Heat storage & the EDP-Rondo project

Shaping the Future of Energy Storage

Policy Priorities for 2024 – 2029

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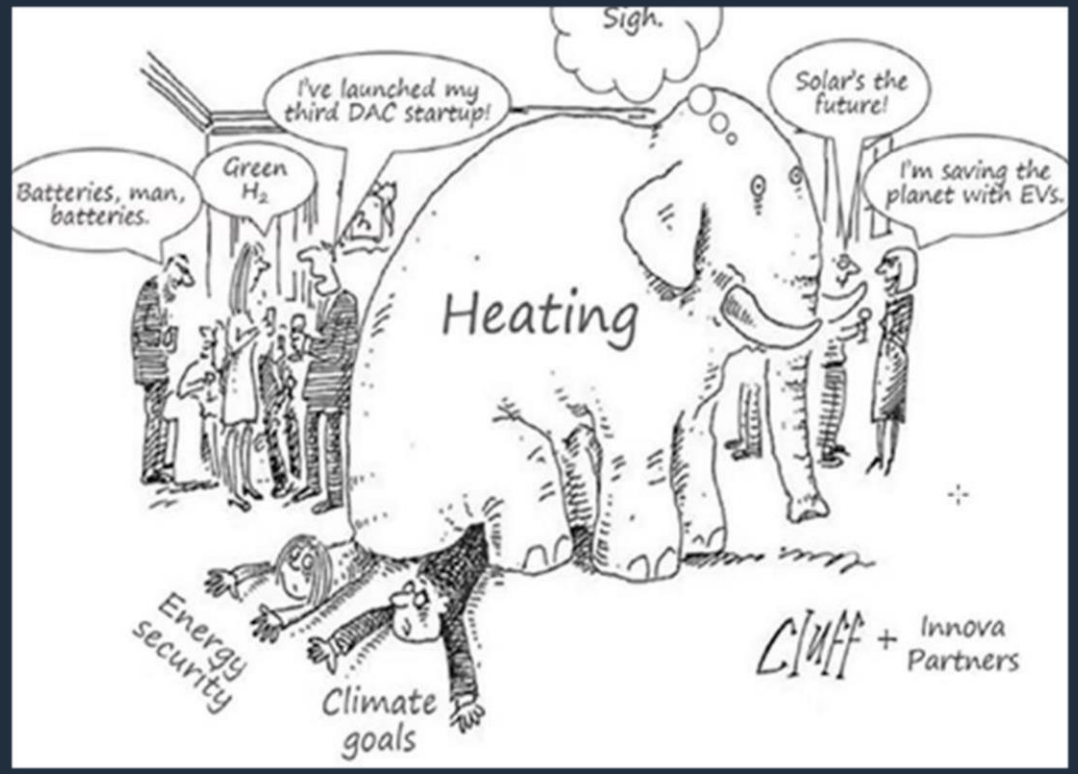
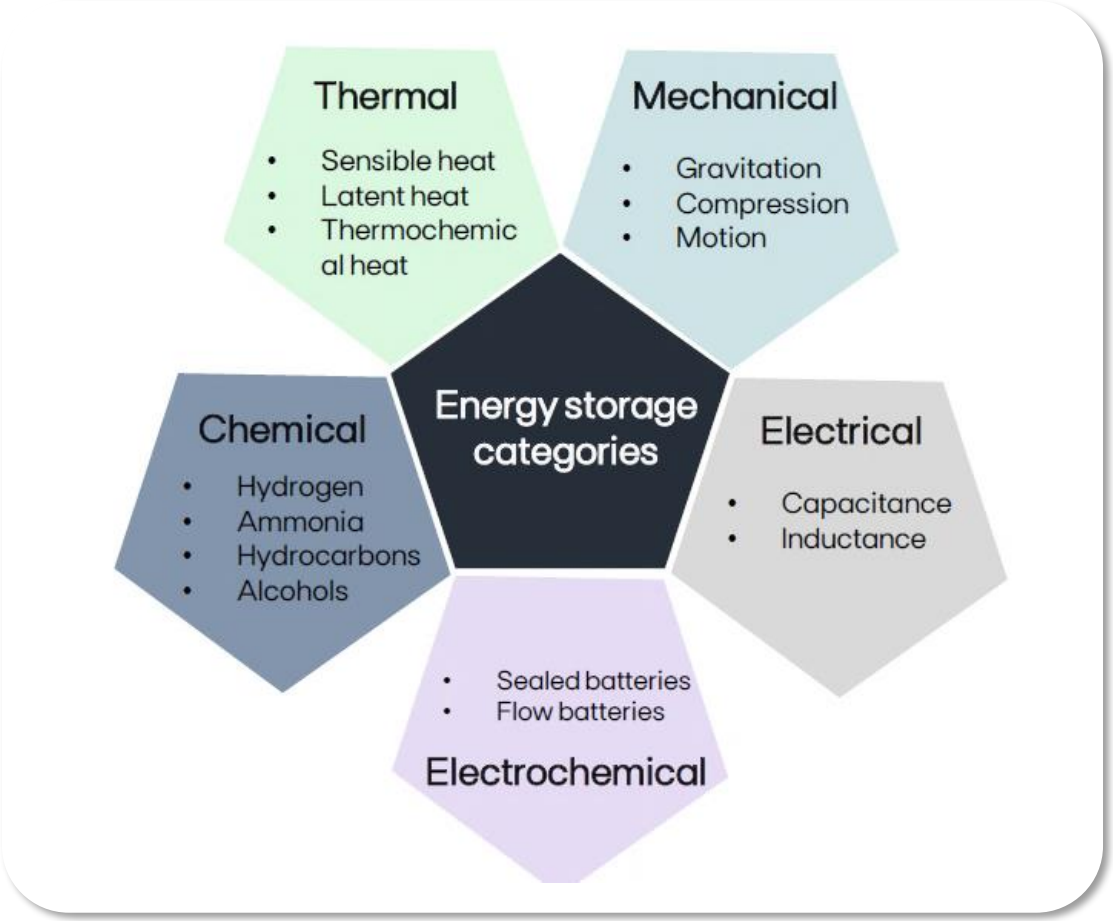
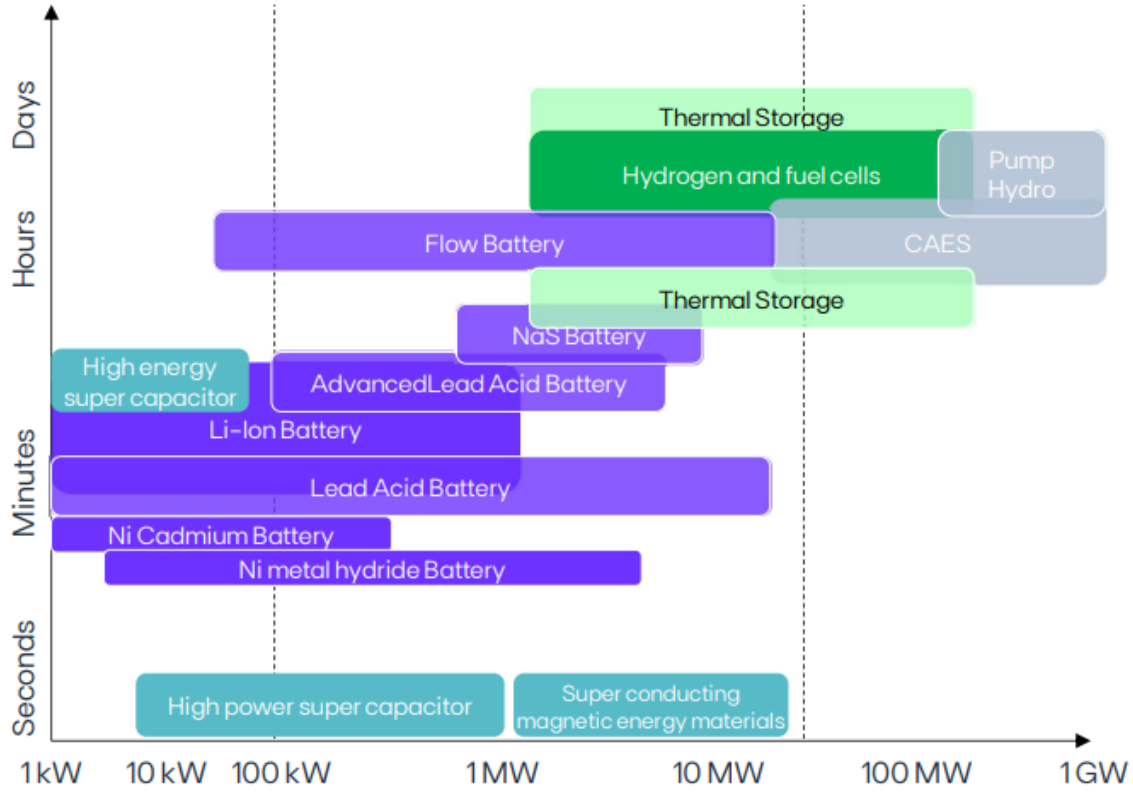


