Position Paper on The Dual-Value Electrification: Affordable Energy & New Revenues for EU Industries

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Position Paper

Executive Summary

Today, only 3–4% of EU industrial heat is electrified. Industrial Thermal Energy Storage could reduce the need for 1,793 TWh of fossil fuel per year, thus shortening the gap to reach EU decarbonisation goals.

This roll-out would reduce total industrial GHG emissions by 60%, by supporting Industry up-takers with 24/7 low-carbon heat and up to 24 hours of grid flexibility. Industry off-takers would access new revenue streams, such as participating in arbitrage and system services markets while protecting from market price volatility without interrupting processes.

Yet deployment remains limited. Several legislative, market, and financial barriers continue to hold back Industry TES projects from contributing to EU electrification goals. Policymakers should address regulatory and administrative policies that hinder electrification, ensure access to new revenue streams, and implement long-term financing solutions that reduce investment risk for the Industry. In particular, Energy Storage Europe identifies the following measures as essential for accelerating industrial electrification at scale:

	Barriers	**Solutions**
1	**No harmonised TES definition** Legal ambiguity leads to legislative inconsistencies across Member States	**Introduce a TES definition** Clarify TES definition in the Electrification Action Plan
2	**Grid connection & permitting barriers** Lack of grid connection, long queues, costly connection charges, and lengthy permitting procedures delay project deployment	**Tailor grid connection & permitting to TES** Ensure grid upgrade planning in Member State's national development plans; prioritise mature projects in grid connection queues and align permitting rules with renewables ones (12–24 months)
3	**Grid fees & electricity taxes** Non-cost-reflective grid fees and flat tariffs penalise Industry TES projects for the flexibility they provide to the grid	**Reform network tariffs & taxation** Introduce dynamic tariffs; remove non-energy-system levies on electricity in the upcoming EU Network Charges & Taxation initiative.
4	**Barriers to wholesale & system services markets** Legacy national laws limit Industry TES projects' participation in arbitrage and system services markets	**Allow wholesale & system services participation** Amend the Electricity Balancing Guideline and assess prequalification criteria that exclude Industry TES projects from accessing these markets
5	**Financing & investment barriers** Bankability challenges and limited access to public funding and State Aid leave Industry TES projects underfunded	**Unlock cheap capital & dedicated funding** Ensure EIB counter-guarantees, low-interest CAPEX loans; make a yearly-basis Innovation Fund Heat Auction, and foster CCfDs for industrial off-takers

This paper assesses EU industrial processes electrification, provides an overview of TES technologies, investigates revenue streams, and looks at deployment barriers and solutions.

Focus: The Questions This Paper Aims to Answer

1. Why shall EU industrial process heat electrify?

2. How do Thermal Energy Storage (TES) technologies support the industry's electrification needs?

3. What are the current business models for cost-efficient and competitive heat Industry electrification?

4. Which legal, economic, and financial barriers currently hinder the development of TES business cases for sustaining Industry decarbonisation?

5. How to ensure EU framework policies support Industry electrification?

And further elaborating on this latter question:

6. How to ensure Thermal Energy Storage supports the industrial actor's access into flexibility and wholesale electricity markets?

7. How to ensure Thermal Energy Storage access EU and national funds for Industry decarbonisation?

Context:

Electrifying EU Industry: Why Energy Storage Matters

Industry in Europe is highly exposed to price spikes. Europe's Industry relies heavily on imported oil and gas. Energy insecurity is impacting EU energy consumption, and industry's competitiveness, with virtually all Industry actors facing costs and price predictability challenges.

Climate goals and Industry electrification needs. The EU's climate goals are to cut emissions by at least 55% by 2030 and reach climate neutrality by 2050. In order to achieve the aforementioned goal by 2030, electrification will need to reach at least 35% of the EU's total energy use. Only around 3–4% of EU industrial heat at high temperatures is currently electrified.

Many barriers, (still) few solutions. Energy storage and in particular, Thermal Energy Storage (TES), decarbonises the EU Industry while optimising processes – therefore reducing operational costs. Yet, TES faces several legislative, market, and financial barriers that slow down deployment.

The dual-value of Thermal Energy Storage. TES has a double value for Industry up-takers: it provides 24/7 cheap heat, and 16-24 hours of grid flexibility and stability services. It increases Europe's industrial competitiveness.

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1. Why Electrifying EU Industries

1.1 Introduction

This chapter focuses on why industrial heat shall electrify, looking at enablers and drivers; market outlook; and the role of energy storage.

1.2 Industry Electrification Enablers and Drivers

Electrifying industrial process heat is critical to ensure competitiveness, and long-term technology innovation of EU Industry while supporting the EU climate goals for 2040 by providing:

- **Energy security and price stability.**
- **Reduced energy costs.**
- **New revenue streams.**
- **Improved Industrial processes.**
- **Security of supply.**
- **Emissions reduction and ESG compliance.**

The following sections elaborate on these drivers and enablers.

1.2.1 Energy Security and Price Stability

From an energy security and price stability perspective, electrifying industrial heat strengthens the EU's energy security as it reduces exposure to volatile fossil fuel markets. This is key in the context of recent price shocks that exposed the EU Industry's reliance on imported fuels: in 2025, electricity costs are 2–4 times higher than in the US and China.

More specifically, shifting to EU- produced electricity reduces exposure to global price swings, stabilises costs, and supports long-term investment decisions. At the same time, replacing imported fossil fuels with EU-generated electricity strengthens a "Made in Europe" industrial model by:

- Retaining energy expenditure within the European economy, supporting domestic value chains;
- Reducing strategic dependencies on external suppliers;
- Helping EU producers to remain competitive against global competitors, benefiting from lower-carbon and lower-cost power systems.

1.2.2 Reduced Energy Costs

Regardless of whether the Industry can ramp up or down production or whether renewables generation is present at the Industry premises, electrification brings costs down.

- Heat production can be scheduled during periods of lower prices or high renewable availability, while maintaining continuous thermal output.
- Supporting real-time selection of the most economically valuable operating mode, ensuring that consumption patterns align with market signals and tariff structures.

- Reducing demand charges, by lowering total grid electricity intake.
- When present, maximise the use of Industrial premises-located renewable energy.

These points are further discussed in Chapter 3.

1.2.3 New Revenue Streams

Electrifying industrial heat leads to new revenue streams that strengthen the business case by:

- Relying on arbitrage, i.e. the buying and selling of electricity.
- Providing system services to TSOs or DSOs, being remunerated.

These points are further discussed in Chapter 3.

1.2.4 Improved Industrial Processes

Electrification allows for more precise industrial processes, while contributing to energy efficiency by:

- Making use of waste heat, therefore increasing energy efficiency.
- Providing faster ramping and precise temperature management than conventional combustion systems, especially for continuous and high-temperature applications.

These points are further discussed in Chapter 2.

1.2.5 Increased Security of Supply

Electrification strengthens both the supply of the energy needed for industrial processes and resilience to disruptive events by:

- Allowing heat production to be decoupled from real-time electricity consumption, ensuring continuous thermal supply while reducing equipment stress and unplanned downtime.
- Reducing dependency on continuous external fuel supply and mitigate the impact of upstream disruptions.
- Enabling immediate backup support in the event of voltage dips or short outages, limiting production interruptions.

1.2.6 Emission Reduction and ESG Compliance

The EU's legally binding decarbonisation targets are complemented by other Industry-focused measures:

- The EU Emissions Trading System (ETS) sets a declining emission cap for Industrial up-takers.
- The Carbon Border Adjustment Mechanism (CBAM) extends carbon pricing to key imported goods (cement, steel, aluminium, fertilisers, electricity, hydrogen).

Together, ETS and CBAM ensure that carbon costs become unavoidable both inside and outside the EU market, with commitments increasing over time – as shown in the following table.

Period	Key impacts on EU Industry
2023–2025	CBAM reporting obligations; rising ETS allowance prices
2026–2030	Start of CBAM payments; rapid reduction of ETS free allowances; strong incentive to electrify industrial heat
2030–2034	Free allowances fully phased out; CBAM fully implemented; fossil-based process heat becomes structurally uncompetitive

Table 1: Timeline of ETS and CBAM impacts on EU Industry. Energy Storage Europe elaboration. Source: European Commission: Effort Sharing 2021–2030

In addition, electrification of industrial heat processes allows Industry up-takers to meet increasingly stringent sustainability and disclosure requirements, including environmental, social, and governance (ESG) performance criteria and scores.

ESG requirements are not voluntary labels, but part of the EU's broader regulatory architecture to achieve its climate targets. Through energy storage solutions, electrified firms can improve their taxonomy eligibility and access to sustainable finance funds.

1.3 The European Industry: Needs and Electrification Potential

1.3.1 European Overview

Despite electrification being central to the EU Green Deal, progress in electrifying industrial process heat has remained under 5% over the last decade. Industrial electrification requires an additional 560 TWh of electricity per year, equivalent to around 69% of current EU electricity consumption.

In the European Union, industrial process heat plays a critical role in an expected full-electrified industrial scenario, which requires 2-3 times more electricity (1786–2313 TWh) than in current days (2020 data). Industry accounts for around one quarter of EU final energy consumption, while around 80% of heat demand is associated with industrial heat processes[1].

The EU industrial energy mix remains strongly fossil-based. Around 75% of industrial process heat demand is currently met by fossil fuels, contributing significantly to emissions. Industry accounts for 28% of total indirect emissions from electricity.

