
energy storage
Energy 2013
NYU / ITP / Feddersen

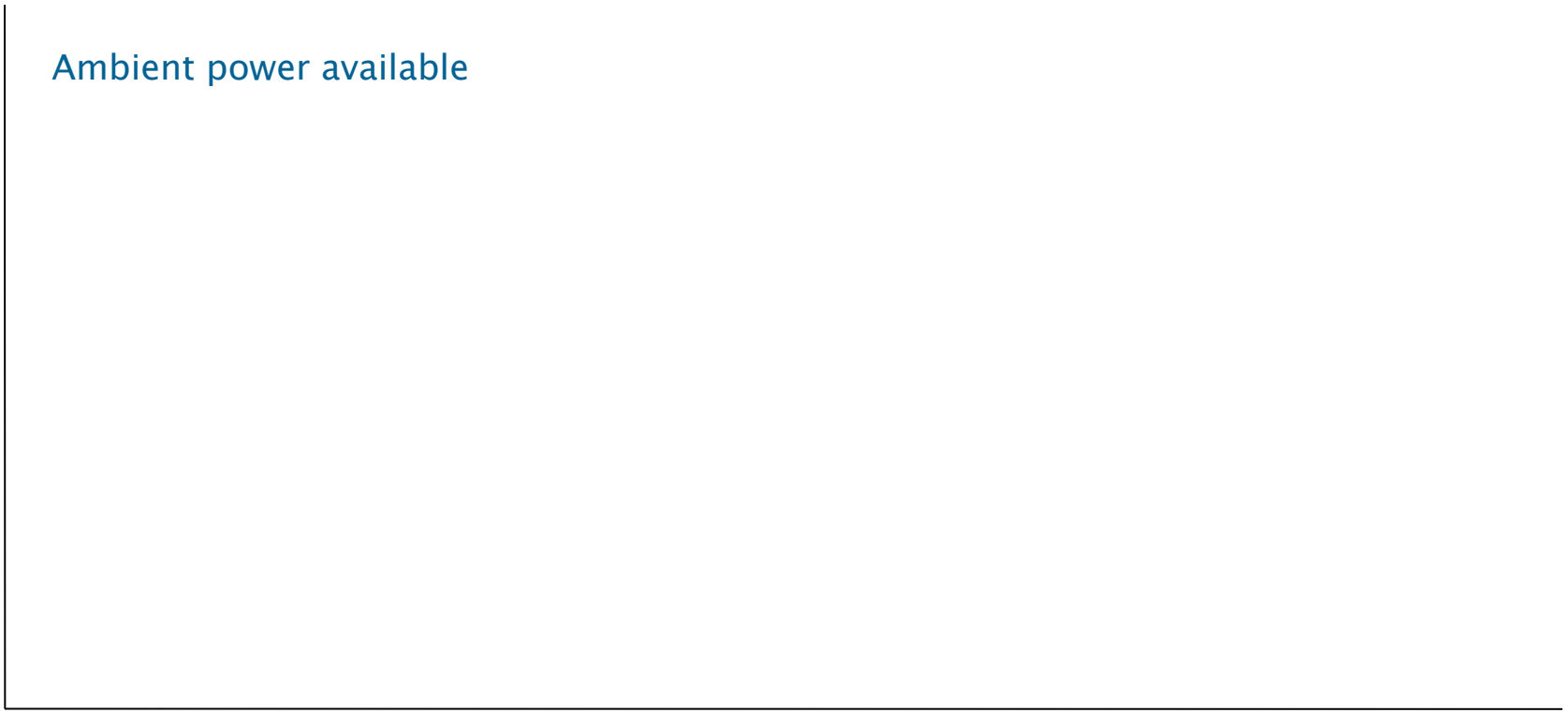
A sustainable system by definition uses energy at or below the rate it is generally available from the environment.

However, it may be necessary for a system to:

- time shift energy usage independent of fluctuating ambient availability
- momentarily exceed the ambient power available
- and/or handle momentary interruptions of power

In these cases, energy storage will be necessary.

System energy usage is out of phase with ambient availability:



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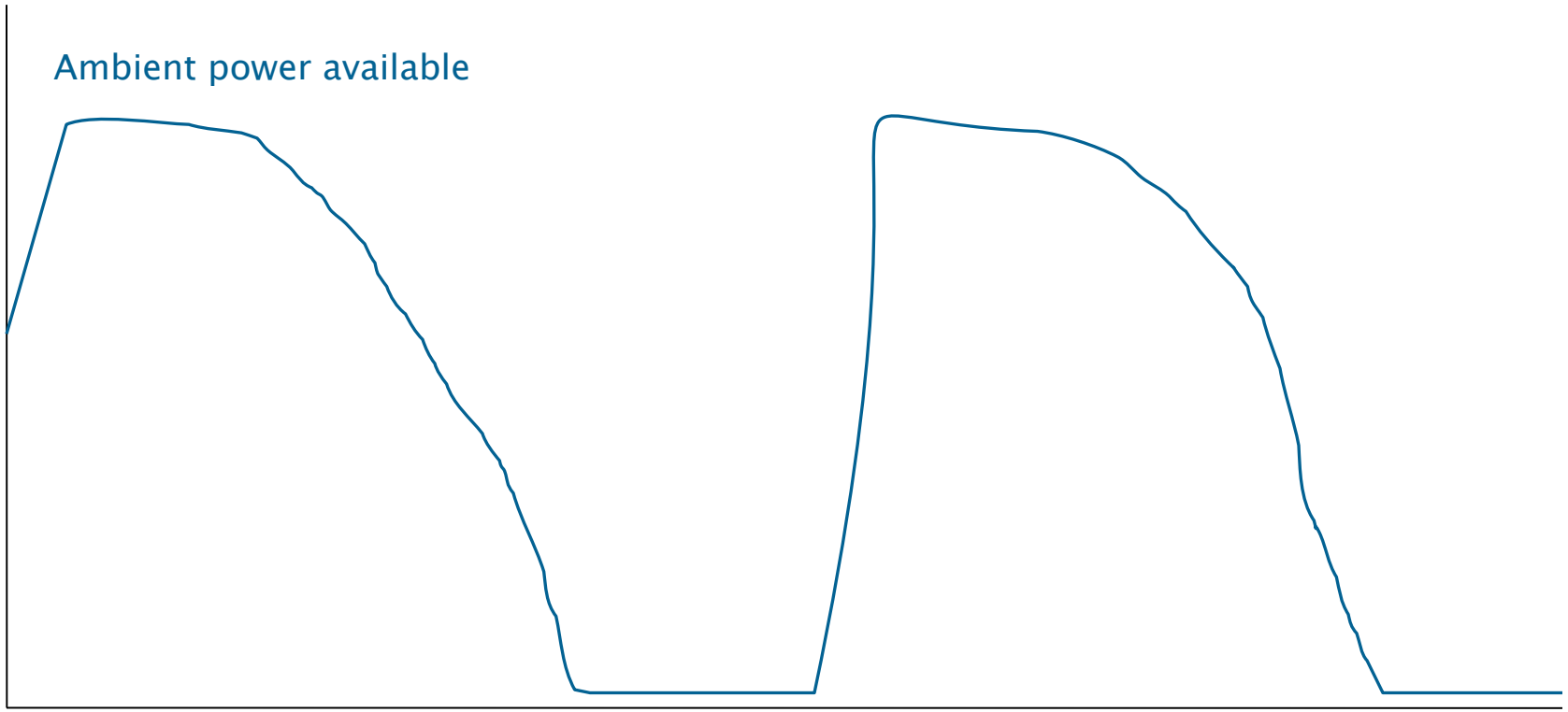