Currently there are different energy storage technologies, with distinct stages of maturity, economics and relevant use cases

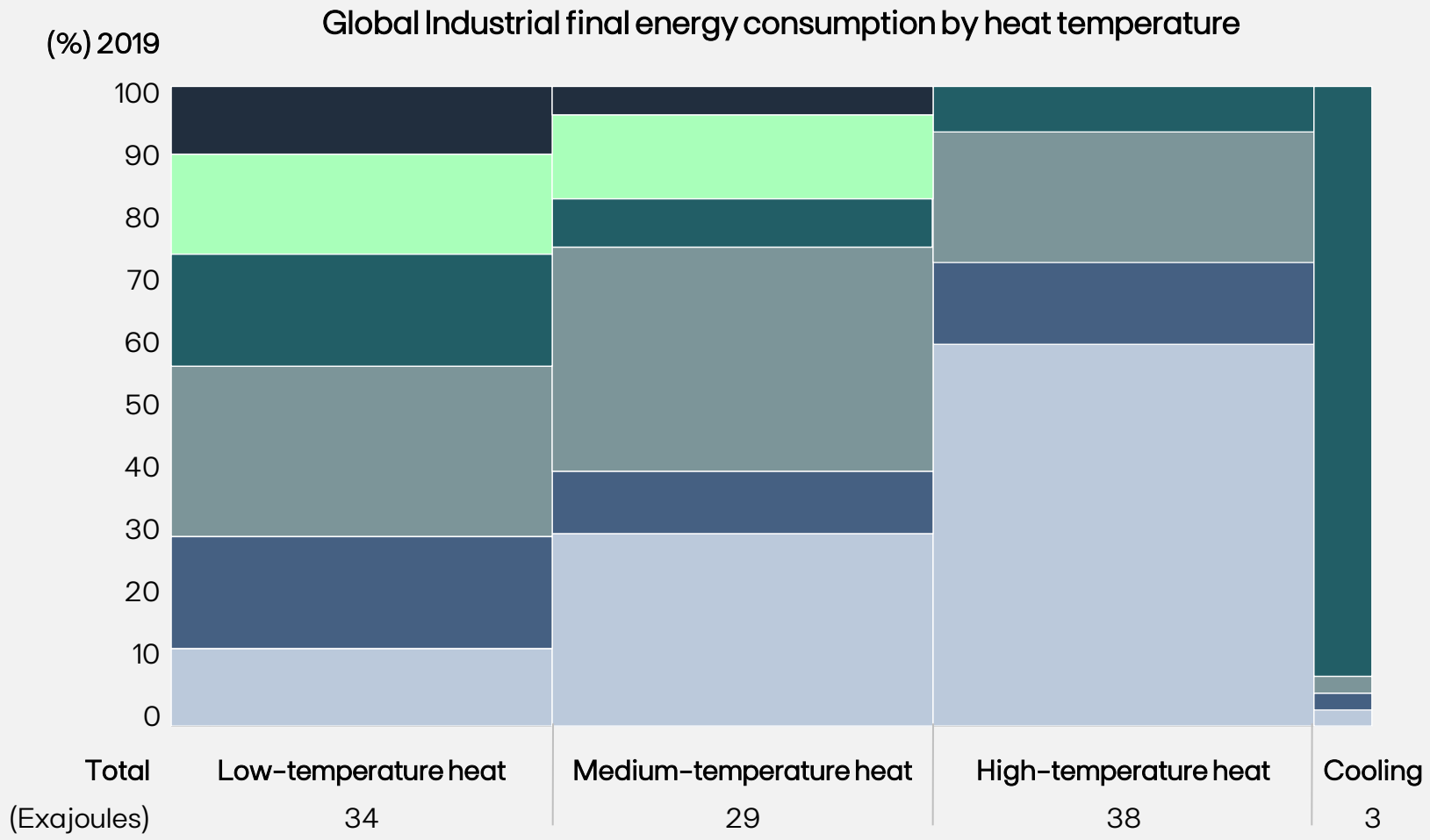


Types of storage systems depending on size and storage capacity



Heat decarbonization is critical for net zero

Heating and cooling use cases are responsible for ~45% of global energy-related CO_2 emissions



Source: McKinsey Global Energy Perspective

Share of total (%)

- <1% On-site renewables