Despite electrification being a cornerstone of the EU Green Deal, progress in industrial process heat remains limited. Only around 3–4% of EU industrial heat is currently electrified[2], even though up to 78% is technically electrifiable using existing technologies[3]. This contrasts with the broader role of electricity in the EU energy system, where electricity already represents around 23–25% of final energy consumption. Based on a 2020 analysis, deep electrification reduces final energy consumption by 20% and reduces CO2 emissions by 9%.

More specifically, the full roll-out of Industry TES projects in the EU could enable the replacement of up to 1,793 TWh of fossil fuel use annually, corresponding to a reduction of approximately 513 Mt CO_2-equivalent per year, which is around 60% of total industrial GHG emissions and 12% of total EU GHG emissions[4].

[1] *For the temperature ranges of 100 to 500 °C and above 500 °C, each range accounts for >40 % of industrial heat demand. Source: Rosenow J. et al., The heat is on: Policy solutions for industrial electrification (2025).*

[2] Eurelectric "Unlocking the untapped potential of industrial electrification" (December 2024), with reference to industrial high-emission heating processes.

[3] J. Rosenow "The heat is on: Policy solutions for industrial electrification" (2025), with reference to all industrial process heat

[4] *EERA Joint Programme Energy Efficiency "Industrial Thermal Energy Storage - Supporting the transition to decarbonise industry (2023)"*

The figure below illustrates the Industry sector's electrification potential in the EU-27. It shows 2019 electricity demand, remaining fuel use, and electrification potential in 2025, 2030, and 2035.

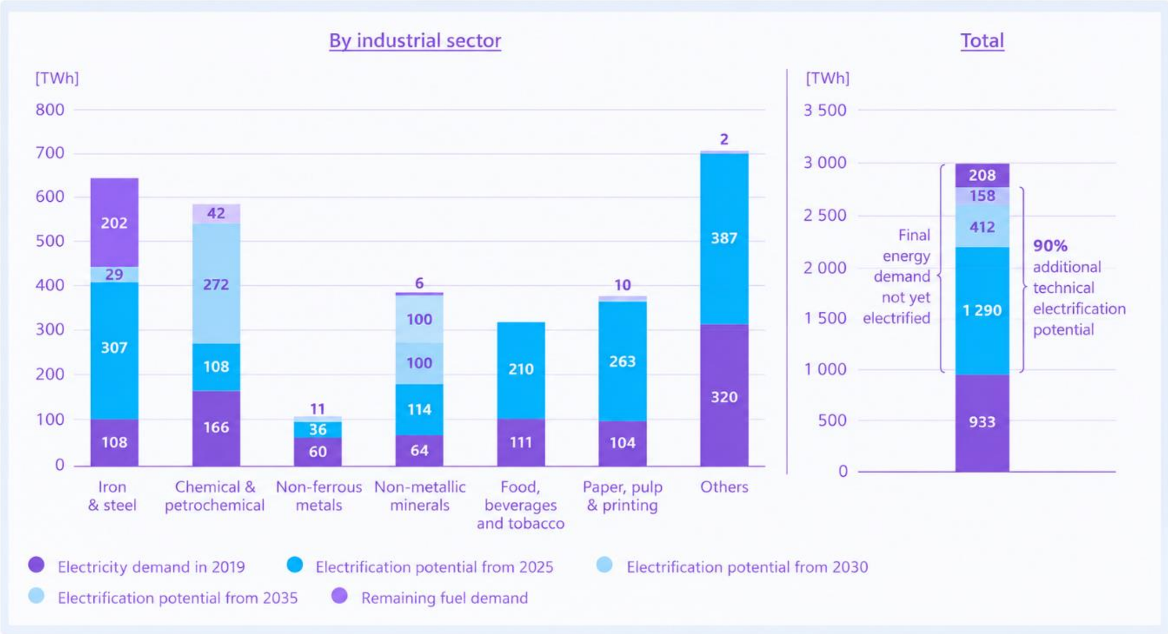

Image: Electrification potentials in the EU-27. Source: Agora Industry. [Direct electrification of industrial process heat - An assessment of technologies, potentials and prospects for the EU](). (2024)

1.4 Electrification of Industrial Processes with Energy Storage

As discussed in section 1.2, electrification of Industrial processes strengthens the business case for Industry up-takers. In reality, most of these benefits can be achieved only by electrifying through energy storage.

Battery energy storage systems (BESS) currently dominate power-to-power flexibility markets. Thermal Energy Storage (TES) provides a complementary and often more efficient solution for industrial heat applications.

This distinction is crucial since:

- **BESS** store and deliver electricity, making them well-suited for short-duration grid balancing, but they cannot directly supply high-temperature industrial process heat.
- **TES**, in the form of Power to Heat storage, stores energy directly in thermal form and delivers it at the temperature required by industrial processes, avoiding additional conversion steps and improving overall efficiency for heat applications.

The following chapter investigates TES solutions for Industry electrification.

2. Overview of TES Technologies for EU Industry Electrification

2.1 Introduction

This chapter focuses on how thermal energy storage provides heat, available technologies, and different Industry process output needs.

2.2 Thermal Energy Storage Technologies

Thermal energy storage technologies can be broadly classified into three main categories:

1. Sensible TES: stores energy by changing the temperature of a storage medium. It is the most commercially mature category and includes solutions based on water, thermal oil, rocks, sand, clay, brick, steel, concrete, and molten salts. Systems can operate across a wide temperature range with relatively few integration constraints.

2. Latent TES: exploits the phase change of materials (PCMs) to store heat at nearly constant temperatures. Systems can reach high volumetric energy densities, thus reducing footprint requirements. Typical materials include paraffin, fatty acids, salt hydrates, inorganic salts, and metals, though higher costs and lower technological maturity currently limit large-scale deployment.

3. Thermochemical TES: relies on reversible endothermic and exothermic reactions, such as sorption or chemical looping. Systems offer very high energy densities and allow long-duration or seasonal storage with minimal losses, since the charged material can be stored at near-ambient conditions. Technological maturity currently limits large-scale deployment.

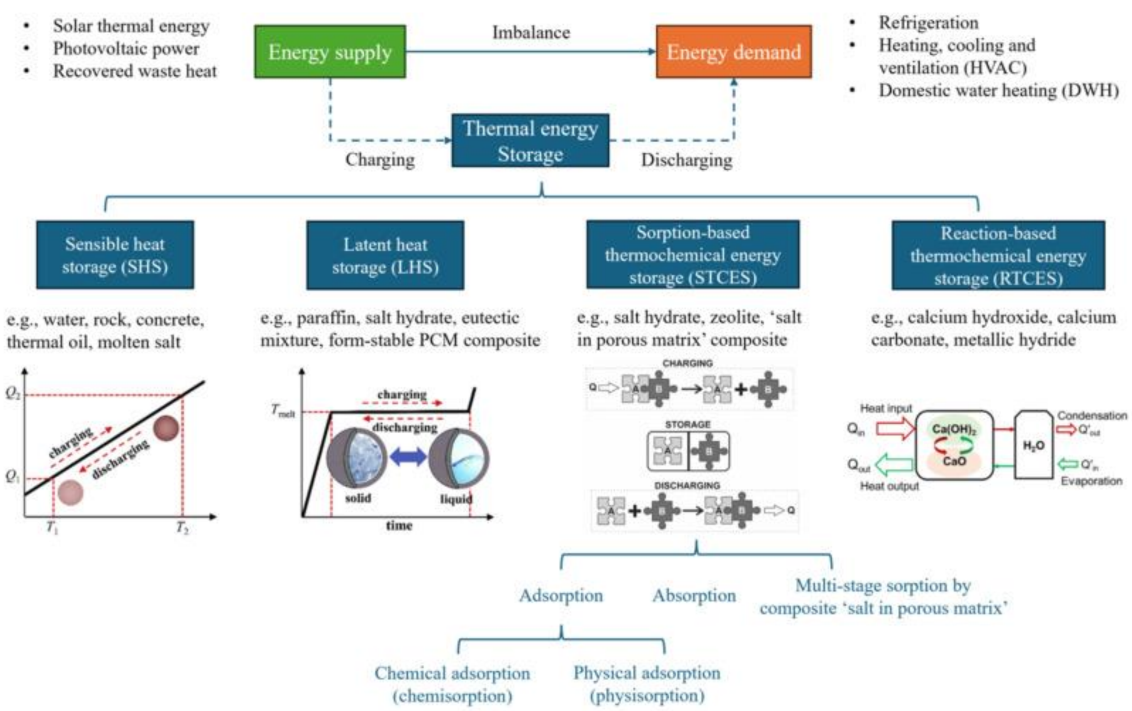

Image: classification of the three above-mentioned thermal energy storage technologies (STCES & RTCES are part of thermochemical TES).
Source: Liu et al. [A systematic evaluation of sorption-based thermochemical energy storage for building applications: Material development, reactor design, and system integration](#) *(2025)*

The following table shows the three technologies' performance improvement and costs reduction over time.

Attribute	Sensible			Latent			Thermochemical		
	2018	2030	2050	2018	2030	2050	2018	2030	2050
Cost (USD/kWh)	25-30	< 15	< 12	25-90	25-35	< 12	Research level	Pilot scale, 80-160	Demon-stration, <80
Efficiency (%)	>90	>92	>95	>90	>92	>95	40-50	(1)	
Energy density (kWh/m^3)	70-200	(2)		30-85			800-1200		
Lifetime (years or cycles)	< 10 000	> 10 000		3 000-5 000	4 000-5 000	5 000-10 000	< 100	500-1 000	> 1 000-3 000
Working temperature (°C)	< 565	600-700	> 700	< 600	600-750	700-850	500-900		500-1000

Notes: (1) Value not available due to low technology readiness level; (2) Value dependent on the material selection.

