RONDO

ERSE ENTIDADE REGULADORA DOS SERVIÇOS ENERGÉTICOS

Can a **brick** solve Portugal´s **heat challenge?**

Electro Thermal Energy Storage: technologies, recent progress, and new perspectives



CONVERSE — ERSE | LISBON, 27 APRIL 2026

OPENING

Thank you, ERSE — and why I am here today

Good afternoon. I am grateful to President Verdelho and the ERSE team for organising this ConvERSE, and for framing it around what the regulator itself calls the ***"missing link"*** of the energy transition — storage.

My background: I lead **Rondo Energy's** commercial activity across Iberia and the Middle East. Before Rondo, I worked at **Breakthrough Energy** — Bill Gates' climate initiative — where I co-authored studies on ETES deployment in Europe, including the **Portugal Energy Storage Roadmap** published with EY and Cleantech for Iberia.

In the next 30 minutes I want to share three things:

- what industrial heat is and why it is Portugal's largest untouched decarbonisation opportunity;
- how thermal energy storage turns renewable variability into an industrial asset — including what we are already building in Lisbon;
- what the regulatory framework would need, in my view, to let this scale.

ABOUT THIS TALK

20 min presentation + Q&A

16 slides, structured in 4 blocks

1 Under-construction project in Lisbon: Heineken + EDP + Rondo

4 regulatory areas where ERSE can make a difference

RONDO

THE OVERLOOKED GIANT

Industrial heat: half the energy, none of the attention

A quick reminder before we dive into Portugal

~50%

of global final energy consumption is HEAT

IEA

~50%

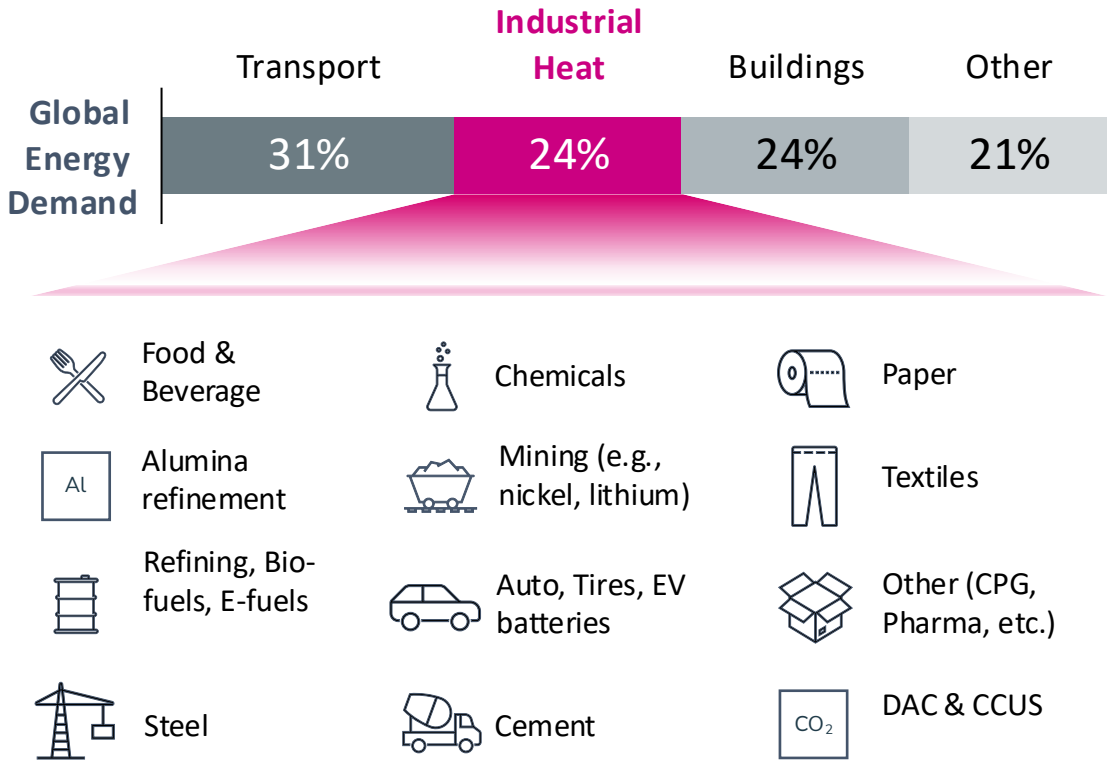
of that heat is consumed by INDUSTRY

IEA

~6 Gt

CO_2/yr — about 20% of global emissions

McKinsey



The power sector has been transformed in a decade. Industrial heat has barely been touched.

Most of it is still generated by burning natural gas, fuel oil, or coal, on-site. In Portugal:
21 TWh/year of industrial heat, ~50% of the country's total gas demand.