- 5% District heat
- 9% Bioenergy
- 14% Grid electricity
- 26% Natural Gas
- 13% Oil
- 33% Coal

70% of industrial heat is still provided by fossil fuels

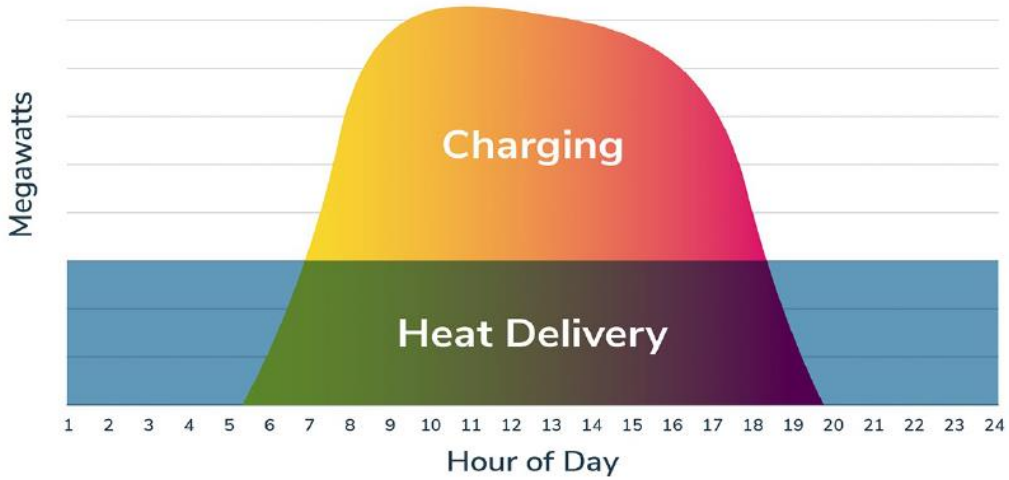
Now is the time to move forward and face heat decarbonization

The growing penetration of renewables is making the energy prices more and more competitive when compared with other alternatives

Heat electrification has been a challenge to industry globally...

