# Present and Future of Thermal Energy Storage

## bGen™ by Brenmiller


BRENMILLER
THERMAL ENERGY STORAGE

Brenmiller Europe
Thermal Energy Storage

green enesys VIRIDI

iENER'24 - Valencia

# Brenmiller Europe

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# Brenmiller Europe

## Introduction

Strong partnership since about 15 years

green enesys

- ✓ Established in 2009
- ✓ Renewable energy project integrator and project developer
- ✓ 67 projects in 16 countries

www.greenenesys.com

VIRIDI

- ✓ From 2006 to 2013: EPC and O&M of 80 PV power plants
- ✓ Today: Project Developer
- ✓ 20 projects in 7 countries

www.viridi.de

BRENMILLER THERMAL ENERGY STORAGE

- ✓ Established in 2012
- ✓ OEM of a thermal energy storage technology (bGen™)
- ✓ 4 projects in 4 countries

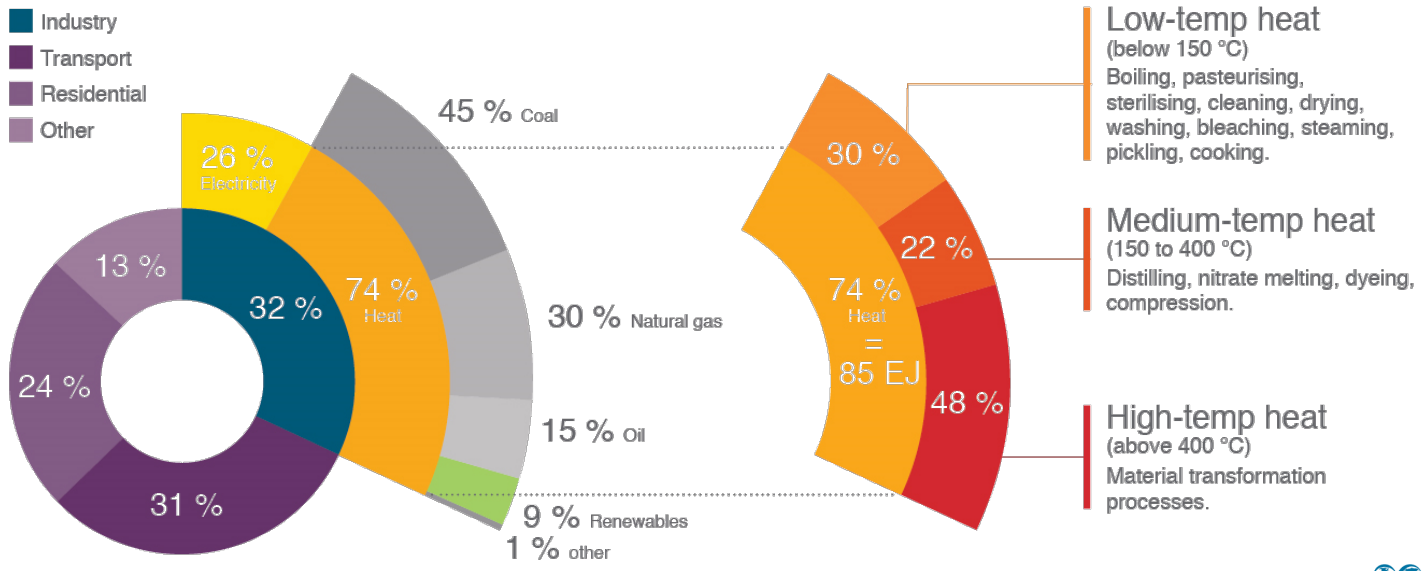
www.bren-energy.com

**Brenmiller Europe**, S.L. is a strategic Joint Venture between three companies

# Brenmiller Europe

## Market insights – Industrial heat

- ✓ One third of final energy consumption is for **heat**
- ✓ Heat accounts for three quarter of total **industrial** energy use
- ✓ Industrial heat demand relies heavily on **fossil fuels** heat
- ✓ Half of industrial heat is at **low and medium temperature**




Source: IRENA, 2020.

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# bGen™
# PRESENT & FUTURE

# Brenmiller Europe

**bGen™ – key advantages**

**Hybrid**
Connects different Energy Sources

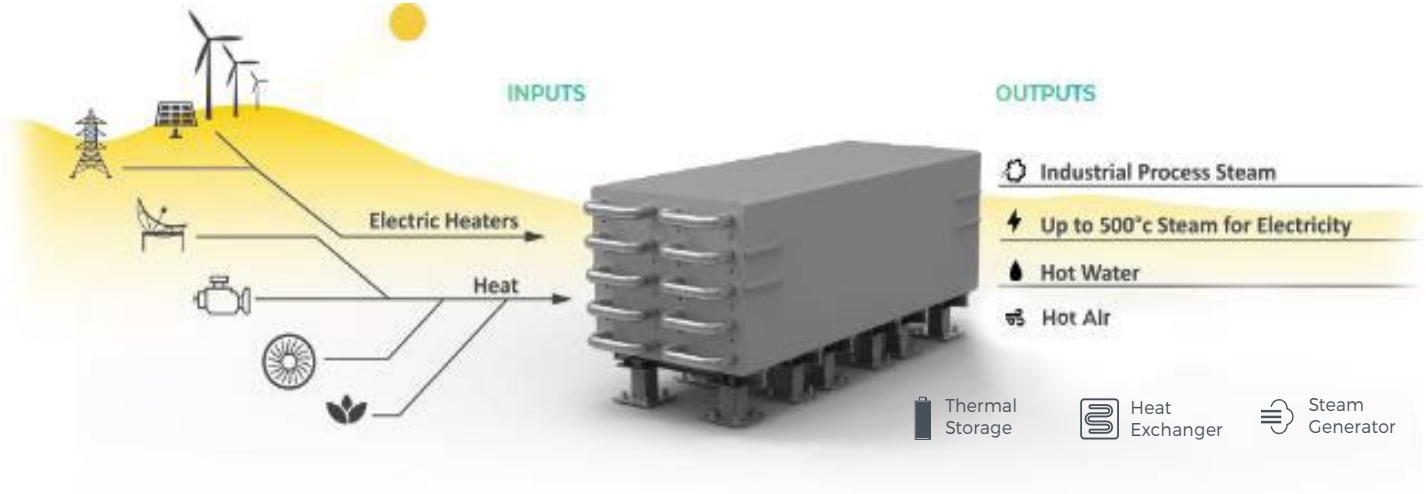
**Modular**
From Industrial to large-scale Power Plants