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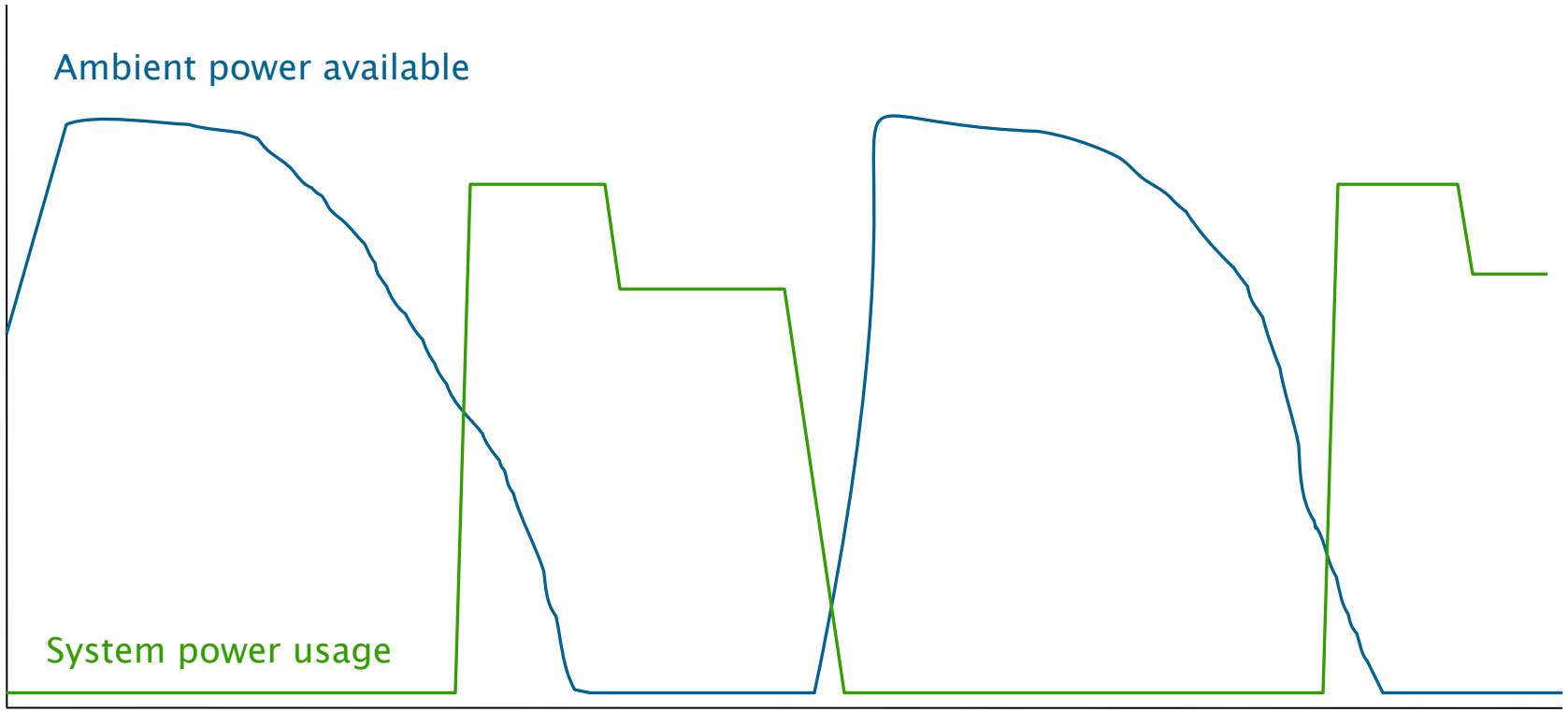
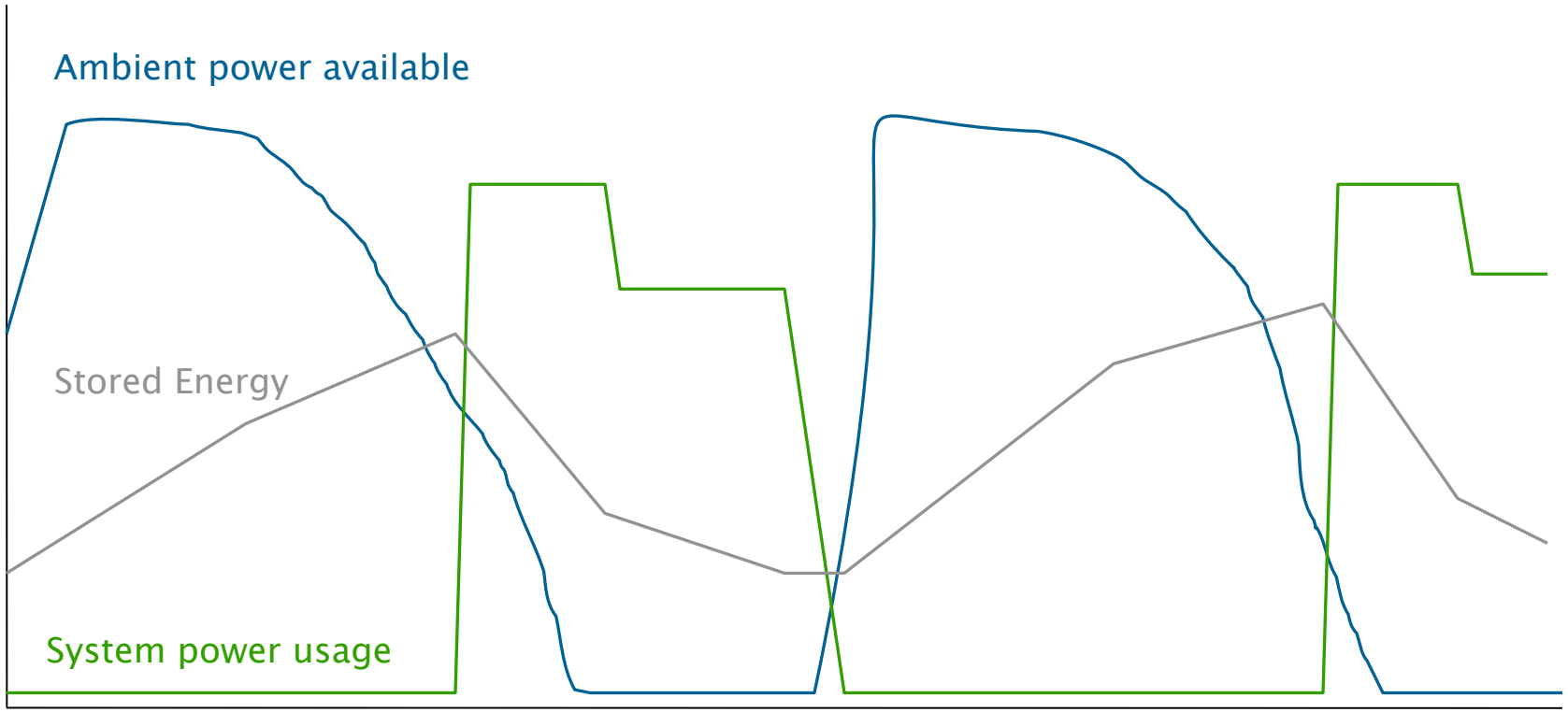
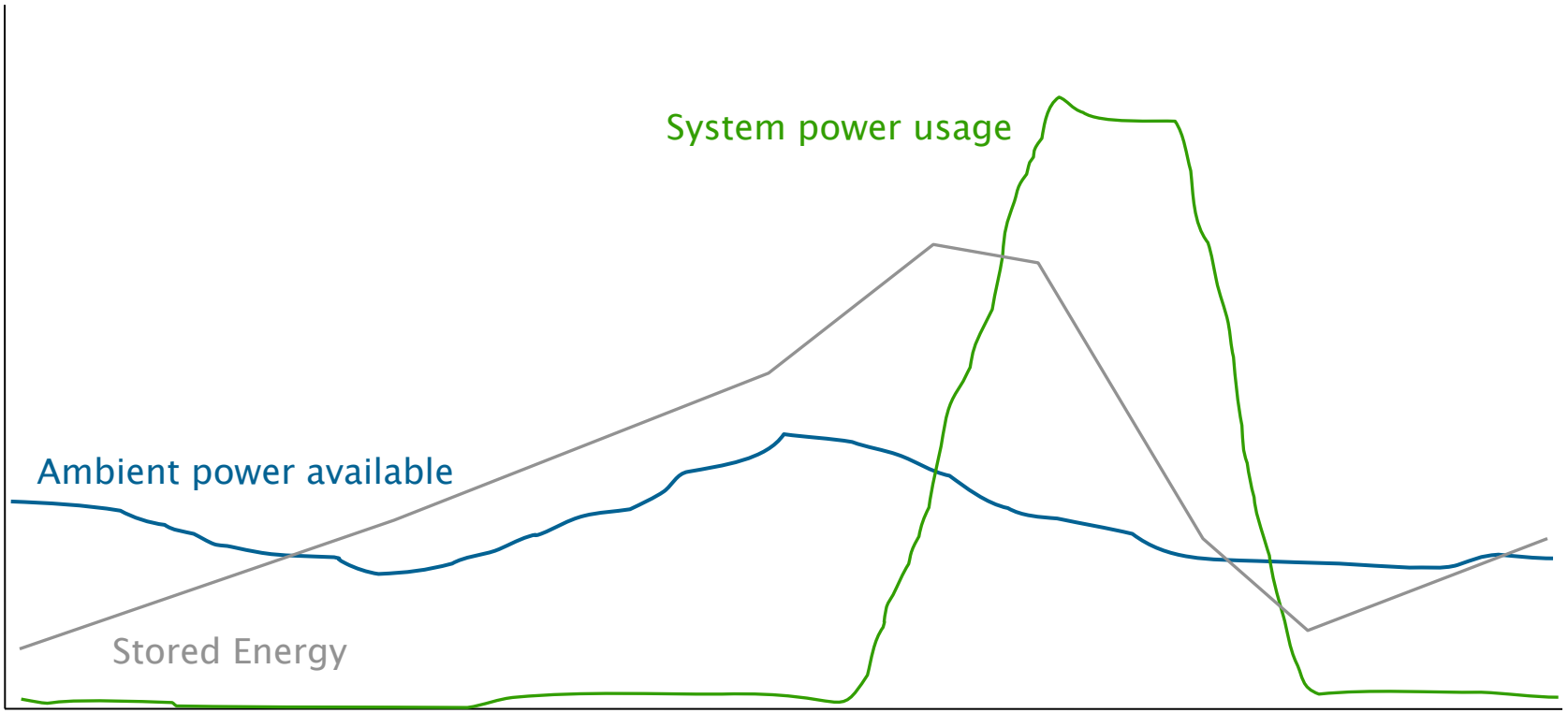


