Energy storage for the grid

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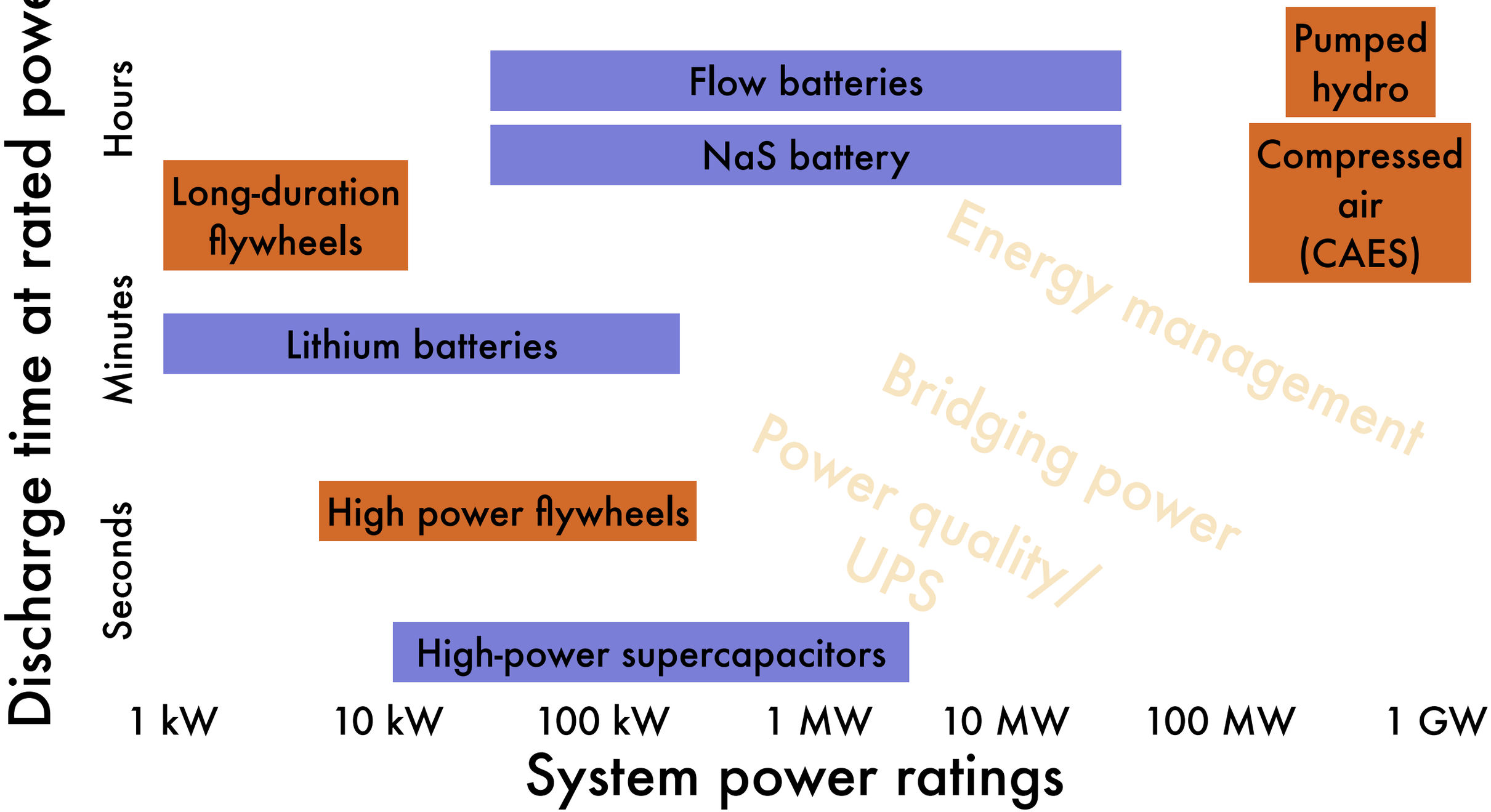
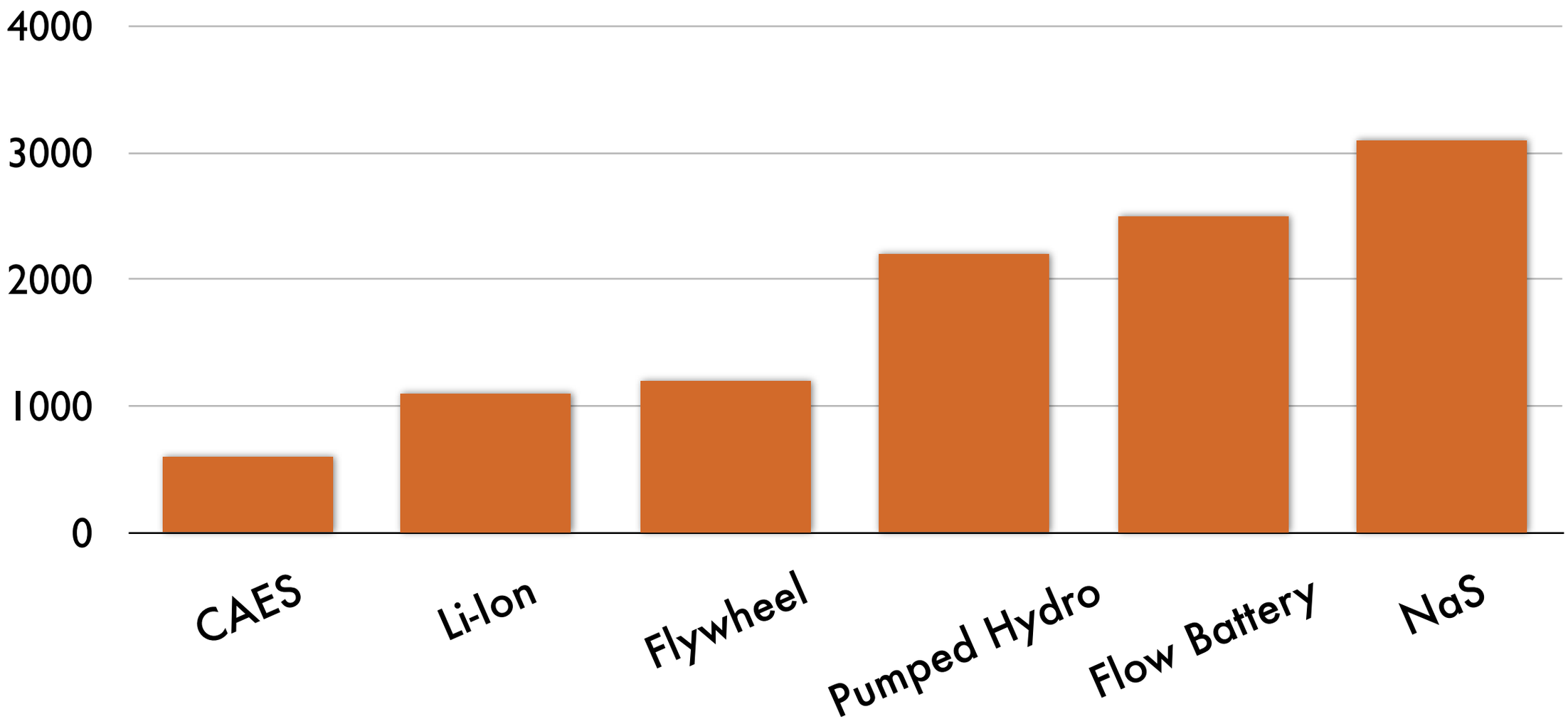
Types of grid storage