**Lifetime**
30+ Years

**Flexibility**
Decoupling generation from demand

**Performance**
Unlimited cycles with minimal daily losses (3%)

**Clean**
Environmentally friendly materials (crushed rocks)



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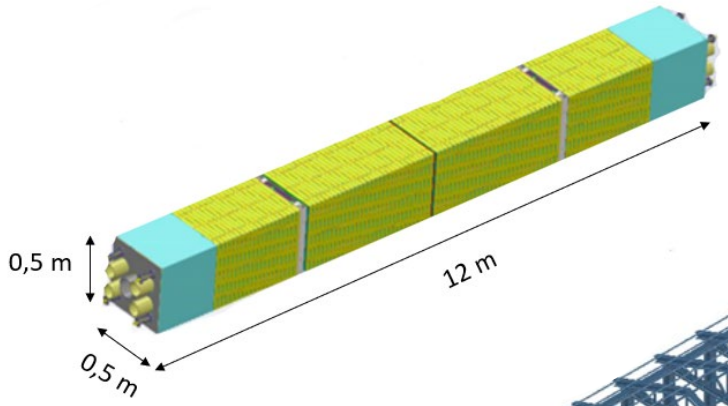
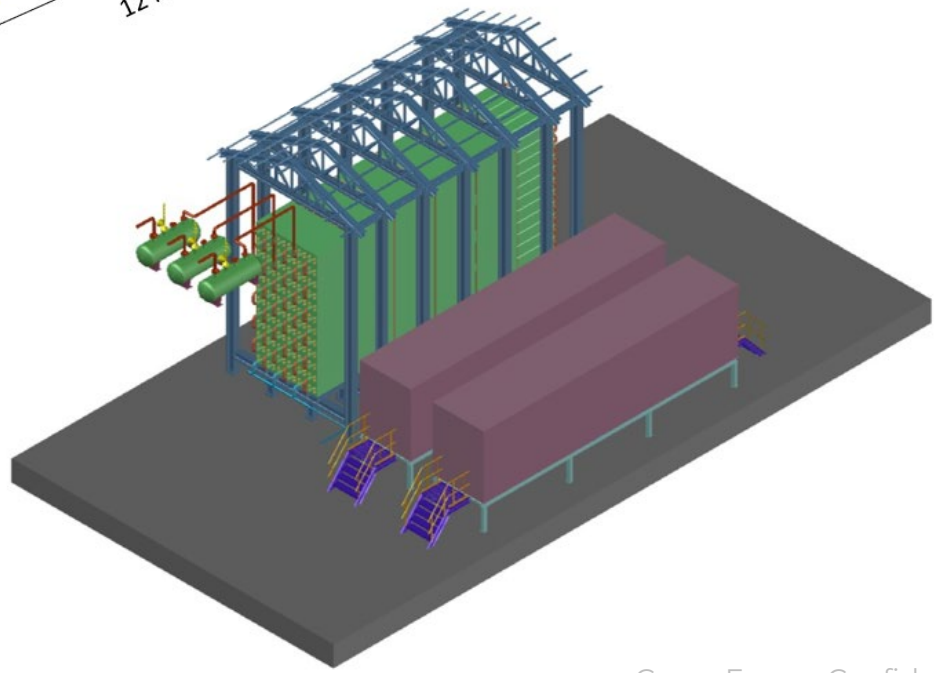
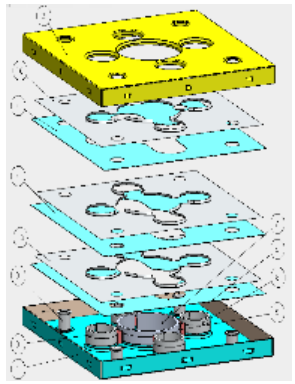
## Basic principle of the bGen™

The bGen™ is comprised of multiple bCubes:





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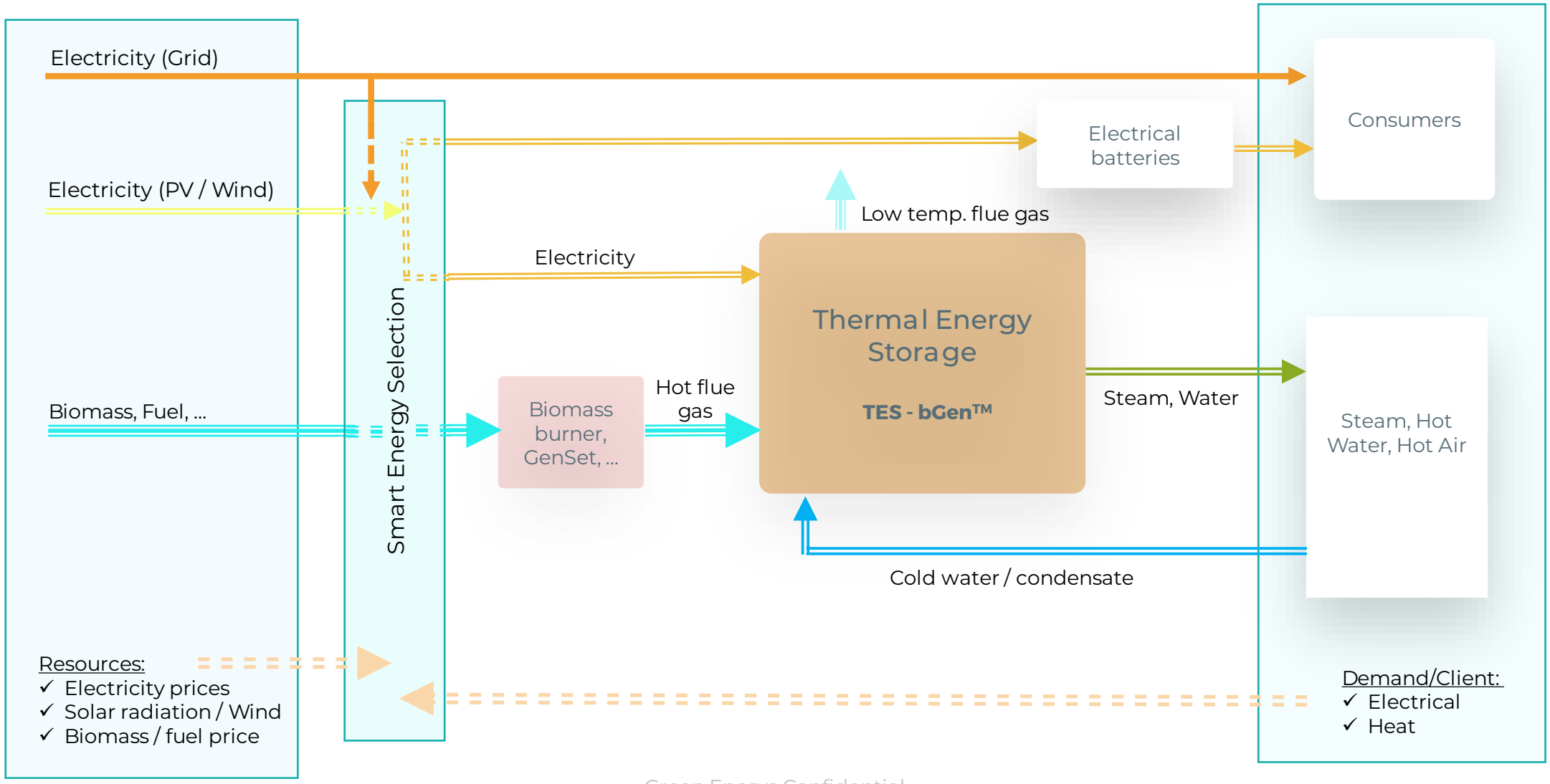
## TES System: Heat / Electricity Charging



