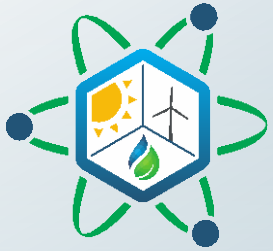

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HERON: Full IES Simulation

FORCE Overview and Training

April 4-6, 2023

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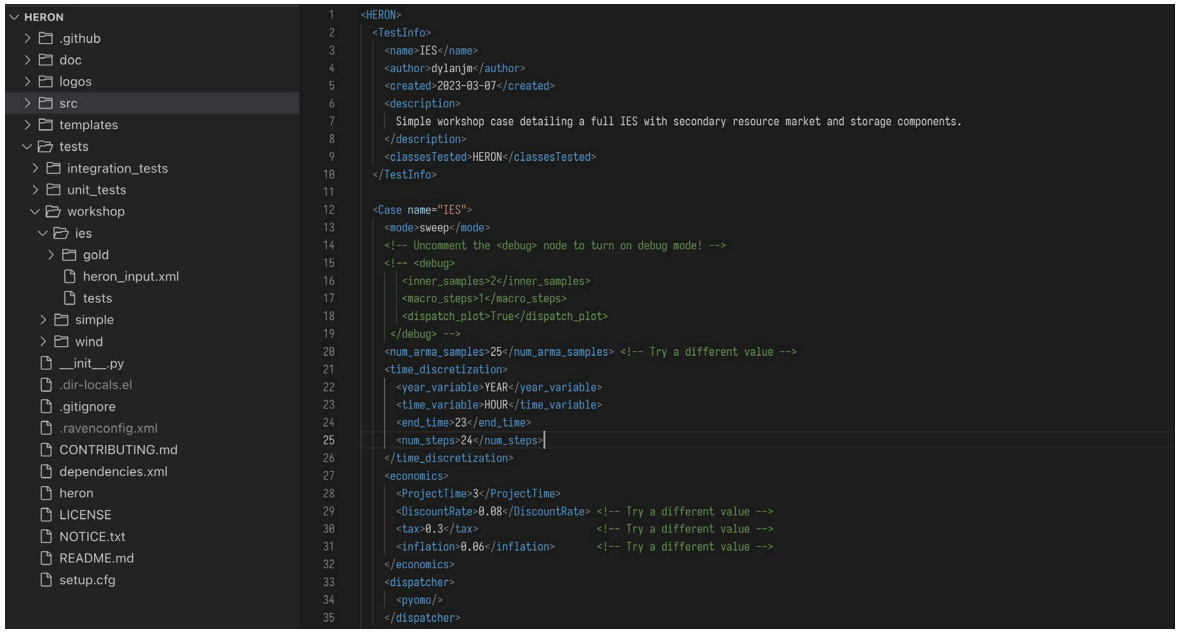
Getting Started

- Navigate into the IES workshop folder

```
~/Documents/projects/HERON  devel
λ cd tests/workshop/ies
```

- Open `heron_input.xml`
  - VSCode
  - Notepad
  - Emacs



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Shortcut Reminder

- Run the following commands to make running HERON & RAVEN easier:

```
~/Documents/projects/HERON/tests/workshop/ies  devel
λ alias heron="<PATH/TO/HERON>/heron"
```

```
~/Documents/projects/HERON/tests/workshop/ies  devel
λ alias raven="<PATH/TO/RAVEN>/raven_framework.py"
```

- Now your commands will look like this:

```
~/Documents/projects/HERON/tests/workshop/ies  devel
λ heron heron_input.xml
```

