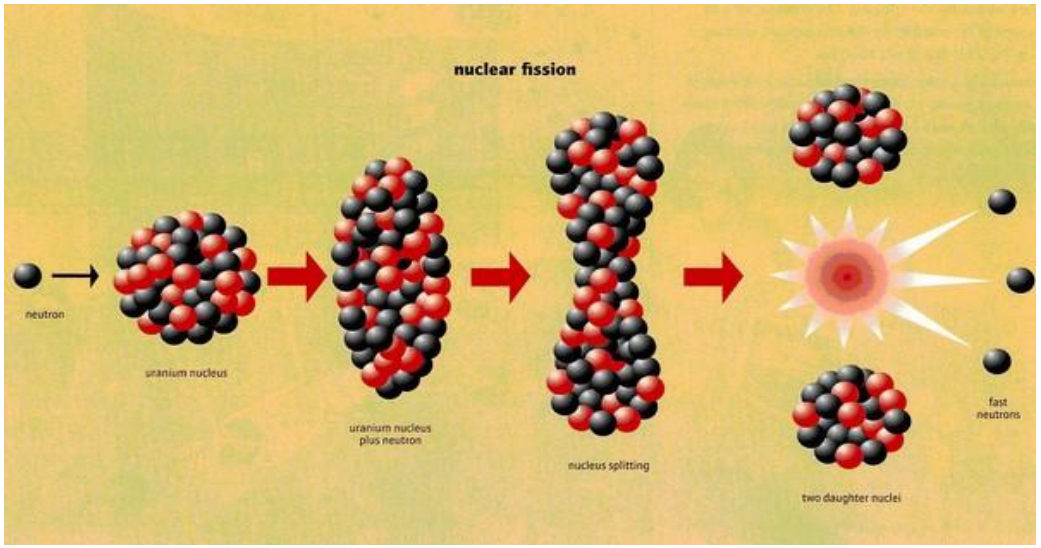
Nuclear Energy: Generation & Storage

Clayton Meranda, Josh Campbell,
Nathaniel Browne, Matthew von Werder

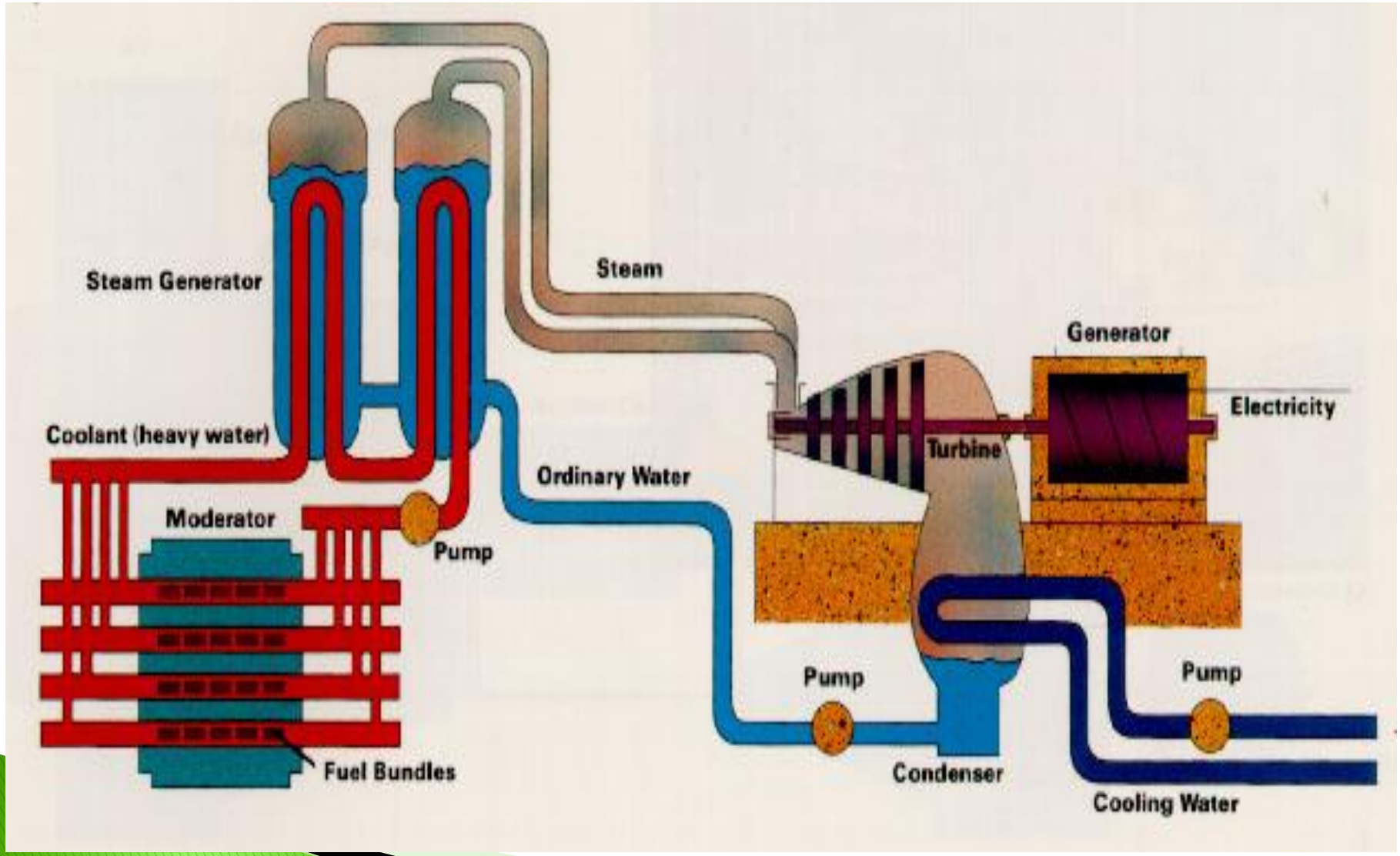
Fission



- The process of one atom splitting into multiple parts, releasing energy

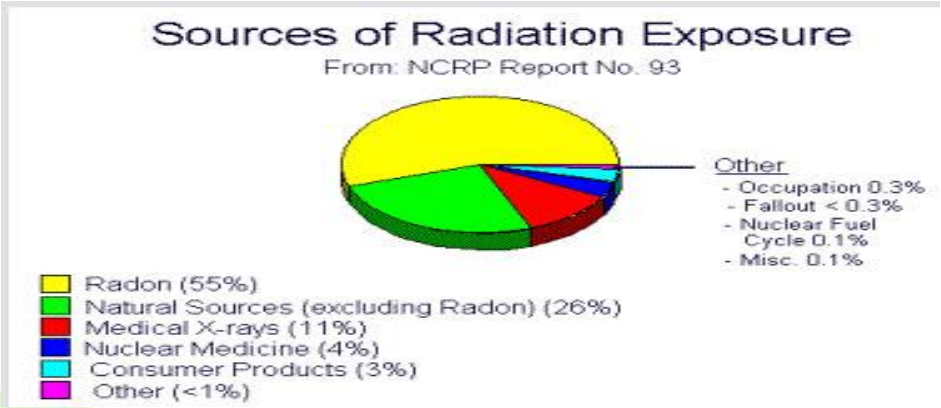
- Enriched uranium undergoes induced fission in a reactor: Fired neutrons split Uranium atom; energy is released

Energy Conversion



Nuclear Information

- Nuclear plants are fully competitive with fossil fuel plants
- Nuclear energy isn't 100% emissions free
- Plants can't exist without government subsidies
- Private investors won't fund because of risk