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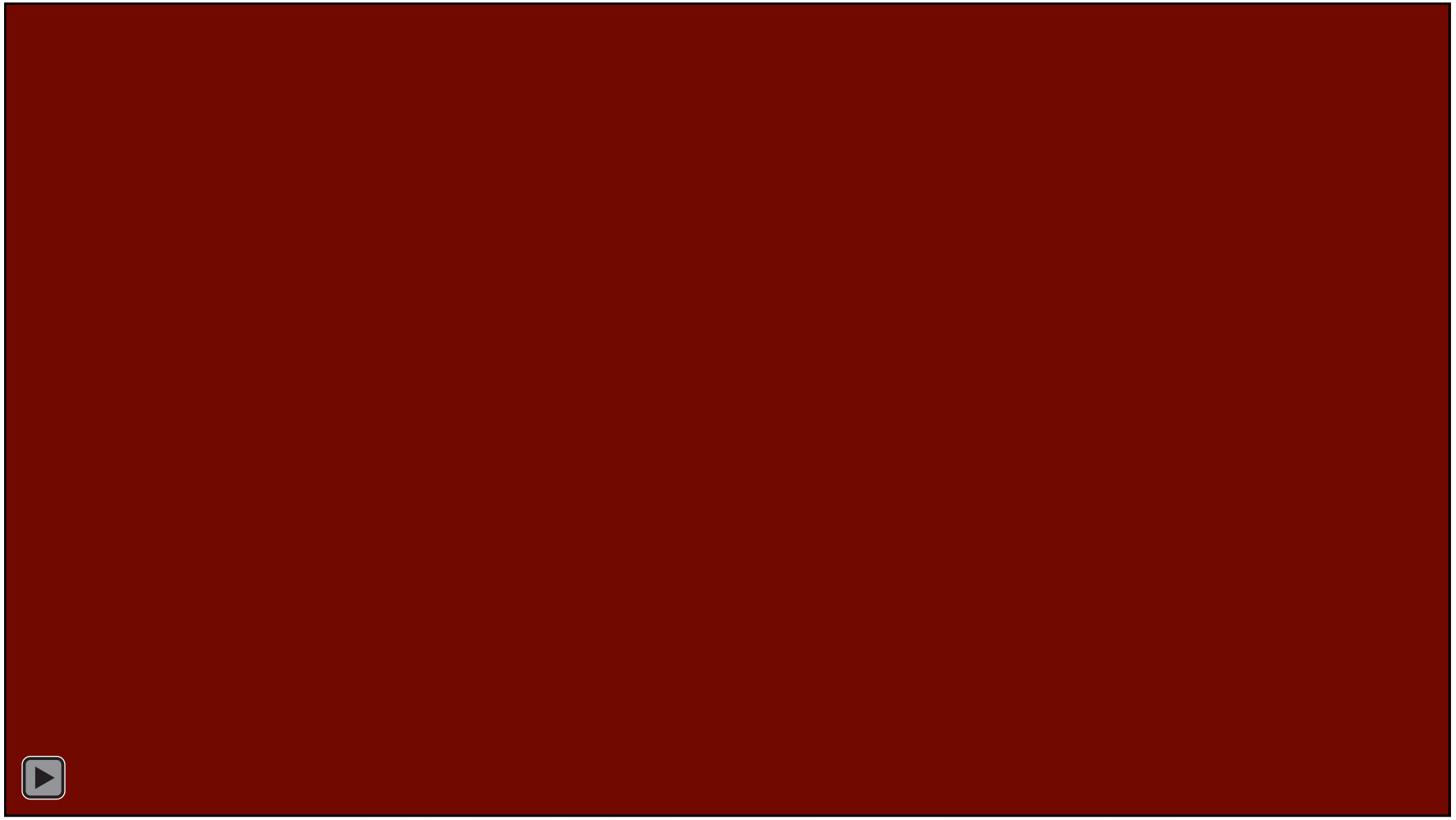
## bGen™ 3D animation



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# Power to Heat
## Grid Services

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## Power to Heat

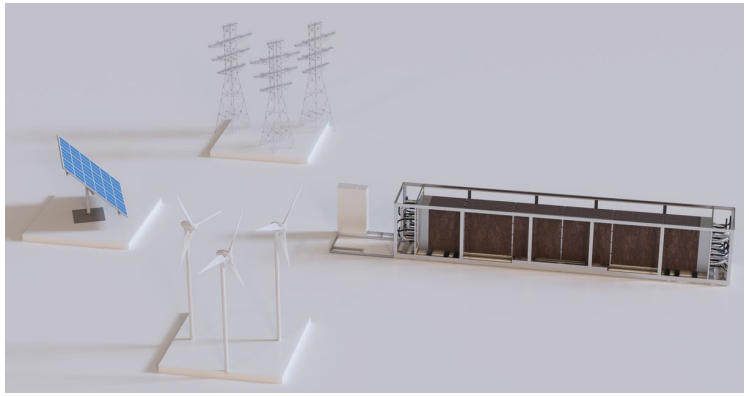
Charging

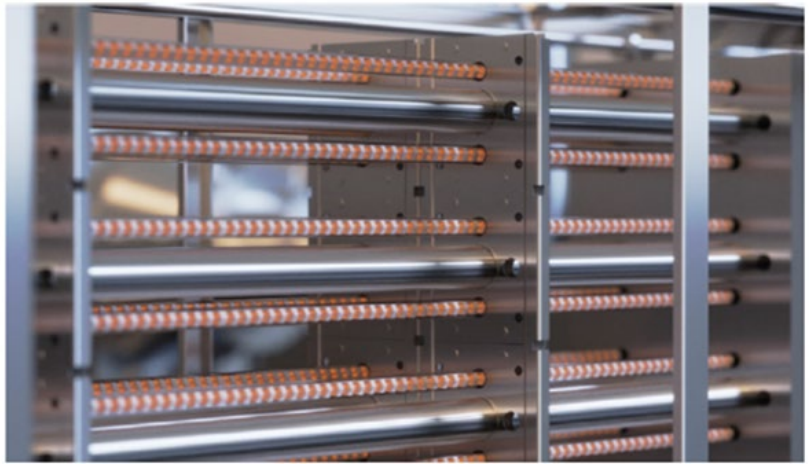
- Charging with Electricity from different sources:
  - PV or Wind
  - Grid (offpeak prices / PPA TES, …)
- Thermal storage temperature:  700 °C

