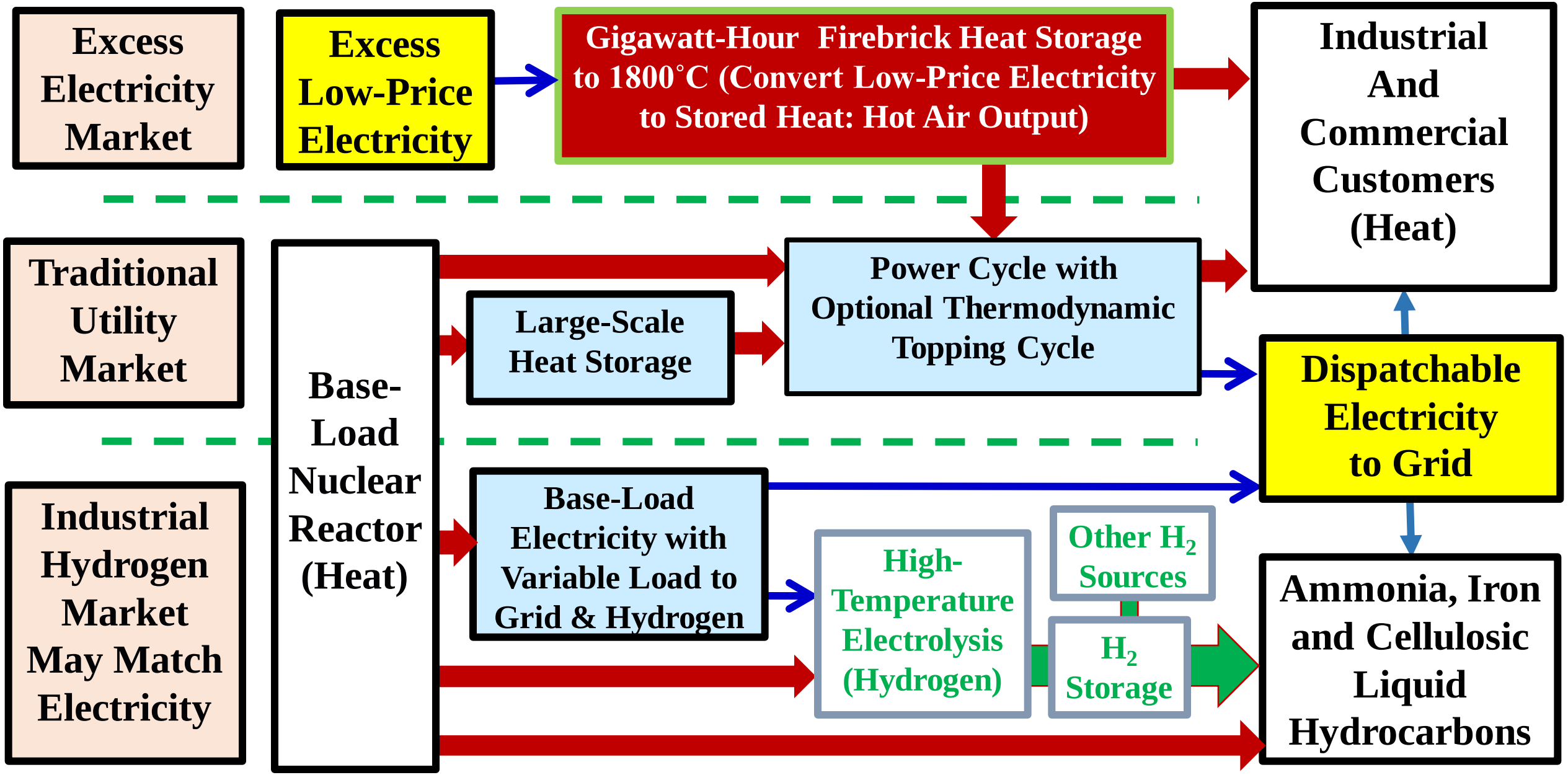
Global Base-Load Nuclear Reactors For Dispatchable Electricity, Ammonia (Fertilizer), Steel and Cellulosic Liquid Hydrocarbons (Replacing All Crude Oil)



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We define a nuclear system with only base-load reactors to supply fully disptachable electricity, replace all crude oil with cellulosic liquid hydrocarbon liquids, produce all steel without the use of coal and meet chemical plant hydrogen demand. The system has strong negative carbon emissions because of the strategy used to produce cellulosic hydrocarbon liquid fuels. The contribution of non-dispatchable wind and solar depends upon location.

- Traditional utility system (middle of figure). Power plants generate electricity for the grid. Some heat may be used for district heating or industrial systems. Nuclear plants may include heat storage so they operate at base-load with variable electricity to the grid. Nuclear plants are traditionally base-load (high-capital cost, low-operating cost). Historically fossil plants providing dispatchable electricity (lower-capital cost, higher fuel costs). Wind and solar can provide electricity but only when the sun is out and the wind is blowing.
- Low-price electricity consumption (top of figure). Large-scale wind and solar result in excess electricity production at some times. Large deployment of nuclear results in excess production capacity at some times. In each case, the fuel costs for this electricity is very low. Need method to productively use all this electricity. We show using excess electricity to heat firebrick to high temperatures—the lowest cost high-temperature heat storage material. Heat is recovered by blowing cold air though the firebrick to produce hot air—the same product as burning fossil fuels. This hot air can be used to produce electricity (including nuclear plants with thermodynamic topping cycles), industrial heat and commercial heat. This enables direct replacement of fossil fuels. If exhaust heat storage, can burn stored fossil fuels, biofuels or hydrogen to provide high-temperature heat. Cheap heat storage can set minimum price for electricity.
- Hydrogen production (bottom of figure). In a low-carbon economy, the one energy product where global production may exceed electricity production is hydrogen. This is hydrogen used in chemical processes: ammonia (fertilizer production), converting iron ore to iron replacing coke and cellulosic hydrocarbon fuel production to globally replace all crude oil. This addresses the transport market and energy storage challenge. Potential demand may exceed 750 million tons of hydrogen per year. To produce that much hydrogen would require 3200 GWe of nuclear or 2 million square miles of wind farms or converting half of global natural gas production to hydrogen with sequestration of the byproduct carbon dioxide. This assumes no hydrogen is burnt as an energy source. Electricity output can be switched from nuclear hydrogen production to the gird to provide 3200 GWe of dispatchable electricity with hydrogen from storage to maintain operation of industrial facilities.

C. Forsberg, Base-Load Nuclear Reactors for Fully Dispatchable Electricity: Nuclear Air-Brayton Combined Cycles, Firebrick Heat Storage, Hydrogen Storage and Hydrocarbon Bio-Fuels, *Energies*, 18(4) 821, 2025. https://www.mdpi.com/1996-1073/18/4/821; https://doi.org/10.3390/en18040821.