Thermal Batteries to increase the demand of renewable energy

Alberto Crespo Iniesta
Director Project Development

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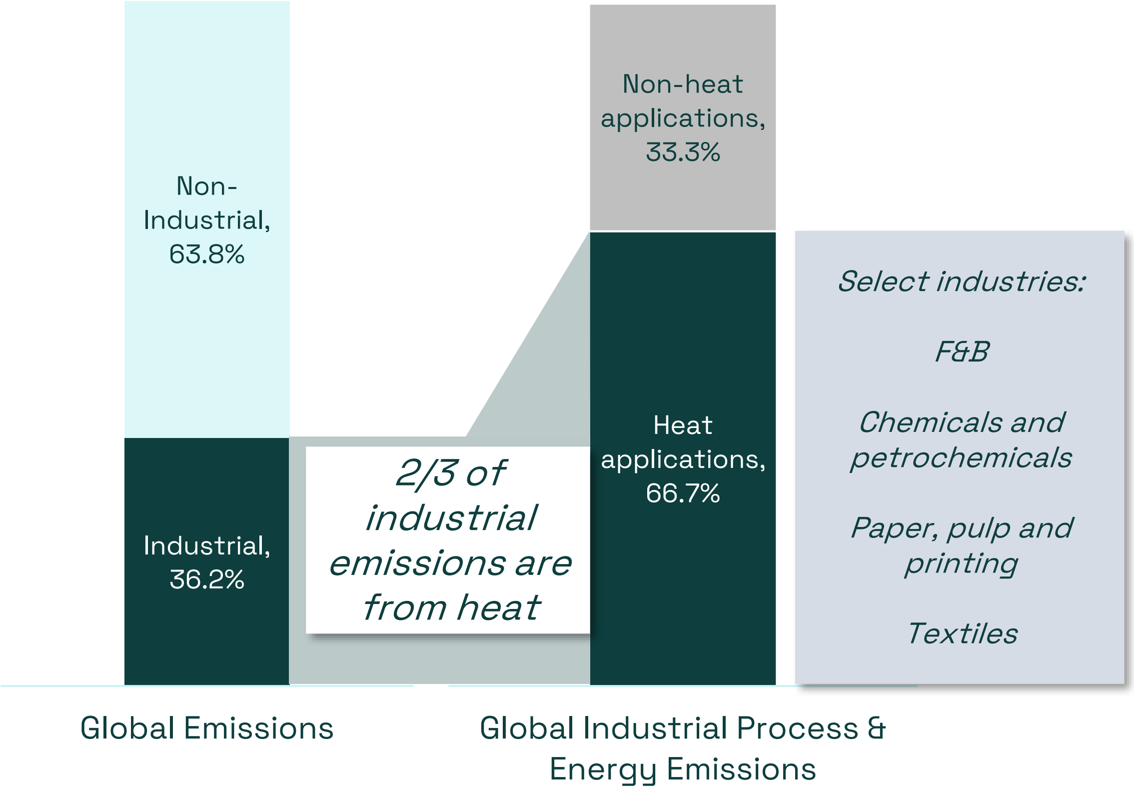
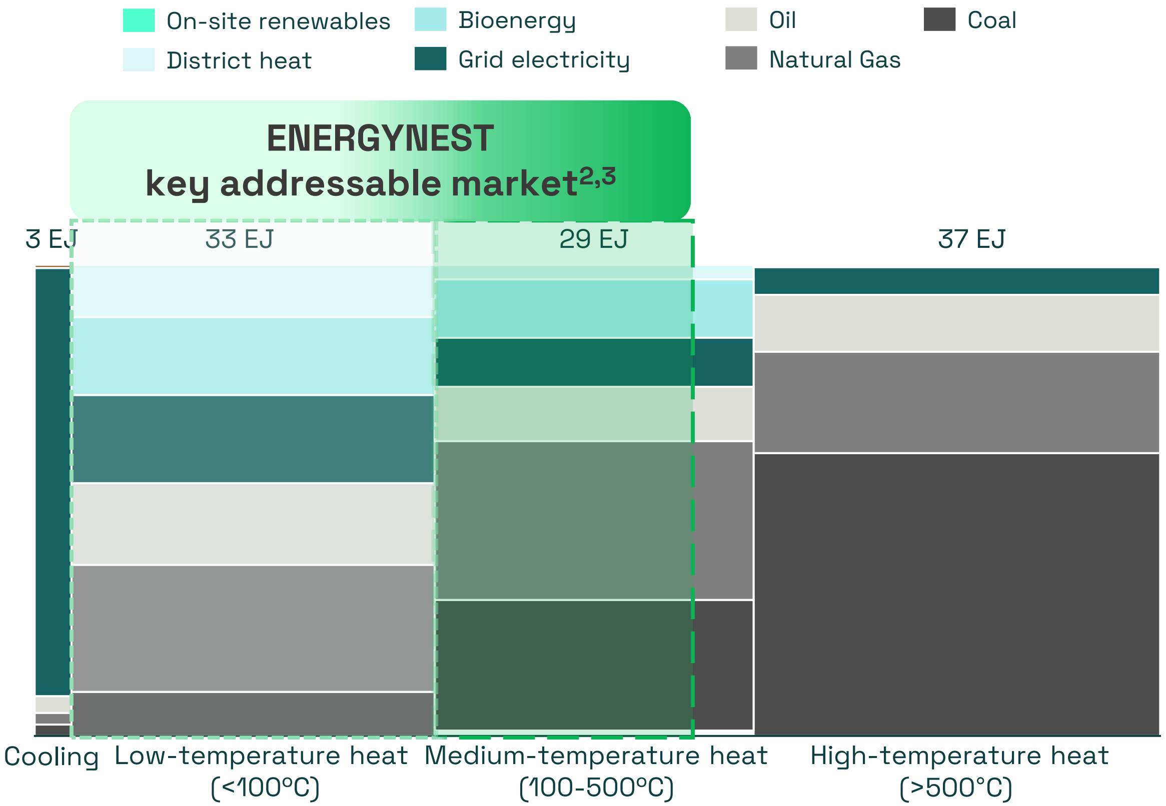
ENERGYNEST

Industrial heat accounts to 25% of global emissions

Global greenhouse gas emissions by sector and industrial segment[1]

