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CONFERENCE OMAINTEC 2025 EXHIBITION FM

المؤتمر الدولي الثاني والعشرون لإدارة الأصول والمرافق والصيانة

The 22nd International Asset, Facility & Maintenance Management Conference

Digitization - Excellence - Sustainability

Superconducting Magnetic Energy Storage (SMES) Energy Applications

Eng. Nehal Alyamani

26-28 January 2025
The Ritz-Carlton Jeddah, Kingdom of Saudi Arabia

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About

Eng. Nehal Alyamani

Electrical and Computer Engineer
Mssc. Renewable Energy Engineering
IEEE WSA member – Head of SIGHT

- **Certified Electrical Engineer.**
- **Certified Trainer Technical and Vocational Corporation.**
- **Received her Bachelor's degree from Effat University (2017), in Electrical and Computer Engineering.**
- **Received her master's degree in (Energy Engineering - Renewable Energy) from Effat University (2021).**
- **Between 2016 - 2022 She published several research work via IEEE and other engineering and research portals; related to Digital systems, Sustainability, Renewable Energy, and Smart cities.**
- **Her current interesting in research projects: on renewable energy (solar & wind), power system development, environment & sustainability studies.**

Topics

- SMES (Superconducting Magnetic Energy Storage)
- SMES Potential, Limitations, and Challenges
- SMES Marketing
- Present And Past Projects / Applications

Introduction

This session will provide an overview of the SMES advantages and the promising advancements as a form of storage technology in the smart grid that can provide a solution to enable the large-scale expansion of renewable energy networking and a faster transition toward a low CO2 energy system, remaining the grid stability and reliability.

Introduction

SMES (superconducting magnetic energy storage) is an energy storage system that stores energy as DC magnetic field

flowing through a superconductor.

Introduction

The SMES principle was imagined in 1969 for large-scale daily load levelling.

Interest in the use of SMES began in the 1960s in US.

The primary superconducting power system application to get the whole commercial status of SMES: 1981 in US.

SMES (Superconducting Magnetic Energy Storage)

Facts

KSA energy consumption:
+(4% - 5%) annually
until 2030

[OIES]

GCC population growth rate

7.5%

[Gcc stat.org]

Avoided GHG
250 M tons CO_2

[2030]

