Alternative Metropolitan Power Strategy 2.0

IPRO 302

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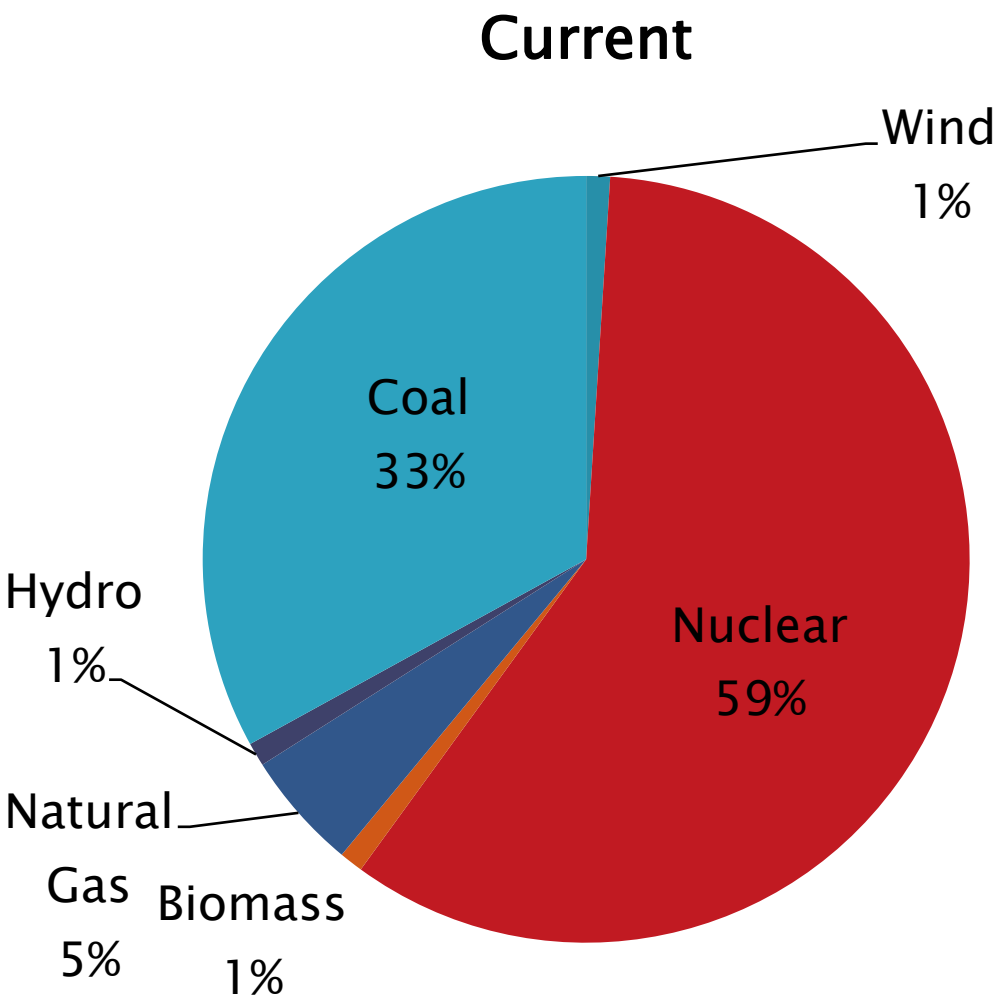
INTERPROFESSIONAL PROJECTS PROGRAM

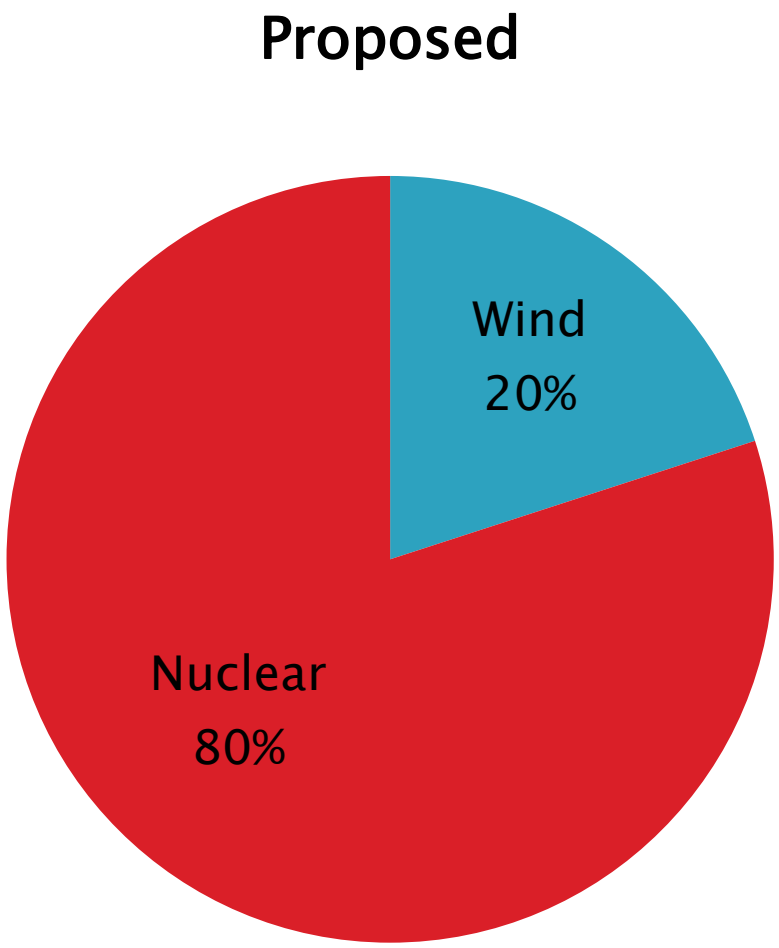
ILLINOIS INSTITUTE OF TECHNOLOGY

Statement of Problem

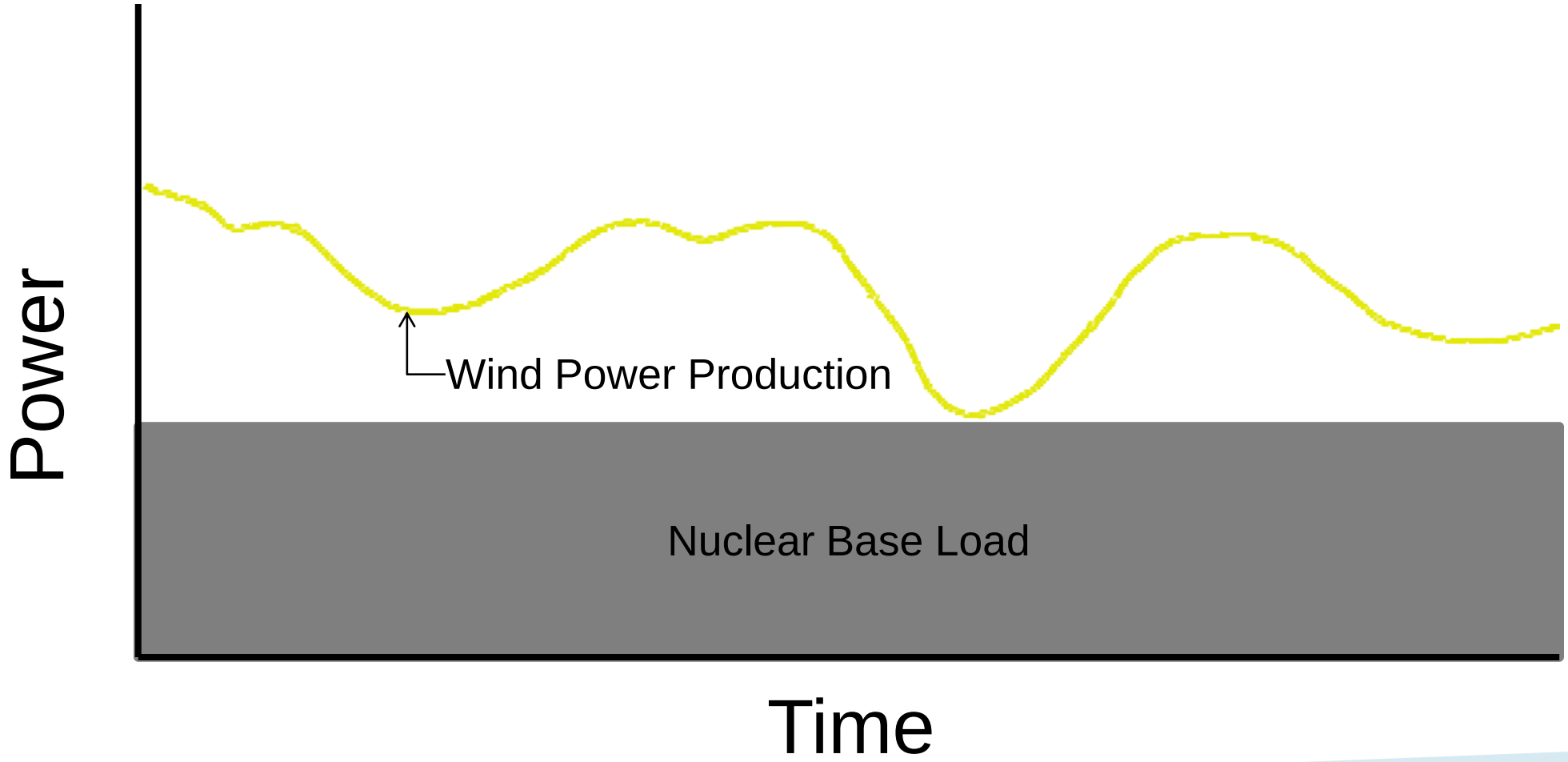
- Carbon-free energy technologies are needed to reduce greenhouse gas emissions
- Determine specifications of a carbon-free system to meet expected electricity demands for Chicago