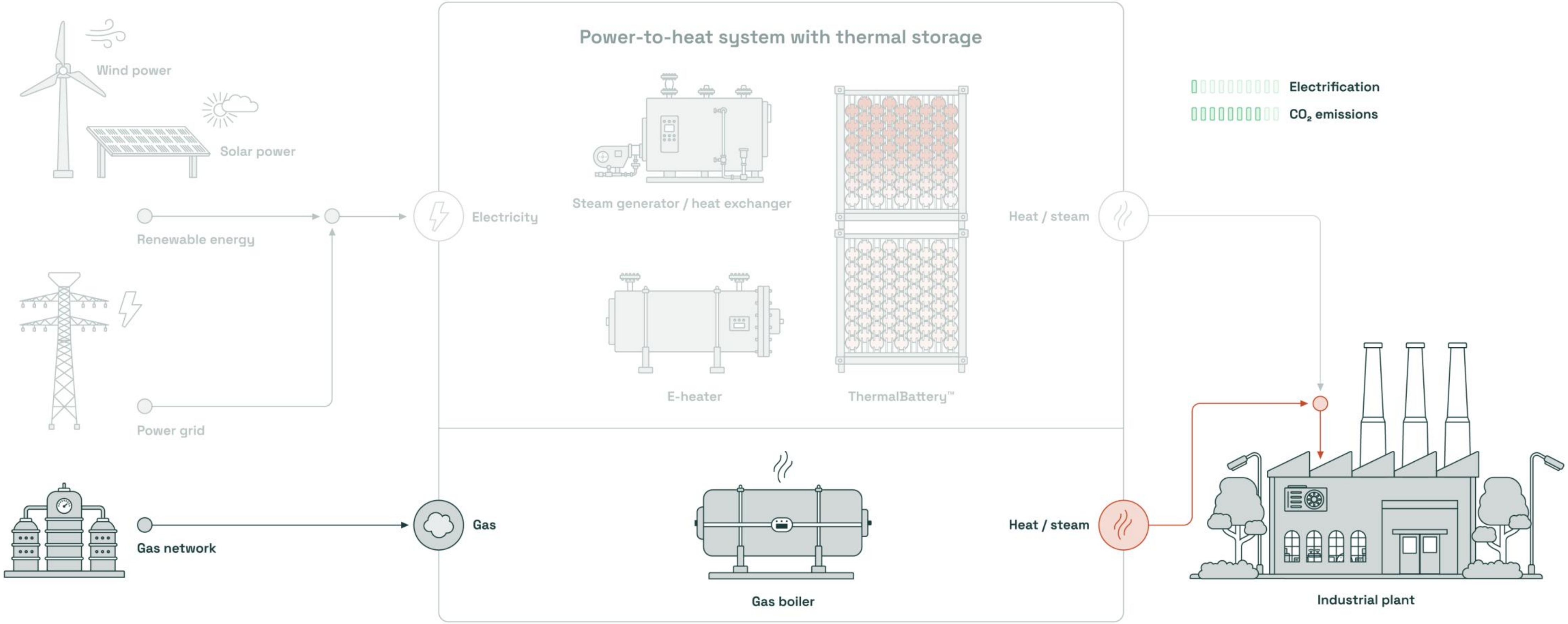


ENERGYNEST displacement opportunity of fossil fuels in industrial heat

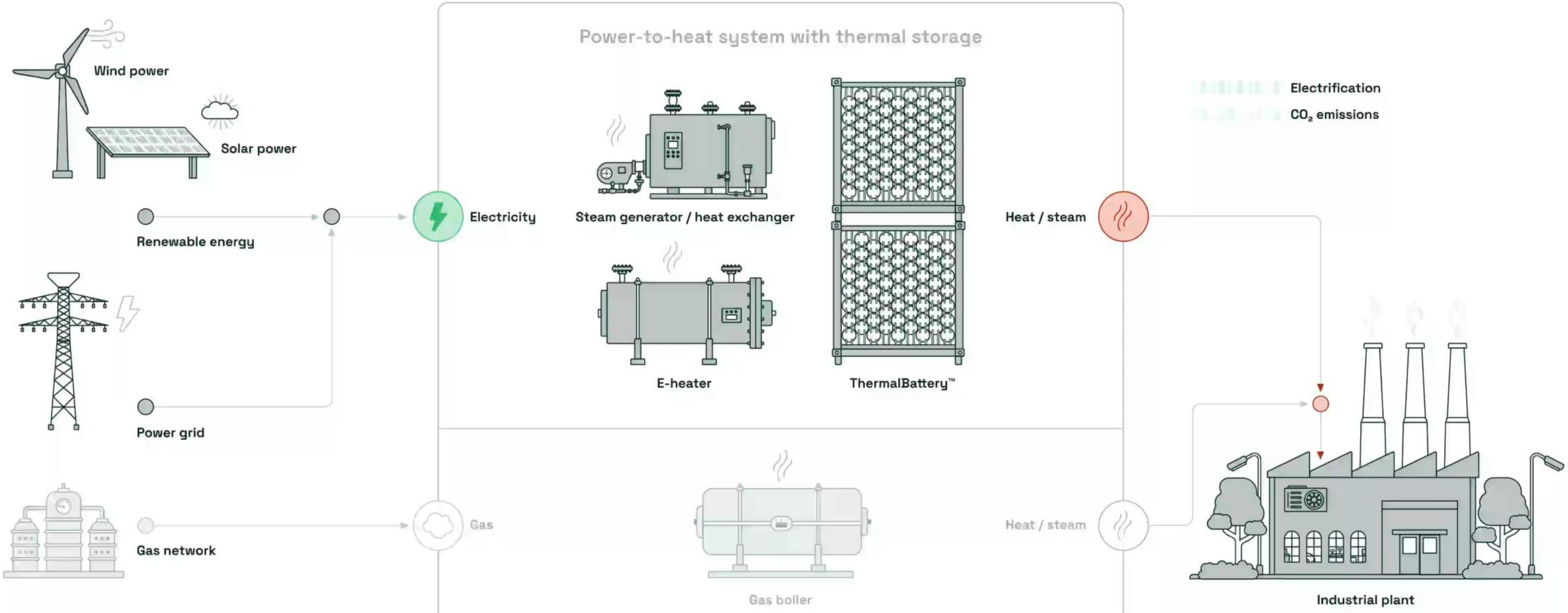


1. Data as of 2016;
2. ENERGYNEST solution can address a proportion of the <100°C temperature market through WHR steam balancing;
3. ENERGYNEST solution can address temperatures up to 400°C;
Source: LDES Net Zero Industry Report, January 2024

Today: Steam and heat generation based on fossil fuels



Electrification with thermal storage: optimizing cost of heat by choosing between electricity of natural gas



Our company: ENERGYNEST

Who we are & what drives our customers

Our offices & our projects

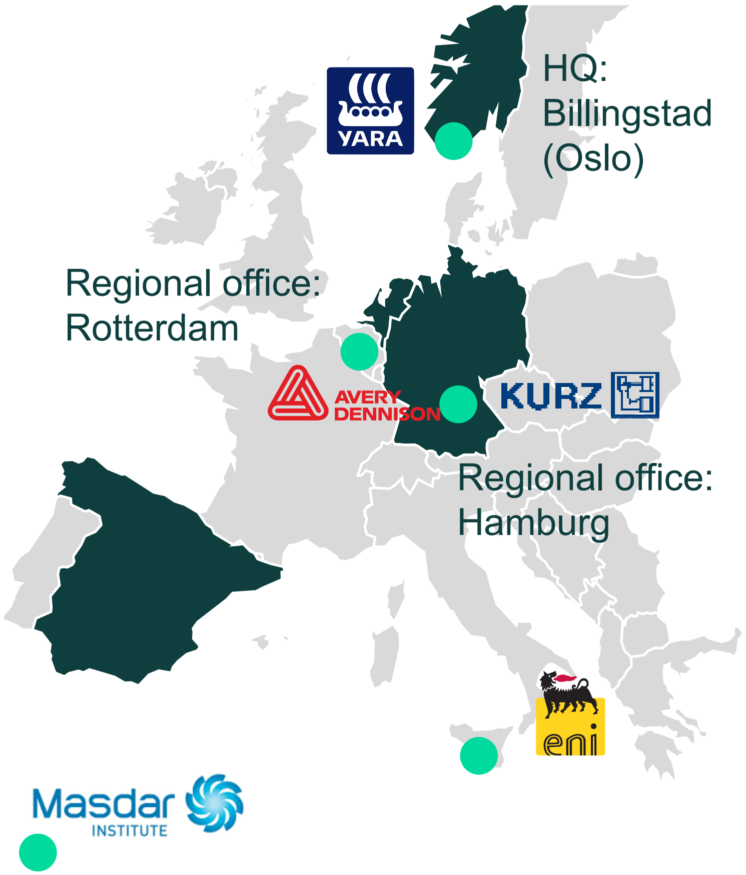
45 employees

Founded in 2011

Majority shareholder

Infracapital

M&G



Regional office:
Seville, Madrid

Energy costs

Decarbonization targets

Reliable operation and security of supply

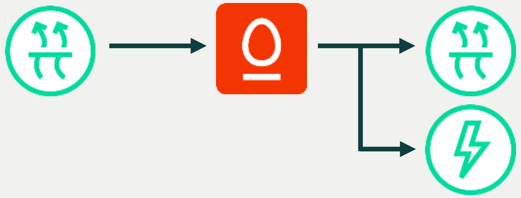
Focus on core business

Value creation in different industrial applications

Electrification
Power-2-heat for industry

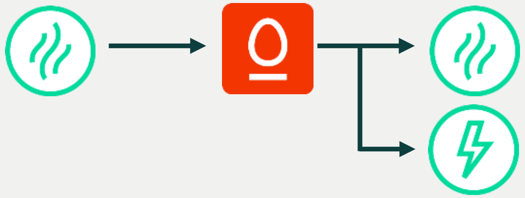
Chemicals, Paper & Pulp,
Food & Beverages, etc.

Waste heat recovery
Capture and time-shift heat



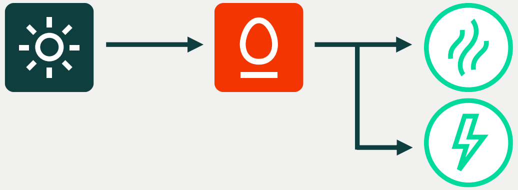
Metallurgy, Chemicals, Cements,
Petrochemical, etc.

Steam grid balancing
Tailor steam supply to demand



Pulp & Paper, Chemicals, Must-run power-plants, CCGTs

Concentrated solar
for 24/7 use on demand



Parabolic trough, Linear
Fresnel, etc.

