Magaldi Green Thermal Energy Storage

Long Duration Energy Storage technology

29.06.2022

MAGALDI
dependable energy storage

www.magaldigreenenergy.com

MAGALDI GROUP

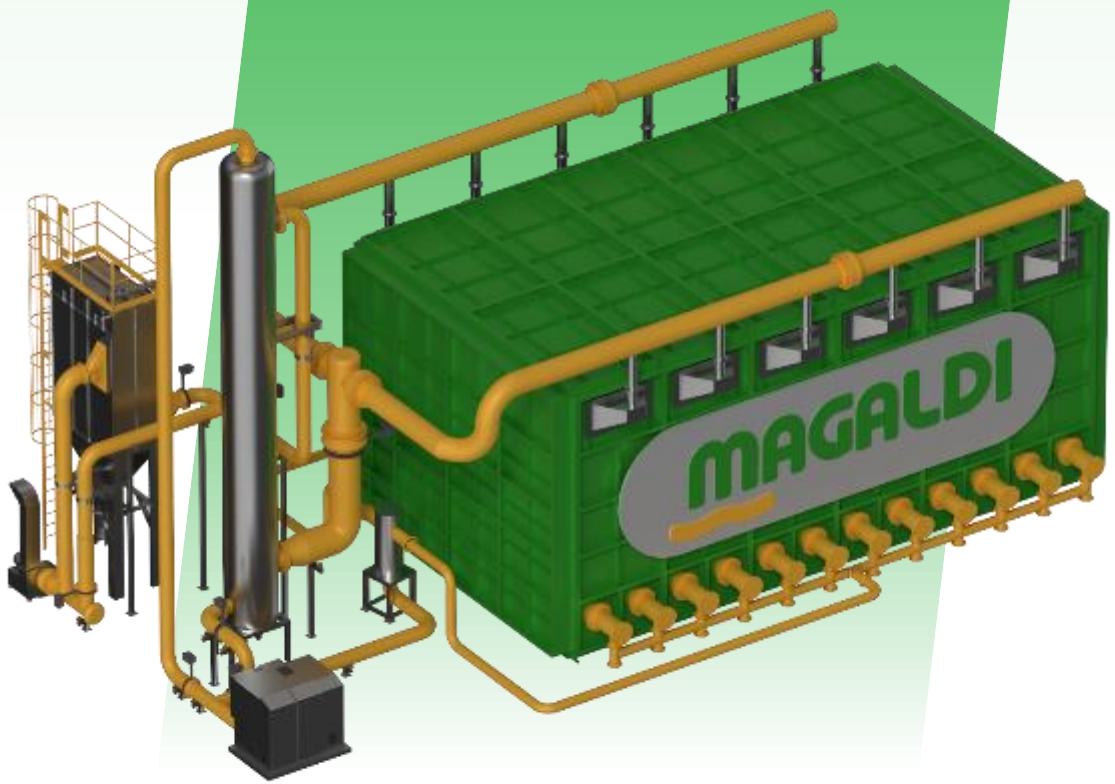
Incorporated in **1929**, Magaldi is a leader in customized solutions to convey materials at very high temperatures and in severe process conditions, guaranteeing the **highest dependability** and **environmental protection**.

The Company has been able to secure more than **55 patents** for proprietary technologies (of which **10 patents** on **STEM** technology).

In the last decade, Magaldi has been developing innovative technologies in the **renewable energy generation and storage** sector.

Corporate video

https://www.youtube.com/watch?v=NeGcs-f5kS8



MAGALDI GTES

MGTES (Magaldi Green Thermal Energy Storage) benefits from the advantages of the fluidized sand bed which allows to reach high temperatures with high density thermal energy storage.

The incoming energy can be independently **thermal energy** and **electrical energy**, which is long term stored and released in the form of steam or hot air for industrial processes or electricity generation.

Used materials are 100% recyclable, there are no geographical constraints.