- High cost of electricity and electric grid fees when compared to the price and grid fees of natural gas
- Lack of proven track record of electrification solutions and lack of temperature reach in some of the electrification technologies
- Lack of incentives towards electrification and inexistent reform of the carbon markets leading to a small impact of CO2 emissions on companies' energy costs

... but the future of heat is renewable

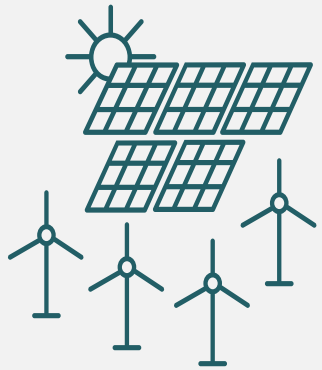


Intermittent wind and solar energy sources currently offer the most economically efficient power, but this power needs to be stored as heat and delivered continuously for industrial use

Thermal storage can deliver cheap heat to industrial processes

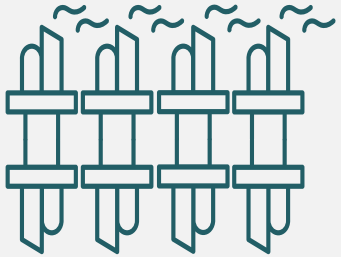
A thermal storage solution coupled with on site renewables can help decarbonize industry by lowering overall LCOH

1 Solar, Wind or Hybrid



- **Energy is produced at marginal cost with a solar or wind plants (co-located or offsite)**, offering a low-cost energy source
- **Space is the most critical element** to produce cheap solar or wind energy

2 Thermal battery



- **Thermal storage unit stores heat at high temperatures** with different technologies
- **Charging at times when power is cheaper** (RES profile)
- **Thermal losses are small,** enabling thermal efficiency

