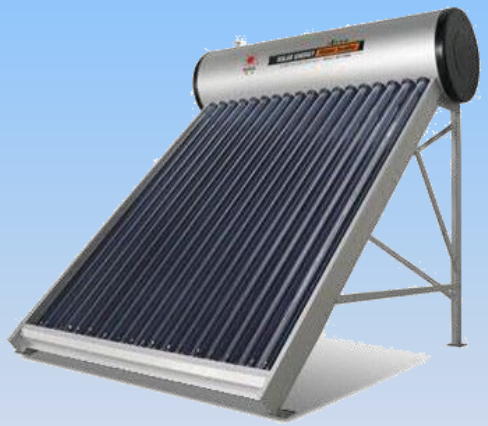
Energy Storage

Alabama Solar Association Meeting

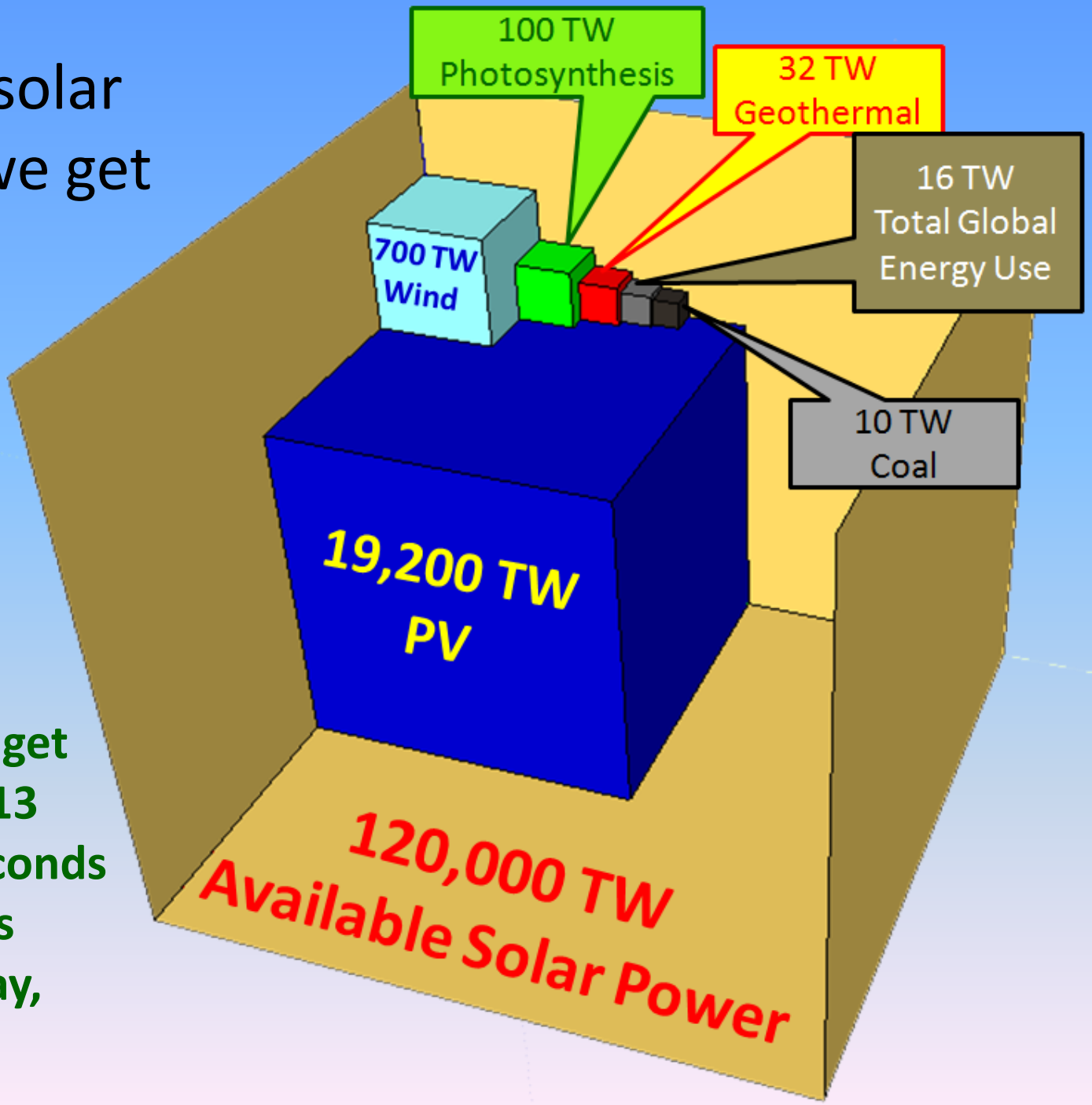
Tuesday, August 15, 2017

Energy Storage



The "Other Half" of ~~solar~~ renewable energy

How much solar energy do we get each day?



With PV alone, we get enough sun every 13 minutes and 20 seconds to meet the world's energy needs all day, every day.

SO WHAT'S THE BUILT-IN I-GOTCHA?

Feast or famine.

Why energy storage?

1. Off grid “end of utility line” savings
2. Self consumption, extend available use time
3. Power failure
4. Peak shaving
5. Energy Arbitrage, time-of-use rate advantage
6. Spinning reserve

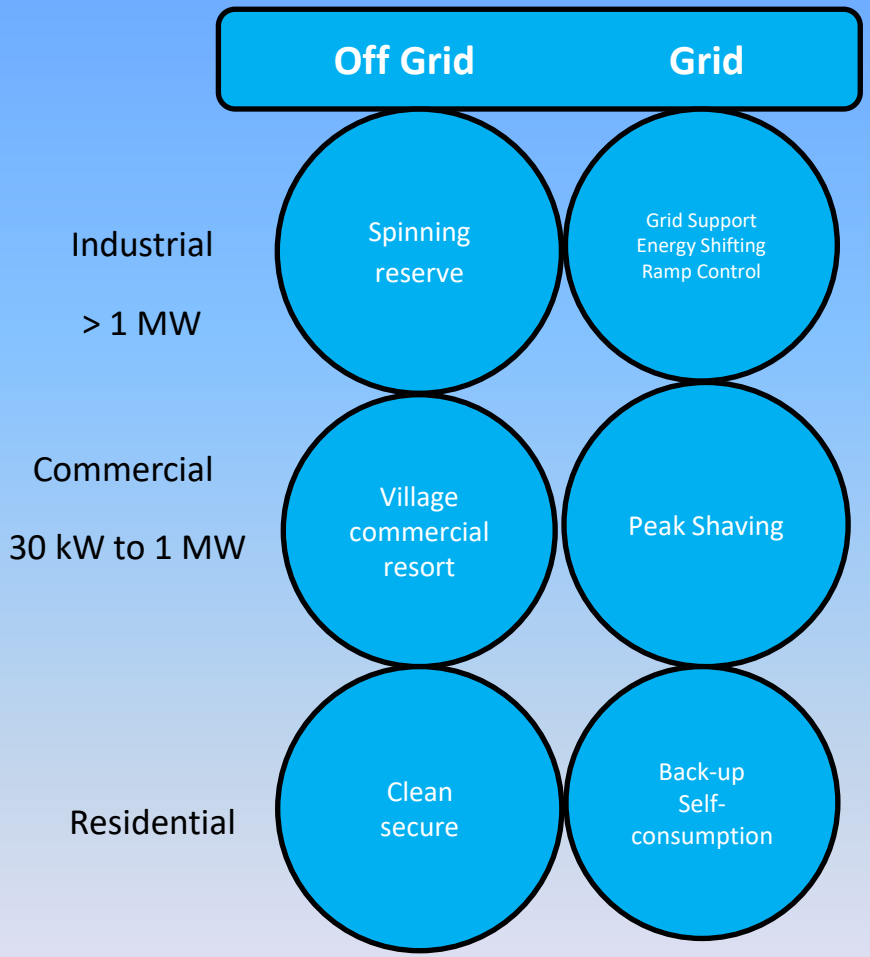
Stacking storage benefits

Why battery storage makes increasing sense:

- ✓ Widespread use of LED lighting reducing per property wattage loads; less demand on battery back up systems.
- ✓ Back up power for:
- ✓ Property LED lighting - lobby, hallways, parking lots, designated property safety areas.
- ✓ Security command and monitoring centers.
- ✓ Low voltage security devices.
- ✓ As common electrical devices and lighting increasingly designed to use less watts, LEDs, it becomes easier to use battery storage to back up these devices.
- ✓ Many other applications; demand response, frequency regulation, self consumption, time of day electricity use/rates.

Flying around the world on solar plus storage

Overview of storage opportunities in each grid type: The Six Pack



Why energy storage?

