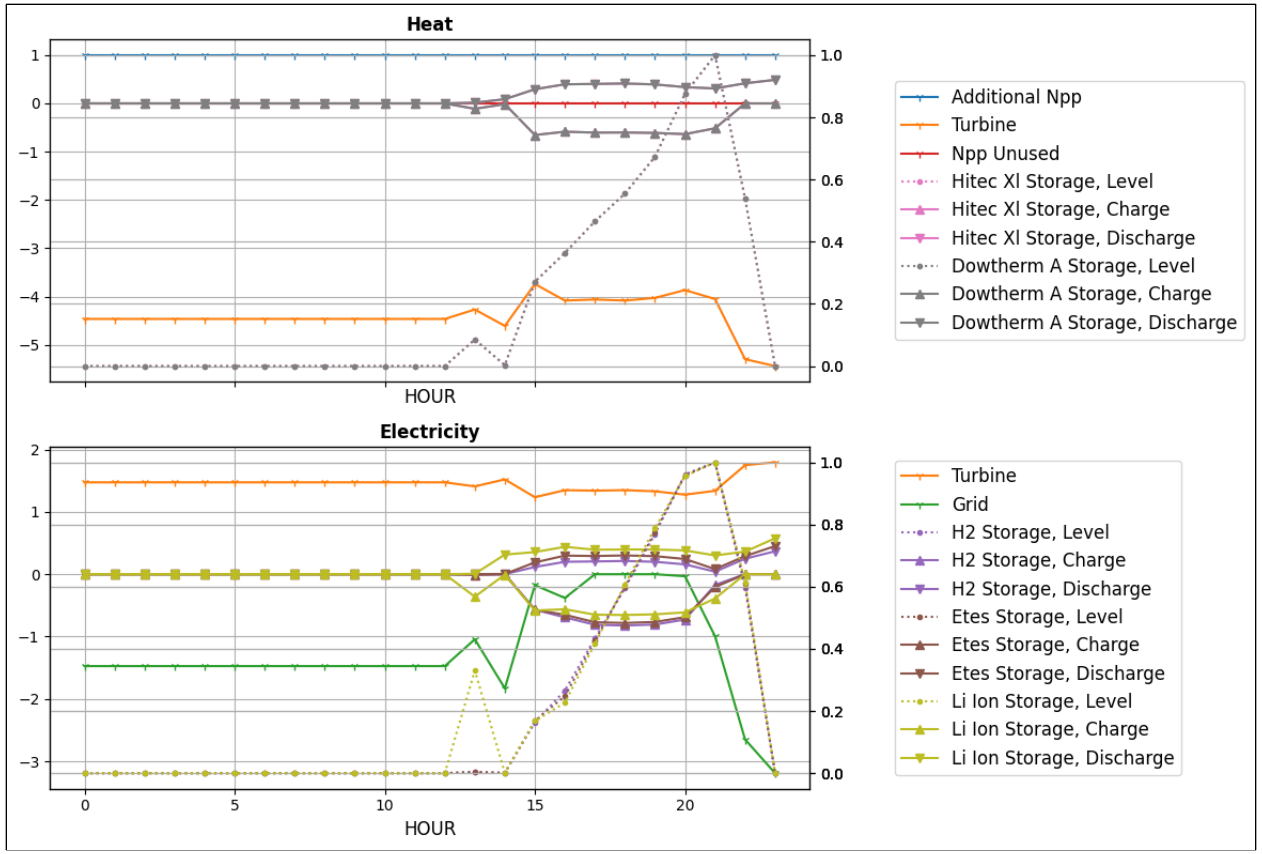
- Heron DispatchPlot.py
- FORCE use case
  - Market simulation results – dispatching
    - Existing nuclear power plant (NPP) coupled with thermal energy storage (TES) in New York Independent System Operator (NYISO) market.



(McDowell et al., 2021)

Output Visualization – Optimized Dispatching

Insight of how the model treats energy demand during specific hours of the day with dispatch optimization mechanics