Sources of Power

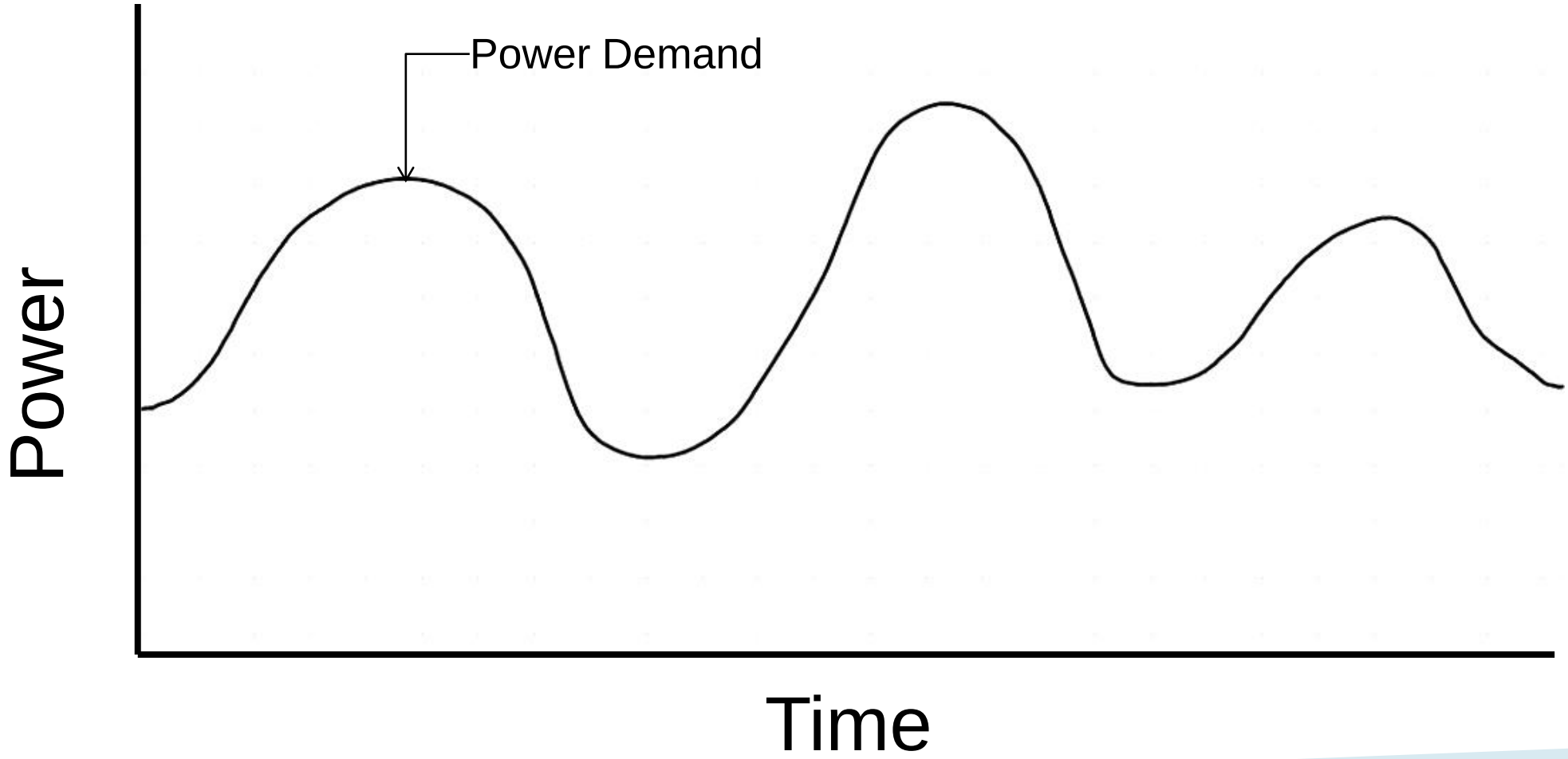




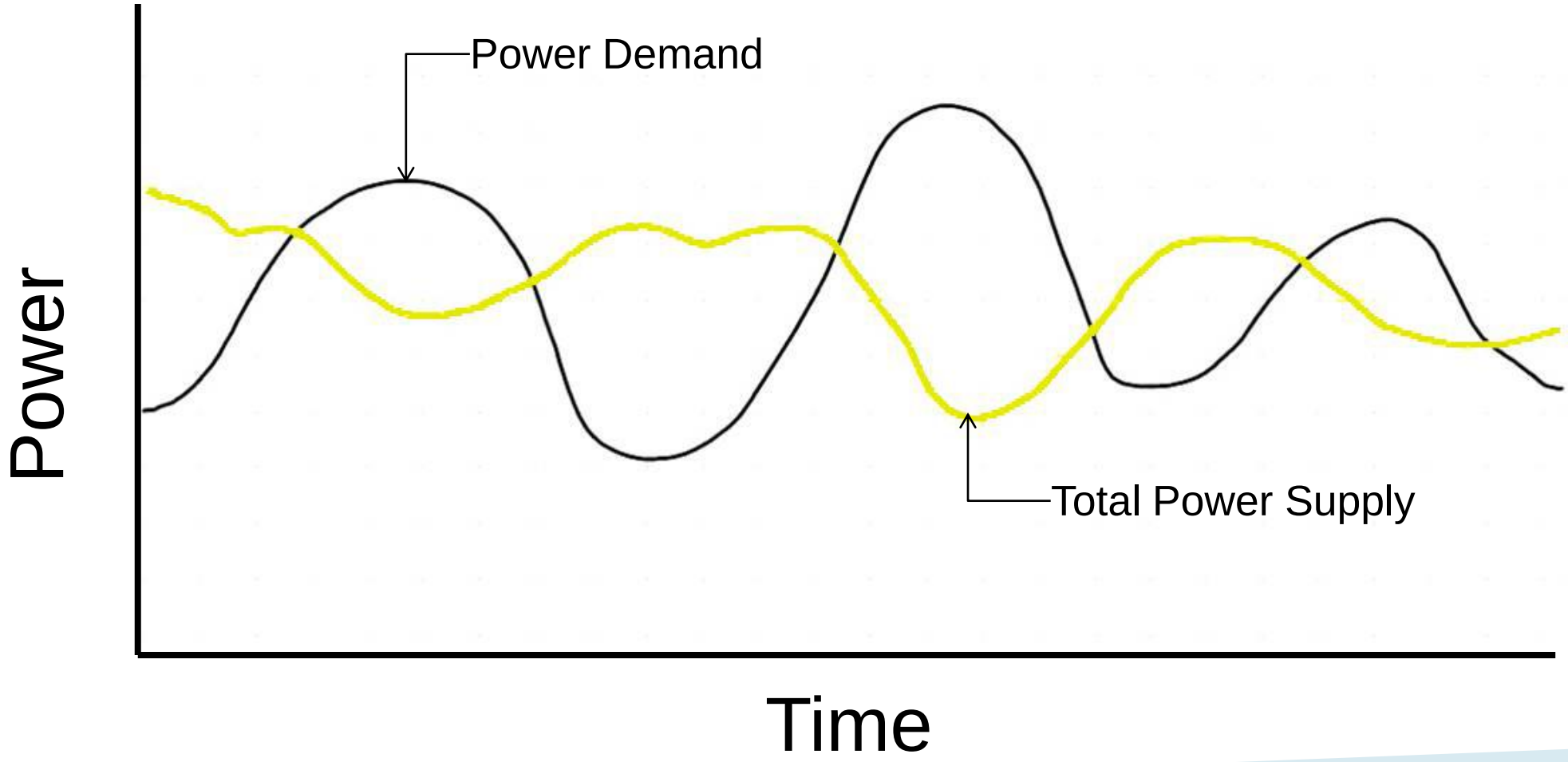
Power Production



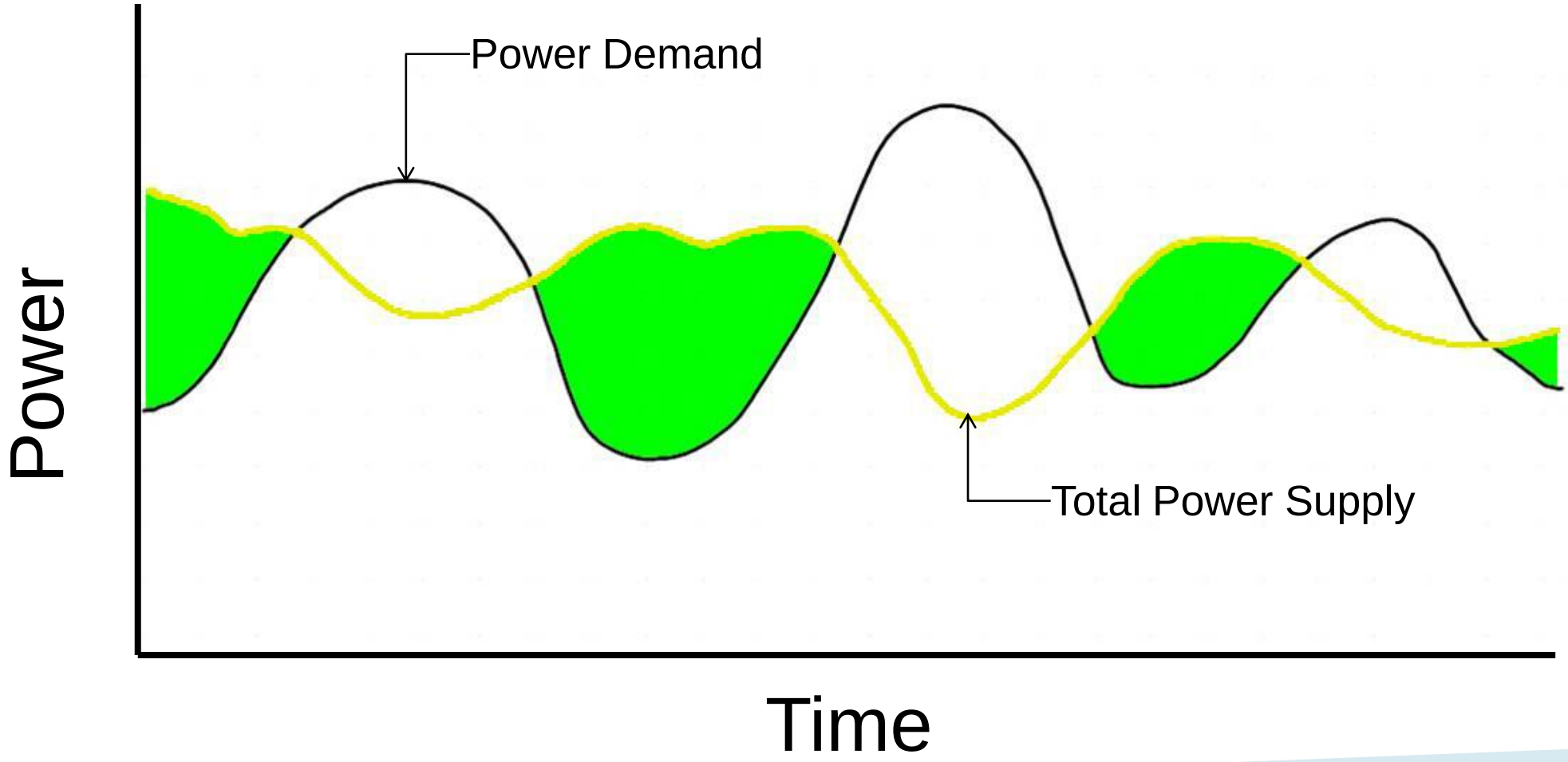
Power Demand



Supply and Demand

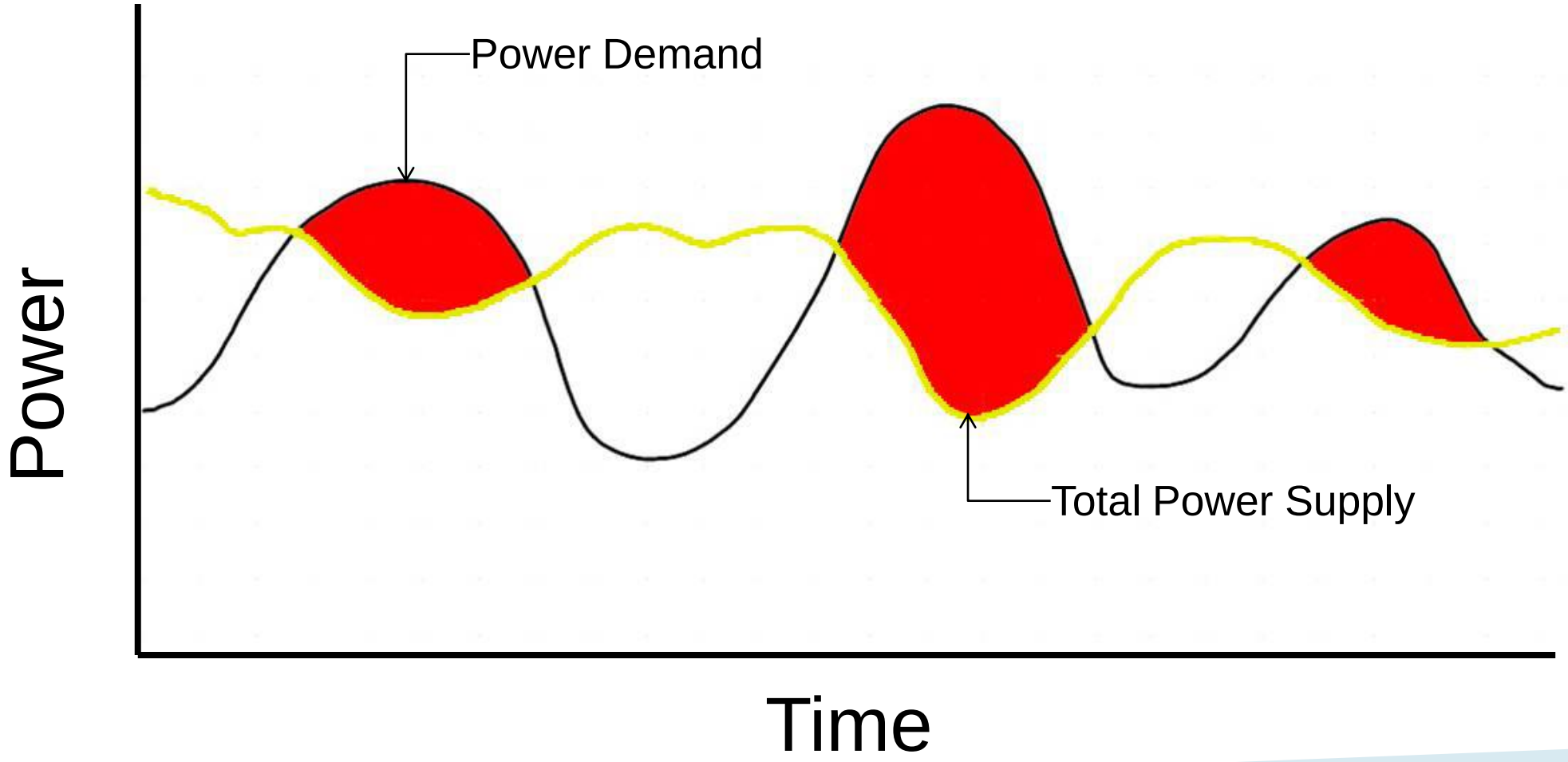