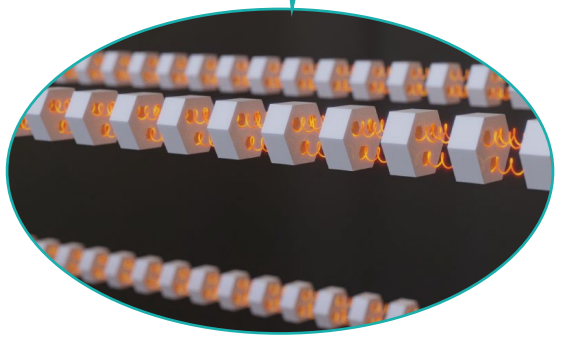
Discharging

- Steam discharging: up to 500 °C and 100 bar

Charging the bGen with electrical heaters







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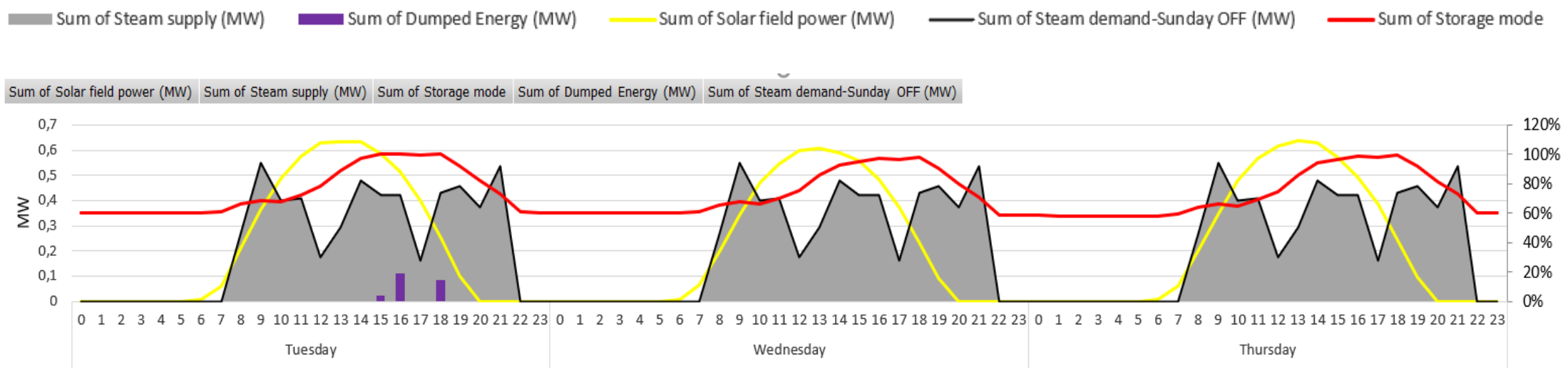
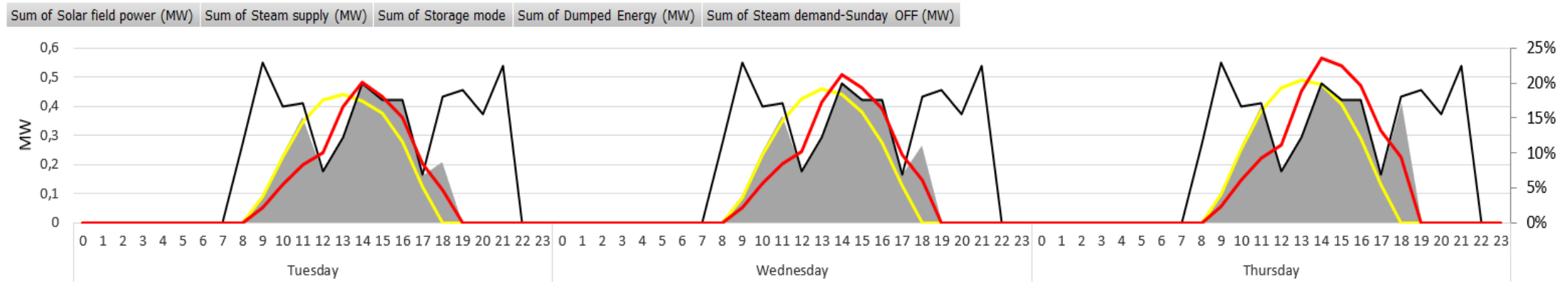
## Thermal energy storage from PV plant

SUMMER




WINTER



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**Thermal energy storage from Grid / Grid Services**

## Key principles

### TES Charging

- First priority - Negative aFRR balancing energy *
- Second priority - PPA TES profile
- Third priority - Grid off peak price

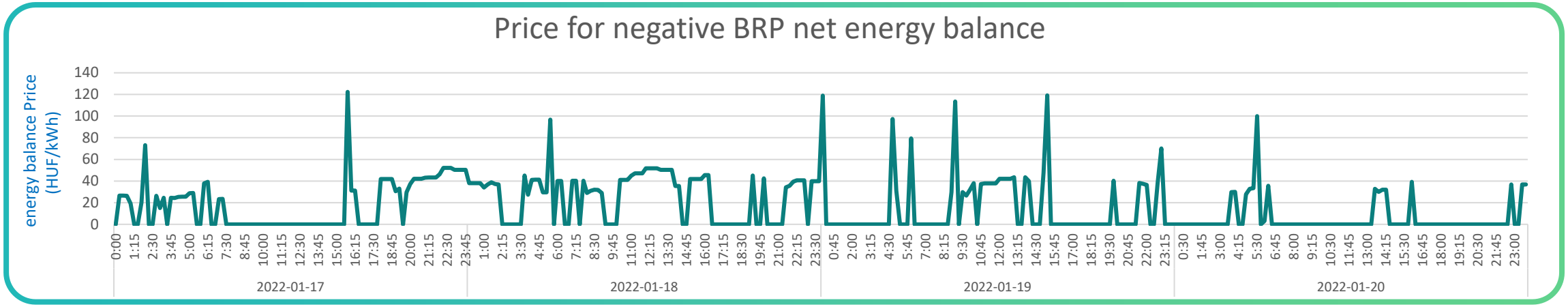
### TES Discharging

- Option a - Process steam for industry
- Option b - District Heating / Grid services

### Revenues

- Balancing capacity payments *
- Negative aFRR/FCR balancing energy *
- Sale of steam / hot water (NG + Emissions Saving)

[*] Not Spain



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**Thermal energy storage from Grid**