Image: Projected economic and technical trends (2018–2050) for thermal energy storage technologies (IRENA). [*Innovation Outlook. Thermal Energy Storage*](#) *(2020)*

However, electrification processes do not exactly correspond to the temperature levels provided by storage systems. It is key to differentiate between the temperature delivered for the industrial process needs and the temperature stored by the TES unit: e.g., some TES solutions store at 1000 °C, but then deliver only at 300 °C.

2.3 Industrial Processes Outputs

2.1.1 Industry Process Temperature Needs

Industrial process temperatures vary according to the industrial processes' needs, outputs: Low (<100°C), Medium (100–400°C), or High (>400°C) processes.

Sector	Sub-processes	Low (<100°C)	Medium (100–400°C)	High (>400°C)
Pulp & Paper	Drying, pulping, bleaching, paper drying	X	X	
Food & Beverage	Pasteurisation, cooking, sterilisation, drying	X	X	
Plastics (PVC)	Polymerisation, extrusion, compounding	X	X	
Gypsum	Calcination, drying	X	X	

Chemicals (general)	Steam cracking, ammonia synthesis, distillation. Bulk processes need medium–high temperatures.		X	X
Cement	Clinker production (kiln), grinding			X
Ceramics	Firing, sintering, drying			X
Lime	Calcination of limestone			X
Iron & Steel	Blast furnaces, rolling			X
Aluminium	Melting & large use of furnaces			X
Glass	Melting, forming, annealing			X
Insulation materials	Mineral melting, fiberising			X

Table 2: Industrial sectors and sub-process temperature ranges for thermal energy needs.

As the paper's focus is on the electrification of EU industrial process heat, the following section will explain how Thermal Energy Storage Solutions address three different industrial process temperature levels.

2.1.2 Low-Temperature Outputs (<100°C)

Low-temperature outputs are the most common use for TES, and its application include both district heating and Industrial processes.

Industrial Process, TES temperature range & type

Application	Required TES Temperature Range	TES technology
District heating	Up to ~100 °C	Sensible Heat Storage
Light industrial heating, washing, cleaning	Up to ~100 °C, with some specific cases up to 150 °C	Sensible Heat Storage
Food processing, refrigeration	~0–100 °C, with some specific cases up to 150 °C	Latent Heat Storage
Multi-day low-temp process buffering	Variable, up to 200 °C	Low-Temperature Thermochemical Storage

Table 3: Summary of low-temperature application of TES.

This document will focus on Industrial processes electrification – therefore the application "district heating" will not be further investigated in this paper.

2.1.3 Medium-Temperature Outputs (100-400 °C)

Medium-temperature outputs operate between 100° C and 400° C. Not as commonly deployed as low-temperature output-focused solutions, TES projects this segment must balance technological maturity, energy density, and ease of process integration. Solid Sensible Heat Storage is commonly deployed but latent and thermochemical systems – which enable higher energy densities, improved thermal control, and longer-duration flexibility – are currently under development.

Industrial Process, TES temperature range & type

Application	Required TES Temperature Range	TES technology
Pulp & paper drying, sterilisation	100–400 °C	Solid Sensible Heat Storage
Chemical processing requiring precise temperature control & long-duration flexibility	200–400 °C	Medium-Temperature Latent Heat Storage & Medium Temperature Thermochemical Storage

Table 4: Summary of medium-temperature application of TES.

2.1.4 High-Temperature Industrial Outputs (>400 °C)

High-temperature processes require temperatures above 400 °C, sometimes exceeding 2,000 °C. These processes demand TES with high thermal stability, mechanical resilience, and long-duration storage capabilities. TES must provide extreme heat tolerance and energy density. Similarly to medium-temperature outputs, solid sensible systems are mostly deployed, but the less mature latent and thermochemical systems are emerging solutions.

Industrial Process, TES temperature range & type

Application	Required TES Temperature Range	Recommended TES Category
Cement, steel, glass production	400–1000 °C	Solid Sensible Heat Storage
Processes needing precise high-temperature control	1000–1600 °C	High-Temperature Latent Heat Storage
Renewable-driven, seasonal high-temperature heat	400–900 °C	Thermochemical Storage

Table 5: Summary of high-temperature application of TES.

3. Dual-Value Business Models

3.1 Introduction

This chapter describes the business for industrial actors electrifying processes with TES solutions.

3.2 Revenue Streams

3.2.1 Arbitrage/Wholesale Market

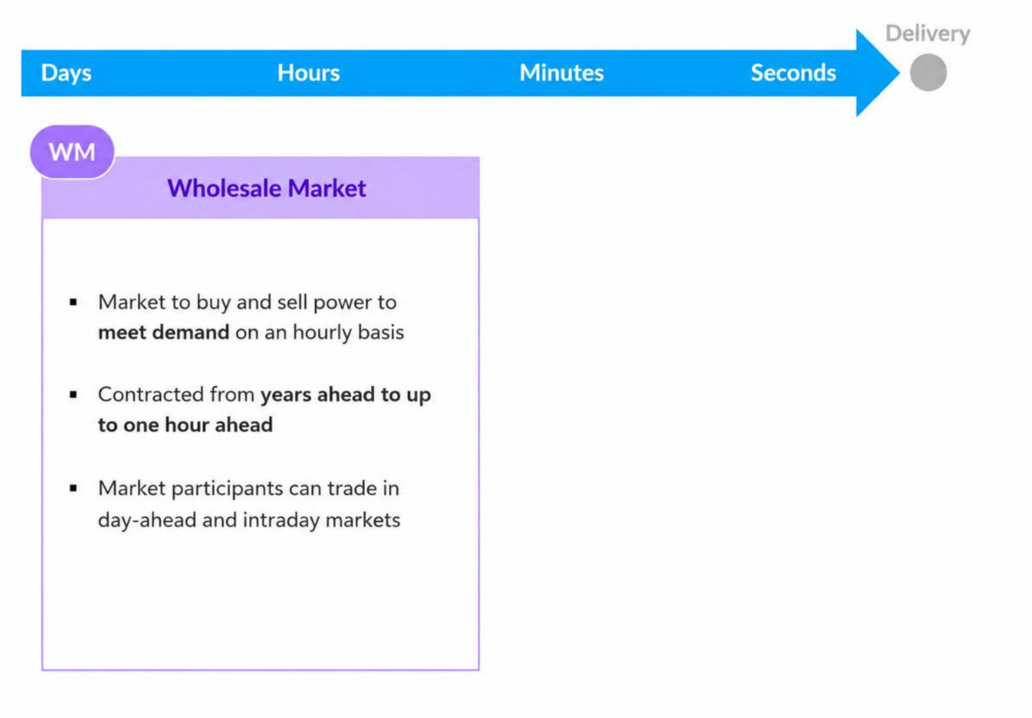

Image: The image presents key features for participation in the wholesale market. Source: Aurora Energy Research "The economics of batteries in Iberia" (2022)

Thermal energy storage systems charge using electricity during low or negative price periods and discharge (as usable heat) when prices peak, helping smooth increasing price volatility. This volatility is driven by rapid market changes, notably the large-scale expansion of variable renewable energy such as solar PV, which leads to curtailment and a growing number of hours with zero or negative prices.

Arbitrage does not necessarily require reconversion to electricity, avoiding efficiency losses and making particularly attractive for industrial heat applications, **becoming a valuable revenue stream in addition to their core production activity**. The value is captured by shifting electricity intake while maintaining continuous heat output, effectively monetising price spreads without exposing industrial processes to intermittency risks, thus increasing profitability.

Configuration	*Electrified heat production coupled with short to medium-duration TES*
Target	*Capture wholesale price spreads and avoid high-price periods*

Benefits	*Reduced energy costs; monetisation of price volatility, especially in case of low-price periods (where TES can be recharged); mitigation of renewable curtailment for on-site applications.*
Merchant exposure	*Low ▮▮▮▮▮▮▮▮ High* *In this case, high merchant exposure is defined by the combination of TES with electricity-based solutions (and by traditional fossil-fuel heat generators). To minimise pioneer risks, industrial actors can adopt a hybrid approach by pairing new Thermal Energy Storage (TES) with their existing fossil-fuel systems as a reliable safety measure.*
Relevance in revenue stacking for the industrial actor	*Medium–High (foundational revenue layer enabling other value streams).*
Potential economic benefits	*Up to –€14/MWh reduction in heat cost5* *In the food Industry: expected up to 20%–70% electricity cost reduction*

Enablers	***Barriers***
• *Dynamic time-differentiated tariffs* • *High renewable penetration & policies for TES located near RES facilities* • *Grid fees reflecting temporal consumption* • *On-site renewables*	• *Static electricity tariffs* • *Price caps or distorted signals* • *Flat or non-coincident grid fees* • *Legal barriers to participation*

Table 6: TES configurations, targets, benefits, and revenue opportunities in wholesale markets.

3.2.2 System Services

TES allows Industrial actor participation in ancillary services and local flexibility markets.