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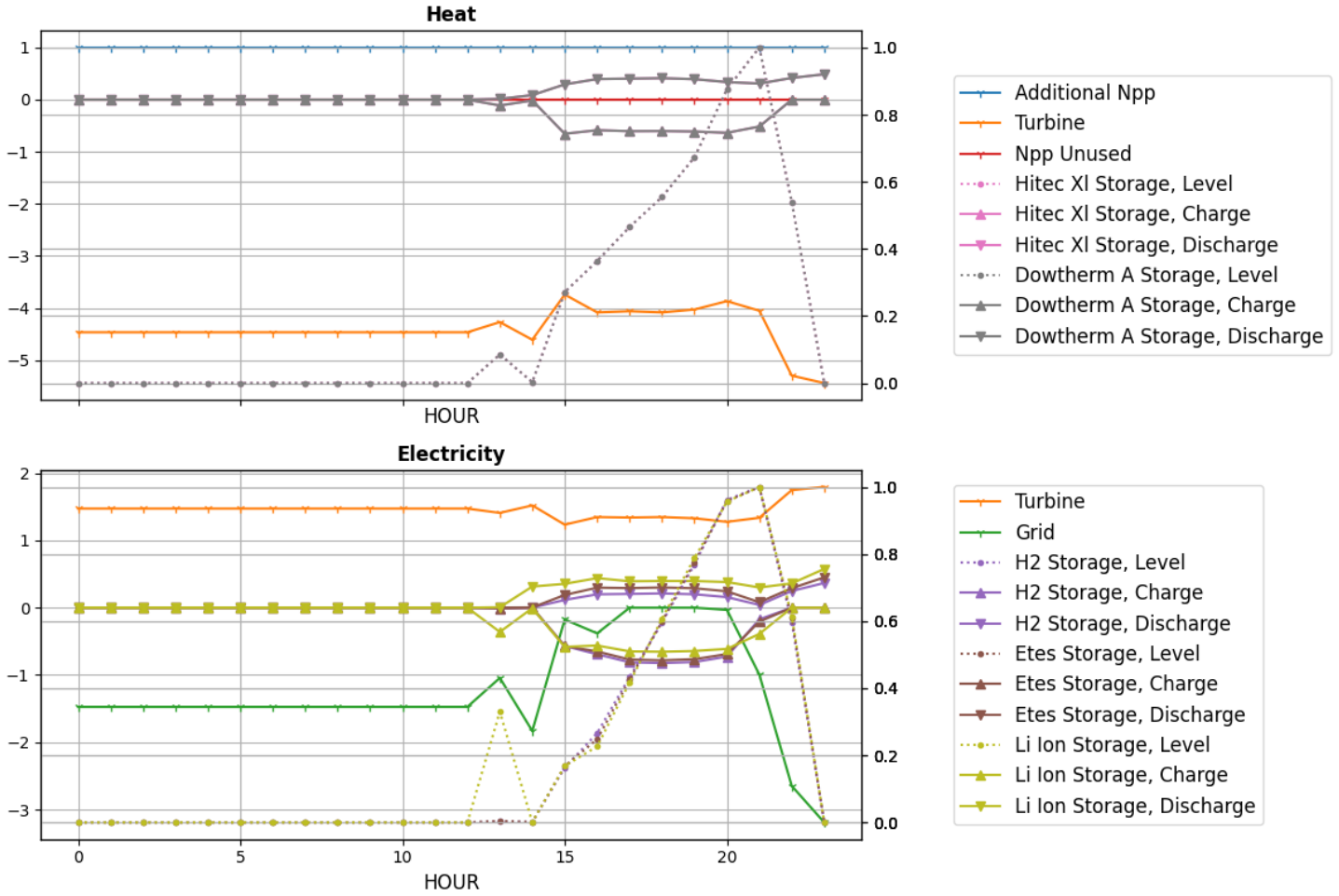
Output Visualization – Optimized Dispatching

When is energy demand high/low?

When does Dowtherm A choose to build up storage?



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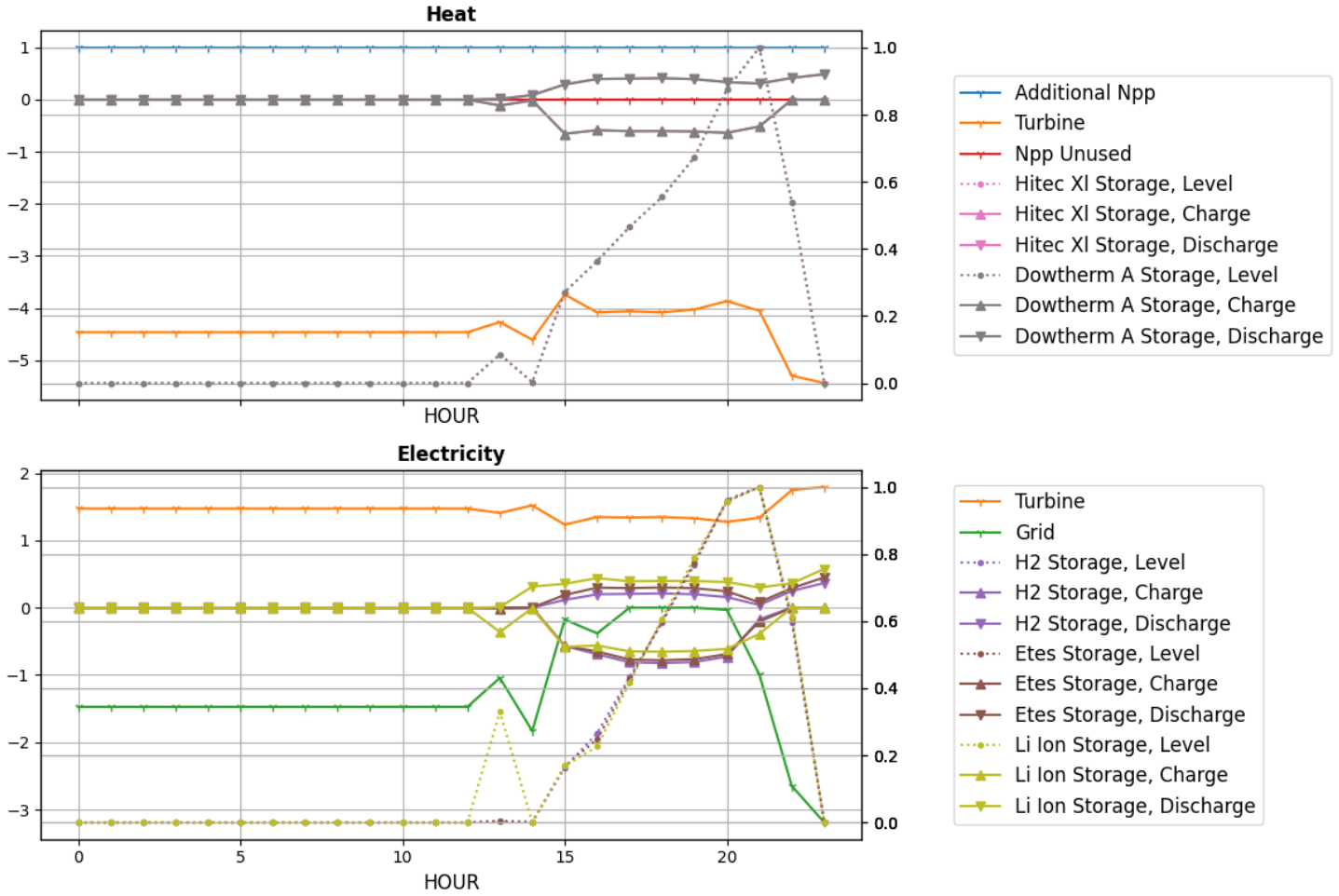
Output Visualization – Optimized Dispatching