RONDO

THE PORTUGUESE PARADOX

A European leader in renewable electricity, yet industry still burns gas

The cleanest grid in Europe, not reaching the factory floor

POWER SECTOR

>73%

renewable electricity share (2025)

Highest in the EU. Negative/near-zero OMIE midday prices are already structural.

INDUSTRIAL HEAT

~85%

fossil-fuelled (gas + oil + coal)

100% of the natural gas Portugal burns is imported.

THE GAP

Cheap renewable electricity cannot reach the factory floor.

Industrial boilers run 24/7.

Low-price electricity is available 6–8 h/day.

Heat pumps and electric boilers cannot bridge this by themselves - **they consume whatever the market charges in every hour of operation.**

The grid transformation needs a heat-side counterpart.
That is what ETES provides.

Sources: REN, OMIE, DGEG, APREN (2025–2026)

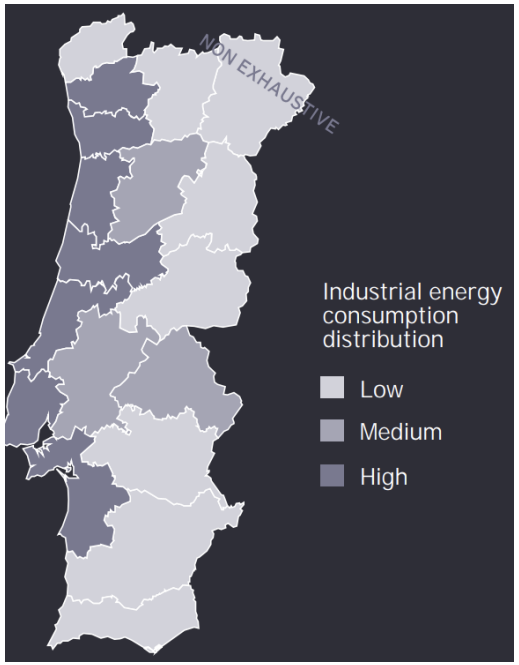
RONDO

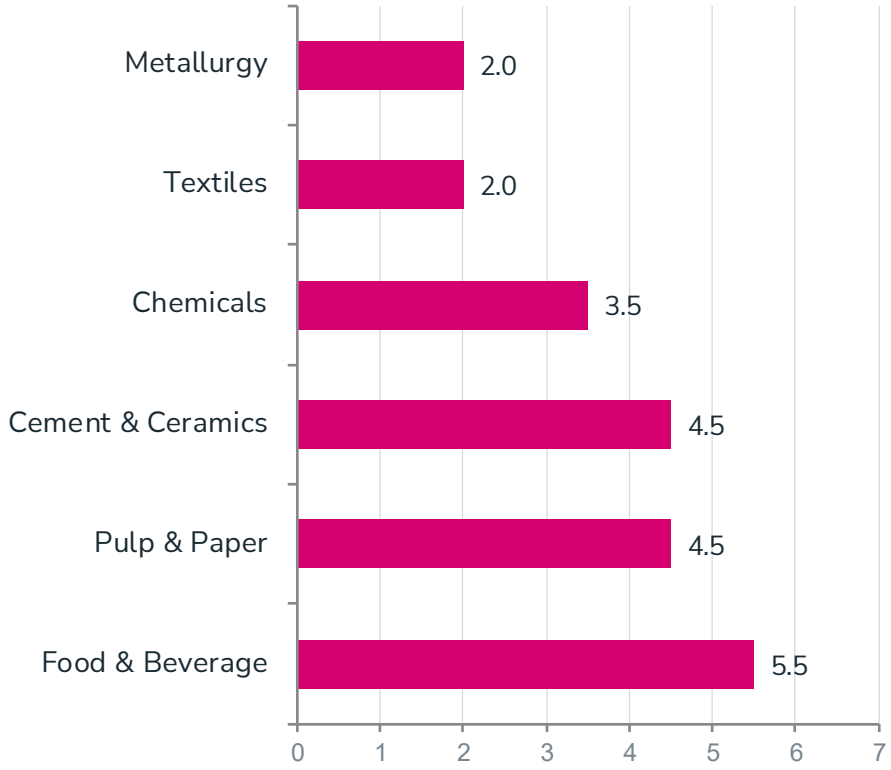
WHERE THE HEAT IS

Portugal's 21 TWh of industrial heat: concentrated in a few sectors and clusters

14 TWh addressable by ETES today; another 6 TWh unlocks with higher temperatures

INDUSTRIAL LANDSCAPE IN PORTUGAL





PRIORITY — TES-ADDRESSABLE TODAY

~14 TWh/yr

F&B · P&P · Chemicals · Textiles
Steam 120–250 °C, process heat up to 1,000 °C — fully within commercial TES range.