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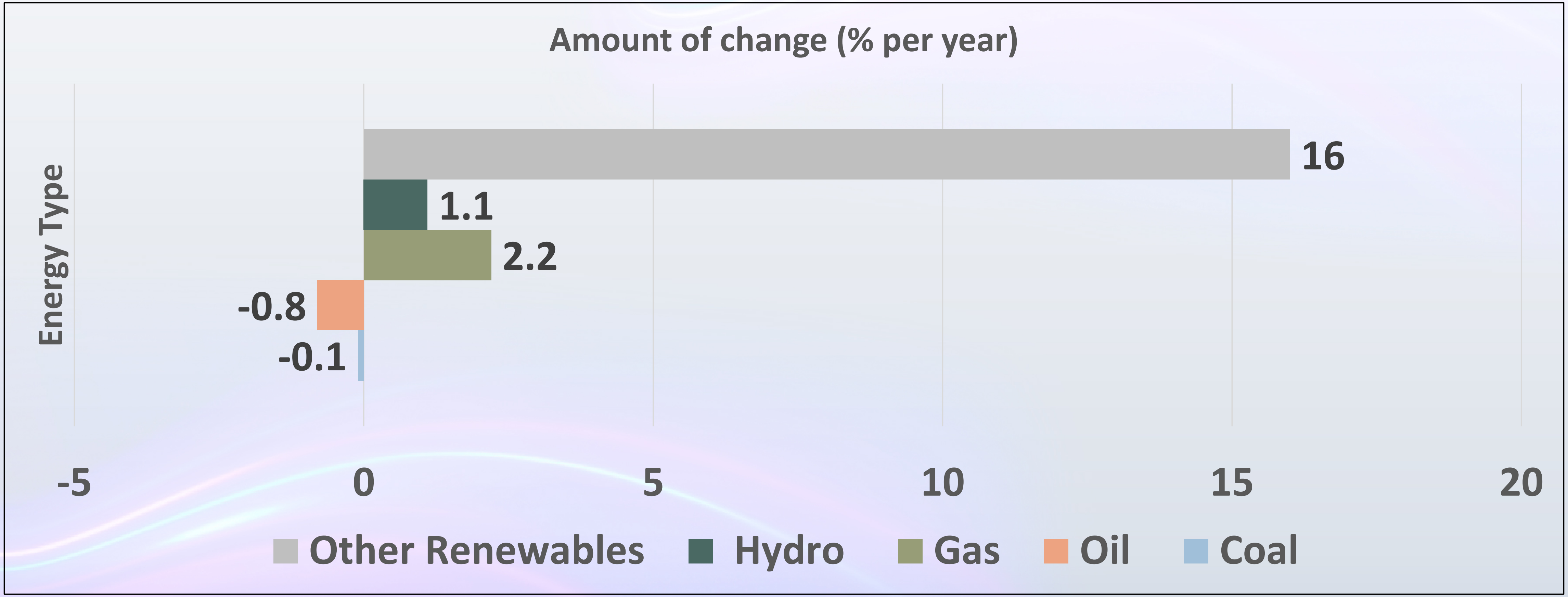
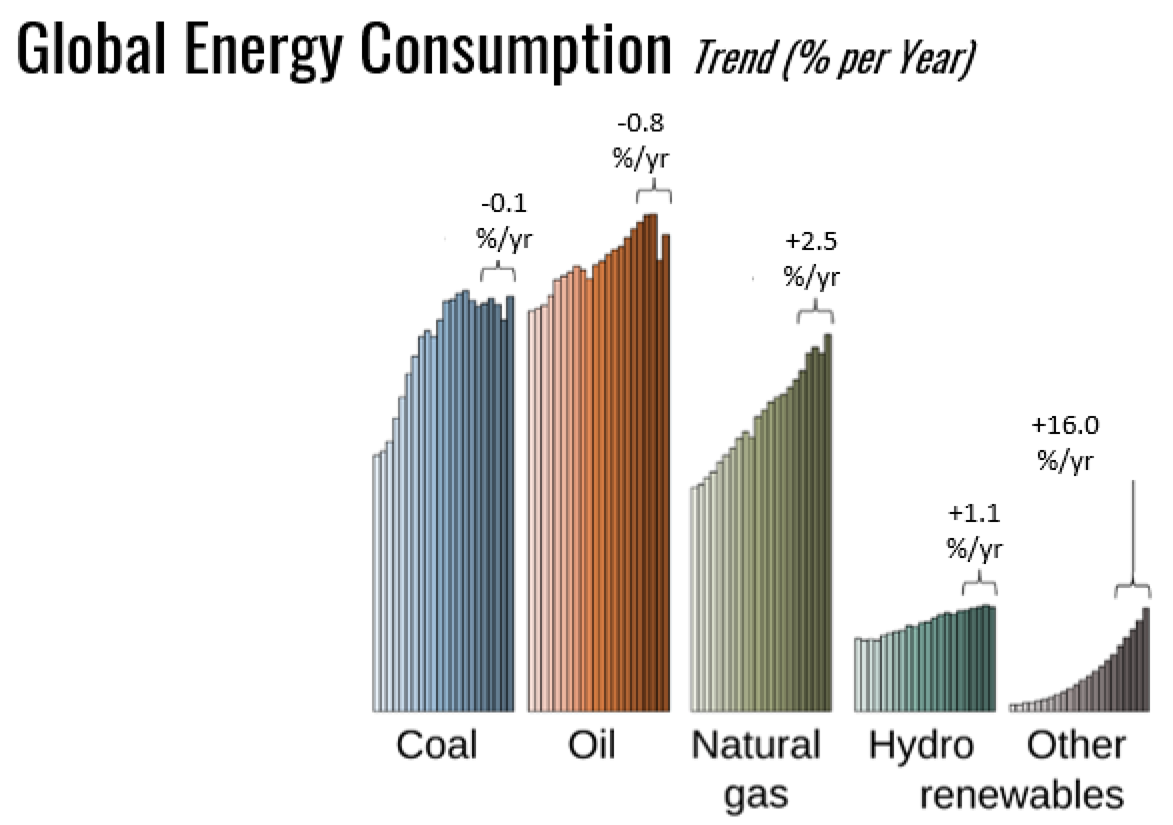
Renewable Energy Involvement

Global Energy Consumption Trend (% per Year)



Renewable Energy Involvement



Jackson RB, et al. (2022). "Global fossil carbon emissions rebound near pre-COVID-19 levels".

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Energy Consumption among “Assets – Facilities”

Figure 9. Saudi Arabia’s energy consumption by sector.

Source: SEEC (2020).