Current Usage

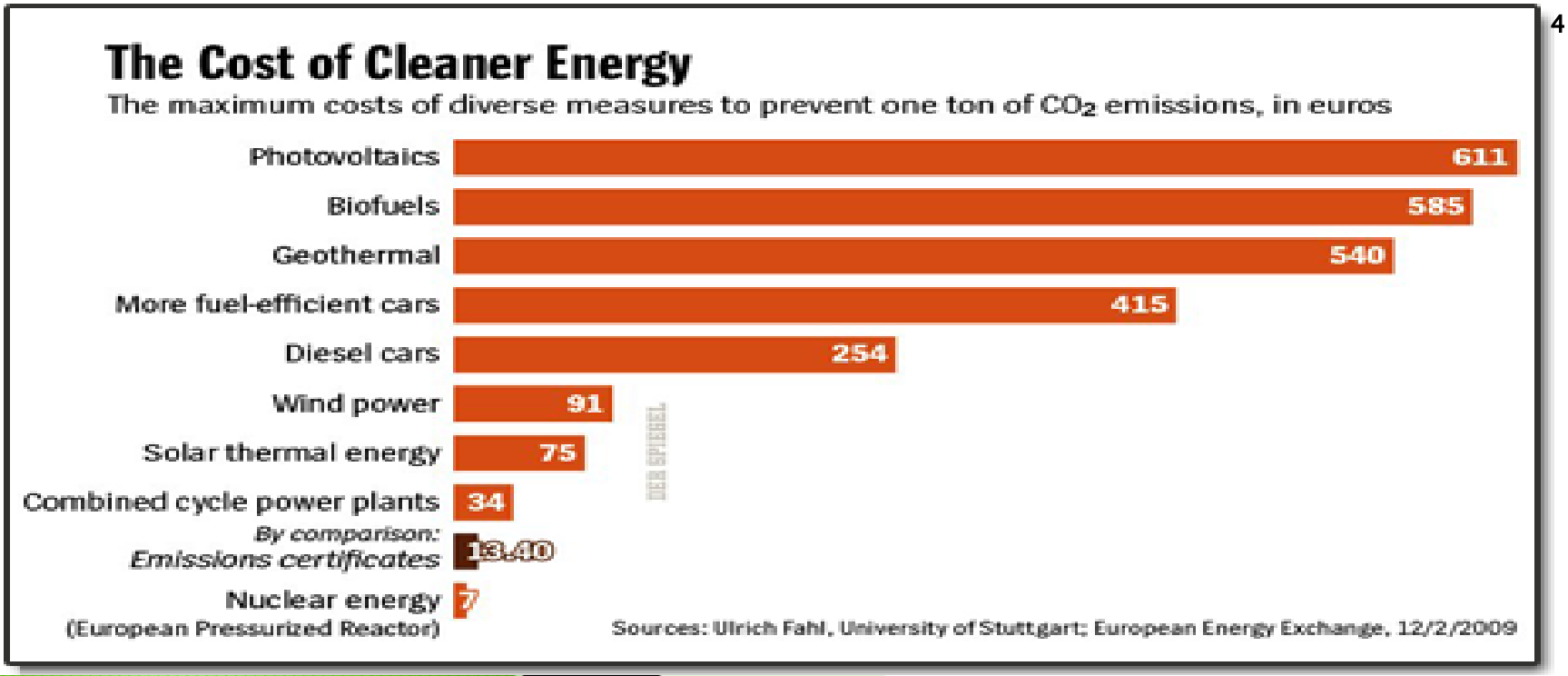
- Provides 13-14% of the world's electricity
- U.S., France, and Japan account for about half of that electricity
- 436 nuclear reactors around the world
- Total US nuclear plants produce roughly 20% of nation's electricity supply
- 150 US naval vessels powered by nuclear energy

Sustainability

- Constant advancement in nuclear field
- New processes being developed to increase efficiency
- Nuclear energy industry is the only power-producing entity to take full responsibility for all waste products
- Cost of waste product management is added to the cost the power supplier charges

Costs

- Nuclear energy comes out to approximately $30 per megawatt hour
- Coal comes in at about $29.10 per megawatt hour

