

MAGALDI GREEN THERMAL ENERGY STORAGE

STORAGE TECHNOLOGIES FOR THE ENERGY TRANSITION

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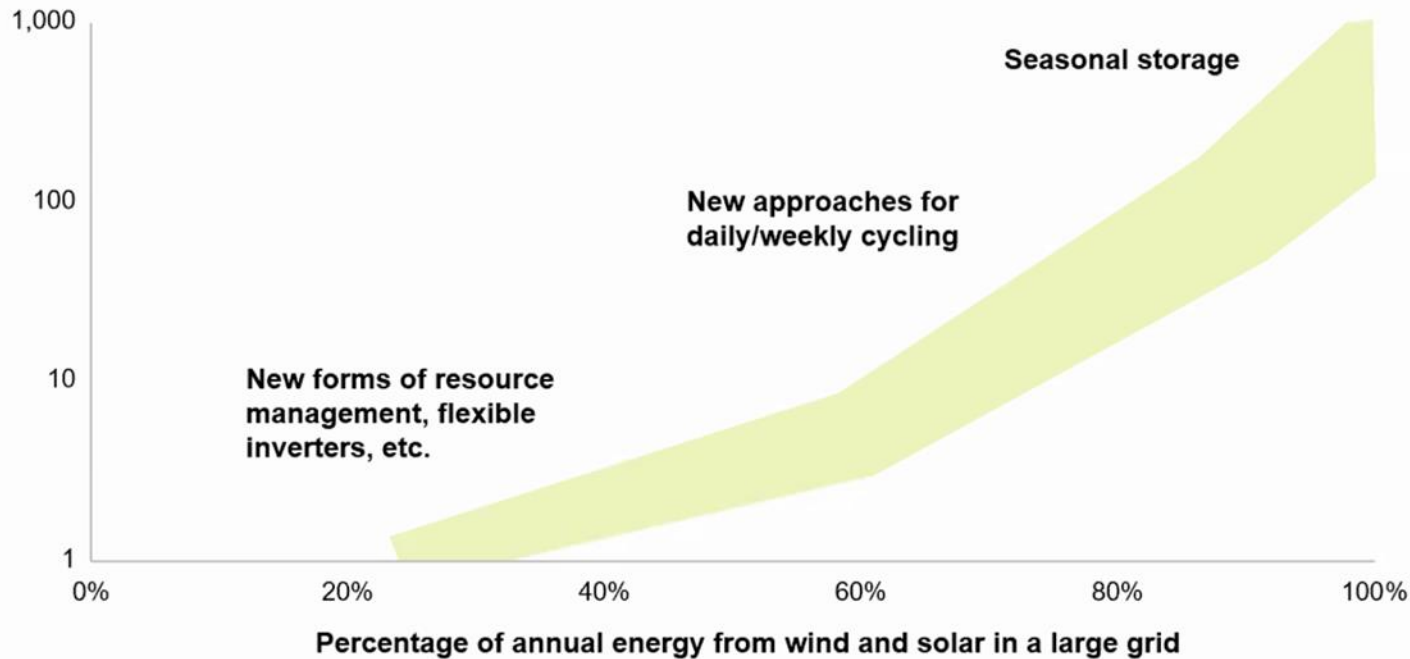
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Storage duration will increase exponentially

Long-term storage is essential to ensure **24/7 power generation** and increase the **stability and resilience of the electricity grid**

Adoption curve of longer flexibility durations accelerates at 60-70% RE penetration

Storage duration, hours at rated power



RES integration leads to new system challenges



Power supply and demand not always in balance



Transmission flow changes potentially require costly and lengthy transmission upgrades



Retirement of conventional, synchronous generators creates need for new sources of grid support services, e.g., reactive power, inertia