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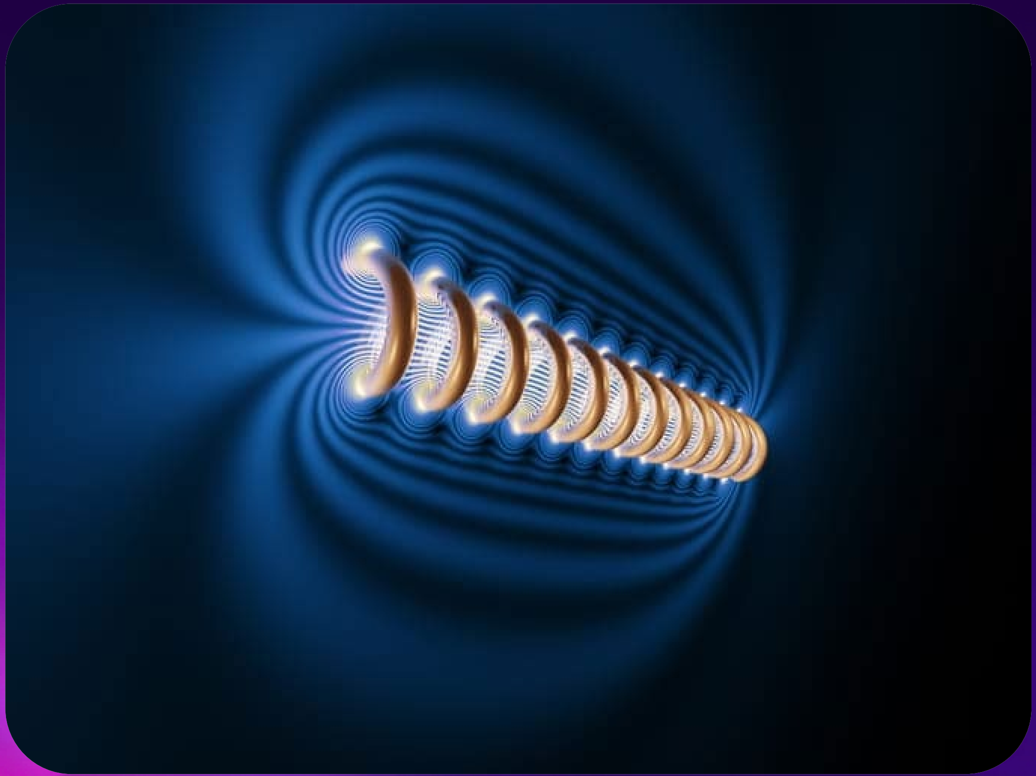
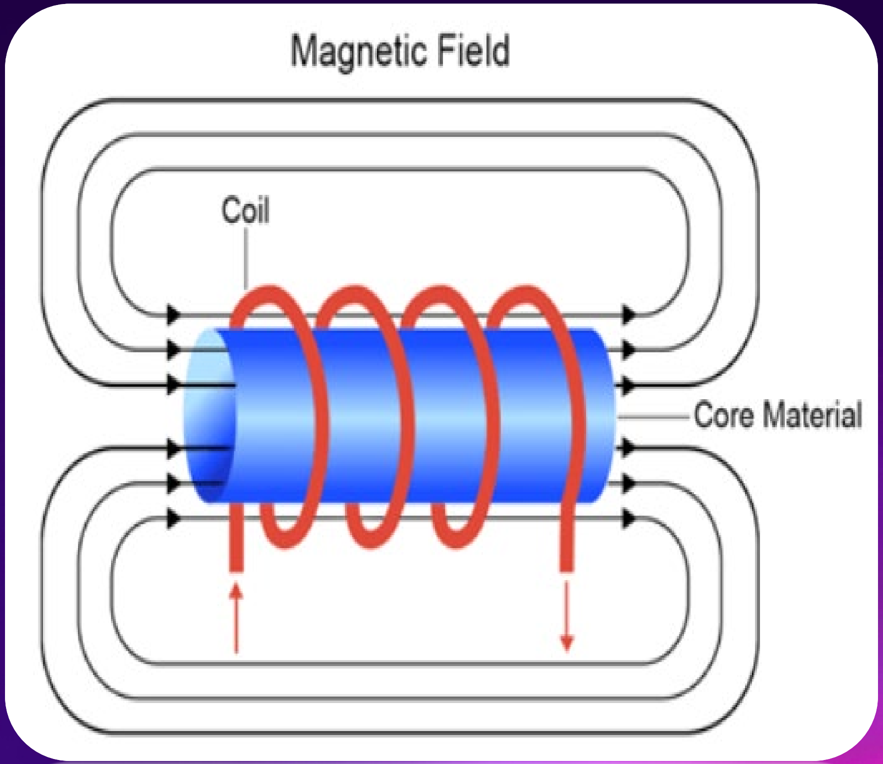
SMES (Superconducting Magnetic Energy Storage) Systems