Category	Applications		Storage Duration
Power Quality & Regulation	Fluctuation Suppression/Smoothing	FS/S	≤ 1 minute
	Dynamic Power Response	DPR	
	Low Voltage Ride Through	LVRT	
	Line Fault Ride Through	LFRT	
	Interruptible Power Supply	UPS	
	Voltage Control Support	VCS	
	Reactive Power Control	RPC	
	Oscillation Damping	OD	
	Transient Stability'	TS	
	Spinning/Contingency Reserves	S/CR	1 minute to 1 hour
Bridging Power	Ramping	R	
	Emergency Backup	EB	
	Load Following	LF	
	Wind Power Smoothing	WPS	
Energy Management	Peak Shaving/Generation/Time Shift	PS/G/TS	1- 10 hours
	Transmission Curtailment	TC	5 - 12 hours
	Energy Arbitrage	EA	
	Transmission & Distribution Deferral	TDD	
	Line Repair	LR	
	Load Cycling	LC	
	Weather Smoothing	WS	
	Unit Commitment	uc	hours - days
	Load Leveling	LL	
	Capacity' Firming	CF	
	Renewable Integration and Backup	RIB	
	Seasonal Storage	SS	≥ 4 months
	Annual Smoothing	AS	

27 Reasons why I Love Energy Storage

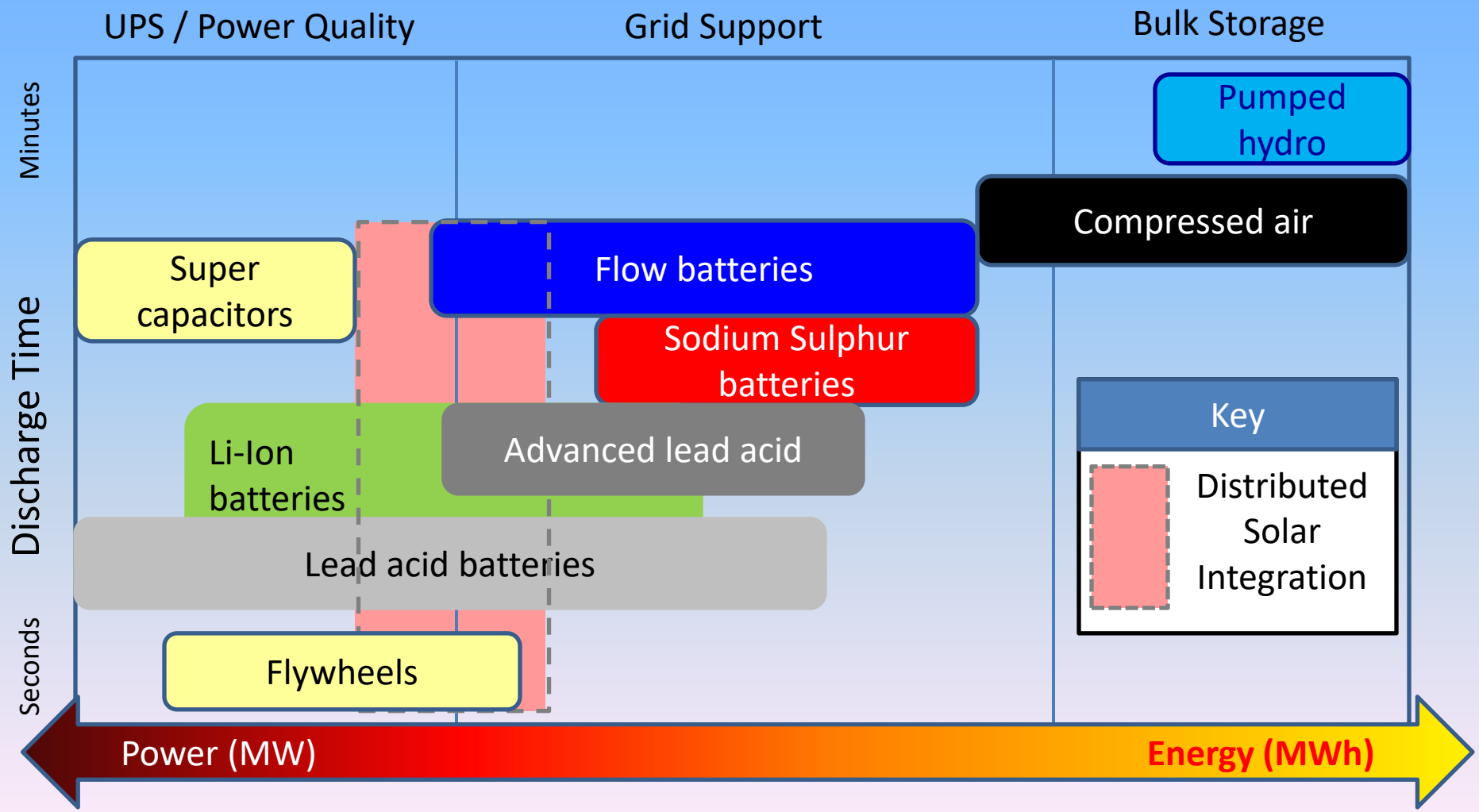
Where storage?

- ✓Behind the meter
- ✓Utility side

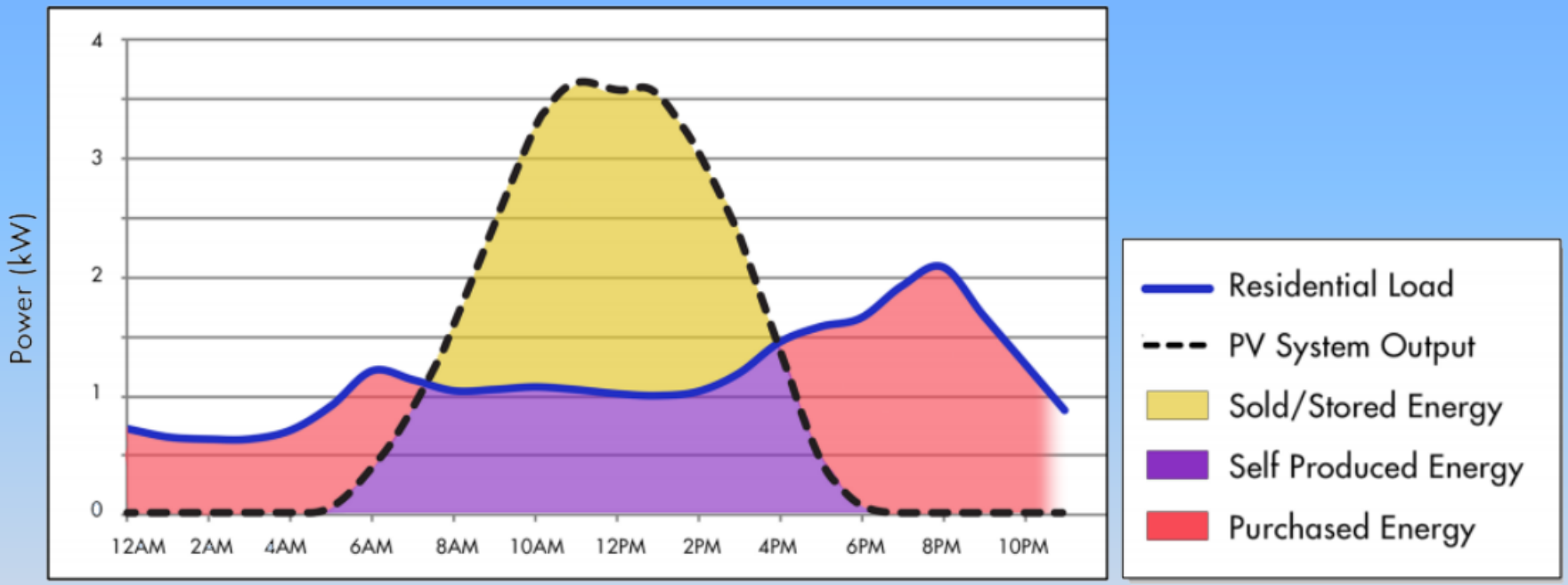
Some Terms:

- ✓ Behind The Meter: A renewable energy generating or storage facility that is on the owner's property, not on the side of the utility electric grid.
- ✓ Black start: Restarting a grid from a total failure or shutdown
- ✓ Distribution Deferral: Delaying, reducing the size of, or entirely avoiding utility investments in distribution system upgrades necessary to meet projected load growth on specific regions of the grid.
- ✓ Energy: The amount of energy generated over time (kWh)
- ✓ Power: The capacity to generate energy (kW)
- ✓ Non-spinning reserve: Generation capacity that can respond to contingency events within a short period, typically less than ten minutes, but is not instantaneously available
- ✓ Spinning reserve: Capacity on the grid that is readily available to support loads. Storage reacts much faster than conventional sources.

How Energy Storage

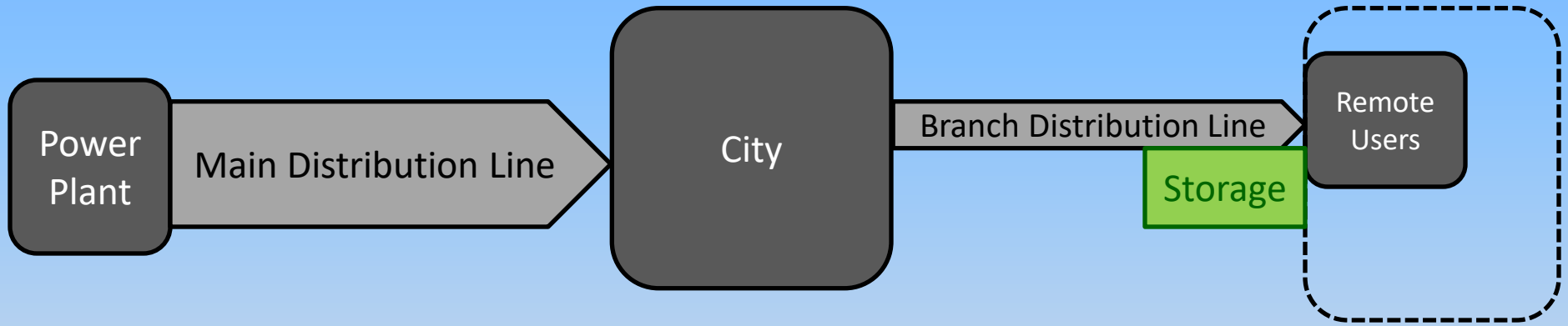


The Duck Curve



To Solve 'Duck Curve,' Missouri Utility to Pay Bonus for West-Facing Solar Panels

Congestion


Power Plant
Main Distribution Line
City
Branch Distribution Line
Storage
Remote Users

About Brand Names

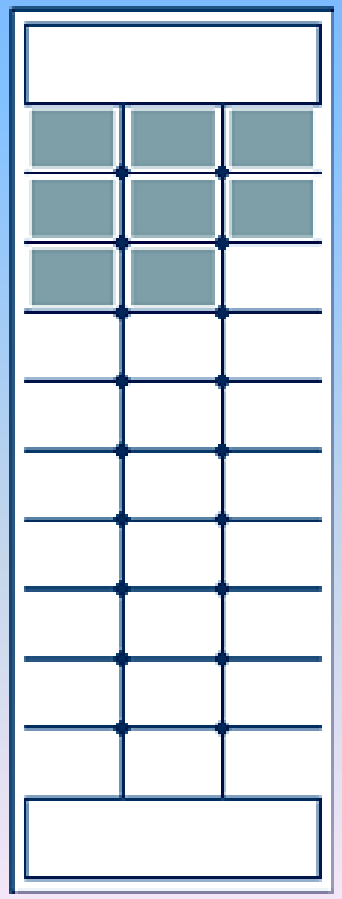
- Brands are for examples, I do not recommend one brand over another:
  - Nobody pays me.
  - Unethical
  - Things change
- Do your own research as you build.

