



# IES

Integrated Energy Systems

## Energy Storage Options for Future Nuclear Systems

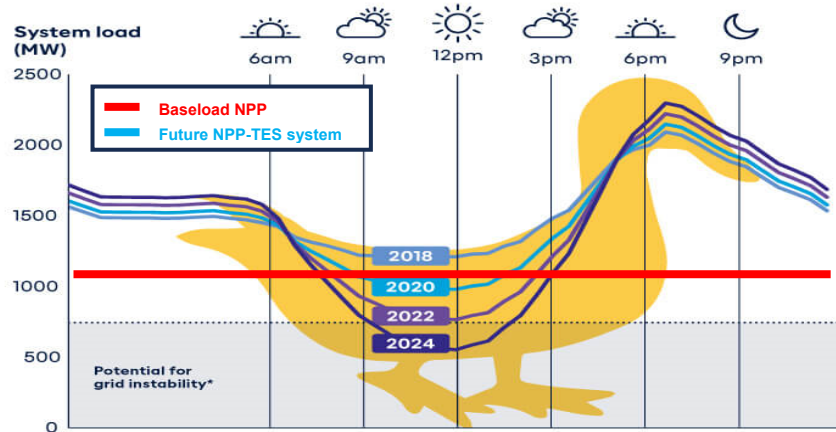
Frontiers in Energy Storage:  
Next Generation AI Workshop

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# Past and Future Role of Nuclear Energy, Role of Storage

## Duck Curve – System load changes in a day\* and Power supply from Nuclear Energy (Past and Future)



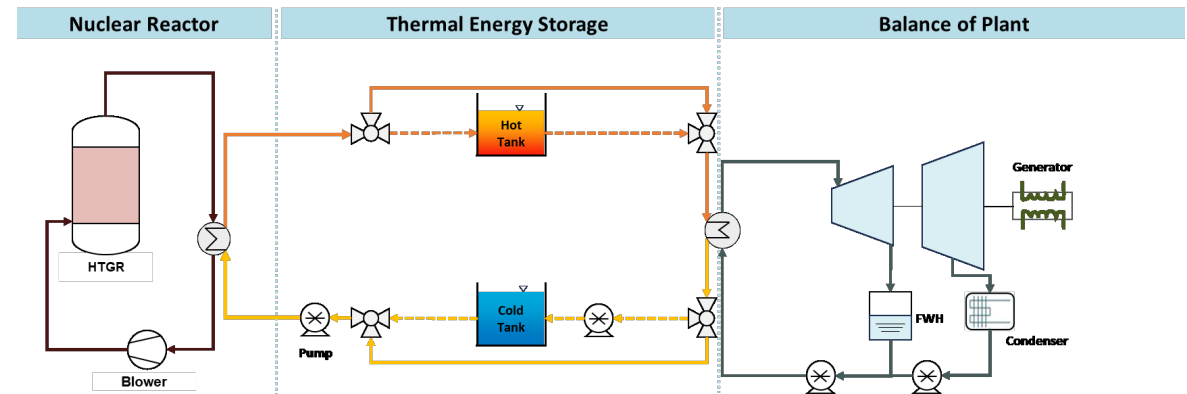
### • In the past...

- Nuclear energy functioned reliably to provide a constant baseload.
- Fossil and hydro energy were responsible for fluctuations in energy demand.

### • In the future, NPP-TES system can contribute to...

- Flexible load following complementing renewable production.
- Low carbon backbone of grid supply in prolonged deficit of renewables.
- Flexible combined heat and power supply

## Nuclear Power integrated with Thermal Energy Storage (TES)



### • Technical options

- Limitations by reactor (temperatures, steam for LWR)
- Thermodynamically best to use heat from primary loop – fully decoupled power production
- Additional el. heaters or PTES approach take advantage also of negative prices

### • Economics

- TES significantly cheaper than electrochemical storage.
- TES systems store nuclear energy in its original form (heat), allowing for solution without penalty of storage conversion efficiency.