A. Price, "Electrical energy storage—a review of technology options,"Proceedings of ICE Civil Engineering 158 November 2005 Pages 52–58 Paper 14175

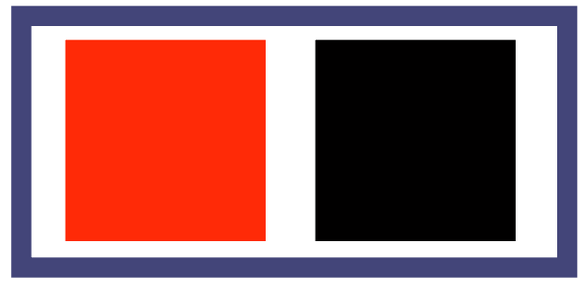
Energy storage technology estimates



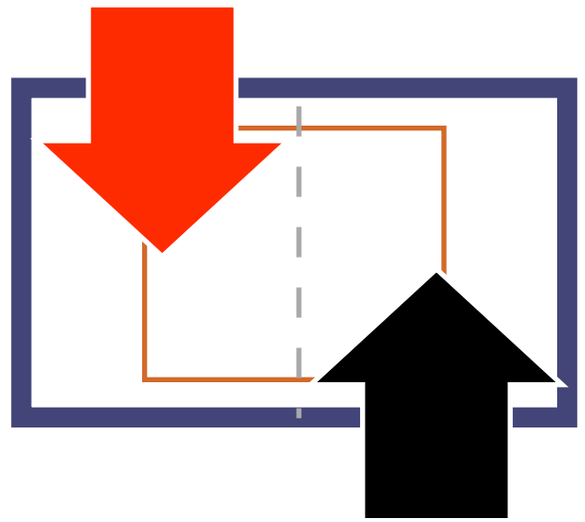
source: "Bottling Electricity: Storage as a Strategic Tool for Managing Variability and Capacity Concerns in the Modern Grid."
http://www.oe.energy.gov/eac.htm

Electrochemical energy storage

- Batteries: energy storage device all of the active material that will react is enclosed within the device

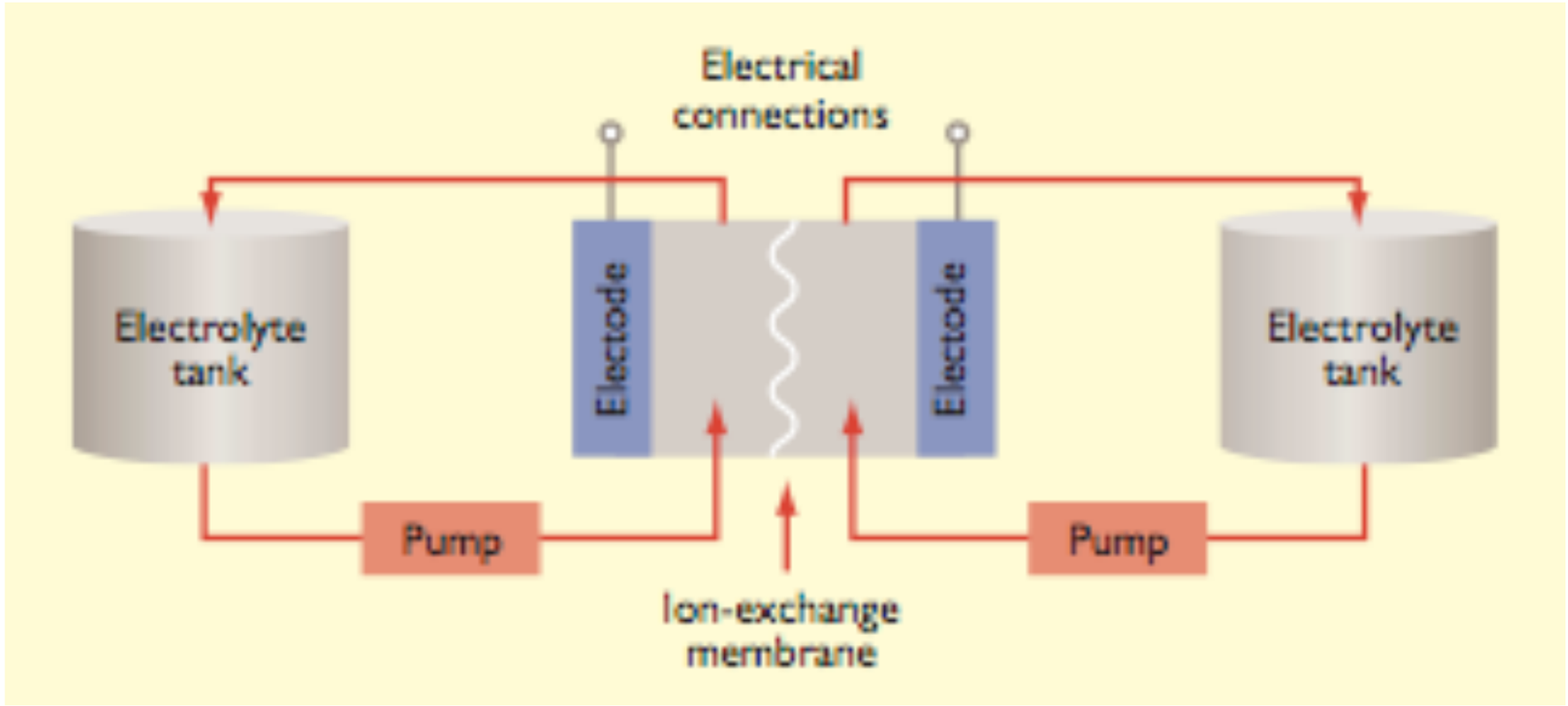


- Fuel cells: energy conversion device
  - deliver fuel to one side and oxygen (air) to the other
  - as long as fuel and air are supplied, can provide electrical power