About Energy Storage & TVA

Battery Storage

Integrated Solar Storage

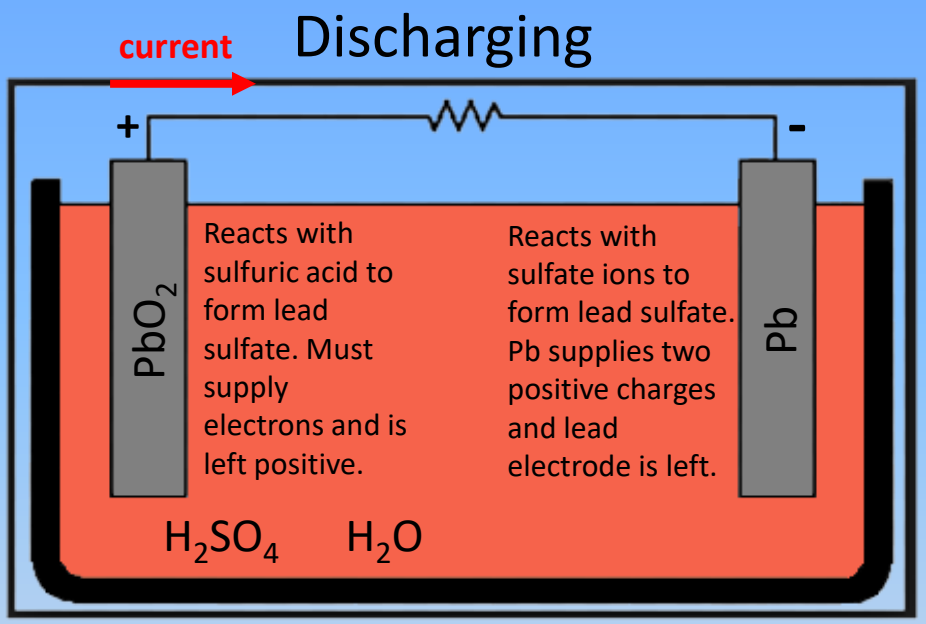
VARTA

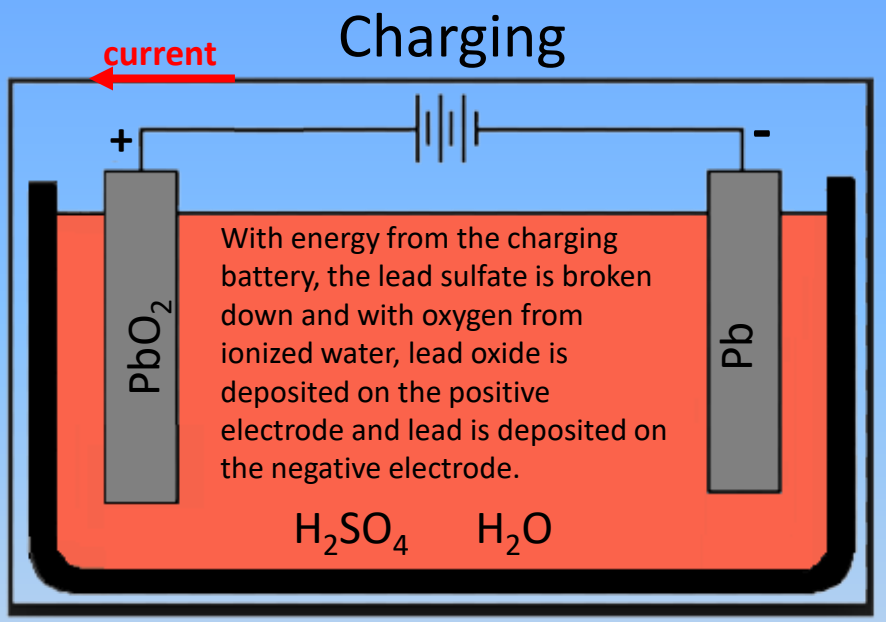


Tesla 20 MW/80 MWh Powerpack system

Enough energy to power more than 2,500 households for a day or charge 1,000 Tesla vehicles

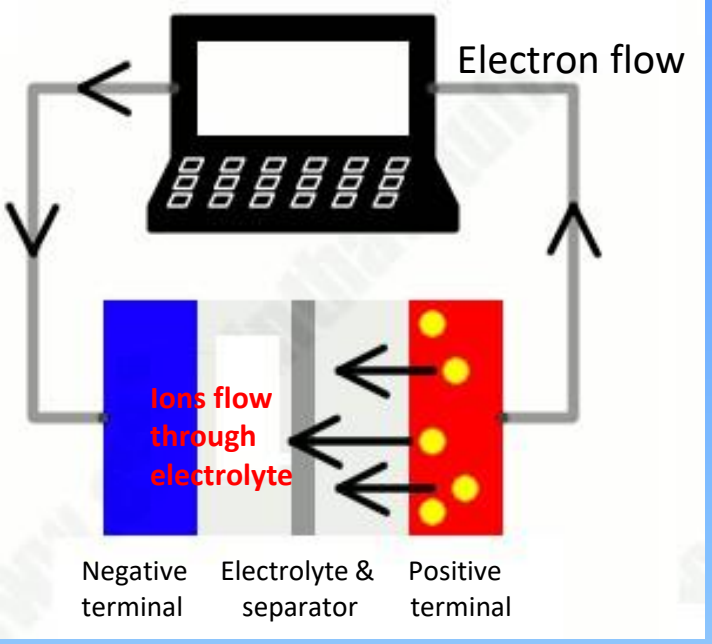
Battery Storage

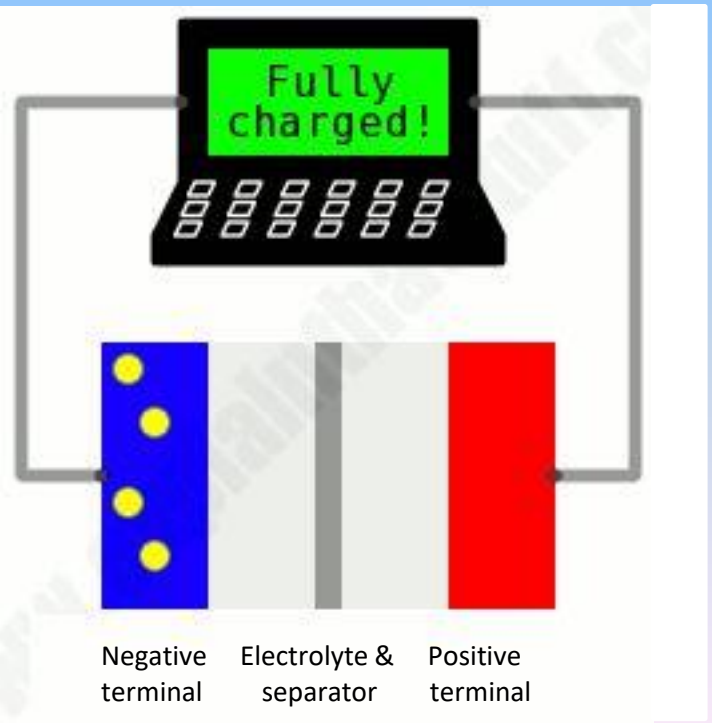




Batteries, regardless of technology, store electricity through chemical reactions.