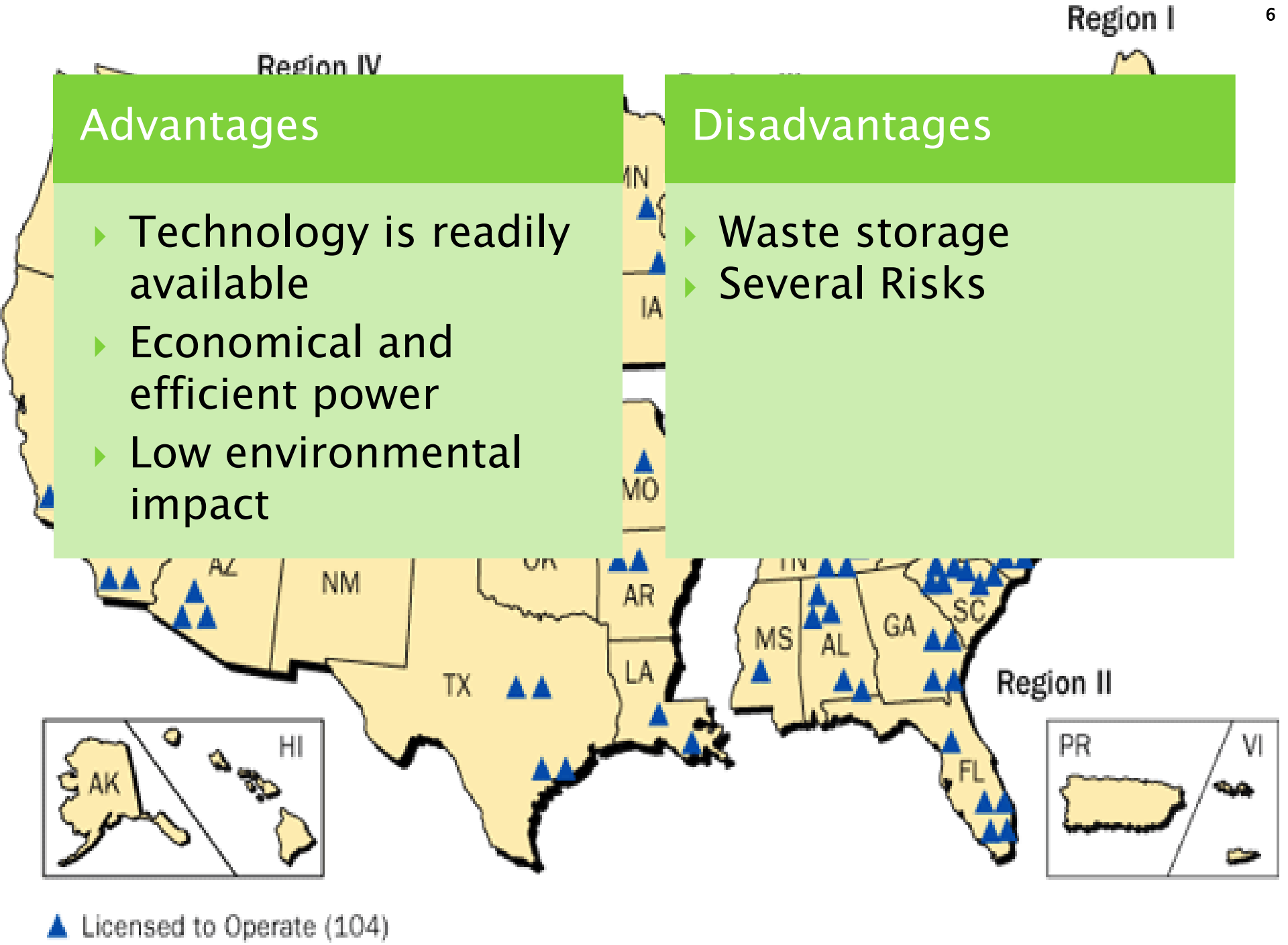


Advantages

- Technology is readily available
- Economical and efficient power
- Low environmental impact

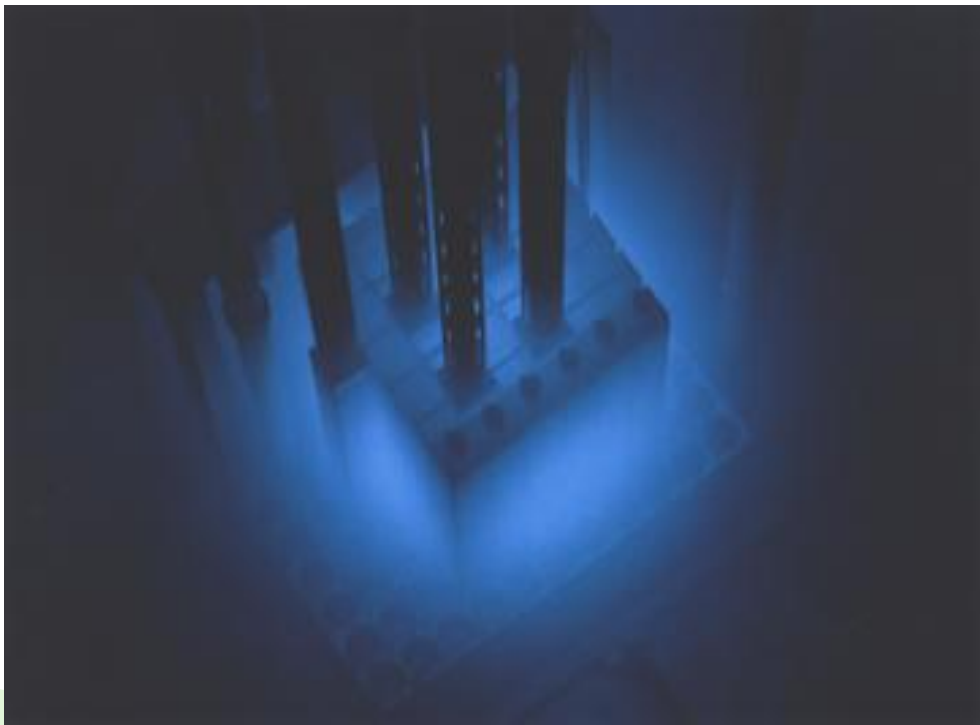
Disadvantages

- Waste storage
- Several Risks



Purdue University Nuclear Reactor Number One (PUR-1)