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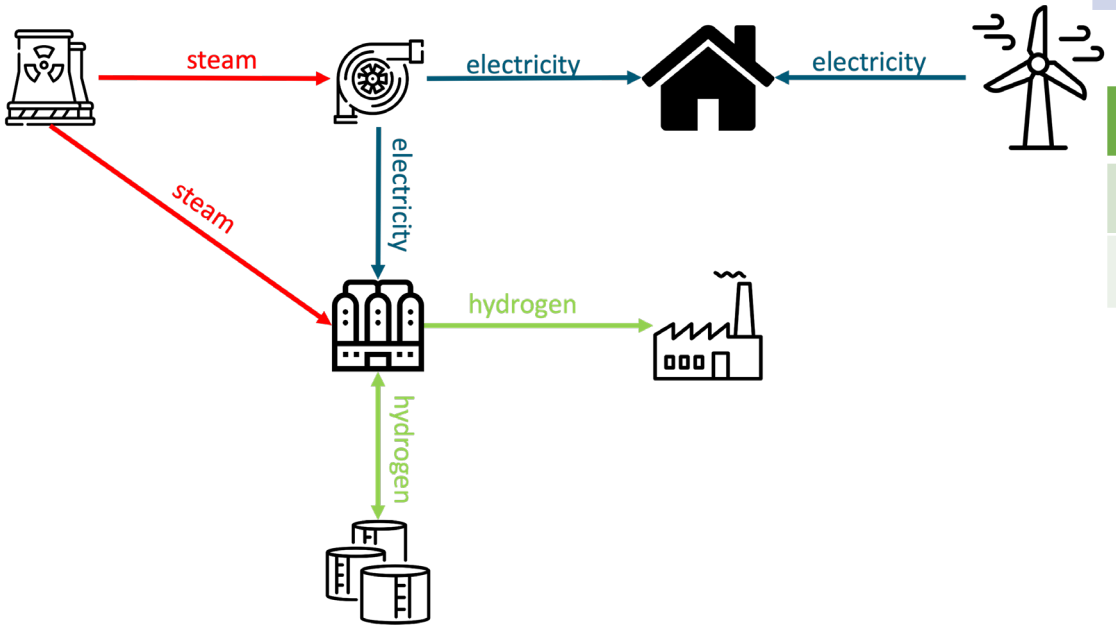
System Configuration & Case Information

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



images: Flaticon.com

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

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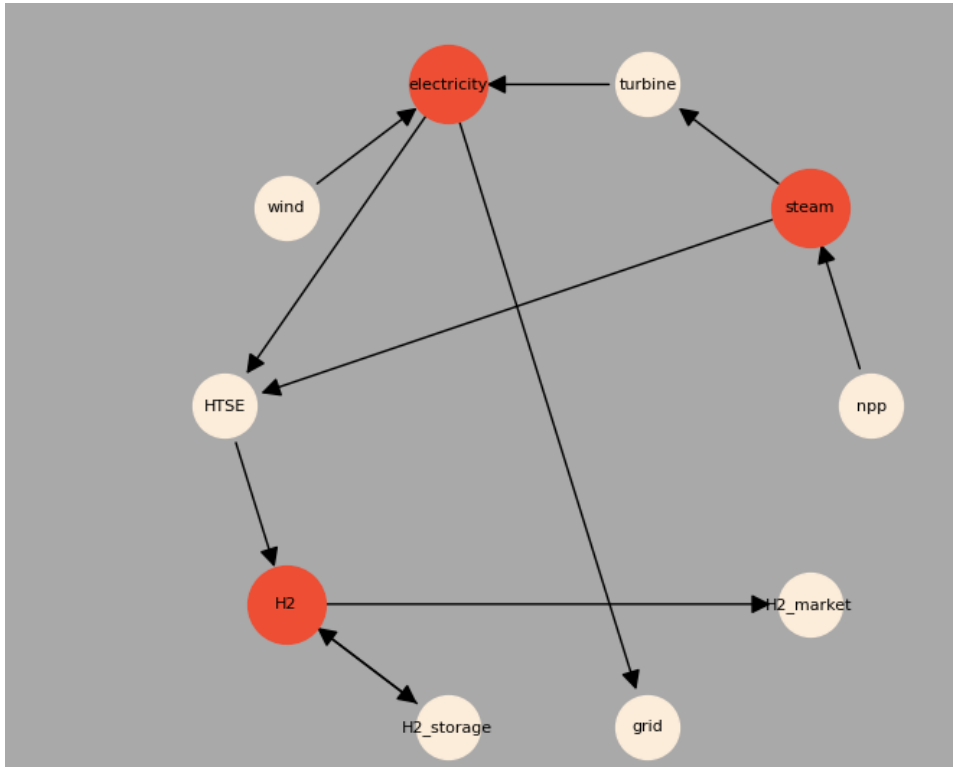
Debug Mode

```
<!-- Uncomment the <debug> node to turn on debug mode! -->
<debug>
  <inner_samples>5</inner_samples>
  <macro_steps>1</macro_steps>
  <dispatch_plot>True</dispatch_plot>
</debug>
```

```
Permissions Size User   Date Changed     Name
drwxr-xr-x     - mcdodj 2023-03-28 10:50 gold
.rw-r--r--  9.7k mcdodj 2023-03-28 11:01 heron.lib
.rw-r--r--  7.1k mcdodj 2023-03-28 11:00 heron_input.xml
.rw-r--r--  8.6k mcdodj 2023-03-28 11:01 inner.xml
.rw-r--r--   63k mcdodj 2023-03-28 11:01 network.png
.rw-r--r--  5.1k mcdodj 2023-03-28 11:01 outer.xml
.rw-r--r--   236 mcdodj 2023-03-28 10:50 tests
.rw-r--r--   917 mcdodj 2023-03-28 11:01 write_inner.py
```

```
~/Documents/projects/HERON/tests/workshop/ies
λ heron heron_input.xml
```

```
~/Documents/projects/HERON/tests/workshop/ies
λ raven outer.xml
```