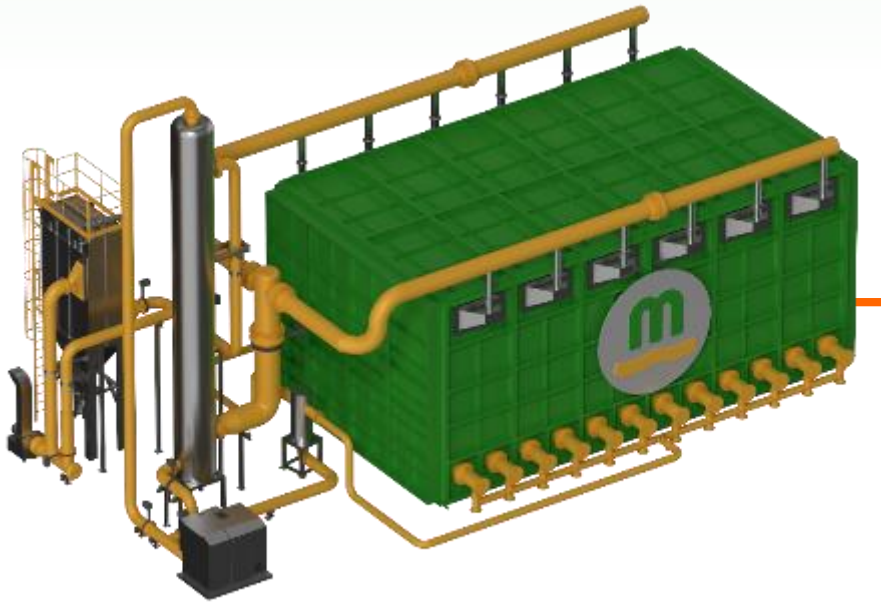
MGTES is **flexible**, **reliable** and **dispatchable** long term energy storage.

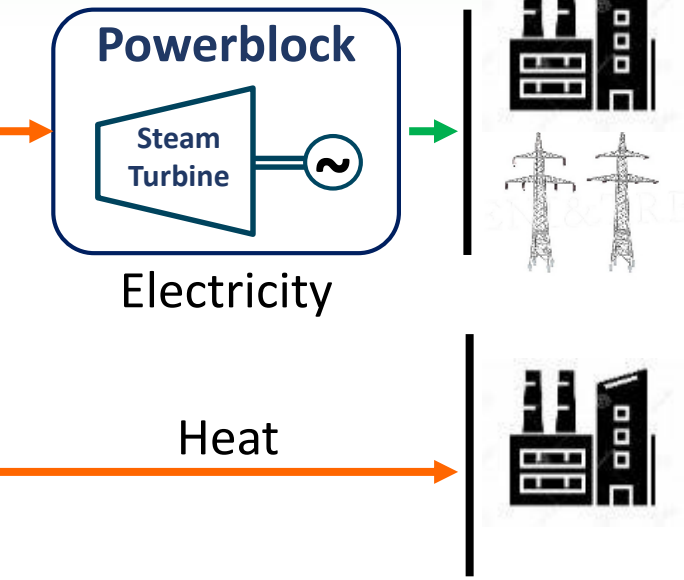
https://www.youtube.com/watch?v=00-IAhwoHIk&ab_channel=MagaldiPowerS.p.A.

MGTES: Renewable Energy Storage

MGTES technology (Magaldi Green Thermal Energy Storage) is a **fluid bed (sand) thermal storage** capable of absorbing both heat and electricity at the input

- Thermal power
  - Power plants
  - Industrial plants
- Electric power
  - Renewable power plants
  - Fossil fuel power plants
  - Grid energy leveling





The charge / discharge of MGTES technology is focused on thermal storage by means of fluidized sand particles that allow to reach high temperatures with high diffusivity and reduced thermal losses.

Principle of Magaldi technology

Bed of fluidizable solid particles

MODE ON
The system is ready to exchange energy

Fluidized Sand Bed

Not fluidized Sand Bed

MODE OFF
Thermal insulation at maximum temperature

High Thermal Diffusivity

~ 1 x 10^{-3} [m^2/s]
i.e. ~ 1000 times higher than concrete, rocks, gravel etc.

