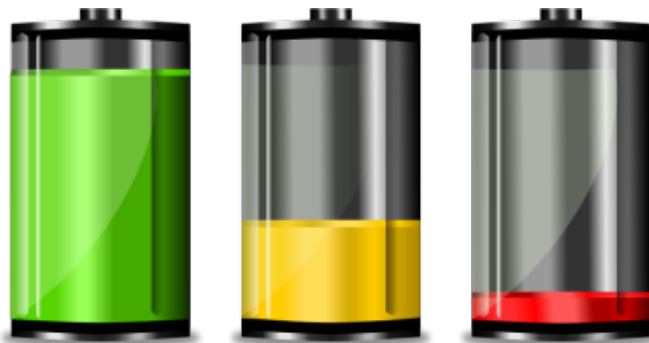
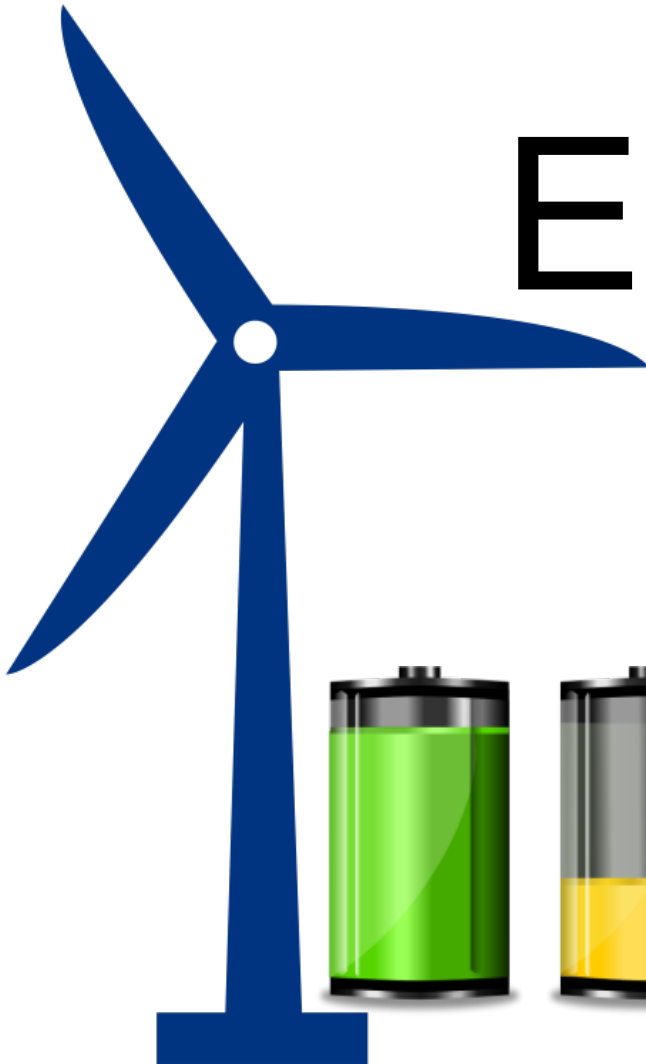


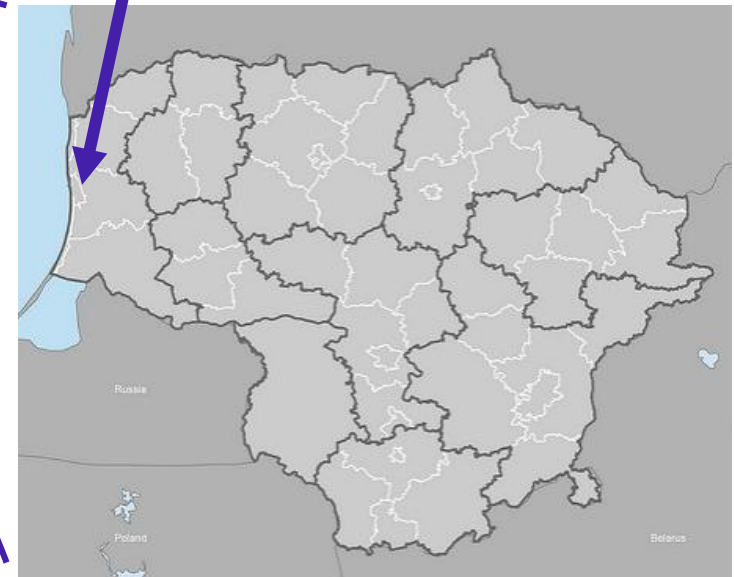
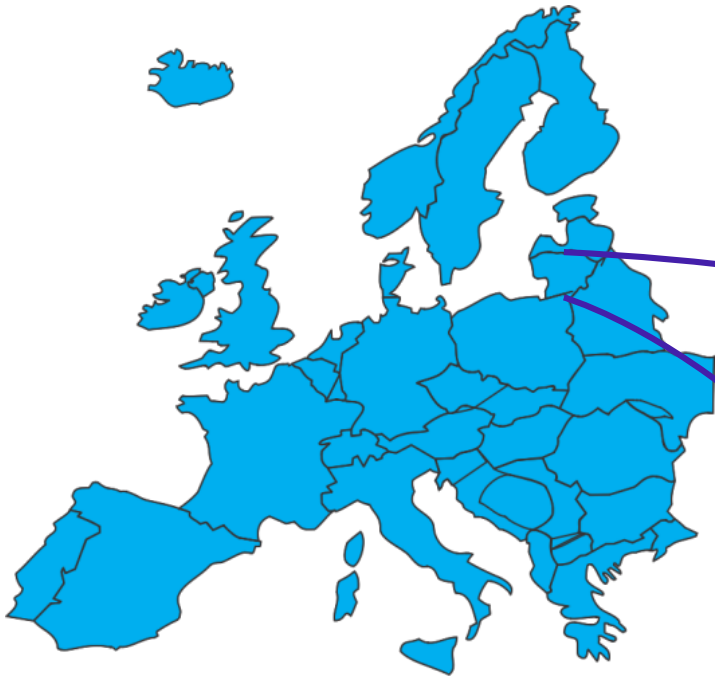
JŪROS
TECHNOLOGIJŲ
IR GAMTOS
MOKSLŲ
FAKULTETAS

Electrical Energy Storage

dr. Valdas Jankunas (Klaipeda University, Lithuania)



Who we are



Who we are



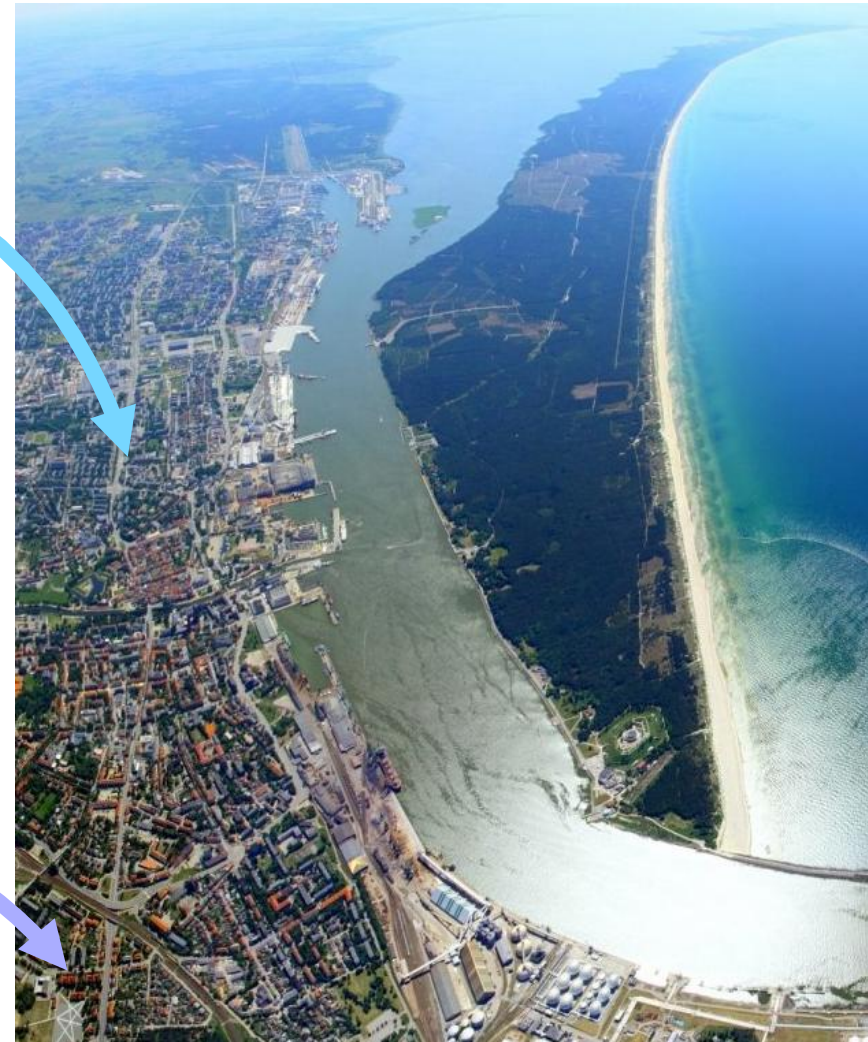
Faculty Of
Marine
Technology
and Natural
Sciences

<http://www.ku.lt/jtgmf/en/>



Klaipeda
University

<http://www.ku.lt/en/>



Who we are

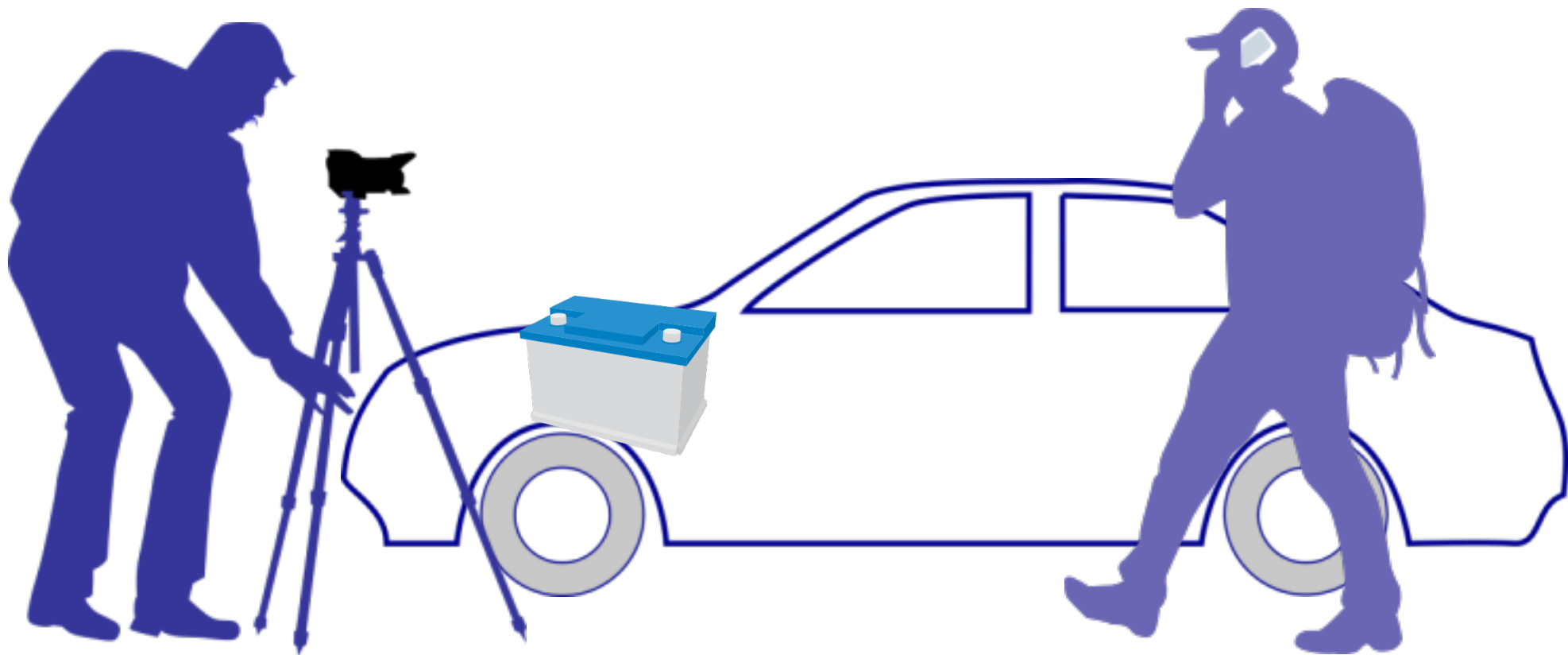


Electrical Energy Storage.

Why?

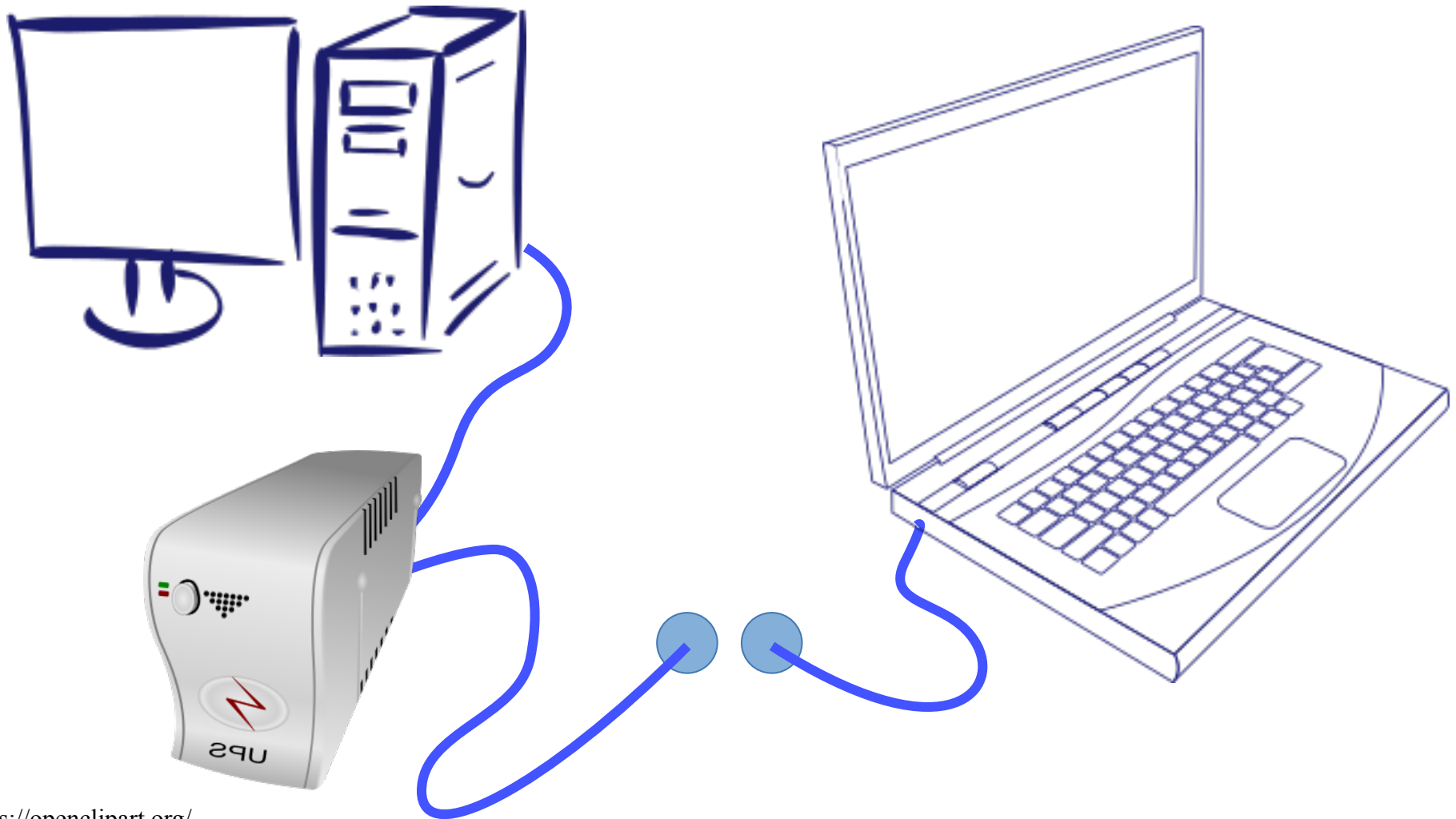
Electrical Energy Storage... why?