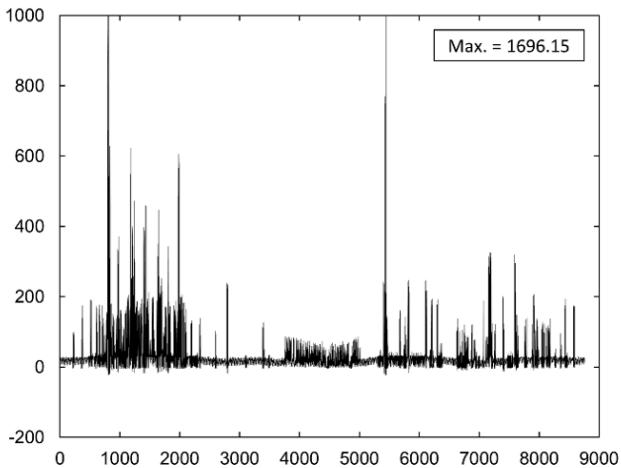
### • Flexibility

- TES enables NPPs to respond to market variability and to participate in restructured markets.

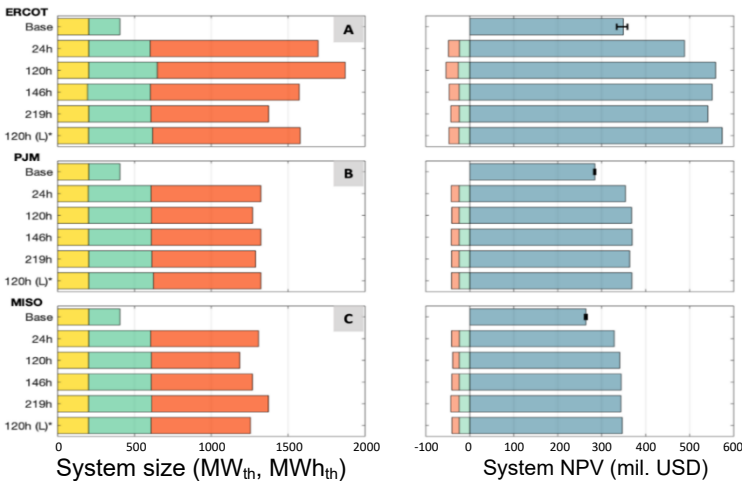
# Optimization of Configurations, Sizing and Dispatch

- **Optimization for arbitrage on electricity markets**
  - Stochastic optimization approach using synthetic price histories
  - NPV improved by 41%, 14%, and 13% for the ERCOT, PJM, and MISO markets, respectively, in comparison to nominal baseload production
  - Optimal storage size ~ 5 hours, discharge capacity ~ 2x of charging

Real time market LMPs for ERCOT's West LZ (2020)

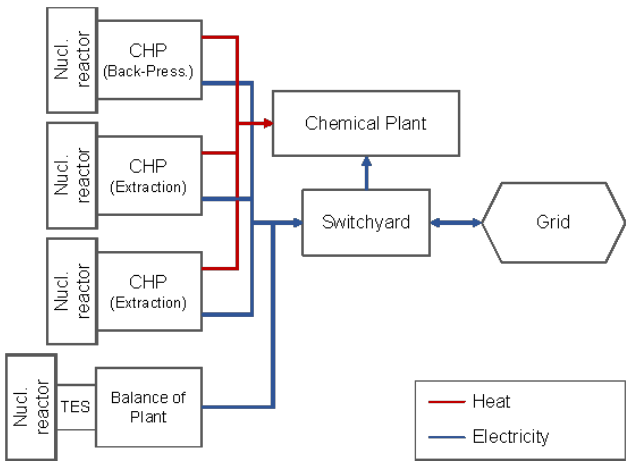


Optimized cases for the HTGR-TES coupling superset capacity (left) and NPV (right)



- **Industrial heat and power integration**
  - TES can smoothen peaks otherwise transmitted to the grid
  - Relatively small storage at single unit out of a multi-pack reactor installation might be sufficient

System configurations of nuclear and TES integration



TES state of charge (top) and work balance before and after TES integration