When is energy demand high/low?

When does Dowtherm A choose to build up storage?

- Energy demand during the day
- Electricity consumed at the grid has negative values
- High electricity demand has large negative numbers
- Generation and consumption rates use the left y-axis
- Energy quantities use the right y-axis



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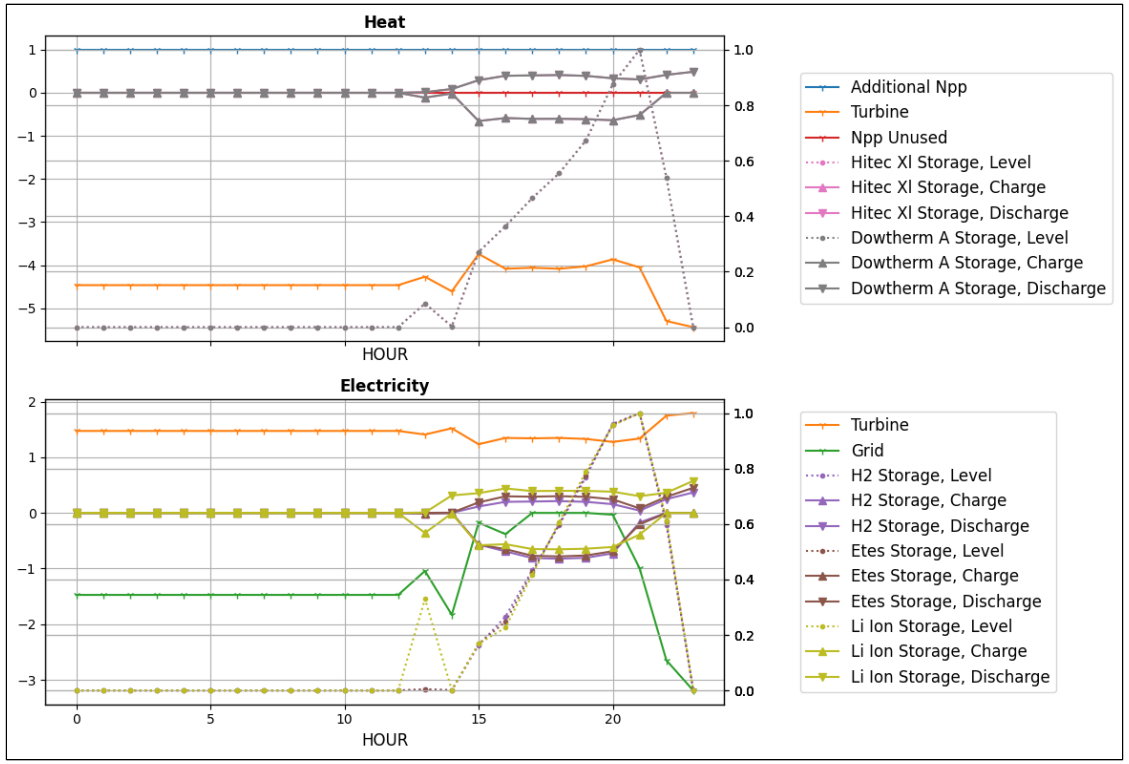
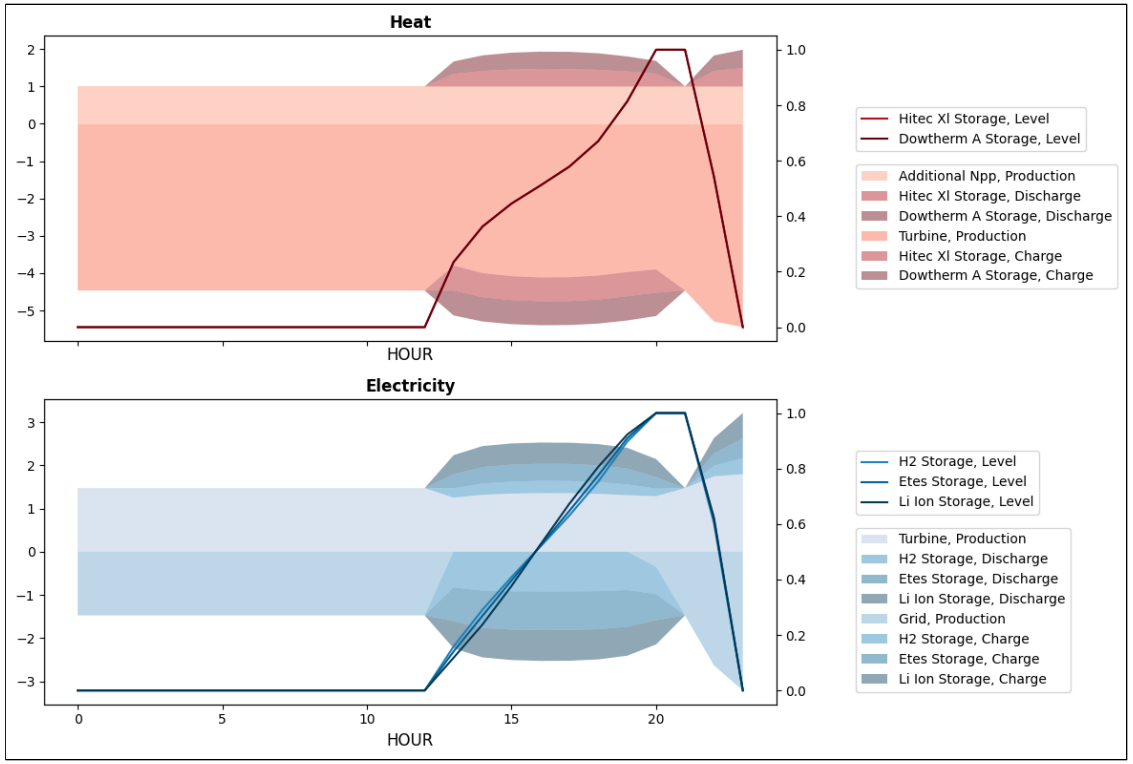
Output Visualization – Optimized Dispatching