Wasted Energy



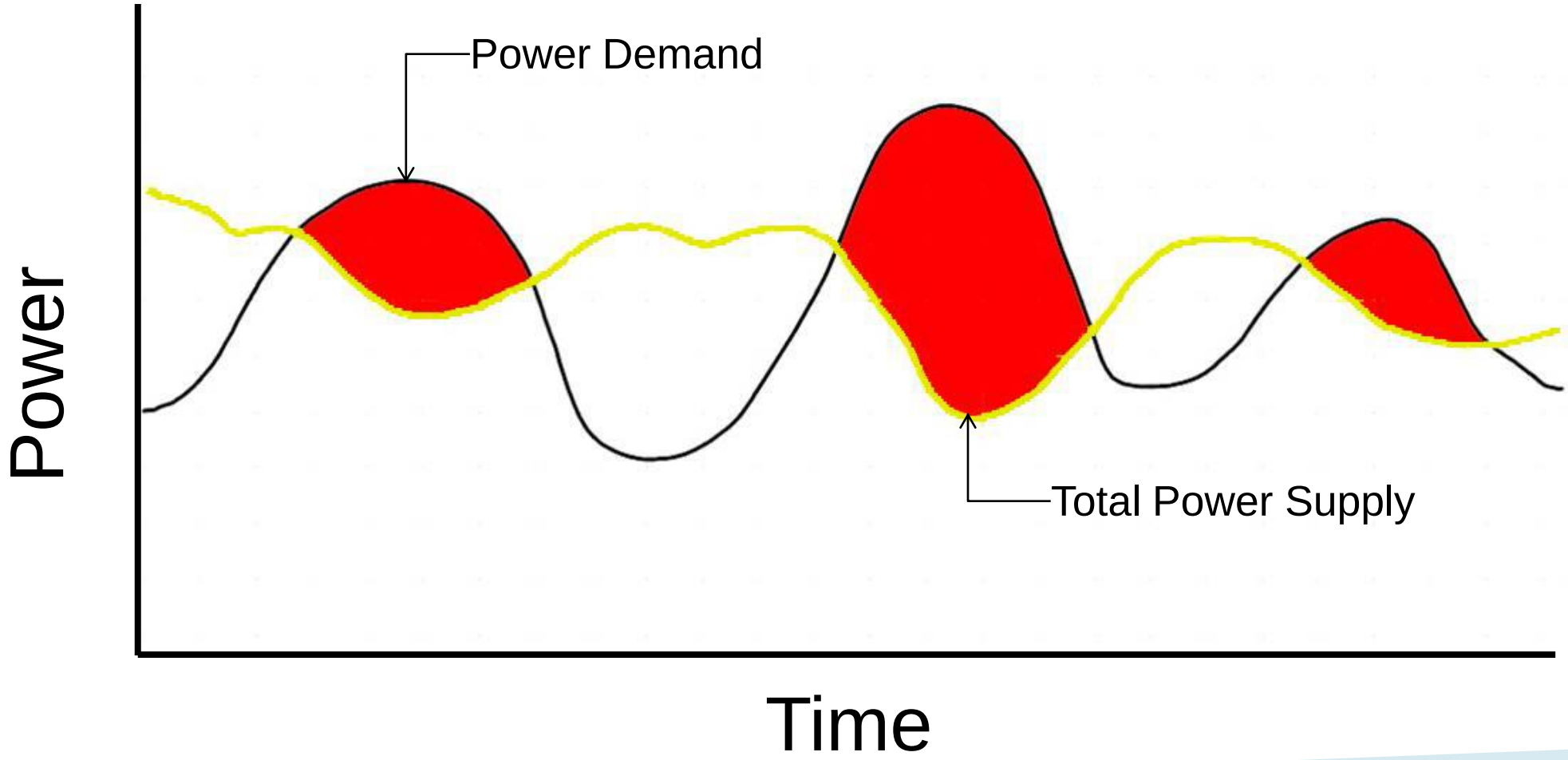
Supply greater than Demand

Blackouts



Demand greater than Supply

The Power Problem



Demand greater than Supply

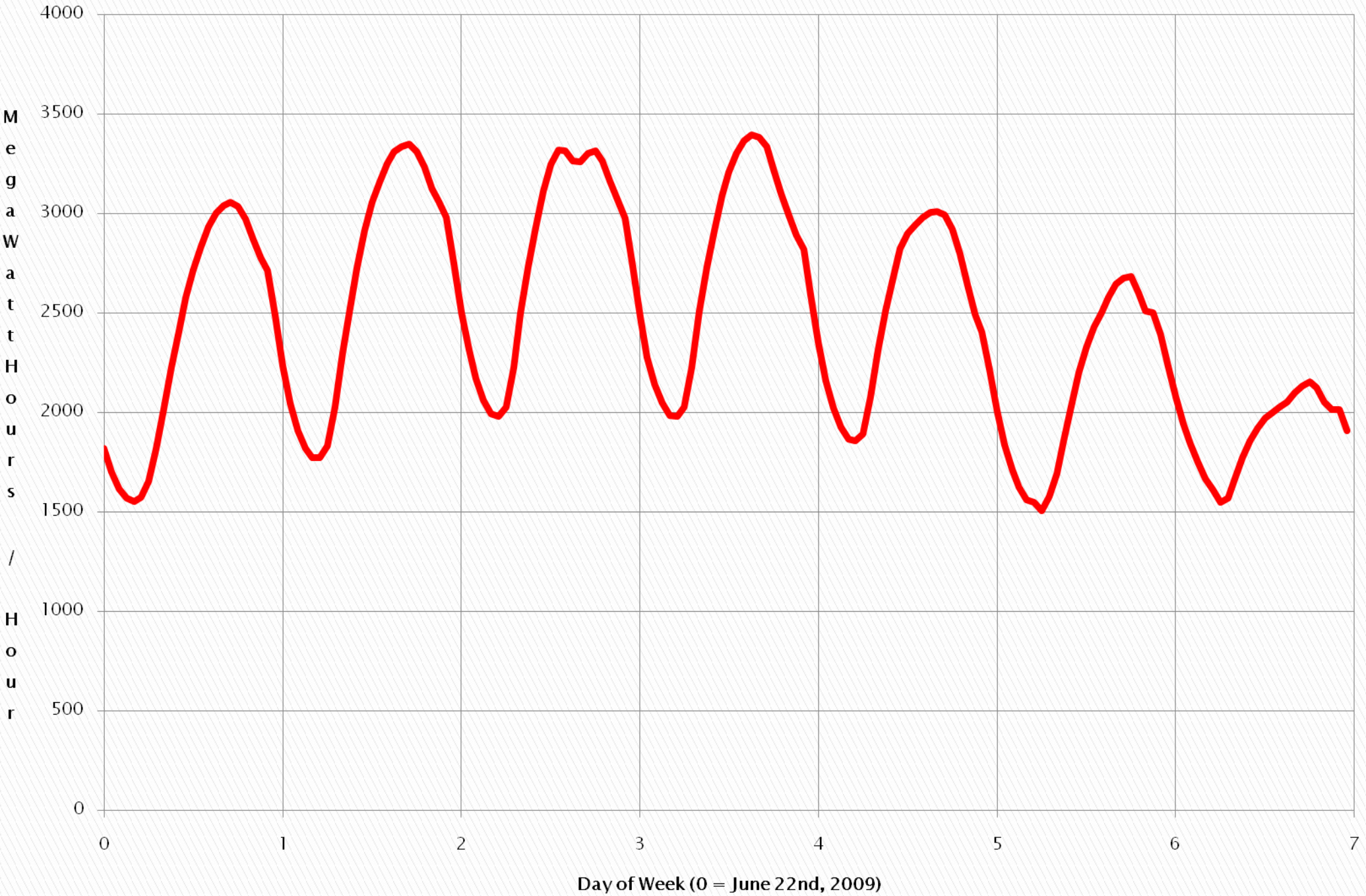
Supply greater than Demand