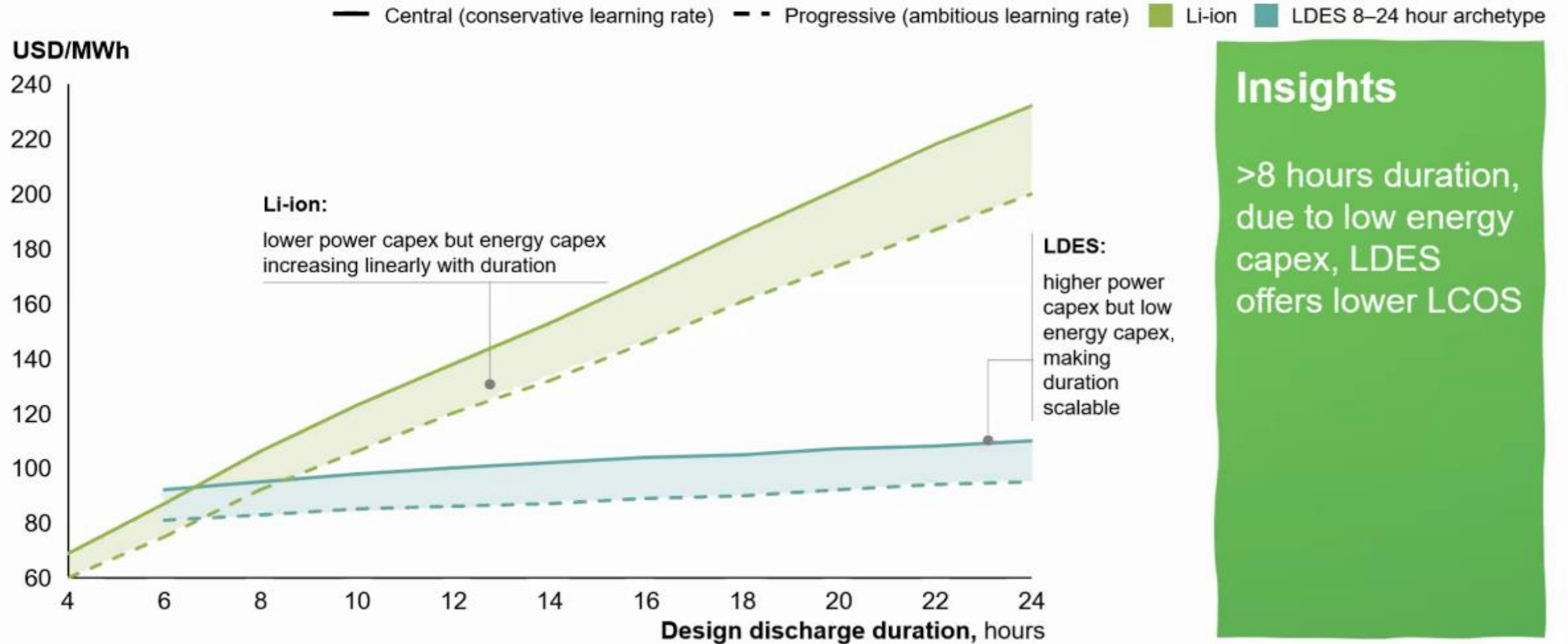


Magaldi Green Energy
Member and global technology provider
LDES Council



LDES likely cost-competitive for durations >6-8 hours

2030 energy storage LCOS competitiveness by duration for selected technologies (USD/MWh)