Source: ENERGYNEST

The core: ThermalBattery™ module – a solid-state high temperature heat storage

Materials
Solid-state thermal concrete: HEATCRETE®
Cast-in steel piping
Steel frame
Carbon payback in 2 months

Integration
Modular design for easy integration and transportation

Process
Charging: 390°C
Discharging:
~125°C to >300°C

Maintenance
No moving parts, predictable maintenance
Lifetime:
30 years+

Capacity
Up to
2 MWh_{th}
per module, depending on temperatures

Technology
Projects in operation and under execution
Reviewed by DNV and Fichtner
Market-ready

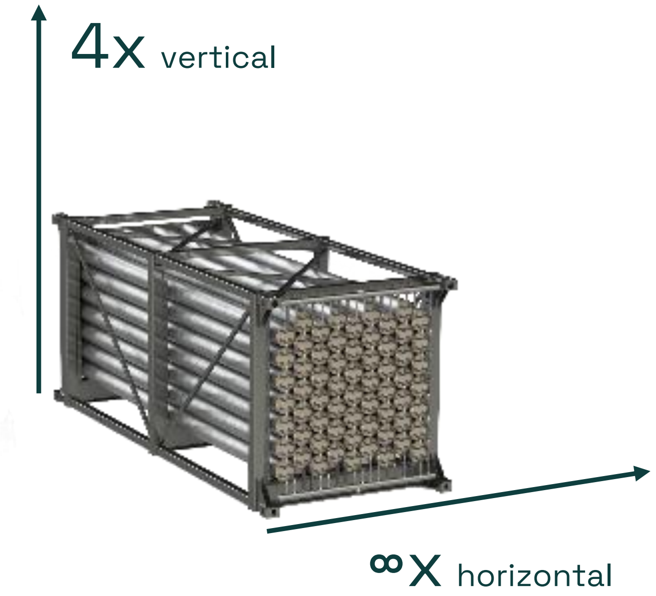
Flexibility
Provision of
- Steam
- Thermal oil
- Hot air

Efficiency
Thermal efficiency
up to 95 %

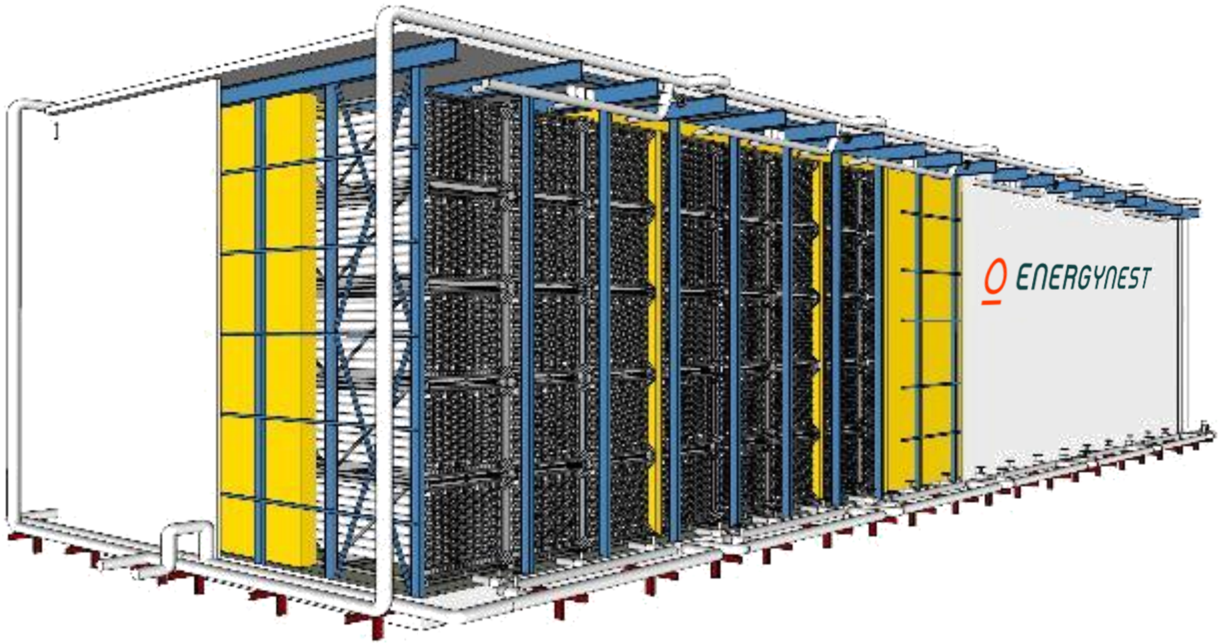
Scalability
Modular system from 3 MWh to
> 1000 MWh

ThermalBattery™ system

ThermalBattery™ module



ThermalBattery™ system



Source: ENERGYNEST

1 ThermalBattery™

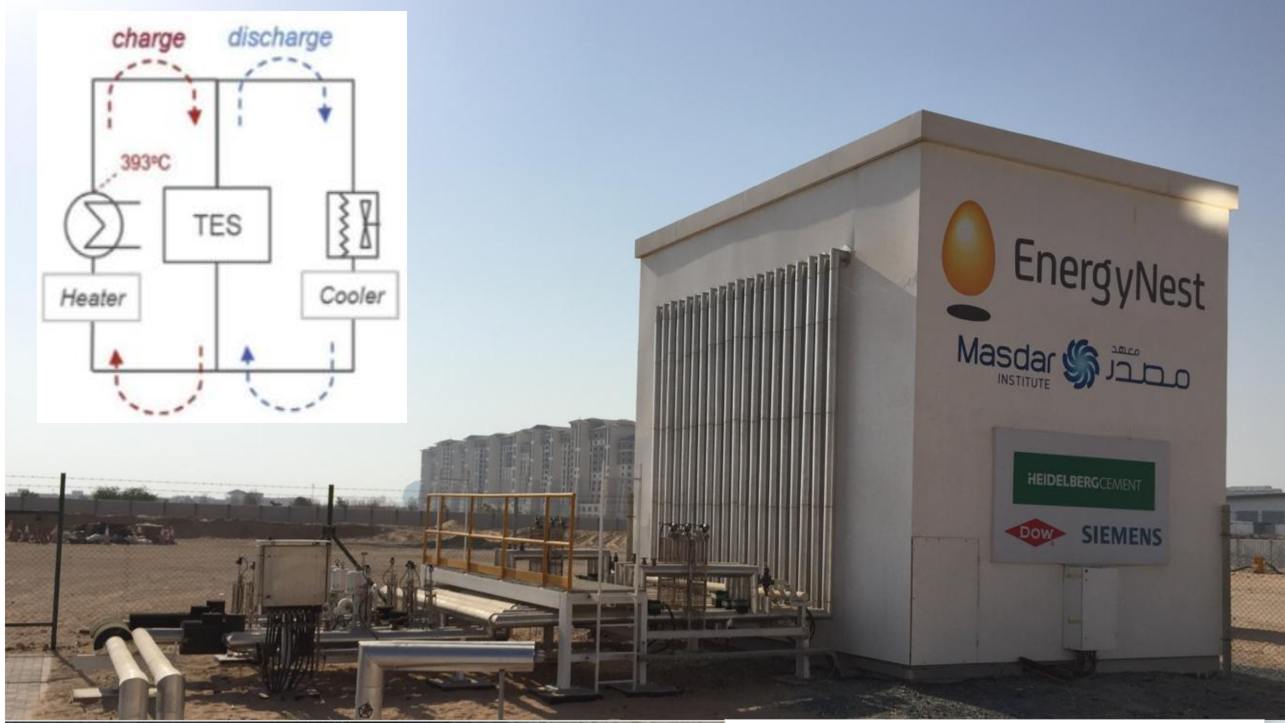
2 **Process plant including:**
- Electric heater
- Steam generation / HEX
- HTF pump
- Expansion tank
- Drain tank
- Electrical and instrumentation container

