FEBRUARY 2024

SYSTEMIQ

ACHIEVING THE POTENTIAL FOR ELECTROTHERMAL ENERGY STORAGE

AN ACTION PLAN FOR DENMARK

Country-specific memo to

CATALYSING THE GLOBAL OPPORTUNITY FOR ELECTROTHERMAL ENERGY STORAGE: PROMISING NEW TECHNOLOGIES FOR BUILDING LOW-CARBON, COMPETITIVE AND RESILIENT ENERGY SYSTEMS

ETES IS A PROMISING ENABLER OF NET-ZERO INDUSTRY IN DENMARK

Electrifying industrial heat is critical for decarbonisation and can increase energy security. ETES is a new, commercially available technology to electrify heat in industry and other sectors.

To reach net-zero greenhouse gas (GHG) emissions by 2050, the Danish energy system will see mass electrification in all sectors. Integration and balancing of large volumes of variable renewable energy will be required for the target of a fourfold increase in solar PV and onshore wind-generated clean electricity by 2030.[1]

ETES is a promising new technology for building low-carbon, competitive and resilient energy systems in Denmark.

WHAT IS ELECTROTHERMAL ENERGY STORAGE (ETES)?

ETES technologies electrify (industrial) heat. The asset can convert electricity into heat at chosen times, such as when the electricity price is low. The heat can be stored for days in the asset and can be discharged to provide continuous heat, for example, to use in industrial processes.

ETES is available at commercial scale through 40+ technology providers. Models that are commercially available today can reach up to 400°C, with higher temperatures in development.

ETES is currently the only technology for electrification of heat that can store energy. Other technologies that electrify heat – heat pumps, electric boilers and electric furnaces – do not have integrated energy storage.

BENEFITS OF ETES FOR THE DANISH ECONOMY

INCREASED ENERGY INDEPENDENCE

Large-scale adoption of ETES could help reduce the equivalent of up to ~80% of Danish gas usage today, which translates to a reduction of up to 9 million tonnes CO_2e or ~20% of Danish energy-related GHG emissions. ETES could also help key sectors like food and beverage, chemicals and steel avoid exposure to global gas price fluctuations.

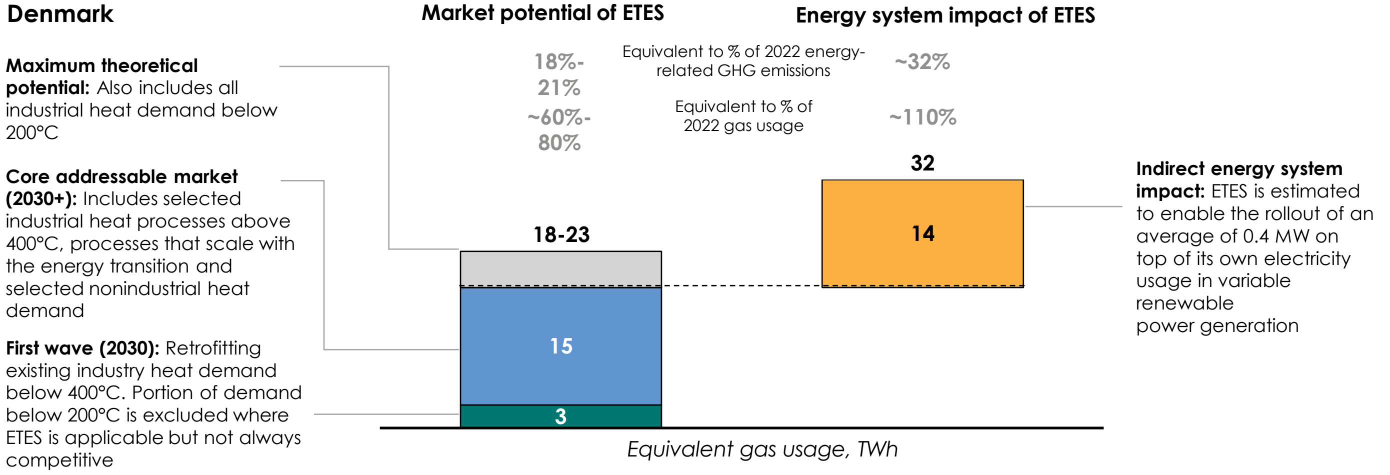
LOWER GRID INVESTMENTS

Peak electricity demand can be up to ~13% lower if industrial heat electrifies with storage. This reduces the grid capacity expansion required compared to electrification without storage. Installation of ETES technologies at Danish industrial sites could add up to 0.5 GW of off-peak electricity demand to Danish energy system by 2030.