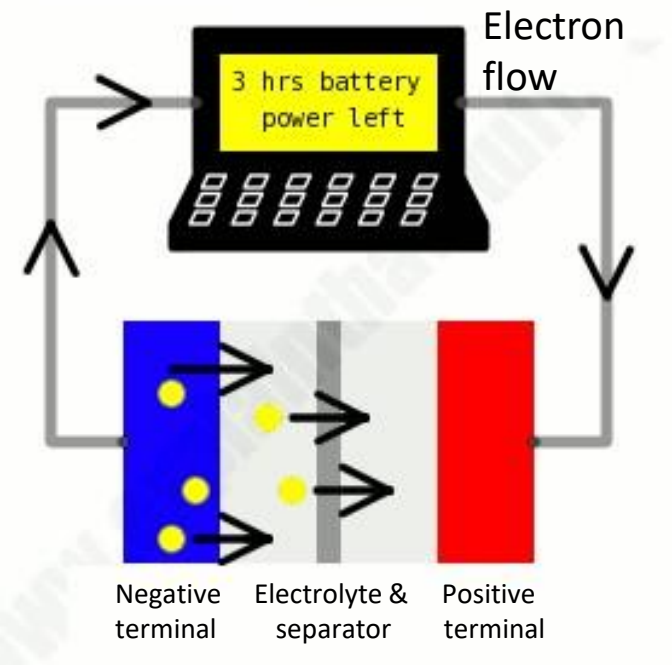
Lithium Ion Battery Operation

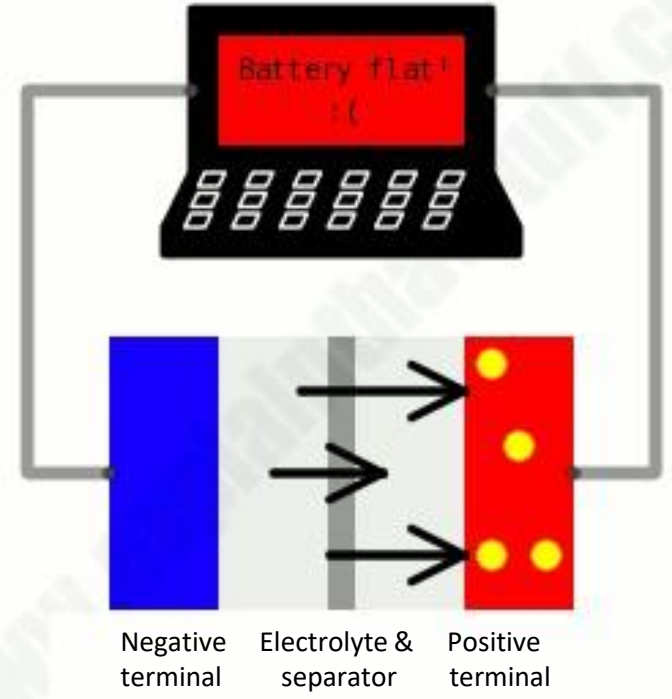




- ✓ During charging, lithium ions (yellow circles) flow from the positive electrode (red) to the negative electrode (blue) through the electrolyte (gray). Electrons also flow from the positive electrode to the negative electrode, but take the longer path around the outer circuit. The electrons and ions combine at the negative electrode and deposit lithium there.

- ✓ When no more ions will flow, the battery is fully charged and ready to use.

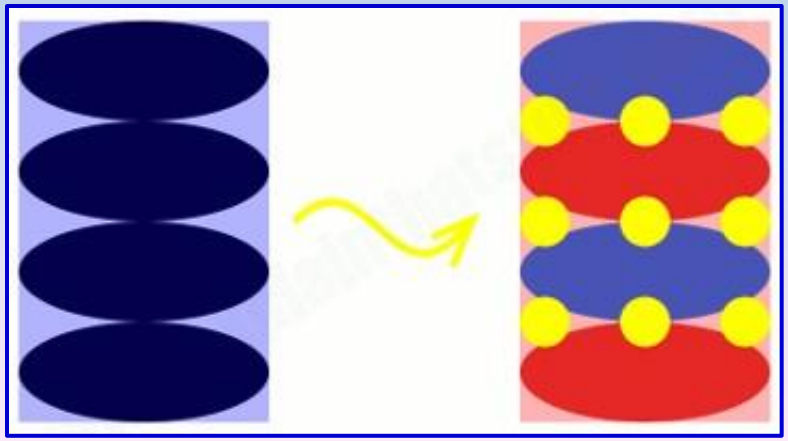




Lithium Ion Battery Operation

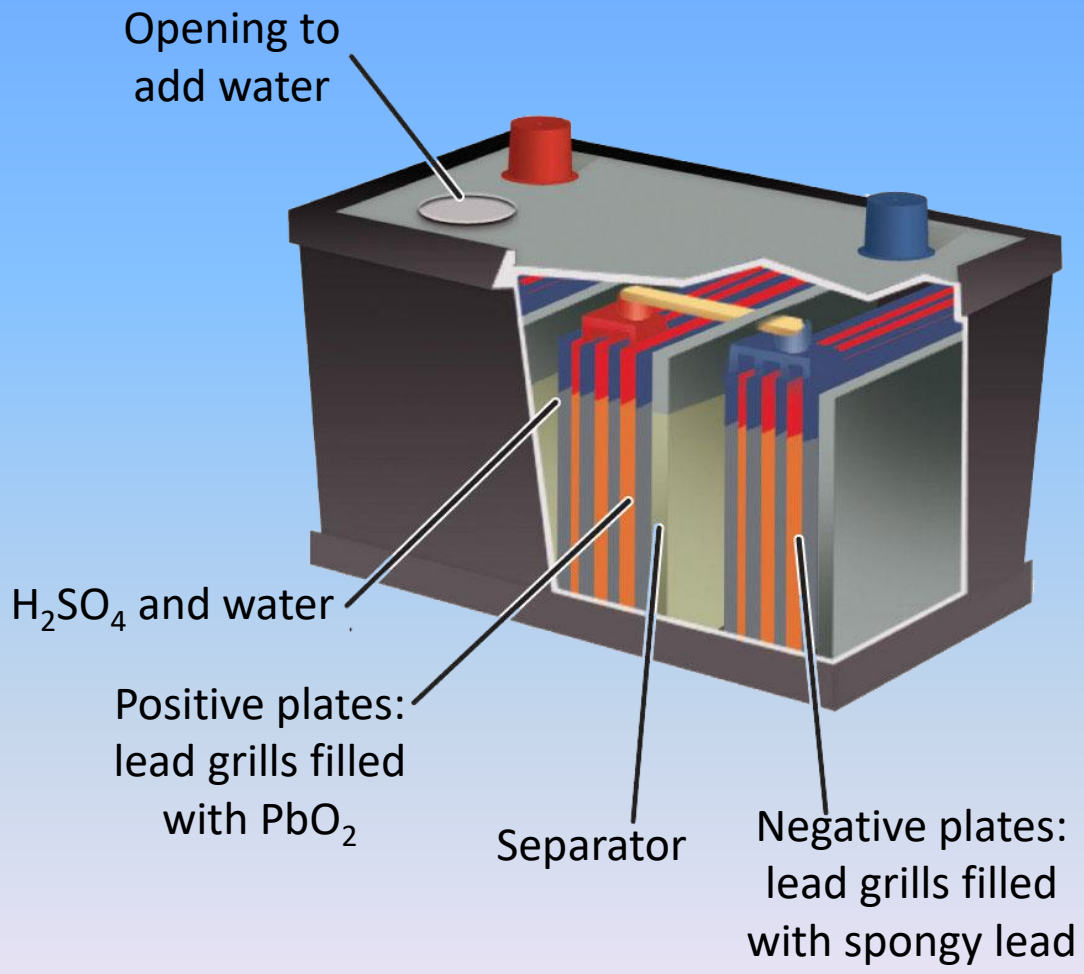
- ✓ During discharging, the ions flow back through the electrolyte from the negative electrode to the positive electrode. Electrons flow from the negative electrode to the positive electrode through the outer circuit, powering your laptop. When the ions and electrons combine at the positive electrode: lithium is deposited there.

- ✓ When all the ions have moved back, the battery is fully discharged and needs charging up again.