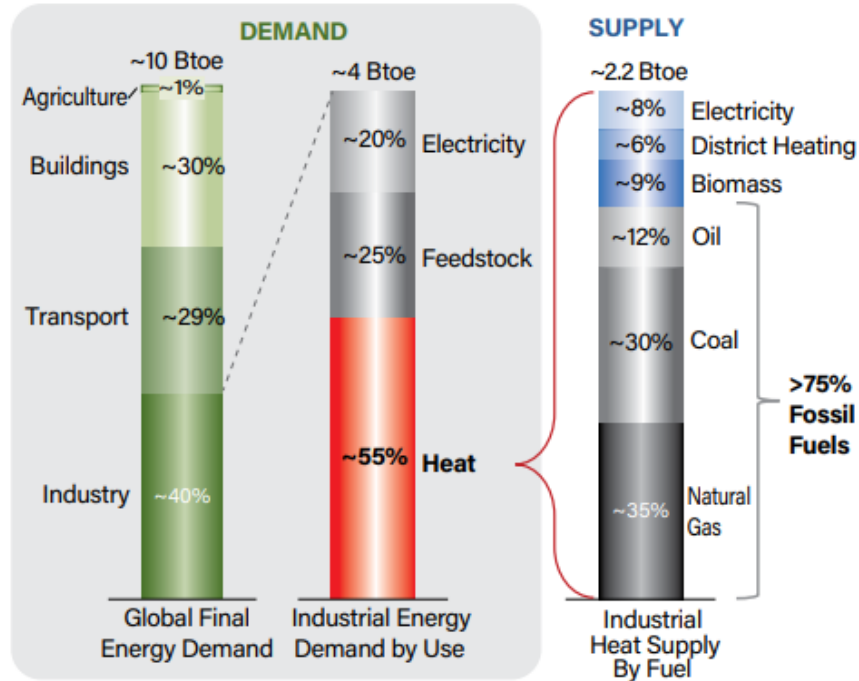
Insights

>8 hours duration,
due to low energy
capex, LDES
offers lower LCOS

Electrification of the global heat demand for industry

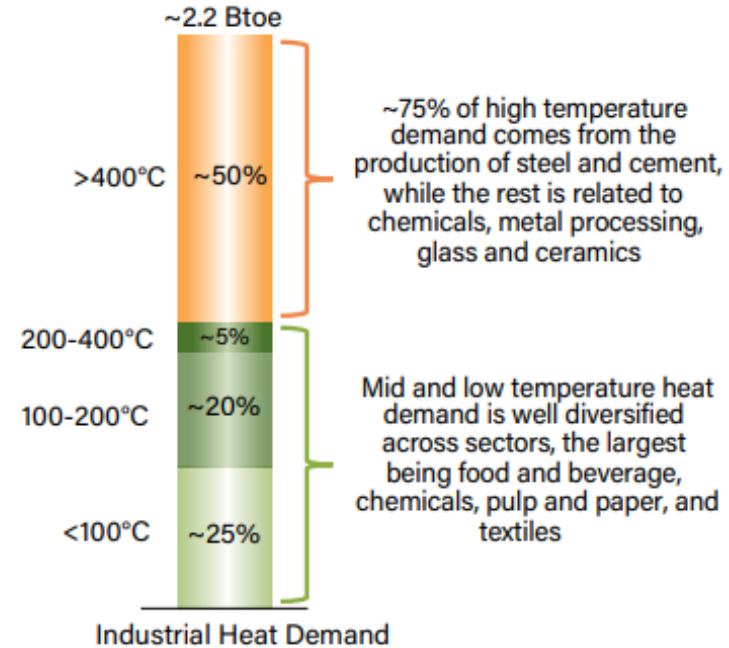
55% of the energy demand for industry is used for heat and process steam

Graph 1: Industrial Heat In Global Energy Demand



Source: Ambienta analysis on IEA and McKinsey Data

Graph 2: Industrial Heat Demand by Temperature



Source: Ambienta analysis on IEA data

75% of the heat required is generated by the combustion of coal, oil and gas

About 50% of industrial applications are above 400 °C

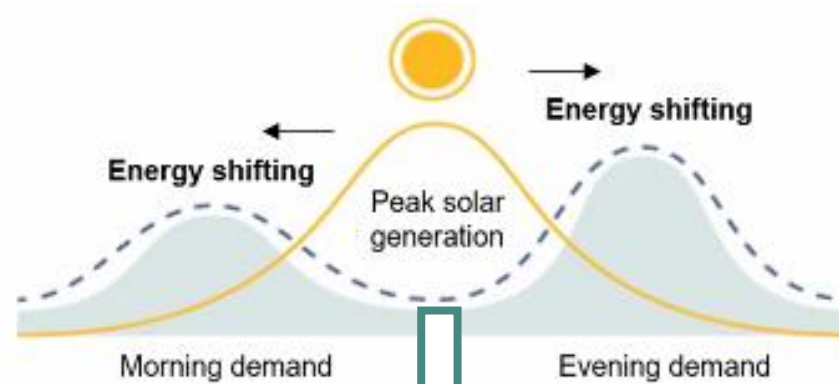
Industrial sectors cause about 28% of total global CO2 emissions, but four industrial sectors in particular (**steel, chemical and petrochemical, cement, lime and aluminium**) account for about 3/4 of total industrial emissions.

A strong integration of clean energy sources with storage solutions, including Thermal Storage, are key elements for the decarbonisation of industries, providing fully dispatchable thermal energy on demand.

Renewables are intermittent: what kind of storage technologies can integrate with green 24/7 industrial heat processes?

Flexibility is critical for the decarbonisation of energy and industrial systems.

Different types of energy storage systems will contribute to the achievement of the target.



Thermal
Storage of energy as heat and releases electricity and heat

Thermal storage technologies include molten salt storage, which captures solar energy as heat and releases it to generate electricity and heat.