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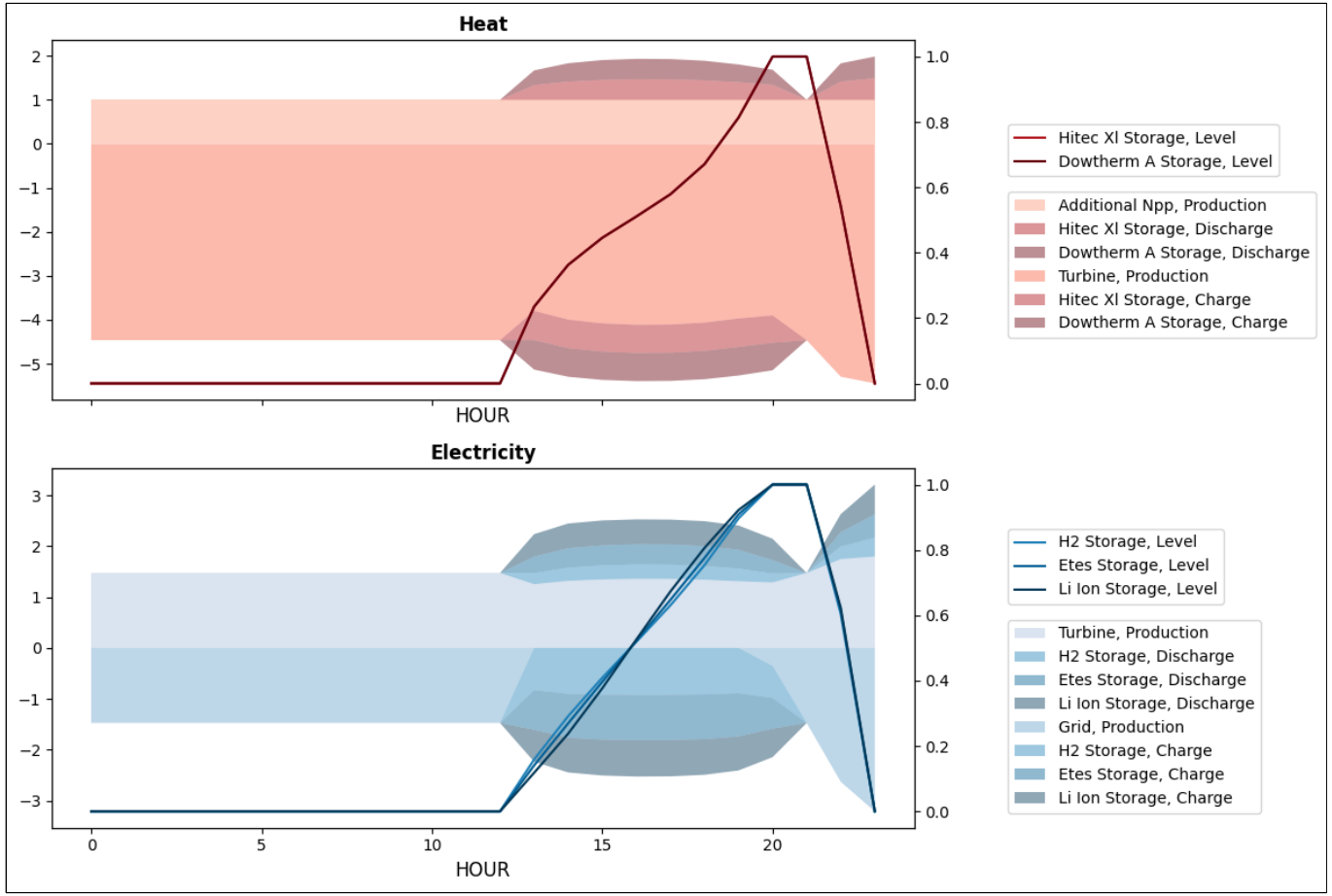