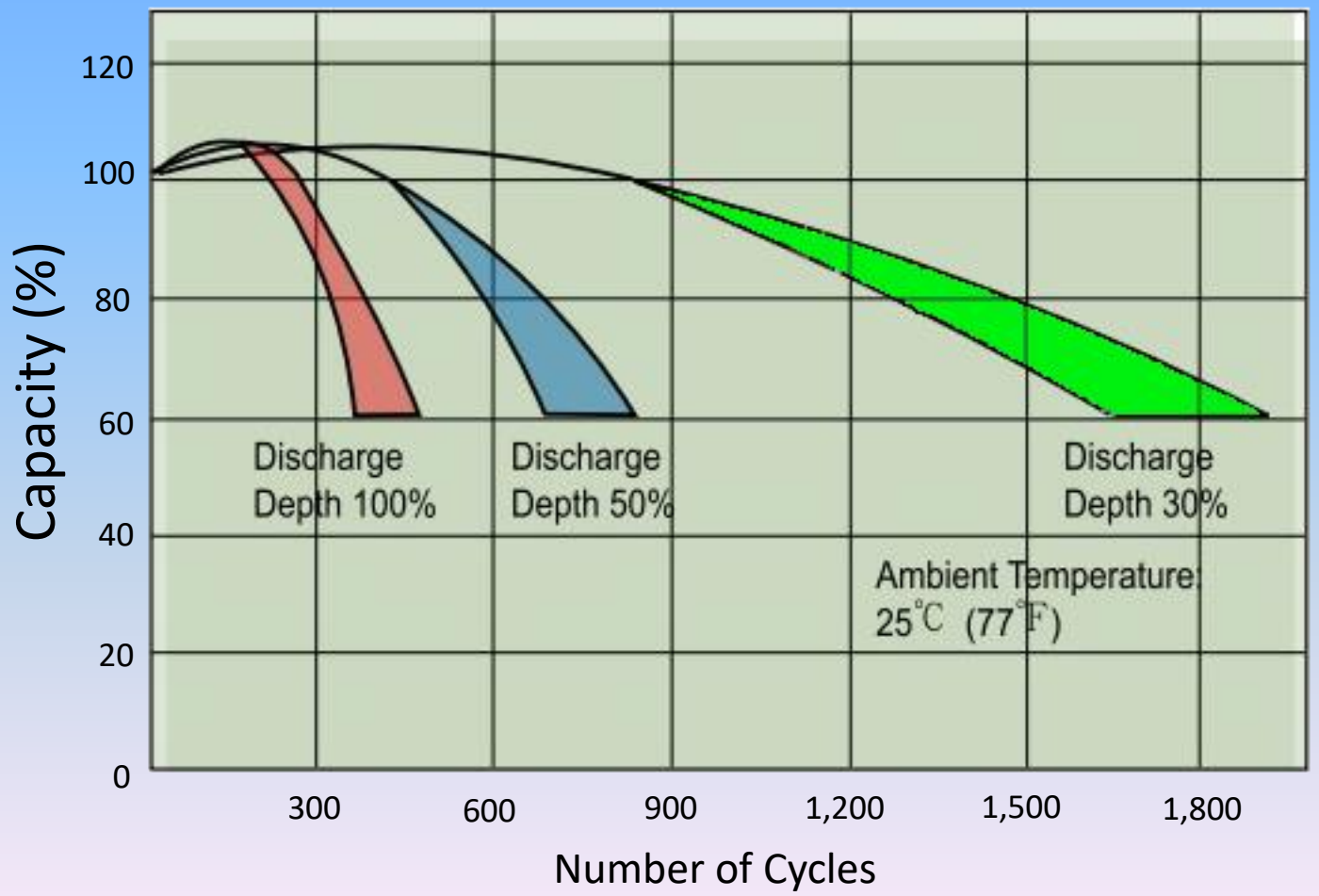


Lithium- ion Storage for a Wind Farm

Deep Cycle, Lead-Acid Battery



Capacity vs. Life of a Valve-Regulated, Lead-Acid Battery



Battery Life

Battery life

Depends on:

- ✓ Technology
- ✓ Time
- ✓ Depth of discharge
- ✓ How often you use them
- ✓ Maintenance

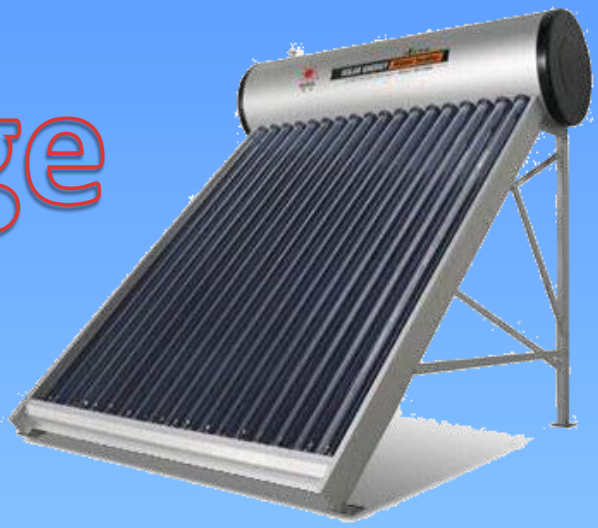
How do years compare to cycles?

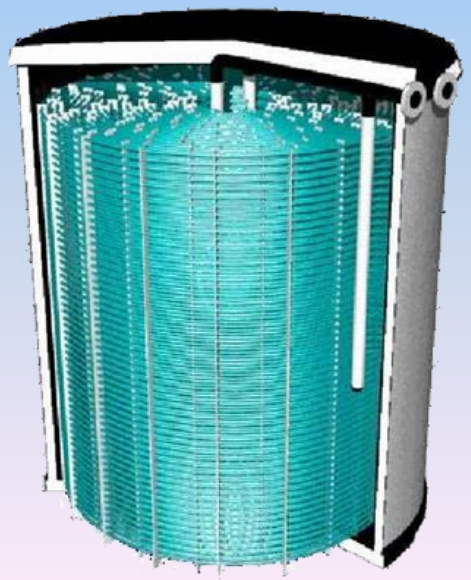
Battery Life		
Use	450 cycles 100% DoD	1,800 cycles 30% DoD
Once a month	10 Yr	10 Yr
Once a week	8.7 Yr	10 Yr
Daily	1.2 Yr	4.9 Yr

Technologies

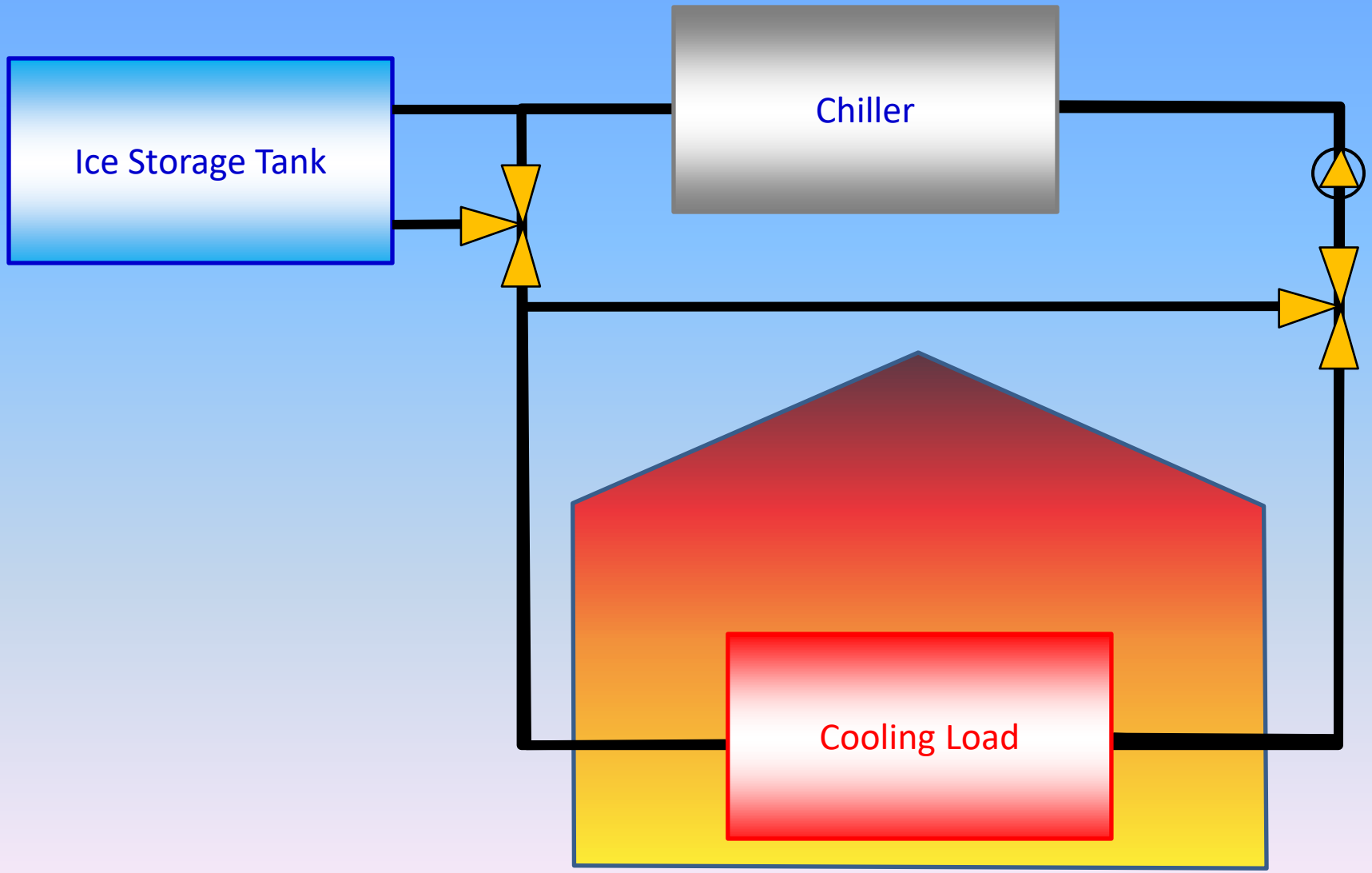
- ✓ Lead acid
  - Flooded, lease expensive, high maintenance, long life if well maintained
  - Valve-regulated, no maintenance, lower life than flooded lead-acid
  - Nano carbon, deep discharge, medium cost, long life
- ✓ Lithium ion, deep discharge, long life, highest energy per square foot, expensive