	Dispatchable?	Governed?
npp	independent	False
turbine	independent	False
wind	independent	False
HTSE	independent	False
H2_storage	independent	False
grid	independent	False
H2_market	fixed	False

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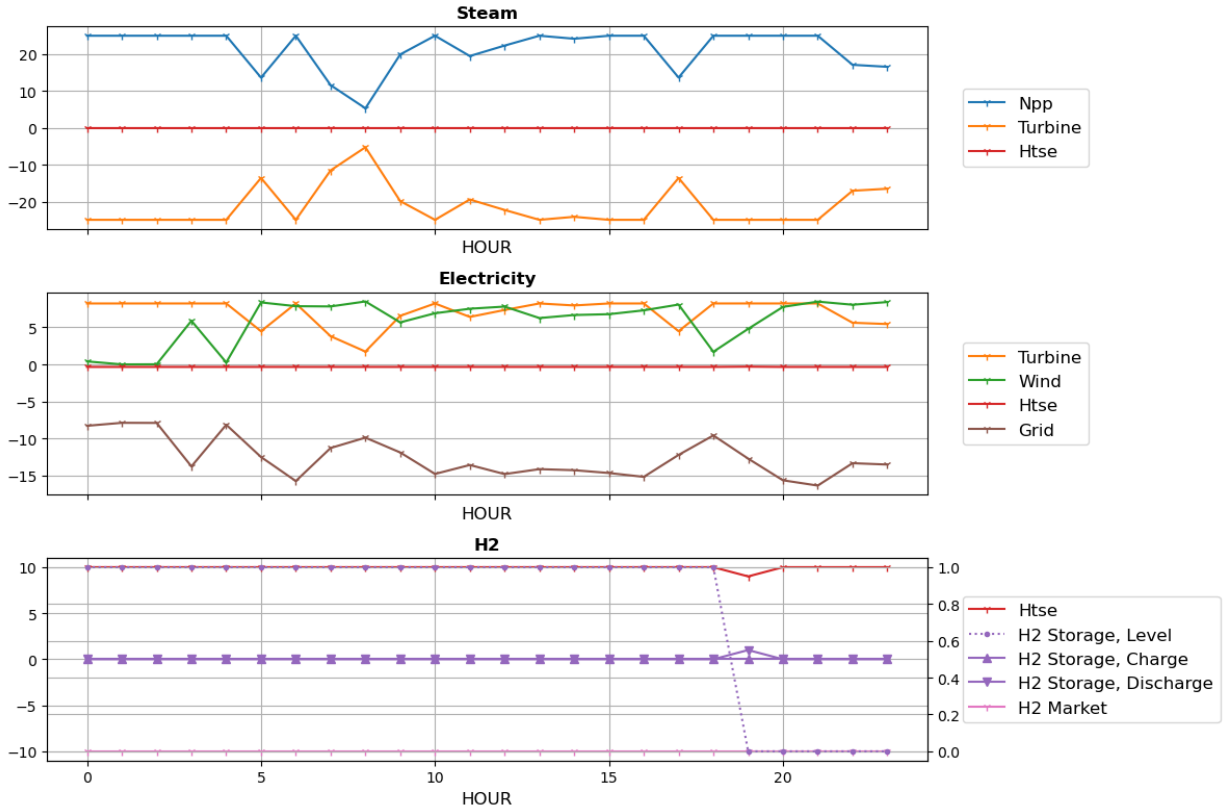
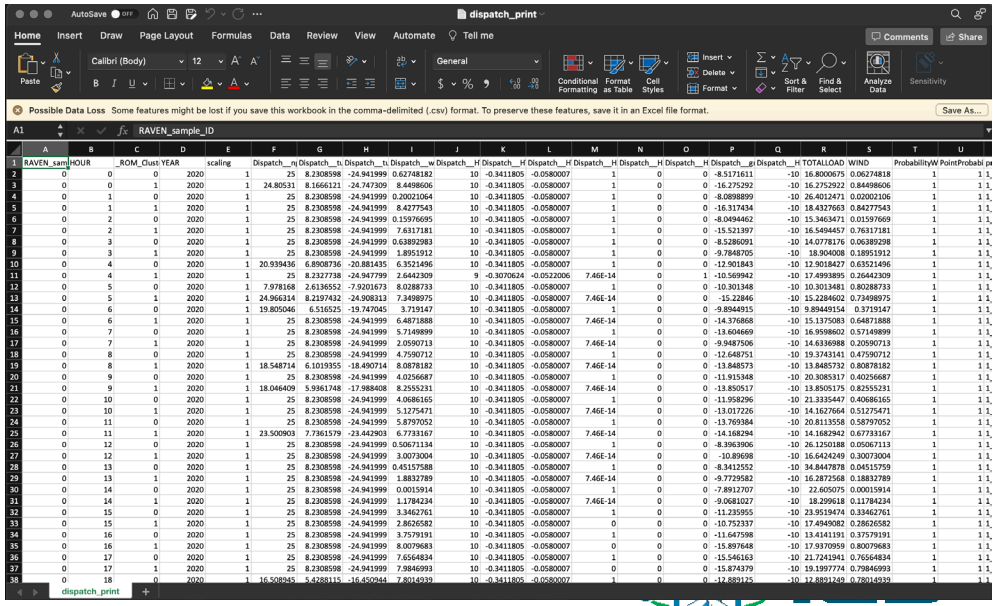
Debug Mode Continued…

```
~/Documents/projects/HERON/tests/workshop/ies  devel
λ cd IES_o
```



