IES

Integrated Energy Systems

Energy Storage Options for Future Nuclear Systems

Frontiers in Energy Storage:
Next Generation AI Workshop

16 April 2024

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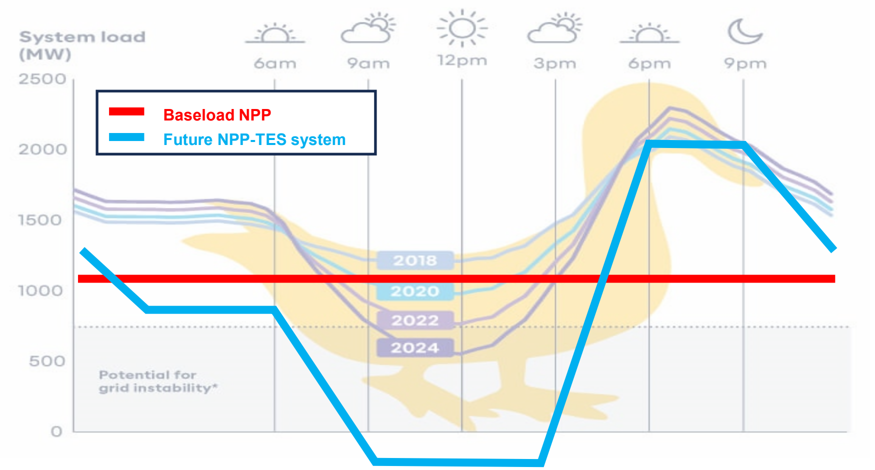
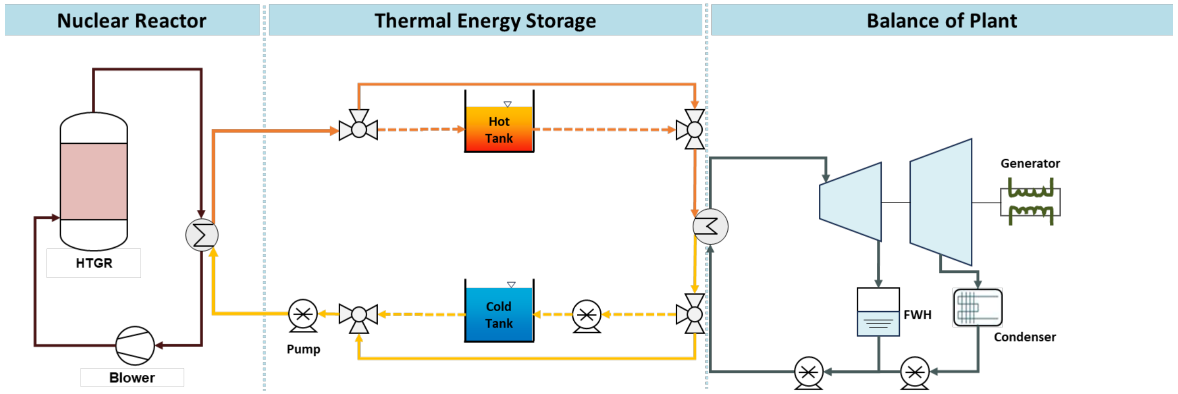
Past and Future Role of Nuclear Energy, Role of Storage

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)



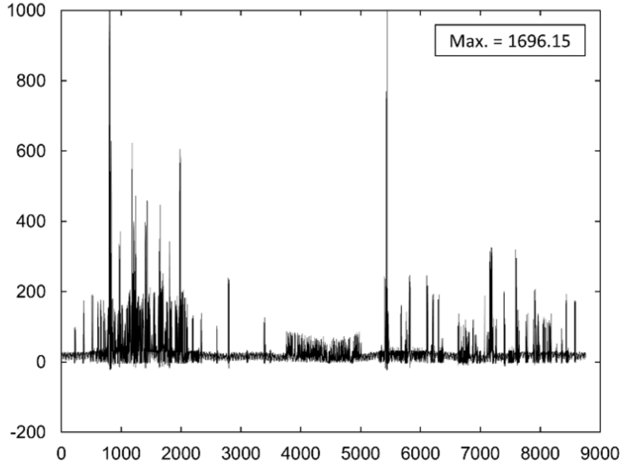
- **Technical options**
  - Limitations by reactor (temperatures, steam for LWR)
  - Thermodynamicaly best to use heat from primary loop – fully decoupled power production
  - Additional el. heaters or PTES approach take advantage also of negative prices
- **Economics**
  - TES significantly cheaper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

*Source: https://www.synergy.net.au/Blog/2021/10/Everything-you-need-to-know-about-the-Duck-Curve

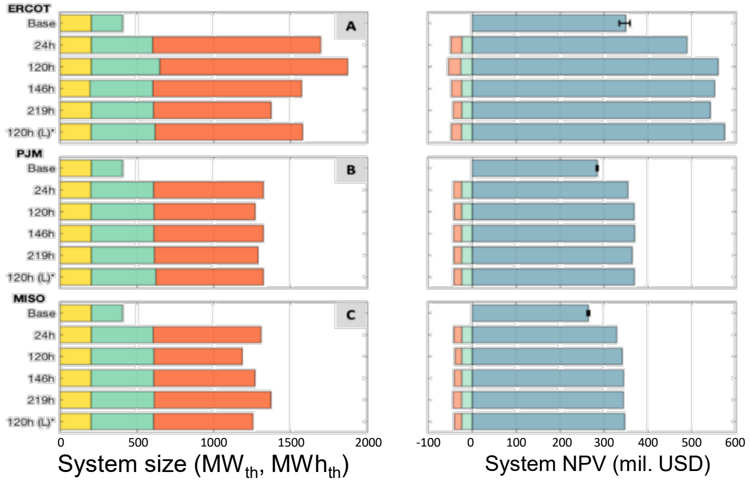
Optimization of Configurations, Sizing and Dispatch

- **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)

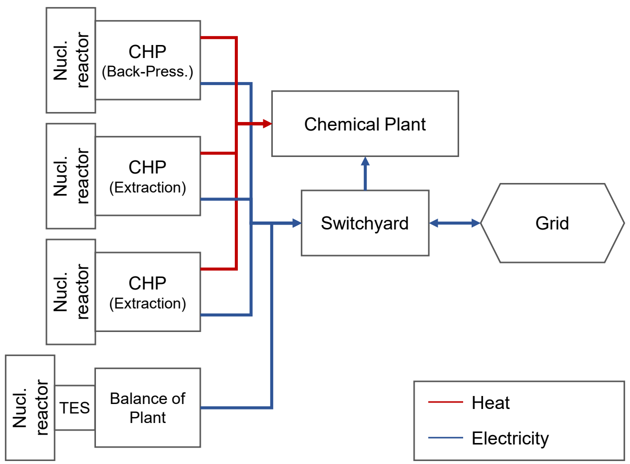


Optimized cases for the HTGR-TES coupling superset capacity (left) and NPV (right)



- **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