Heat Storage

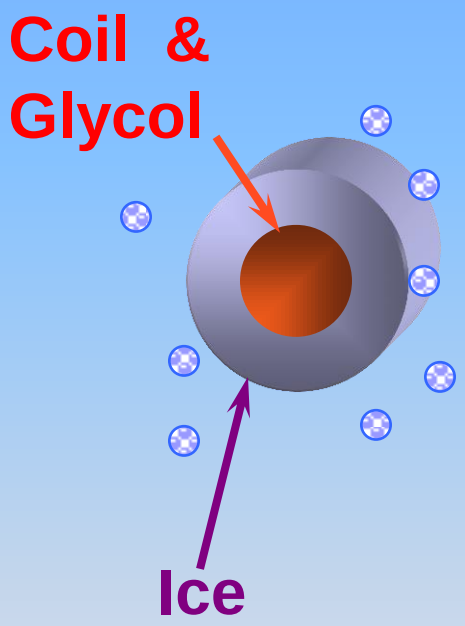


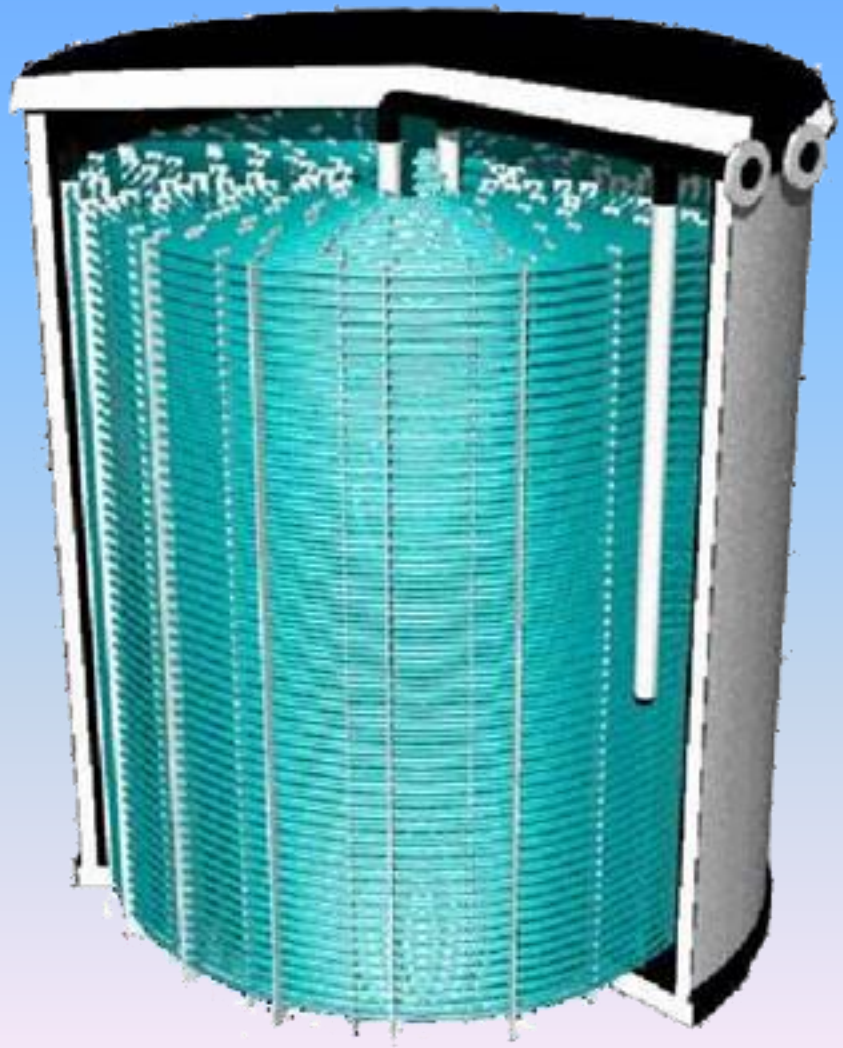


Ice Storage



Ice Storage



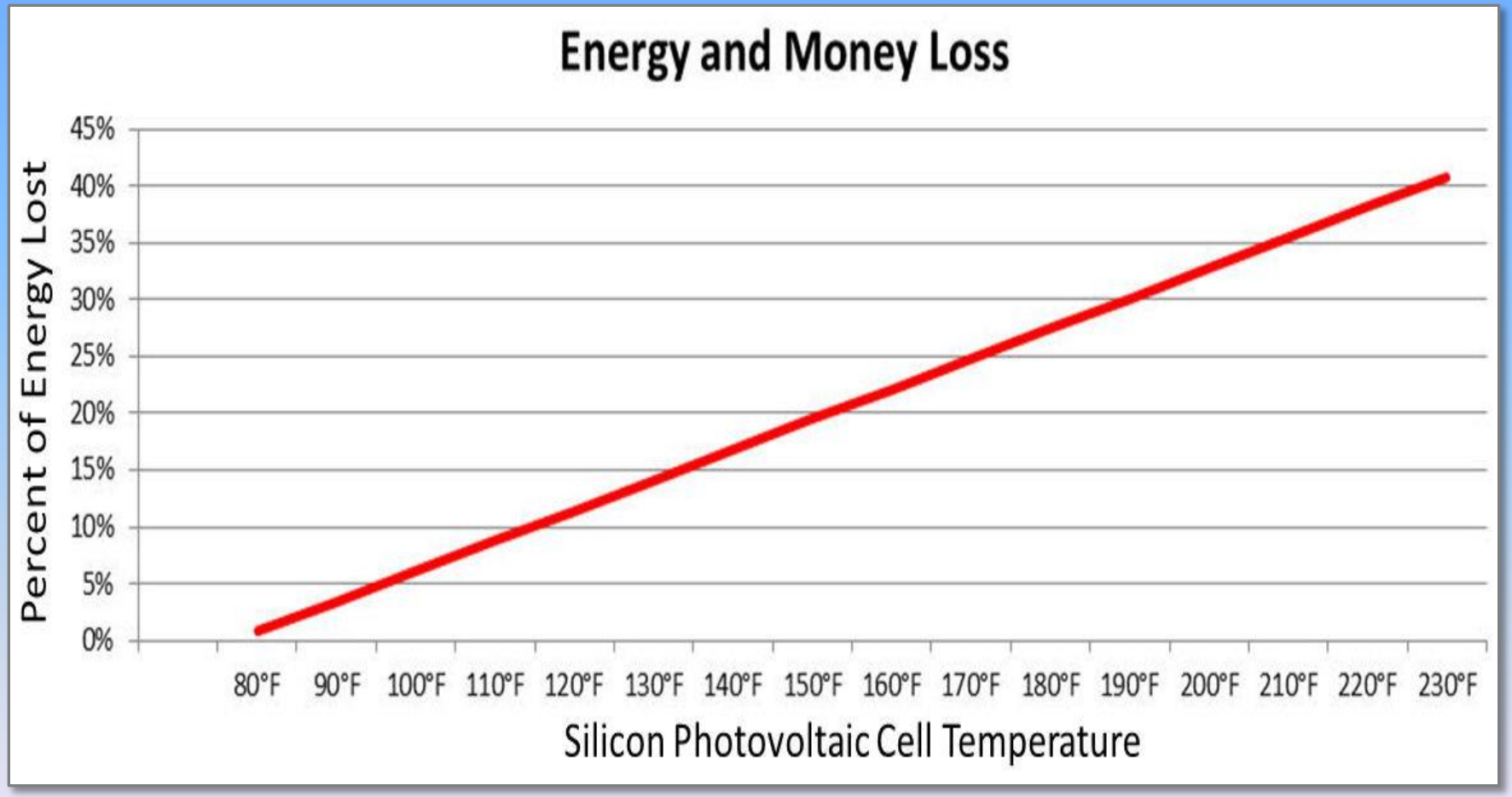


Benefits of Ice Storage Systems

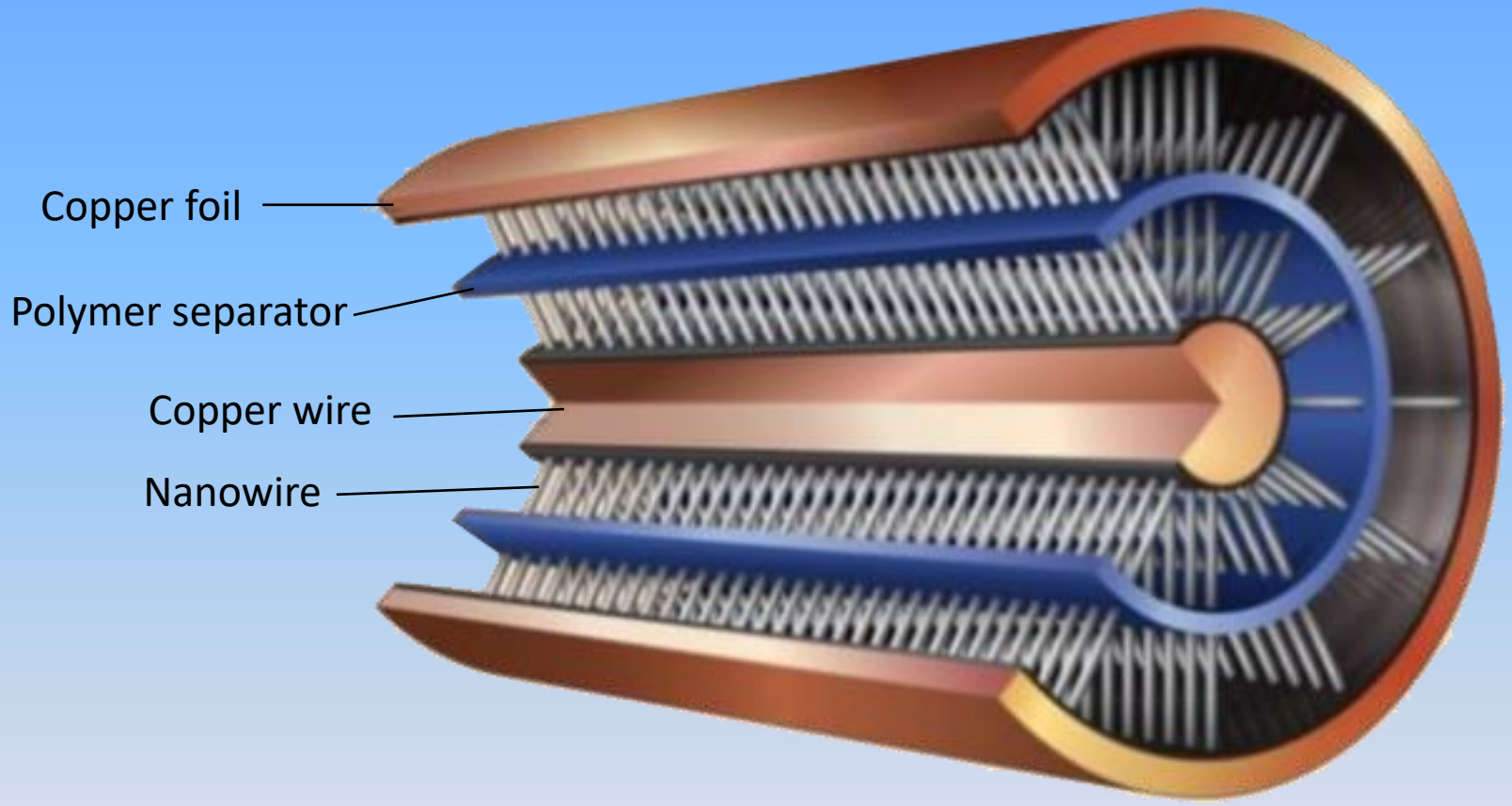
- ✓ Reduced Energy Costs
  - Use the least expensive power available... solar-generated electricity, off peak electricity
- ✓ Chiller maintenance done during the day with no loss of cooling
- ✓ LEED Points available
- ✓ Have the ability to reduce peak load; a requirement of ASHRAE 189- High Performance Buildings
- ✓ Back up Cooling source in case of loss of power. Generator sized for airside and pumps; not the chiller
- ✓ Reduced Chiller Tonnage means more full load hours for your chillers and less low-load cycles.