SECONDARY — 2030+ WITH HIGHER-T TES

~6 TWh/yr

Cement, ceramics, metallurgy — above 1,000 °C.

Geographic clusters: Figueira da Foz – Estarreja – Aveiro corridor · Porto region · Sines

Sources: DGEG / Energia em Números (2024); EY Energy Storage Roadmap for Portugal (2025); INE Balanço Energético (2023)

RONDO

WHY NOW — NOT IN 2035

The business case is no longer abstract

Four forces converge in 2026

01 Gas price shock, again

TTF spiked +55% in February 2026 after renewed Middle East tensions. Portugal imports ~100% of its gas. Delivered industrial gas: €55–75/MWh.

02 EU ETS tightening

Carbon at €60–90/tCO_2 adds €20–30/MWh penalty to gas heat. Free allowances phase down from 2026 under CBAM. Total fossil heat burden: €75–100+/MWh.

03 Capital outflow

Every euro spent on imported gas to make steam leaves the Portuguese economy. Estimated Portuguese industrial gas bill: ~€1.1–1.5 bn/yr, structurally.

04 The China parallel

China did not dominate EVs because of climate policy — it did it because oil imports were a strategic vulnerability. Europe has the same logic with industrial gas.

Sources: TTF spot (Feb 2026); EU ETS registry; DGEG; Enagás; IEA Global EV Outlook 2025

RONDO

THE MENU

No silver bullet: a toolbox with different jobs

Why ETES is not a competitor to heat pumps or e-boilers — but their enabler

Technology	Temperature	Cost	Flexibility	Best fit
Hydrogen	Any	Very high	None	Niche hard-to-abate
Biomass boilers	Up to 400 °C	Medium	Low	Limited by feedstock
Heat pumps	≤ 200 °C	Low OPEX	None (no buffer)	Low-T processes
Electric boilers	Up to 400 °C	High OPEX	None (no buffer)	Small / back-up
Electro-thermal Energy Storage (ETES)	**Up to 1,000 °C+**	**Low OPEX**	**High (buffered)**	**150–1,000 °C mainstream**

Key insight: *ETES does not replace the other electrification technologies — it enables them. A typical industrial retrofit may combine ETES for baseload steam with a heat pump for low-T loops, or e-boiler, or keep a gas boiler as back-up.*

Source: IEA; IRENA Thermal Energy Storage Innovation Outlook 2020; Agora Industry; Breakthrough Energy / Systemiq 2024.

RONDO

TES TECHNOLOGY LANDSCAPE

Three storage principles, many implementations

Solid-media and liquids sensible-heat systems are the ones reaching commercial deployment first

Sensible heat — solids

★ COMMERCIAL DEPLOYMENT

Refractory bricks · concrete · packed bed

Temperature: Up to 1,500 °C
Maturity: TRL 8–9

Mature materials (used in steelmaking Cowper stoves since 1860); lowest storage cost; > 30 yr service life

Sensible heat — liquids

★ COMMERCIAL DEPLOYMENT

Molten salt (nitrate)

Temperature: 290–565 °C
Maturity: TRL 7–9 (CSP-charged); adapting for electric charge

~50 GWh deployed via CSP globally; electric-charge adaptation under way

Latent heat (PCM)

Phase-change materials

Temperature: Material-dependent
Maturity: TRL 4–7

Higher energy density per m³; lower thermal conductivity, degradation challenges

Thermochemical

Reversible reactions

Temperature: Up to 900 °C
Maturity: TRL 4–6

Highest theoretical density; enables seasonal storage; early stage for industrial heat

