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A glance at the possibilities for improving efficiency in grid energy storage by superconducting technology

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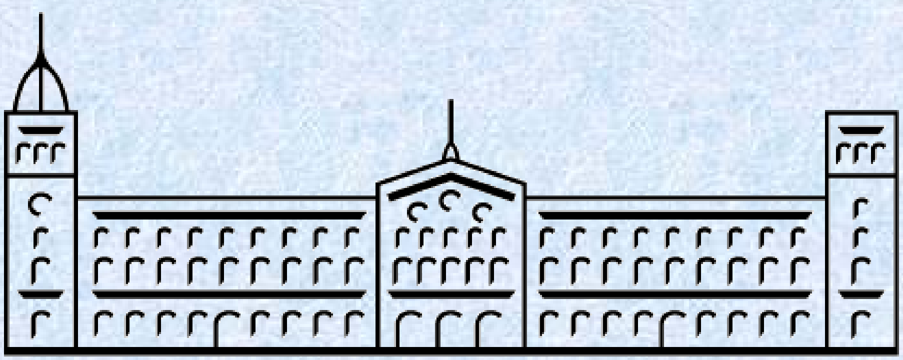

International Workshop on
Energy Storage in the Grid:
Low, Medium and Large Scale Requirements.
Barcelona, 8th - 10th January 2014

Where we are

Spain
Extremadura
Badajoz

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Outline

- Overview of energy storage technologies
  - Cycle of work
  - Round trip eficiency
  - Power / Energy applications
- SMES
  - Physic
  - Current application
  - ‘Why-not’ applications

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Overview of storage technologies

$$\Delta E_{in} \xrightarrow{\;E_{loss}\;} E_{stored} \xrightarrow{\;E_{loss}\;} \Delta E_{out} = P \cdot \Delta t$$

Charge rate

GRID

Discharge rate

$$RTE = \frac{\Delta E_{out}}{\Delta E_{in}}$$

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Overview of storage technologies

$$\Delta E_{out} = P \cdot \Delta t$$

- Power applications
  - High power (rated grid power or more)
  - Short periods of time (seconds to few minutes)
  - *A low stored energy is enough*
- Energy applications
  - High power (near rated grid power)
  - Longer periods of discharge
  - *A high stored energy in needed*

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Overview of storage technologies

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)	●	●

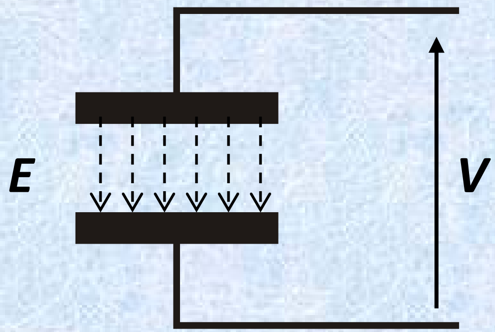
Source: ESA (http://www.electricitystorage.org) AAG

Overview of storage technologies

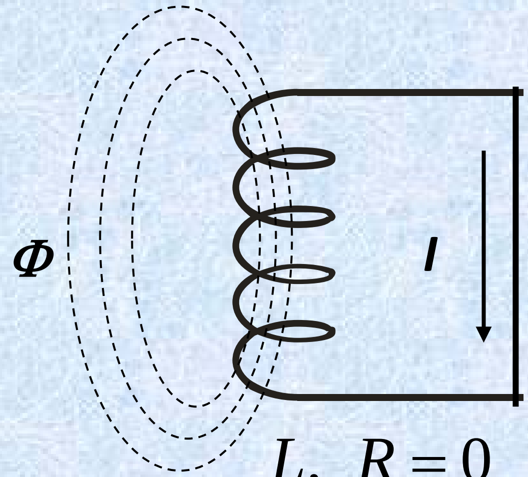
Storage Technologies	Main Advantages (relative)	Disadvantages (Relative)	Power Application	Energy Application
Li-ion	High Power & Energy Densities, High Efficiency	High Production Cost, Requires Special Charging Circuit	●	○
Ni-Cd	High Power & Energy Densities, Efficiency		●	◐
Other Advanced Batteries	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	●	○
E.C. Capacitors	Long Cycle Life, High Efficiency	Low Energy Density	●	◐
SMES, DSMES	High Power	Low Energy Density, High Production Cost	●	