Chemical
It stores energy in chemical vectors

Electrochemical
Batteries of different chemicals that store electrical potential energy

Mechanical
Store gravitational potential or kinetic energy

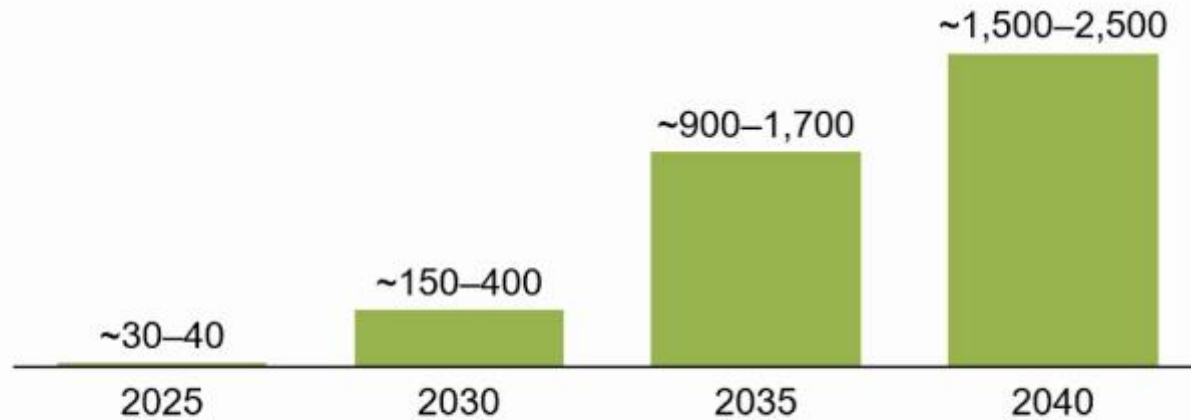


Total market size for LDES can reach a 1.5 to 2.5 TW by 2040, supporting the required flexibility in net-zero power systems