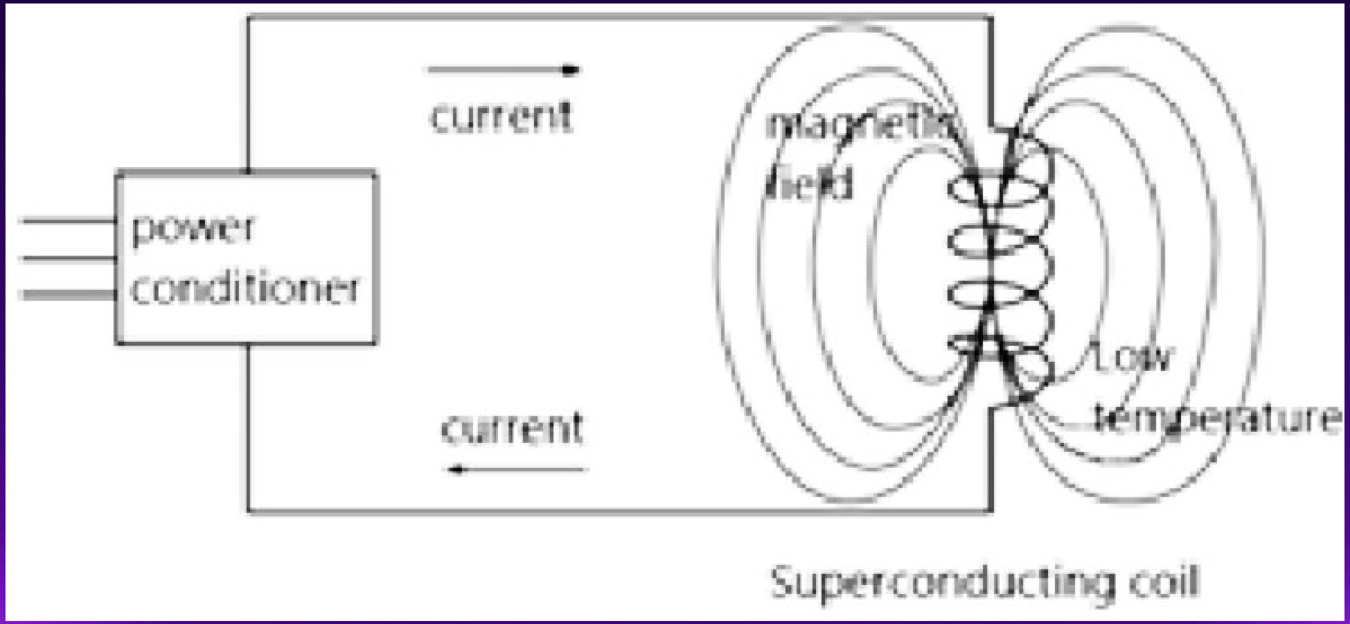
Concept





SMES (Superconducting Magnetic Energy Storage) Systems

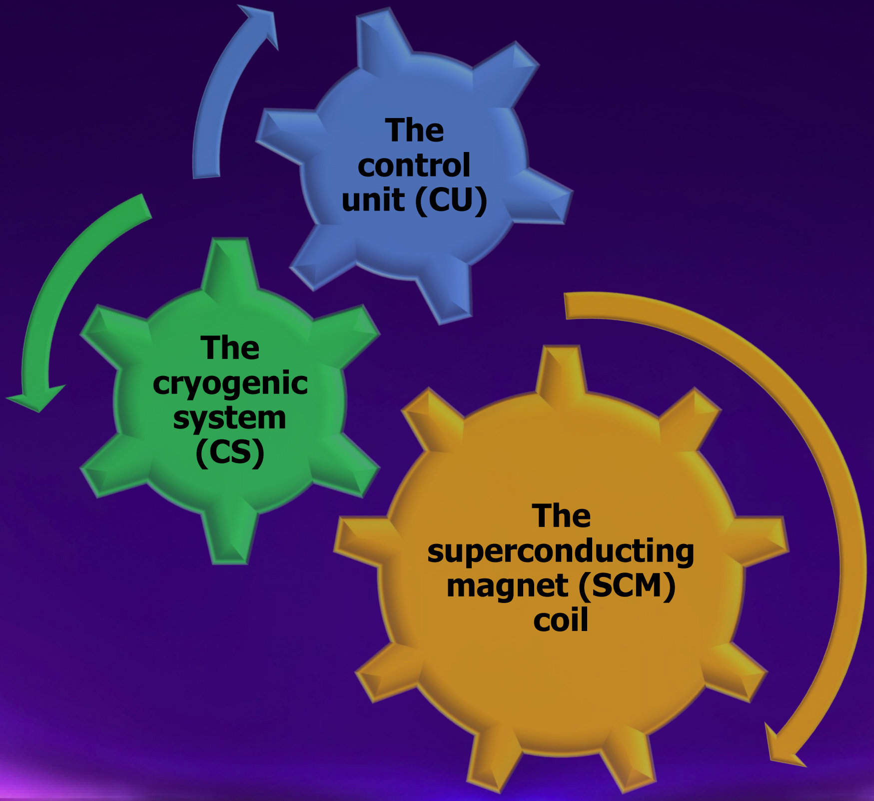
Concept



At cryogenic (very low) temperatures, the current-carrying conductor transforms into a superconductor with essentially zero resistive losses while it produces a magnetic field.