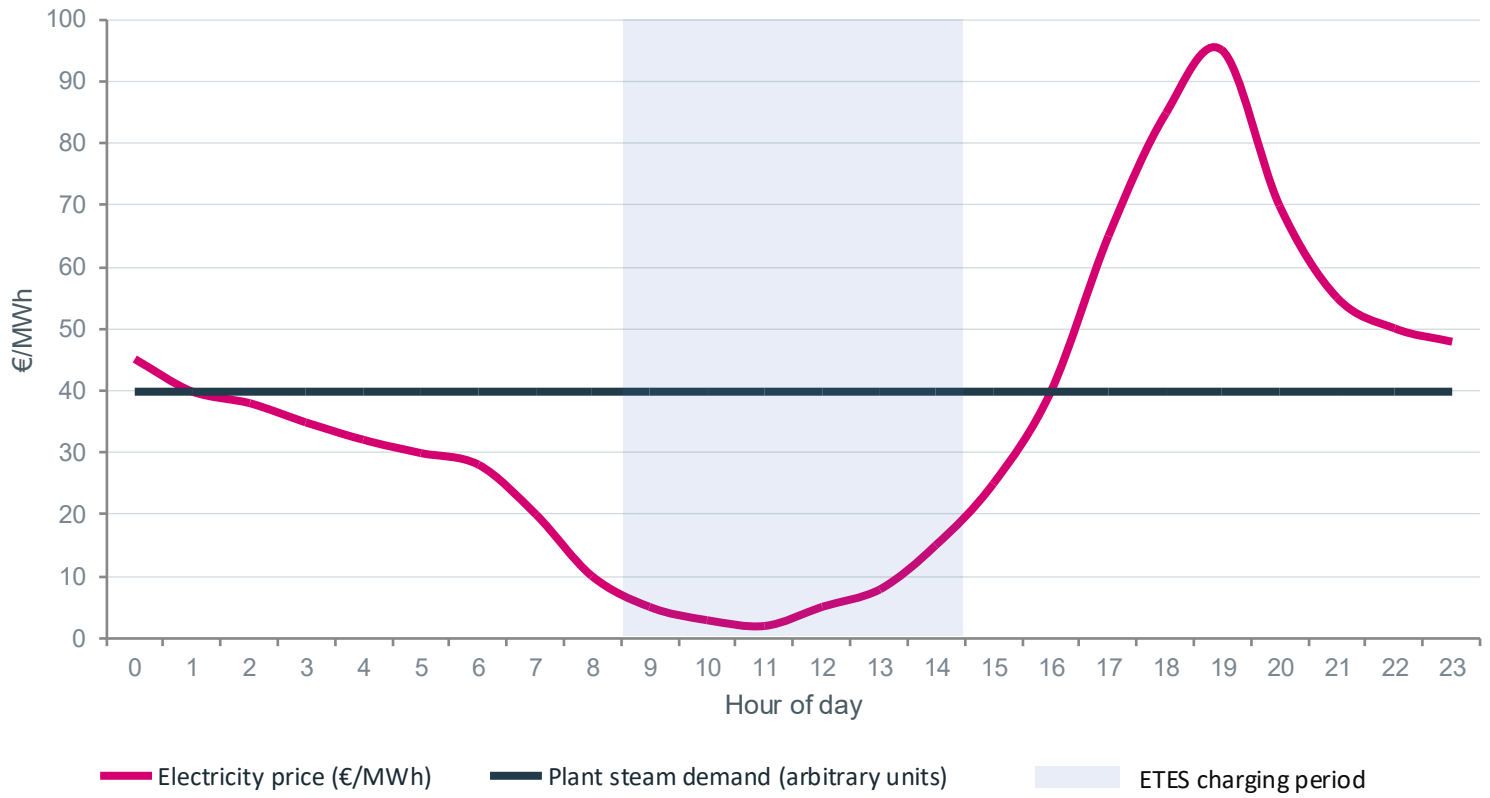
Over 40 ETES technology providers globally. *We now focus on solid-media refractory systems — the architecture closest to commercial scale in industrial settings.*

RONDO

THE VOLATILITY PROBLEM

Industry needs 24/7 heat. Cheap electricity is 6–8 hours/day.

Why direct electrification without storage still loses to gas on an all-hours basis



THE MATH

Solar peak: €2–10/MWh

Evening peak: €85–95/MWh

24-hour average: ~€50/MWh

Gas delivered: €55–75/MWh

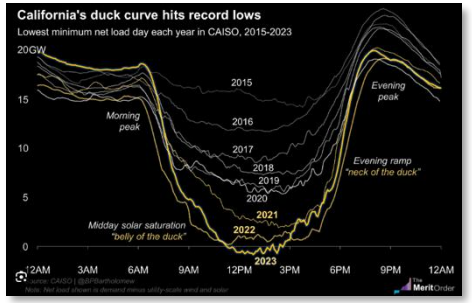
An e-boiler that buys power across all 24 hours pays the average — still above gas.

Illustrative Iberian day-ahead pattern. Source: OMIE 2025 observations, stylised.

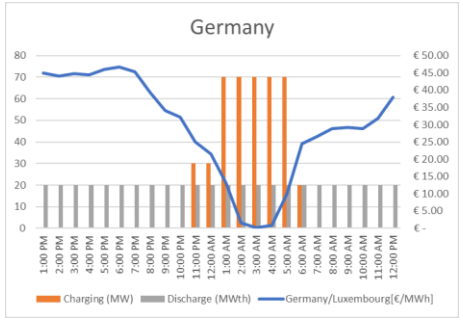
RONDO

Global renewables roll-out leading to cheapest-ever energy prices, now cost competitive with fossil-fuels, intermittently

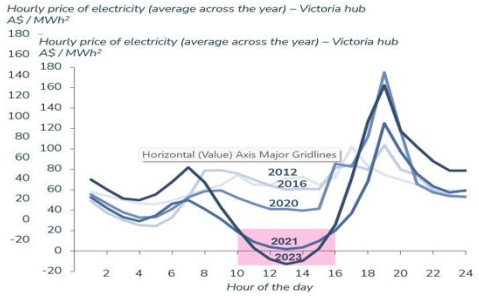
Grids with high solar penetration offer access to low or negatively-priced energy...