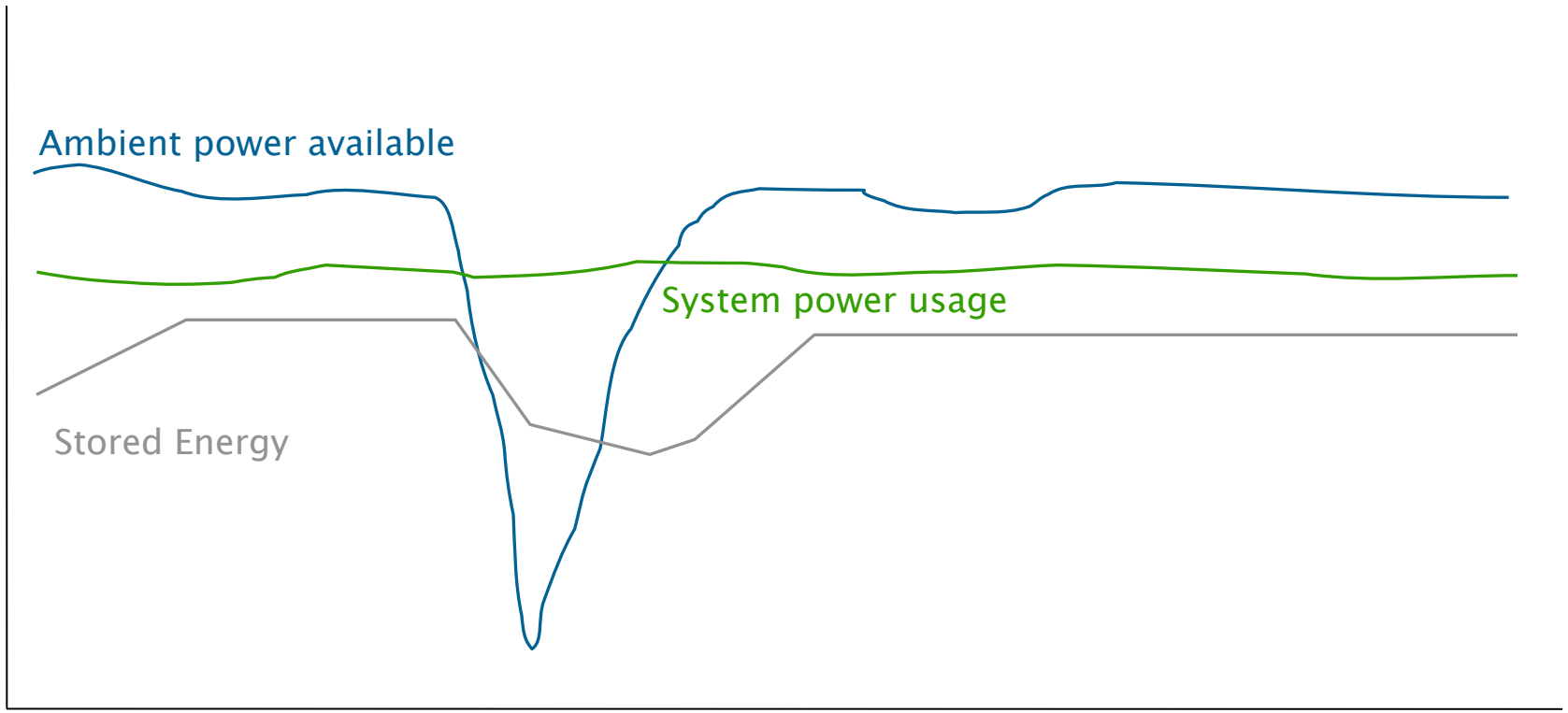
System energy usage is out of phase with ambient availability:



System requires higher momentary power than is available from the environment:



System must handle power fluctuations:

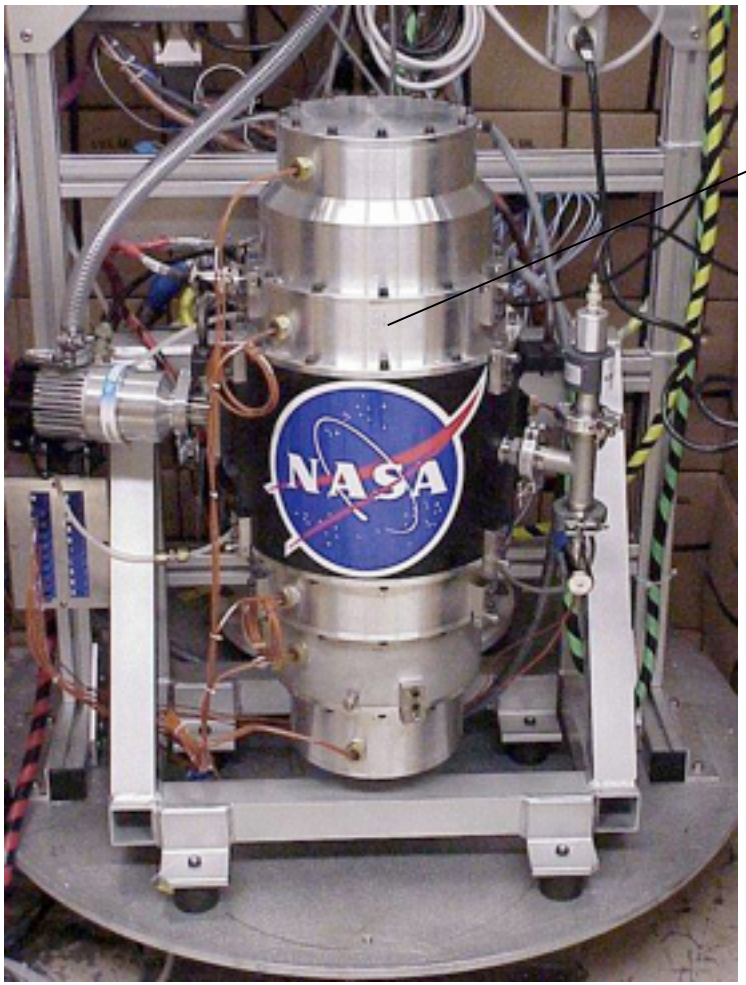


Chemical bonds (in food, firewood, fuel)

Suspended mass

Elastic deformation

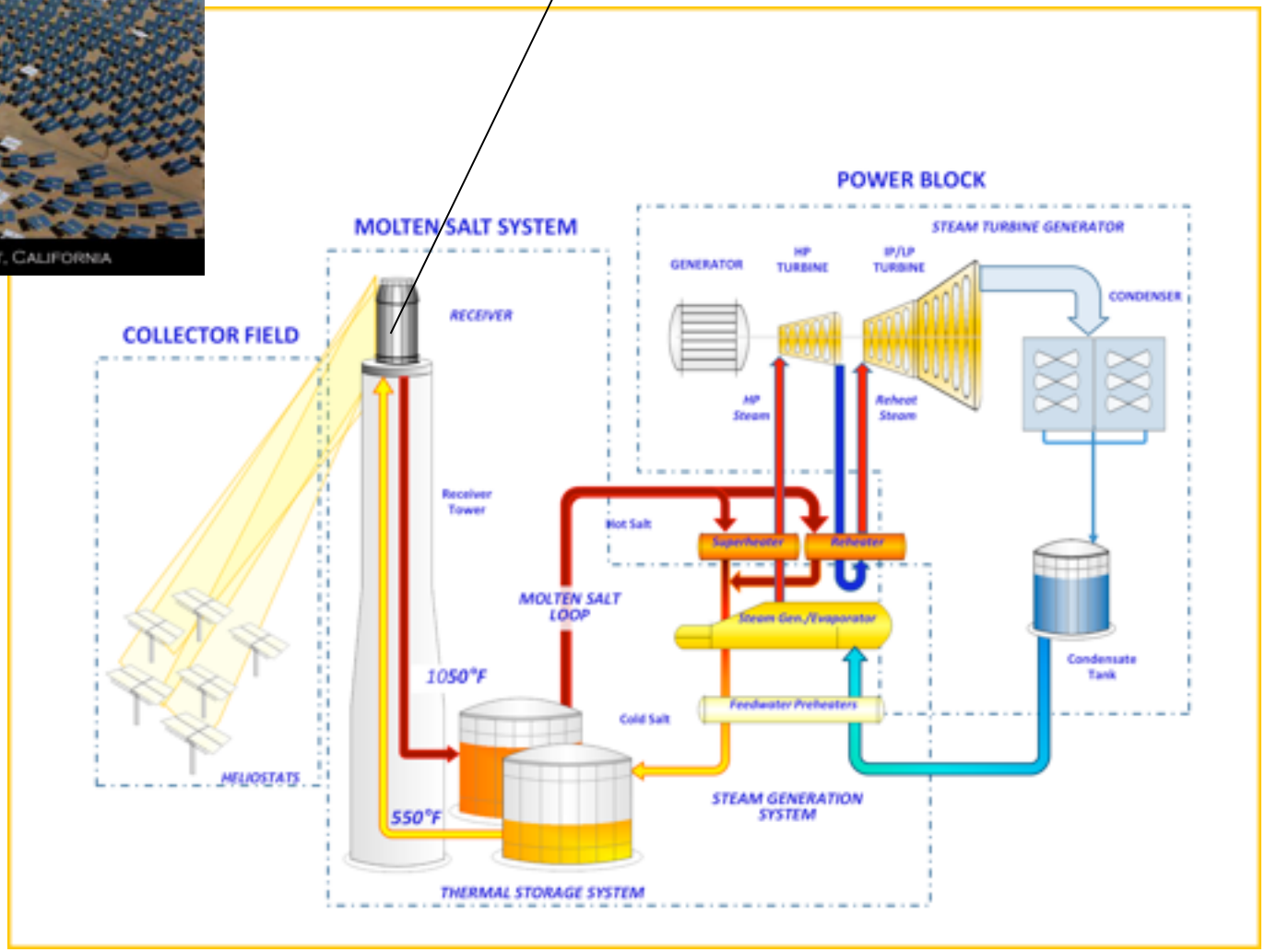
Compressed fluid

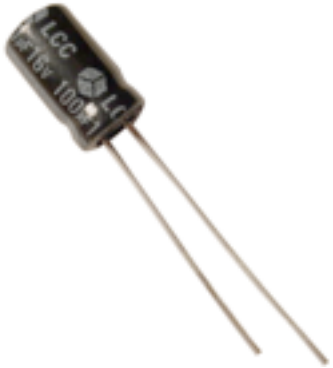


Rotating mass (flywheel)