3 Energy offtake

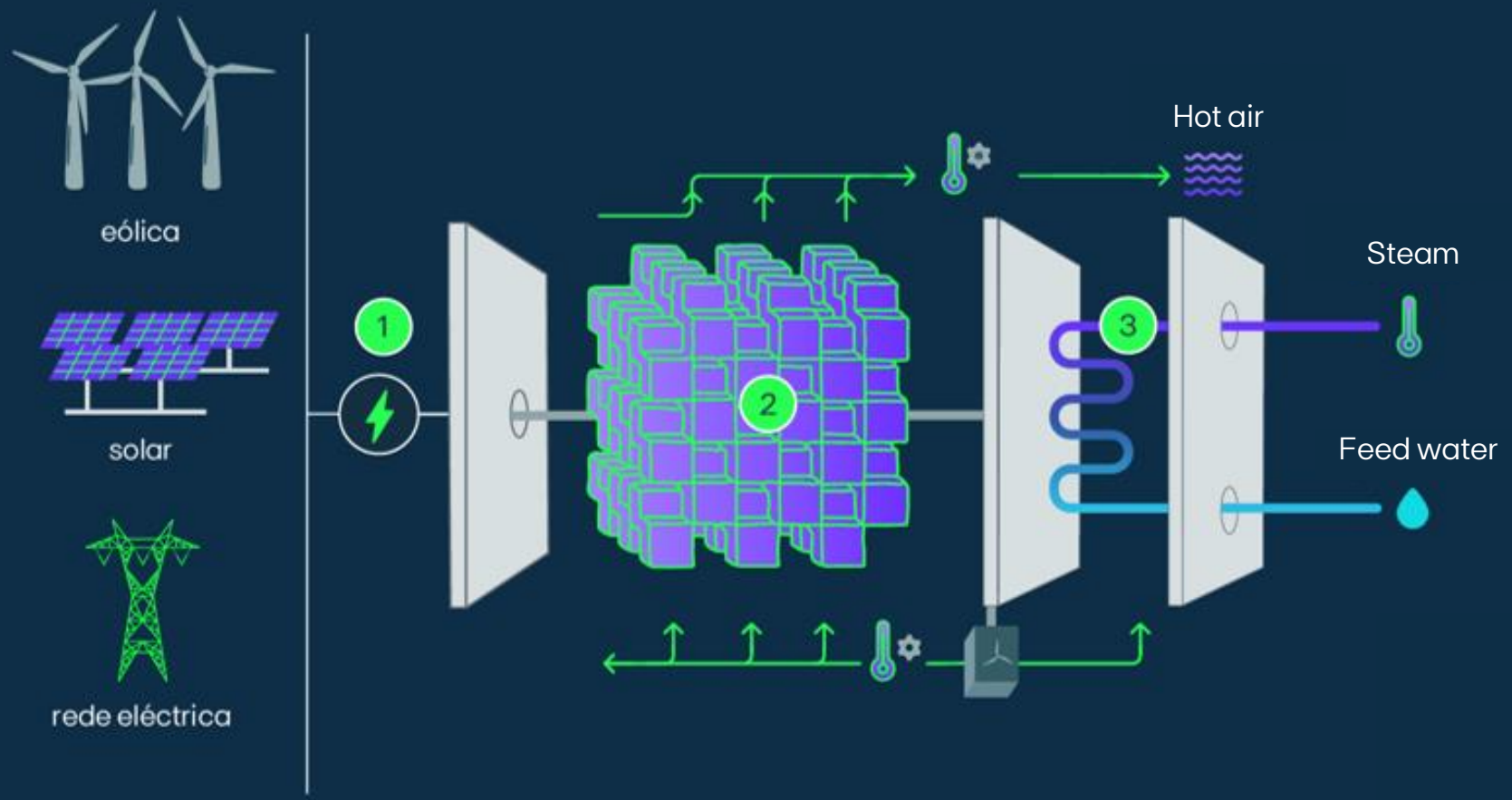
HEAT

STEAM

- **Energy can be consumed in the industrial processes as steam or hot air**
- Customer has total flexibility to dispatch stored heat

Amongst energy storage technologies, Rondo Energy Solution stands out in the market

How does the Rondo heat battery work?



1. The Rondo Heat Battery charges with **intermittent electricity** from local wind and solar or from the grid

2. Refractory brick is rapidly, uniformly heated to high temperature, and stores heat for hours or days

3. The battery delivers continuous superheated air for use as process heat, steam, or electric power at over 98% total efficiency

Why Rondo Energy

ElectricThermal Energy Storage (ETES) is much cheaper than electrochemical batteries and only requires half the capital cost and energy usage compared to hydrogen-for-heat systems