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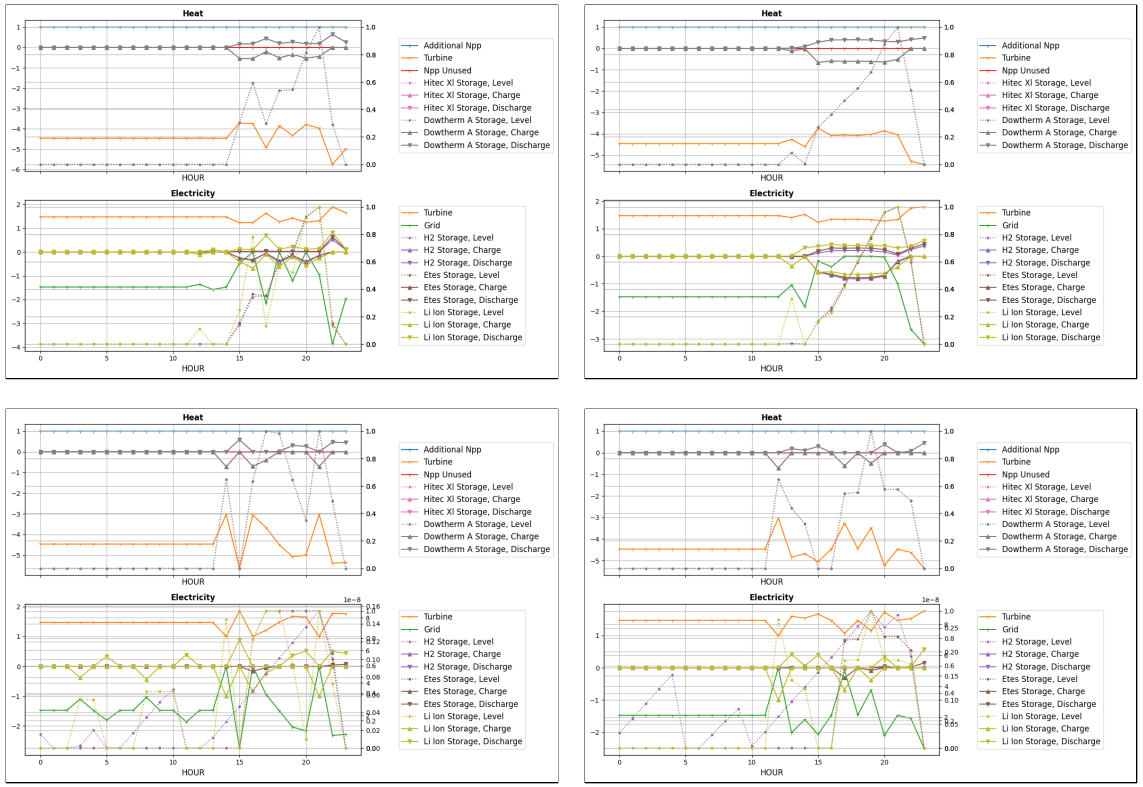
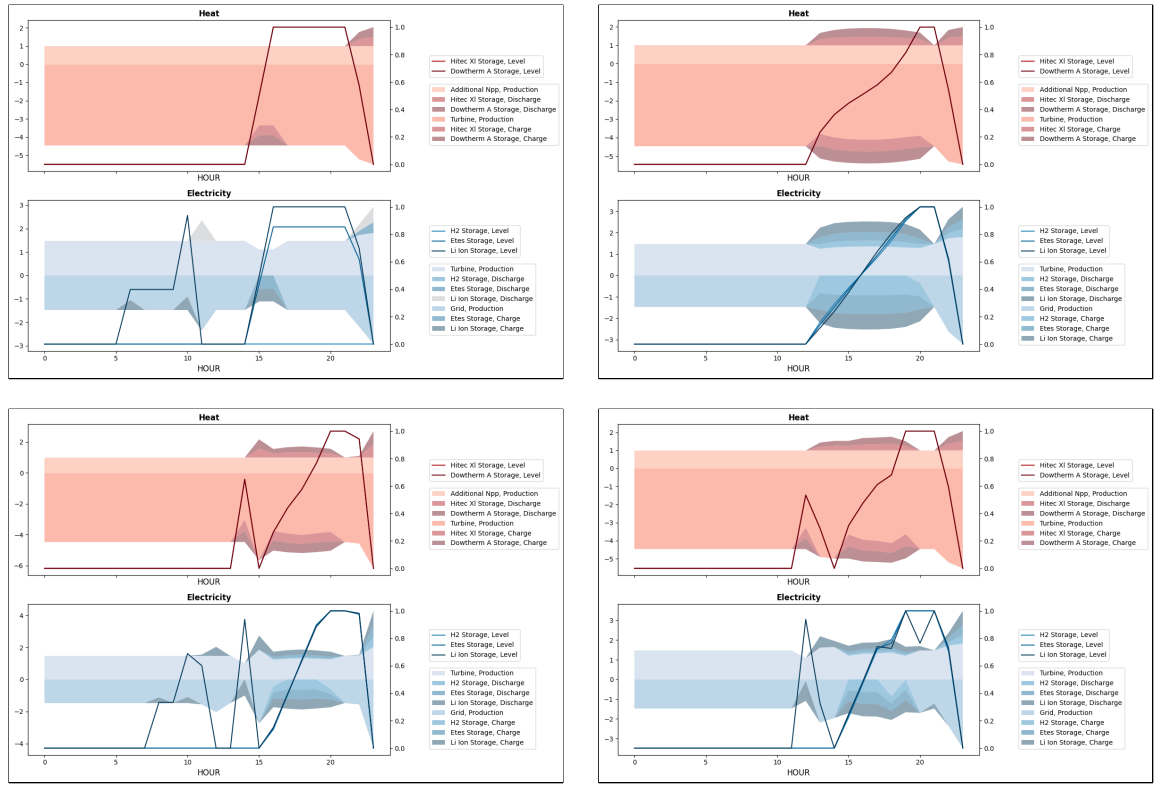