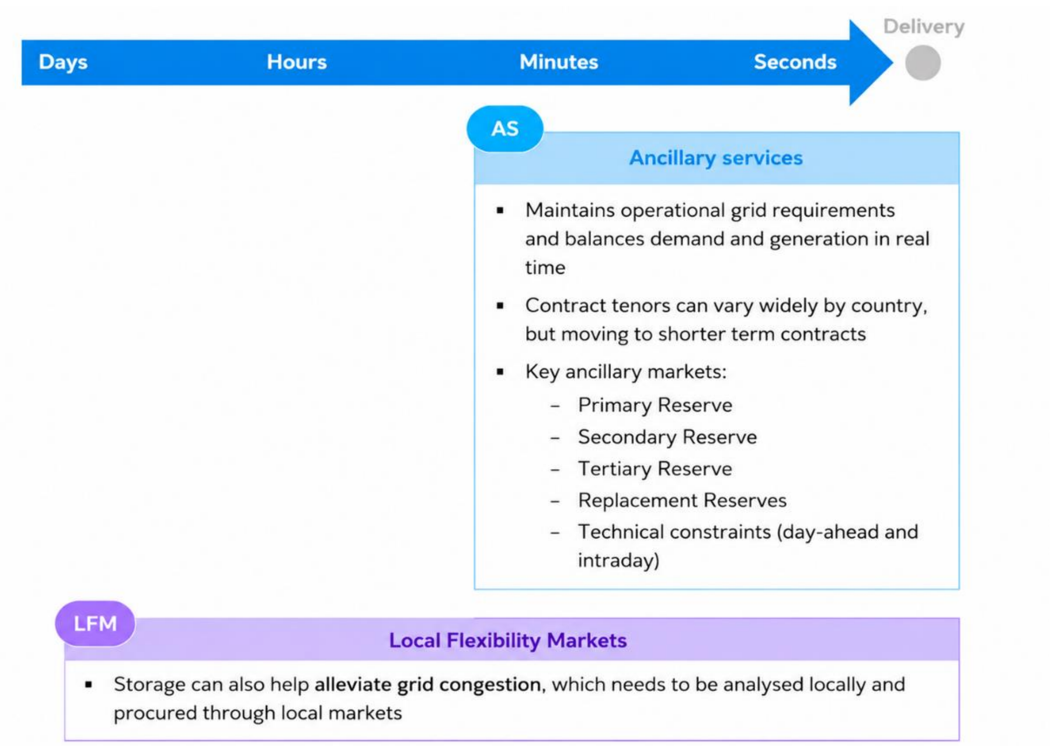

Image: The image presents key features for participation in ancillary services and local flexibility markets. Source: Aurora Energy Research "The economics of batteries in Iberia" (2022)

[5] Source: Enspired presentation. "Monetizing Flexibility: Trading Opportunities for Thermal Assets." Thermal Energy Day (2025) - It refers to day-ahead arbitrage with the support of 80 MWh TES capacity, as a Power-to-heat technology asset with a flat heat demand profile on a sunny day in Germany, with RES-based electricity. More information in the Annex.

On ancillary services, Industry TES projects enable rapid electrical response without disrupting heat supply. Revenues from these services are dynamic and market-dependent (due to competition with other ancillary services providers) but can be significant. Industrial actors using TES are better suited to participate in flexibility markets requiring slower, sustained responses, as TES systems are not designed for ultra-fast activation – needed e.g., grid forming, black start, etc. All in all, feasibility varies significantly depending on reaction time and operational system limitations, such as automation and configuration.

The following table looks specifically at the EU legislation-codified frequency services.

Flexibility Market	**Technical feasibility in accessing the market**
Manual Frequency Restoration Reserve (mFRR)	**High technical feasibility**: it requires to balance the grid during long-term imbalances. It requires response times of 12,5 to 15 minutes, well aligned with standard industrial thermal systems.
Automatic Frequency Restoration Reserve (aFRR)	**Partially limited technical feasibility**: it requires to respond automatically to digital signals within 2 to 5 minutes to correct frequency deviations. It necessitates high-speed automation and precise thermal monitoring systems.
Replacement Reserve (RR)	**Conditional feasibility**: Technical feasibility is highly dependent on the specific TES design and technical capabilities, particularly the duration of energy discharge. Different TES systems can provide different levels of support, so feasibility must be assessed on a case-by-case basis.

Table 8: This table summarises the technical feasibility of using TES to participate in different flexibility markets, highlighting which services are most suitable for standard industrial thermal systems.

In local flexibility markets/congestion services, industrial actor with the support of a TES solution can provide them. TES shifts energy consumption or supply over time to alleviate grid constraints when provided as a demand-side response (DSR) strategy. Unfortunately, these markets are yet to fully emerge across Europe, being remunerated only in the Netherlands and France.

Configuration	Electrified heat assets with TES providing fast electrical modulation capability
Target	Provide upward/downward flexibility
Benefits	New revenue streams; improved grid stability; reduced grid congestion
Merchant exposure	Low ▰▰▰▰▰▰▰▰ ▱▱ High
Relevance in revenue stacking	High (complements arbitrage and self-consumption models)
Potential economic benefits	Up to €27/MWh/day additional revenue from arbitrage + participation in aFRR.[6] Up to €300,000/year per MW of flexible power (in highly potential flexible sectors like cement & paper)[7]
Enablers	***Barriers***
• *Regulatory framework allowing system services frameworks via TES support*	• *Restrictive prequalification rules for industrial participants*

[6] Source: Enspired presentation. "Monetizing Flexibility: Trading Opportunities for Thermal Assets. Thermal Energy Day 2025" - It refers to revenues achieved by optimising across multiple markets, including Day-Ahead, Intraday, and ancillary services (aFRR) with the support of 80 MWh TES capacity, as a Power-to-heat technology asset with a flat heat demand profile on a sunny day in Germany with RES-based electricity. More information in the Annex.

[7] Source: Regulatory Assistant Project (RAP) "Flex Machina: Unlocking industrial flexibility's full potential" (2026).

• *Regulatory framework allowing/remunerating system services* • *Plant configuration enabling fast response* • *Remote control / continuous monitoring availability* • *National framework promoting revenues from balancing markets*	• *Uncertainty of access to remuneration for system services* • *Complex market rules or regulatory barriers* • *Product designs favouring conventional generation* • *Taxation not aligned with system service revenues*

Table 9: TES configurations, targets, benefits, and revenue opportunities in system service markets.

3.2.3 Self-Consumption Maximisation

Industry TES projects allow the electricity produced by on-site PV or wind installations to be converted into heat during periods of high renewable output (e.g. peak solar or wind hours). The stored heat is then discharged as needed, without requiring continuous electricity from the grid. This approach increases the share of self-generated renewable electricity directly consumed on-site, reduces exposure to grid price volatility, and significantly limits the need for fossil-based back-up generation by maximising electricity self-consumption.

Configuration	*On-site RES (PV/wind) + electrified heat + TES*
Target	*Maximise use of self-generated renewable electricity, especially for energy-intensive industries*
Benefits	*Lower energy costs; reduced emissions; limited exposure to market volatility*
Merchant exposure	*Low* ▮▮▯▯▯▯▯▯▯▯ *High*
Relevance in revenue stacking	*Medium (strong cost-reduction lever, indirect revenue effect)*
Potential economic benefits	*Up to 27% total energy cost savings.*[8]
Enablers	***Barriers***
• *On-site renewable generation* • *TES decoupling power and heat demand* • *Client site location (latitude)* • *Predictable industrial heat profiles* • *Access to grants & subsidies to integrate TES and PV/Wind*	• *Limited co-location policies* • *High variability in industrial process demand* • *High fixed energy tariff components & grid fees* • *Heat profiles requiring different heat temperatures & different system integration* • *Limited access to grants & subsidies to integrate TES and PV/Wind*

Table 11: TES configurations, targets, benefits, and revenue opportunities from self-consumption maximisation.

3.2.4 Demand Charge Management

As per EU law, industrial electricity tariffs include demand charges based on peak power draw. TES enables electrified heat systems to cap or flatten peak electricity demand by shifting charging to off-peak hours. Therefore, TES reduces charges for industrial actor, which represent a significant share of industrial electricity bills. This value stream is especially relevant for electrified steam generation, where instantaneous power demand would otherwise result in higher costs for the Industry.

Differently from demand-side management from other energy storage solutions, which often requires curtailing or shifting industrial operations, TES provides flexibility without interrupting production.

[8] Source: Prenzel “Zero-emission chemical sites– combining power purchase agreements with thermal energy storage” (2025) - It refers to a typical chemical industry in Germany.

Configuration	*Electrified heat with TES sized for peak-shaving*
Target	*Reduce peak electricity demand and network charges*
Benefits	*Predictable cost savings; avoided grid upgrades; improved connection feasibility*
Merchant exposure	*Low █□□□□□□□□□ High*
Relevance in revenue stacking	*High (stable backbone for combined business models)*
Potential economic benefits	*Not quantified, but estimated a significant reduction cost from demand-charge management.*
Enablers	***Barriers***
• *Industrial load with high & well-defined peaks* • *TES-enabled peak shaving* • *Availability of dynamic software for load management* • *Clear and transparent demand charge calculation*	• *Regulatory changes (e.g., peak-chasing rules)* • *System equipment integrated with other energy sources* • *Opaque calculation methods, poorly signalled peaks, or purely volumetric charges that provide no incentive to avoid peaks* • *Frequent regulatory changes impacting tariffs*

Table 13: TES configurations, targets, benefits, and revenue opportunities via demand-charge management.

3.3 Overview of Contractual Options

Industry up-takers do not necessarily own the TES solution. A wide array of contractual models can be established, as per the following figure.