Global LDES deployment through 2040

GW

Cumulative installed power capacity



TWh

Cumulative installed energy capacity



USD bn

Cumulative capex investment



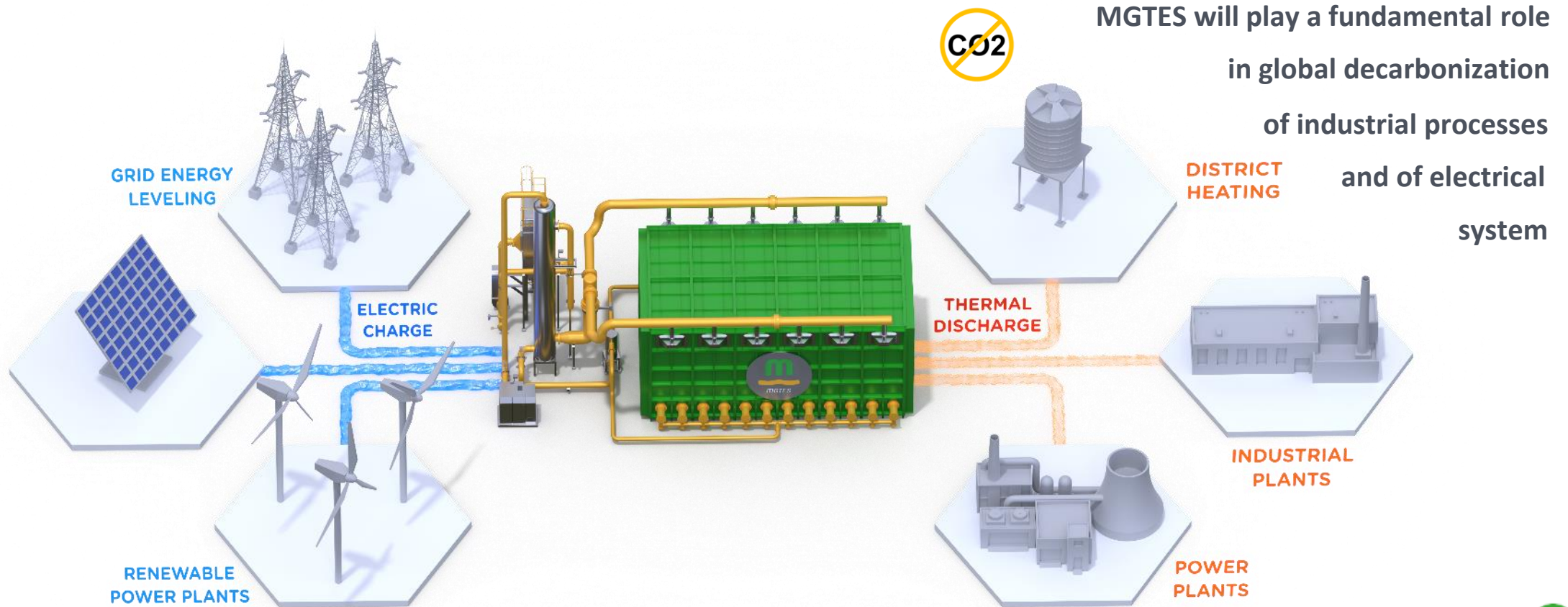
Insights

USD ~50bn investments required over the next 5 years

2040 cumulative investment equal to the current global T&D investment made every 2-4 years

MGTES – Magaldi Green Thermal Energy Storage

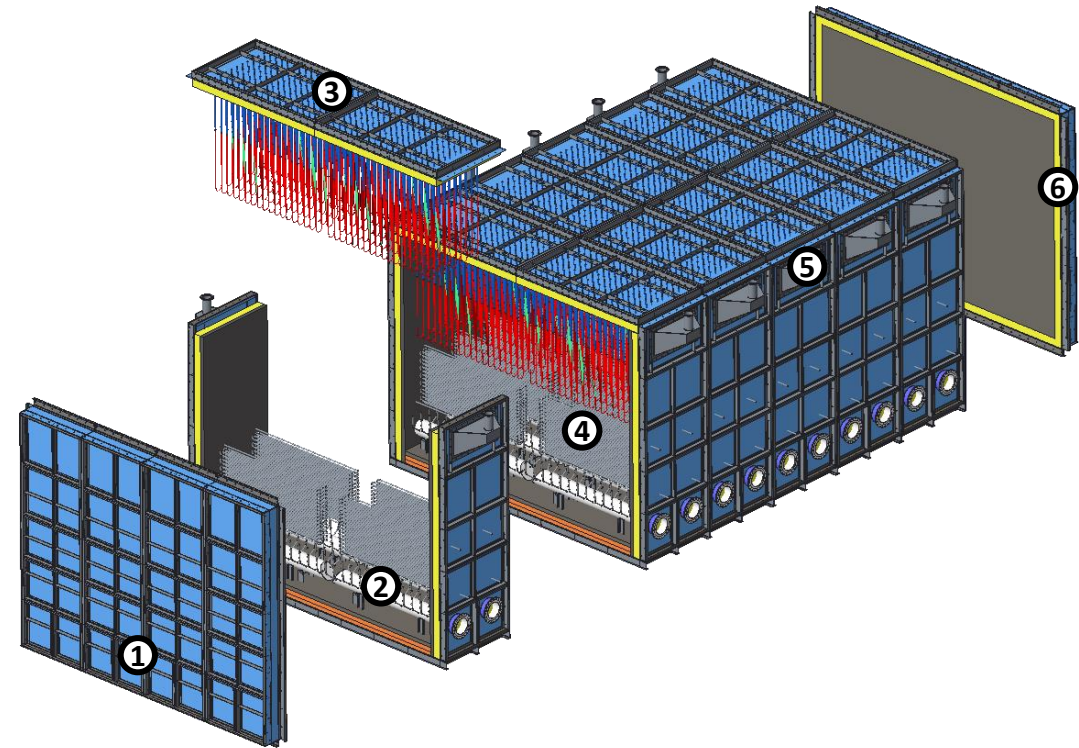
MGTES is a Thermal Energy Storage (TES) technology based on a fluid bed of solid particles (sand) capable of absorbing both incoming heat and electricity and delivering Green Heat on demand, also for applications in hard to abate industries.



