Objectives: Participants will become familiar with HERON and other tools within the FORCE framework. Participants will use HERON to learn about system optimization and the financial and technical implications of different component sizes within an IES system.

Outcomes: Participants will be able to describe the benefits of integrated energy systems.

Report: Participants will describe the results from running the code and answer the accompanying discussion questions.

Assignment #1: Simple IES System

1. Complete the code using the HERON user guide and the table below:

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Type | Dispatch Type | Capacity |
| NGCC | Producer | Independent | Optimize from 10-40 GW |
| Import | Producer | Independent | Very large (100 GW) |
| Grid | Consumer | Fixed | Based on CSV input |

1. Run the HERON code in “opt mode”
   1. How many runs were required to find the optimal design?
   2. What is the optimal size of the NGCC?
   3. What is the NPV of the optimal system?
2. Change the code to “sweep mode.” Run the code to sweep over 5 NGCC capacities. One of these capacities should be the optimal value from step 2. Two capacities should be below the optimal value and 2 should be higher than the optimal value.
3. Using the results of step 3, graph the NGCC capacity (x-axis) vs. NPV (y-axis). Describe the shape of the graph and where the optimal NGCC capacity is located
   1. What does this show about the importance of optimization algorithms?
   2. What is a situation in which the optimal design might include a few MWh of expensive import throughout the year? (hint: think capital costs vs. variable costs)

Assignment #2: Full IES System

1. Complete the code using the HERON user guide and the information below.

|  |  |
| --- | --- |
| **Project Lifetime** | 3 Years |
| **Discount Rate** | 8% |
| **Tax Rate** | 30% |
| **Inflation Rate** | 6% |
| **ARMA Samples** | 25 |

|  |  |  |
| --- | --- | --- |
| **Component** | **Capital Expenditure** | **Fixed O&M** |
| Nuclear Power Plant (NPP) | $12.8M / MW |  |
| Wind Turbine | $1.3M / MW | $15,000 / MW |
| Steam Turbine | - | - |
| High Temperature Steam Electrolysis (HTSE) | $1.9M | $131,333 |
| Hydrogen Storage | $1.2M | - |

|  |  |
| --- | --- |
| **Component** | **Sales Price** |
| Energy Grid Market | $100 / MW |
| Hydrogen Market | $8 / Kg |

Diagram

Description automatically generated

1. Run the case in “sweep” mode
2. When the run completes, naviage to ///sweep.csv
   1. What system configuration provides the highest NPV?
   2. What system configuration provides the lowest NPV?
3. Modify the code to answer the following questions. Document your modifications along with the answer.
   1. How does std\_NPV change as you increase the number of samples?
   2. What configuration makes the system profitable in only 3 years?
   3. What is the NPV and most profitable system configuration for a 20-year project lifetime?
   4. What is the NPV and most profitable system configuration when a lithium battery is added for electricity storage (sweep any capacity values)
   5. What happens if you fix the dispatch of the H2 Market AND the grid?
4. IF TIME ALLOWS: run the original system configuration in “opt” mode. Choose the opt bounds based on the most profitable system configuration from step 2.

Other discussion questions:

Can a clean grid system meet demand using only wind?

What factors lead to the economic balance between clean, firm energy sources and clean, variable energy sources?

Why does the system configuration in step 2 include so many different energy sources and components? What is beneficial about this “all of the above” solution to decarbonization?