Every day usage



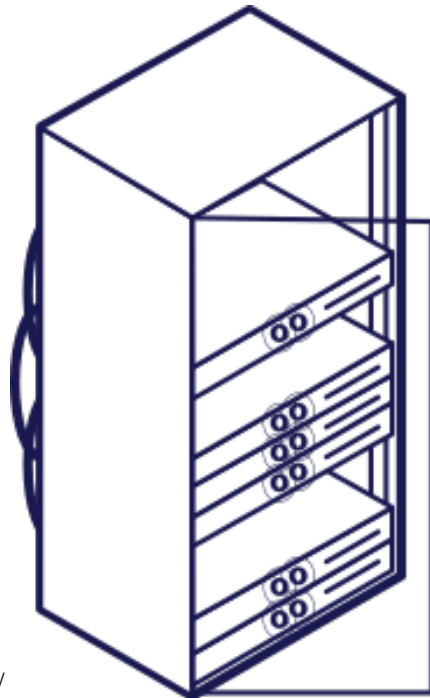
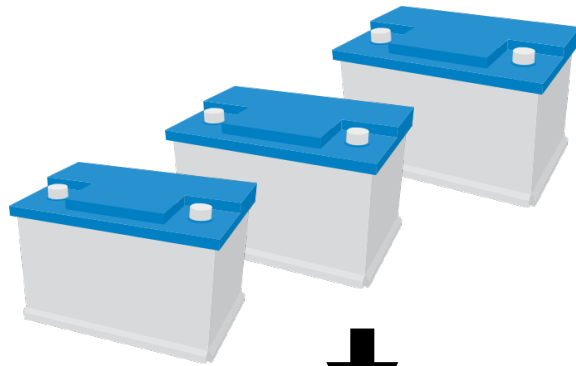
Electrical Energy Storage... why?

Every day usage



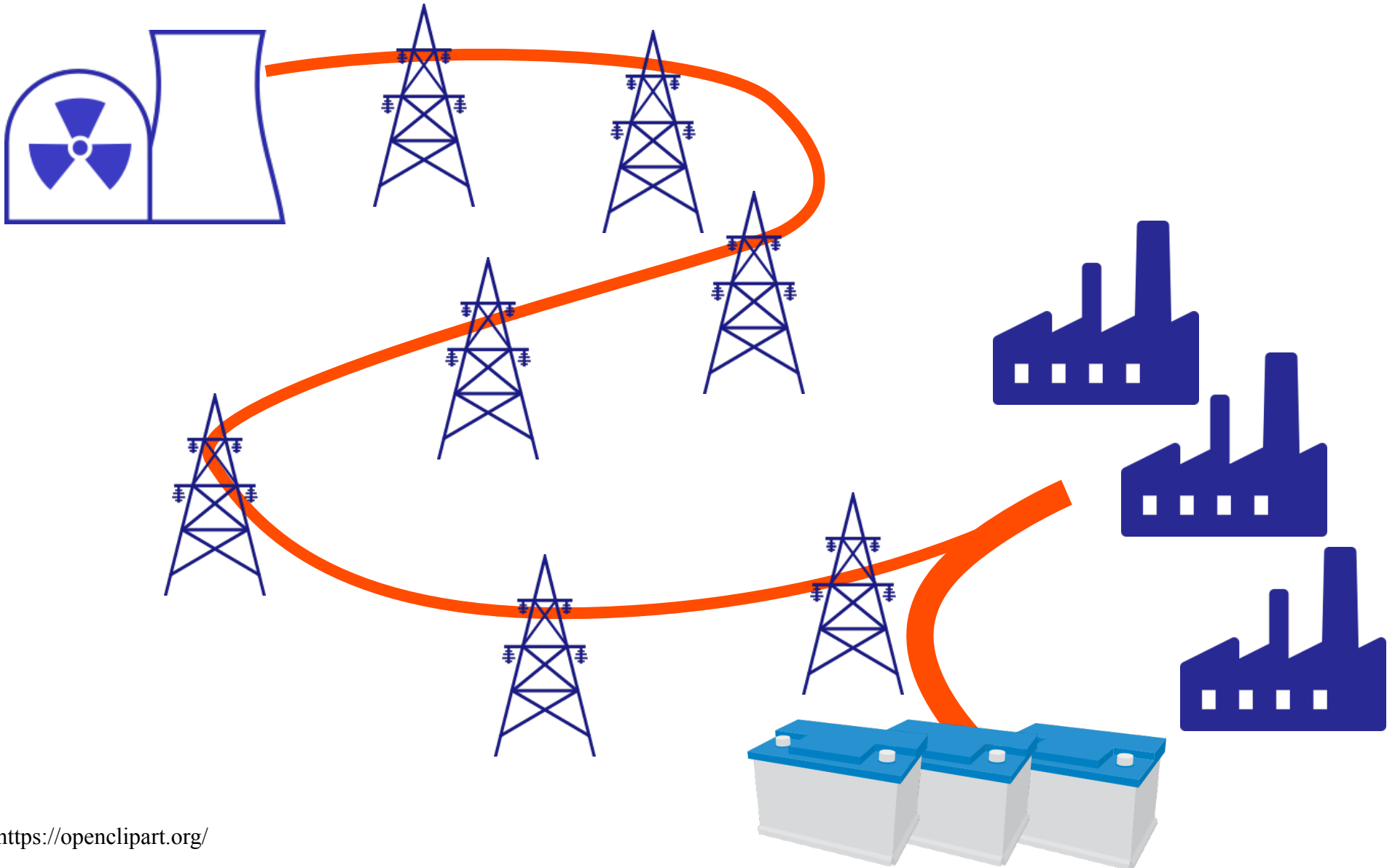
Electrical Energy Storage... why?

Every day usage (advanced)



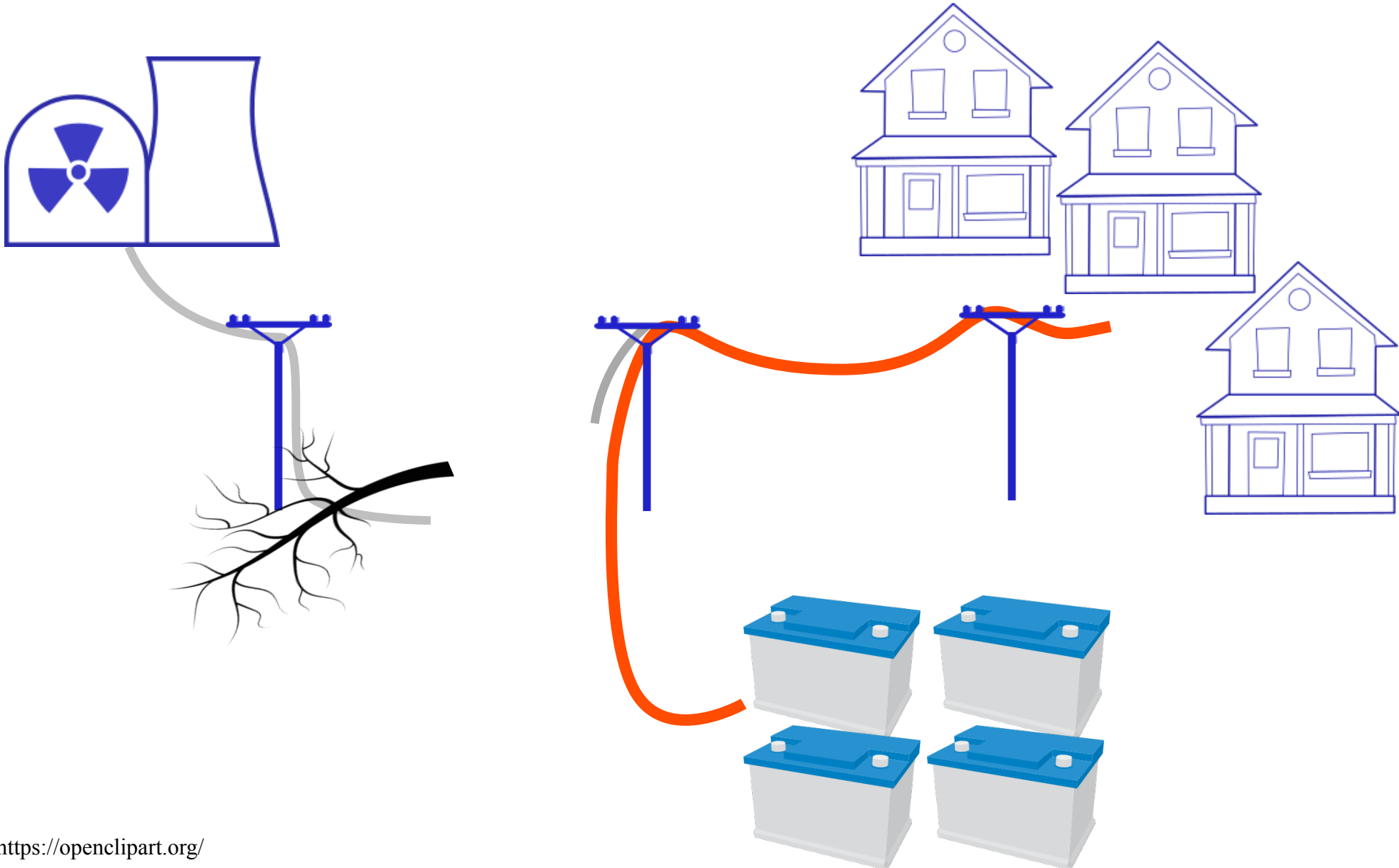
Electrical Energy Storage... why?

Power quality



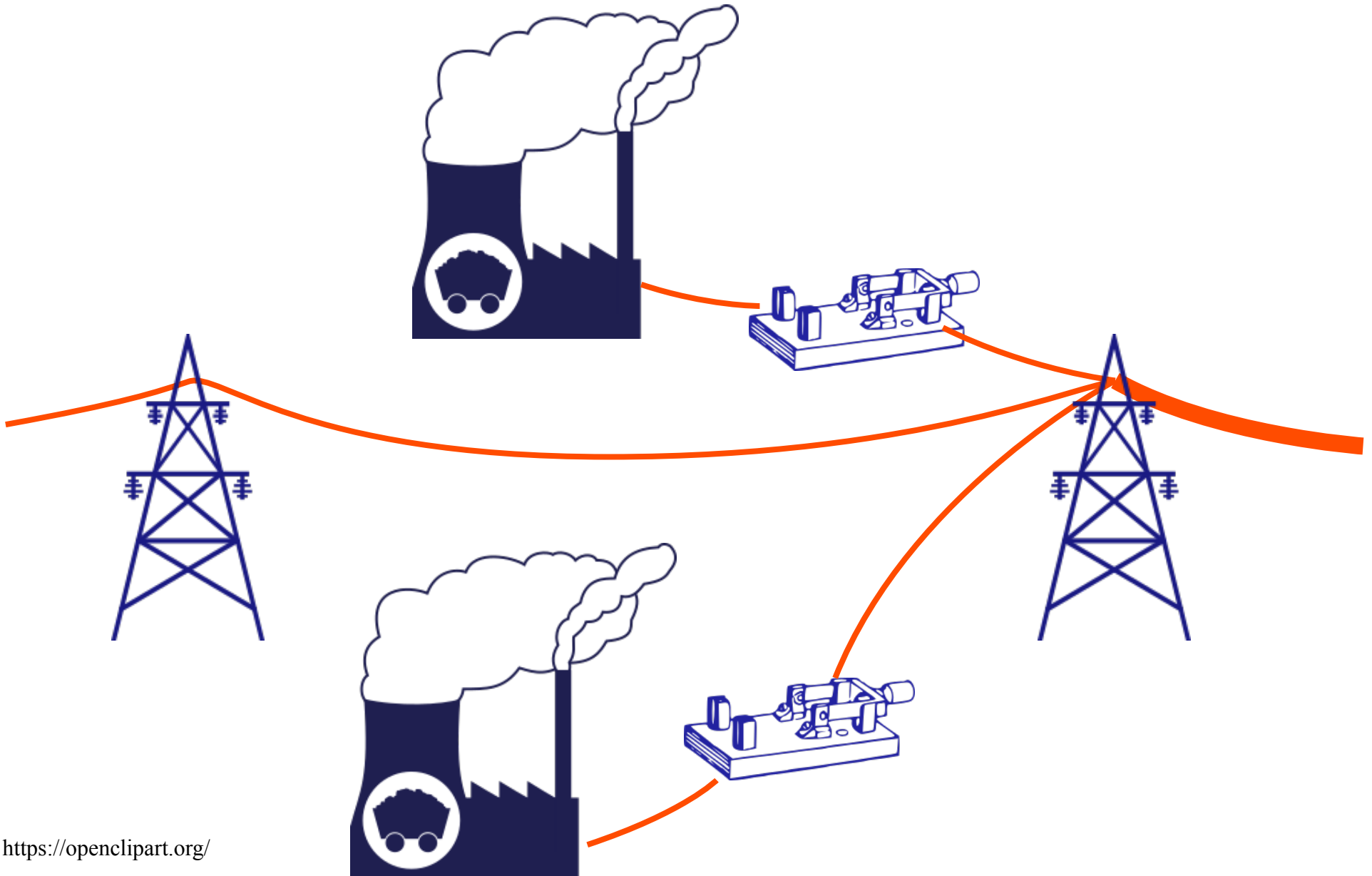
Electrical Energy Storage... why?