California



Germany

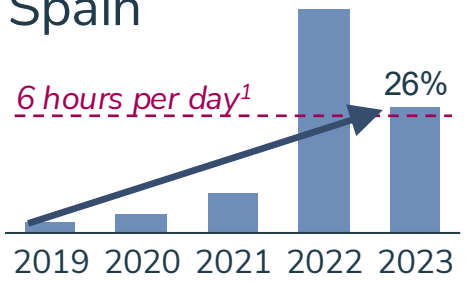


Australia

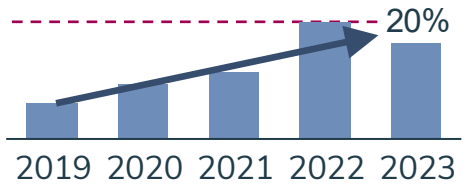
... increasingly offering access to energy prices below the price of gas + carbon

Share of hours with electricity prices below gas + CO_2, (%)

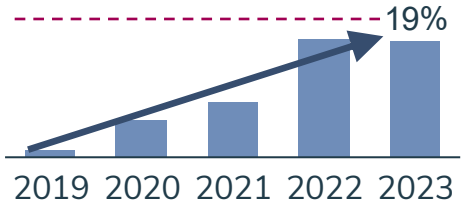
Spain



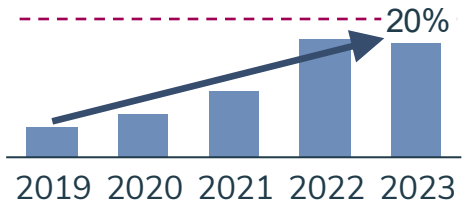
Germany



Netherlands

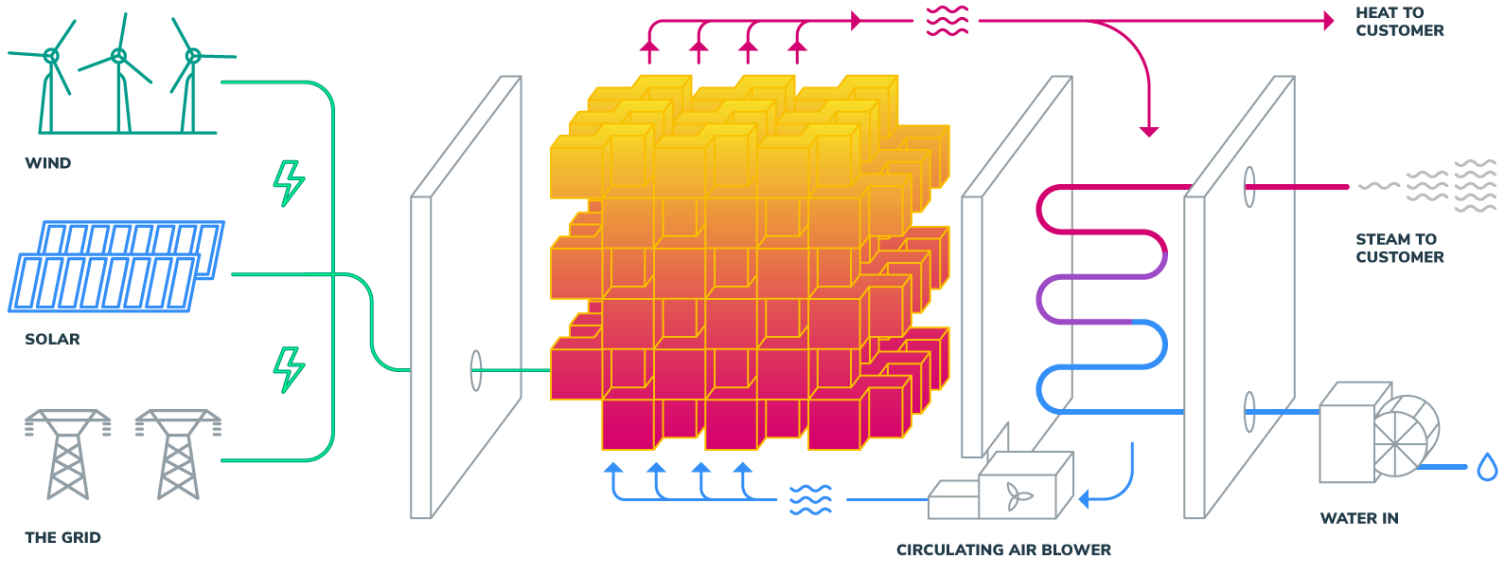


Belgium



RONDO

The Rondo Heat Battery is a drop-in, zero-carbon boiler replacement powered by cheap off-peak electricity