Storage to the Rescue!

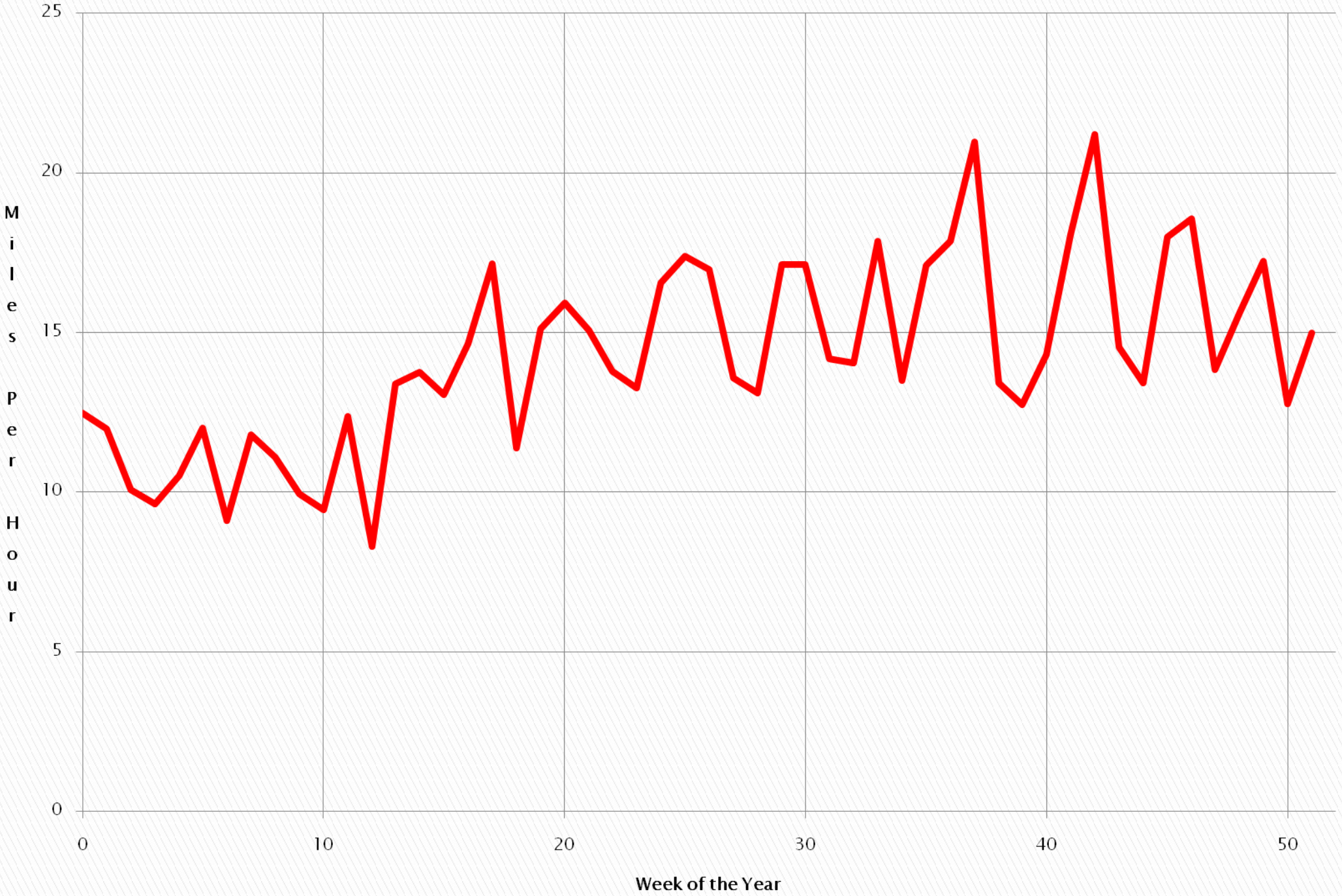
Demand greater than Supply

Supply greater than Demand

Weekly Power Demand (Northern Illinois)



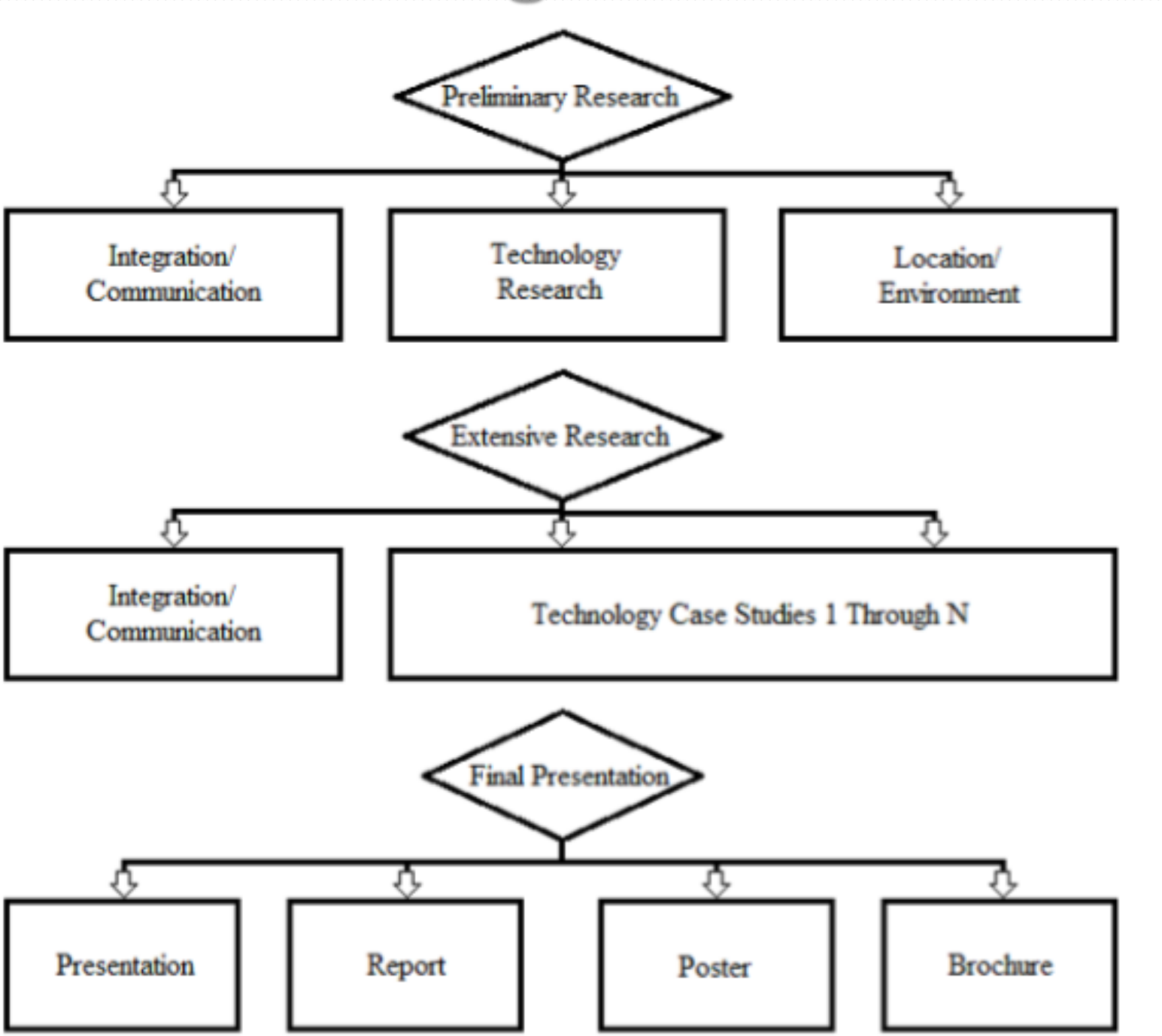
Average Annual Wind Speed (Northern Illinois)