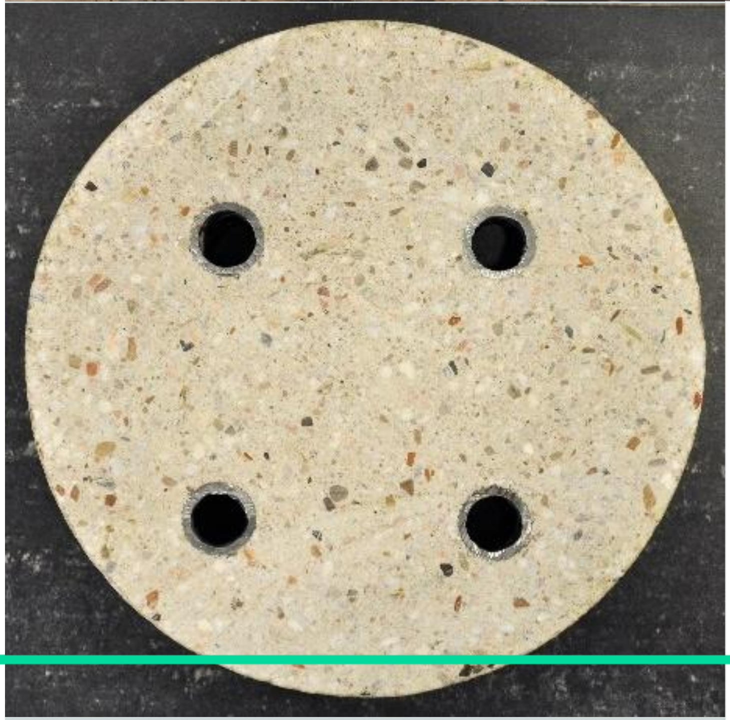
Validated technology - Pilot

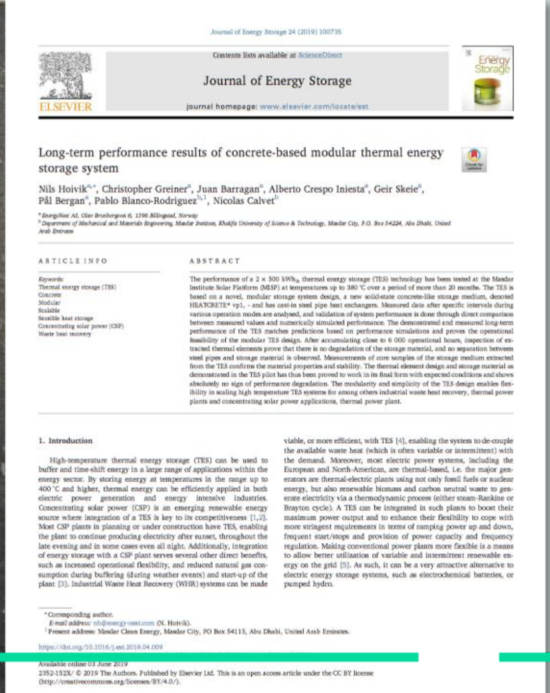
- Location: Masdar Institute, Abu Dhabi
- Operational from Q3-2015 to Q2-2017
- Thermal oil up to 380 °C
- 2 small-scale modules totaling 500 kWh (thermal)
- R&D setup validated by DNV
- Stable performance over lifetime
- Post-mortem testing confirmed thermal-mechanical integrity

– **Peer reviewed article:** Journal of Energy Storage

Source: ENERGYNEST







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Long-term performance results of concrete-based modular thermal energy storage system

Nils Hoivik[a,*], Christopher Greiner[a], Juan Barragan[a], Alberto Crespo Iniesta[a], Geir Skeie[a], Pål Bergan[a], Pablo Blanco-Rodriguez[b,1], Nicolas Calvet[b]

[a] EnergyNest AS, Olav Brunborgsvei 6, 1396 Billingstad, Norway
[b] Department of Mechanical and Materials Engineering, Masdar Institute, Khalifa University of Science & Technology, Masdar City, P.O. Box 54224, Abu Dhabi, United Arab Emirates

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Concrete
Modular
Scalable
Sensible heat storage
Concentrating solar power (CSP)
Waste heat recovery

ABSTRACT

The performance of a 2 × 500 kWh_{th} thermal energy storage (TES) technology has been tested at the Masdar Institute Solar Platform (MISP) at temperatures up to 380 °C over a period of more than 20 months. The TES is based on a novel, modular storage system design, a new solid-state concrete-like storage medium, denoted HEATCRETE® vp1, - and has cast-in steel pipe heat exchangers. Measured data after specific intervals during various operation modes are analysed, and validation of system performance is done through direct comparison between measured values and numerically simulated performance. The demonstrated and measured long-term performance of the TES matches predictions based on performance simulations and proves the operational feasibility of the modular TES design. After accumulating close to 6 000 operational hours, inspection of extracted thermal elements prove that there is no degradation of the storage material, and no separation between steel pipes and storage material is observed. Measurements of core samples of the storage medium extracted from the TES confirms the material properties and stability. The thermal element design and storage material as demonstrated in the TES pilot has thus been proved to work in its final form with expected conditions and shows absolutely no sign of performance degradation. The modularity and simplicity of the TES design enables flexibility in scaling high temperature TES systems for among others industrial waste heat recovery, thermal power plants and concentrating solar power applications, thermal power plant.

1. Introduction

High-temperature thermal energy storage (TES) can be used to buffer and time-shift energy in a large range of applications within the energy sector. By storing energy at temperatures in the range up to 400 °C and higher, thermal energy can be efficiently applied in both electric power generation and energy intensive industries. Concentrating solar power (CSP) is an emerging renewable energy source where integration of a TES is key to its competitiveness [1,2]. Most CSP plants in planning or under construction have TES, enabling the plant to continue producing electricity after sunset, throughout the late evening and in some cases even all night. Additionally, integration of energy storage with a CSP plant serves several other direct benefits, such as increased operational flexibility, and reduced natural gas consumption during buffering (during weather events) and start-up of the plant [3]. Industrial Waste Heat Recovery (WHR) systems can be made viable, or more efficient, with TES [4], enabling the system to de-couple the available waste heat (which is often variable or intermittent) with the demand. Moreover, most electric power systems, including the European and North-American, are thermal-based, i.e. the major generators are thermal-electric plants using not only fossil fuels or nuclear energy, but also renewable biomass and carbon neutral waste to generate electricity via a thermodynamic process (either steam-Rankine or Brayton cycle). A TES can be integrated in such plants to boost their maximum power output and to enhance their flexibility to cope with more stringent requirements in terms of ramping power up and down, frequent start/stops and provision of power capacity and frequency regulation. Making conventional power plants more flexible is a means to allow better utilization of variable and intermittent renewable energy on the grid [5]. As such, it can be a very attractive alternative to electric energy storage systems, such as electrochemical batteries, or pumped hydro.

* Corresponding author.
E-mail address: nh@energy-nest.com (N. Hoivik).
1 Present address: Masdar Clean Energy, Masdar City, PO Box 54115, Abu Dhabi, United Arab Emirates.

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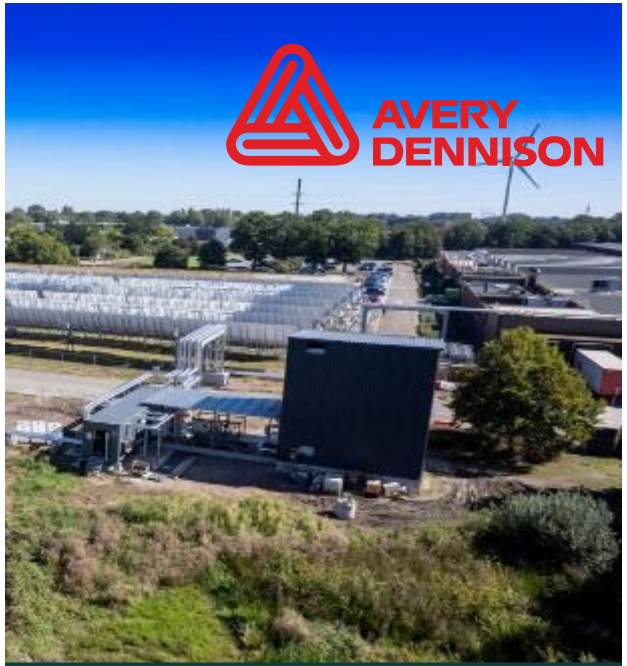
Our thermal storage is already helping industrial customers to decarbonize

- Turnkey Power-to-heat solution
- Nurberg, Germany
- **>70% heat demand coverage** of one production line
- **>3.5 GWh natural gas saved and >700 ton CO_2 avoided per year**

- Thermal Battery integrated into steam network
- Porsgrunn, Norway
- **Steam provision 1-5 t/h**
- **6,000 t CO2 savings / year**
- Electricity savings > 12 GWh / year