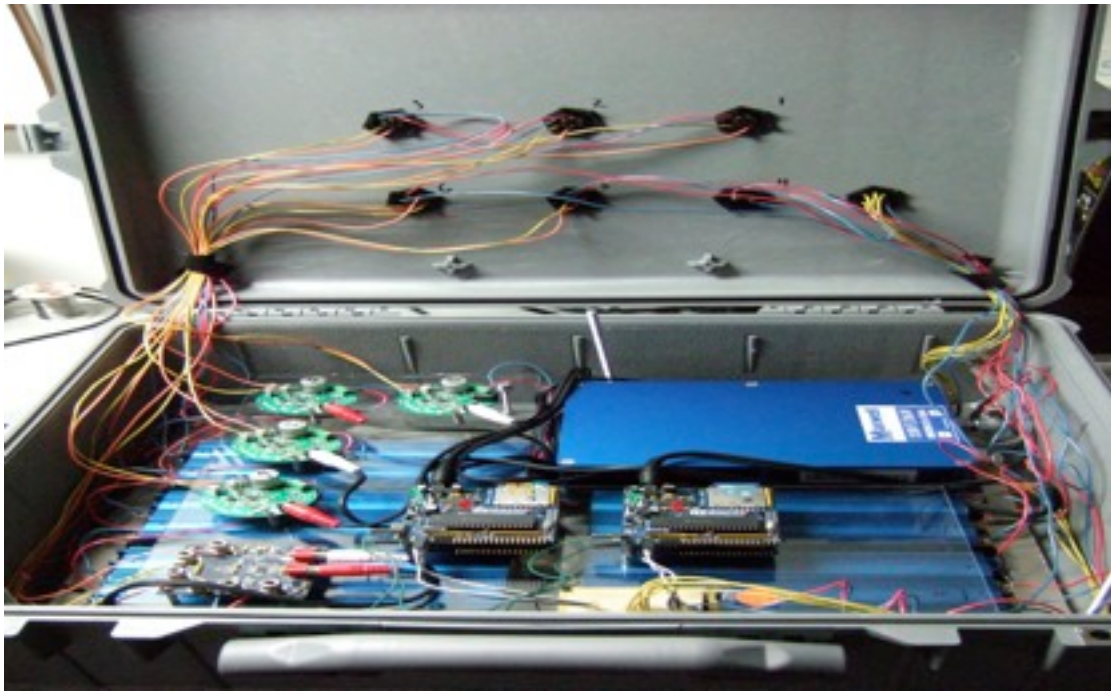

Solar Two - Mojave Desert, California

Heat


POWER BLOCK
MOLTEN SALT SYSTEM
STEAM TURBINE GENERATOR
GENERATOR
HP TURBINE
IP/LP TURBINE
CONDENSER
COLLECTOR FIELD
RECEIVER
HP Steam
Reheat Steam
Receiver Tower
Hot Salt
Superheater
Reheater
MOLTEN SALT LOOP
Steam Gen./Evaporator
Condensate Tank
1050°F
Feedwater Preheaters
Cold Salt
HELIOSTATS
STEAM GENERATION SYSTEM
550°F
THERMAL STORAGE SYSTEM



Electrical potential



Basic concepts for any energy storage:

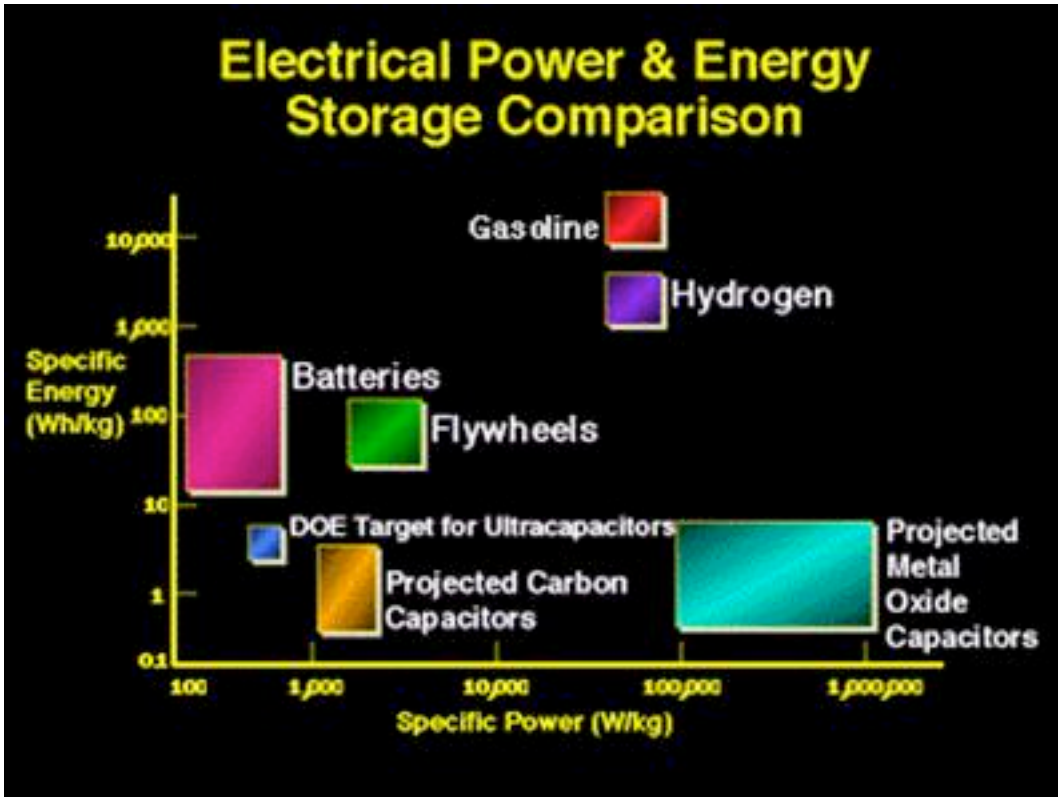
Specific Energy : energy / mass

Energy Density : energy / volume

Specific Power : power (input or output) / mass

Power Density : power (input or output) / volume

Efficiency: energy in / energy out


Electrical Power & Energy Storage Comparison
Gasoline
Hydrogen
Batteries
Flywheels
DOE Target for Ultracapacitors
Projected Carbon Capacitors
Projected Metal Oxide Capacitors
Specific Energy (Wh/kg)
10,000
1,000
100
10
1
0.1
100
1,000
10,000
100,000
1,000,000
Specific Power (W/kg)

NREL

*

Smoothing

.5 * (100 microfarads) * ((5 volts)^2) = 0.00125 joules
More about calculator.

.5 * (3300 microfarads) * ((5 volts)^2) = 0.04125 joules
More about calculator.

.5 * (1 farad) * ((5 volts)^2) = 12.5 joules
More about calculator.