Goals of the Project

- Propose solution that would supply Chicago's energy needs without producing carbon
- Determine the most cost efficient combination of power production and storage technologies to meet the expected electricity demands for Chicago
  - Rank current storage technologies based on cost, efficiency, feasibility, and size

AMPS2 Team Organization



Storage Technologies Considered

Pumped Hydro Storage
Compressed Air Energy Storage
Batteries
Fuel Cells
Flow Batteries
Solar Fuels
Superconducting Magnetic Storage
Flywheels
Capacitors/Supercapacitors
Thermal Energy Storage

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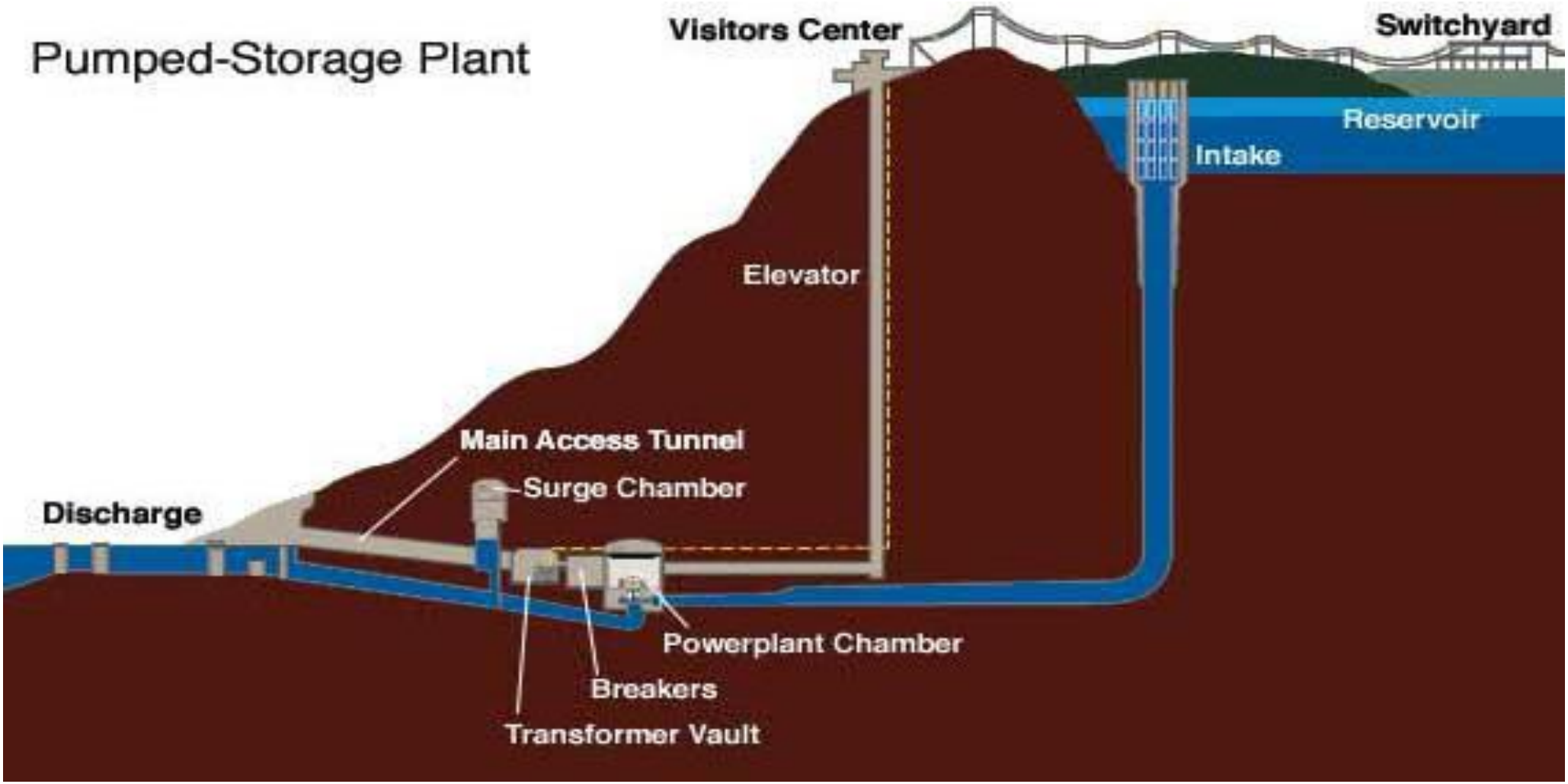
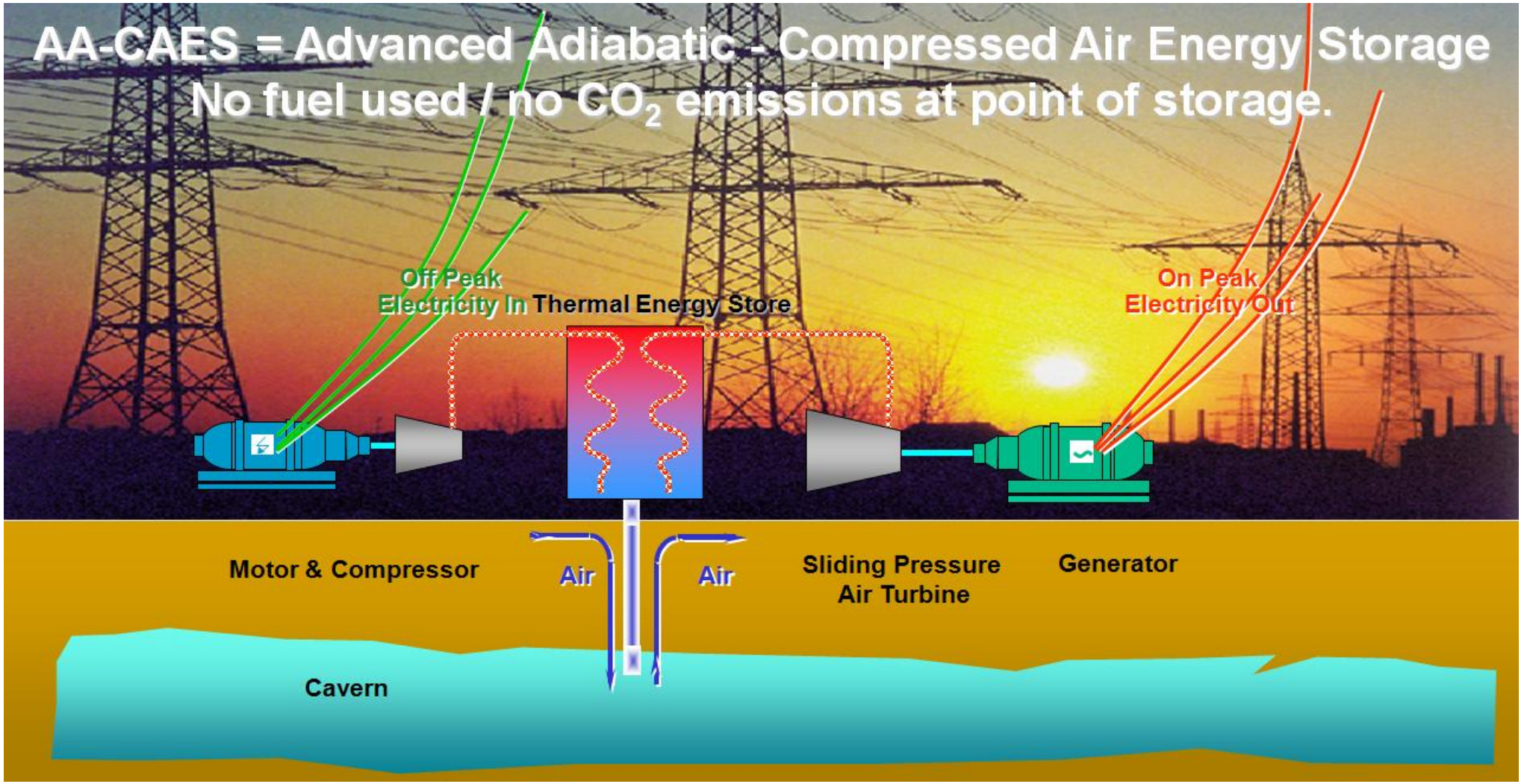
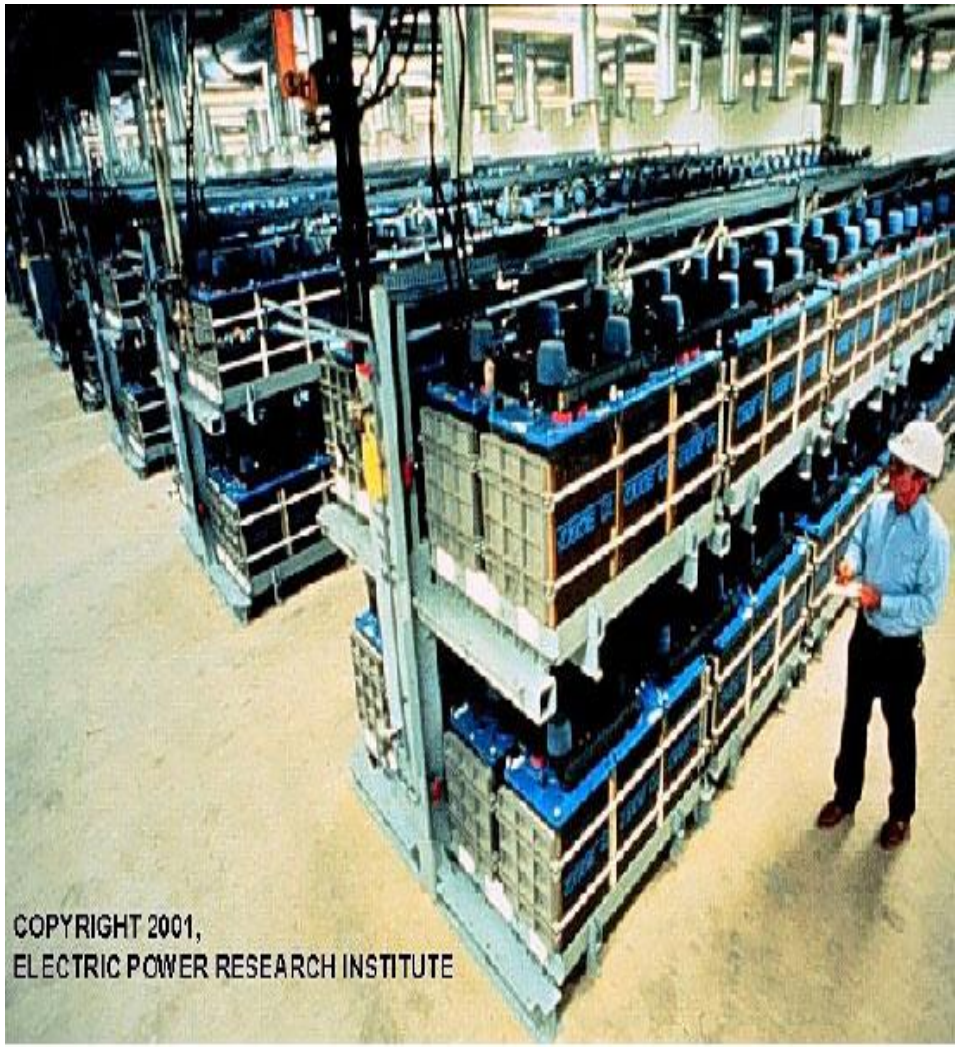
Pumped Hydro Storage