Source: ESA (http://www.electricitystorage.org) AAG

SMES



$C,\ \ R \to \infty$

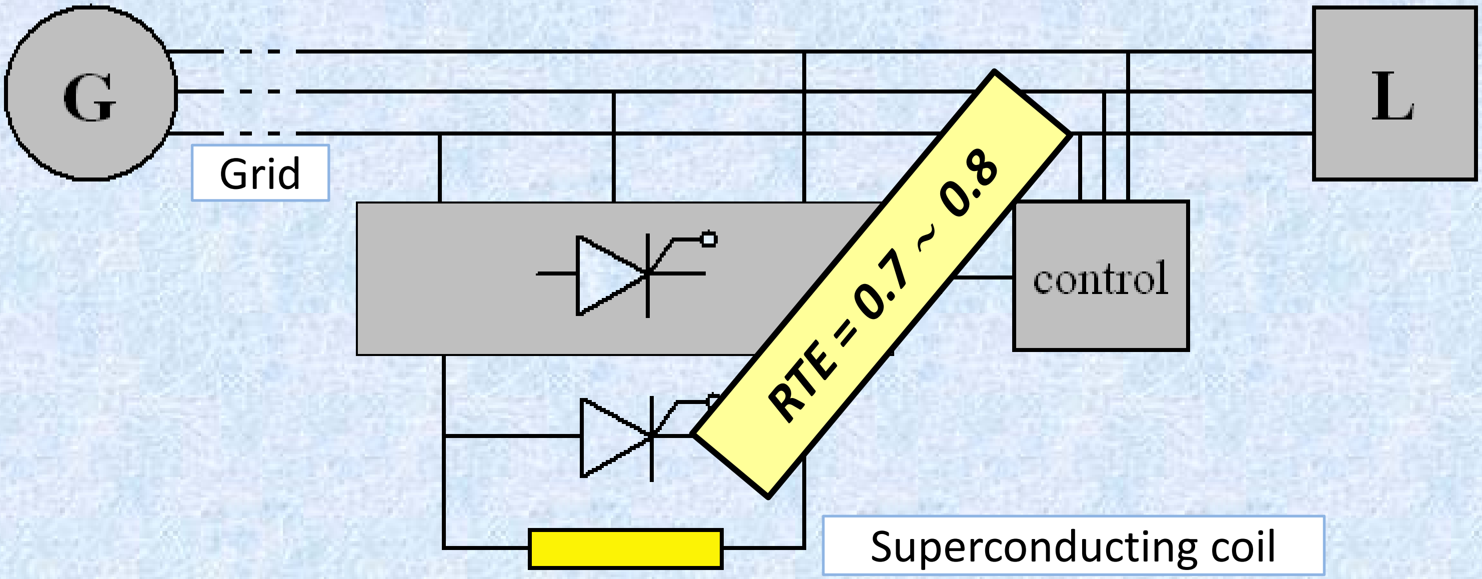


$L,\ \ R = 0$

$$E_{stored} = \frac{1}{2} C V^2$$

$$E_{stored} = \frac{1}{2} L I^2$$

SMES



- High power
- High velocity
- Reasonable eficiency

- Low energy density
- High production cost

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Superconducting Magnetic Energy Storage
State-of-the-Art of HTS SMES Development