Storage

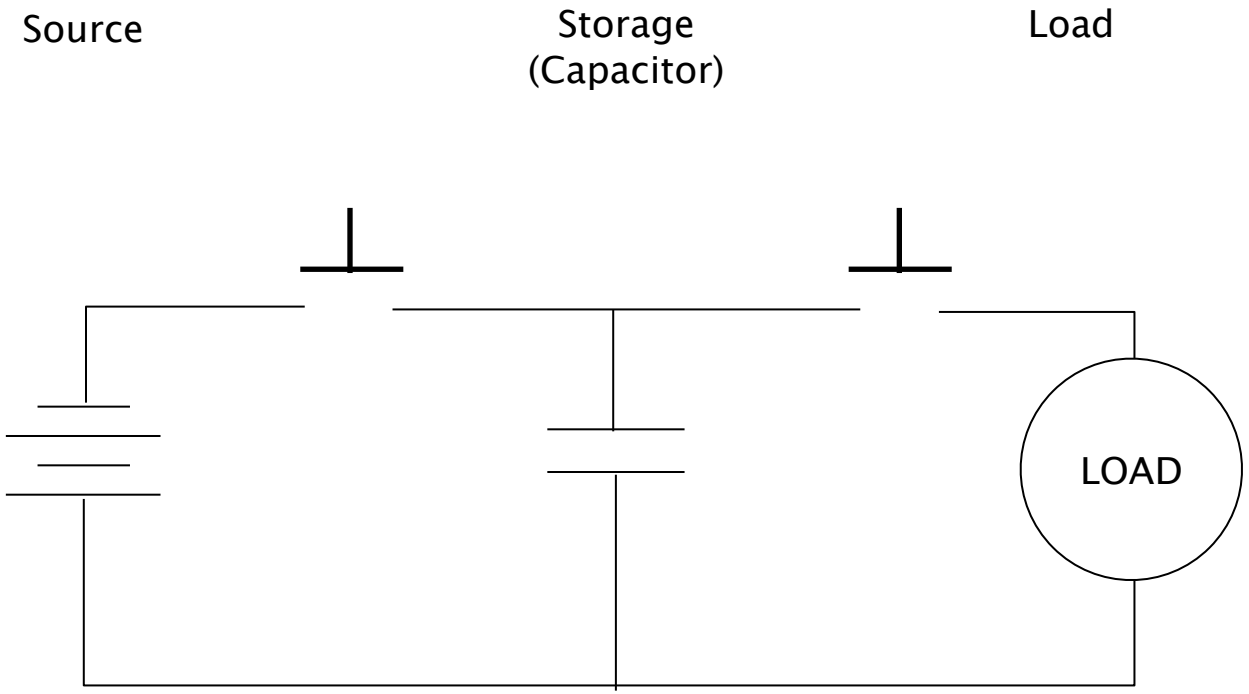
.5 * (60 farad) * ((5 volts)^2) = 750 joules
More about calculator.

Energy in a capacitor is:

$1/2\ C * V^2$

* Would need 2 2.5V caps in series to get 5V.