Compressed Air Energy Storage



Batteries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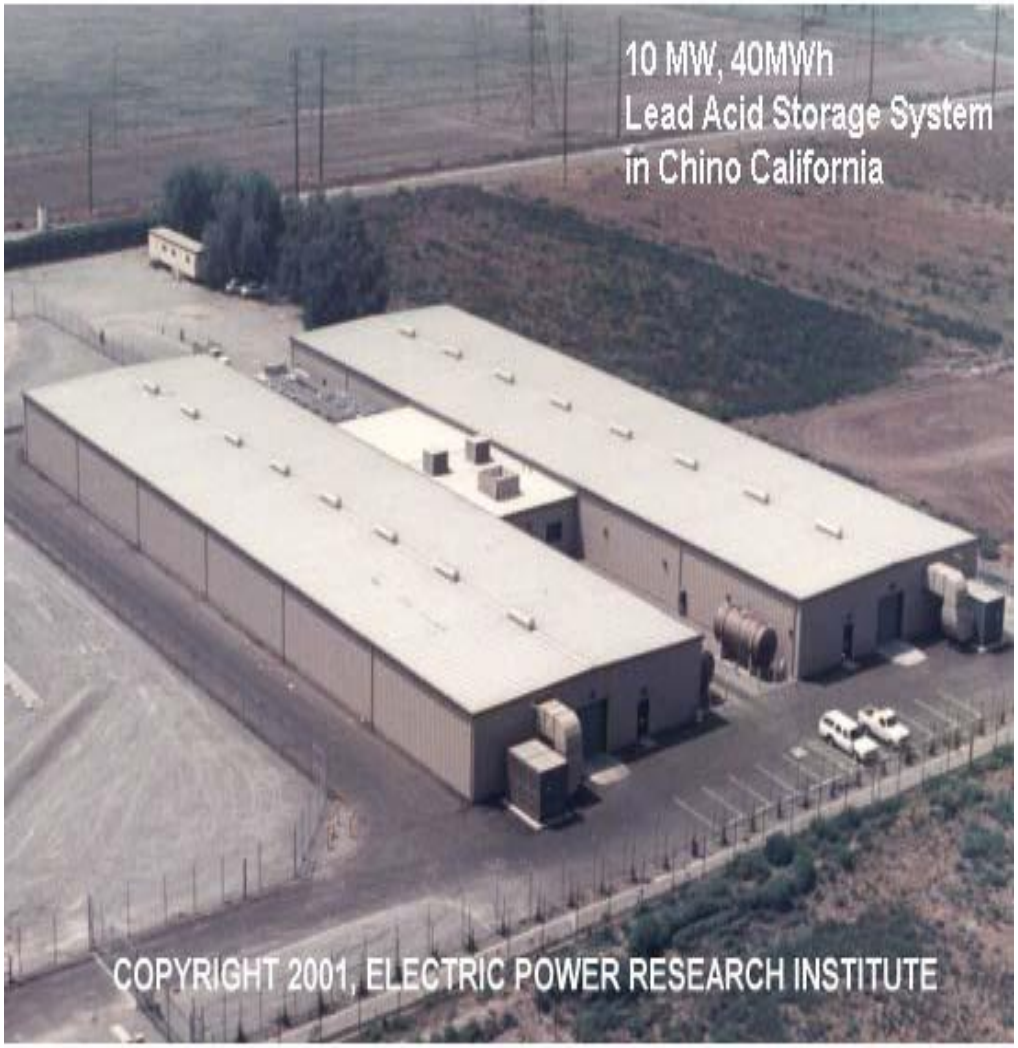
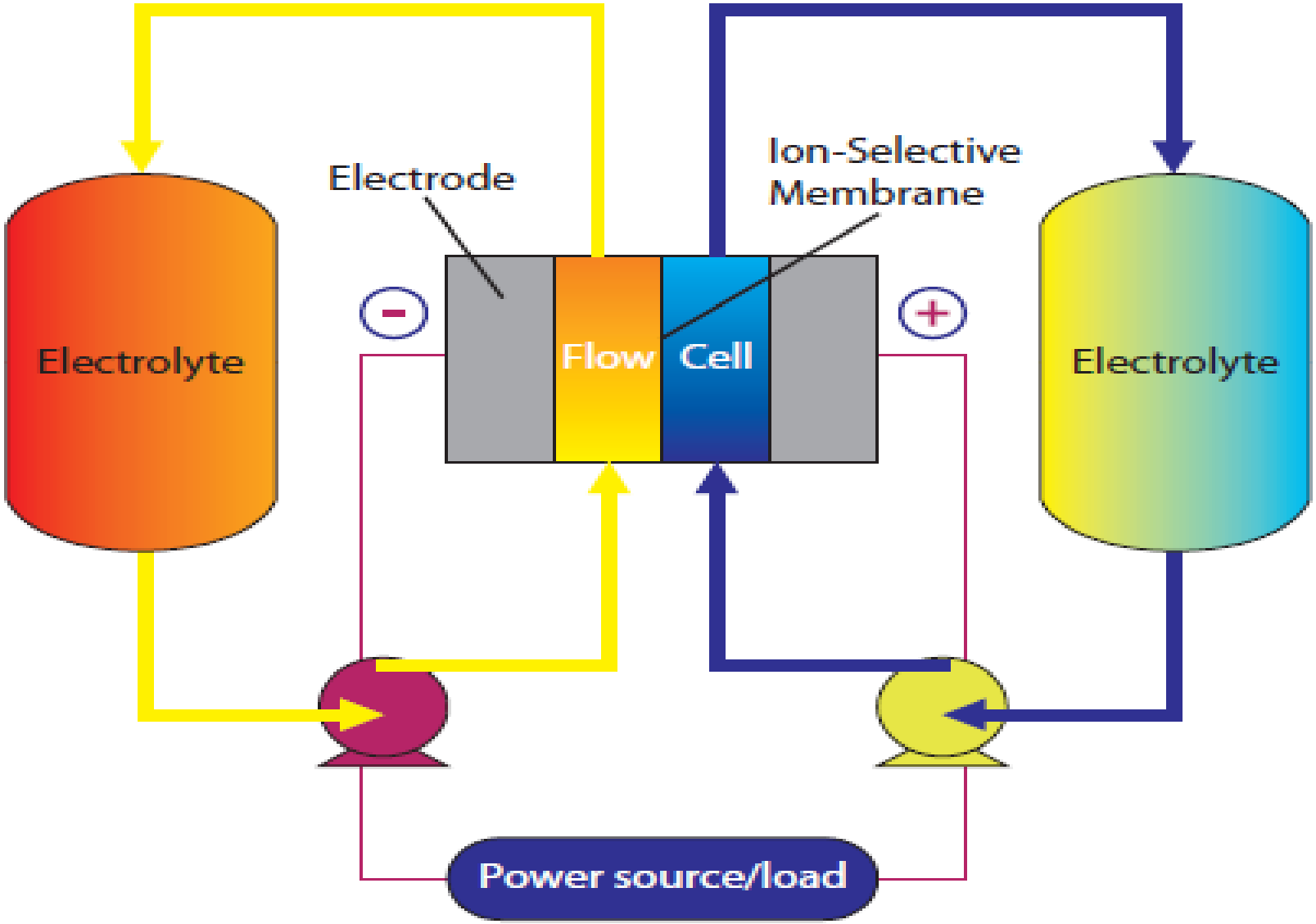
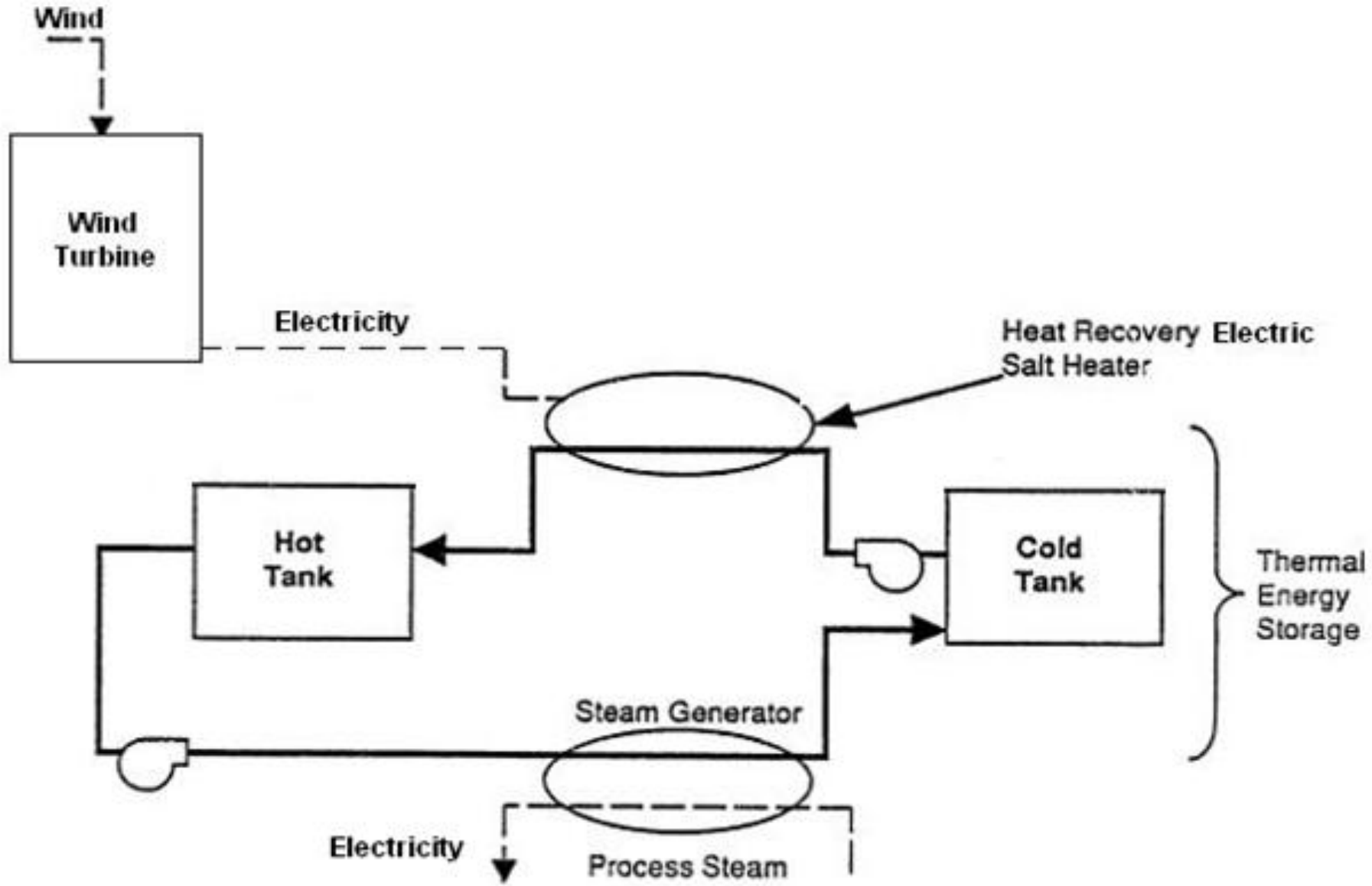
ELECTRIC POWER RESEARCH INSTITUTE