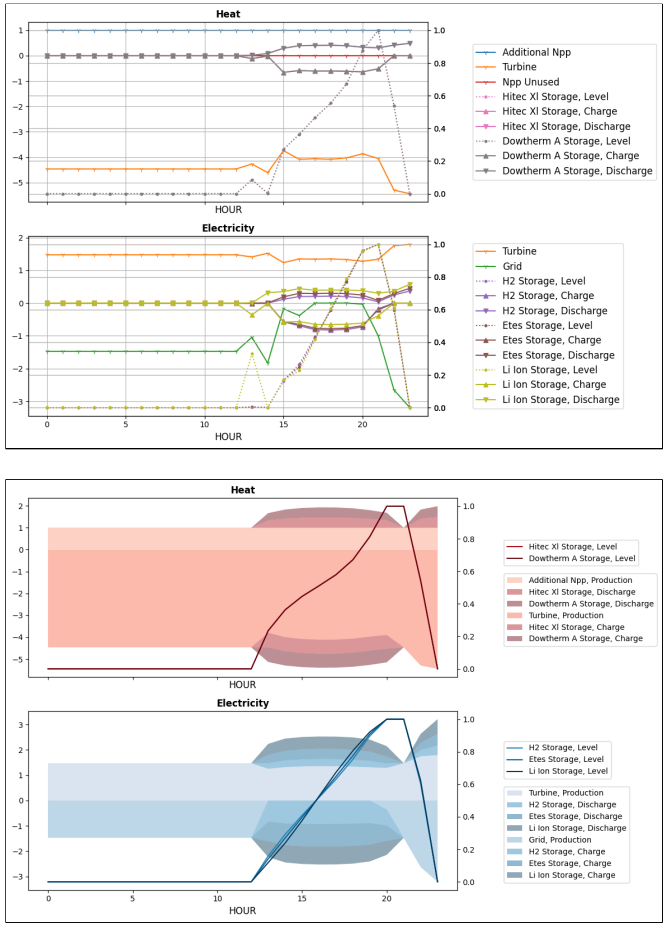
Before

After

Output Visualization – Optimized Dispatching

Technical details:

- Direct visualization output from HERON
- Matplotlib Python library
- Stack plot and line plot
- Hide technologies with consistent zero values
- Alignment of style and color choices
  - Random sequential colormap selection
  - Color matching for each technology including discharge, charge, and level