Integration options for Industrial sites

-Steam: connect as a boiler replacement to existing steam headers (saturated or superheated up to ~600°C).
-Hot air / gas: direct supply to dryers, calciners, anode baking or other high-temp furnaces (up to >1000°C).
-CHP: high-pressure steam can drive a steam turbine to provide power + LP/MP steam (high efficiency).
-Commercial models: CAPEX, Storage-as-a-Service, or Heat-as-a-Service.

Output temperature bands

STEAM	Up to 600°C
HOT AIR	Up to 1300°C
CHP	Steam turbine + LP/MP steam

1 CHARGE (6–8 h/day)
Use lowest-cost power: grid low-price hours, renewables, PPAs, behind-the-meter.

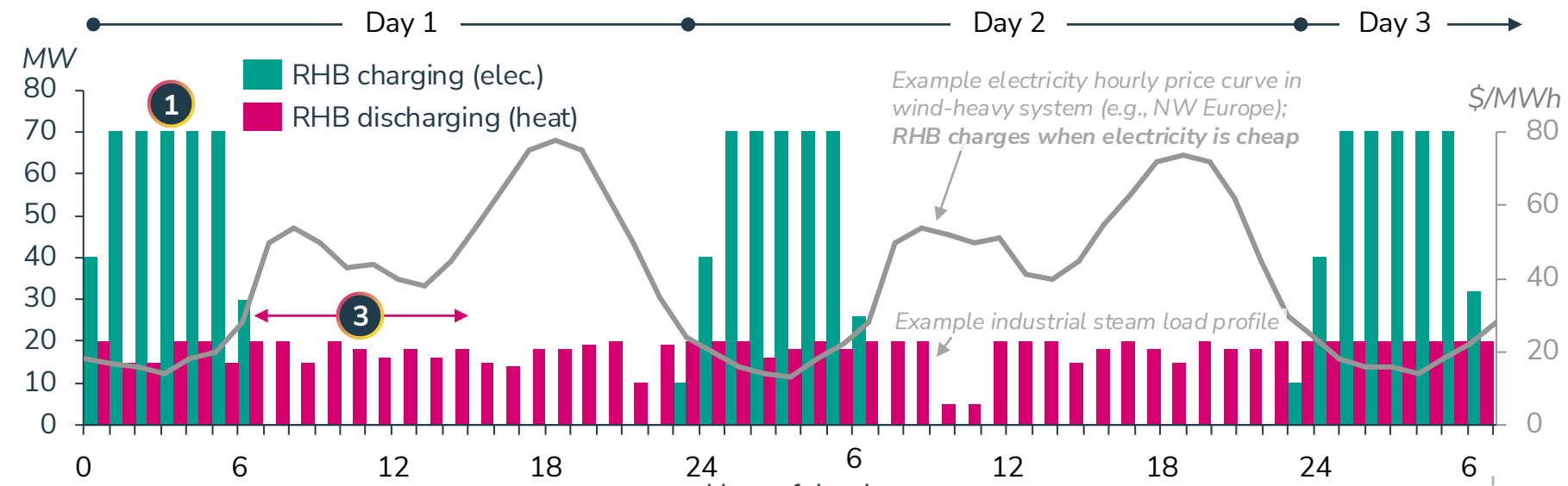
2 STORE (hours → days)
Radiant heaters heat refractory brick uniformly to ~1100°C. No chemistry, no combustibles.