Chubu, Japan
Bridging voltage dips

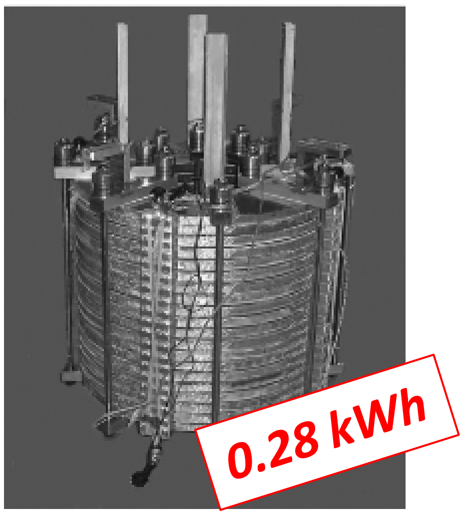


Figure: Chubu Electric

1 MJ , 1 MW
Bi 2212 tape
500 A,
5 K conduction cooled
Voltage: 2.5 kV

KERI, Korea
Power quality

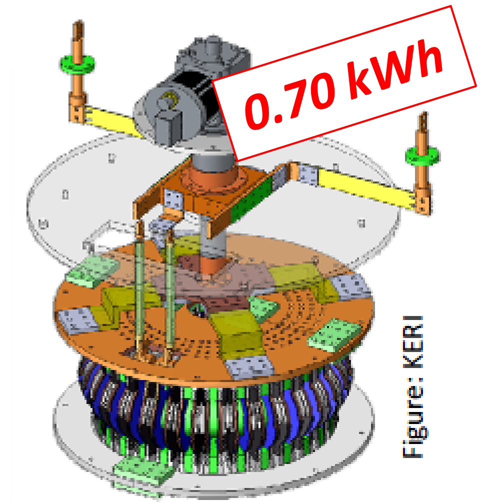


Figure: KERI

2.5 MJ
YBCO tape, 22 km
550 A
20 K conduction cooled
B_{maxII} 6.24 T
Test in 2011

CNRS, France
Military application

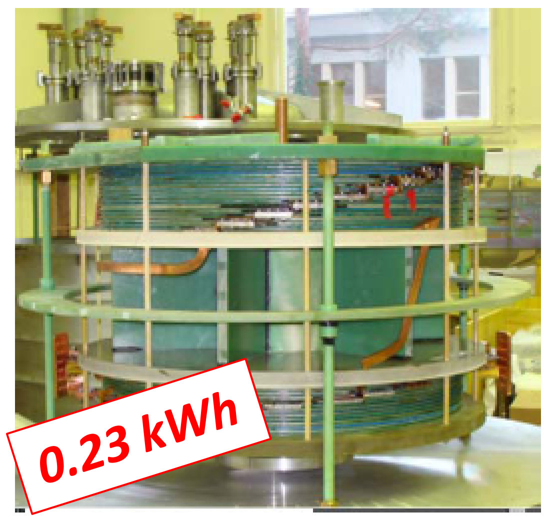
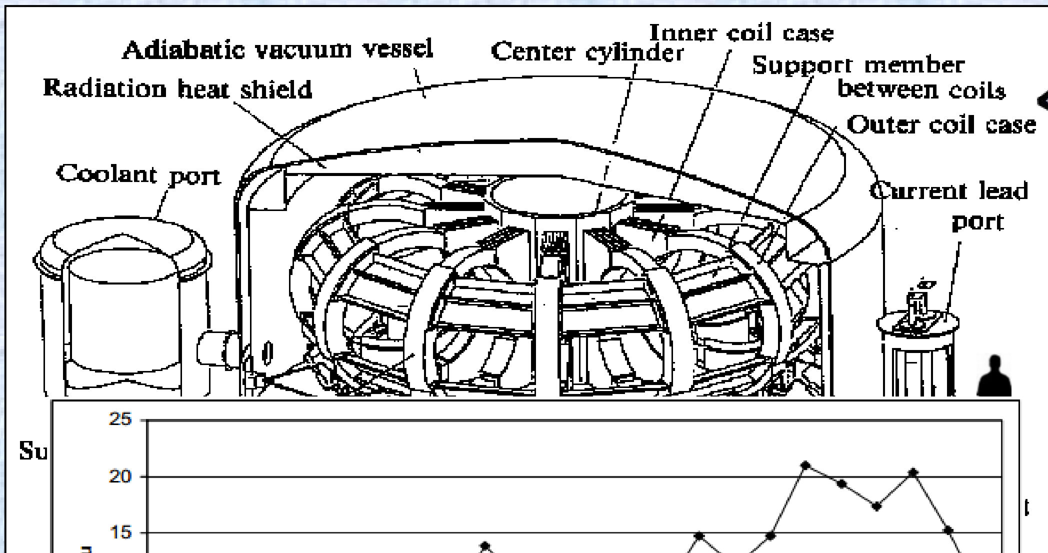


