# Researchers Model the Economics of Energy Storage

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Flexible Plant Operation and Generation

Energy storage is an important new technology for use in energy systems. Should owners of every electrical utility invest in this technology? It depends on several factors. LWRS Program researchers at Idaho National Laboratory (INL) have developed a simulation model to help decision-makers consider the relevant factors and evaluate energy investment decisions. The model is called HERON which stands for Holistic Energy Resource Optimization Network. In December 2021, researchers released HERON 2.0 which includes an 'energy storage' component.

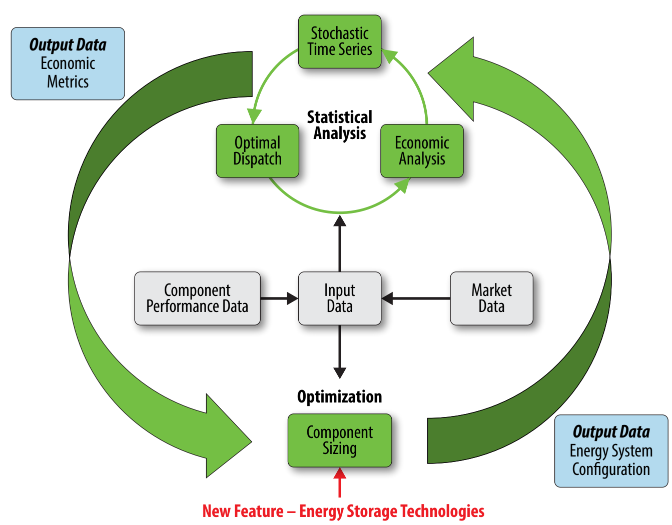
HERON 2.0 is a computational framework that takes input data, optimizes a decision, and then outputs the economic results. The input data includes cost and performance characteristics of system components and pricing data for markets where system products might be sold. An important feature of HERON 2.0 is that it represents uncertainty in pricing data based on known statistical features of the observed pricing data. Then it simulates millions of possible system configurations, looking at alternative sizes for each of the components in the system. The optimization is economic because for each iteration (i.e., possible configuration) in the simulation, the framework records the Net Present Value (NPV) revenues less costs.

Researchers set the model up to run in a comparative fashion. They define a 'with' system that contains the new technology under consideration and a 'without' system that simulates outcomes in the absence of the new technology. HERON 2.0 records the NPV from both cases to obtain what the researchers refer to as the 'Delta NPV,' or the computed profitability difference of the two cases. Figure 11 shows the data flow and analytical workflow that HERON 2.0 follows.

With the energy storage component added, researchers can identify which configuration of energy storage technologies optimizes the economic performance of the system. This feature can be used to answer questions such as, what size should the energy storage system be, how many units should be installed, and others. But most importantly, because HERON 2.0 represents uncertainty in the pricing data, the answers to these questions reflect market risks where the energy system, with storage included, will engage.

The researchers tested out HERON 2.0's new addition on a case study based on the electricity market in New York state (i.e., New York Independent System Operator [NYISO]). This market relies on a portfolio of energy-generating technologies, the mix of which contribute to a level of price volatility the researchers were after. They created a set of cases for analysis based on policy and projected costs of nuclear energy. The policy case reflected a representative clean energy standard and the nuclear costs were modeled under a baseline scenario and a scenario of low-cost nuclear. The modeled energy storage technologies were representative of concepts under development, and for which estimated preliminary cost and performance data were available. Figure 12 shows the stylized energy system the researchers evaluated. Excess heat from the nuclear generator is stored in one of the modeled energy storage technologies. Then later, when electricity prices rise to a level where additional sales improve profitability, the stored heat is converted to electricity for market sale. The energy system also represented battery storage for wind and solar.

***Figure 11. HERON Analysis Workflow.***



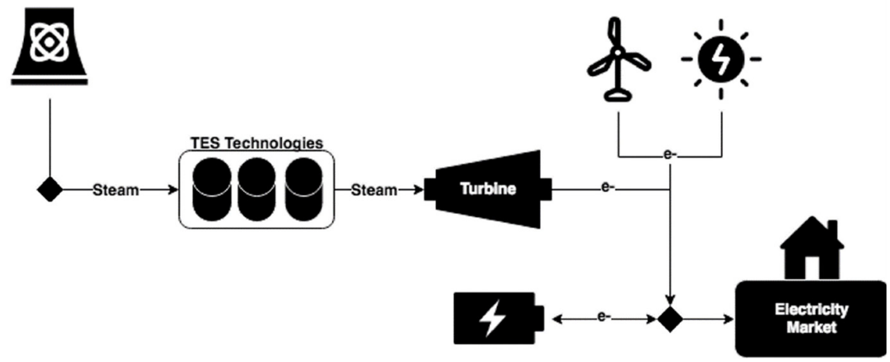



*Figure 12. Modeled Energy System in NYISO.*

Figure 13 shows an example of the output data from the scenarios evaluated in the report, "A Technical and Economic Assessment of Light Water Reactor Flexible Operation for Generation/Demand Balancing to Optimize Plant Revenue," INL/EXT-21-65443 issued in December 2021. The plots show how the model simulates the build out of a nuclear capacity under an optimized scenario. This occurs because in the example, and under economic optimization, energy storage improves the economic performance of the nuclear reactors. The plot of the economic metric, NPV, shows how the performance changes in the modeling iterations.

Notably, in the scenarios analyzed in this case study, HERON found that building out a larger nuclear and storage capacity was more profitable in scenarios that contained higher energy prices. These high-priced conditions offset the large capital expenditure costs required to construct nuclear and storage facilities. The optimal solution found under this condition indicates the importance of minimizing upfront capital expenditures while maximizing cash flow and revenues. Particularly as the United States heads into an era of rising rates and cost of capital, these metrics will hold more weight in future analyses.

HERON 2.0 simulates the size possibilities of the nuclear facility and the thermal energy storage options. It also can be set up to evaluate additional market opportunities and generation technologies of interest.

In the race to decarbonize the U.S. economy, clean, new energy technologies will be needed in energy systems. Because of the LWRS Program's research on HERON 2.0, decision-makers in the energy systems arena now can evaluate the economic performance of emerging technologies. HERON 2.0 allows for better understanding of how energy storage technologies drive economic outcomes. Those interested in adding energy storage technologies to their systems may want to consider applying HERON 2.0 in their analysis.

## Reference

1. Li, B., Talbot, P. W., McDowell, D. J., and Hansen, J. K. (2021). Release a public version of HERON (HERON 2.0) with improved algorithms for the treatment of energy storage (Vol. INL/EXT-21-65473). United States: Idaho National Laboratory.
2. McDowell, D., Wrobel, A., Talbot, P., Frick, K., Bryan, H., Hansen, J.,. Boyer, C. (2021). A Technical and Economic Assessment of LWR Flexible Operation for Generation/Demand Balancing to Optimize Plant Revenue (INL/EXT-21-65443). United States: Idaho National Laboratory.

*Figure 13. Example of Optimization Results.*