Lots of joules

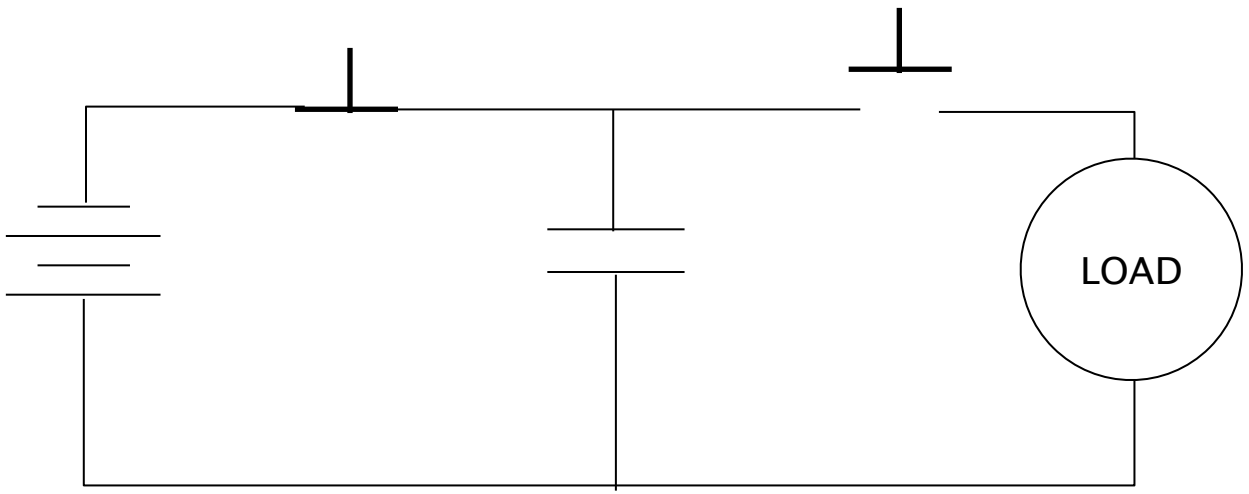

Source
Storage
(Capacitor)
Load
LOAD

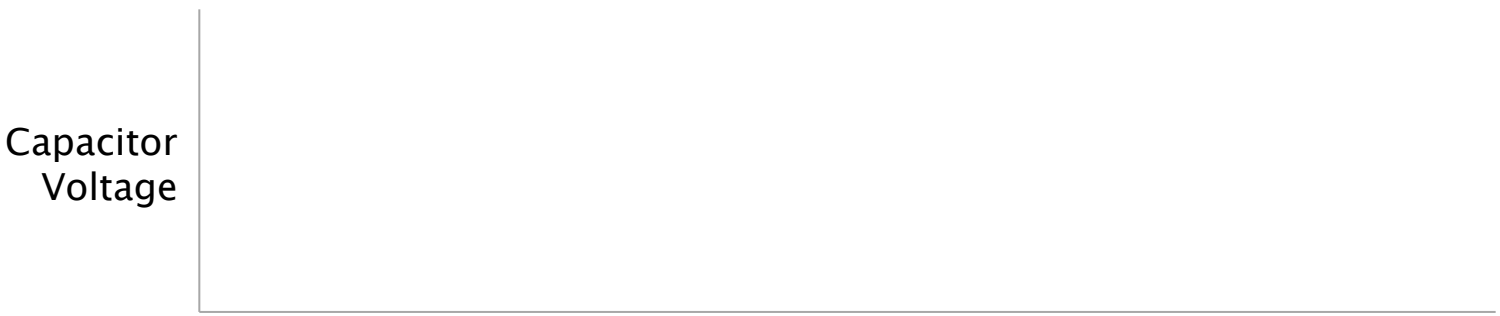
Charging

Source

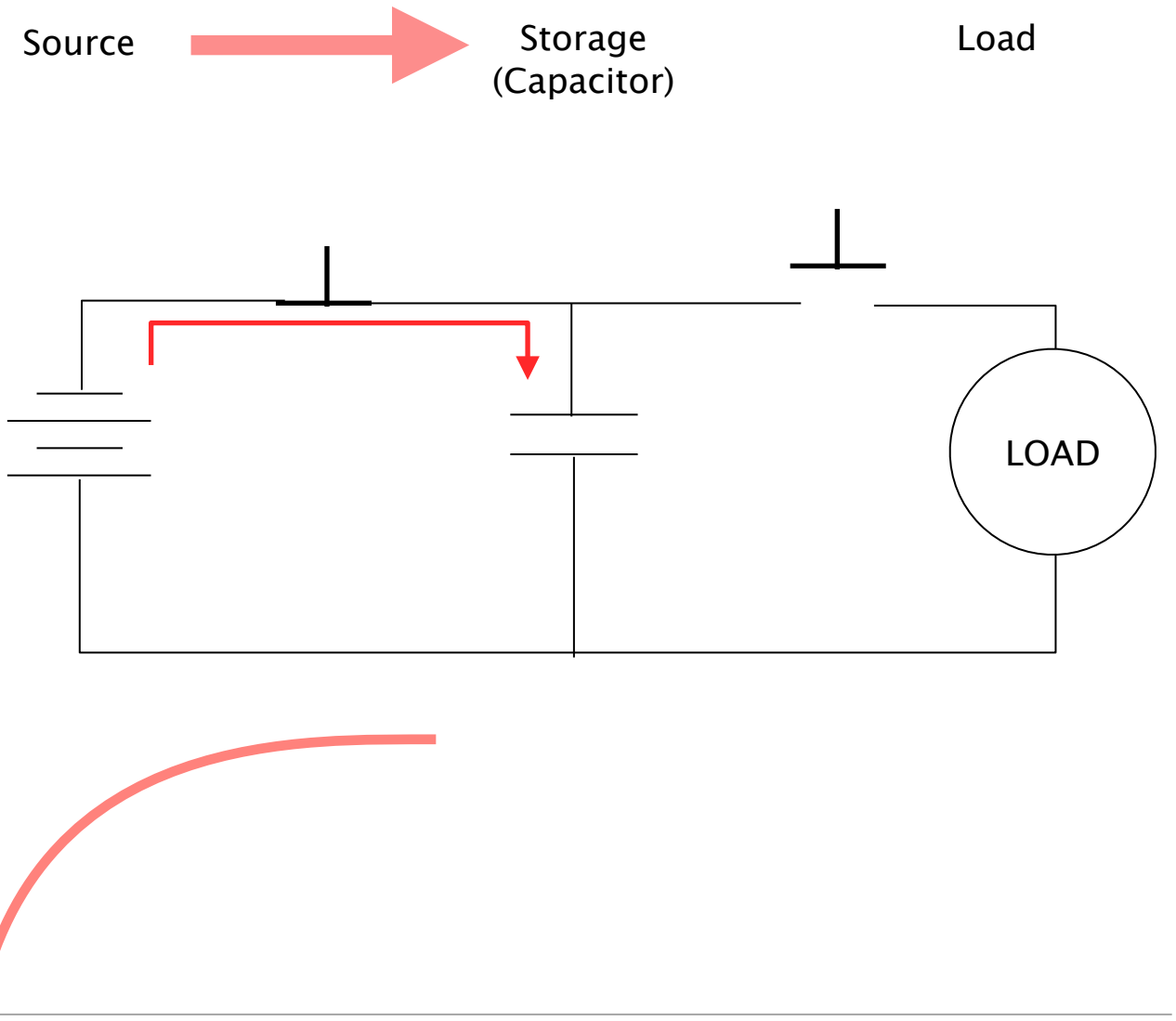
Storage
(Capacitor)

Load





Charging

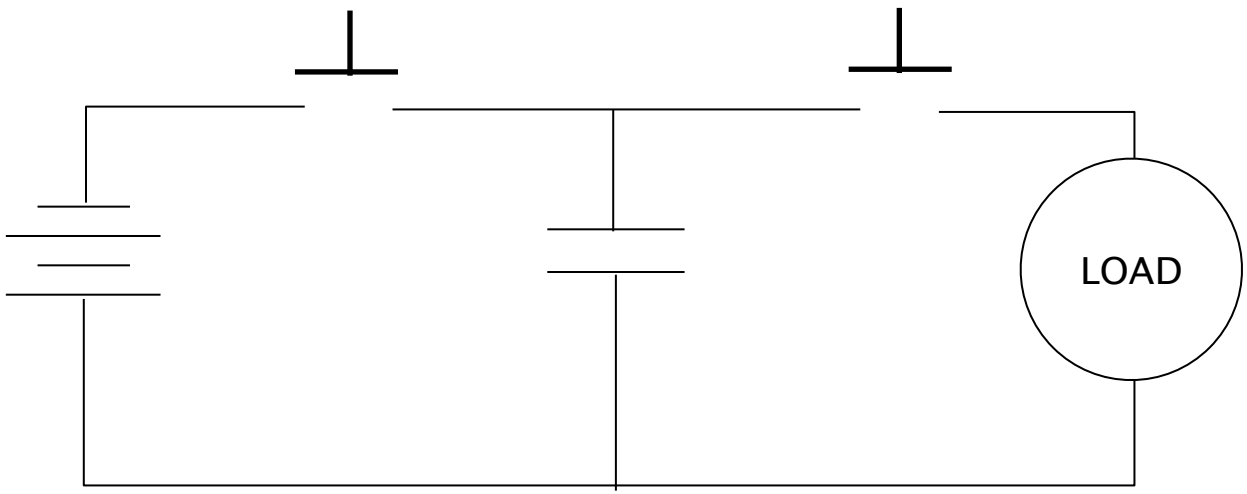


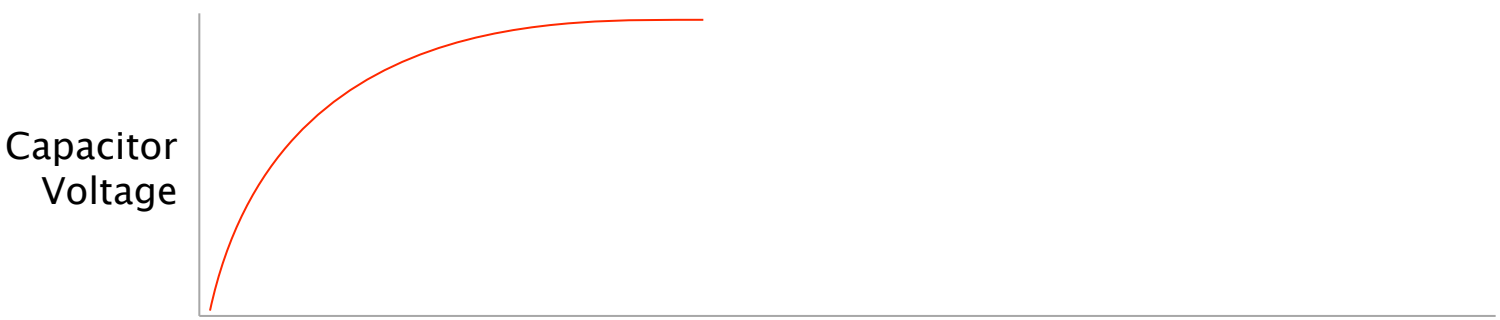
Stasis

Source

Storage
(Capacitor)