- Indiana's first and only nuclear reactor
- Produces 1000 watts maximum
- Located underground in the Electrical Engineering building



Radioisotope Batteries

- Emitted particles contact conductive medium, directed into stream of electricity
- Non-thermal: betavoltaics
- Thermal technologies: thermoelectric, thermoionic

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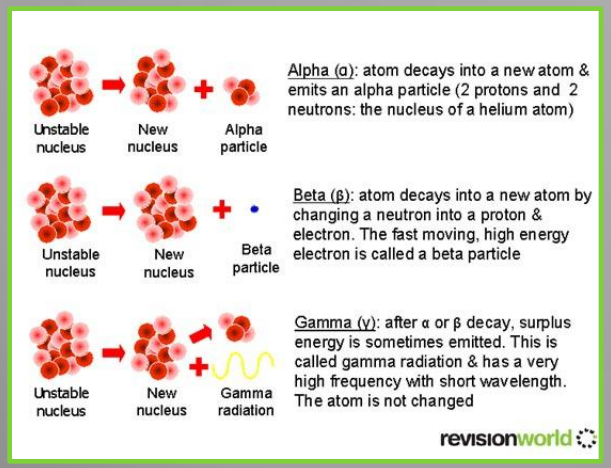

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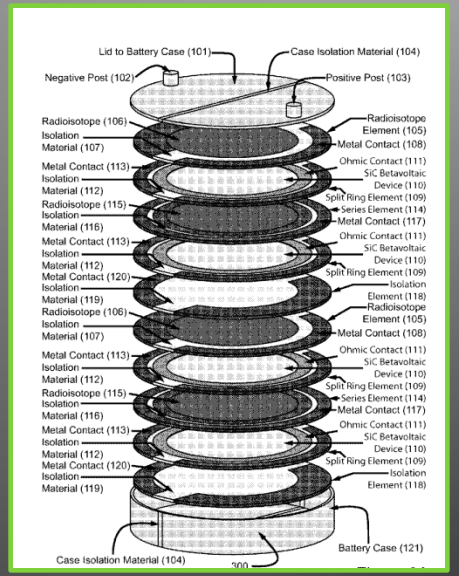

Long-Lasting Energy for Remote Locations

- Simple nuclear batteries provide power for 10-20 years
- Potential lifespans of centuries
- Early pacemakers
- Used by NASA probe missions (*Voyager, Ulysses, Curiosity)*

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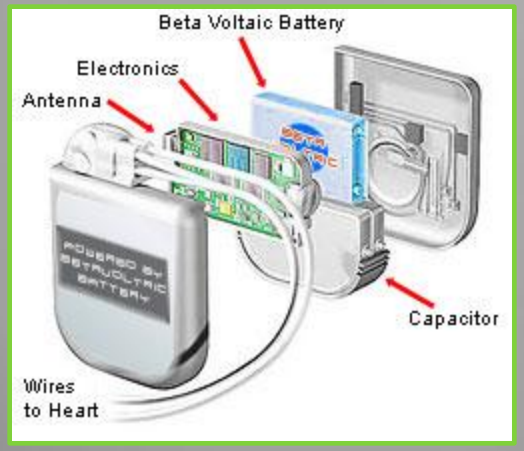

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Storing the energy

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Storage Technologies	Main Advantages (relative)	Disadvantages (Relative)	Power Application	Energy Application
Pumped Storage	High Capacity, Low Cost	Special Site Requirement		●
CAES	High Capacity, Low Cost	Special Site Requirement, Need Gas Fuel		●
Flow Batteries: PSB VRB ZnBr	High Capacity, Independent Power and Energy Ratings	Low Energy Density	◑	●
Metal-Air	Very High Energy Density	Electric Charging is Difficult		●
NaS	High Power & Energy Densities, High Efficiency	Production Cost, Safety Concerns (addressed in design)	●	●
Li-ion	High Power & Energy Densities, High Efficiency	High Production Cost, Requires Special Charging Circuit	●	○
Ni-Cd	High Power & Energy Densities, Efficiency		●	◑
Other Advanced Batteries	High Power & Energy Densities, High Efficiency	High Production Cost	●	○
Lead-Acid	Low Capital Cost	Limited Cycle Life when Deeply Discharged	●	○
Flywheels	High Power	Low Energy density	●	○
SMES, DSMES	High Power	Low Energy Density, High Production Cost	●	
E.C. Capacitors	Long Cycle Life, High Efficiency	Low Energy Density	●	◑