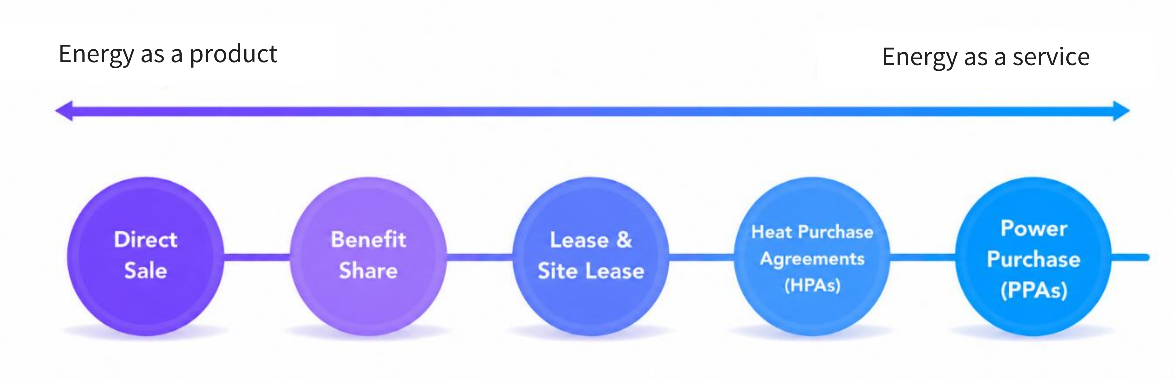

Image: This line illustrates this spectrum, from direct product sales toward integrated service models.

The following paragraphs compare various available contractual options and how operational responsibilities are distributed based on the contractual agreement's structure.

3.3.1 Direct Sale

Direct sale
TES provider sells solution directly to the industrial customer, typically priced in €/MWh, with volumes, delivery conditions, and quality parameters contractually defined.

Heat is treated as a traded energy commodity rather than a bundled service, and the contractual focus is placed on the purchase of delivered heat rather than on the performance of the underlying assets.	
Dimension	**Description**
Strengths	• Contractual simplicity • Familiarity for uptaker (contract mirrors established industrial energy procurement practices for e.g. gas) • Potentially lower headline heat prices • Greater transparency over energy cost components • Preserves Industry actor control over energy procurement • Scalability
Weaknesses	• Higher exposure to energy price volatility • Partial allocation of technical and integration risks to the industrial user • Limited monetisation of TES system-level flexibility
Cost recovery	Typically, OPEX-based or hybrid OPEX–CAPEX, with industrial actor avoiding full asset ownership while bearing integration or connection costs.
Example use case	An industrial site procures low-carbon heat from a nearby TES-equipped supplier under a direct sale contract, replacing gas-based steam supply while retaining control over energy procurement strategy.

Table 15: This table summarises the benefits, barriers, and an example use case of direct sale contracts for TES-based heat supply.

3.3.2 Benefit Share

Benefit share contracts are revenue-sharing agreements where both the industrial user and the TES provider share the economic benefits from TES operation, rather than assigning all revenues or savings to one actor.	
Dimension	**Description**
Strengths	• Flexible revenue allocation • Reduce upfront investment • Co-optimisation of sharing mechanism to Industry Up-taker needs (e.g.: fixed percentage split, performance thresholds)
Weaknesses	• Revenue uncertainty (based on market fluctuation) • Contractual complexity • Limited standardisation
Example use case	A TES system generates savings through electricity price arbitrage and ancillary services, with value shared between the industrial site and the TES provider.

Table 16: This table summarises the benefits, barriers, and an example use case of benefit share contracts for TES-based heat supply.

3.3.3 Lease & Site Lease Models

Leasing models shift TES from a CAPEX expenditure to a predictable operating expense (€/MWh or flat rate), with industrial users renting the asset from a provider under long-term contracts (typically 10–20 years), often including site agreements for installation and operation on the customer's premises.	
Dimension	**Summary**
Strenghts	• No upfront CAPEX for the industrial user • Predictable payments • Risk transfer to provider
Weakeness	• Long-term site access required • Alignment with production cycles • Limited user control over operation
Example use case	A TES unit is installed on an industrial site under a long-term lease, supplying low-cost heat while it manages operation and maintenance.

Table 17: This table summarises the benefits, barriers, and an example use case of lease & site lease contracts for TES-based heat supply.

3.3.4 Heat Purchase Agreement Model

For marketing purposes, this model is also commonly known as "Heat-as-a-Service" (HaaS).

A Heat Purchase Agreement (HPA) is a service contract where the industrial actor buys heat at an agreed price and quality over a defined period, while the TES provider is responsible for financing, installing, operating, and optimising the system.	
Dimension	**Summary**
Strenghts	• High-cost predictability (€/MWh) • Guaranteed heat availability and quality • Simplified "heat as a service" procurement • Minimised system costs
Weakenesses	• Long-term contractual commitment • Reduced operational control for the user • Contract design complexity (indexation, guarantees)
Example use case	An industrial site replaces a gas boiler with a TES solution under an HaaS contract, receiving reliable low-carbon heat at a stable price.

Table 18: This table summarises the benefits, barriers, and an example use case of lease & site lease contracts for TES-based heat supply.

3.3.5 Power Purchase Agreements (PPAs)

A Power Purchase Agreement (PPA) is a service contract where the industrial actor buys electricity at an agreed price and quality over a defined period, while the TES provider is responsible for financing, installing, operating, and optimising the system.	
Dimension	**Summary**

Strengths	• Long-term price stability (fixed price) • Improved decarbonisation outcomes • Facilitate renewable utilisation of low-carbon electricity • Minimised system costs
Weaknesses	• Contractual and operational complexity • Exposure to electricity market dynamics • Need to align PPA and TES operational lifetimes and heat demand
Example use case	An industrial actor secures renewable electricity via a PPA, with TES enabling a continuous low-carbon heat supply despite variable generation.

Table 19: This table summarises the benefits, barriers, and an example use case of lease & site lease contracts for TES-based heat supply.

4. Barriers to EU Industry Electrification

4.1 Introduction

As mentioned in Chapter 3.1 the development of business models for Industry electrification with TES is limited to several barriers. This chapter describes the main administrative, economic, and financial constraints to TES deployment.

4.2 Lack of Harmonised TES Definition

The regulatory status of TES projects remains:

- (Thermal) Energy storage definition: legal unclarity may lead to TES being treated as consumers, or producers. This ambiguity complicates permitting and licensing processes, affects obligations related to metering, reporting, and technical standards, and may lead to grid fees and taxation not tailored to TES, making the project economically unviable. Ultimately, it leads to TES being treated very differently across the different Member States.

4.3 Grid Connection and Permitting Barriers

4.3.1 Absence of Grid Infrastructure

Industry TES projects suffer from a lack of grid infrastructure sufficiently close to the Industrial premises:

Lack of infrastructure reinforcement: while nearly all potential new electric heat demand is within 20 km of the high-voltage grid, DSOs might request grid upgrades to allow Industry TES project's connection.

4.3.2 Connection Rules Constraints

Industry TES projects face several constraints linked to connection rules:

- Long connection queues: speculative or non-maturing projects delay ready-to-deploy TES installations. This leads to investment uncertainty. Grid connection times can lead to years-long delays.
- Costly connection charges: Regulated entities may require grid reinforcements, even for small-scale Industry TES projects, that provide system flexibility rather than grid stress. As a result, project developers may face varying reinforcement costs depending on the solution deployed, existing capacity, and added power needs.

4.3.3 Permitting Procedures

Permitting procedures impact Industry TES projects deployment extensively:

- Lengthy, costly, and complex procedures: sequential rather than parallel administrative processes, fragmented responsibilities across authorities, and inconsistent transposition of EU permitting rules lead to years of delays. E.g., needing grid access confirmation before assessments creates permitting delays.

- Rules misalignment with TES deployment time: requirements for projects to become operational within 36 months are not compatible with Industry TES projects deployment time, permitting procedures, and grid connection upgrade timelines.
- Complex Environmental Impact Assessments and multiple land-use or construction permits: local authorities exercise discretion on visual, safety, or land-use impacts, which sometimes end in automatic rejections or lengthy appeals.

4.4 Charges and Taxation Barriers

4.4.1 Grid Fees

Grid fees represent a major barrier to the deployment of TES projects:

- Network charges favouring constant or stable electricity loads: TES projects are negatively affected, as this storage technology is usually classified (e.g., in Germany) as a variable or interruptible load despite its potential system-supporting functions.
- High fixed capacity access charges: imposed by Member States; by paying grid access charges for both the charging phase and the facility's discharge operations, it inflates the marginal cost of stored energy.
- Flat tariffs9: tariff structure lacking a temporal component disincentivise flexibility and reduces the economic feasibility of Industry TES projects.

4.4.2 Electricity Taxes

Electricity taxes represent a major barrier to the deployment of TES projects:

- Lack of level-playing field between gas and electricity: electricity bills include taxes and charges not related to the energy system. These additional charges are not present in gas bills, therefore penalising Industry actor electrifying processes.

4.5 Barriers to Wholesale and System Services Market Participation

4.5.1 Barriers to System Services Provision & Wholesale Markets Participation

EU legislation[10] mandates non-discriminatory market access for energy storage and its aggregation across wholesale markets and system services. Still, there are technical and operational barriers:

- Impossibility to participate in system service or wholesale markets: legacy national law, prequalification criteria (although being progressively harmonised by ACER and ENTSO-E methodologies), and other administrative processes untailored to Industry TES projects may either prohibit or dramatically limit the Industry's ability to participate in wholesale and system services markets - even when legally allowed by EU law.
- Information and data gaps: There is a notable lack of sufficient data to accurately quantify the value potential of some flexibility services, such as congestion management, making it difficult for industries to build robust business cases.

[9] **Flat tariffs** (a common structure in several Member States) apply a uniform network fee regardless of the time of day, location, or system conditions; therefore, storage operators receive no signal to charge or discharge in ways that support system efficiency, potentially leading to inefficient grid usage.

[10] Particularly Directive (EU) 2019/944 and Regulation (EU) 2019/943.