<u>Fast Response Time</u>

Long term storage

< 2 % per day

Negligible losses

MGTES features

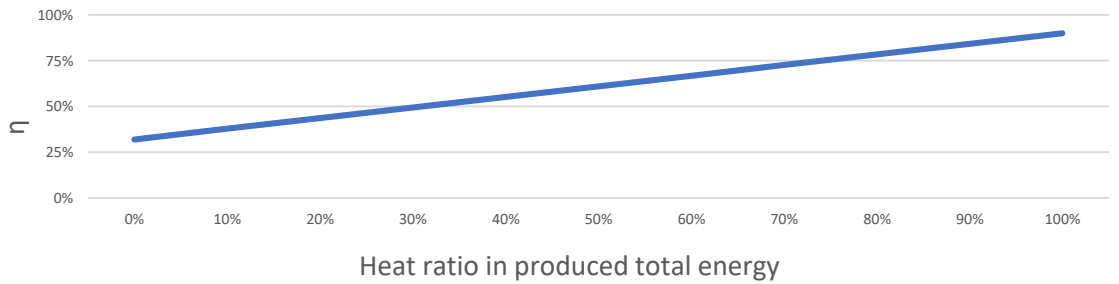
Storage medium data		
Material	Solid particles (silica sand)	
Thermal capacity	1.0-1.1	kJ / kg K
Solid Particles operating max T	1000	°C
Fluid bed typical data		
Fluid bed thermal diffusivity	1 x 10-3 [m^2/s]	
Heat transfer coefficient (FB - steam)	250	W /m^2 K
Fluidized Bed activation time	< 2	min
TES module data		
Solid particles mass, typical	40, 125, 250, 500, 1000	Tons
Thermal Capacity range, per module	5-120	MWh,t
Daily heat losses	< 2%	
Charging / Discharging power range (typical), per module	0,5 - 20	MW
Charging / discharging profile	Symmetrical or asymmetrical	

100% ESG

The materials used are mainly sand and steel;
Safe, Recyclable and Readily available.

Modularity

Efficiency

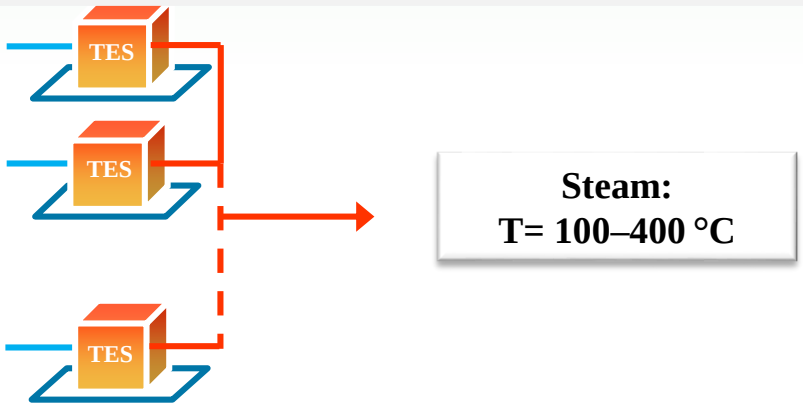


MGTES configuration - steam generation

Modules in Parallel

By connecting the modules in parallel it is possible to discharge them:

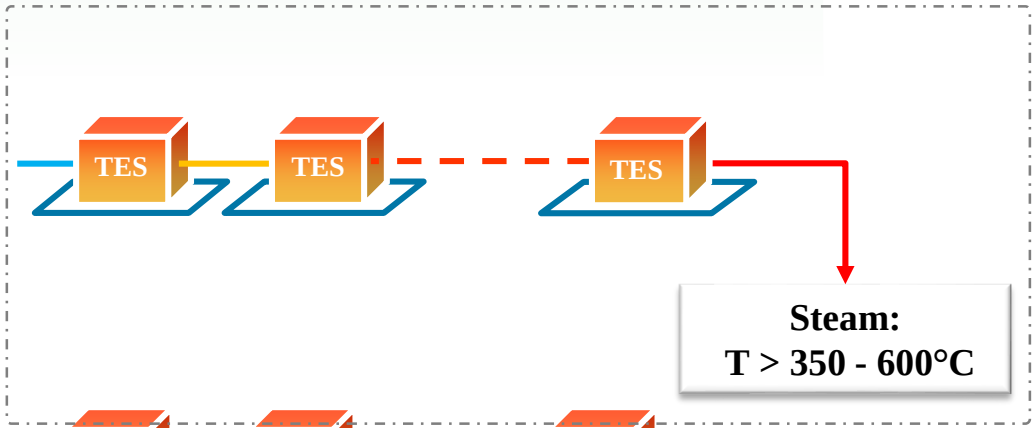
- Simultaneously, to **increase the power output**
- In sequence, to **increase the energy discharge duration**



Modules in Series

By connecting the modules in series it is possible:

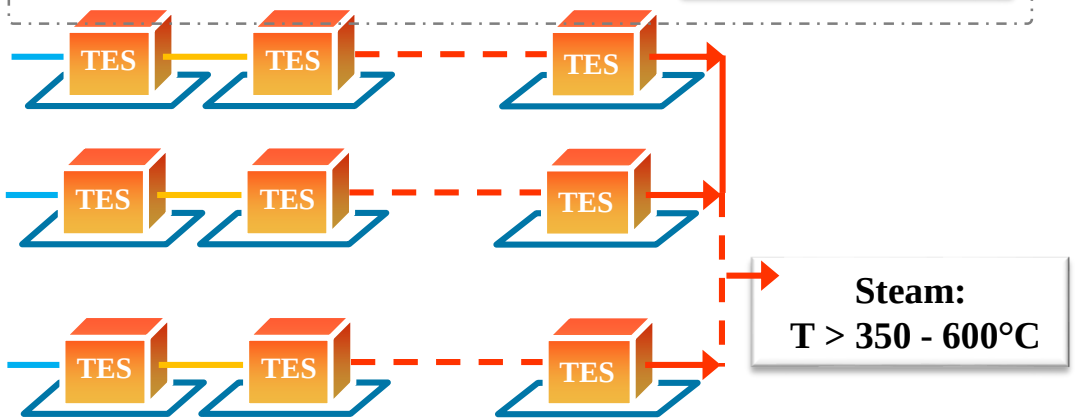
- To **increase the HTF temperature** maintaining a high thermal capacity



Modules in Series/Parallel

By combining the configurations of modules in series and parallel it is possible to take advantage of both modes:

- **Increase the power output**
- **Increase the temperature**
- **Extend discharge duration**



MGTES: Potential grid services in P2H configuration

✔ Able to provide the service

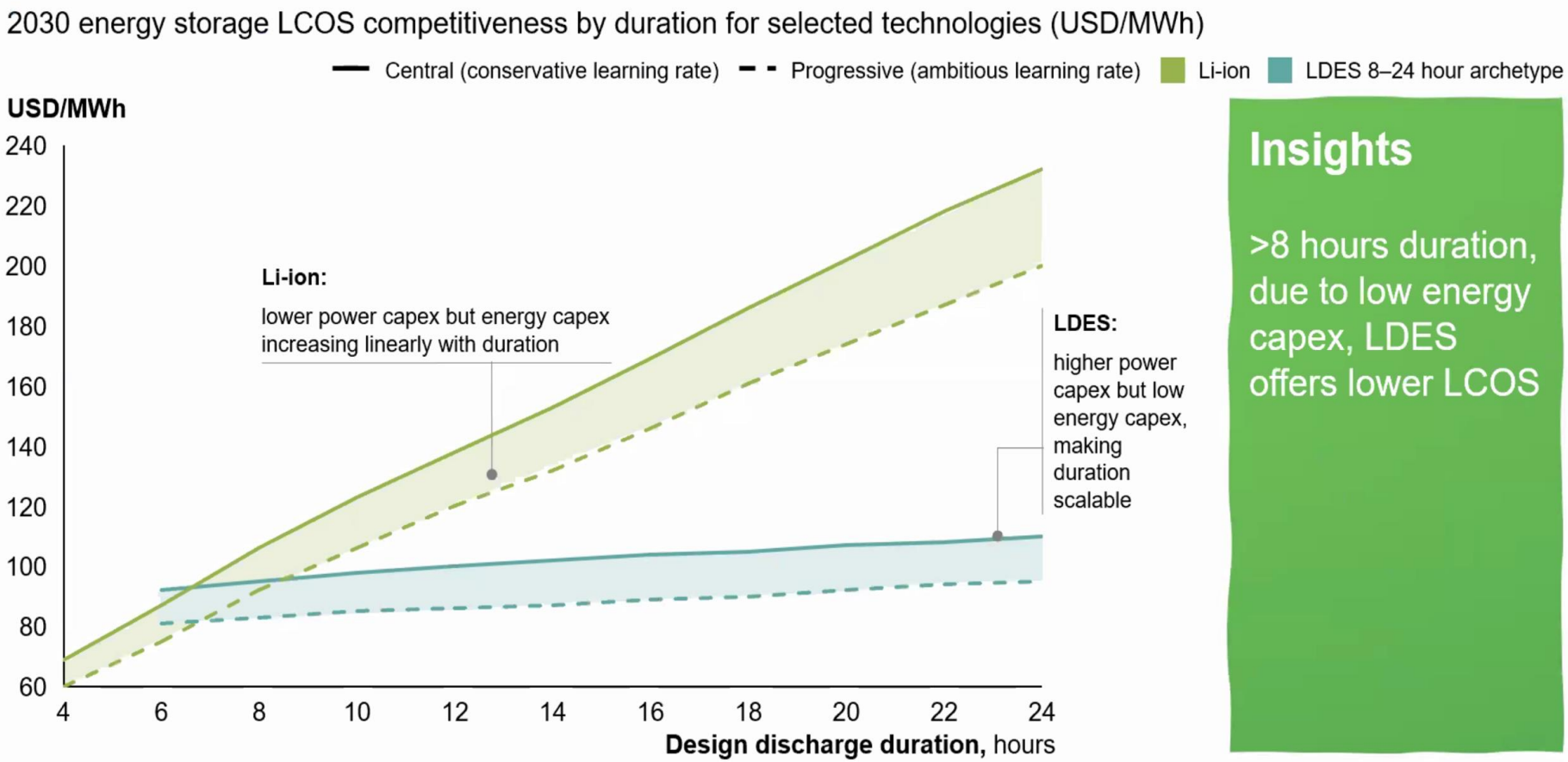
▬ Able to provide the service but limited due to current regulations and/or technological limitations