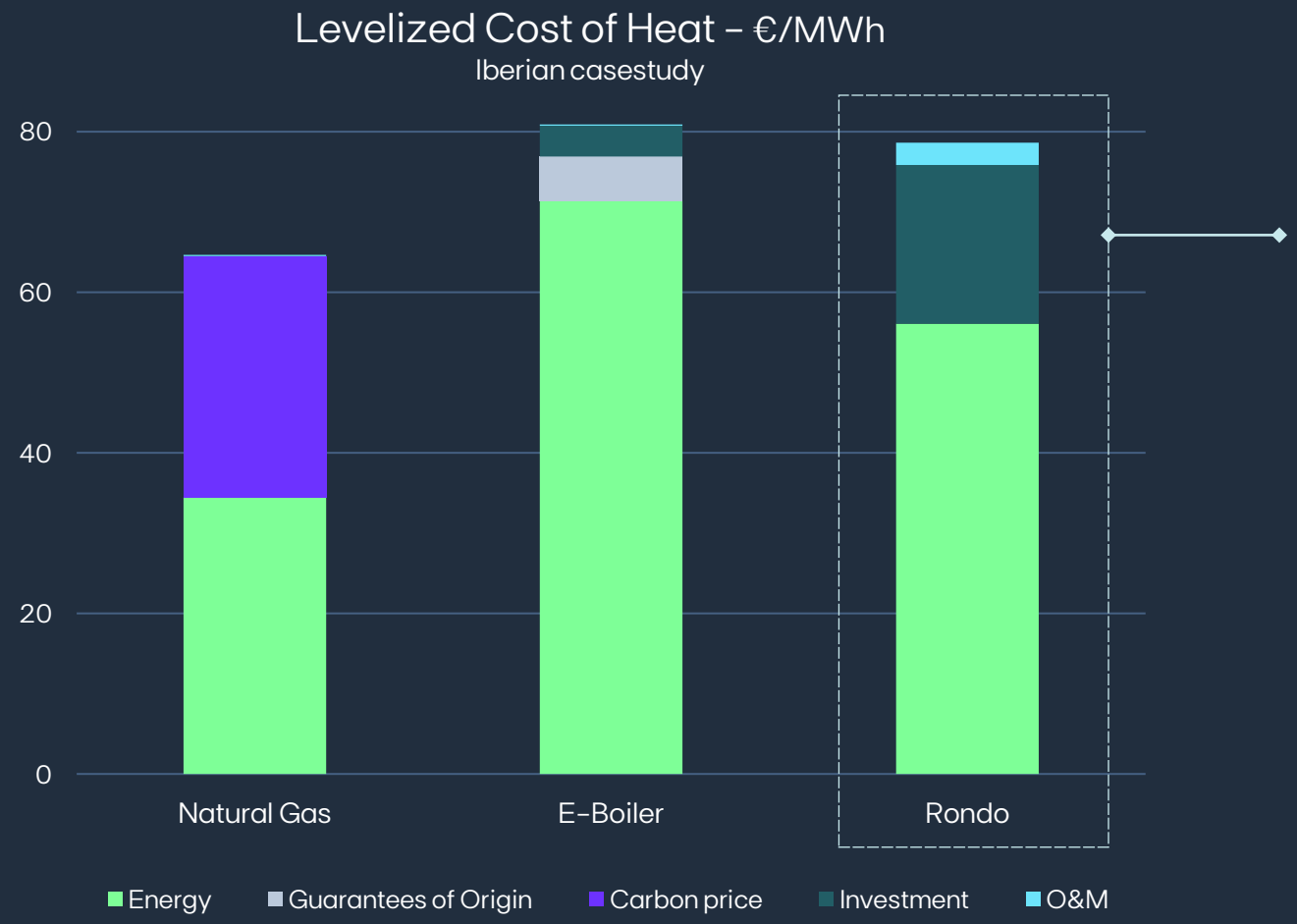
	Li-Ion	Hydrogen	Concrete	Molten Nitrate Salt	Unstructured solid media	Graphite	Molten Silicon	Rondo Heat Battery
Efficiency	85%	52%	90%	95%	90-95%	92%	90-95%	98%
Energy Output	Electricity	2000°C	350°C	560°C	750°C	1500°C	1200°C	1100°C
Safety	Moderate risk: fire/toxics	Moderate risk: explosion/fire	Moderate risk: toxic HTF	High risk: spills/gases	Low risk	Moderate risk (fire)	Moderate risk (fire/spill)	Low risk
Durability	5 years	10 years	Unproven; known risks	20 years	20 years	Unknown; no first article	Unknown; no first article	50+ years
Proven	Yes	Yes	Small pilot	CSP Onlu (not electric)	Yes	No	No	In process
Materials availability	Poor	Moderate	High	High	High	Moderate	Moderate	High
Footprint MWh/m^2	0.1	0.05-7	0.1	0.4	0.2	0.7	Unproven	1.2

Rondo Heat Battery Advantages:

- Operate the highest temperature and highest efficiency commercial ETES installation worldwide
- Provide long-term, low-cost, safe, reliable steam
- Fit smoothly into existing facilities with existing operating practices

Why Rondo Energy

Choosing the optimal solution cannot solely be based on the one with the lowest cost, there are other variables that we must take into consideration



While Rondo's solution may not always be the most cost-effective compared to alternatives such as natural gas, it presents a distinctive value proposition:

- 100% green and entirely safety
- carbon free
- certainty and predictability in consumption
- allows businesses to project an image of environmental responsibility and commitment to decarbonization
- Other value streams can be added, such has ancillary services and flexible energy profile improvement

The solution presents several advantages

Complete solution towards full or partial decarbonization

Replacing NG or other Fossil Fuel will ensure a major reduction in Scope 1 emissions

Competitive cost of steam

That can be delivered in a:

- CAPEX Model
- Heat as a Service

Joint model between EDP, Rondo

Combining experience to deliver all the necessary parts:

- On-site Solar
- Off-site PPA
- Electrical Infrastructure
- Rondo Battery