MGTES – Renewable Energy Storage

Integrated TES module

1. Steel bin
2. Fluidization air distribution system
3. Immersed electrical resistors
4. Immersed heat exchanger
5. Fluidization air suction system
6. Lining and refractory



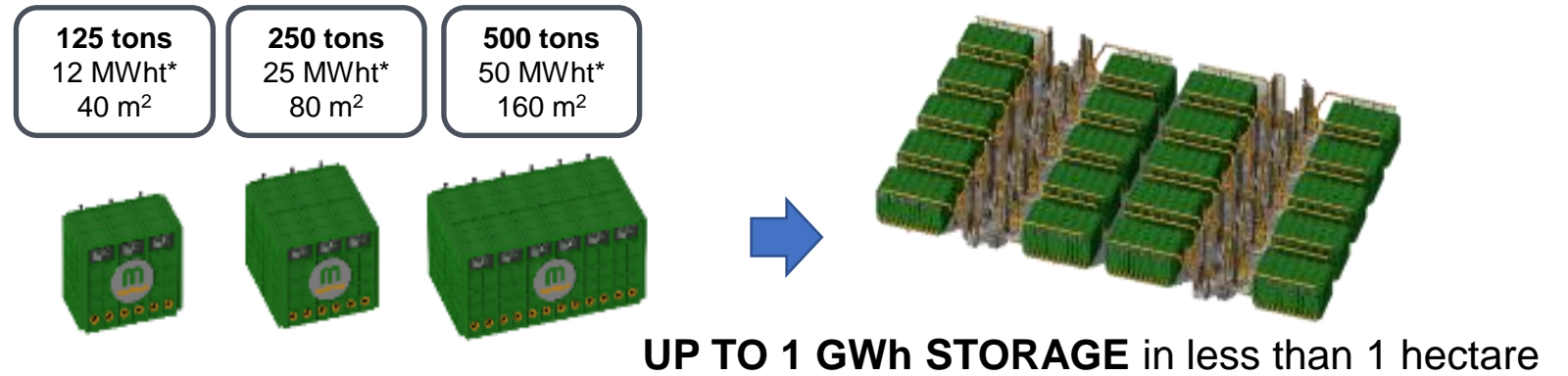
Actual development stage

MGTES pilot plant up to 40 tons of sand is right now in operation in the Magaldi workshop in Italy.



MGTES: a standard 500 Tons Module can store up to 50-60 MWht daily

Modularity



ESG

100%: the materials used are mainly sand and steel

Storage media temperatures

Sand up to 1000 °C, compared to 250-560 °C of Molten Salts

Charging time

Power to Heat configuration, 7-8 hours to reach full storage capacity

Response time

Fluid bed activation time < 2 minutes

Storage duration

Daily Thermal losses <1.5% allow thermal storage for weeks

(*) Detailed data on MGTES system sizing, performance and costs are available when discussing specific applications

Servizi di rete potenziali, DIAEE Electrical engineering area - UniSapienza

Risorse di rete Servizi di frequenza	TERMO- ELETTRICO	FRNP	DEMAND SIDE	IDRO / POMPAGGI	BATTERIE	
Fast reserve	—	✗	✗	✗	✓	—
Primaria	✓	✗	✗	✓	✓	—
Secondaria	✓	— ↓	— ↑	✓	✓	✓
Terziaria "pronta"	✓	✗	✗	✓	—	✓
Terziaria "rotante"	✓	— ↓	— ↑	✓	✓	✓
Terziaria "sostituzione"	✓	— ↓	— ↑	✓	✓	✓
Risoluzione Congestioni	✓	— ↓	— ↑	✓	—	✓
Bilanciamento	✓	— ↓	— ↑	✓	—	✓



Adatto a fornire il servizio



Non adatto a fornire il servizio



In grado di fornire il servizio ma impossibilitato da attuale regolamentazione e/o da limiti di tipo tecnologico



Solo regolazione a salire / scendere

- NB: MGTES è valutato esclusivamente nella configurazione Power to Heat mentre le altre tecnologie sono valutate nella configurazione Power to Power



"Power to Heat" applications enable electrifying industrial processes and bringing green heat energy to various contexts



Heat Electrification:

1. 24/7 Green Steam
2. PV and WIND + MGTES
3. Industrial processes to be decarbonized
4. Green Desalination



Energy Storage Hubs:

1. Plants to be requalified
2. PV + MGTES + batteries
3. Grid services, green heat to other off-takers



Diesel/gas boilers replacement:

1. PV + MGTES + (solar thermal)
2. Pet-Chem industrial sub-processes
3. Remote areas



Cogen integration:

1. Boost Cogen heat with PV + MGTES
2. Integration with existing turbines
3. Higher flexibility with green heat



TES offshore/offgrid, EOR:

1. Offshore platforms
2. Wind + Heat + MGTES
3. Upstream/midstream processes in remote areas (e.g. EOR)



Green Mining:

1. Off-grid mining areas
2. PV+MGTES (avoid diesel generation)
3. Reduce ESG impact of mining

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