Power reliability



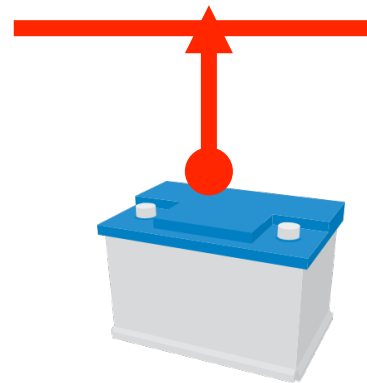
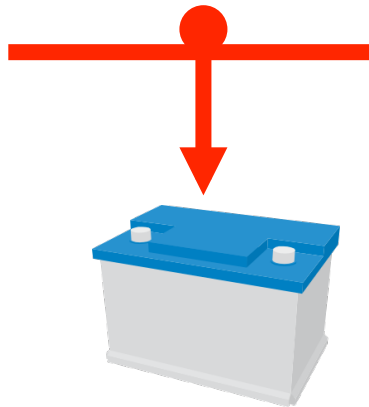
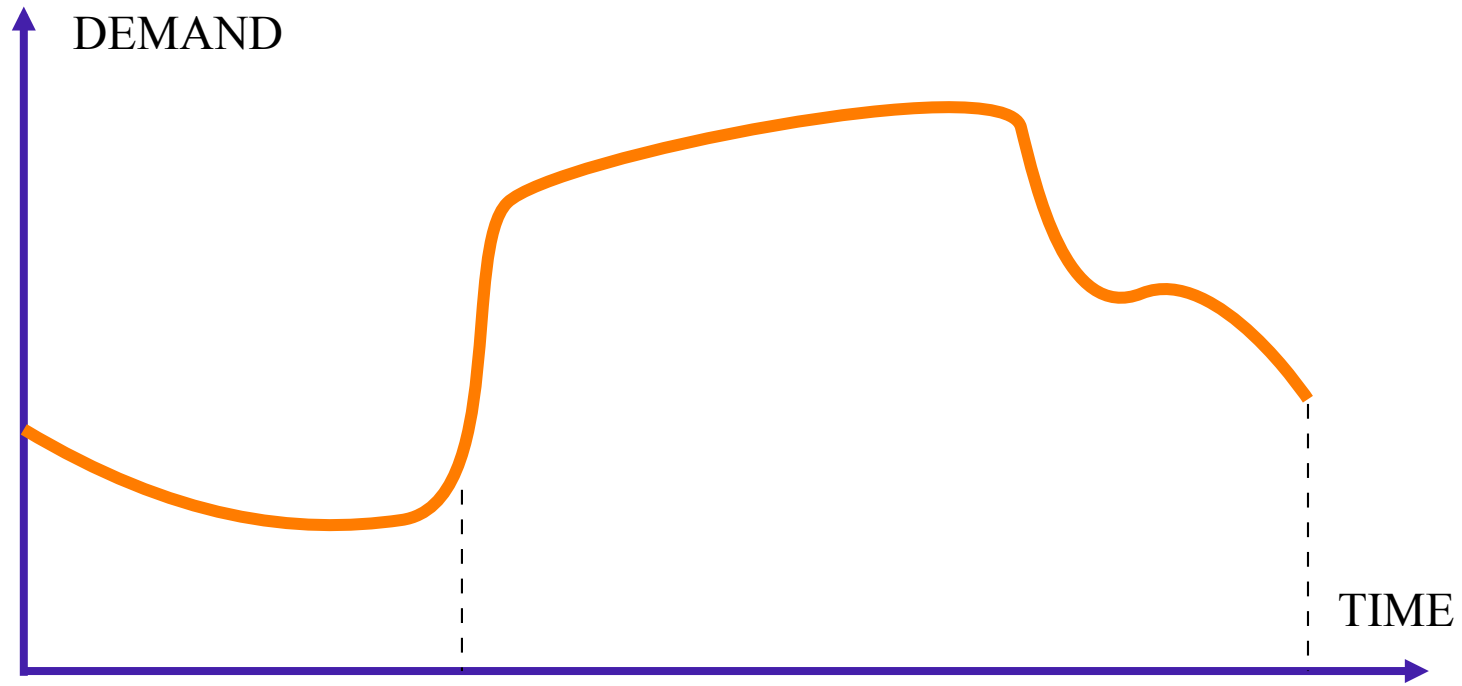
Electrical Energy Storage... why?

Generation costs



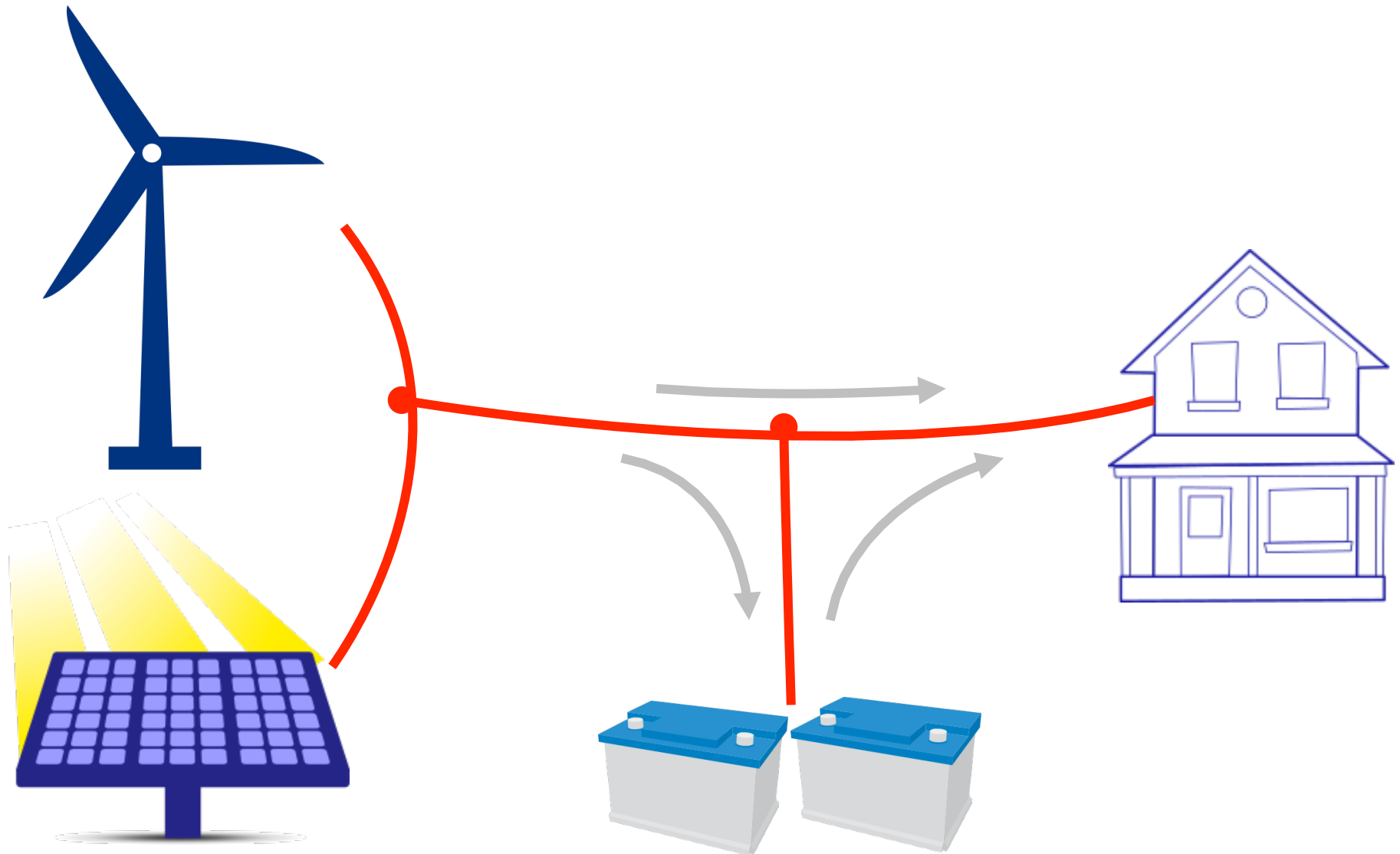
Electrical Energy Storage... why?

Generation costs



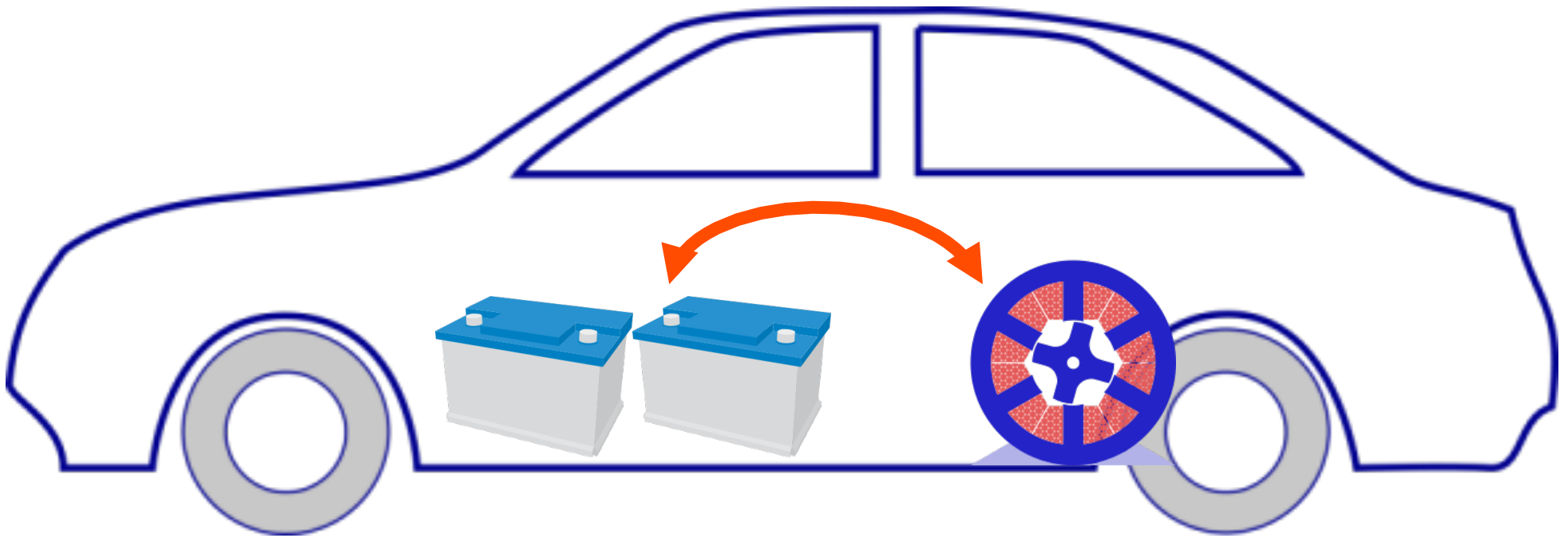
Electrical Energy Storage... why?

Off-grid



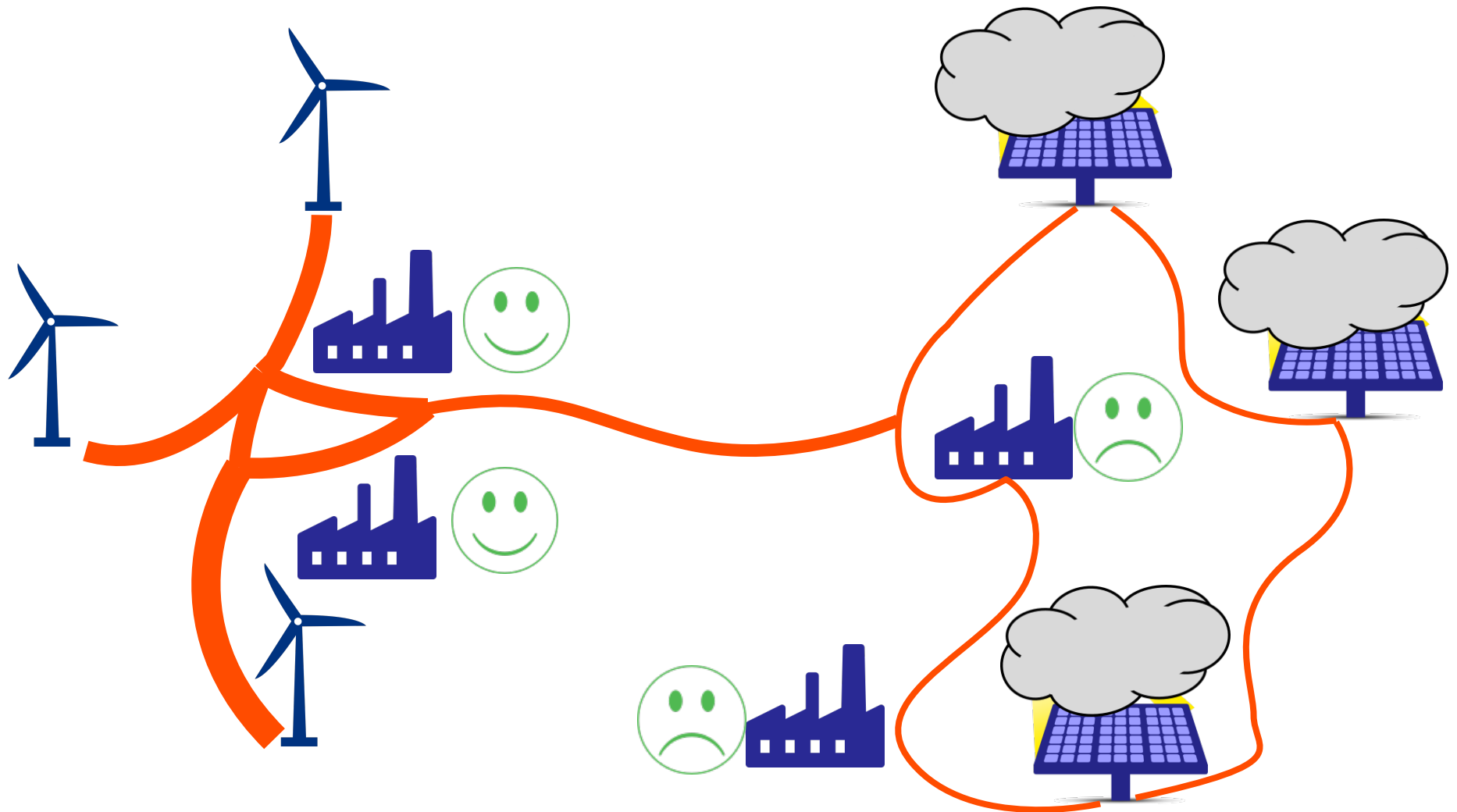
Electrical Energy Storage... why?

Off-grid (mobile)



Electrical Energy Storage... why?