● Fully capable and reasonable

◑ Reasonable for this application

○ Feasable but not quite practical or economical

None Not feasable or economical

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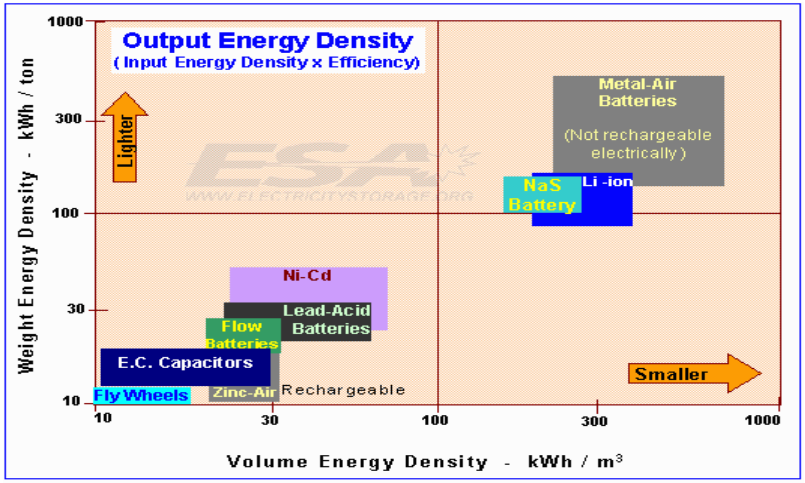

How it works

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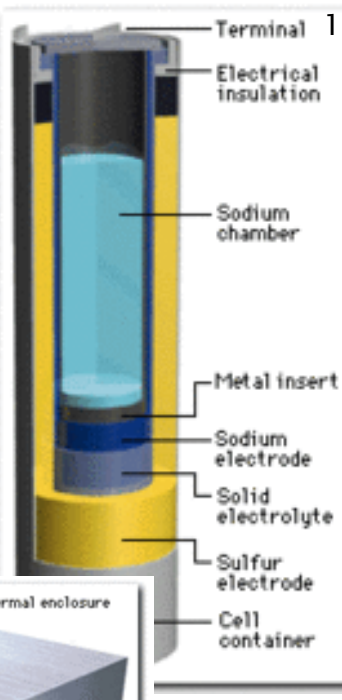

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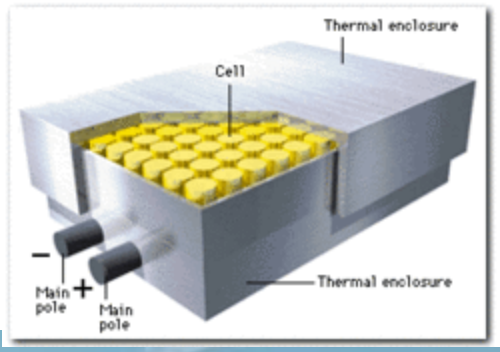
- Molten Sodium Sulfur at approximately 300C
- Approximately 89% efficiency
- Lifetime of 2,500 cycles (at 100% DOD – depth of discharge)
- Approximatley20-50 kW (per cell)



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SMES

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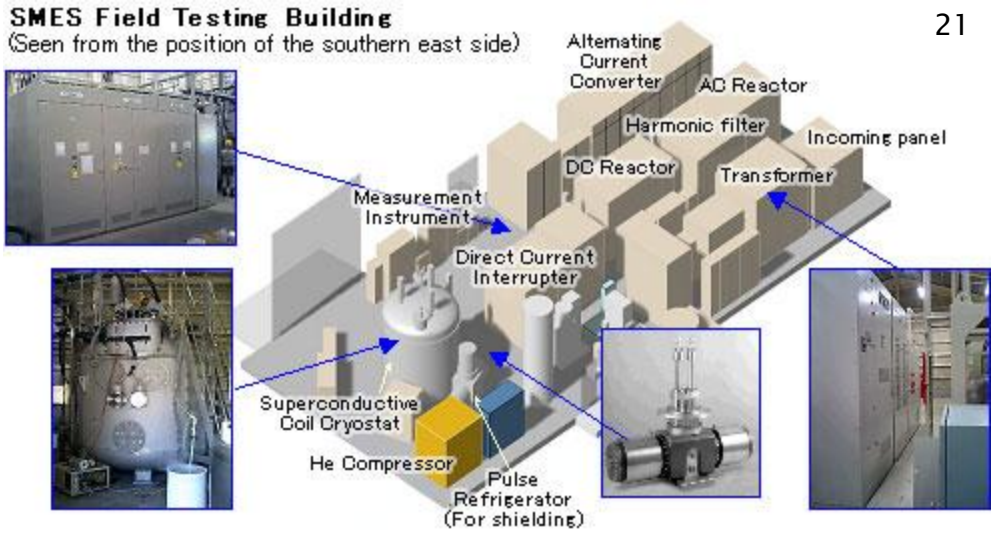