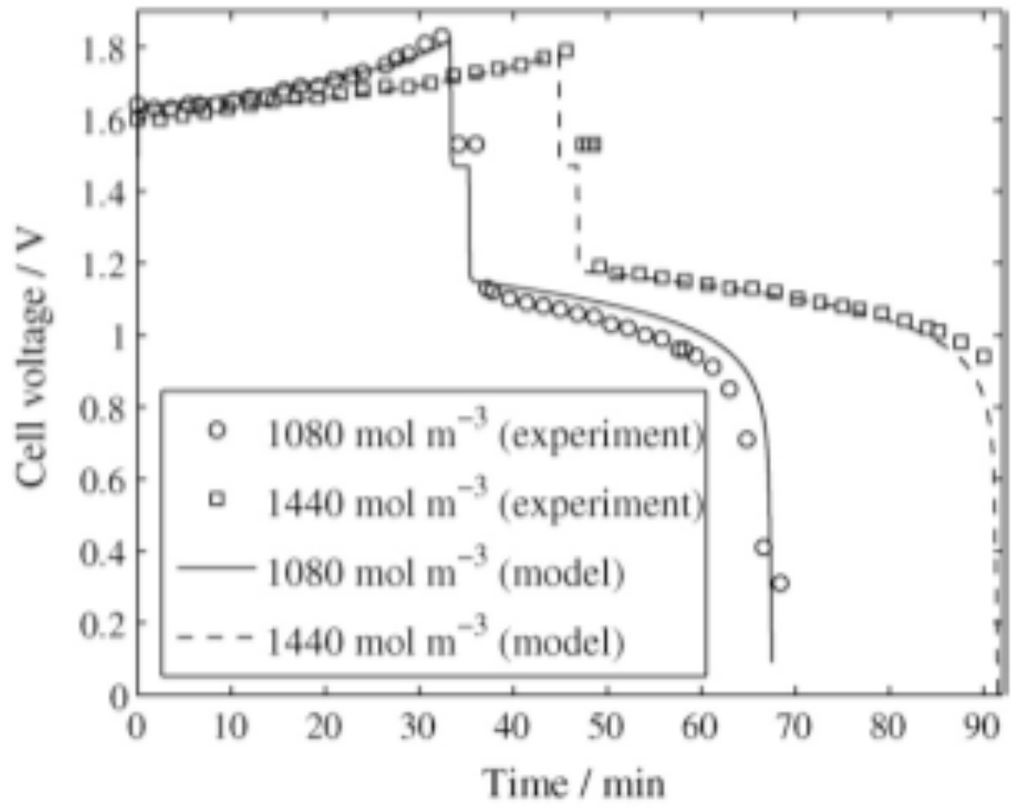
Flow batteries

- allow for de-coupling of power and duration of storage



Flow batteries

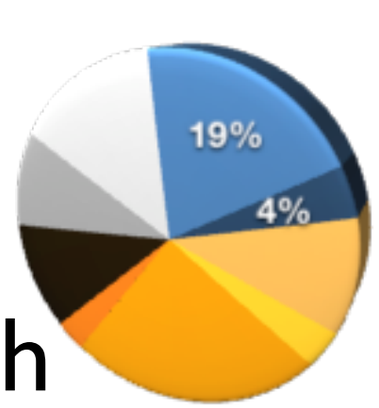
- Separate storage, flexible siting
- Good efficiency
- Stable electrodes (less cycling degradation)
- Expensive, need to improve kinetics



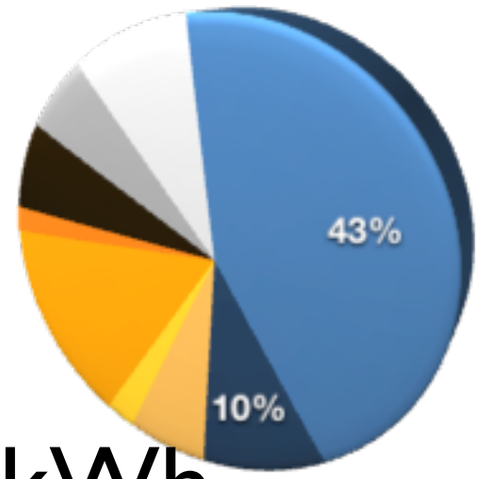
A. Shah *et al.*, "A dynamic performance model for redox-flow batteries involving soluble species" *Electrochimica Acta* ***53*** *(2008) 8087–8100*