Permissions	Size	User	Date Changed	Name
drwxr-xr-x	-	mcdodj	2023-03-28 11:03	debug
.rw-r--r--	7	mcdodj	2023-03-28 11:03	.ravenStatus
.rw-r--r--	10k	mcdodj	2023-03-28 11:03	dispatch.nc
.rw-r--r--	96k	mcdodj	2023-03-28 11:03	dispatch_id0_y2020_c0.png
.rw-r--r--	69k	mcdodj	2023-03-28 11:03	dispatch_id0_y2020_c0_SIGNAL.png
.rw-r--r--	94k	mcdodj	2023-03-28 11:03	dispatch_id0_y2020_c1.png
.rw-r--r--	83k	mcdodj	2023-03-28 11:03	dispatch_id0_y2020_c1_SIGNAL.png
.rw-r--r--	100k	mcdodj	2023-03-28 11:03	dispatch_id1_y2020_c0.png
.rw-r--r--	74k	mcdodj	2023-03-28 11:03	dispatch_id1_y2020_c0_SIGNAL.png
.rw-r--r--	84k	mcdodj	2023-03-28 11:03	dispatch_id1_y2020_c1.png
.rw-r--r--	75k	mcdodj	2023-03-28 11:03	dispatch_id1_y2020_c1_SIGNAL.png
.rw-r--r--	16k	mcdodj	2023-03-28 11:03	dispatch_print.csv
.rw-r--r--	2.2k	mcdodj	2023-03-28 11:03	dispatch_print.xml



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Sweep Run

- Now let's go ahead and run an entire sweep case:

```
~/Documents/projects/HERON/tests/workshop/ies  devel
λ heron heron_input.xml
```

```
~/Documents/projects/HERON/tests/workshop/ies  devel
λ raven outer.xml
```

```
(  418.97 sec) CODE MODEL              : Message         -> Execution command submitted: python /Users/mcdodj/Documents/projects/raven/raven_framework.py inner.xml
(  437.16 sec) STEP MULTIRUN           : Message         -> ***       Run finished       ***
(  437.16 sec) STEP MULTIRUN           : Message         -> ***     Closing the step     ***
(  437.16 sec) STEP MULTIRUN           : Message         -> ***       Step closed        ***
(  437.16 sec) SIMULATION              : Message         -> -- End step sweep of type: MultiRun --

(  437.16 sec) SIMULATION              : Message         -> Run complete!
```

Sweep Run Continued…

- There should now be a `sweep.csv` inside of `IES_o/`

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	npp_capacity	turbine_capa	wind_capaci	HTSE_capaci	H2_storage_	H2_market_(	mean_NPV	std_NPV	med_NPV	max_NPV	min_NPV	perc_5_NPV	perc_95_NPV	samp_NPV	var_NPV
2	25	40	5	10	0	-10	-226753980	23771.1369	-226750342	-226707954	-226812328	-226799543	-226719118	25	565066949
3	25	40	10	10	0	-10	-228165877	136243.553	-228129119	-227935358	-228461839	-228378687	-227969718	25	1.8562E+10
4	50	40	5	10	0	-10	-441760262	174335.638	-441734759	-441384270	-442064106	-442023151	-441517080	25	3.0393E+10