- 95% Efficiency
- No moving parts
- 1-20 MW-h
- 2/20/200 MW

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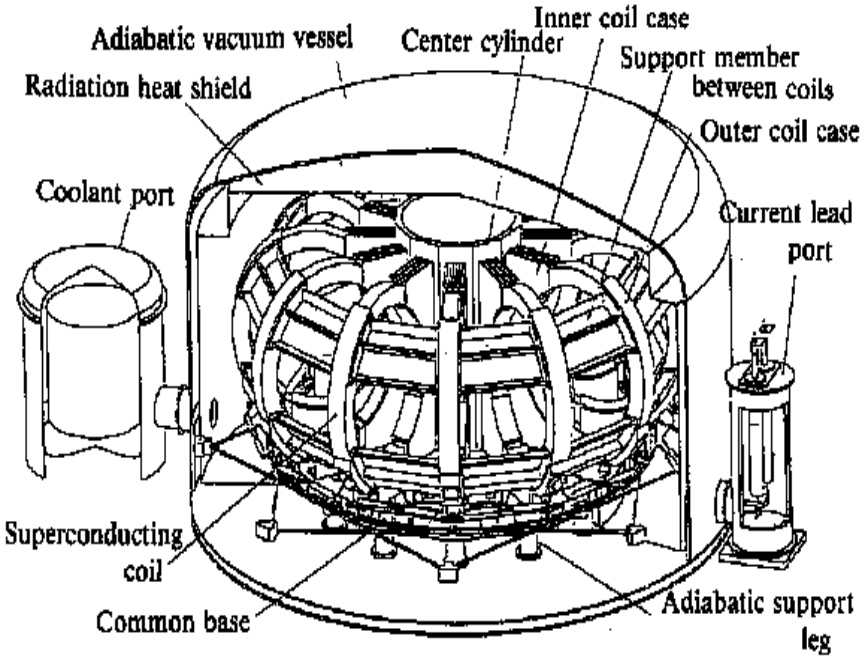