4.6 Financing & Investment Barriers

4.6.1 Bankability Challenges

Access to and availability of cheap capital is a major challenge for Industry TES projects.

- Lack of access to affordable capital (high CAPEX): industry TES projects upfront costs are higher than fossil fuels-based solutions. shall
- Bankability challenges: TES is perceived as an unproven solution due to limited deployment portfolios. This leads to high interest rates. Banks generally favour large or aggregated projects, leaving smaller TES units (under 2–3 MW) reliant on third-party aggregation to meet minimum thresholds, adding complexity.
- Short payback-time expectations from the Industry: the Industry perceives investments into TES as highly risky, due to limited paybacks in the short term. This is because TES economics rely on long-term life-cycle benefits, encompassing both CAPEX and operating expenditures (OPEX).

4.6.2 Limited Access to Public Funding and State Aid

Public funding and State Aid is rarely tailored to Industry TES projects:

- Lack of EU dedicated funding: despite its importance, TES has no dedicated instrument to support its deployment. As an example, TES currently accounts for less than 0.5% of Innovation Fund investments. Besides, such schemes usually do not support projects developed in the context of Heat-as-a-service contracts, despite being a common path to market.
- Limited and costly access to national funding support schemes: complex eligibility rules and caps often exclude TES from EU and national funding. As an example, the Dutch “WIS scheme” limits support to 30% of costs (capped at €4,000 per connection), thus limiting the project’s feasibility.
- Limited access to Energy Efficiency funding opportunities: national funding schemes for industrial energy efficiency projects often exclude Industry TES projects due to technology-based eligibility criteria. As an example, the Italian “Conto Termico 3.0” for small-scale energy efficiency residential and industrial projects do not include Industry TES projects in the list of applicable technologies.
- Strict requirements to access State-Aid support schemes: restrictive eligibility requirements often make TES companies fall under the definition of “Undertaking in Difficulty”, thus limiting their access to State-Aid support schemes.
- Current schemes focus on CAPEX reductions for renewables: Carbon Contracts for Difference (CCfDs) – where Member States pay Industry up-takers the gap between a fixed carbon price and the market price, are rarely available for Industry TES projects. This exposes off-takers to volatile fossil fuel prices, making business planning unreliable and limiting the deployment of low-carbon heat solutions. As an example, an Industry off-taker aiming to decarbonise with a TES solution would receive compensation by the Member State if the market carbon price fell below the agreed strike price (e.g. a €40 top-up if the market price drops to €60 versus a €100 pre-fixed price). But since CCfDs are rarely accessible for these projects, Industrial off-takers are excluded from the price certainty needed to invest.

5. Policy Recommendations

5.1 Introduction

This chapter discusses, based on the barriers highlighted in Chapter 4, policy recommendations to incentivise industrial electrification.

5.2 Introduce a Thermal Energy Storage Definition

To clarify the legal status of Thermal Energy Storage (TES), Energy Storage Europe recommends:

- **The European Commission and ACER shall clarify that "Thermal Energy Storage" must be treated as "energy storage"**, not as "consumption" or "generation", by specifying the definition in the upcoming Electrification Action Plan. For the European Commission, such clarification shall reference Article 2(59) of the Electricity Directive (EU) 2019/944. For ACER, a Guidance Note shall be issued under Article 6 of Regulation (EU) 2019/942.
    - This reduces legal uncertainty in a.o. permitting, grid charges, and licensing across Member States.

5.3 Tailor Grid Connection and Permitting to Industry TES Projects

To tackle lengthy and costly grid connection and permitting processes for Industry TES projects, Energy Storage Europe recommends:

- **The European Commission shall ask Member States to identify anticipatory investments for connecting the Industrial infrastructures to the grid** (including local grid line extensions and substation upgrades) by updating the EU Guidance on anticipatory investments for developing forward-looking electricity networks.
    - This ensures the needed grid upgrades for Industry TES projects are provided in a timely and cost-effective manner, thus enabling the electrification of industrial heat.
- **Member States shall mandate TSOs and DSOs to actively plan and invest in upgrading the grid** by including timelines and investment allocation in their Network Development Plans. These shall address new substations and local grid extensions in industrial clusters, ports, airports, and logistics hubs, and shall comply with the European Commission guidance discussed above.
    - This measure expands the local grid, allowing Industrial up-takers to connect more easily to the grid for electrifying their processes, while leading to cost savings per MW of grid capacity built.
- **The European Commission shall ensure that minor grid connection modifications resulting from small-scale Industry TES projects** (e.g.: limited grid upgrades needed to support the increased industrial flexibility demand from integrating a TES unit) **must be treated by National Regulatory Authorities (NRAs) as revisions to existing grid connections**, by amending Article 4(1) of the Demand Connection Code (DCC) - Regulation (EU) 2016/1388, thus not requiring costly and lengthy new connection agreements.
- **ACER shall specify grid connection requirements tailored to Thermal Energy Storage in the Demand Connection Code**, by issuing a Guidance Note under Article 3(1) of Regulation (EU) 2019/942.
    - These measures ensure that minor technical integrations or very limited grid reinforcements do not trigger lengthy and costly connection procedures typical of a new connection.

- **TSOs and DSOs shall prioritise mature and ready-to-deliver Industry TES projects** over speculative and non-mature projects, by reforming national grid connection queue rules. New rules shall include milestone-based queue criteria with periodic readiness checks. This shall be in line with the EU Guidance on Grid Connection, the Electricity Directive, and the Electricity Regulation.
    - These reforms ensure that viable TES installations are not delayed for years by non-maturing projects.

- **The EU institutions shall align Industry TES projects grant-permitting deadlines with renewables ones** (12 months in acceleration areas, 24 months in any other case), by amending permitting rules in Article 16(a) of the Renewable Energy Directive (EU) 2018/2001.
    - This establishes clear deadlines for permitting procedures, enabling industrial users to plan projects more predictably and deliver them cost-efficiently.
- **The European Commission shall clarify that Environmental Impact Assessments for Industry TES projects shall be required only when there are proportionate environmental risks** (e.g. impacts on protected ecosystems, or fire/chemical hazards) by amending Environmental Impact Assessment Directive 2011/92/EU.
    - These measures clarify when such an assessment for Industry TES projects is needed, thus avoiding permitting delays.
- **Member States shall allow parallel rather than sequential permitting** procedures for Industrial decarbonisation projects with a TES solution, by amending national permitting rules.
    - This shortens processes and limits delays, allowing the Industrial up-takers to have a clearer estimate of the project's expenditures and delivery timelines.

5.4 Design Network Tariffs that Reflect Real Costs and Benefits of Storage, and Appropriate Taxation for Industry TES Projects

To ensure grid charges recognise the value of Industry TES projects to the system and that taxation rules promote electrification, Energy Storage Europe recommends:

- **The European Commission shall ensure that Member States network charges methodologies reflect Industry TES projects system value as a flexible system services provider**, by amending the upcoming EU legislative initiative on Network Charges and Taxation.

  Member States shall revise their national network tariff methodologies in compliance with the amended EU legislative initiative on Network Charges and Taxation.
    - These two measures ensure TES is valued consistently across the EU, preventing system costs from unfair and disproportionate network charges related to charging, storing, and discharging energy phases.
- **Member States shall prioritise dynamic network tariffs over flat ones** by designing national tariffs that reflect temporal consumption.
    - This measure rewards the Industry TES project capability to provide flexibility and congestion management to the grid. **The European Commission shall promote tax reduction for electricity and heat produced by low-carbon energy** for industrial decarbonisation projects supported by a storage solution, by amending the European Energy Taxation Directive and addressing the point in the upcoming Network Charges and Taxation legislative initiative.
    - This ensures a level playing field between the industry-electrified process and gas-sourced Industry processes.

- **The European Commission shall encourage Member States to reduce taxes unrelated to electricity supply** (e.g., the German KWKG surcharge) by issuing a Recommendation on Energy Taxation to Member States and addressing the point in the upcoming Network Charges and Taxation legislative initiative.
    - This ensures that national energy taxation unrelated to electricity bills does not disproportionally affect Industry TES projects in different Member States.

5.5 Allow Industry TES Projects Participation in Wholesale and System Services Markets

To ensure Industry TES projects contribute to grid stability and has access to revenue streams from wholesale and system markets participation. Energy Storage Europe recommends:

- **The European Commission shall ensure Industry TES projects participation in wholesale and system service markets** by amending the Electricity Balancing Guideline (EBGL) - Commission Regulation (EU) 2017/2195, specifically to ensure that Industry TES projects:
    - Accesses balancing markets as a storage solution, by competing on a level-playing field with other assets located at the distribution level - Article 3;
    - Acts as a balancing service provider (BSPs) and is allowed to provide balancing services via aggregation of different energy storage facilities - Article 18(4)(b) and (c);
    - Is not excluded from accessing balancing markets by TSOs and DSOs' rules for prequalification processes - Article 18(5);
  - These measures strengthen grid resilience and reliability by enabling Industrial up-takers to provide arbitrage and system services, reducing congestion.

- **ACER shall investigate whether current TSOs' and DSOs' prequalification criteria** (e.g., minimum capacity thresholds, response time requirements, and technology classification rules) prevent Industry TES projects from accessing these markets, by formally requesting information from national TSOs and DSOs **under** Regulation (EU) 2019/942.
    - This ensures TSOs and DSOs' prequalification methodologies ensure a level-playing field access to Industry TES projects in accessing balancing markets across different Member States.