- Solar thermal field with Thermal Battery
- Turnhout, Belgium
- **10% coverage of the total heat** demand and **100%** coverage over **summertime**

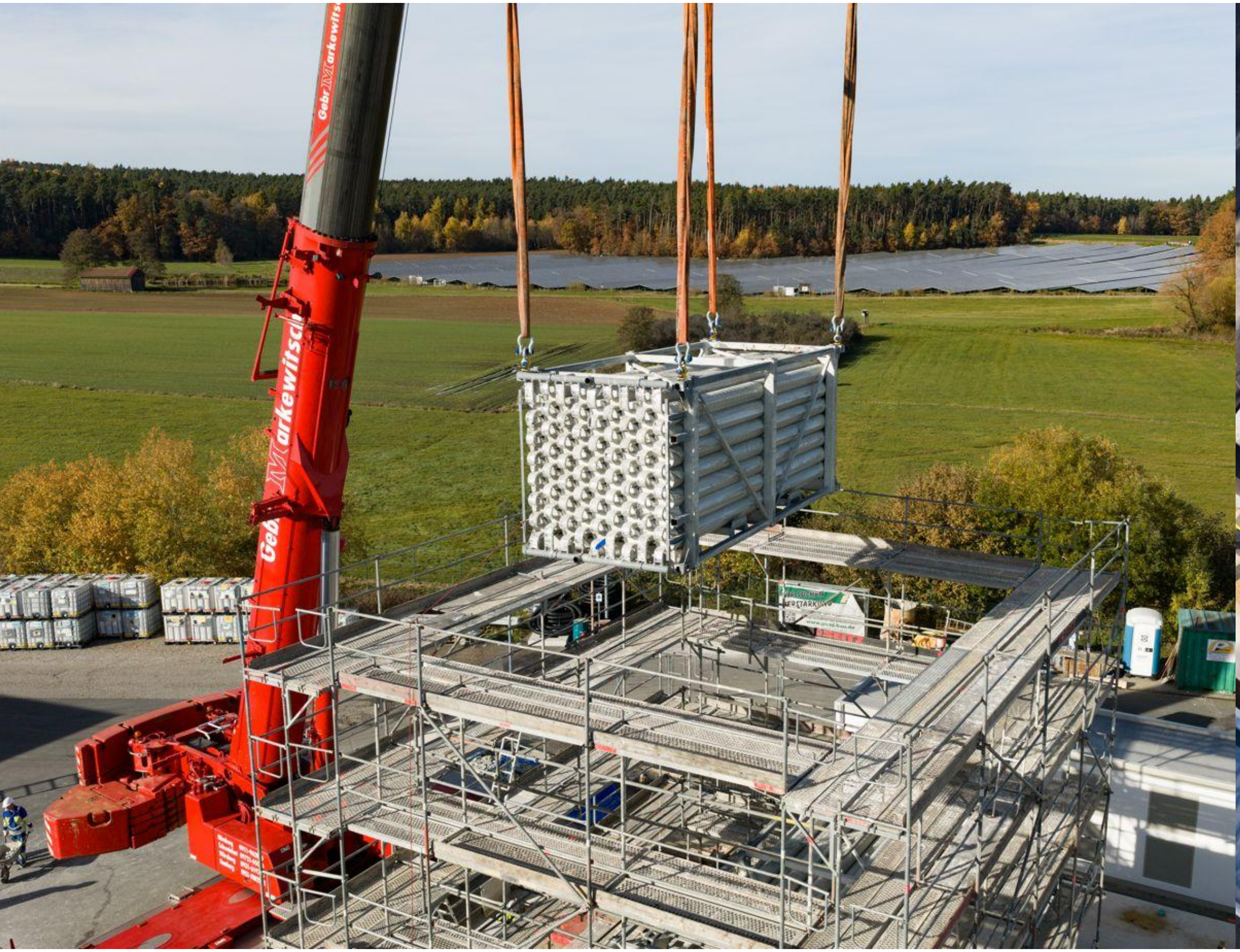
- Solar thermal field with Thermal Battery
- Sicily, Italy
- Steam on demand for on-site consumption and micro steam turbine electricity production

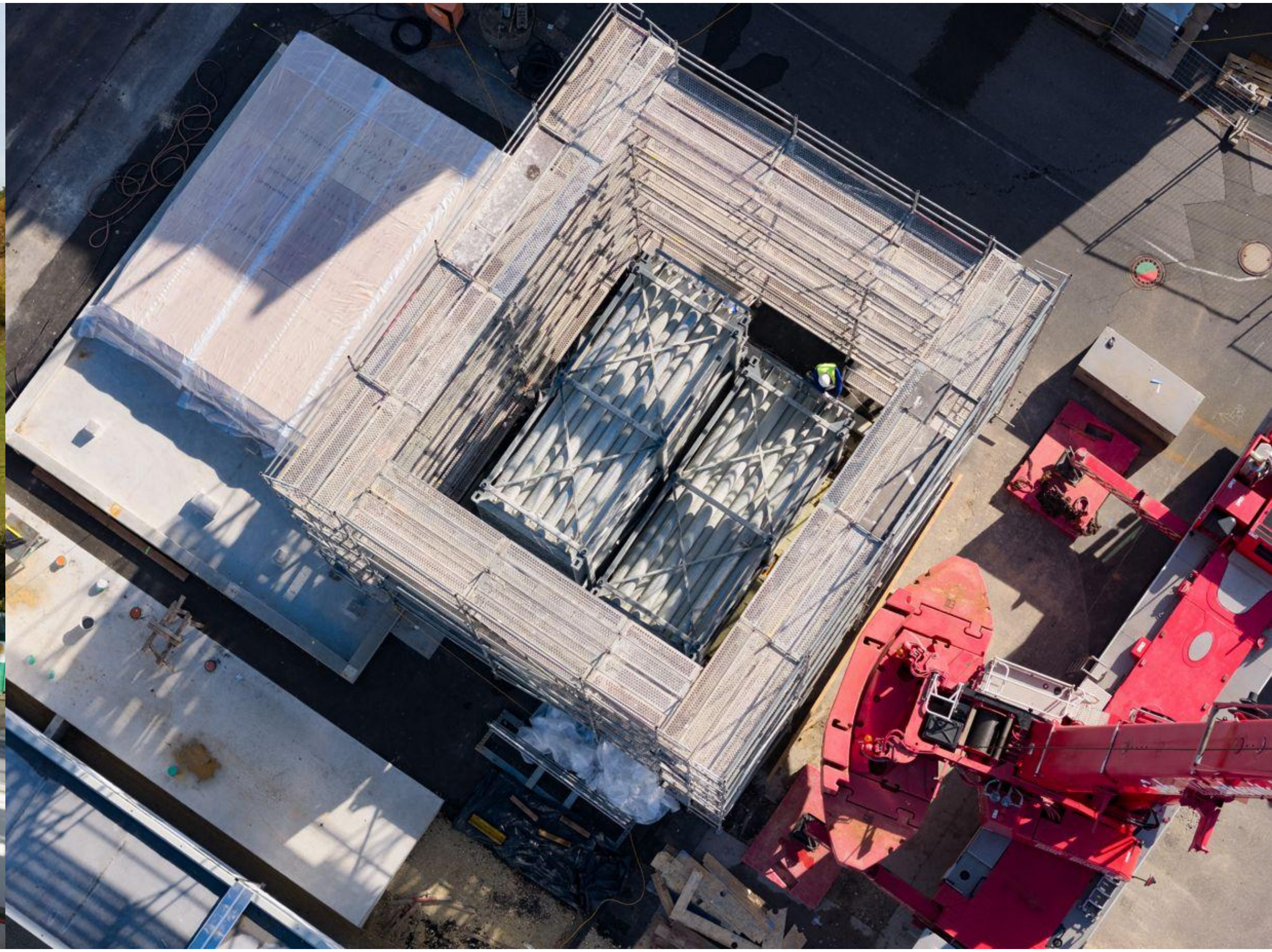
Source:

Impressions from Avery Dennison

Impressions from Avery Dennison

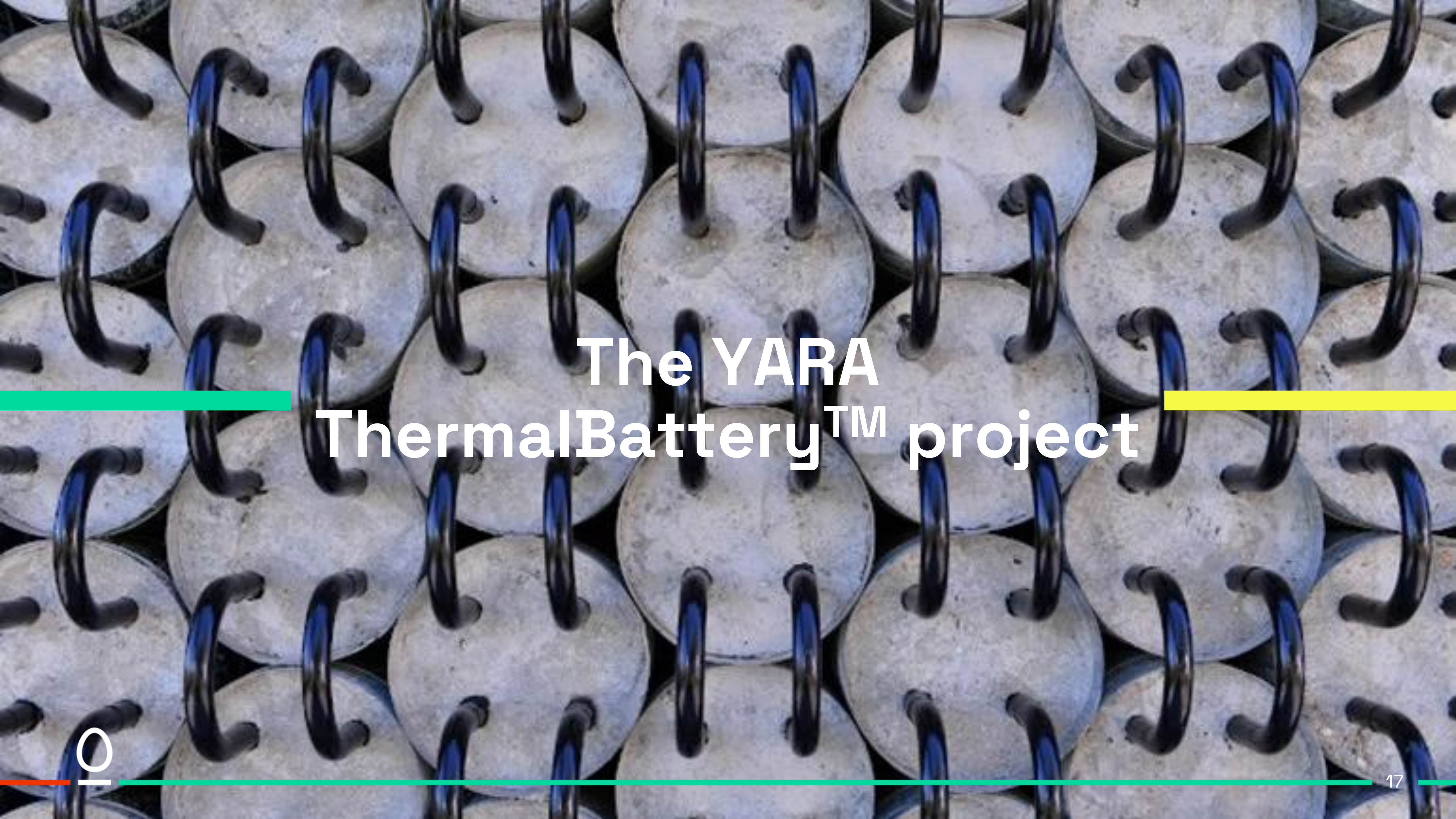
Impressions from Leonhard Kurz





Source:

Impressions from Yara



The YARA ThermalBattery™ project

Onsite assembly of modules

Source: ENERGYNEST

Direct steam thermal battery

Description: Connected to steam grid at Herøya industrial park in Porsgrunn, Norway. ThermalBattery™ balances fluctuations in steam supply, utilizes excess steam, and increases energy efficiency. Project is supported by ENOVA and Innovation Norway

Highlights:

– Charge: 34 barg, de-superheated from 330°C
– Discharge: 5 barg, dry 10-30 °C superheated steam
– Capacity: 1.5-4.5 t/h (1.0-2.9 MW)*, 5.5 t (4 MWh)*
– Design life: 200,000 hours. 462,000 cycles
– Config.: 4 modules + 8.7 m^3 pressure vessel

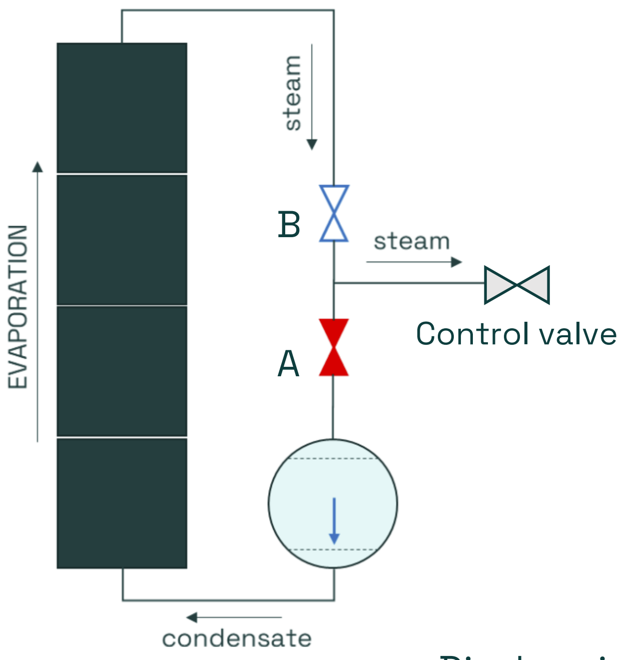
Facility has so far completed >4,000 cycles

* Reference enthalpy is condensate at 10°C (open loop system)

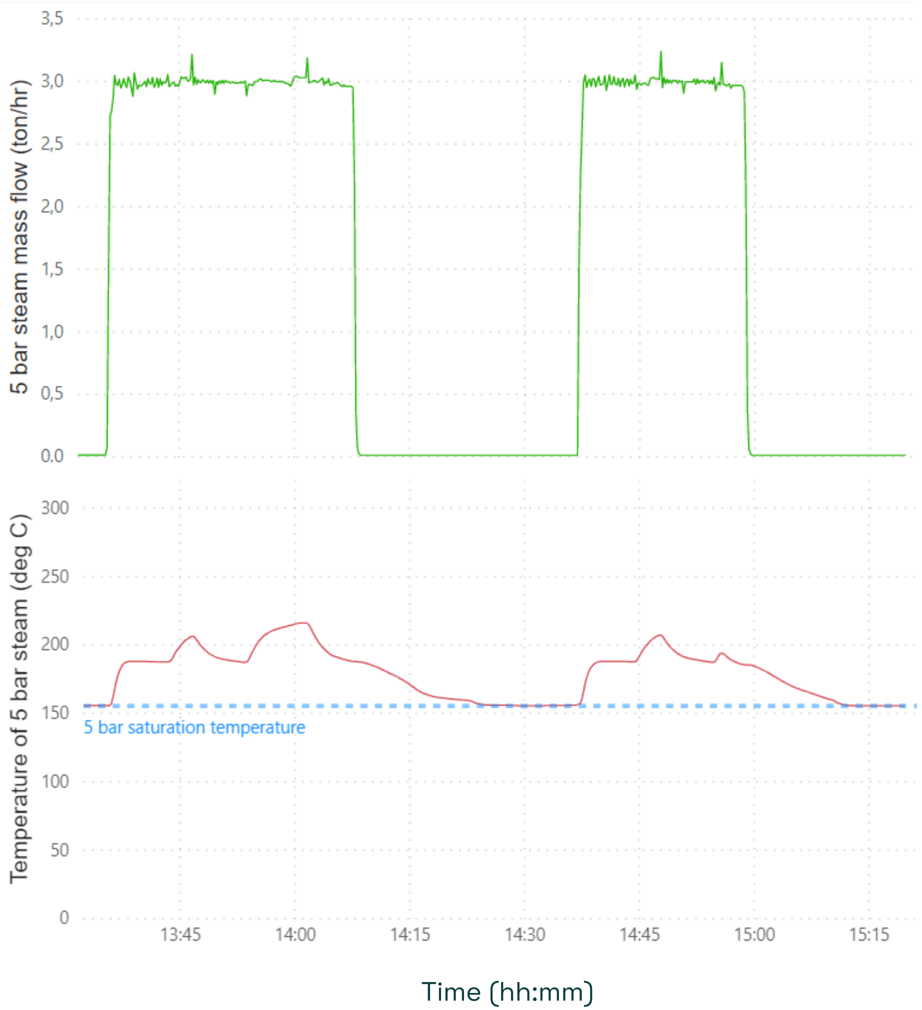
Source: ENERGYNEST

Operational results – dry steam during discharge

- System designed to **ensure dry steam** delivered to the grid
- Valves (A and B) tuned for stable mass flow of steam