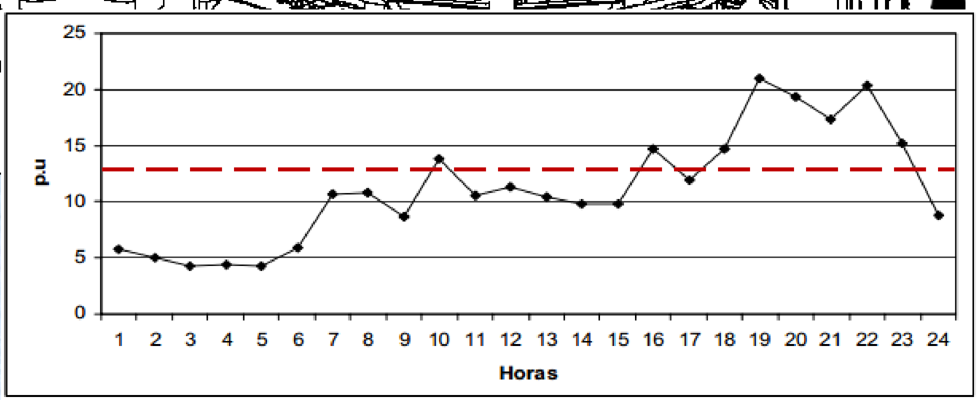
Figure: CNRS

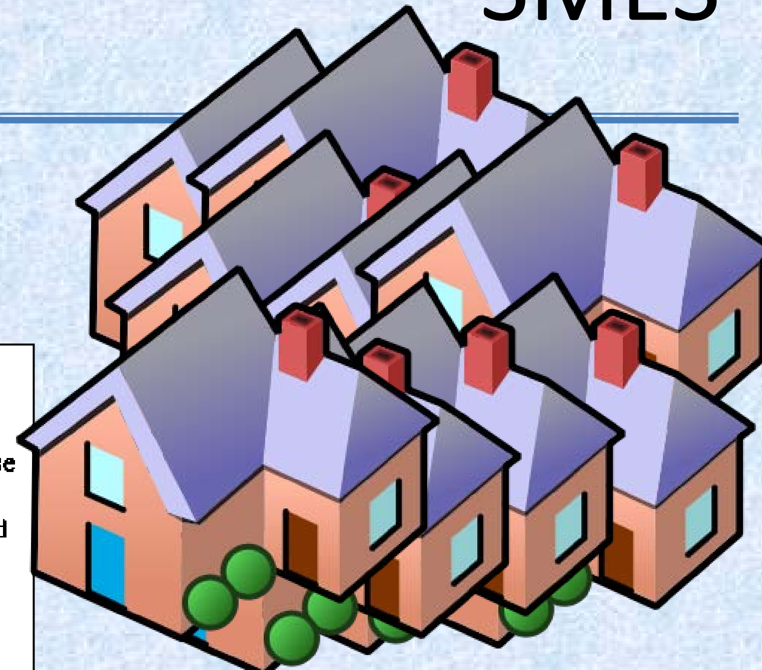
814 kJ
Bi 2212 tape
315 A
20 K conduction cooled
Diameter : 300/814 mm
Height: 222 mm