Ice Storage Systems

Solar Module Efficiency

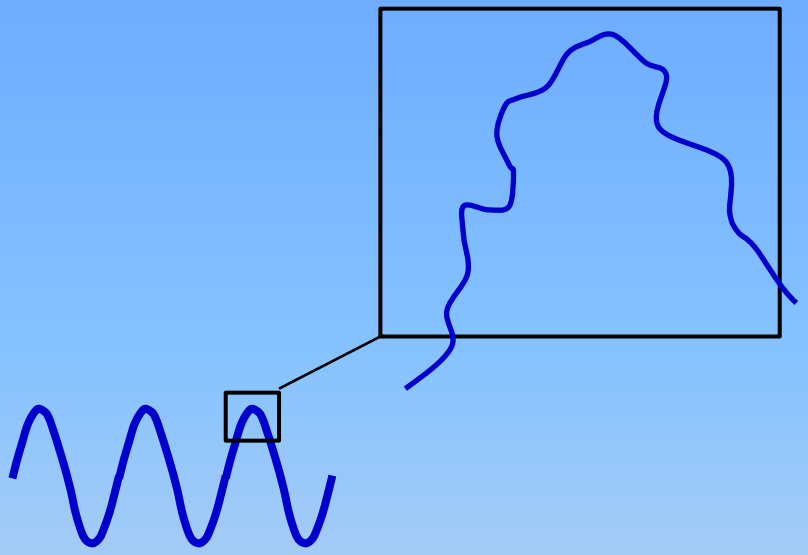


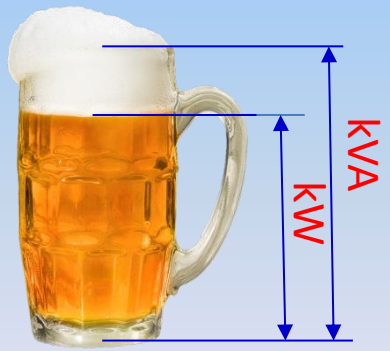
Capacitor Storage



Capacitors

- ✓Energy storage
- ✓Power conditioning
- ✓Power factor correction
- ✓Motor starters

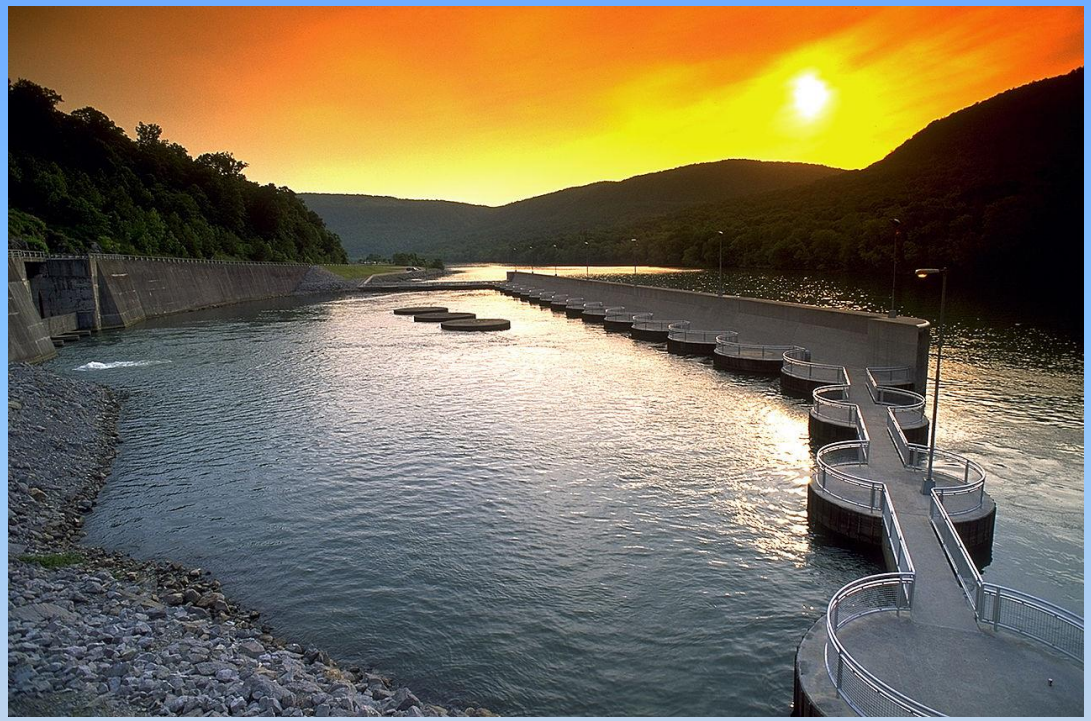




PF = kW / kVR

Hydro Storage

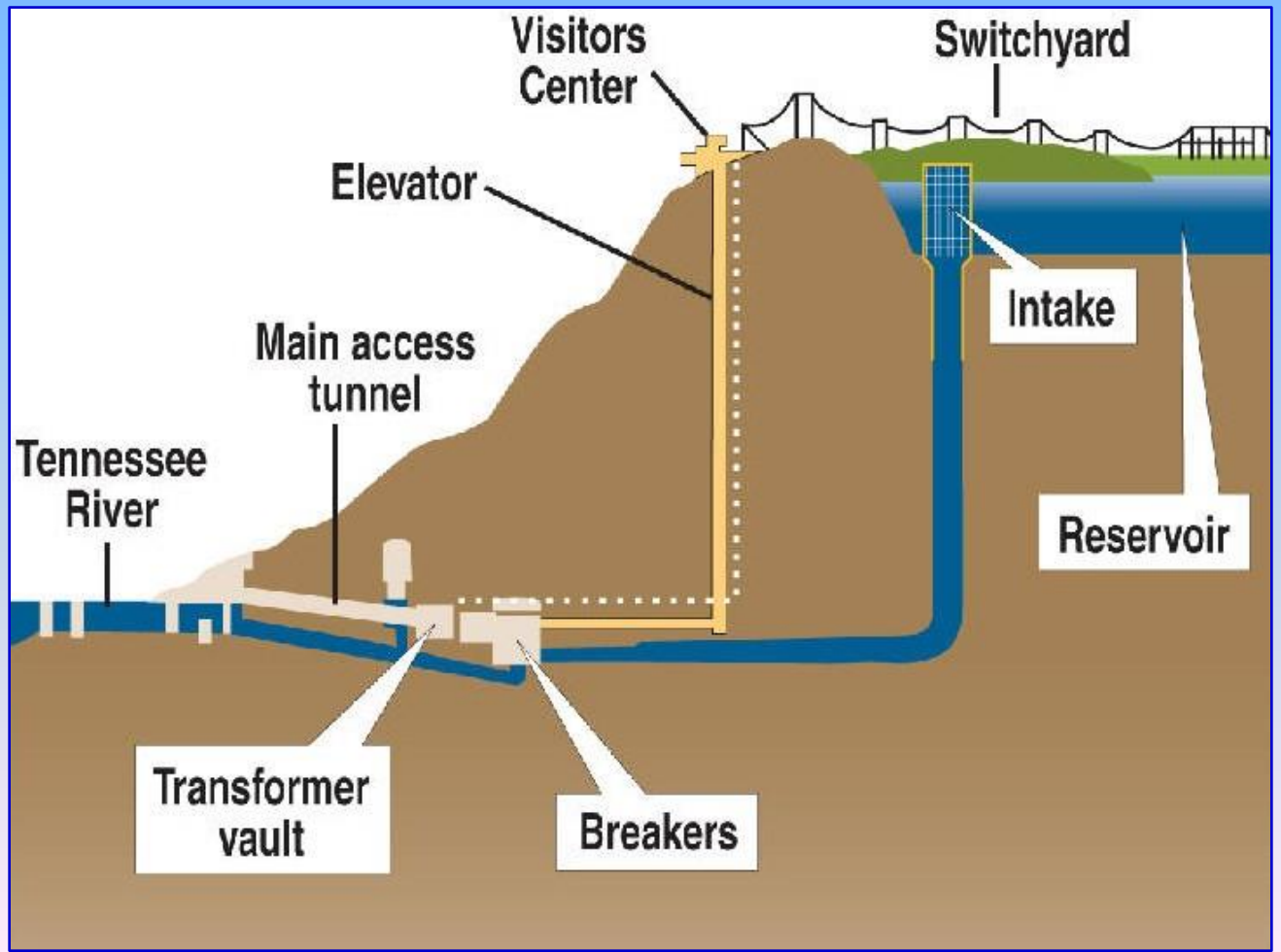
500,000 gallons



107 billion gallons

Pumping water for energy

When electricity demand is low, water is pumped from the Tennessee River at the base of Raccoon Mountain to the reservoir at the top. When demand is high, water is released through a tunnel in the mountain to drive generators in the plant.