10 MW, 40MWh
Lead Acid Storage System
in Chino California
COPYRIGHT 2001, ELECTRIC POWER RESEARCH INSTITUTE

Flow Batteries



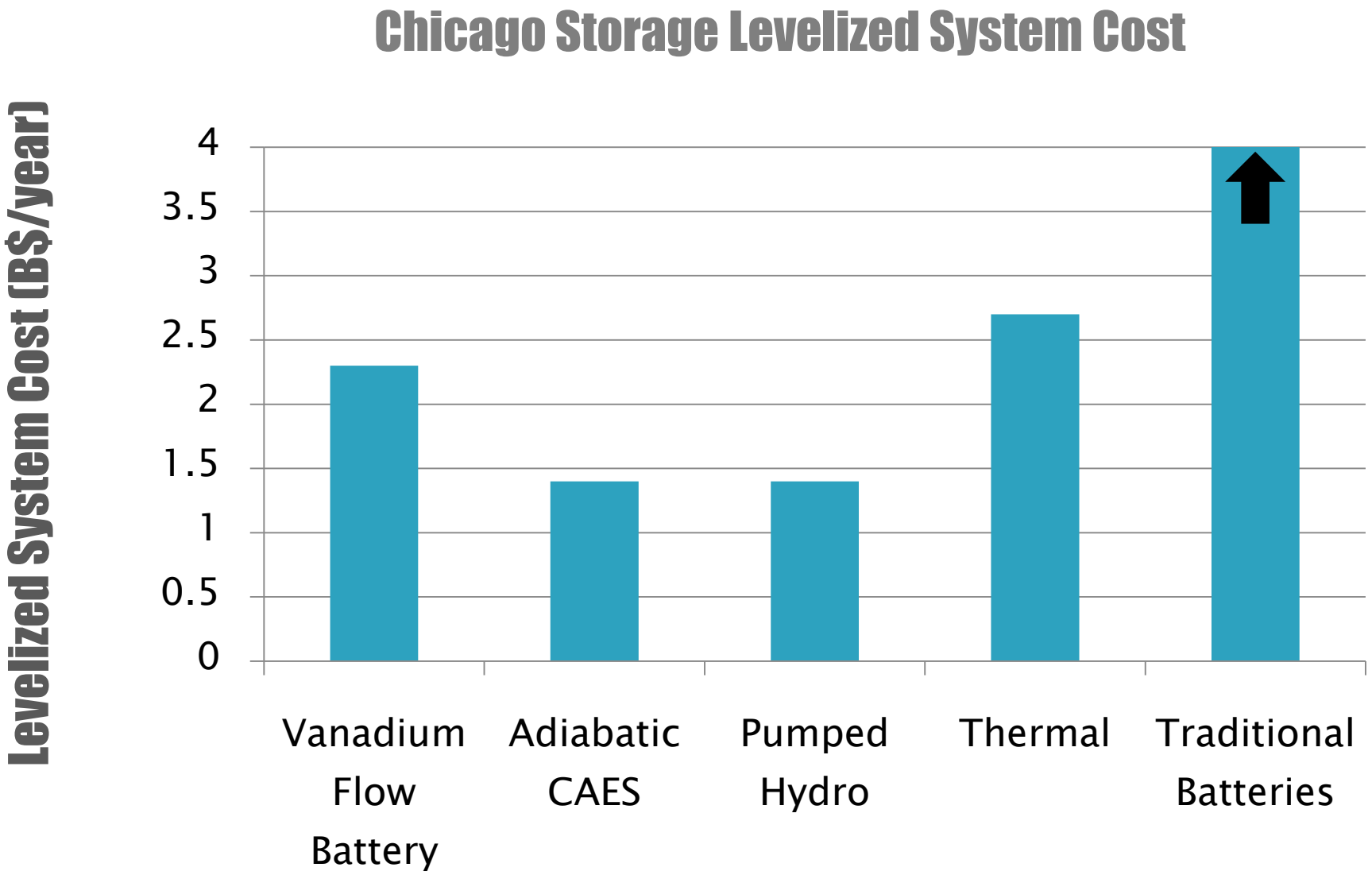
Thermal Energy Storage



Demands on Storage

Power Rating: 1,500 MW

Storage Capacity: 320,000 MWh


Chicago Storage Levelized System Cost
Levelized System Cost (B$/year)
4
3.5
3
2.5
2
1.5
1
0.5
0
Vanadium Flow Battery
Adiabatic CAES
Pumped Hydro
Thermal
Traditional Batteries