3 DISCHARGE (24/7)
Deliver steam, hot air (up to >1000°C) or CHP steam turbine output at >97–98% efficiency.

6-8 hours of cheap electricity turned into **baseload steam**

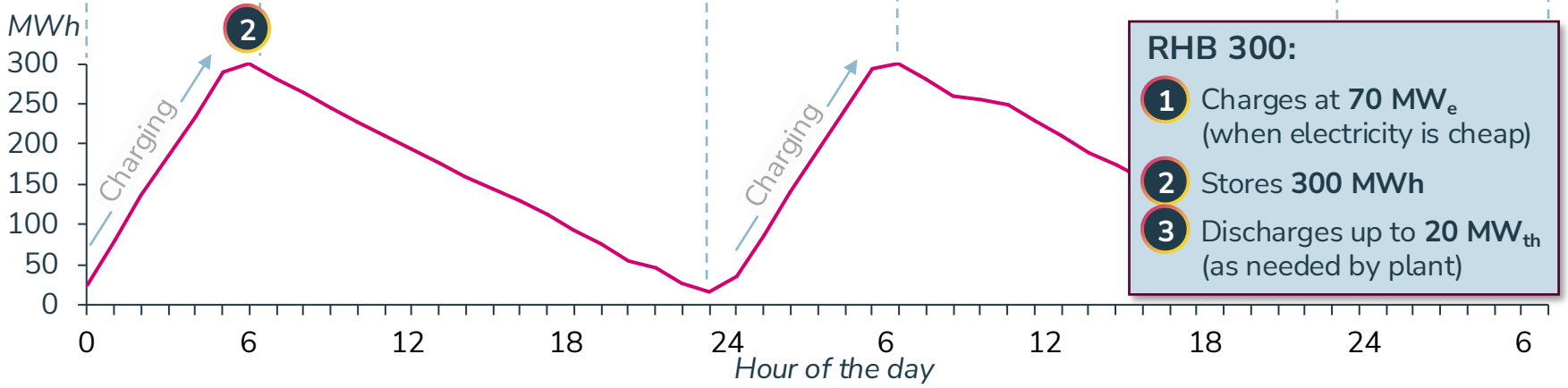
Rondo Heat Battery (RHB)
CHARGE & DISCHARGE

Example pattern for RHB300[1]



Rondo Heat Battery (RHB)
STORAGE

Energy stored in RHB



RHB 300:

1. Charges at **70 MW_e** (when electricity is cheap)
2. Stores **300 MWh**
3. Discharges up to **20 MW_{th}** (as needed by plant)

Notes: [1] RHB300 is a product size that refers to 300 MWh of energy storage capacity. See later slide for more information on product sizes.

3 years of commercial operation, 135MWh now in service

1 Commercial Pilot operations

Pilot unit running 3 years

2 Commercial operation

RHB33 in Thailand; RHB100 in California

link

link

+4 In contract and construction

4 in Europe announced, CODs 2026-27

Breakthrough Energy

European Investment Bank

Greener food, fuel and chemical production in Europe boosted by EIB, European Commission and Breakthrough Energy

link

covestro

Covestro to deploy innovative heat battery from Rondo Energy

link

GreenLab

Heat battery replaces fossil fuels for companies in GreenLab

link

Heineken

HEINEKEN pioneers one of the largest heat battery systems in Portugal in partnership with EDP and Rondo Energy

link

Rondo has secured **$100M USD project financing facility from Octopus Energy** to finance Rondo Heat Battery projects.
Rondo has also demonstrated the ability to pass rigorous project finance diligences, namely with the European Investment Board and Breakthrough Energy Catalyst to secure a **$75M USD financing package** to finance 3 Rondo projects in Europe

A CASE IN POINT — LISBON

The largest electrothermal storage project in the Iberian Peninsula

100 MWh

thermal storage capacity, Heat-as-a-Service

Heineken

brewery operating partner — PT industrial anchor

EDP

energy partner — renewable charging + project structuring

WHY THIS MATTERS FOR THIS ROOM

A first-of-its-kind industrial-scale deployment is being built by a Portuguese utility (EDP) and a global industrial (Heineken), with a Portuguese regulatory framework (DL 99/2024 + Order 1859/2025) that already allowed it to reach financial close.

The question now is: ***how do we move from one project to twenty?***

SYSTEM VALUE FOR PORTUGAL

BUT…ETES is not only a decarbonisation tool — it is a grid flexibility asset

Three measurable benefits for REN, E-REDES, and the Portuguese consumer

CURTAILMENT ABSORPTION

4.6–5.0 TWh

of forecast renewable curtailment in 2030 (NECP scenario) — absorbable by flexible industrial demand

EY 2025

MORE RENEWABLES ONLINE

~2.6×

renewable generation capacity enabled per unit of ETES thermal capacity — creates grid headroom

Systemiq 2024

PEAK-DEMAND RELIEF

6–30%

potential reduction in peak electricity demand vs. non-flexible industrial electrification

Systemiq 2024

The Portuguese grid already produces cheap midday electricity. *ETES is the demand-side asset that turns that cheap electricity into an industrial asset — rather than curtailed output.*

RONDO

Sources: EY Energy Storage Roadmap for Portugal (2025); Jenkins & Van der Jagt (2021); Breakthrough Energy / Systemiq (2024).

WHAT A SCALE-OUT COULD LOOK LIKE

ETES could address 14–20 TWh of Portugal's industrial heat demand

With proportional effects on emissions, gas imports, and industrial competitiveness

14 TWh

addressable in priority sectors by 2030

F&B · P&P · Chemicals · Textiles

–15 to –18 Mt

CO_2/year at full penetration

≈ 32–38% of Portugal's total emissions

€ hundreds of millions

of gas imports avoided per year

Structural improvement in trade balance

6 TWh more

beyond 2030 with higher-T ETES

Cement, ceramics, metallurgy

If Portugal moves decisively now, it can be Europe's first country to industrialise TES at scale — just as it led on renewable electricity.