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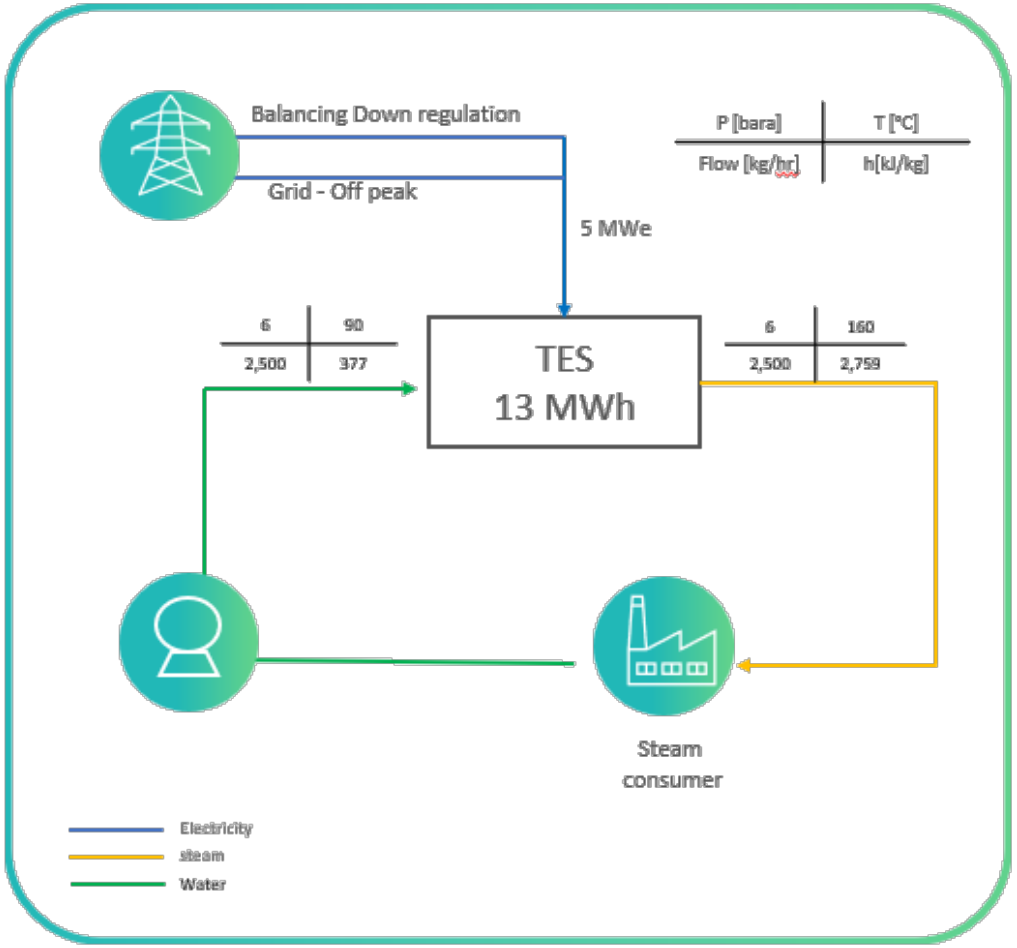
# Project in Hungary

## System Description

- Charging with electricity
- Supply 2 MW process steam
- Maximum charging power: 5 MW
- Storage Duration: 7 Hours



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# Reference projects

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## Reference projects

| PROJECT | LOCATION | SIZE | APPLICATION | CHARGE | DISCHARGE | STATUS | COD |
|---|---|---|---|---|---|---|---|
| **IDF** | Israel | 1 MWh | Heat to Heat | Flue Gases | Hot Water | Operation | 2020 |
| **Fortlev** | Brazil | 2 x 2 MWh | Heat to Heat | Biomass | Hot Air | Operation | 2021 |
| **NYPA** | USA | 1 MWh | Heat to Heat<br>Power to Heat | Flue Gases<br>Electricity | Hot Water | Operation | 2023 |
| **ENEL** | Italy | 23 MWh | Heat to Power | Steam | Steam | Commissioning | 2024 |
| **Tempo Beverage** | Israel | 32 MWh | Power to Heat | Electricity | Steam | Engineering | 2024 |
| **Wolfson Hospital** | Israel | 12 MWh | Power to Heat | Electricity | Steam | Engineering | 2024 |
| **13 MWh TES** | Hungary | 30 MWh | Power to Heat | Electricity | Steam | Development | 2024 |
| **SolWinHy Cadiz** | Spain | 55 MWh | Power to Heat | Electricity | Steam | Development | 2026 |

Technology Maturity Level - BRENMILLER: TRL 9 (1-9 levels. 27 MWh commercial plants in operation)

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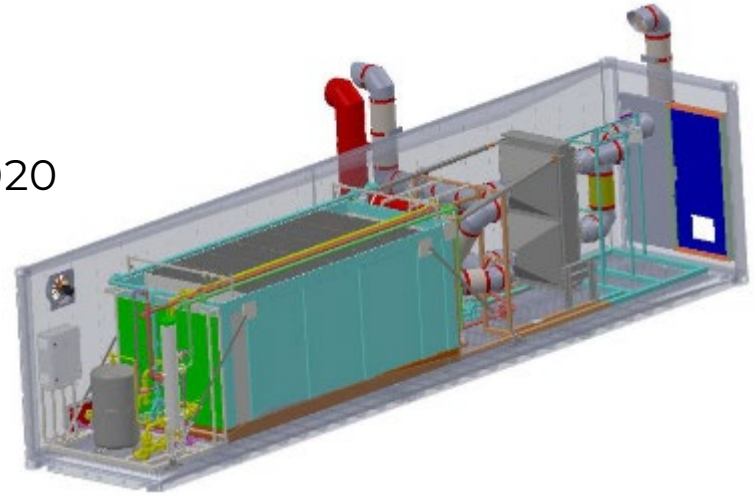
**Heat to Heat – From GenSet**

OPERATION

## NYPA IDF 1 MWh TES

- ✓ TES charged from diesel GenSet flue gases
- ✓ Delivers hot water on demand
- ✓ Annual diesel savings of 36 $m^3$
- ✓ Annual reduction of 112 Tons of $CO_2$
- ✓ Payback: 3 years
- ✓ Commissioned in June 2020



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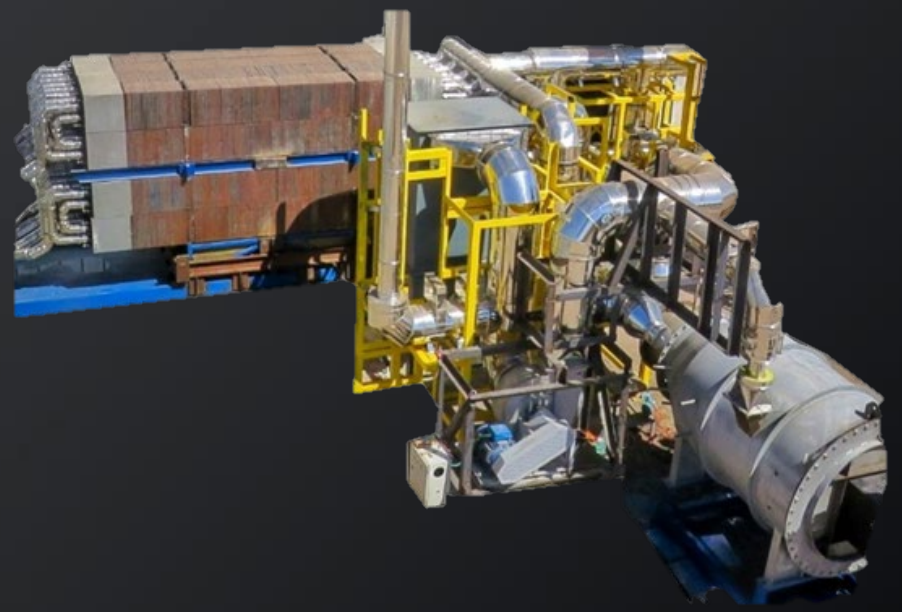
**Heat to Heat – From Biomass**