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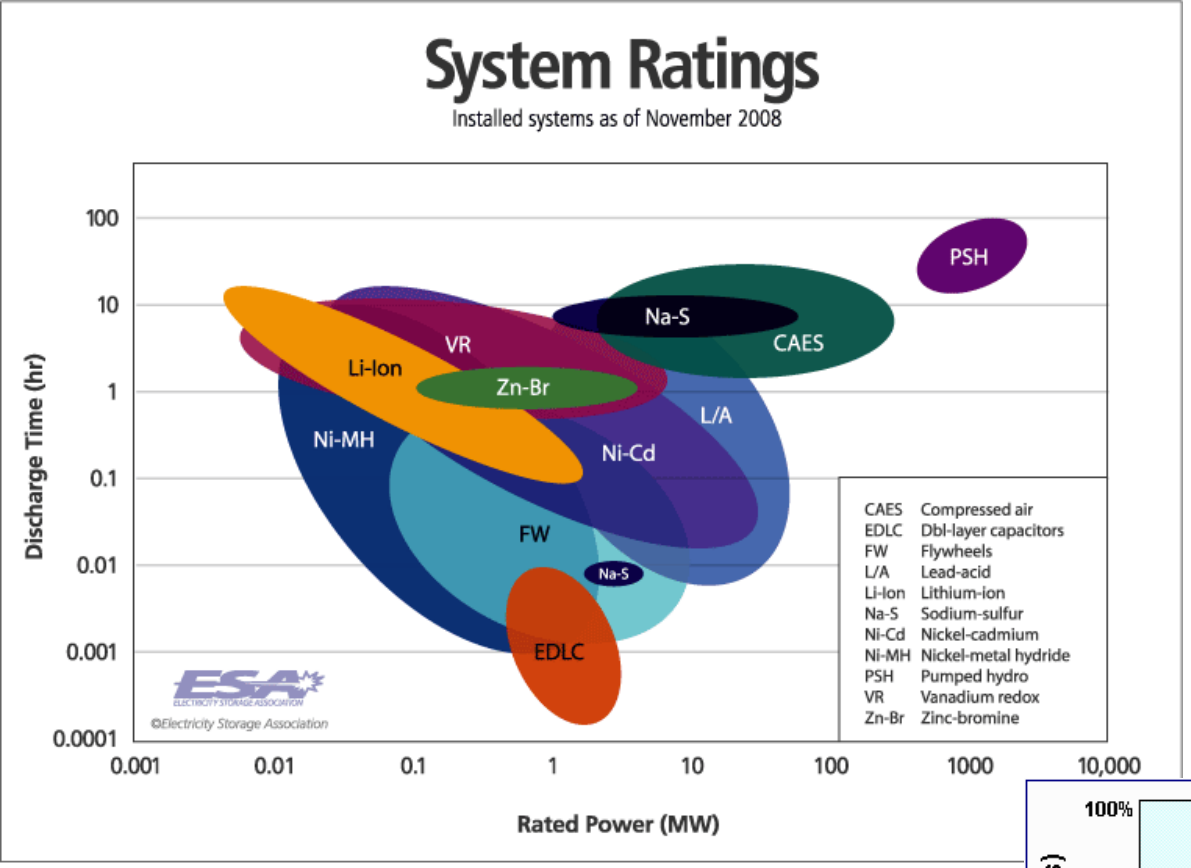
Questions?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Installed systems as of November 2008
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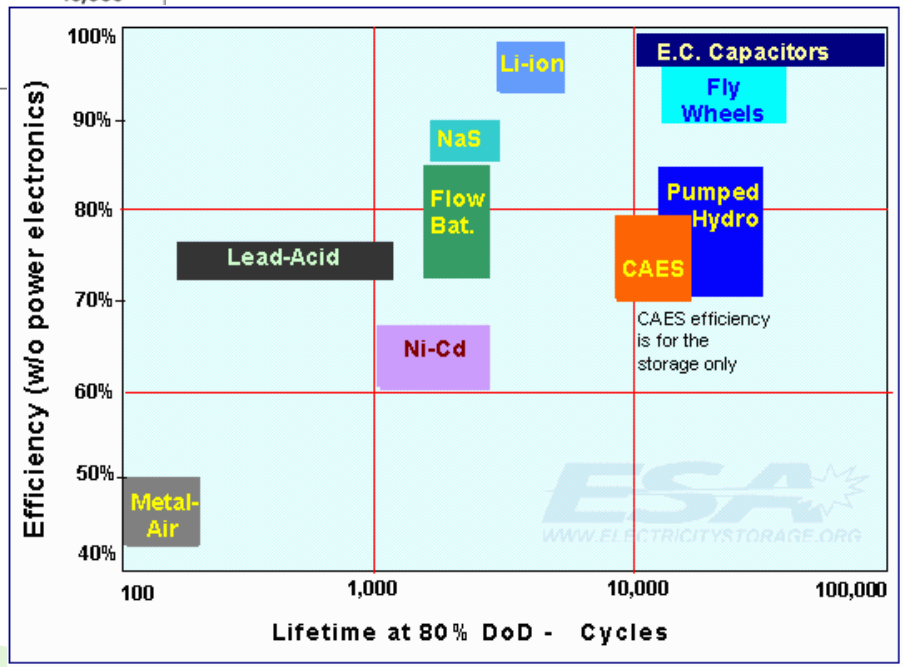
0.1
0.01
0.001
0.0001
0.001
0.01
0.1
1
10
100
1000
10,000
Rated Power (MW)
PSH
Na-S
CAES
VR
Li-Ion
Zn-Br
L/A
Ni-MH
Ni-Cd
FW
Na-S
EDLC
ESA
©Electricity Storage Association
CAES Compressed air
EDLC Dbl-layer capacitors
FW Flywheels
L/A Lead-acid
Li-Ion Lithium-ion
Na-S Sodium-sulfur
Ni-Cd Nickel-cadmium
Ni-MH Nickel-metal hydride
PSH Pumped hydro
VR Vanadium redox
Zn-Br Zinc-bromine


Efficiency (w/o power electronics)
100%
90%
80%
70%
60%
50%
40%
100
1,000
10,000
100,000
Lifetime at 80% DoD - Cycles
E.C. Capacitors
Fly Wheels
Li-ion
NaS
Flow Bat.
Pumped Hydro
Lead-Acid
CAES
Ni-Cd
Metal-Air
CAES efficiency is for the storage only
ESA
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