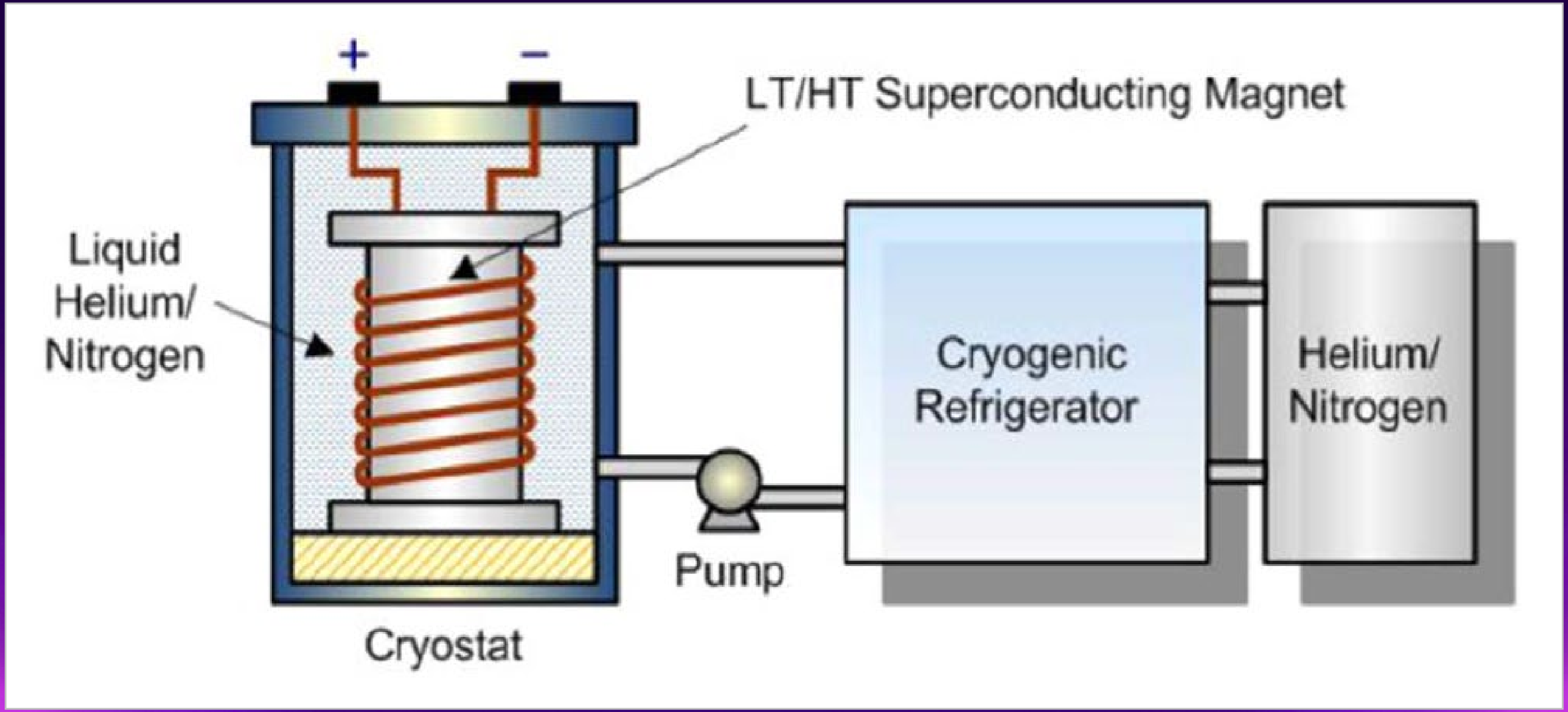
SMES (Superconducting Magnetic Energy Storage) Systems

Elements



SMES (Superconducting Magnetic Energy Storage) Systems

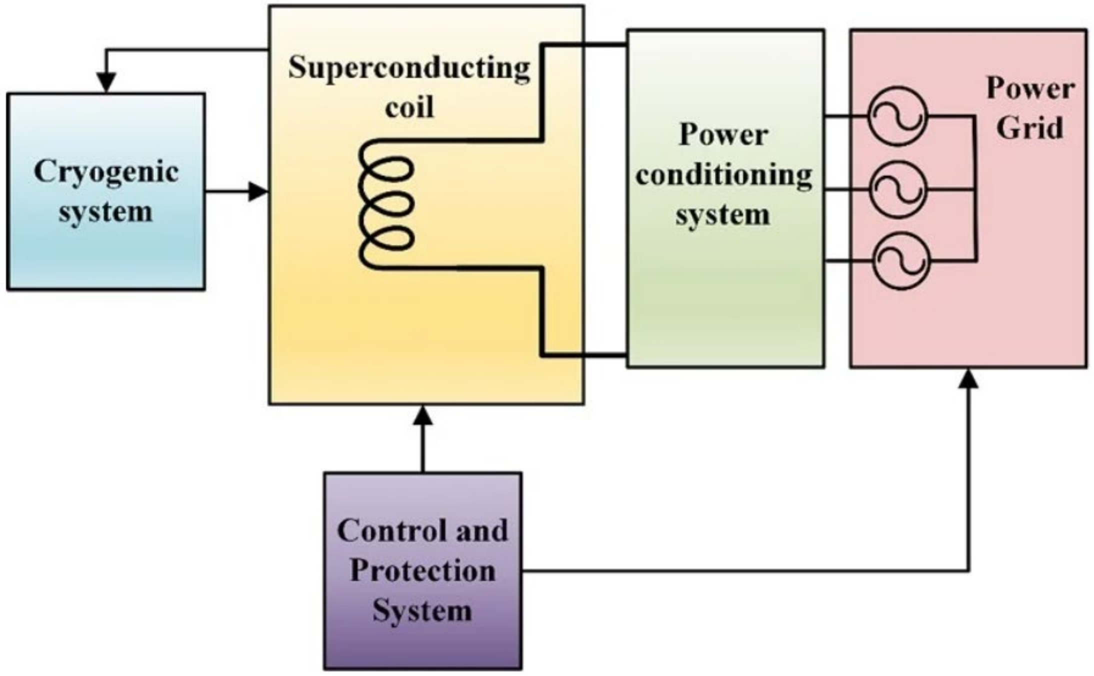
Elements



From: https://www.researchgate.net/figure/Schematic-diagram-of-superconducting-magnetic-energy-storage-67_fig29_344123996
2019/09/01-Mathematical and Bayesian Inference Strategies for Optimal Unit Commitment in Modern Power Systems Pavlos Nikolaidis