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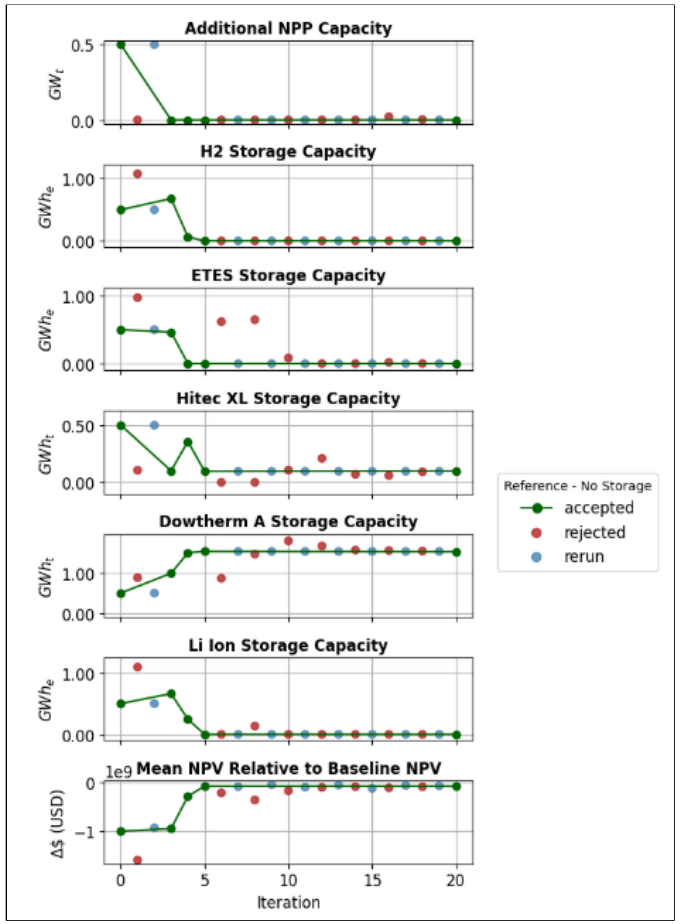
Output Visualization – Optimized System Portfolio Capacity

- FORCE use case
  - Market simulation results – optimization results
- At each iteration, HERON evaluates the expected value of the configuration's net present value (NPV) by sampling many synthetic histories and optimizing dispatch to each then decides to accept, reject, or rerun. Each of these is shown as a function of the optimization iterations.



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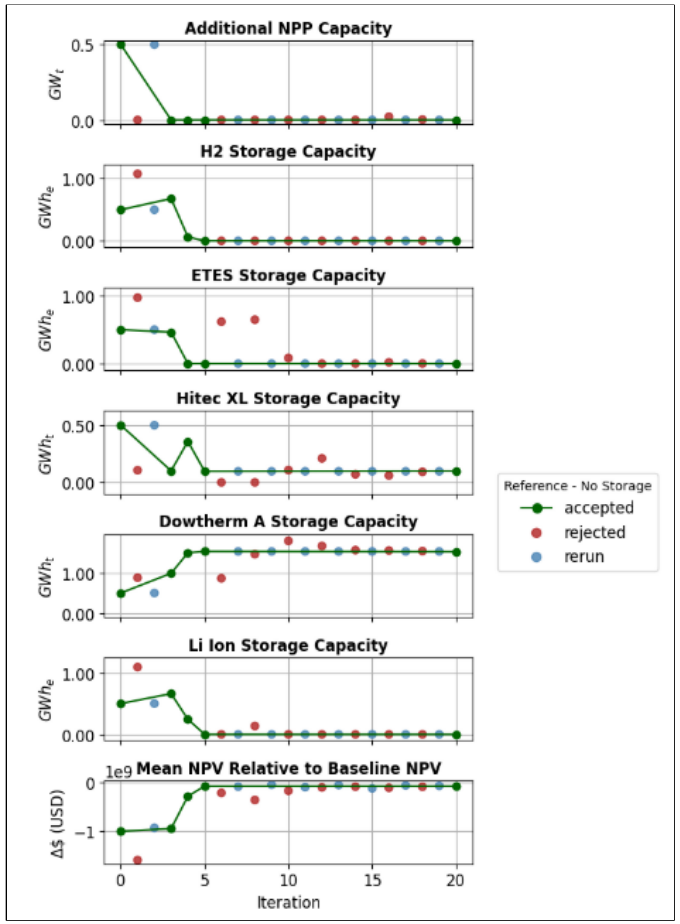
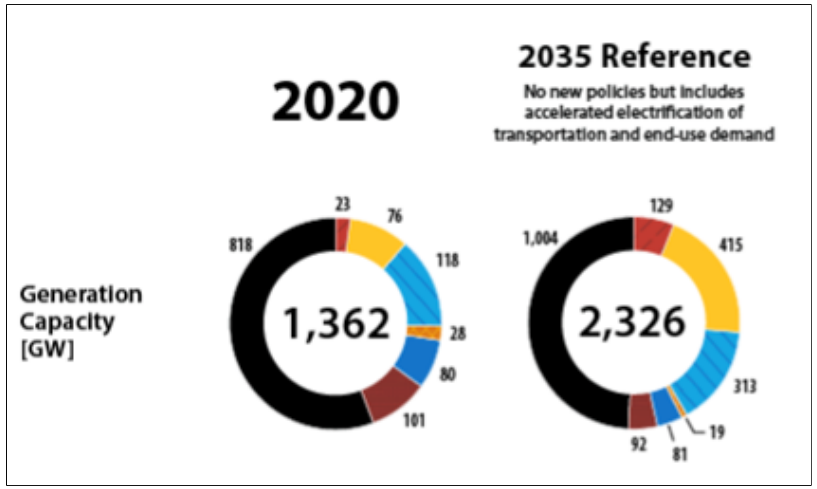
Output Visualization – Optimized System Portfolio Capacity