OPERATION



## FORTLEV 2 MWh TES

- ✓ TES charged from biomass combustion (wood chips)
- ✓ Delivers hot air at 300 ℃ on demand
- ✓ Thermal power: 300 kW
- ✓ 60% fuel savings, 100% emission reduction
- ✓ Payback: 4 years
- ✓ COD 2021

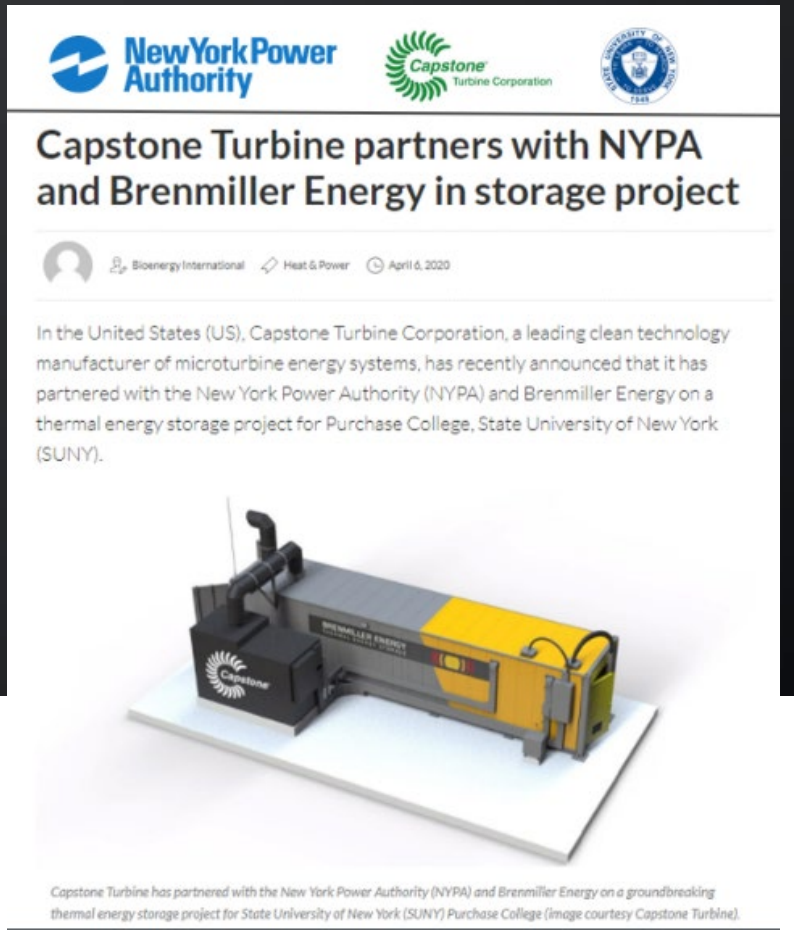
# Brenmiller Europe

**Heat to Heat – From Gas Turbine**

OPERATION

## NYPA 1 MWh TES

- ✓ Charged with flue gases from a gas turbine (GT 200 kW)
- ✓ Delivers hot water on demand
- ✓ 25% fuel savings and emissions reduction
- ✓ COD 2022



New York Power Authority · Capstone Turbine Corporation

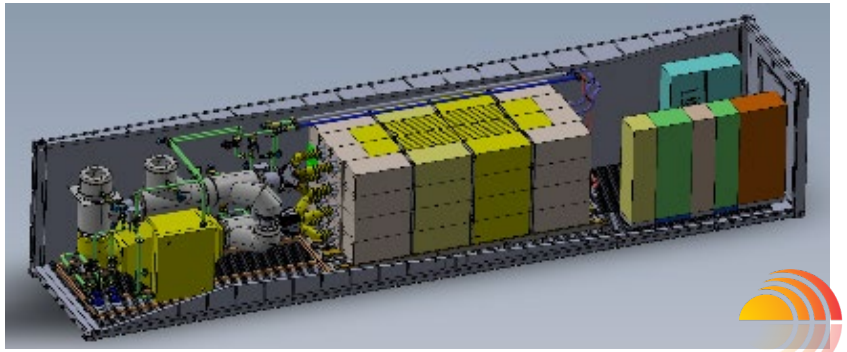
Capstone Turbine partners with NYPA and Brenmiller Energy in storage project

Bioenergy International · Heat & Power · April 6, 2020

In the United States (US), Capstone Turbine Corporation, a leading clean technology manufacturer of microturbine energy systems, has recently announced that it has partnered with the New York Power Authority (NYPA) and Brenmiller Energy on a thermal energy storage project for Purchase College, State University of New York (SUNY).




*Capstone Turbine has partnered with the New York Power Authority (NYPA) and Brenmiller Energy on a groundbreaking thermal energy storage project for State University of New York (SUNY) Purchase College (image courtesy Capstone Turbine).*



# Brenmiller Europe

**Heat to Heat – Combined Cycle Gas Turbine**

COMMISSIONING

## ENEL 23 MWh TES

- ✓ Energy shifting
  - ✓ Charged with excess steam at hours with low electricity prices
  - ✓ Delivers steam at hours with high electricity prices
- ✓ Increasing maximum load and reducing minimum load
- ✓ Optimizing revenue streams & ancillary services
- ✓ Reducing ramp-up time
- ✓ Charging Steam: 9 427 kg/h, 550 °C → 295 °C, 80 bar
- ✓ Discharging Steam: 6 600 kg/h, 150 °C → 360 °C, 30 bar