Estimated costs 2kW system

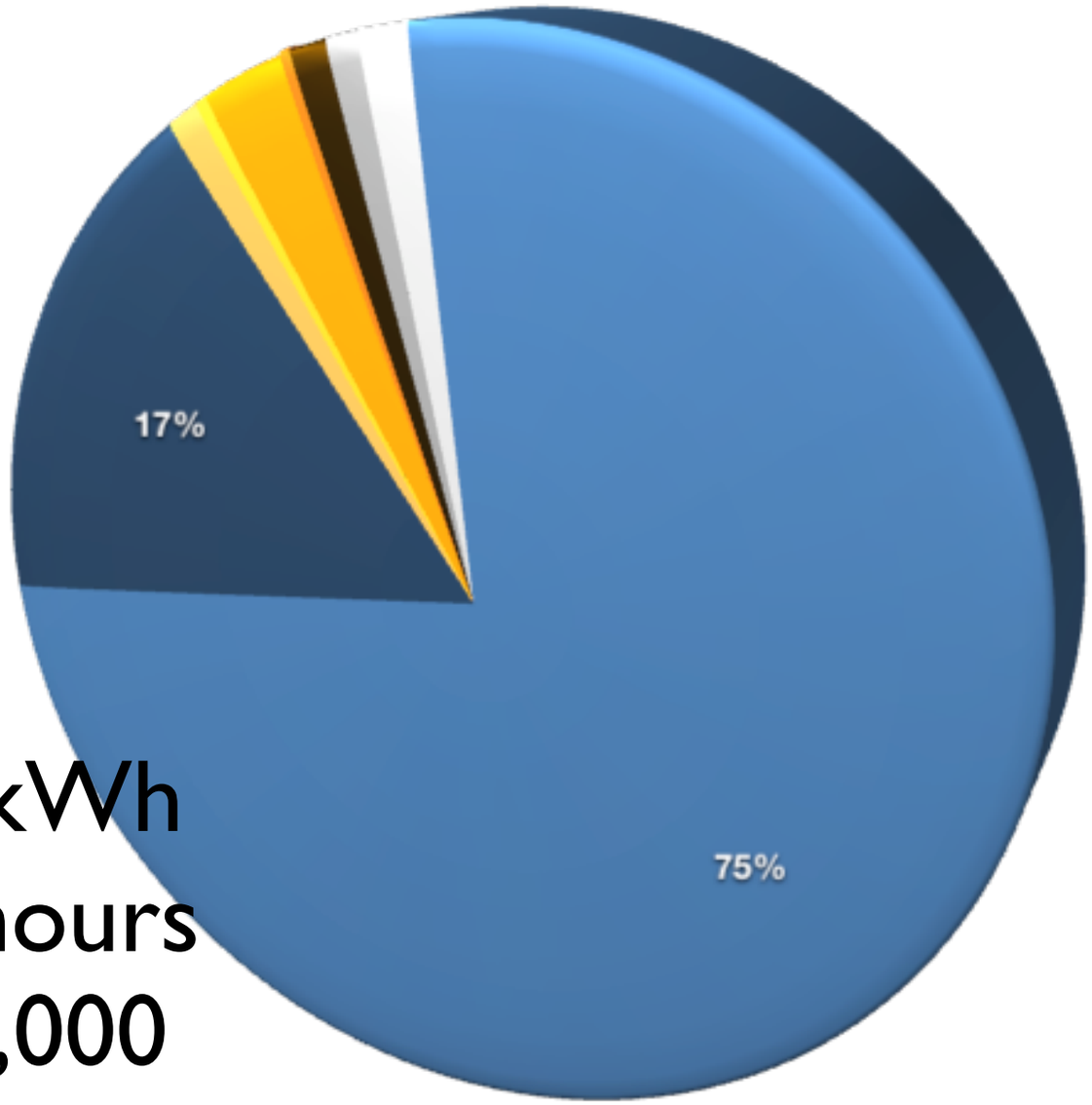
- V2O5
- Activation felt
- Flow frames
- Tanks
- Battery management system
- Electrolyte preparation
- Bipolar plates
- Separator
- Pumps



8 kWh
4 hours
$ 4300



30 kWh
15 hours
$ 7000



300 kWh
150 hours
$ 41,000

Research areas in electrochemical storage

- identifying inexpensive electrochemical couples that are highly reversible and which provide a sufficiently large cell voltage
- cheap, durable electrode materials that will provide rapid kinetics for the preferred reaction, while resisting corrosion and degradation under operating conditions
- cell designs to optimize electrode utilization and to minimize external pumping and control requirements.