On-grid

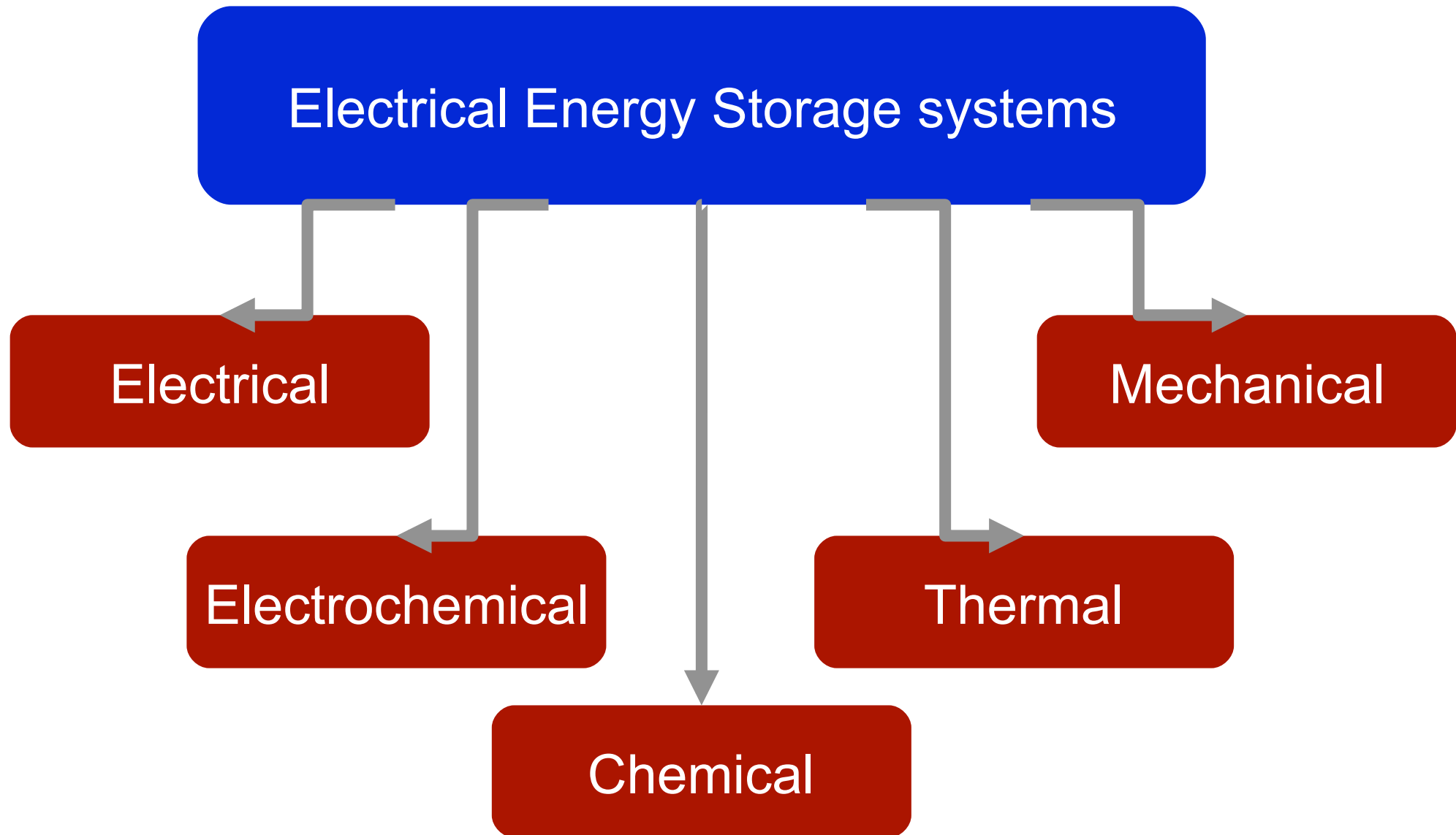


Electrical Energy Storage.

How?

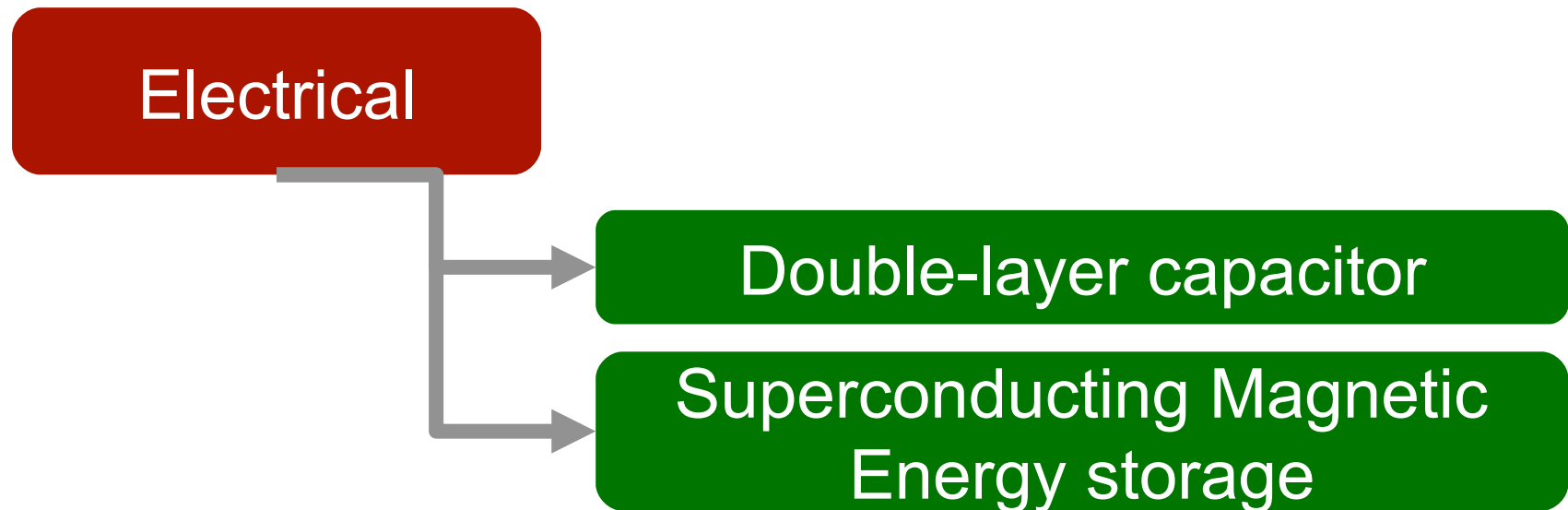
Electrical Energy Storage... how?

Clasification



Electrical Energy Storage... how?

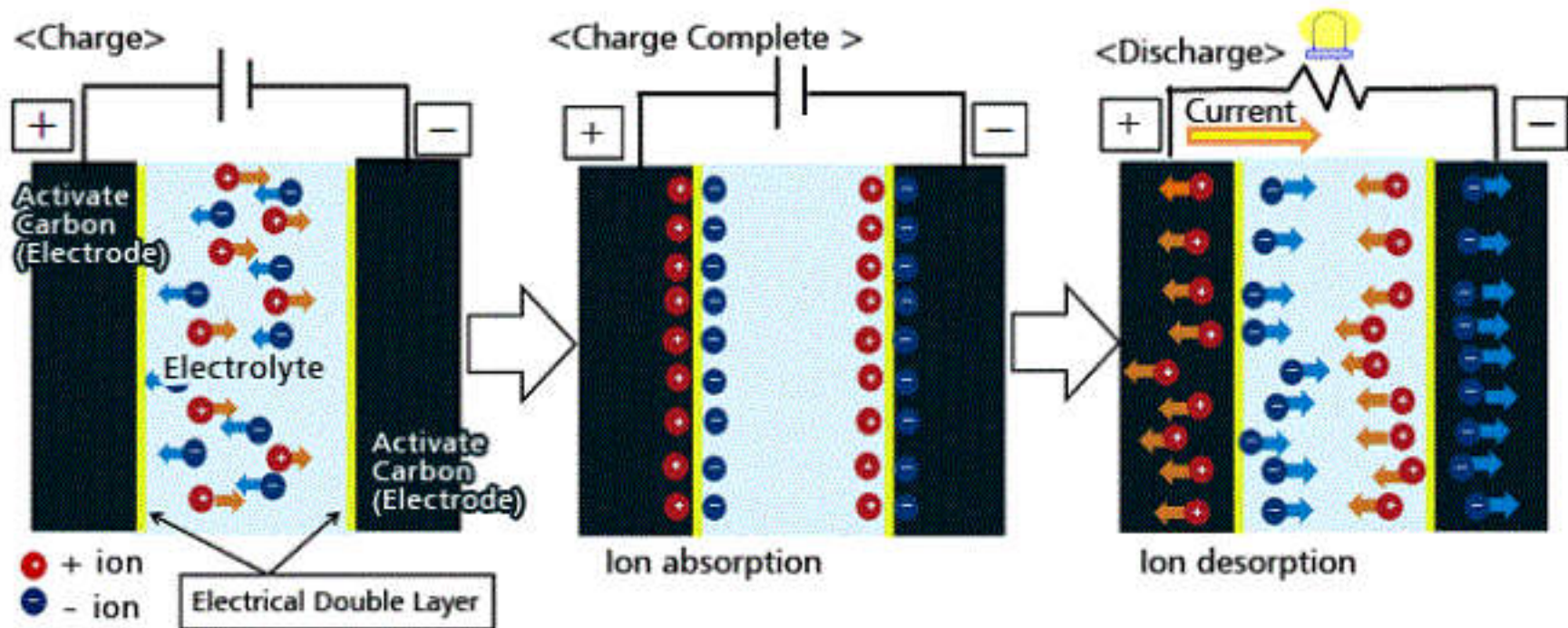
Clasification: Electrical



Electrical Energy Storage... how?

Electrical

Double-layer capacitors (1957)



Electrical Energy Storage... how?

Electrical

Double-layer capacitors



<http://p.globalsources.com/IMAGES/PDT/B1127750751/Electric-Double-Layer-Capacitors.jpg>

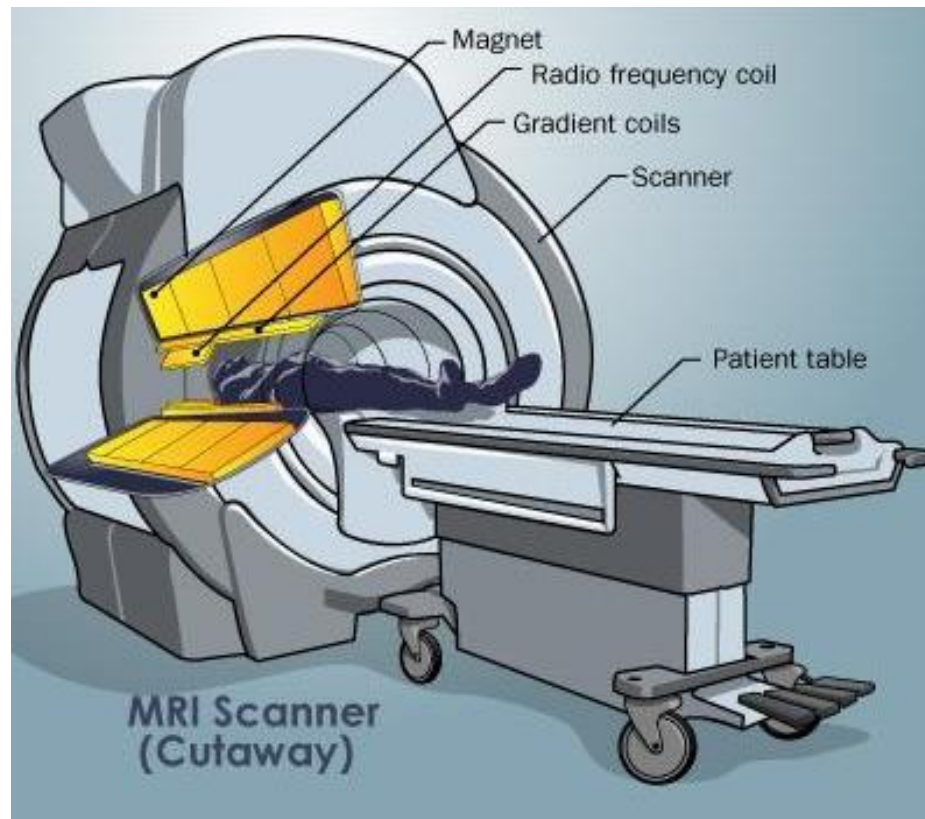
<http://lerablog.org/wp-content/uploads/2013/04/supercapacitor.jpg>

<http://www.greentechee.com/uploadfile/category/5b15329c25c1e618c5338b5f2668f5ae.jpg>

Electrical Energy Storage... how?

Electrical

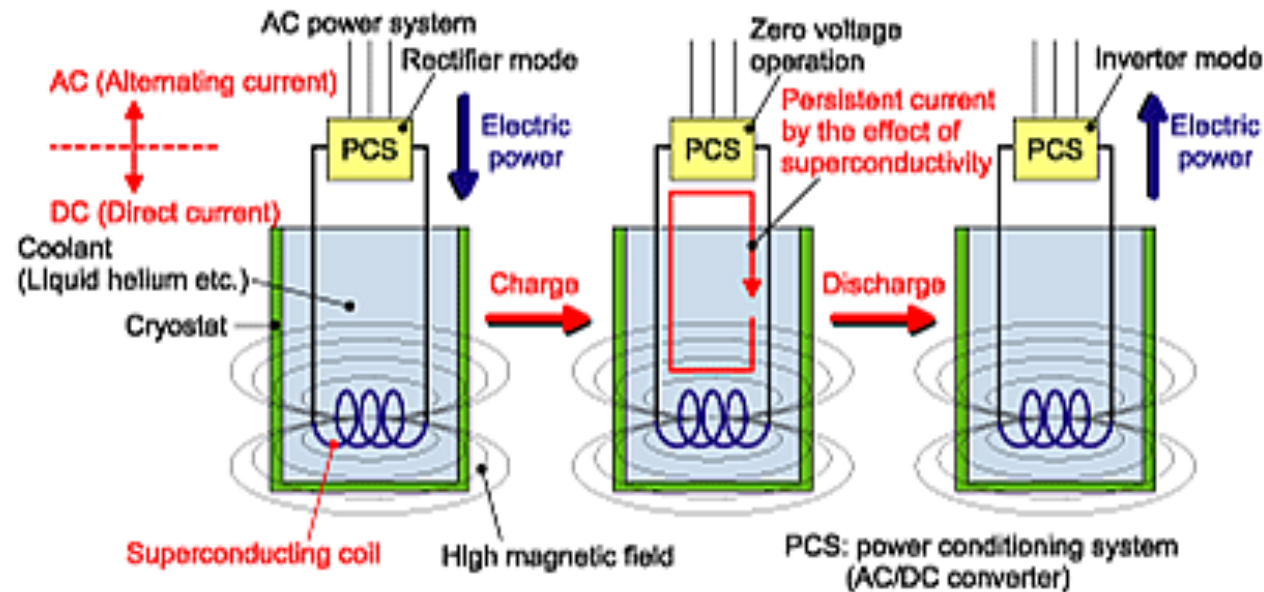
Magnetic Resonance Imaging



Electrical Energy Storage... how?