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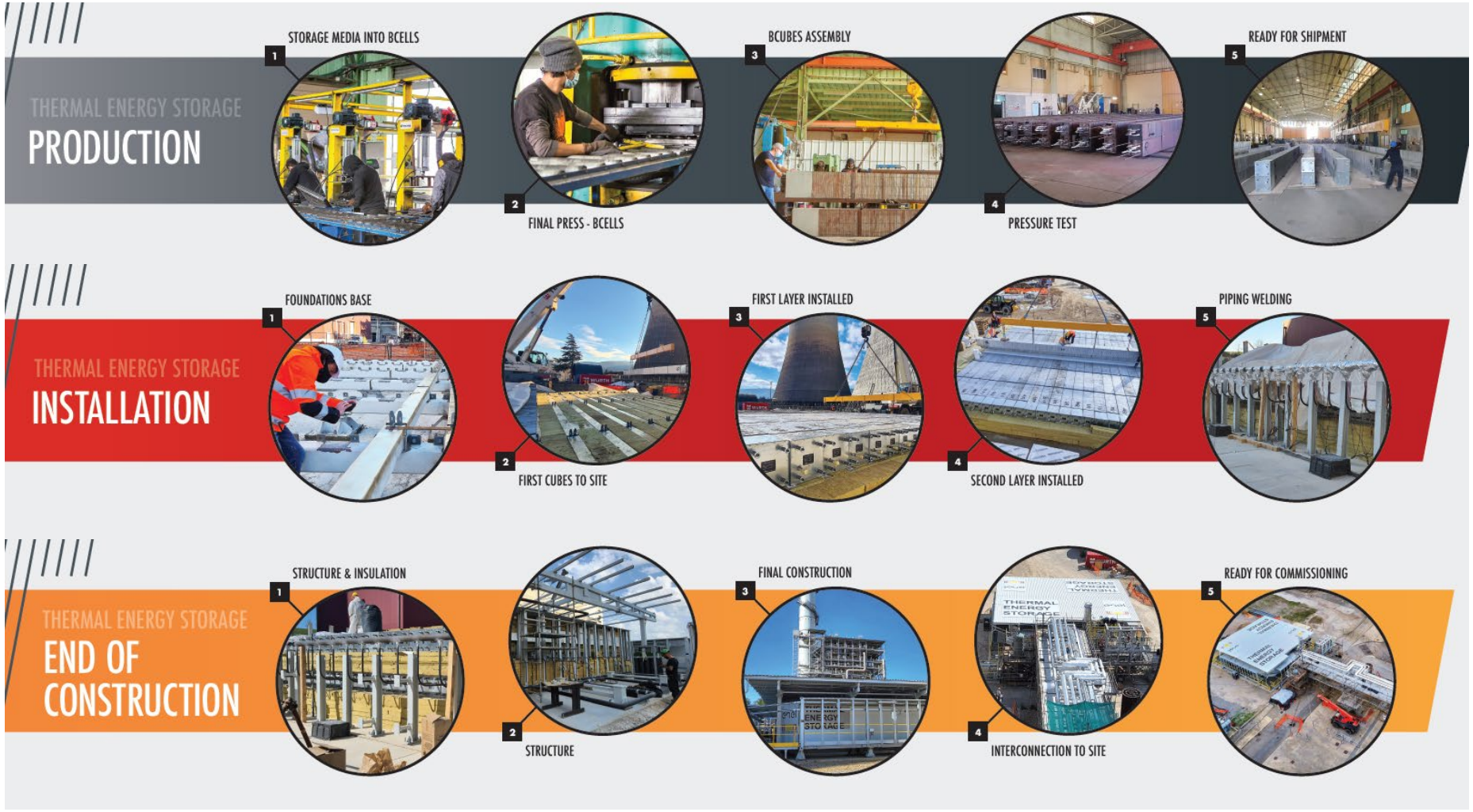
## ENEL 23 MWh TES



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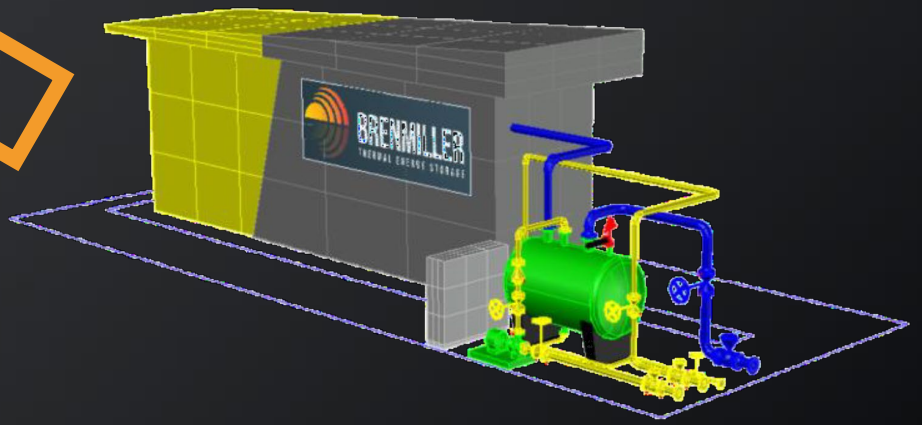
**Power to Heat – Industry decarbonization**

ENGINEERING




## Tempo Beverage (Israel) - 32 MWh TES

- ✓ Tempo Beverage Company, Netanya (owned by Heineken)
- ✓ TES will supply base load and peaks process steam
- ✓ Charged with 5.6 MWe from the grid (off-peak prices) and PV sources
- ✓ Discharge max steam flow of 14 tn/h at 7 bara and 168 °C
- ✓ Dimensions (L x W x H): 13 x 5 x 6 meters
- ✓ TES will replace 85 % of current fossil fuel burning
- ✓ Eliminate 6,200 tn CO2eq emissions anually
- ✓ Implementation of Energy Service Company (ESCO) mode
- ✓ Expected cost savings of $7.5 million for Tempo over the span of 15 years

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**Power to Heat – Real Estates decarbonization**

ENGINEERING

Wolfson Children's Hospital

## Wolfson Hospital, Hulon (Israel) - 12 MWh TES

- ✓ TES will supply steam for the use of the hospital
- ✓ TES charged with electricity from the grid (off-peak prices)
- ✓ TES expected to eliminate 95 % of local GHG in the city center
- ✓ Existing boiler will be downsized to use for back-up purposes only
- ✓ Integration with existing steam distribution infrastructure
- ✓ 20-40% reduction in the price for each ton of steam produced
- ✓ System implemented under Energy Service Company (ESCO) model

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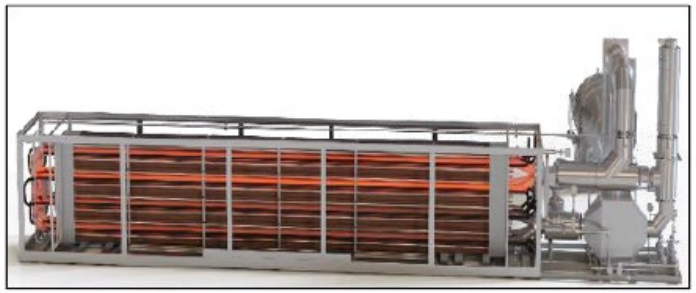