COST-EFFECTIVE AND FLEXIBLE INDUSTRY HEAT DEMAND

ETES is the most efficient technology today for storing zero-carbon energy for heat usage. It is also a relatively low investment compared with equivalent systems. Other technologies to electrify heat require additional storage (such as batteries) to align with variable renewable energy. These have lower energy storage efficiency (~80%) and 0.3–4 times higher capital costs by 2040.[2]

So far, only 4MW of ETES have been built[3] or taken to final investment decision in Denmark. ETES is an emerging commercial technology and less well known compared with other decarbonisation of industry technologies. As with other energy storage, existing policies, regulations and energy market design can unintentionally disincentivise uptake. **Targeted changes can make ETES more affordable and accessible and support the piloting and advancement of lower TRL ETES technology.**



Please see Figure 5 in the main report or the Technical Appendix for full details on assumptions and sources

1: Denmark draft NECP revision 2023; 2: *Driving to Net Zero Industry*, LDES Council; 3: Energy storage database, Kyoto Group

CRITICAL ENABLERS
to accelerate ETES uptake in Denmark

Enabler in place | Enabler in progress | Enabler not in place

AFFORDABILITY

Enabler not in place	ETES is **eligible for net-zero subsidies that support** heating and energy storage technologies
Enabler in progress	**Grid costs charging structure** reflects congestion alleviation and off-peak utilisation benefits of flexible demand
Enabler in place	**Electricity market design** gives right signals to incentivise flexible assets to come into the system
Enabler in place	ETES can participate in **balancing mechanism, capacity markets** and **ancillary market services**
Enabler in place	Customers can use **private wires** to directly connect renewables sites with industrial sites, eliminating grid charges

ATTRACTIVENESS

Enabler in place	**Industrial users are familiar** with thermal storage technology and applications
Enabler in place	Industrial users have the access and capability to **optimise in the wholesale price market**
Enabler in place	**Public procurement** requirements are in place for industrial products with low embedded carbon

ACCESSIBILITY

Enabler in progress	Companies are readily **able to connect and access grid** capacity required
Enabler in place	Companies are able to deploy **private wires** between renewables generation and industrial sites

ACTIONS NEEDED
by stakeholders in Denmark

POLICYMAKERS AND REGULATORS

Widen the eligibility criteria for thermal battery subsidies to put them on a level playing field with carbon capture and storage and hydrogen. The current subsidy scheme is not designed for commercial rollout because a university partner is necessary.

Consider introducing a gas tax to help close the gap between gas and power costs and grid fees.

Introduce regulatory sandbox for small-scale pilots and introduce grants and guarantees for first-of-a-kind commercial projects for nascent ETES technologies at lower TRL.

INDUSTRIAL END USERS

Assess market appetite and, if possible, introduce green premium price products to help fund the cost gap between ETES and boilers. There is increasing demand from sectors across the board for Scope 2 and Scope 3 decarbonisation.

Execute business case comparisons for a cost-effective electrification plan for sites. Applicable industries of food and beverage, chemicals and pulp and paper can invest the time to work with technology companies to assess whether ETES would be a cost-effective solution for electrifying processes.

Collaborate with technology companies and other value chain stakeholders to rapidly improve technology towards commercial deployment.

GRID OPERATORS

Change grid fees in line with some other European countries to incentivise flexible and off-peak load through (1) removing baseload discount, (2) transmission system operator continuing to introduce interruptible connection for 50% grid fee discount and (3) distribution system operator to increase differential between winter peak and other time bands.

Continue introducing interruptible connection process to enable flexible demand to skip the connection queue.

TECHNOLOGY PROVIDERS

Identify and focus commercial activities and product design on locations and sectors where ETES technologies are competitive today. This will sustain technology providers whilst technology continues to mature and market conditions improve further.

Work with policymakers, grid operators and industry to raise awareness of ETES applications and benefits and to drive forward the implementation. This is especially important because there will be a much wider variety of applications in the future.

Establish relationships with grid operators and utilities to provide a turnkey solution for customers that removes the complexity of permitting, grid connection and charging pattern optimisation.