SMES

ISTEC-TOSHIBA
100 kWh 20 kW







3600 kWh / year

10 kWh / day

x 1, 10 days
x 10, 1 day
x 30, 8 hours

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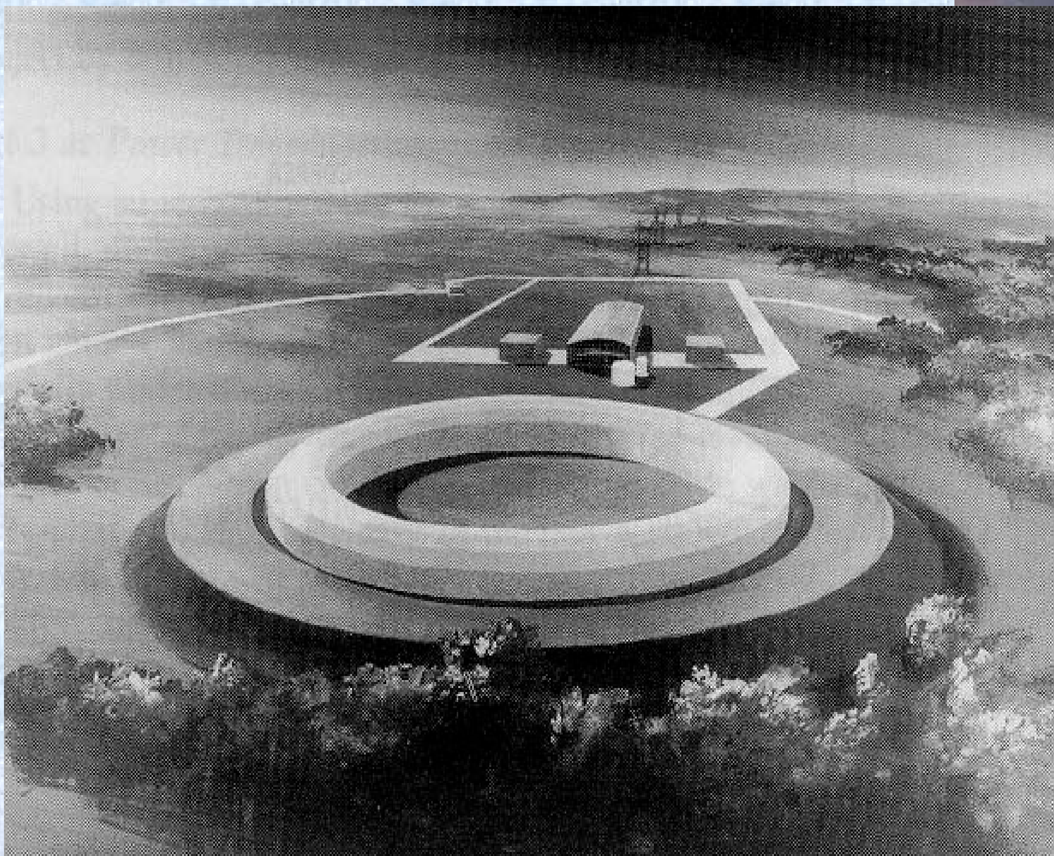

20 MWh SMES

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Conclussions

- SMES is currently a real solution in ***Power Applications*** as UPS or quality solutions.
- In ***Energy Applications,*** SMES are usually rejected because of
  - High production cost (due to the superconducting tape cost and structural materials, mainly)
  - Low energy density (what is not a problem in others storage systems)
- Depending on the rated power and energy, we think that SMES can be a solution for all applications, both alone or in a hybrid storage system.

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The end

Thank you for attention

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