Service*	Response time and power variation		Dwell time		MGTES P2H (TES)
	Enabled Units (traditional)	UVAM	Enabled Units (traditional)	UVAM	
Fast reserve	< 1sec	< 1sec	15 min	15 min	▬
Primary regulation**	30 sec	n.a.	15 min	n.a.	▬
Secondary regulation	All band in 200 sec Continent and 100 sec Islands	All band in 200 sec Continent and 100 sec Islands	2 h	1 h	✔
Tertiary regulation	15 min (> 10 MW)	15 min (> 1 MW)	2 h	2 h	✔
Congestion resolution	15 min (> 10 MW)	15 min (> 1 MW)	Unlimited (thermal) 4 h (hydro)	2 h	✔
Balancing	15 min (> 3 MW)	15 min (> 1 MW)	Unlimited (thermal) 4 h (hydro)	2 h	✔

* Italian grid transmission regulation
** 50% of power in 15 s

MGTES: Long Duration Energy Storage

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



Data Source: LDES Council McKinsey 2022

Insights

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

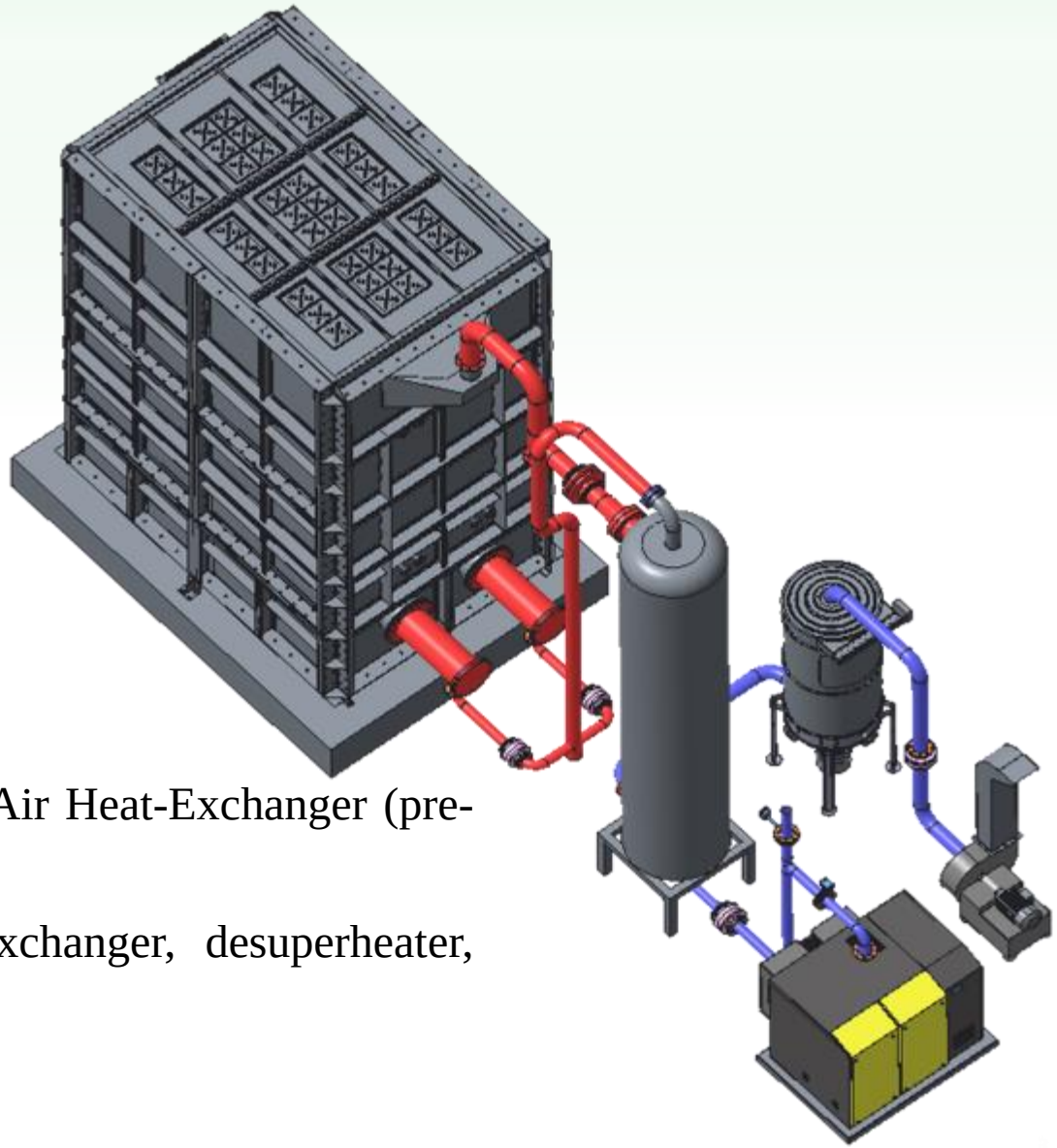
LDES LONG DURATION ENERGY STORAGE COUNCIL

Magaldi Green Energy member and global technology provider LDES Council

Alpha 4 system composition

Process Conditions

- Power for Electrical charge system : 400 kW_e