SMES (Superconducting Magnetic Energy Storage) Systems

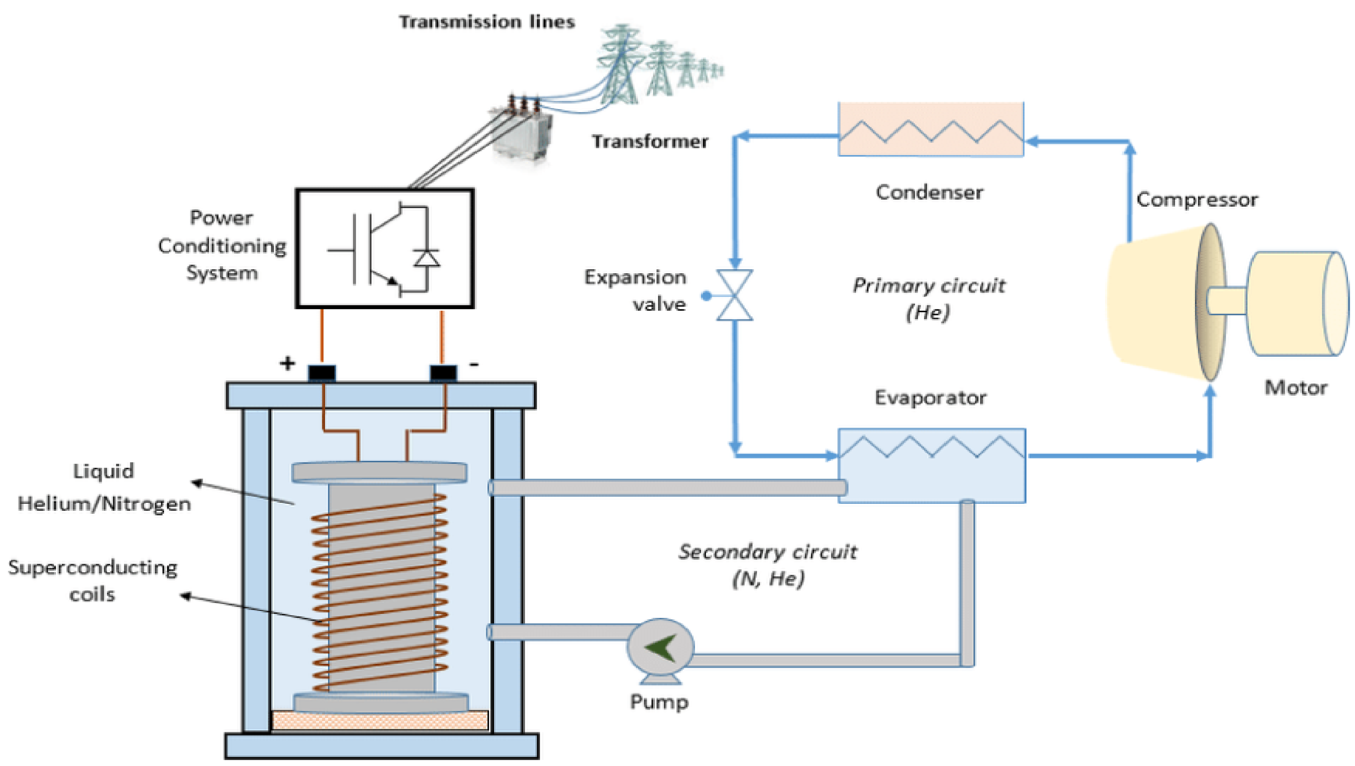
Elements



Source: N. Mughees

SMES (Superconducting Magnetic Energy Storage) Systems

Schematic Diagram



Schematic diagram of superconducting magnetic energy storage [67].

From: https://www.researchgate.net/figure/Schematic-diagram-of-superconducting-magnetic-energy-storage-67_fig29_344123996
2019/09/01-Mathematical and Bayesian Inference Strategies for Optimal Unit Commitment in Modern Power Systems Pavlos Nikolaidis

SMES (Superconducting Magnetic Energy Storage) Systems

General SMES performance

Cycle efficiency	97%
General Power Capacity	100 kW to 10 MW
Cycle Lifetime	No degradation
Discharging	≥ mins-hrs
Reaction time	5 ms
Carbon footprint	Environment friendly
Technical lifetime	30 years