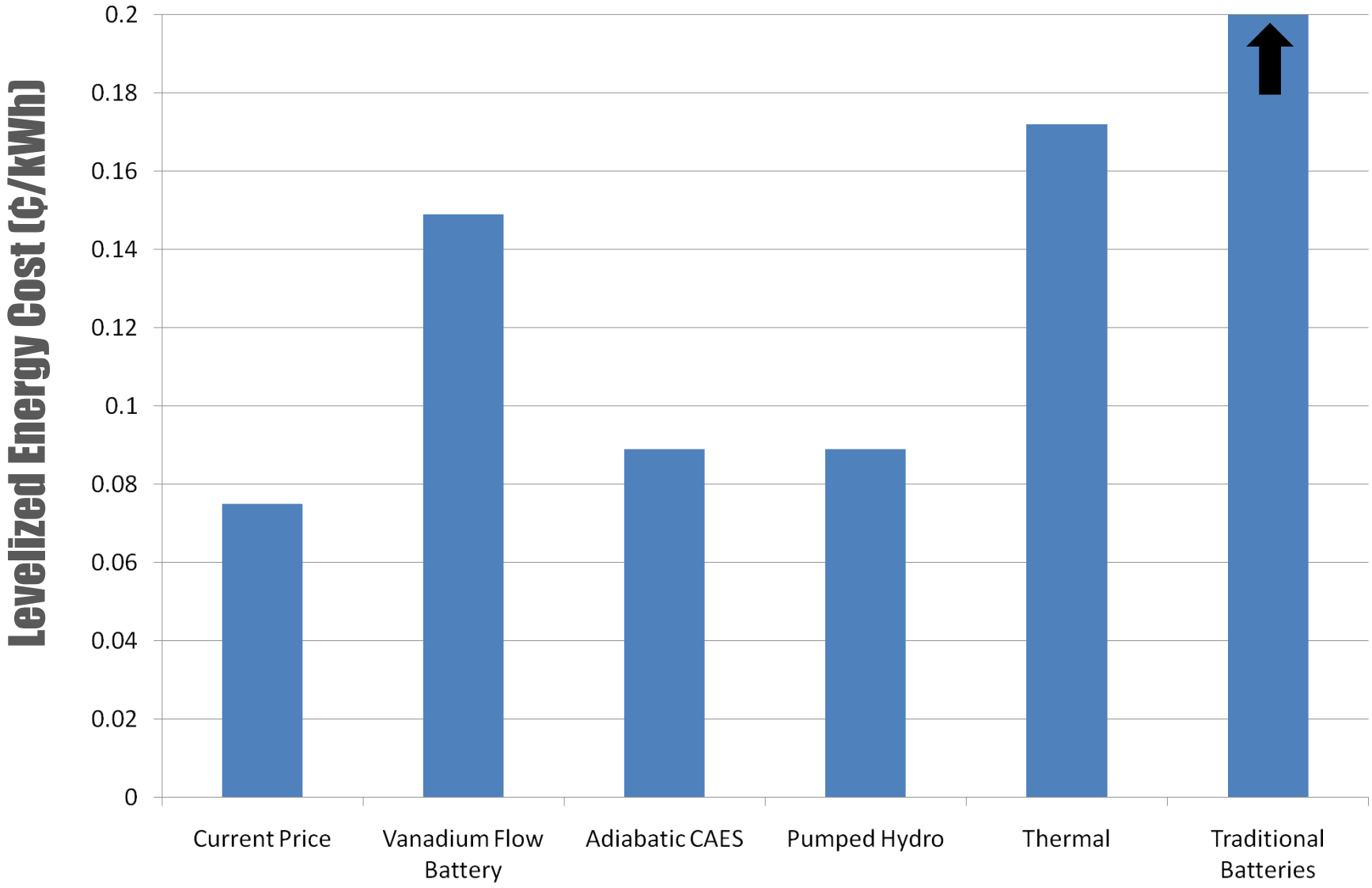
LEC Calculations

- LEC = Average lifetime levelised electricity generation cost
- I_t = Investment expenditures in the year t
- M_t = Operations and maintenance expenditures in the year t
- F_t = Fuel expenditures in the year t
- E_t = Electricity generation in the year t
- r = Discount rate
- n = Life of the system

$$\text{LEC}=\frac{\text{Capital+O\&M+Input}}{\text{Output}}$$

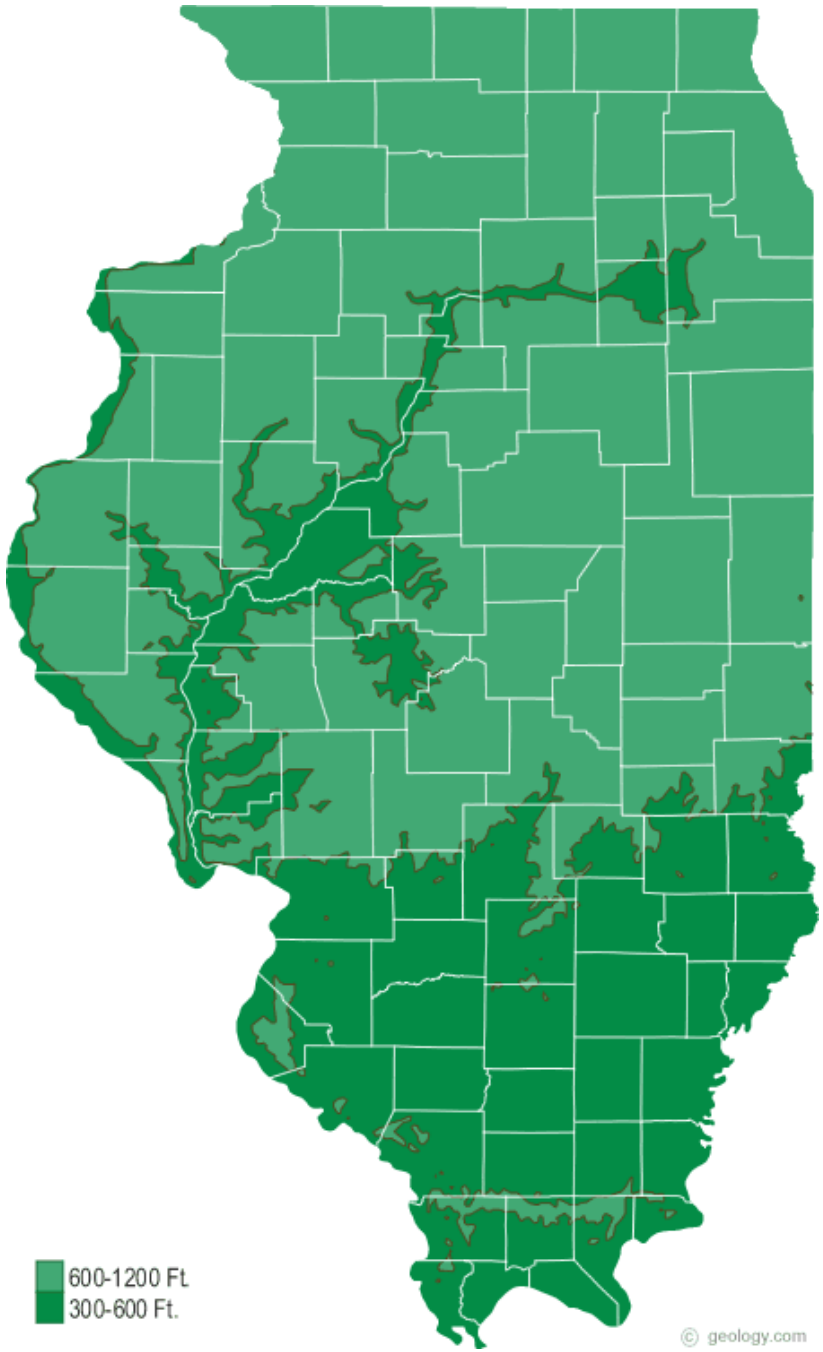
$$\text{LEC} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

Chicago Storage Levelized Energy Cost

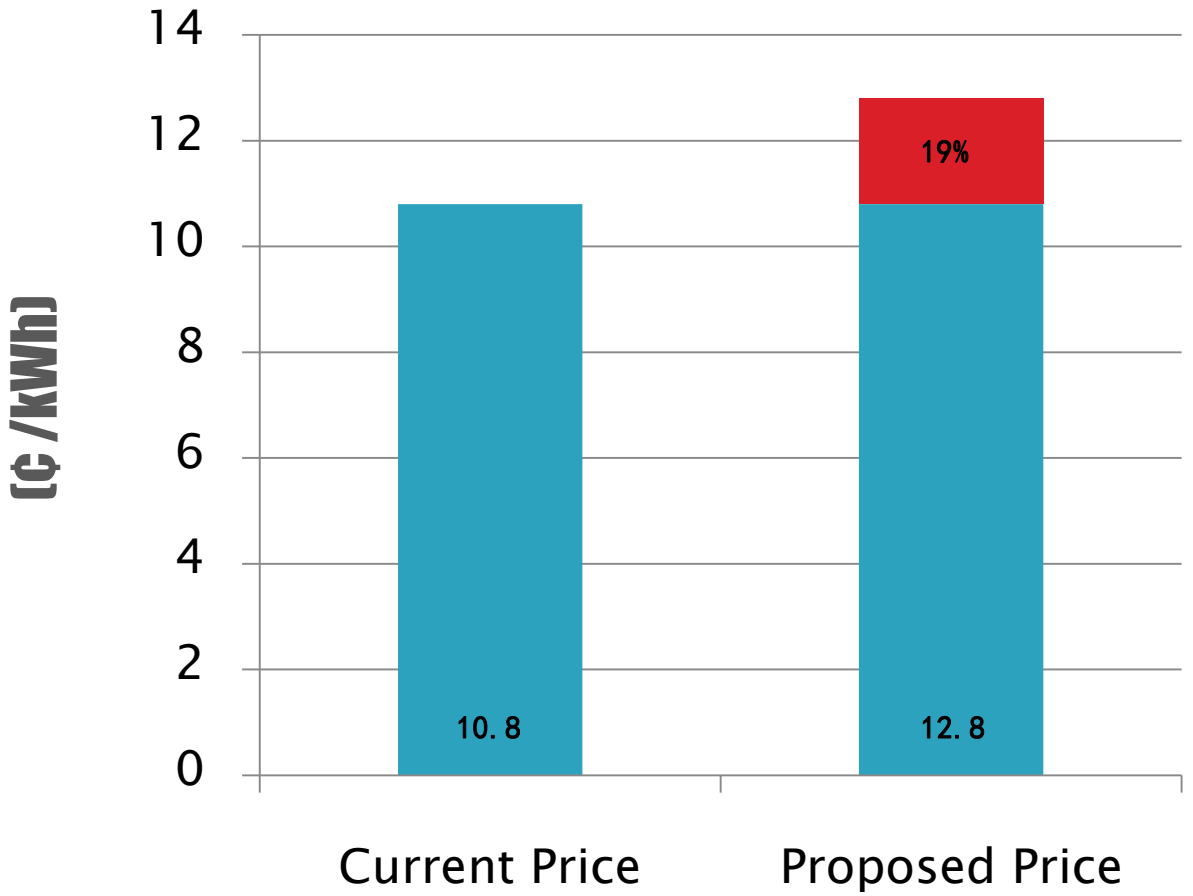


Which Storage?

- CAES cheapest option (LSC)
- Identical price (¢ kWh) as Pumped Hydro
- Area requirements



Final Cost of Energy



Result

- More expensive than today's cost of energy
- More feasible and efficient than pure nuclear
- Cheaper than Carbon-Capture Coal plants
- Would not produce Carbon Emission