5	50	40	10	10	0	-10	-445854823	250466.567	-445848414	-445324539	-446302829	-446157219	-445444834	25	6.2734E+10
6	25	40	5	15	0	-10	-234560936	28521.7183	-234557659	-234490299	-234601148	-234596946	-234512985	25	813488415
7	25	40	10	15	0	-10	-235974460	139603.922	-235980976	-235720473	-236205044	-236173875	-235743096	25	1.9489E+10
8	50	40	5	15	0	-10	-449559219	185407.814	-449566199	-449102024	-449889406	-449780788	-449238432	25	3.4376E+10
9	50	40	10	15	0	-10	-453609275	208060.405	-453632154	-453088670	-453942393	-453840080	-453278836	25	4.3289E+10
10	25	40	5	10	5	-10	-230950829	37635.1698	-230946061	-230893771	-231020401	-231005324	-230898953	25	1416406003
11	25	40	10	10	5	-10	-232295969	153181.027	-232297841	-232002873	-232547987	-232540171	-232082372	25	2.3464E+10
12	50	40	5	10	5	-10	-445909521	146063.452	-445936691	-445600863	-446212919	-446073767	-445652560	25	2.1335E+10
13	50	40	10	10	5	-10	-450050998	213229.225	-450011928	-449603219	-450421865	-450373215	-449662950	25	4.5467E+10
14	25	40	5	15	5	-10	-238758812	35403.7066	-238751173	-238711083	-238849908	-238839055	-238713284	25	1253422443
15	25	40	10	15	5	-10	-240134056	159636.786	-240123042	-239823456	-240432720	-240358948	-239904714	25	2.5484E+10
16	50	40	5	15	5	-10	-453690449	161989.786	-453702792	-453240865	-453927520	-453926009	-453447213	25	2.6241E+10
17	50	40	10	15	5	-10	-457816857	187853.568	-457797180	-457514948	-458260619	-458105657	-457607771	25	3.5289E+10
18	25	40	5	10	8	-10	-233458535	31380.5822	-233454462	-233365695	-233503467	-233498541	-233415112	25	984740937
19	25	40	10	10	8	-10	-234834948	174517.746	-234820680	-234500053	-235148788	-235087981	-234553304	25	3.0456E+10
20	50	40	5	10	8	-10	-448419017	130541.793	-448437549	-448125122	-448583810	-448573805	-448171570	25	1.7041E+10
21	50	40	10	10	8	-10	-452523123	179531.328	-452541241	-452184488	-452903717	-452800553	-452198226	25	3.2231E+10
22	25	40	5	15	8	-10	-241276084	29182.3407	-241280142	-241217669	-241336544	-241313285	-241235011	25	851609006
23	25	40	10	15	8	-10	-242603271	187649.634	-242582595	-242282578	-242963469	-242873052	-242318005	25	3.5212E+10
24	50	40	5	15	8	-10	-456209524	153709.611	-456209827	-455858394	-456497833	-456444429	-456000052	25	2.3627E+10
25	50	40	10	15	8	-10	-460297232	190648.693	-460260425	-459944034	-460715292	-460665668	-460054293	25	3.6347E+10