SMES - Potential, Limitations, and Challenges

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SMES

1

Potentials

2

Limitations

3

Challenges

SMES Potentials

High efficiency

Long lifetime

Capacity scalability

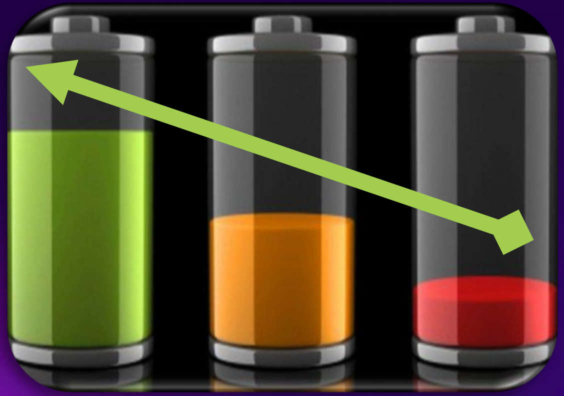
Recyclability

SMES Limitations

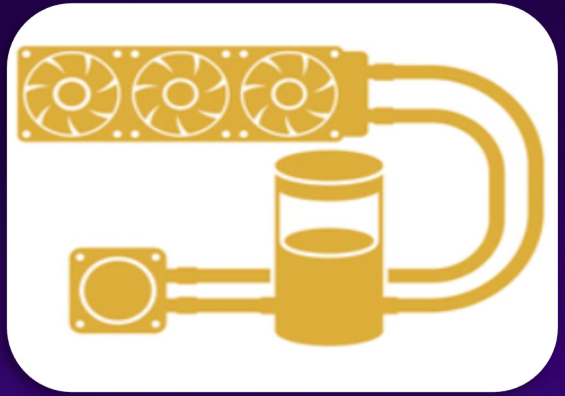
Emerging technology

High investment costs

SMES Challenges



Increase energy density

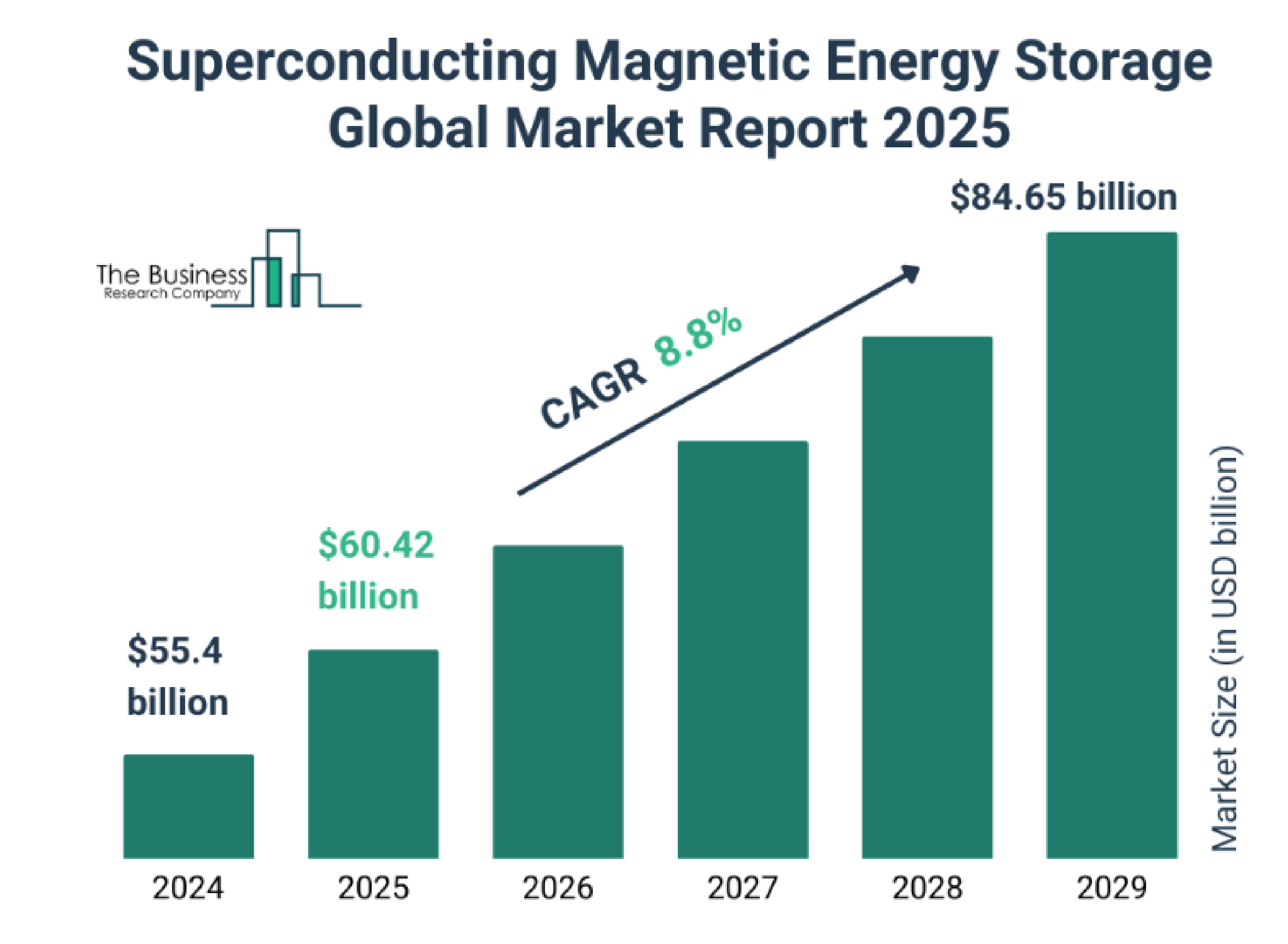


Improve cooling system

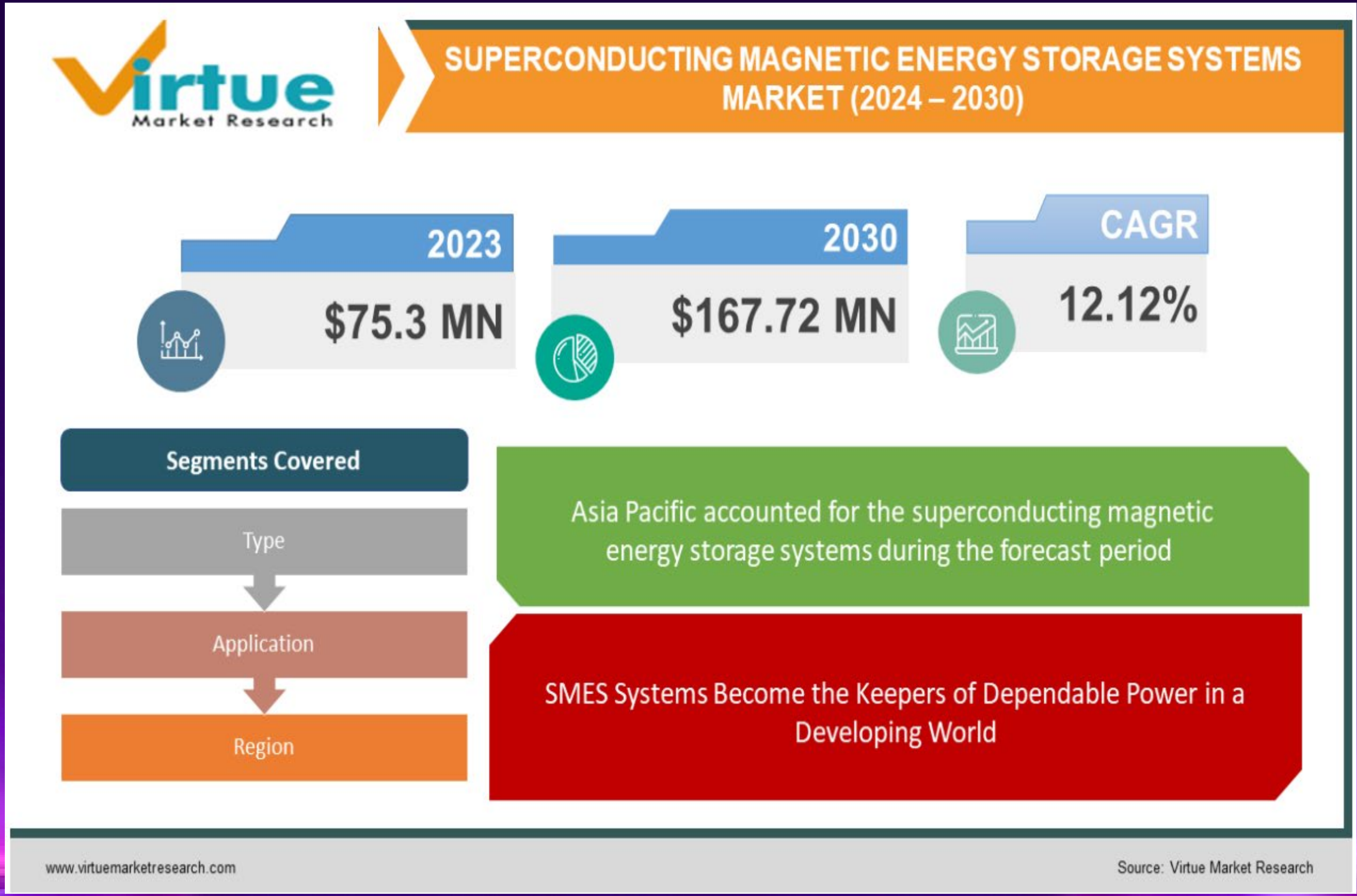
Reduce cost

SMES – Market

SMES Marketing



SMES Marketing



SMES Marketing

The global market for SMES systems value in 2027: $ 81.3 billion.

During the COVID-19, the market value of SMES systems in US jump from $ 44.6 billion (in 2020) to $ 81.3 billion (in 2027), with a CAGR: 9%, compared to 11.9% for China.

Currently, APAC region is the leader in contributing to the SMES system market.

SMES – Applications

SMES Present and Past Projects

Location and Company	Specifications	Application
Nosoo Power Station, Japan	10 MW	System stability and power quality
Upper Wisconsin (AmericanTransmission)	3 MW / 0.83 kWW 8 MVA each	Power quality and reactive power Support
Korea Electric Power Corporation (Hyundai)	3 MJ, 750 kVA	Power Supply quality
University of Houston, USA (SuperPower)	2 MJ, 20 kW	Voltage distribution

Applications of SMES systems

- Microgrids
- Renewable energy (PV systems / wind) systems.
- Contingency systems.
- EV chargers.

Applications of SMES systems

- Grid-connected renewable energy systems (PV and wind)

have shown that SMES is a sustainable and competitive option for applications like:

- Reducing output power fluctuations,
- Reactive power compensation,
- controlling frequencies,
- boosting transient stability,
- uninterruptable power supply,
- and enhancing power quality.

SMES devices can be employed in places where pumped hydro storage or compressed air energy storage would be impractical.

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