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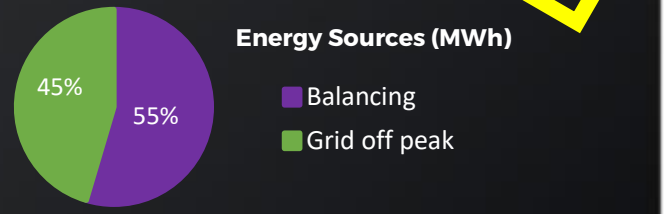
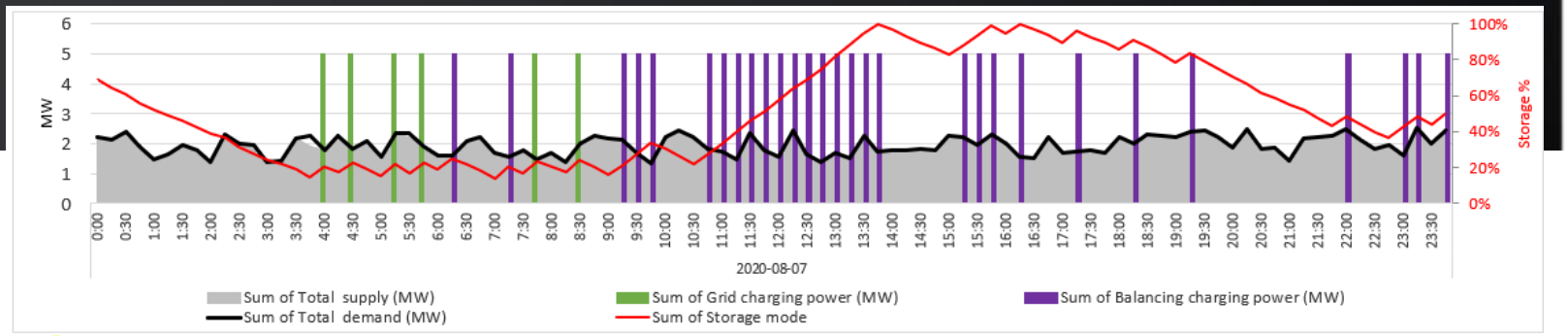
**Power to Heat - Industry decarbonization (Grid Services)**

DEVELOPMENT

## HUNGARY 13 MWh TES

- ✓ TES charged with negative aFRR/FCR balancing energy
- ✓ Grid off peak price

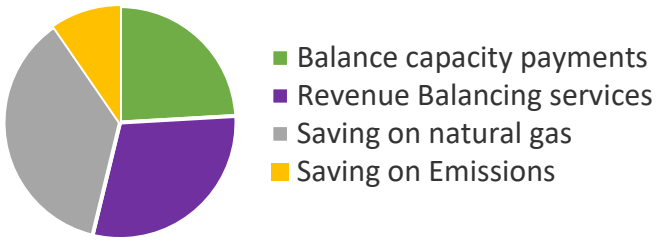


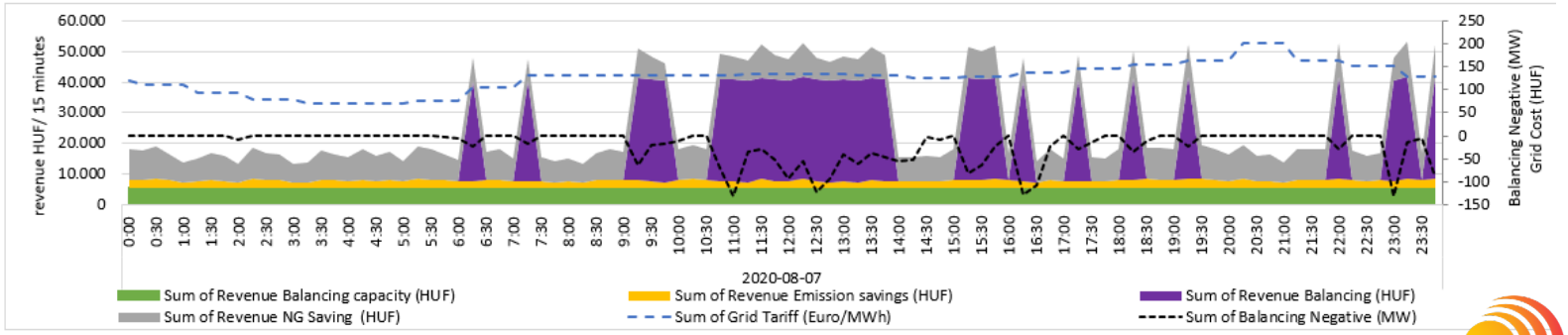




## Key Results

| | | |
|---|---|---|
| Annual production | 16,800 | MWh |
| Annual production Steam | 21,921 | Ton |

### Revenue Break down



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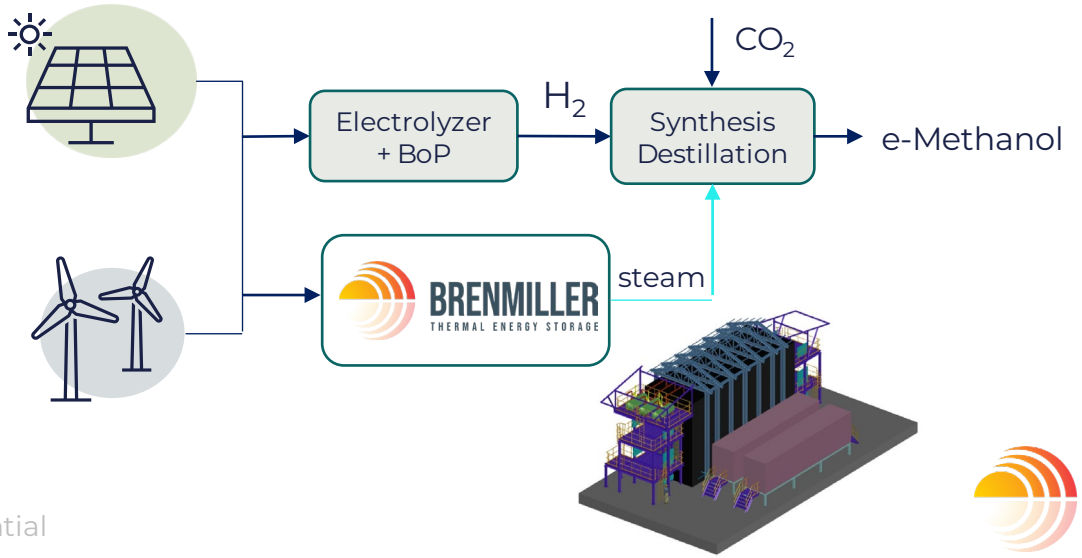
**Power to Heat – Green Hydrogen / e-Methanol Plant**


## SolWinHy Cádiz (Spain) - 55 MWh TES

- ✓ Green hydrogen and e-methanol plant - COD in 2026
- ✓ Process Plant disconnected from the grid
- ✓ TES will supply steam required for methanol distillation
- ✓ Possible to charge the TES with excess energy (daytime) and discharge steam 24/7 at partial loads
- ✓ Charge: 8.6 MWe from the PV+Wind excess energy
- ✓ Discharge: max steam flow 8.5 ton/h at 6 bara and 160 °C
- ✓ Dimensions (L x W x H): 15 x 6 x 8 meters



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**Contact information**

# Thank you

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