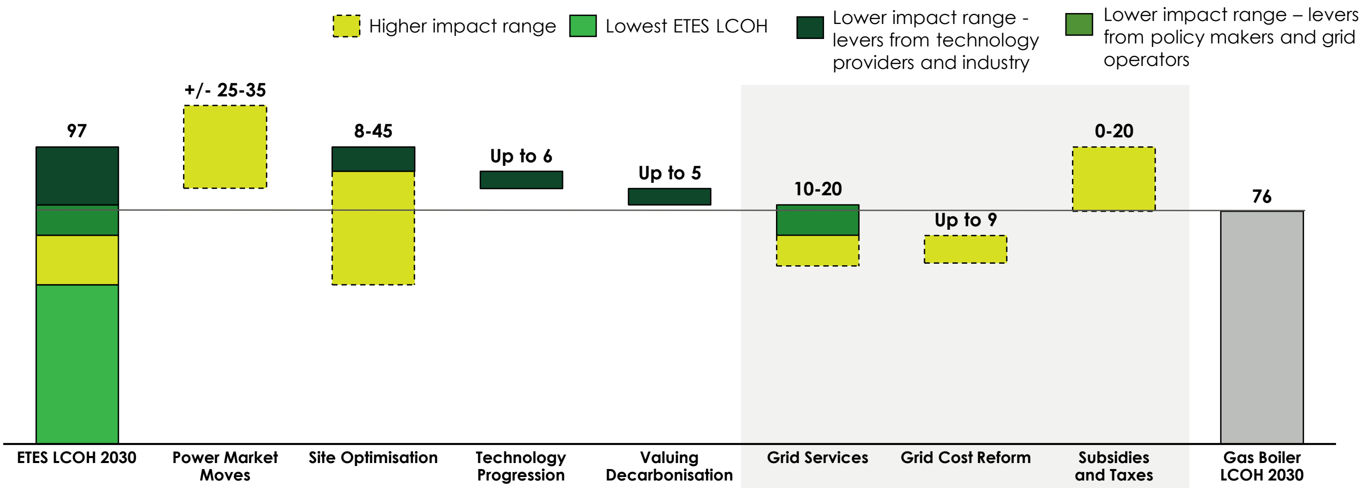
LEVERS TO CLOSE THE ETES AFFORDABILITY GAP

The immediate use case of ETES is anticipated to be replacement of industrial gas boilers. To serve this market, ETES technologies need to achieve cost parity with gas boilers. The figure below illustrates the levers to close the affordability gap by 2030, an important moment because ETES assets being considered now will be operational before 2030.

Almost all levers can be actioned now by the relevant parties, except the technology progression (which requires production scale). In the absence of all other levers, a moderate subsidy of at most ~20 EUR/MWh thermal (~90 EUR/t CO_2) will be required for ETES to reach cost parity with gas boilers

It is important that technology providers, industrial end users, policymakers and grid operators act now to realise the impact these levers. If all levers materialise, **the affordability gap in Denmark can be closed without subsidies.**

Levers to bridge the affordability gap in Denmark , levelised cost of heat (LCOH) in EUR/MWh thermal 2030



	Power Market Moves	Site Optimisation	Technology Progression	Valuing Decarbonisation	Grid Services	Grid Cost Reform	Subsidies and Taxes
Relevant parties	**Market participants**	**Industry, tech providers**	**Tech providers**	**Industry**	**Regulators, grid operators**	**Regulators, grid operators**	**Policymakers and regulators**
Examples	• Change in power purchasing agreement cost • Change in wholesale power prices • Change in discount for off-peak power	• Optimised charging • On-site power supply • Gas boiler as backup • Combined heat and power setup	• Further capital expenditure reductions	• Green premium • Other environmental opportunity costs	• Payment for services to balance electricity grid *(discounted at 50% for market risk)*	• Further decrease in grid fees and taxes in line with other EU countries	• Maximum financial support of up to 90 EUR/t CO_2 if no other levers are actioned

← **Action by regulators and policymakers** →

Please note that the LCOH for a specific case can be different from the generic numbers represented in this graph. See the Technical Appendix for details on the assumptions.

Sources: Technology provider interviews, P2H Cost Calculator (2022) – Agora, IRENA Remap 2030, TNO Technology fact sheet (2015), Thermal Energy Storage (2023) – RTC, Industrial Thermal Batteries (2023) - LDES, Prospects for LDES in Germany (2022) – Aurora, expert interviews, TSO And DSO websites; Capturing the green-premium value from sustainable materials (McKinsey, 2022); Scaling textile recycling in Europe–turning waste into value (McKinsey, 2022); The Promising Effect of a Green Food Label in the New Online Market (Jiang Y, Wang HH, Jin S, Delgado MS, 2019); Historical gas TTF futures and day-ahead spot market power (investing.com); ERCOT; Thermal Batteries: Opportunities To Accelerate Decarbonization of Industrial Heat (Renewable Thermal Collective, 2023)

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