5.6 Unlock Cheap Capital and Funding Tailored to Industry TES Projects

To ensure Industry TES projects has access to capital and can tap into funding. Energy Storage Europe recommends:

- **The European Investment Bank (EIB) shall set up counter-guarantees for Industry TES** projects (e.g.: by providing "guarantee letters" to Industry TES projects), as these reduce perceived investment risk and are often required by commercial banks.
    - This allows public guarantee to absorb part of the investment risk, making banks more inclined to finance Industry TES projects.

- **The European Investment Bank (EIB) shall ensure cheap capital** by providing low-interest loans to small-scale Industry TES projects (under 2–3 MW), as these often face stricter requirements (e.g., a higher number of track record projects) for accessing loans.
    - This allows small-sized Industry TES projects to access financing.

- **The European Commission shall ensure the Innovation Fund Heat Auction takes place yearly** by moving from pilot to a regular call.
    - This ensures a stable, predictable and recurring access to EU-funded capital support for Industry TES projects, enabling developers to plan investments, reduce upfront investment risks, and support the scaling of industrial heat solutions across the EU.

- **The European Commission shall refine the Innovation Fund Heat Auction call to incentivise projects delivering deep industrial heat decarbonisation**, by amending the ranking criteria in the next Innovation Fund Heat Auction's Terms and Conditions (T&C) (e.g., by shifting from a price-only ranking per tonne of CO2 abated to including rewarding bonus points, bid-price incentives, or dedicated funding streams for the most cost-efficient Industry decarbonisation project).
    - This ensures the next Innovation Fund Heat Auction fully taps into the decarbonisation value of hard-to-abate industrial heat processes, allowing Industry TES projects to compete on a level playing field with other solutions.

- **The European Commission shall ensure that TES providers, defined as "Undertaking in Difficulty"** (i.e.: SMEs companies with more than 3 years of activities facing more than 50% accumulated losses) **access State Aid support schemes**, by amending Article 2(18)(a) of the upcoming General Block Exemption Regulation revision.
    - This measure ensures that early-stage TES companies are not structurally banned from state aid schemes due to financial indicators that reflect strategic investment rather than insolvency risk.

- **Member States shall ensure Industry TES projects access to national support schemes** by simplifying eligibility rules in national funding programmes (e.g., unlike the Czech heat production and distribution licenses required to access the Modernisation Fund) and by raising caps on eligible costs in national subsidiarity schemes, currently excluding or limiting Industry TES projects access to these funds.
    - This ensures Industry TES projects have an easier and cost-efficient access to national and EU funding for Industry TES projects.

- **Member States shall ensure TES is listed as an eligible technology to access national energy efficiency funds** by removing technology-based restrictive criteria currently preventing Industry TES projects from accessing energy efficiency funds (e.g.: the British Industrial Energy Transformation Fund, which does not explicitly include Industry TES projects).
    - This ensures all available technologies for industrial decarbonisation can access funds on a level-playing field.

- **The European Commission shall facilitate matching between industrial off-takers and TES providers** by establishing a matchmaking platform (e.g.: similarly to the AggregateEU – an EU-based platform for matching natural gas demand and supply). This platform shall showcase solutions and contractual options (e.g.: leasing and Heat-as-a-Service).
    - These platforms ensure that industrial off-takers are aware of solutions and contractual options.

- **Member States shall ensure that Industrial off-takers access Carbon Contracts for Difference (CCfDs) for Industry TES projects** (e.g.: similarly to the German Klimaschutzverträge bid) by providing a guaranteed carbon price based on the difference between a "fixed" carbon price and market price volatility.
    - This ensures industrial off-takers have a clear investment outlook, enabling them to assess the project's benefits against fossil-based solutions while receiving compensation from Member States if prices fall below a set threshold.

6. Conclusions

Industrial electrification is more important than ever. It is key for energy security, by supporting Europe's Industry competitiveness, and sustainability.

Thermal Energy Storage (TES) uniquely unlocks electrification benefits for Industrial actors. It reduces energy costs, by ensuring the Industry can make the most of cheap renewables while reducing high demand charges. It strengthens the business case with new revenue streams related to trading electricity in the market and providing system services to grid operators. It optimises industrial processes by absorbing and reusing waste heat, therefore increasing energy efficiency. And it strengthens security of supply – i.e. it ensures energy is available even in case of grid disruptions.

Maybe more importantly: it ensures Europe's Industry becomes globally competitive again, while decarbonising at the same time.

Importantly, Thermal Energy Storage unlocks these benefits without changing the way Industries operate: i.e., ensuring uninterrupted operations. Yes, Industries have more complex, dual-value business case: their core activities and as flexibility providers. But this complexity is counter-balanced by economic benefits.

Several obstacles remain, as project developer do not have access to cheap capital, and public funding is rarely tailored to Industry TES projects. Projects are delayed due to slow permitting and grid connection processes, improper grid fees and taxation hinder the business case, and Industry actors with TES have limited access to wholesale and system services markets. To tackle these barriers, regulatory changes are needed both at the European Union and national level.

7. Annex I

This section presents how national electricity billing frameworks across EU Member States include a range of surcharges in addition to the wholesale cost of electricity. These typically take the form of grid tariffs (for network use) and various taxes and levies linked to system funding and public revenue.

The following table below summarises the national-level surcharges in six EU Member States. These include **grid tariffs** (charges for network usage) and **taxes & levies** (other additional costs).

Country	National Charge / Mechanism	Impact on Thermal Energy Storage (TES) projects
Germany	StromNEV §19	Industrial consumers can receive significant grid fee reductions (up to 80-90%) if they maintain a "flat" load profile (StromNEV §19). If an Industry uses a TES unit to provide flexibility to the industrial processes, this results in the loss of this exemption (the "flexibility trap").
	KWKG & Offshore Surcharges	Additional national-level costs to fund Combined Heat and Power projects and offshore grid expansion are added to electricity prices. These are often applied to every MWh of electricity used to charge a TES, whereas natural gas is only subject to the CO_2 price.
	Peak Load Pricing	German grid fees are largely based on the annual peak load (the single highest point of consumption). A TES unit that needs to "charge" quickly when electricity prices are negative will create a high peak demand, leading to massive increases in annual grid costs.
France	TURPE (Peak Load Pricing)	High fixed costs are based on peak subscribed power, which penalises the high-power intake required for fast TES charging.
Poland	Capacity Market Fee	National levy added to electricity bills to fund capacity adequacy, increasing overall electricity costs for Industry.
Italy	Oneri di Sistema	National levies for general system costs that increase the price of electricity.
Spain	Access Tolls (Peajes)	Regulated charges for grid usage that often lack the granularity to reward flexible behaviour.
	Special Electricity Tax (*Impuesto Especial a la Electricidad* - IEE)	The Special Electricity Tax is an indirect tax in Spain levied on the consumption of electricity. It is officially classified as an excise duty, often called the "electricity tax" or "special tax on electricity," and is separate from VAT. It foresees that all revenues from this tax are fully transferred to regional governments to finance education, healthcare, social services, etc, but not to the energy system.
	IVPEE (*Impuesto sobre el Valor de la Producción de la Energía Eléctrica*)	The Tax on the Value of the Production of Electrical Energy is a 7% tax established in Spain in 2012, levied on the income obtained from the production and injection of electricity into the Spanish grid.
	IAE (*Impuesto a las Actividades Económicas)*	Direct tax, jointly managed (by the State and local authorities), which is levied on business, professional or artistic activities. Unlike taxes on profits, the IAE is based on fixed rates calculated on specific categories, not on actual profitability.

Table 20: This table shows how electricity tariffs and levies in selected EU Member States penalise flexible thermal energy storage despite its benefits.

8. Annex II

This section includes case studies of the electrification of EU industrial process heat. The first two case studies focus on revenue streams (savings and profitability). Case study 3 provides an overview of the electrification of industrial process heat, focusing on expected natural gas savings and CO_2 emissions reduction, while case study 4 highlights the advantages from HPA and self-consumption maximisation.

1) Kraftblock project - Revenues from participation in aFRR Market with Thermal Energy Storage

This case study shows how a large-scale Thermal Energy Storage (TES) system can generate additional revenues by providing flexibility to the power system through participation in the automatic Frequency Restoration Reserve (aFRR down) market.

More specifically, thermal energy storage can contribute to system stability by increasing electricity consumption when frequency regulation is required. By absorbing excess electricity during periods of system imbalance (downward regulation), TES supports grid flexibility while maintaining its heat supply function.

In the case analysed, a 300 MWh TES system offers aFRR service for 30 minutes per day at full power. The service is remunerated based on capacity availability, with prices in 2023 ranging from €1/MW per hour to €129/MW per hour, and an annual average of approximately €15/MW per hour. This flexibility provision results in a significant additional revenue stream.

Metric	Data	Contextual Information
TES Capacity	300 MWh	Total thermal energy storage capacity available for flexibility and heat supply
Power Rating (Charge/Discharge)	50 MW	Maximum electrical consumption when providing downward flexibility
Ancillary Service	aFRR (downward)	Automatic Frequency Restoration Reserve via increased electricity consumption
Operation Duration	30 minutes/day at full capacity	Availability window for frequency response service
Remuneration (Average 2023)	~€15/MW per hour	Average capacity price across the year
Price Range (2023)	€1–€129/MW per hour	Reflects strong seasonal and intraday volatility
Additional Annual Revenue	€164,250	Revenue generated from providing aFRR (down) capacity

Table 21: This table shows how a 300 MWh TES system can generate additional revenue to the industrial actor by providing flexibility services, while supporting grid flexibility & maintaining heat supply. Source: Kraftblock. Flexible electrification with thermal storage - cost benefits whitepaper (2025)

This project demonstrates how thermal energy storage can:

- Unlock a new revenue stream by participating in an FRR market, generating €164,250 per year in additional income

- Supporting grid stability through controlled increases in electricity consumption.
- Creating optimisation opportunities, with the wide remuneration range (€1–€129/MW per hour)

2) Enspired presentation at Thermal Energy Day 2025, hosted by Kyoto Group - Revenues & Savings from Arbitrage with participation to Flexibility Markets

This case study shows how a thermal energy storage solution can combine wholesale market arbitrage with ancillary service participation to maximise revenues and reduce industrial heat costs.