Electrical

Superconducting Magnetic Energy storage (1969)



Electrical Energy Storage... how?

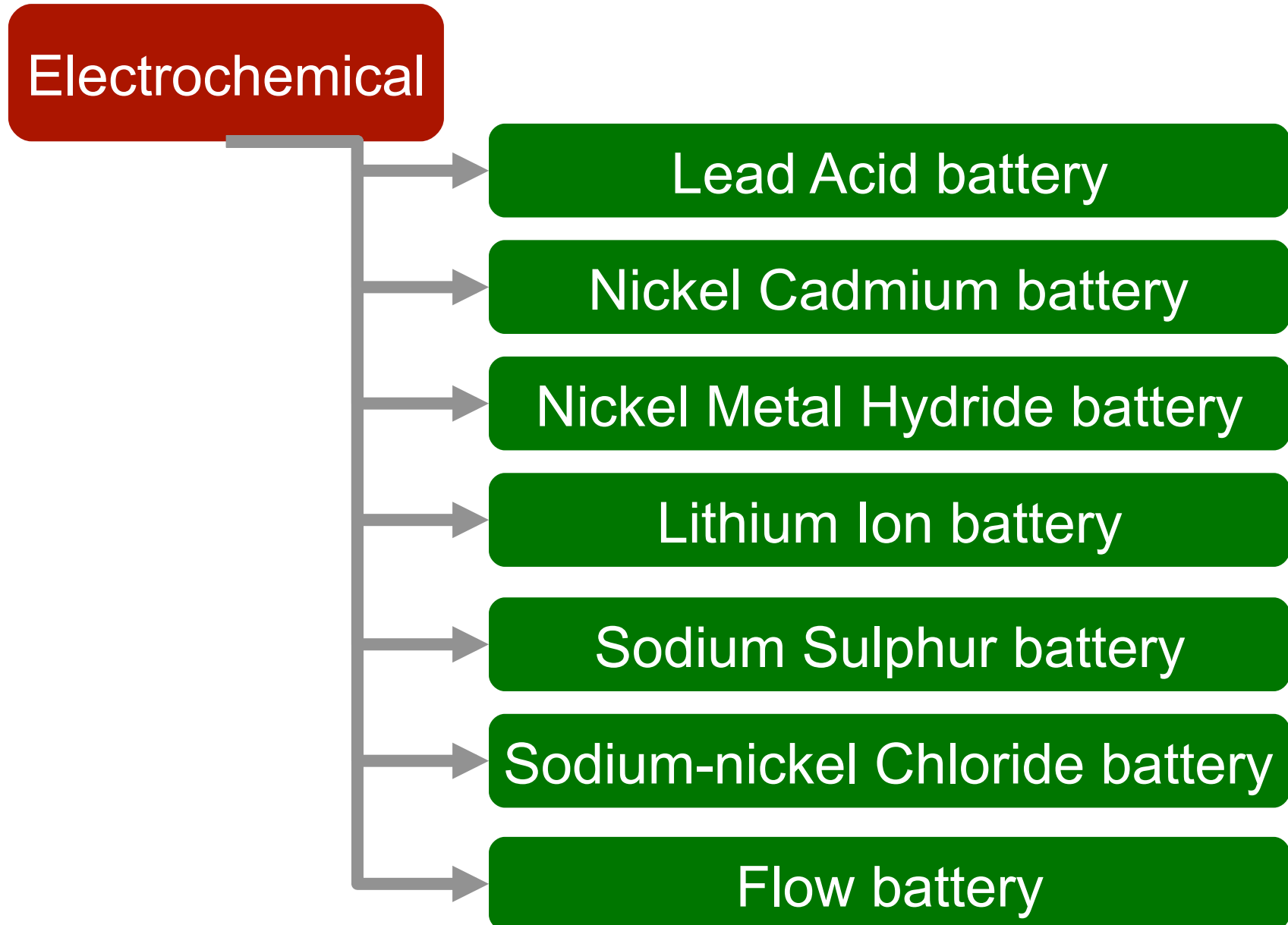
Electrical

Superconducting Magnetic Energy storage



Electrical Energy Storage... how?

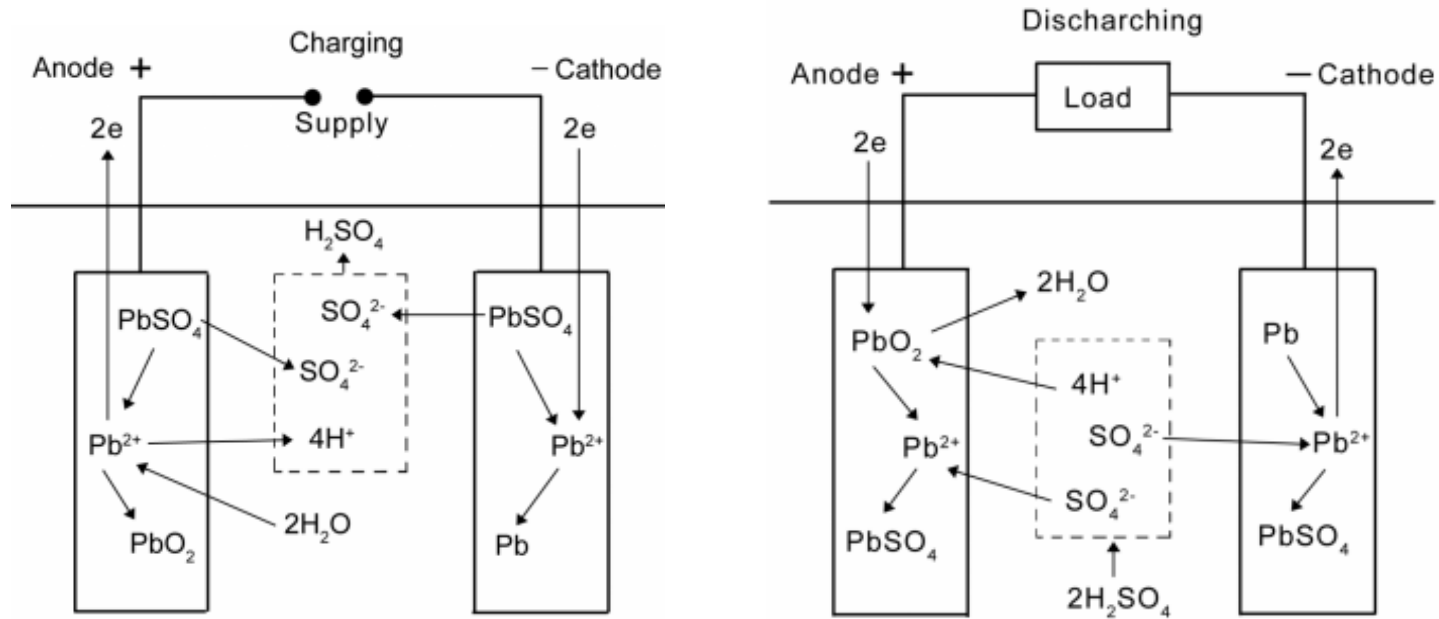
Clasification: Electrochemical



Electrical Energy Storage... how?

Electrochemical

Lead Acid battery (1890)



Electrical Energy Storage... how?

Electrochemical

Lead acid battery



<https://prezi.com/0tk5df9xvxfp/the-life-of-a-lead-acid-battery/>

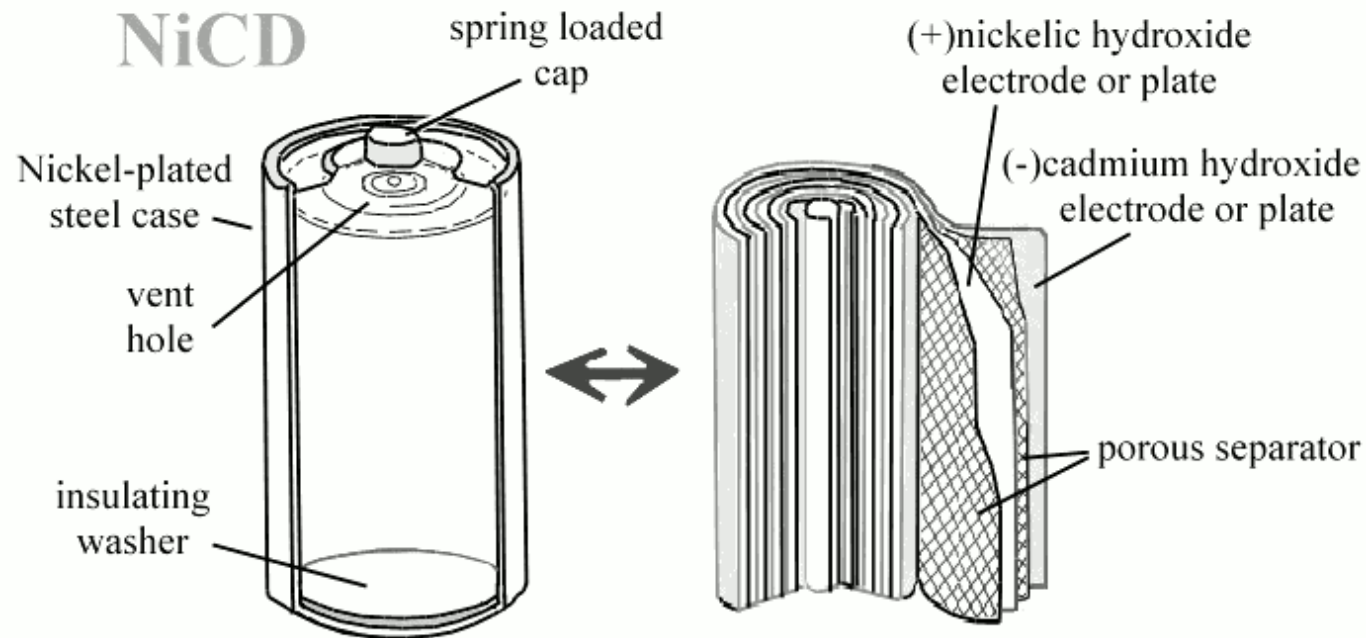
<http://www.elec-intro.com/cms/plus/view.php?aid=13838>

http://www.c-battery.com/photo/pl8430776-1000ah_2_v_gel_deep_cycle_batteries_telecommunication_ups_lead_acid_battery.jpg

Electrical Energy Storage... how?

Electrochemical

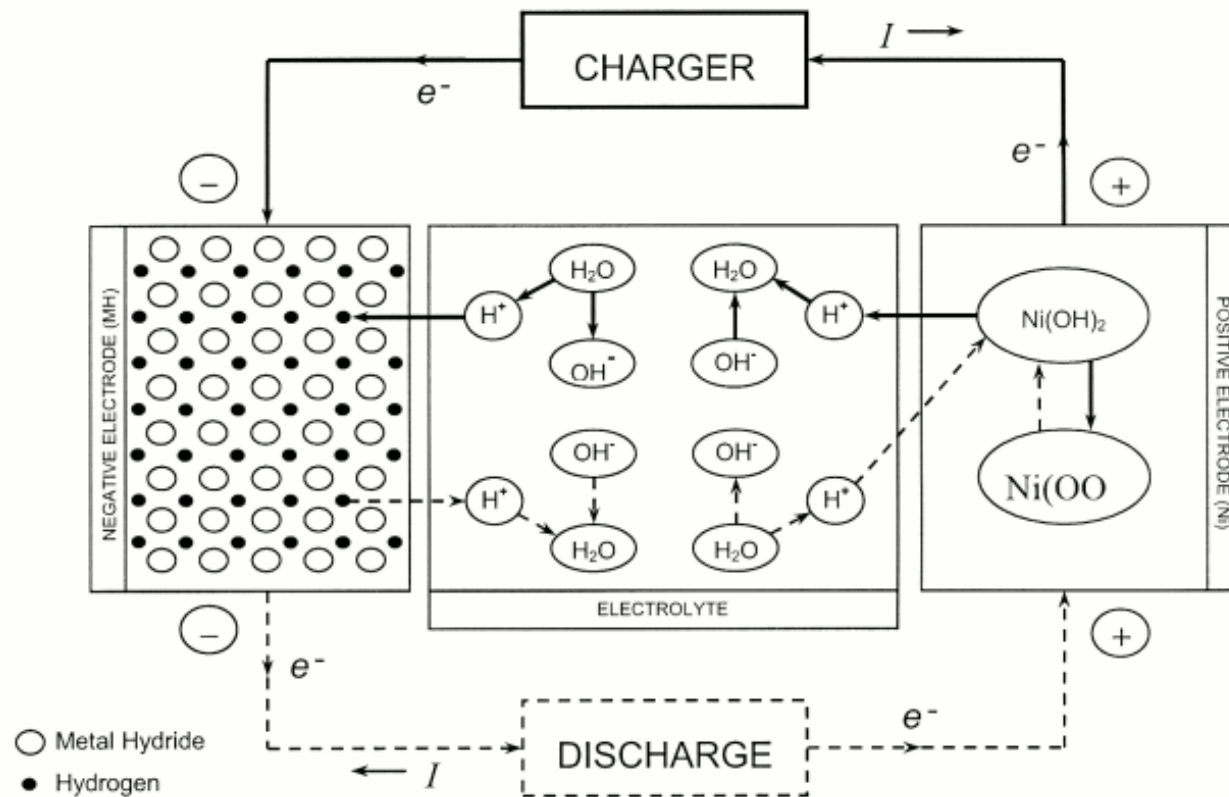
Nickel Cadmium battery (1915)



Electrical Energy Storage... how?

Electrochemical

Nickel Metal Hydride battery (1995)



Electrical Energy Storage... how?