Load



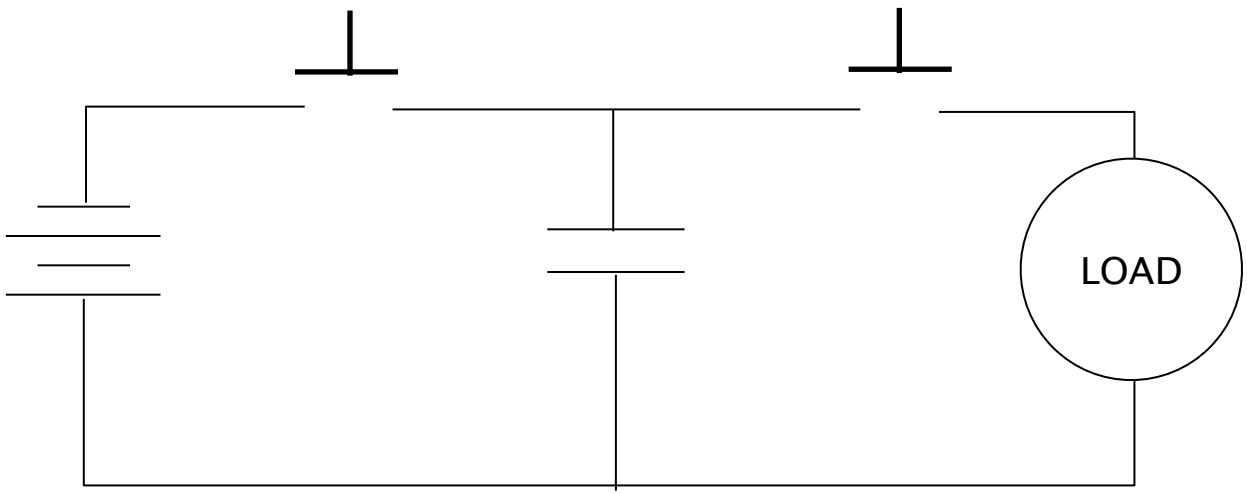


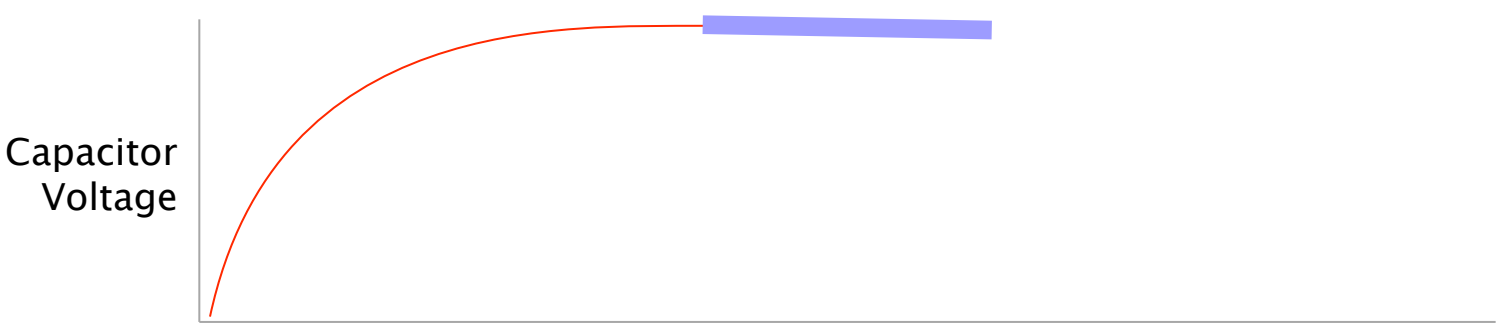
Stasis

Source

Storage
(Capacitor)

Load



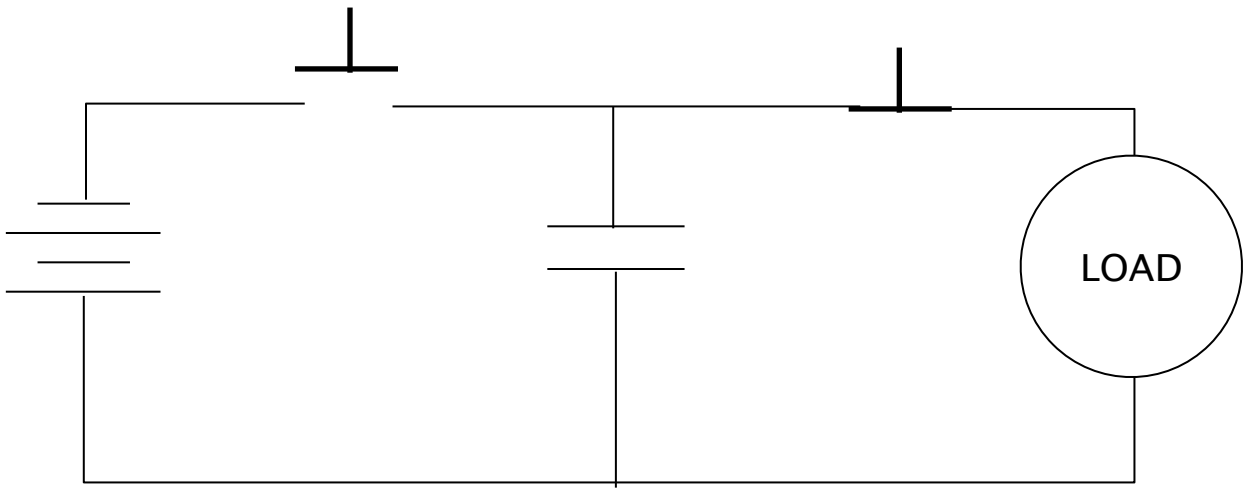


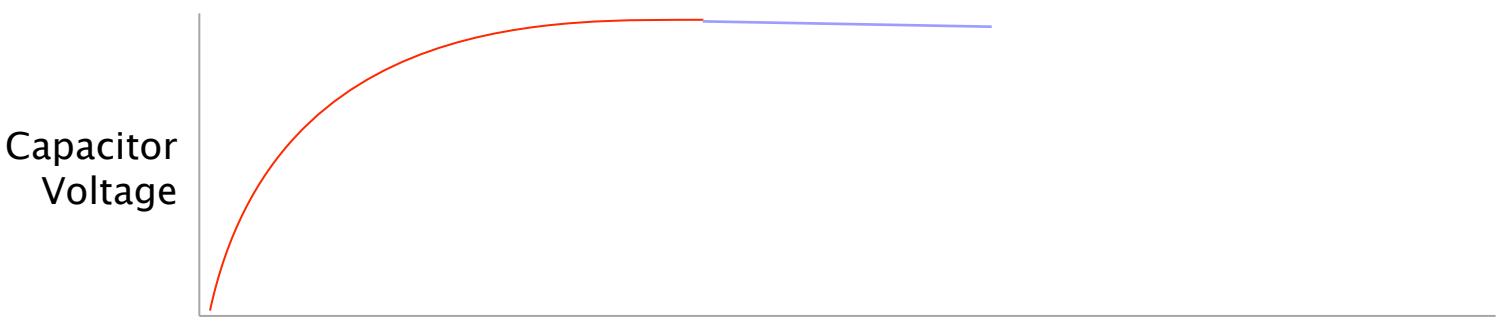
Discharge

Source

Storage
(Capacitor)

Load





Discharge