By optimising charging in the Day-Ahead Market (DAM), the TES system captures electricity price spreads and achieves direct cost savings. When this strategy is expanded to include cross-market optimisation, particularly in the participation in the automatic Frequency Restoration Reserve (aFRR), the asset unlocks an additional revenue stream.

This combined "value stacking" significantly improves overall margins. In practice, day-ahead arbitrage alone can deliver savings of €14/MWh, while cross-market optimisation can increase revenues to up to €27/MWh. This results in a substantial reduction in the average steam price for the industrial actor.

Metric	Data	Contextual Information
TES Capacity	80 MWh	The energy storage capacity of the simulated thermal storage asset, based on a 4-hour discharge duration at full power.
Power Rating (Charge/Discharge)	20 MW/h	The rate at which a TES asset can absorb electricity or discharge heat.
Operation Duration	4 hours	The storage duration of the asset at full capacity, which allows for shifting energy across different market periods.
Day-Ahead Arbitrage Value	-14 EUR/MWh (Cost)	Represents the average cost when charging is optimised solely based on Day-Ahead Market (DAM) prices.
Cross-Market Optimisation Revenue	+27 EUR/MWh (Profit)	The potential revenue achieved by optimising across multiple markets, including Day-Ahead, Intraday, and ancillary services (aFRR down).
Performance Improvement	+0.5 Million EUR	The additional margin generated through advanced cross-market optimisation for a 20 MW asset from July to October 2024.

Table 22: This table shows how a TES system can generate revenues by combining arbitrage with ancillary service participation, while reduce industrial heat costs and maintaining heat supply. Source: Enspired presentation. Monetizing Flexibility: Trading Opportunities for Thermal Assets. Thermal Energy Day 2025

This project demonstrates how thermal energy storage can:

- Combine wholesale market arbitrage with ancillary service participation to build a strong value stack;
- Day-ahead optimisation alone can generate cost savings of €14/MWh;
- Cross-market optimisation, including participation in automatic Frequency Restoration Reserve (aFRR down), can increase revenues to up to €27/MWh;
- By stacking these revenue streams, TES significantly improves total margins and reduces average steam price for industrial customers.

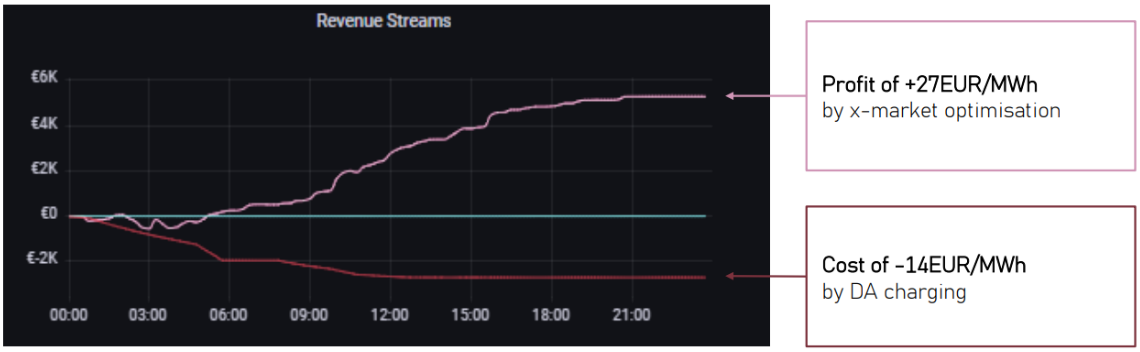

Image: Exemplary day of a 20 MW, 4h thermal storage asset in summer 2025 with flat heat demand profile. Source: Enspired presentation. Monetizing Flexibility: Trading Opportunities for Thermal Assets. Thermal Energy Day 2025

3) PepsiCo "Volt" & Kraftblock Project – Industrial Electrification with High-Temperature Thermal Energy Storage

This case study illustrates how high-temperature Thermal Energy Storage (TES) enables the electrification of EU industrial heat by substituting industrial gas boilers, while delivering substantial fuel savings and emissions reductions.

The site produces around 1 million bags of chips per day, with continuous (24/7) natural gas combustion used for frying. **The project replaces a 25 MW gas boiler with an electrified high-temperature storage system**, to be operational in its first phase by Q2 2026.

The system operates through power-to-heat conversion (up to 1,200°C), storing renewable electricity as thermal energy and delivering steam or process heat on demand. Charging occurs via resistive heaters, while discharge provides stable industrial heat independently of electricity price fluctuations.

Metric	Data	Contextual Information
Objective : Replaced Boiler Capacity	25 MW	Existing natural gas boiler substituted by an electrified thermal storage solution
Commissioning Timeline	Q2 2026	First phase operational milestone
TES temperature	High-temperature TES (up to 1,200°C)	Converts renewable electricity into stored thermal energy
Operational Profile	24/7 industrial heat demand	Substitute continuous frying operations
Natural Gas Savings	9 million m^3/year	Direct fossil fuel displacement
CO_2 Emissions Avoided	17,000 tonnes/year	Based on full project deployment
Emissions Reduction (Phase 1)	51%	Partial electrification prior to full deployment
Emissions Reduction Potential	98% (full project)	Near-total Scope 1 decarbonisation

Table 23: This table shows how high-temperature Thermal Energy Storage (TES) enables the electrification of EU industrial heat by substituting industrial gas boilers, while delivering substantial fuel savings and emissions reductions. Source: Kraftblock website. Best Practice: Industrial Decarbonisation with Thermal Energy Storage

This project demonstrates how high-temperature thermal energy storage can:

- Mitigate fuel price volatility by replacing natural gas with electrified heat;
- Enhance system flexibility by shifting electricity consumption to periods of high renewable availability or low prices;
- Expected natural gas reduction, with 9 million m^3/year fuel savings and 17,000 tonnes/year CO_2 emissions savings;
- Provide a scalable deployment model (with 51% emissions reduction expected in phase 1);
- High decarbonisation potential of heat processes (up to 98%);

This type of project is particularly suitable for high-temperature, continuous industrial processes such as food production.

4) Bayer and Iberdrola España – Decarbonisation and Electrification of Bayer's Steam Production in Asturias.

This case study illustrates how industrial electrification coupled with thermal storage can decarbonise a major chemical manufacturing site, reduce exposure to fossil fuel volatility, and support local renewable energy deployment.

More specifically, the industrial actor and the TES provider signed an agreement to electrify steam generation at the industrial production plant under the first industrial **Heat Purchase Agreement (HPA)** of its kind in Spain. The TES provider will install an innovative molten salt thermal storage system adjacent to the plant and convert 100 % renewable electricity from an onsite photovoltaic (as a self-consumption facility) and other renewable sources into the steam required for operations. The €17 million project supported by the Ministry of Industry's strategic decarbonisation programme (PERTE) and the Institute for the Diversification and Saving of Energy (IDAE), it is expected to be completed by June 2026. When online, the facility is expected to decarbonise steam production, improving industrial competitiveness while reducing CO_2 emissions and reliance on fossil fuels.

Metric	Data	Contextual Information
Project Investment	€17 million	Total capital expenditure for electrification and thermal storage installation.
Contractual Option	Heat Purchase Agreement (HPA) with TES solution	Pioneering contract enabling industrial steam electrification.
Expected Completion	June 2026	Project development timeline.
TES Technology	Molten salt thermal storage	Innovative system converting renewable electricity into industrial steam.
Renewable Electricity Source (Self-consumption maximisation)	Onsite photovoltaic + various renewable plants	100 % renewable electricity used for steam generation and storage charging.

CO_2 Emissions Reduction	Significant reduction (plant decarbonised)	Decarbonisation of steam production previously reliant on fossil fuels.
Jobs Creation	>30	Employment during construction and commissioning phases.

Table 24: This table shows how industrial electrification coupled with thermal storage can decarbonise a major chemical manufacturing site, reduce exposure to fossil fuel volatility, and support local renewable energy deployment. Source: Bayer website. Bayer ratifica con Iberdrola el acuerdo que permitirá la descarbonización de su planta asturiana gracias a la electrificación de su vapor

The project demonstrates that industrial electrification with integrated thermal energy storage, via an industrial Heat Purchase Agreement (HPA), can:

- Delivers 100% renewable steam by converting clean electricity into thermal energy;
- Reduces exposure to fossil fuel price volatility;
- Strengthens industrial competitiveness through local renewable deployment;
- Provides a scalable, replicable framework supported by national decarbonisation programmes and molten salt storage innovation.
- Promote job market value, by increasing the number of employees during construction and implementation phase.

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About the Energy Storage Europe:

Energy Storage Europe is the leading member-supported association representing organisations active across the entire energy storage value chain. The Association supports the deployment of energy storage to further the cost-effective transition to a resilient, carbon-neutral, and secure energy system. Together, Energy Storage Europe members have significant expertise across all major storage technologies and applications. This allows us to generate new ideas and policy recommendations that are essential to build a regulatory framework that is supportive of storage.

For more information, please visit www.energystorageeurope.eu

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