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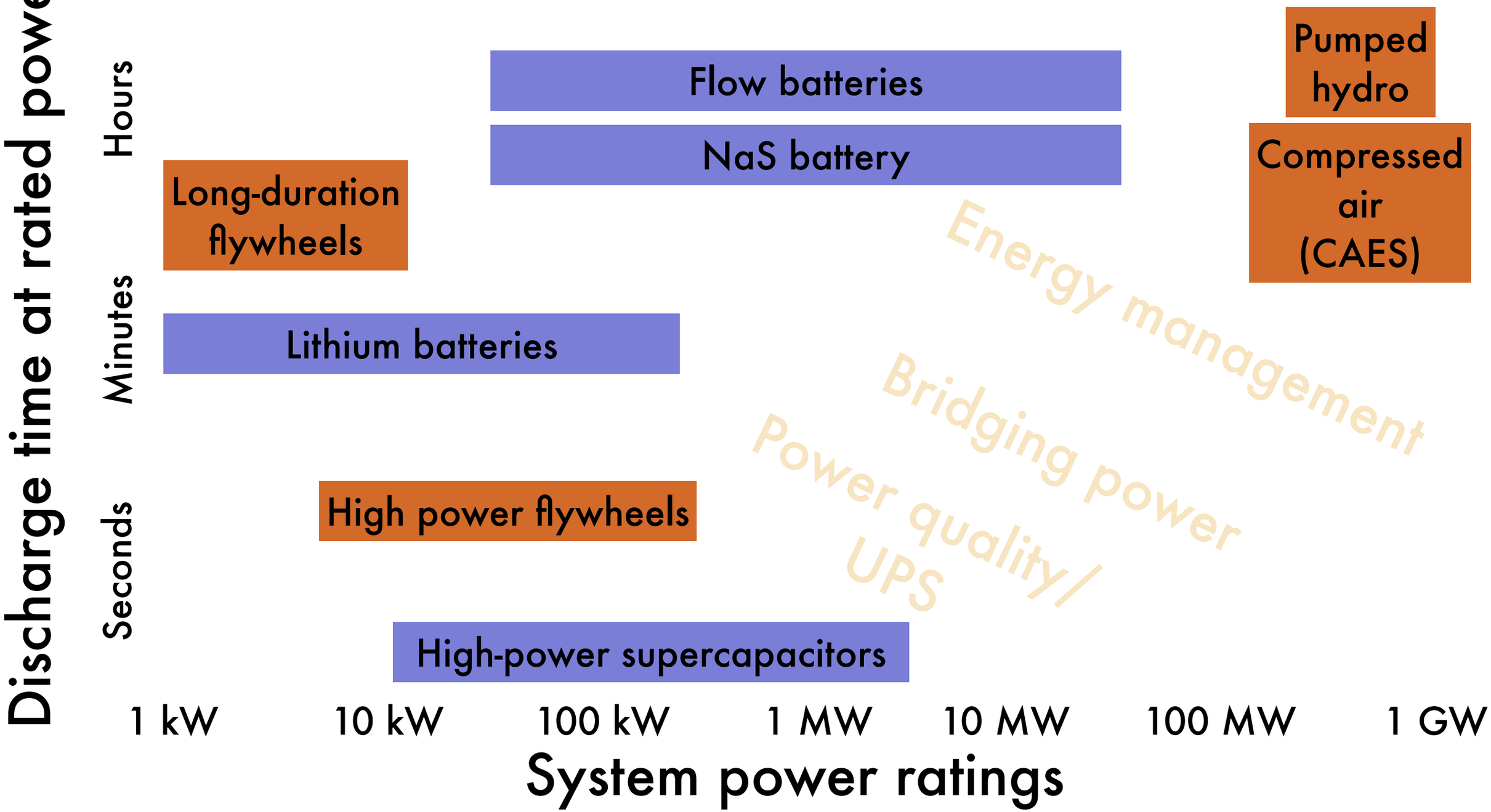

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