Electrochemical

Nickel Metal Hydride battery



https://www.cordlessrenovations.com/?page_id=391

<http://www.large-battery.com/wp-content/uploads/2012/02/280mAh-7.2V-nickel-metal-hydride-battery.jpg>

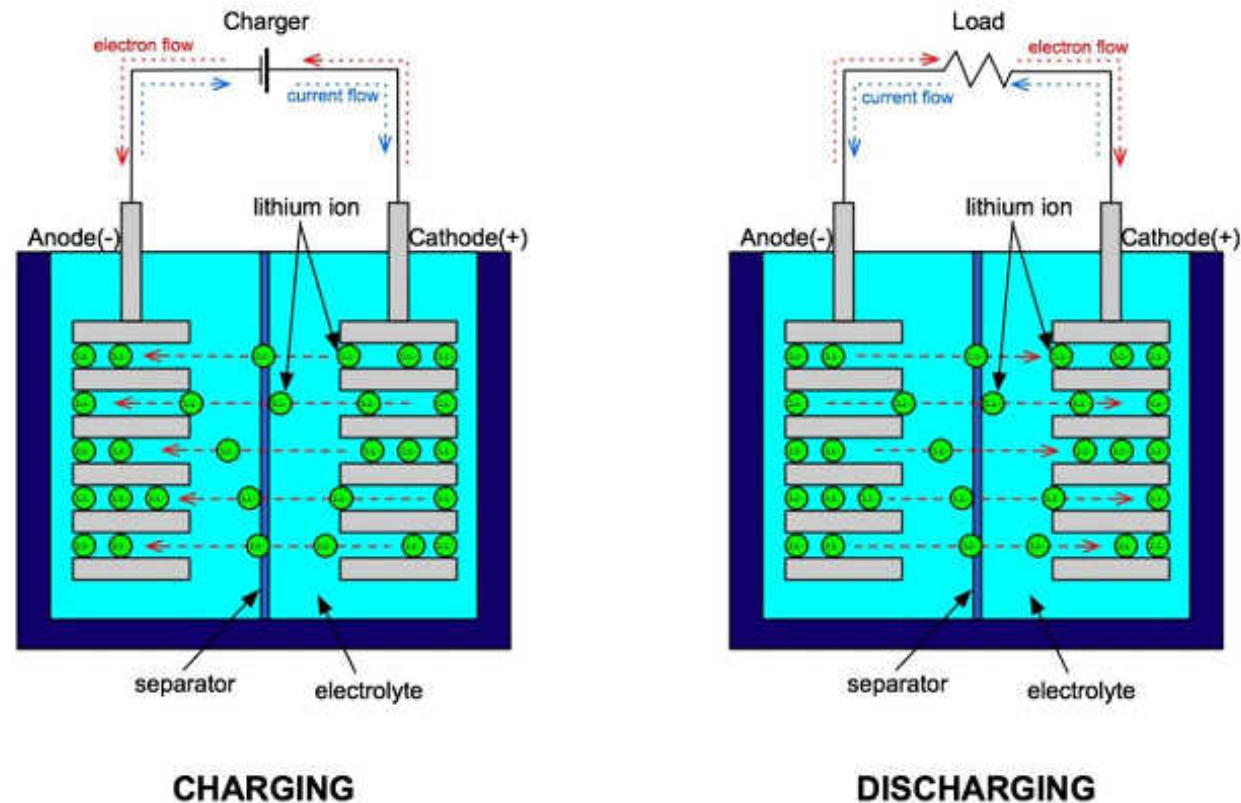
<http://www.batteryspace.com/images/products/detail/1637.png>

<http://www.blogcdn.com/green.autoblog.com/media/2009/03/nimh-battery-greenlings.jpg>

Electrical Energy Storage... how?

Electrochemical

Lithium Ion battery (2000)



Electrical Energy Storage... how?

Electrochemical

Lithium Ion battery



<http://media.treehugger.com/assets/images/2011/10/explodelaptop.jpg>

http://thechronicleherald.ca/sites/default/files/imagecache/ch_article_main_image/articles/B97143949Z.120130207200625000GV8292PC.11.jpg

Electrical Energy Storage... how?

Electrochemical

Lithium Ion battery



<https://infolyst.files.wordpress.com/2014/03/lithium-ion-battery.jpg>

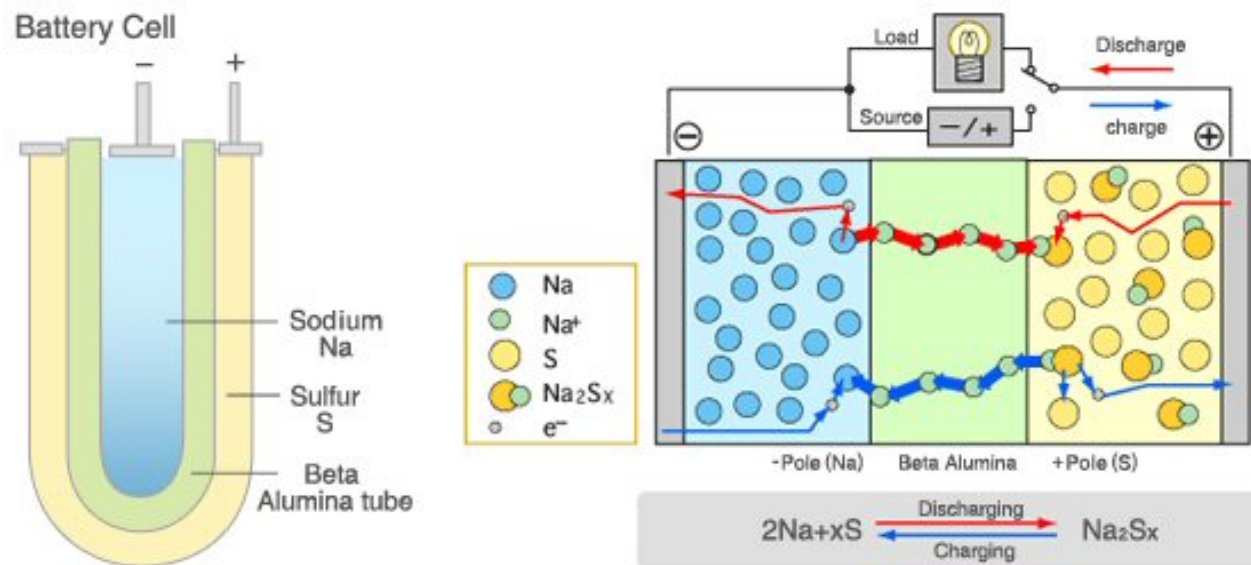
<http://cdn.wccfttech.com/wp-content/uploads/2015/10/NHP13.jpg>

http://beckettenergy.com/wp-content/uploads/BeckettEnergyBattery_Jul14.jpg

Electrical Energy Storage... how?

Electrochemical

Sodium Sulphur battery (1960)



Electrical Energy Storage... how?

Electrochemical

Sodium Sulphur battery

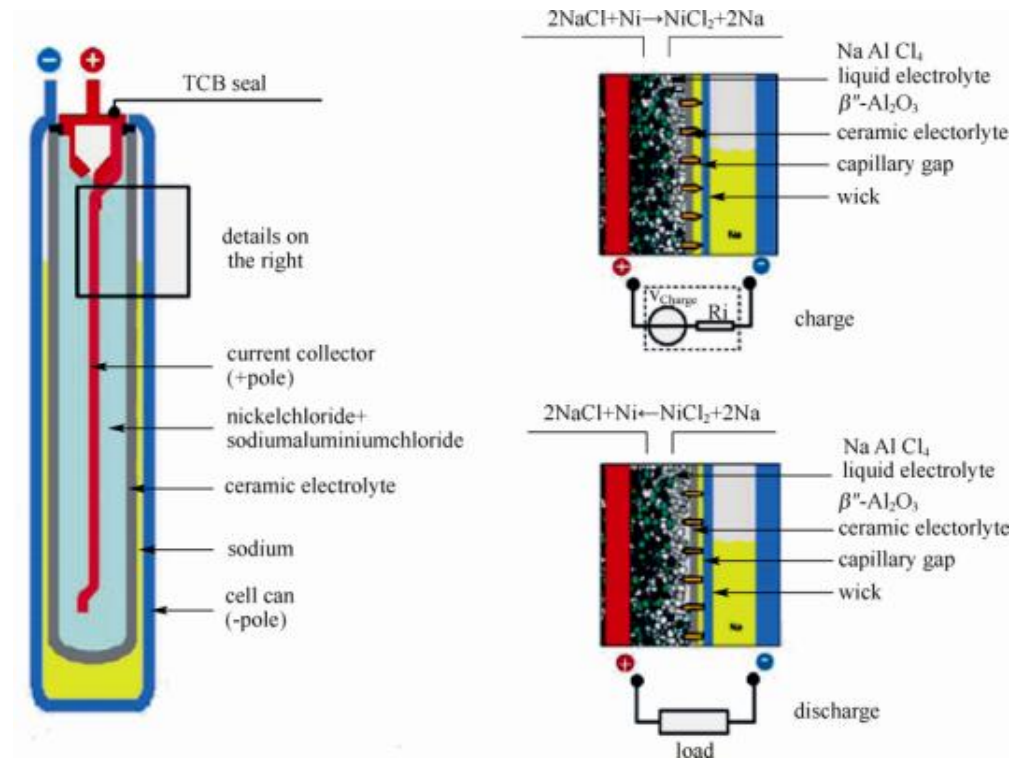


http://www.ladailypost.com/sites/g/files/g616891/f/styles/media_gallery_large/public/_DSC7454%20cropped%20F.jpg?itok=YOW_fZwp
http://www.bestmag.co.uk/sites/default/files/styles/news-listings-image/public/Buzen%20Substation%20in%20Buzen%2C%20Fukuoka%20Prefecture%20_0.jpg?itok=ZT47sM6H

Electrical Energy Storage... how?

Electrochemical

Sodium-nickel Chloride battery (1995)



Electrical Energy Storage... how?

Electrochemical

Sodium-nickel Chloride battery



<http://www.fiamm.com/media/177673/110rw80.jpg>

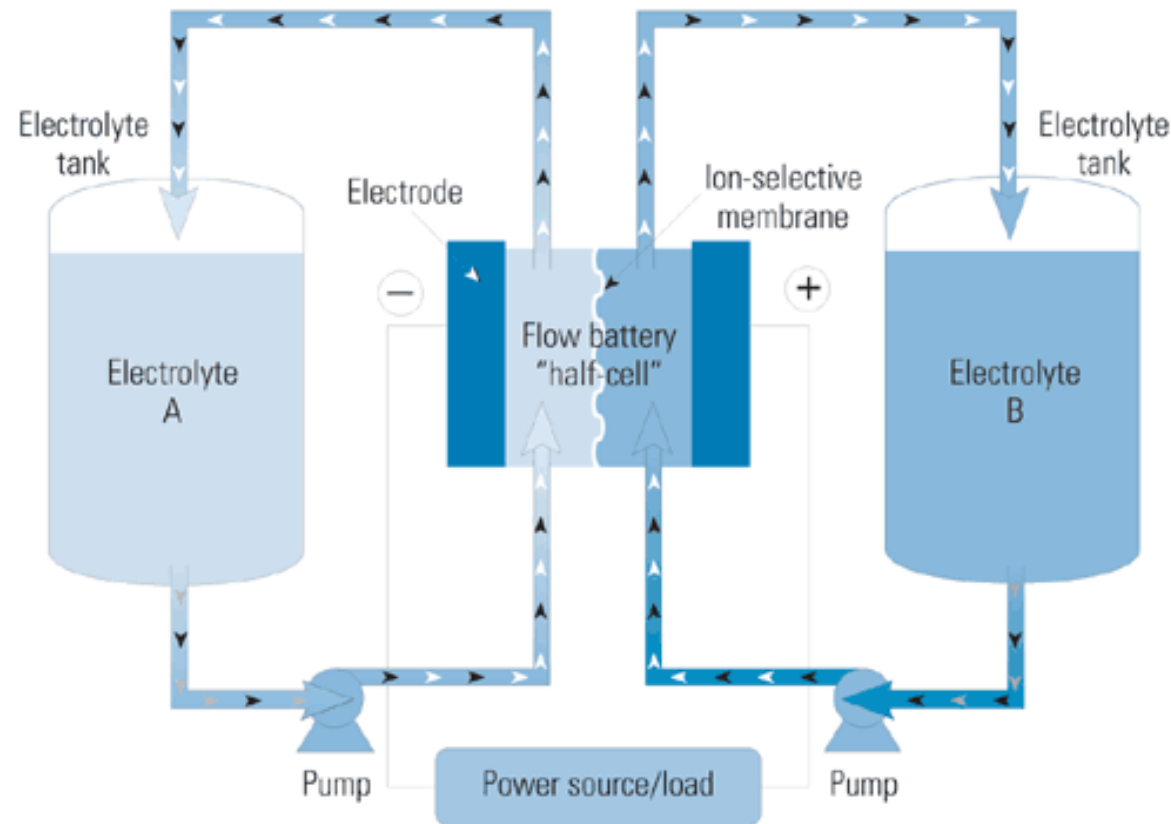
http://www.pv-magazine.com/fileadmin/PVI_website_pictures/SoNick_battery_FIAMM_S.p.A.jpg

<http://events.r20.constantcontact.com/register/event?oeidk=a07e86449uyd158ee83&llr=5kjlyfdab>

Electrical Energy Storage... how?

Electrochemical

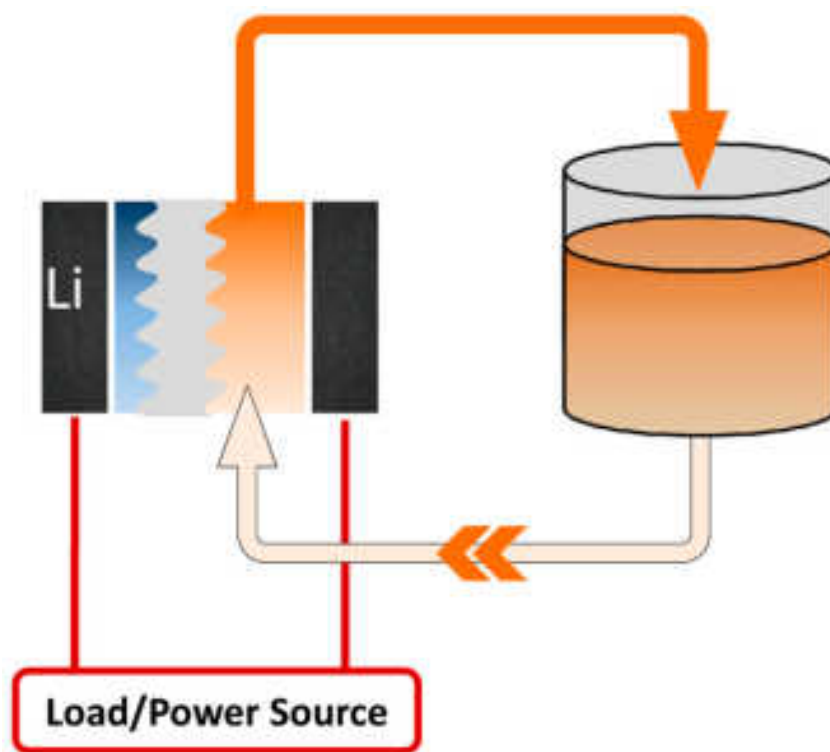
Redox flow battery (1970)



Electrical Energy Storage... how?

Electrochemical

Hybrid flow battery (1970)



Electrical Energy Storage... how?