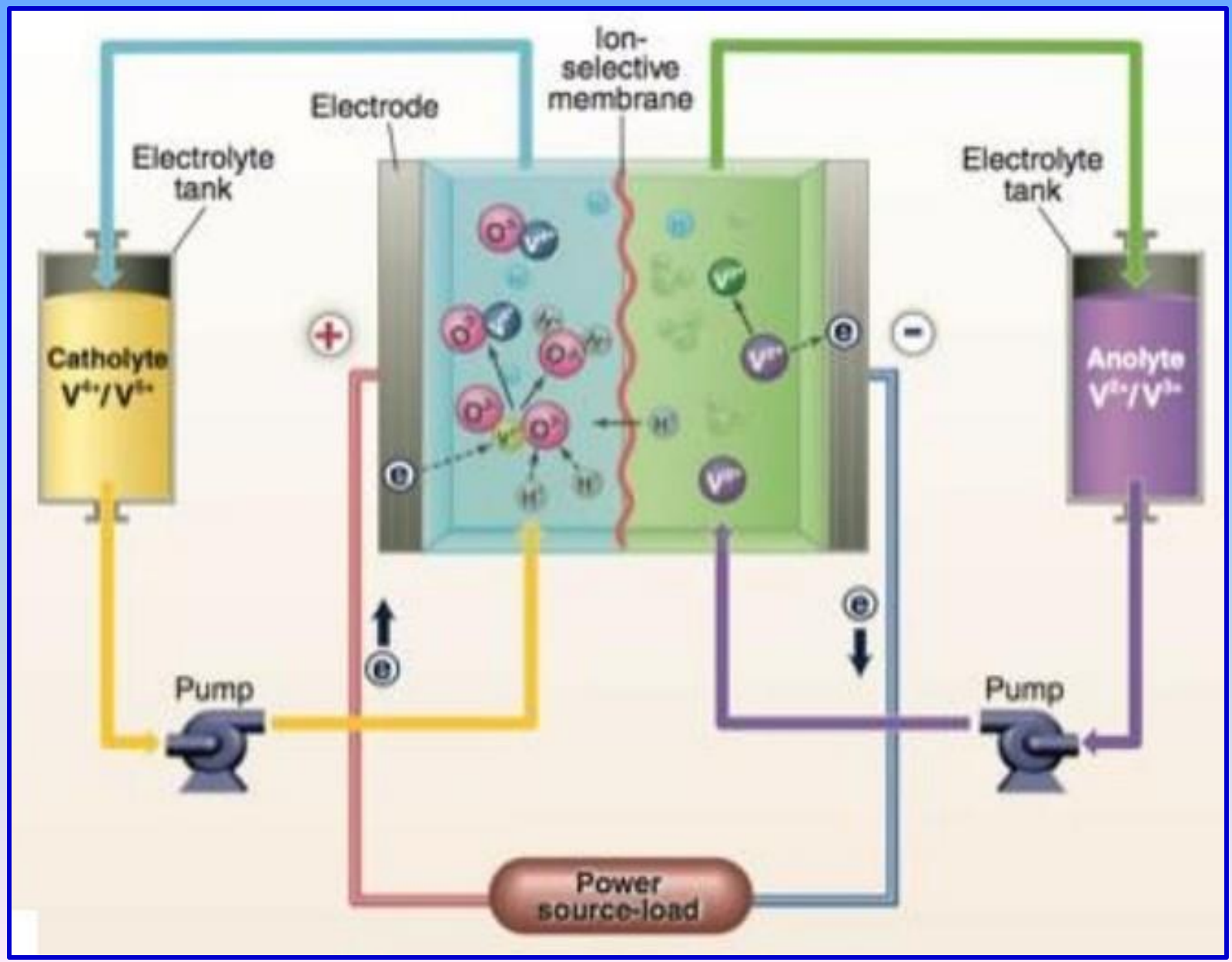
Mechanical Storage

http://www.climatetechwiki.org/technology/jiqweb-caes

Spinning Reserve

Chemical Storage

Flow Batteries

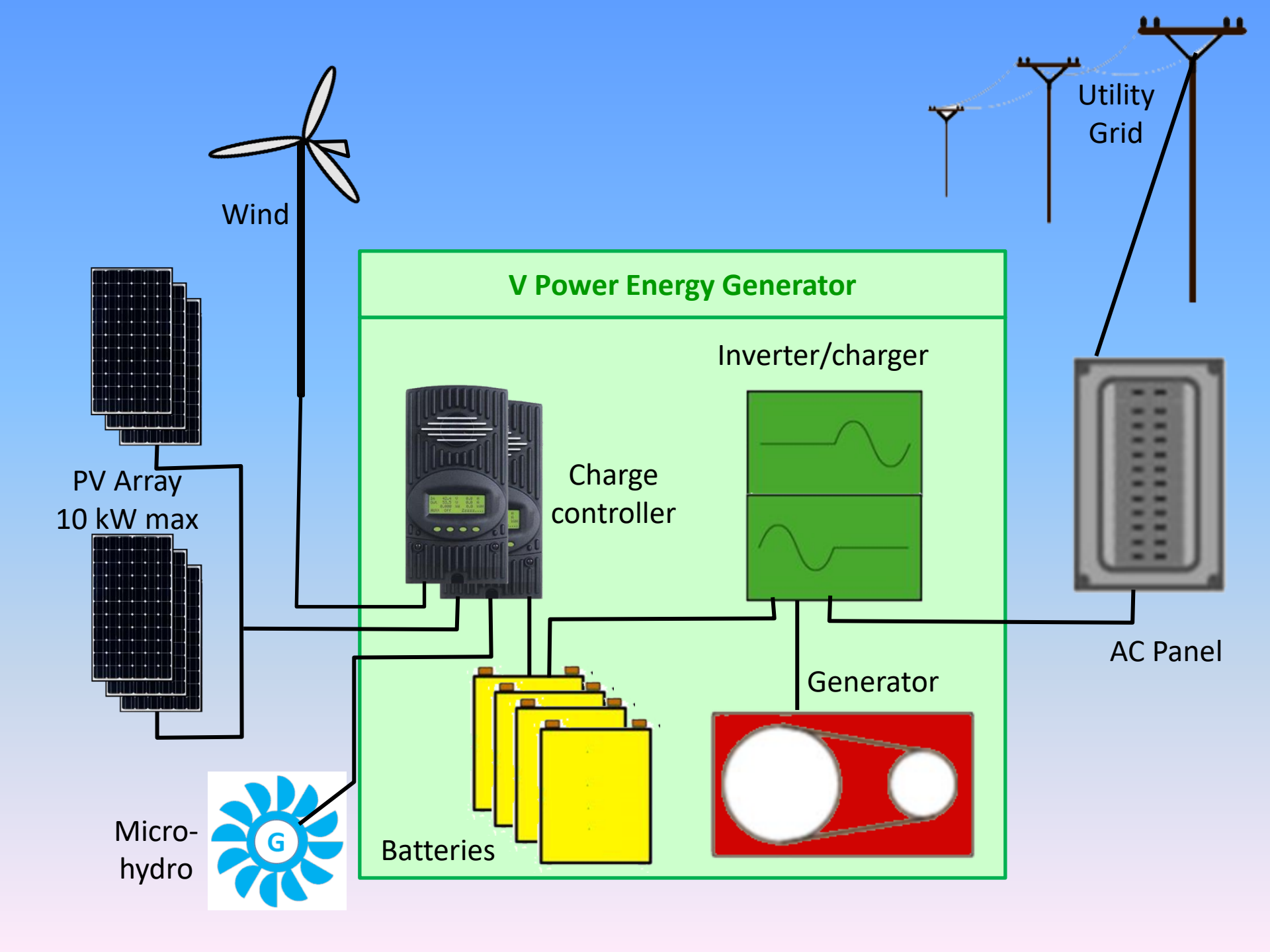


Chemical Storage - Generators

Say WHAT????

Fossil fuels??????

~~**GREEN**~~


Utility
Grid
Wind
V Power Energy Generator
Inverter/charger
PV Array
10 kW max
Charge
controller
AC Panel
Generator
Micro-
hydro
G
Batteries

VSP 14KW FEATURES AT A GLANCE
14KW of stored battery power
Overload shut down
6000W continuous [18KW surge]
Pure sine wave power
110/220V split phase
50/60 HTZ
Built-in, two-way transfer switch
Real time input/output gauge
Auto walk drive system [an industry first]
Automatic fuel generator start, built in solar controller

VSP 14KW BENEFITS
No gas
No smoke
No smell
100% silent
Indoor/outdoor/underground use
Remote power
Home back up
Renewable energy
No daily fuel cost
Recharged through
Solar/Wind/Grid/Fuel Powered
Generator

Chemical Storage

References:

- ✓ www.ashrae.org
  - ASHRAE Standard 90.1, https://www.ashrae.org/resources--publications/bookstore/standard-90-1
- ✓ www.ieee.org
- ✓ Alabama Solar Association, www.AL:-Solar.org
- ✓ www.GetAffordableEnergy.com

We’d like you to join us

See Brandon Hunt

Discount for joining tonight.

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