RONDO

Sources: EY Energy Storage Roadmap for Portugal (2025); Breakthrough Energy / Systemiq 2024; DGEG.

WHAT BLOCKS SCALE TODAY

The technologies are ready. The framework needs tuning.

Four areas where the Portuguese regulator can make the most difference

01 Grid access for flexible industrial loads

Today's connection queues treat ETES as a conventional industrial load. In reality, it can absorb curtailment during peaks and consume off-peak renewable surplus. It should not queue behind it.

02 Asymmetric taxation: electricity vs. gas

The cost of a MWh of delivered electric heat includes tariffs, system charges, and levies that can more than double the wholesale price. Gas heat carries only fuel and ETS. The net effect penalises the cleaner option.

03 The flexibility market — still under design

ERSE is preparing the 2026 flexibility framework. If it is battery-centric, multi-hour thermal storage will be excluded from services it is economically and physically suited to provide.

04 CAPEX/OPEX support — stackable, predictable, ETES-eligible

PRR + Innovation Fund + Fundo Ambiental + Order 1859/2025: the pathways exist. What is missing is explicit ETES eligibility and predictable stackability.

Developed further in the annex

RONDO

CLOSING

Portugal can lead Europe on industrial heat — just as it did on renewable electricity.

1 **The technology is ready.**

Commercial ETES systems deliver industrial heat up to +1,000 °C at >97% efficiency. Rondo and 40+ providers are scaling now.

2 **Portugal has the conditions.**

Highest-RES grid in Europe, concentrated industrial clusters, strong NECP ambition. Heineken-EDP proves project bankability in-country.

3 **The framework is the lever.**

Grid access, tariff rebalancing, ETES-ready CEE and flex market, stackable CAPEX+OPEX support — all within ERSE's and DGEG's reach.

Thank you.

Alberto Toril Castro · Head of Iberia & Middle East, Rondo Energy · alberto.toril@rondo.com

Annex

FLEXIBLE GRID ACCESS

Flexible connections for industrial demand that helps the grid

Learn from UK, NL, DE; align with Spain's RDL 7/2026

THE PRINCIPLE

Flexible demand is not the same as firm demand.

A ETES plant consumes only in hours of system surplus and absorbs curtailment that would otherwise be wasted.

It should access the grid under different terms from continuous loads — because it imposes a different burden.

PRECEDENTS ALREADY IN PLACE

United Kingdom

Non-firm connections with time-of-use access capacity — widely used by industrial flex consumers

Netherlands

Interruptible connections with discounted tariffs in congested zones (TenneT, Liander)

Germany

§14a EnWG: reduced network charges for controllable consumption devices

Spain (peer)

RDL 7/2026 establishes legal basis for flexible grid access for demand-side storage

RONDO

Design the rules with multi-hour ETES in mind from day one

ERSE's flexibility market + DGEG's CEE methodology are both in design now

RONDO

FLEXIBILITY MARKET (ERSE, 2026)

Don't make it battery-centric

Batteries and TES provide complementary flexibility:

- Batteries — short-duration, seconds-to-hours, frequency services.
- TES — multi-hour to day-long, load-shift, curtailment absorption.

A market design that only rewards short-duration response will under-value ETES.

Spain is building a similar framework (SRAD). Aligning design now keeps MIBEL coherent.

CEE METHODOLOGY (DGEG)

Include ETES from day one

Certificados de Eficiência Energética will be the operational OPEX signal for industrial electrification.

Three design choices matter:

1. Measured displacement of fossil heat qualifies — not just primary-energy efficiency.
2. Long-duration contracts (10+ years) to match investment horizons.
3. Alignment with Spain's CAE (mature since 2023) for Iberian stackability.

A well-designed CEE is the single most impactful OPEX lever available.

RONDO

CAPEX AND OPEX SUPPORT FOR ETES

The instruments exist. What is needed is clarity, eligibility, and stackability.

Portugal already has most pieces on the table

PRR

EU Recovery & Resilience Plan — industrial decarbonisation envelope open through 2026

Innovation Fund

EU Horizon — accessible for TES demonstrations and first-of-a-kind projects

Fundo Ambiental

National grants and loans for environmental and decarbonisation projects

Order 1859/2025

Direct support for industrial electrification and renewable thermal energy

Explicit ETES eligibility

in every relevant instrument — not inferred, written down.

Stackability across instruments

so projects can combine EU, national, and environmental support within EU state-aid limits.

OPEX support, not just CAPEX

critical: industrial investment decisions follow OPEX trajectories. CAPEX grants alone leave a first-mover risk.

RONDO