Electrochemical

Flow battery

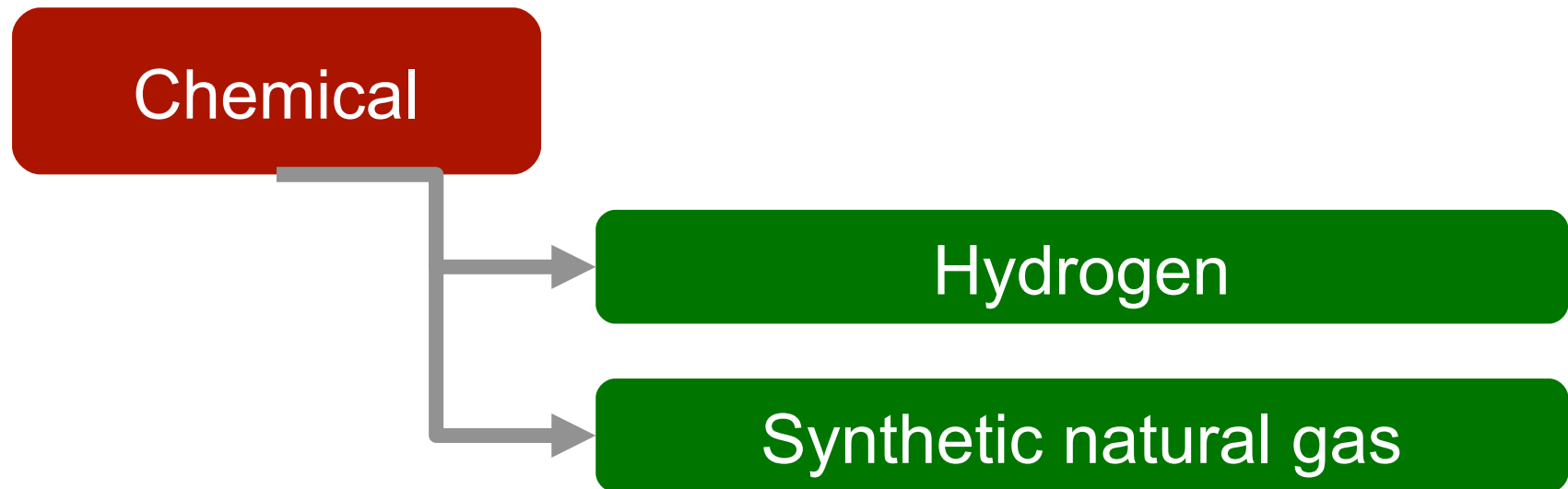


<http://energystoragereport.info/wp/wp-content/uploads/2014/06/Sumitomo-vanadium-redox-flow-batteries.jpg>

<https://www.betterworldsolutions.eu/wp-content/uploads/2015/02/Yokohama-Works-%E2%80%93-using-the-worlds-largest-vanadium-redox-flow-battery.jpg>

Electrical Energy Storage... how?

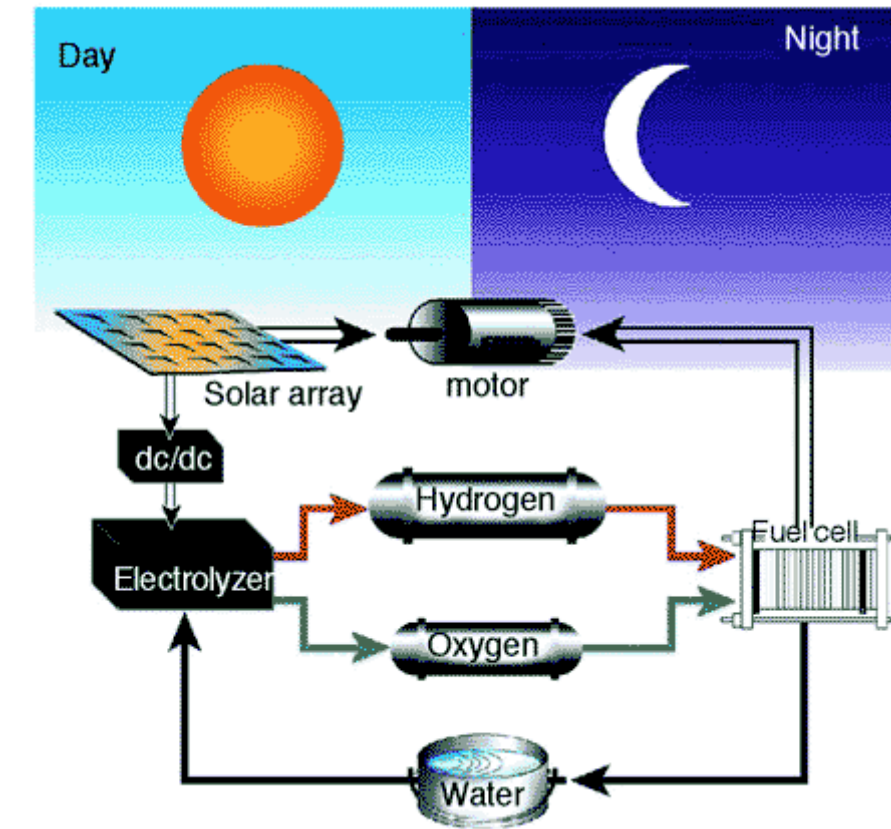
Clasification: Chemical



Electrical Energy Storage... how?

Chemical

Hydrogen



Electrical Energy Storage... how?

Chemical

Hydrogen



http://www.energytrendsinsider.com/wp-content/uploads/2014/04/IMG_3143-1024x768.jpg?00cfb7

http://images.techhive.com/images/article/2016/02/rsofc-2_january-2016_roi-15-01537-bds-100645009-primary.idge.jpg

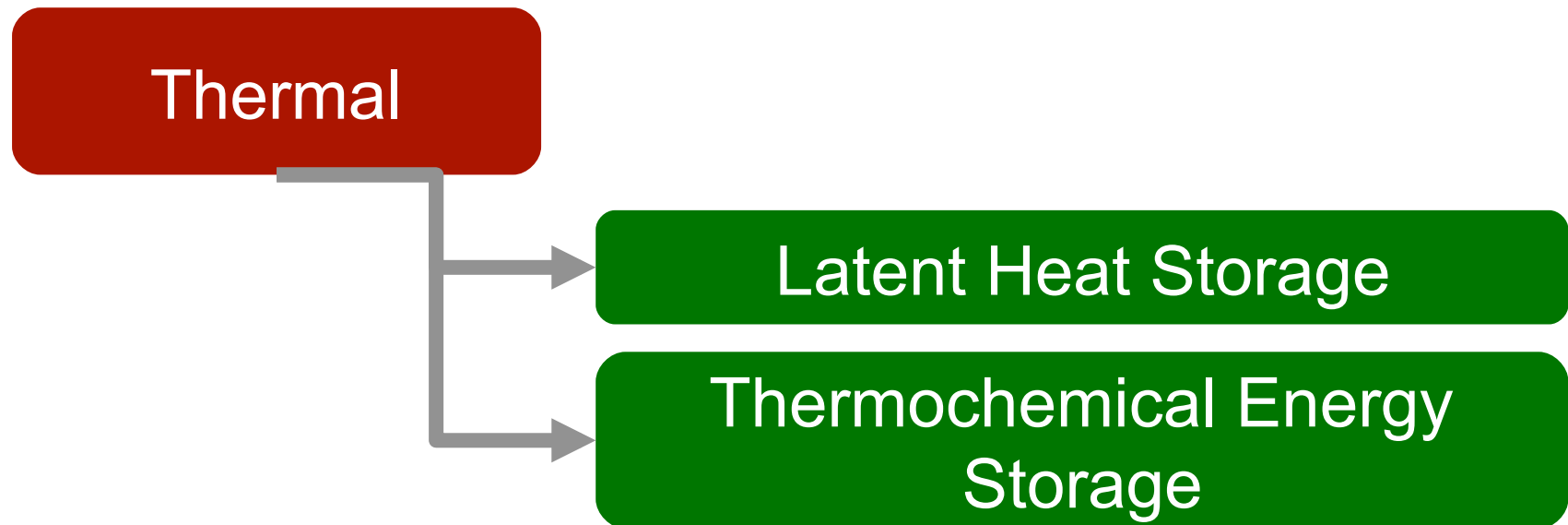
Electrical Energy Storage... how? Chemical

Synthetic Natural Gas



Electrical Energy Storage... how?

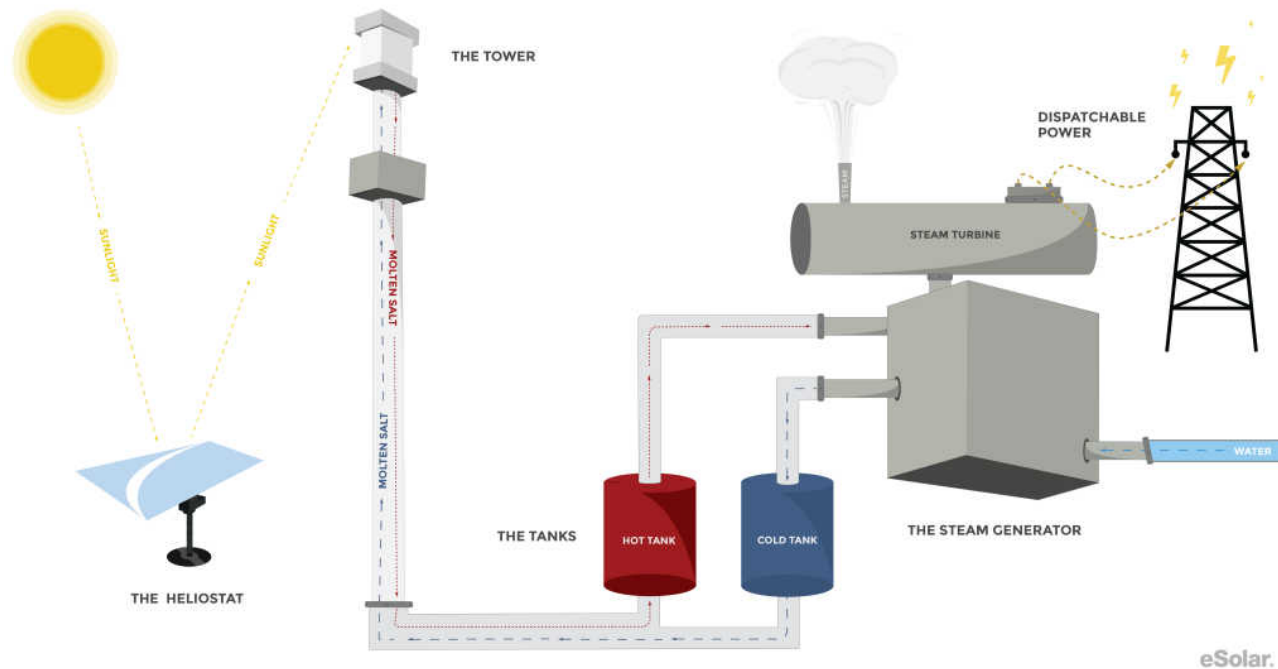
Clasification: Thermal



Electrical Energy Storage... how?

Thermal

Latent Heat storage



Electrical Energy Storage... how?

Thermal

Latent Heat storage



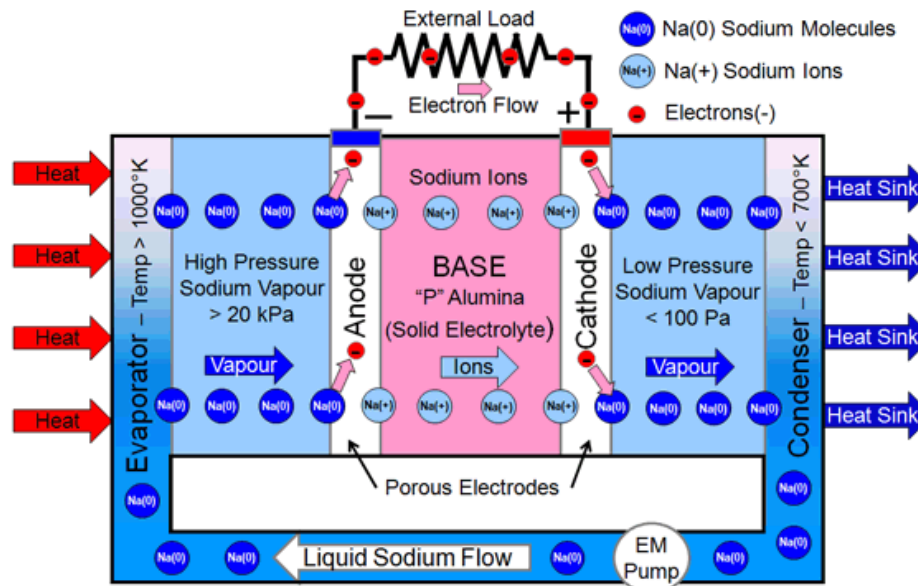
<http://energystoragereport.info/wp/wp-content/uploads/2014/09/Crescent-Dunes-Solar-Energy-Project-SolarReserve-thermal-energy-storage-2-300x262.jpg>

http://www.avea.com/news/liblocal/docs/CP_pro/2014/20140505-Sandia_Project%20Profile.pdf

Electrical Energy Storage... how?

Thermal

Thermochemical Energy Storage (1960)



AMTEC Direct Energy Conversion

Electrical Energy Storage... how?

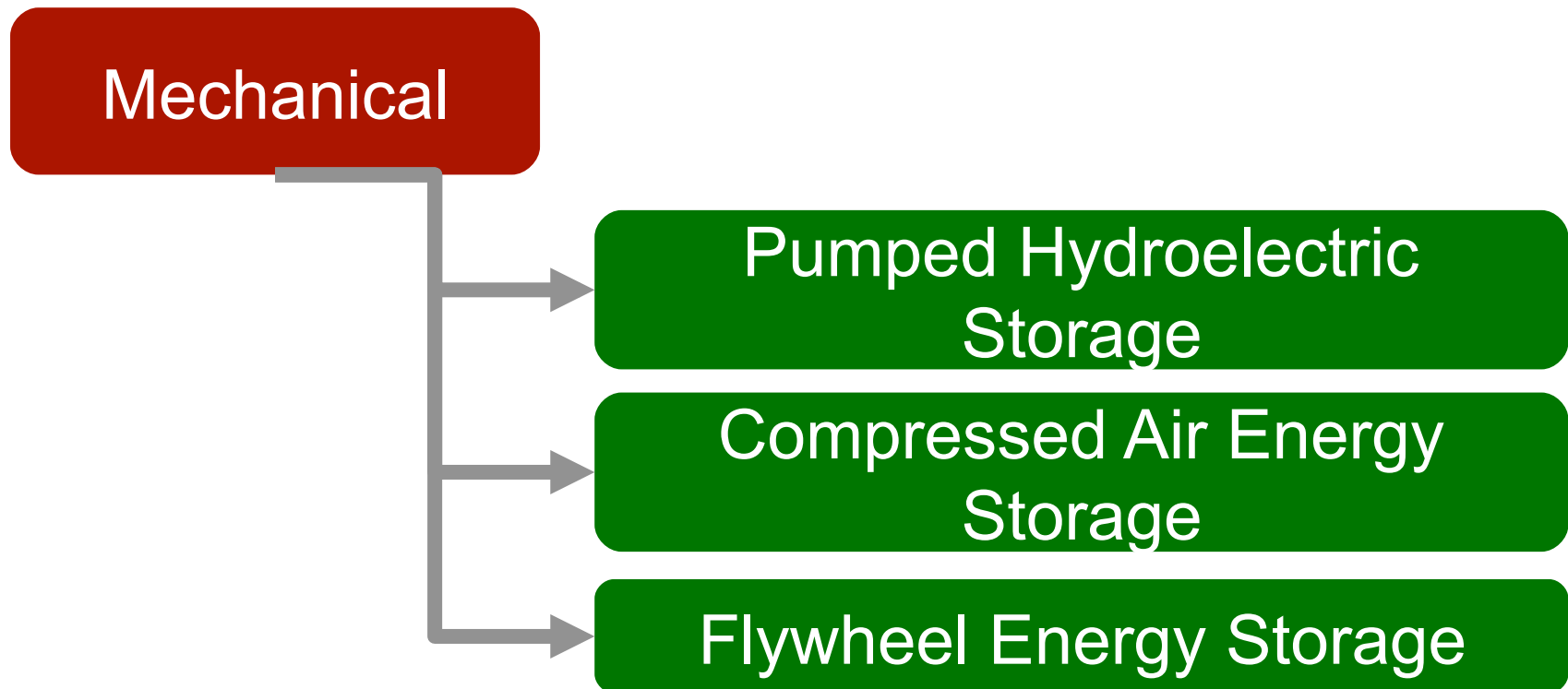
Thermal

Thermochemical Energy Storage



Electrical Energy Storage... how?