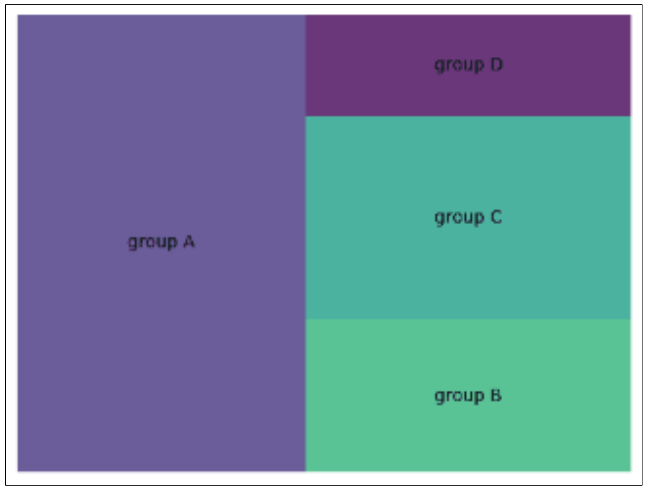
- The further right on the x-axis, the more optimal the solution.
- Current figure provides useful information for optimization developers. However, for most HERON users, it fails to clearly report the optimal component sizing with associate profitability.

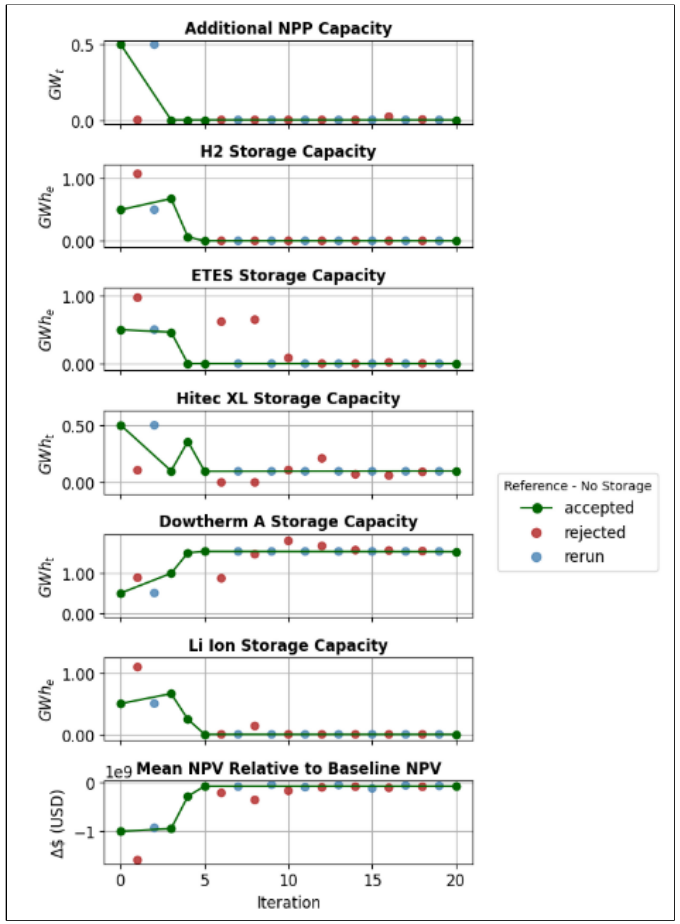


Output Visualization – Optimized System Portfolio Capacity

- Goal: Obtain the final accepted run and communicate the contributions of energy types to total generation capacity.
- Solutions: donut plot or tree map







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- McDowell, Dylan James, Talbot, Paul W., Wrobel, Anna Marie, Frick, Konor L., Bryan, Haydn C., Boyer, Chad, Boardman, Richard D., Taber, John, and Hansen, Jason K.. A Technical and Economic Assessment of LWR Flexible Operation for Generation and Demand Balancing to Optimize Plant Revenue. United States: N. p., 2021. Web. doi:10.2172/1844211.
- Talbot, Paul, McDowell, Dylan James, Woods, Nathan, Yang, Xingyue, Koudelka, John, Ephiney, Aaron. Data Visualization Update Plan for FORCE, FY 23. 2022.

Images:

- https://hartfordrents.com/wp-content/uploads/2020/08/pageImage-Microsoft-HoloLens.jpg
- https://encrypted-tbn0.gstatic.com/images?q=tbn:ANd9GcRb8ZkY5qAhmN1dlePiIgz3F2TmjD2RMKMoRg&usqp=CAU
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Thank You

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