- Fluidized bed operational T range : 200 – 620 °C
- Nominal TES capacity (ΔT= 420 °C) : 4.9 MWh_t
- Steam generation power : 400 kW_t
- Sand mass : ~ 41.6 t



Main Process Equipment

- Fluidized Bed TES system, with electric power charge system;
- Fluidization air system, with Air Blower, Filter, Fan, ducts, Air-to Air Heat-Exchanger (pre-heater);
- Steam generation system, with feedwater pump, in-bed heat exchanger, desuperheater, condenser (to be finalized);
- Instruments & Control, MCC.

MGTES: Integrations

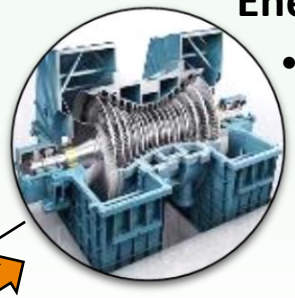
MGTES

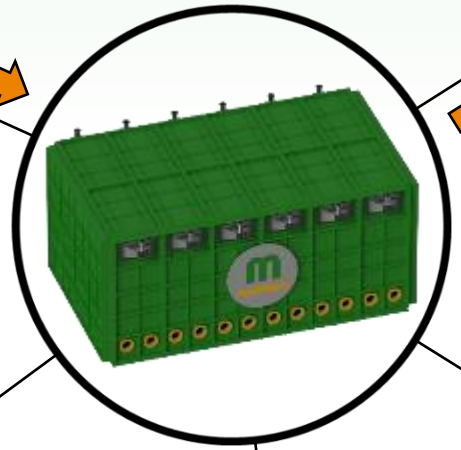
Industrial Plant

- High T heat (> 1000 °C)

Conversion of coal plants in Thermal Energy Storage Hub

- Power-block recovery





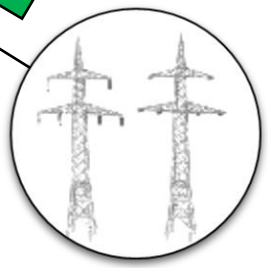
Surplus Renewable Electricity

- Curtailment reduction

Fossil Fuel Power Plant

- Increase Flexibility

Power Grid



- Ancillary services

Energy output

Energy input	Electric energy	Heat
Heat	Heat to Power	Heat to Heat
Electric energy	Power to Power	Power to Heat

Electric power

Thermal power

MAGALDI

dependable energy storage

www.magaldi.com