- What system configuration provides the highest mean NPV?

Now it's time to play!

- What would it take to make the system profitable in only three years?
- What about a 20-year investment timeline?
  - Try replacing the 3 year synthetic history with a 20-year one:
    - The file-path: `%HERON%/tests/integration_tests/ARMA/NYISO_20yr/nyiso_arma_20yr.pk`
    - Remember to change ProjectTime
- Try adding a Lithium-Ion Battery for electricity storage
- How does `std_NPV` change as you increase the number of samples?
- What would it take to run an optimizing case?
- What happens if you fix the dispatch of the H2 Market **and** the grid?

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Hints… 20 Year Investment Horizon

```
<ProjectTime>20</ProjectTime>
```

```
<lifetime>5</lifetime>
```

- You may also want to change the lifetime nodes to last longer than 5 years:

```
<DataGenerators>
  <ARMA name='synth' variable="TOTALLOAD,WIND">%HERON%/tests/integration_tests/ARMA/NYISO_20yr/nyiso_arma_20yr.pk</ARMA>
</DataGenerators>
```

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Hints… Adding Lithium-Ion Battery

- Start by copying the H2 Storage Node and then modifying as necessary

```
<Component name="LI_ION_Battery">
  <stores resource="electricity" dispatch="independent">
    <capacity resource="electricity">
      <sweep_values debug_value="5">0, 5, 8</sweep_values> <!-- MW -->
    </capacity>
    <initial_stored>
      <fixed_value>0.0</fixed_value> <!-- Try a different value -->
    </initial_stored>
    <RTE>0.9</RTE>
  </stores>
  <economics>
    <lifetime>5</lifetime>
    <CashFlow name="capex" type="one-time" taxable="True" inflation="none" mult_target="False">
      <driver>
        <variable>LI_ION_Battery_capacity</variable>
      </driver>
      <reference_price>
        <fixed_value>-900_000.00</fixed_value> <!-- Try a different value -->
      </reference_price>
    </CashFlow>
  </economics>
</Component>
```

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Hints… Optimization Runs

```
<mode>opt</mode>
```

```
<sweep_values debug_value="25">25, 50</sweep_values> <!-- MW -->
```

Change all sweep_values to opt_bounds

```
<opt_bounds debug_value="25">25, 50</opt_bounds> <!-- MW -->
```

Note: This may take a long time to run!