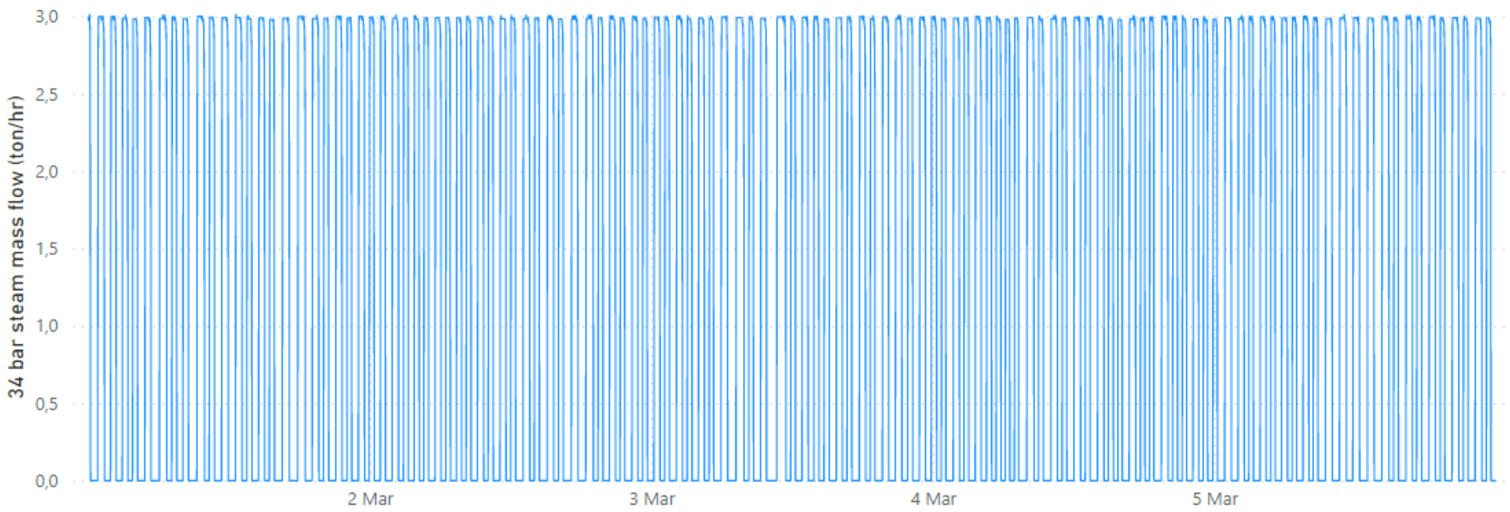
Discharging process



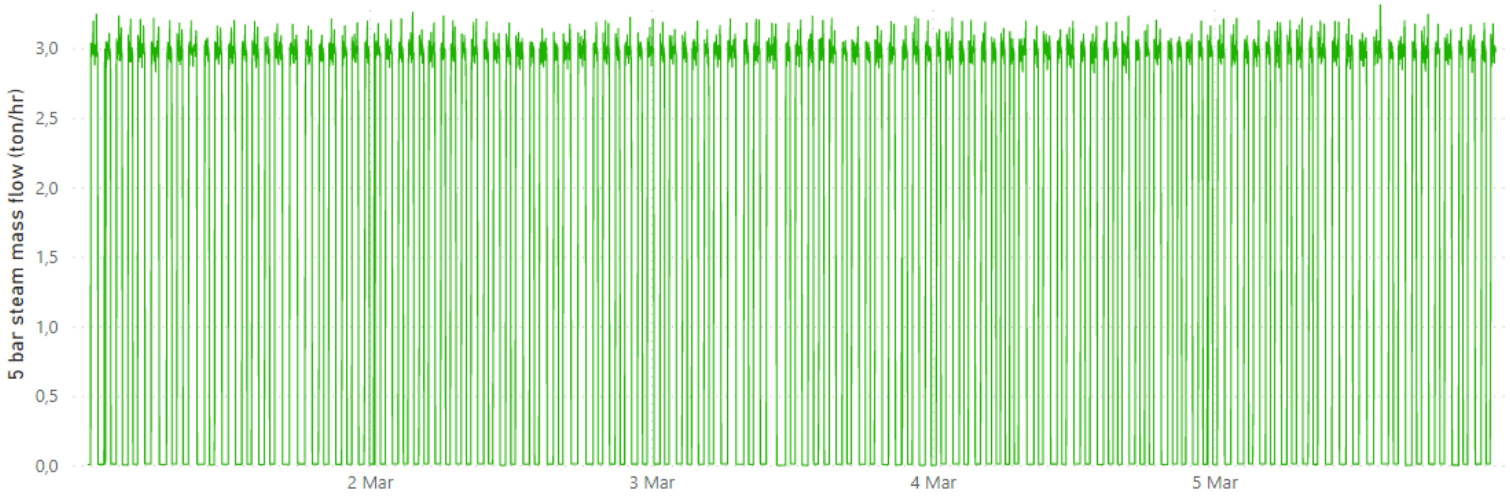
Source:

Continuous & autonomous load-following mode

- Stable performance in load-following operational mode with
- 3 ton/hr mass flow rate for charge and discharge



Charging

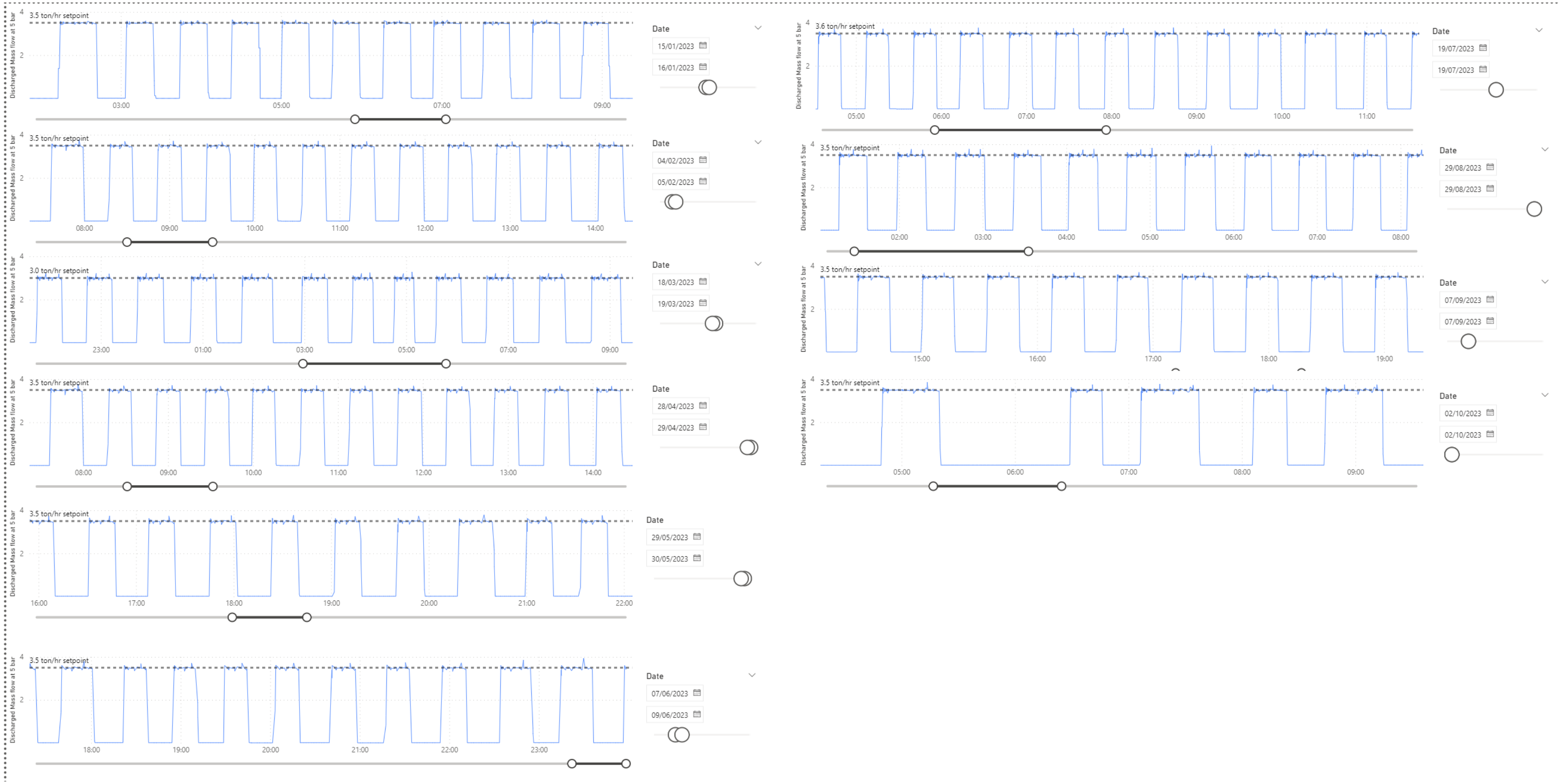


Discharging

Source:

Reliability proven by stable mass flow during discharge

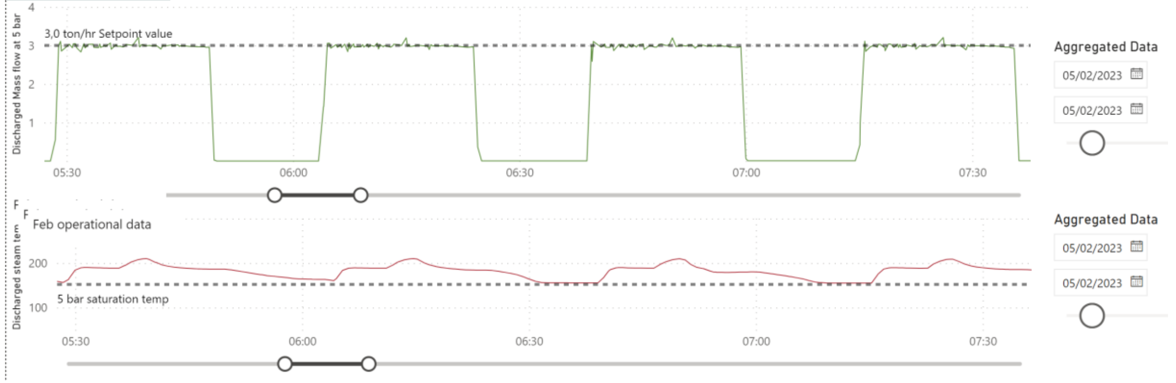
– TB system delivers steam reliably according to the setpoint defined by operators



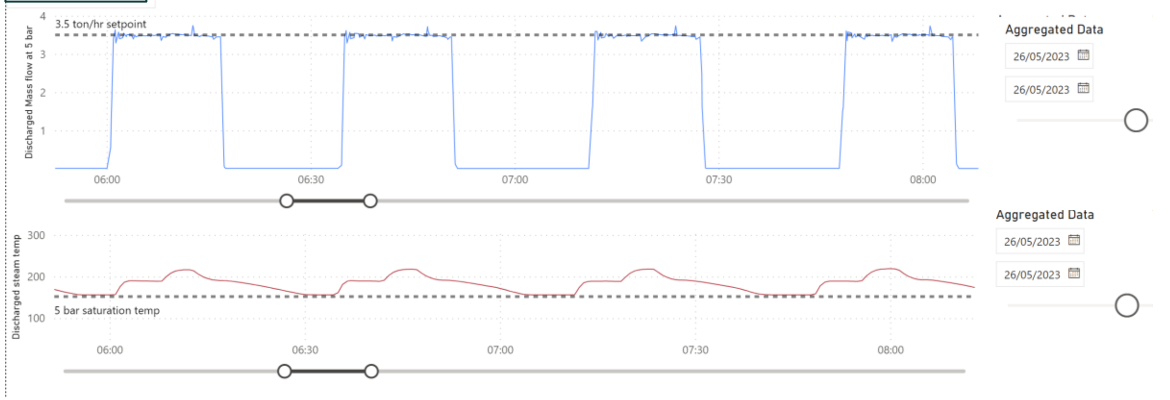
Source:

Dry steam – delivered during discharge

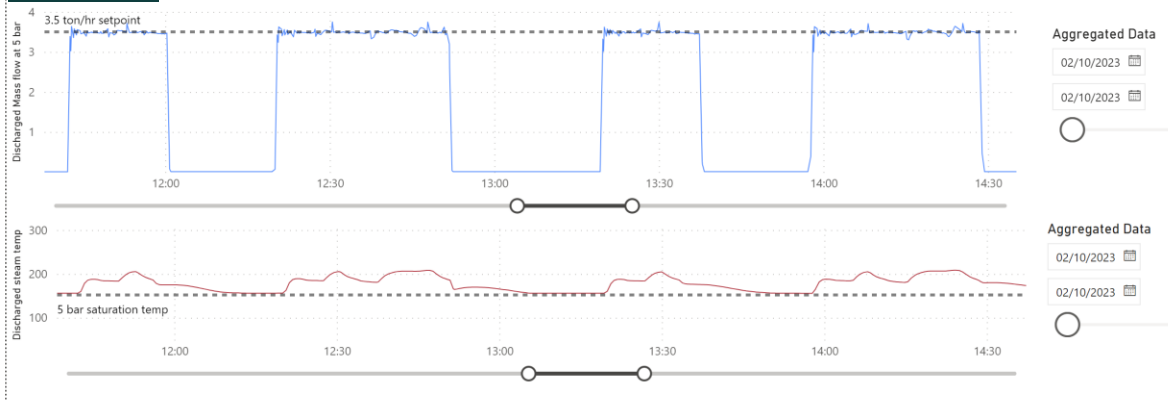
February



May



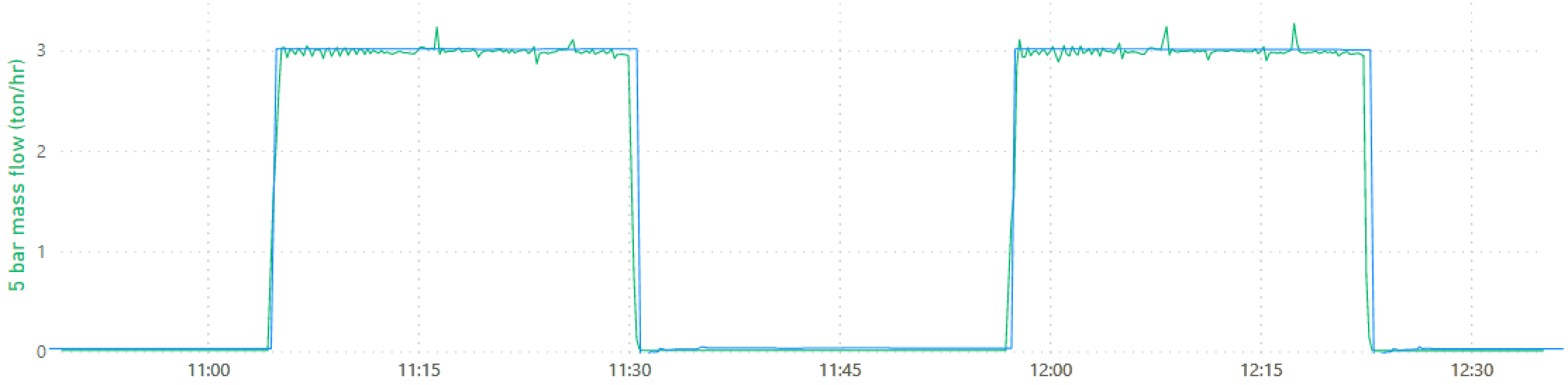
October



- Stable performance demonstrated over entire operation period (2023)
- **Delivered 5 bar steam always above saturation temperature**

Source:

Response time



- Valve response programmed to respect valve specifications and limitations within balance of plant where On/Off valve are located at a distance from the flow control valves
- **Approximately 20 seconds to reach 100 % mass flow**

Source:

Get in touch

Alberto Crespo Iniesta
Director Project Development
+34 657 52 33 15
aci@energy-nest.com

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