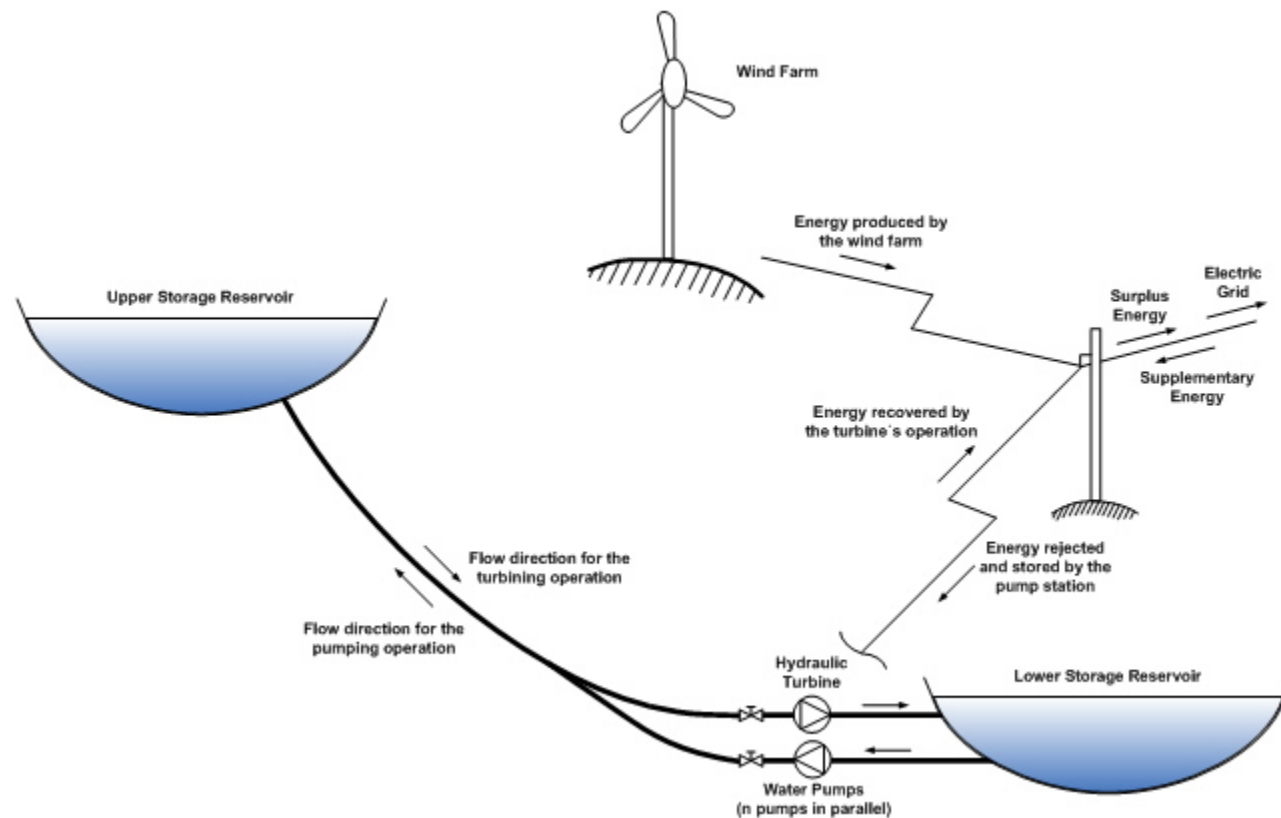
Clasification: Mechanical



Electrical Energy Storage... how?

Mechanical

Pumped Hydroelectric storage (1890)



Electrical Energy Storage... how?

Mechanical

Pumped Hydroelectric storage



<http://205.186.157.185/wp-content/uploads/2010/08/SPSPaerial.jpg>

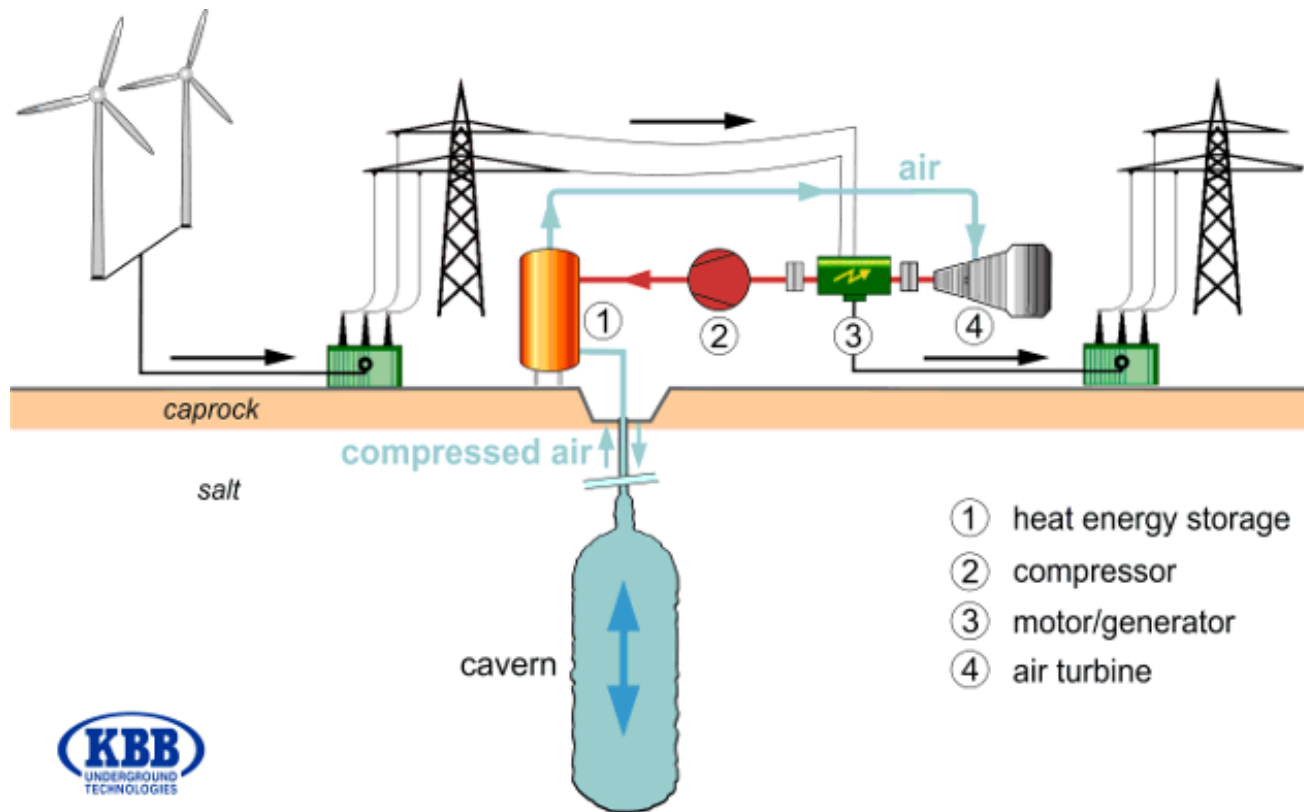
<http://www.gettyimages.com/detail/photo/the-water-reservoir-hydroelectric-power-station-in-royalty-free-image/155385378>

http://www.afconsult.com/globalassets/images/do-business/references/energy-and-power/hydro-power/kruonis_luftaufnahme_peg.jpg

Electrical Energy Storage... how?

Mechanical

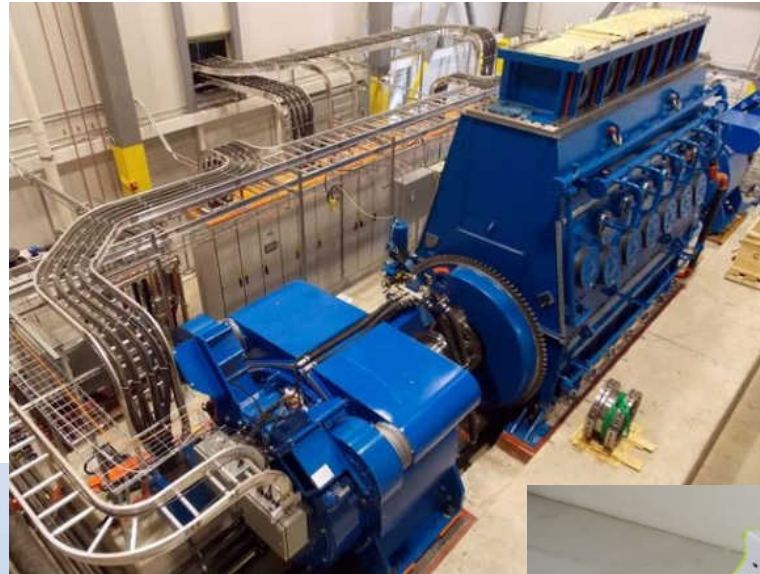
Compressed Air Energy storage (1978)



Electrical Energy Storage... how?

Mechanical

Compressed Air Energy storage



<http://www.bine.info/typo3temp/pics/6d070f9cc9.jpg>

http://www.nanalyze.com/app/uploads/2014/06/SustainX_System-600x449.jpg

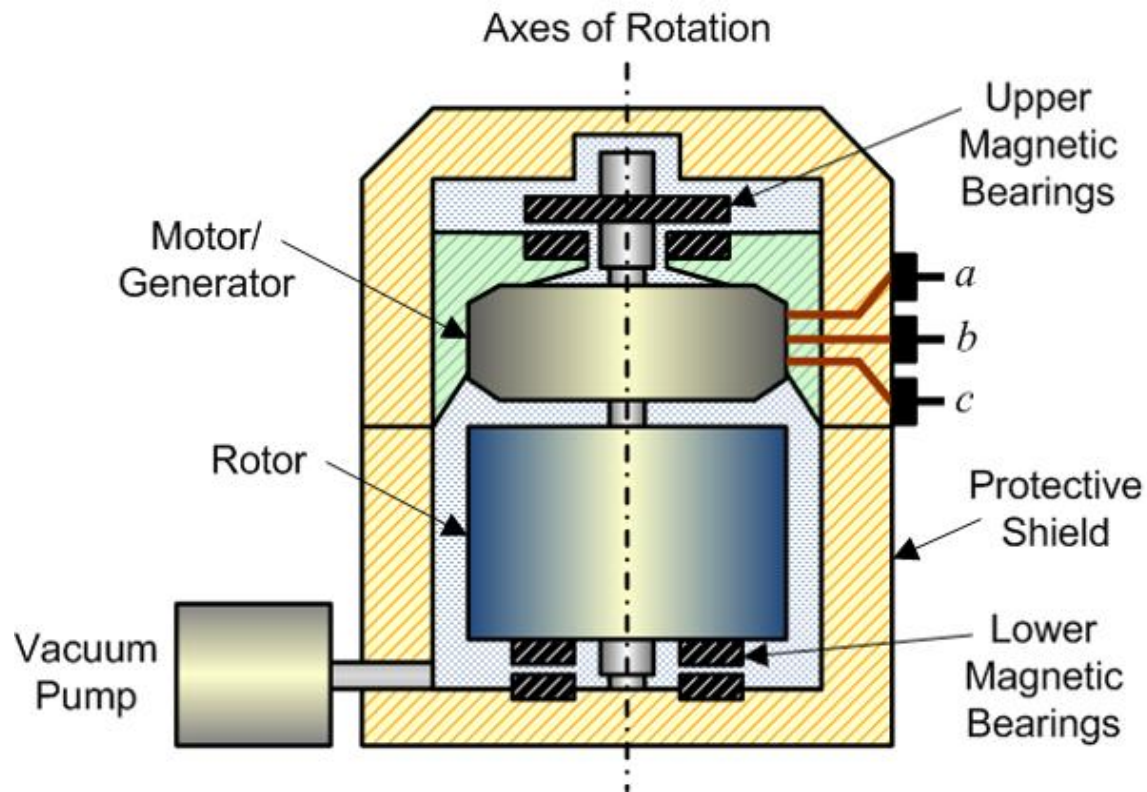
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Electrical Energy Storage... how?

Mechanical

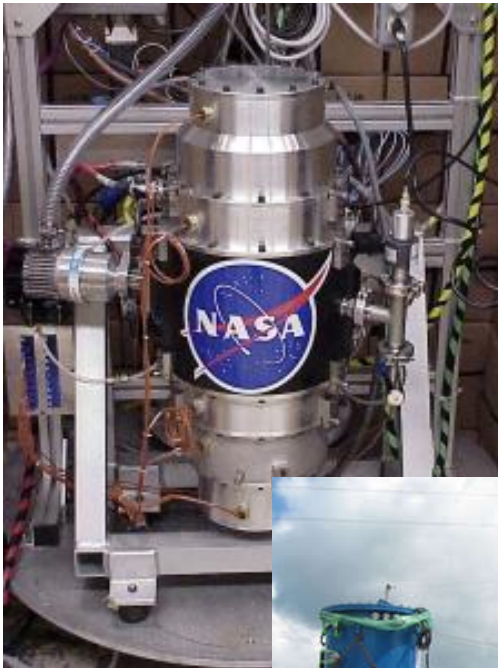
Flywheel Energy Storage (1970)



Electrical Energy Storage... how?

Mechanical

Flywheel Energy Storage



https://upload.wikimedia.org/wikipedia/commons/2/2f/G2_front2.jpg

http://energy.gov/sites/prod/files/styles/borealis_article_hero_respondlarge/public/flywheel400x300.jpg?itok=khSpzj4S

<http://www.nrstor.com/wp-content/uploads/2014/04/Minto-Flywheel-Project.jpg>

<http://www.extremetech.com/wp-content/uploads/2011/08/911GT3RHybrid-5.jpg>

Thank you!