To see pre-run optimization results, look in: `gold/IES_o/opt_soln_0.csv`

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Hints… Fixing Grid Dispatch

```
<Component name="grid">
  <demands resource="electricity" dispatch="fixed">
    <capacity>
      <ARMA variable="TOTALLOAD">synth</ARMA>
      <multiplier>-1</multiplier>
    </capacity>
  </demands>
```

```
(    0.08 sec) CODE MODEL              : Message         -> job "1" submitted!
(    0.08 sec) STEP MULTIRUN           : Message         -> ***    Initialization done    ***
(    0.08 sec) STEP MULTIRUN           : Message         -> ***       Beginning run       ***
(           ) UTILS                    : Message         -> importing module /Users/mcdodj/Documents/projects/HERON/tests/workshop/ies/write_inner.py
current working dir /Users/mcdodj/Documents/projects/HERON/tests/workshop/ies/IES_o/sweep/1/IES_i
already exists, this might imply deletion of present files
(    0.11 sec) CODE MODEL              : Message         -> Execution command submitted: python /Users/mcdodj/Documents/projects/raven/raven_framework.py inner.xml
(    8.57 sec) CODE MODEL              : Message         -> ************************************************
(    8.57 sec) CODE MODEL              : Message         ->  Process Failed python /Users/mcdodj/Documents/projects/raven/raven_framework.py inner.xml  returnCode 1
(    8.57 sec) CODE MODEL              : Message         -> Ouput is in "/Users/mcdodj/Documents/projects/HERON/tests/workshop/ies/IES_o/sweep/1/out~inner"
(    8.57 sec) CODE MODEL              : Message         -> ************************************************
```

```
Traceback (most recent call last):
          File "/Users/mcdodj/Documents/projects/raven/ravenframework/Models/EnsembleModel.py", line 744, in __advanceModel
            evaluation = modelToExecute['Instance'].evaluateSample.original_function(modelToExecute['Instance'], origInputList, samplerType, inputKwargs)
          File "/Users/mcdodj/Documents/projects/raven/ravenframework/Models/ExternalModel.py", line 324, in evaluateSample
            result,instSelf = self._externalRun(inRun,)
          File "/Users/mcdodj/Documents/projects/raven/ravenframework/Models/ExternalModel.py", line 266, in _externalRun
            self.sim.run(externalSelf, InputDict)
          File "/Users/mcdodj/Documents/projects/HERON/src/DispatchManager.py", line 756, in run
            dispatch, metrics = runner.run(raven_vars)
          File "/Users/mcdodj/Documents/projects/HERON/src/DispatchManager.py", line 209, in run
            all_dispatch, metrics = self._do_dispatch(meta, all_structure, project_life, interp_years, segs, seg_type)
          File "/Users/mcdodj/Documents/projects/HERON/src/DispatchManager.py", line 285, in _do_dispatch
            dispatch = self._dispatcher.dispatch(self._case, self._components, self._sources, meta)
          File "/Users/mcdodj/Documents/projects/HERON/src/dispatch/pyomo_dispatch.py", line 199, in dispatch
            subdisp = self.dispatch_window(specific_time, start_index,
          File "/Users/mcdodj/Documents/projects/HERON/src/dispatch/pyomo_dispatch.py", line 324, in dispatch_window
            raise RuntimeError(f"Solve was unsuccessful! Status: {soln.solver.status} Termination: {soln.solver.termination_condition}")
        RuntimeError: Solve was unsuccessful! Status: warning Termination: infeasible
```

Open:
`IES_o/sweep/1/out~inner`

What We Didn't Cover

- Custom Dispatching Strategies
  - Price-Taker vs. Price-Maker
- Custom User-Defined Functions
- Control Strategy for Storage
- Different HERON Workflows:
  - DISPATCHES
  - MOPED
- We are Open-Source!
  - Open an issue on repository
  - Contribute meaningful code changes

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