



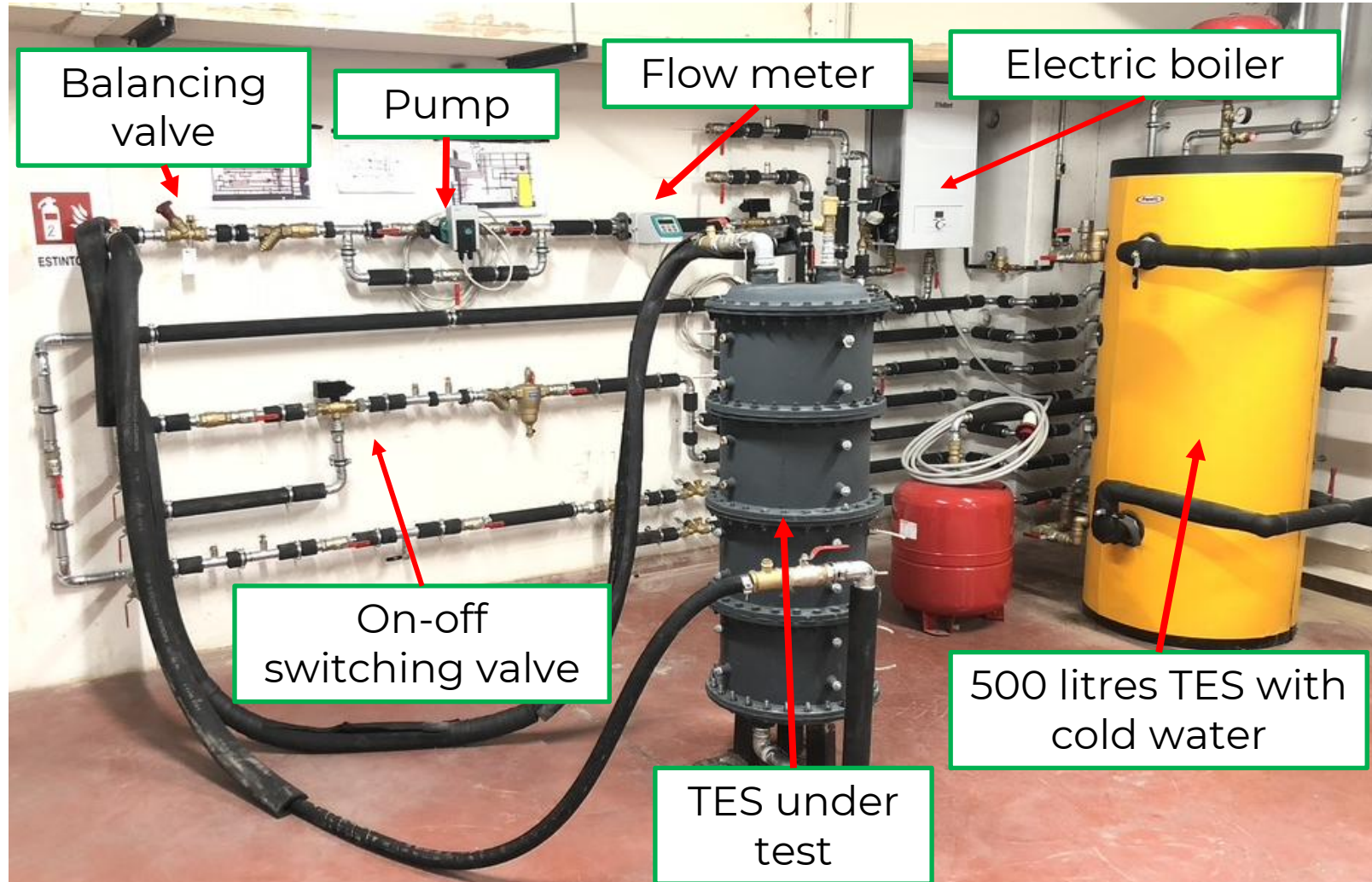
SVILUPPO E INTEGRAZIONE DI ACCUMULI INNOVATIVI NELLE COMUNITÀ ENERGETICHE RINNOVABILI

3° Meeting avanzamento progetto, 16 Settembre 2025

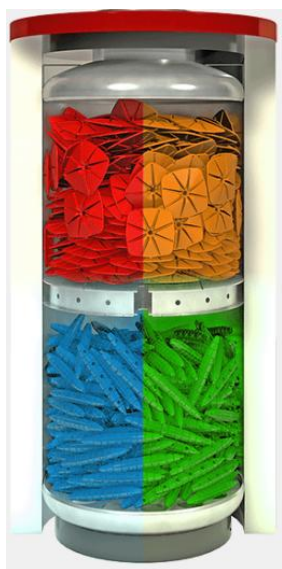
Stato di avanzamento WP3

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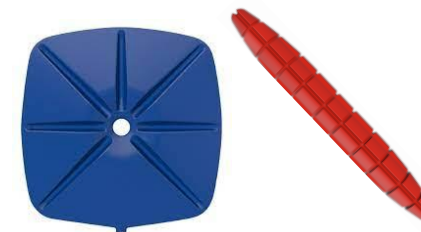
Test rig for the study of STES and LTES systems in several operating conditions



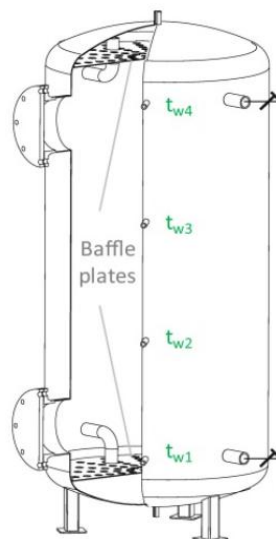
- Identification of Phase Change Materials (PCM) suitable for the development of thermal storage tanks: **ATS50** and **ATS31** (inorganic salts from Axiotherm, high performance);



- Purchase of new macro-encapsulated PCM modules (**HeatSel** and **HeatStixx L** from **kraftBoxx GmbH**);

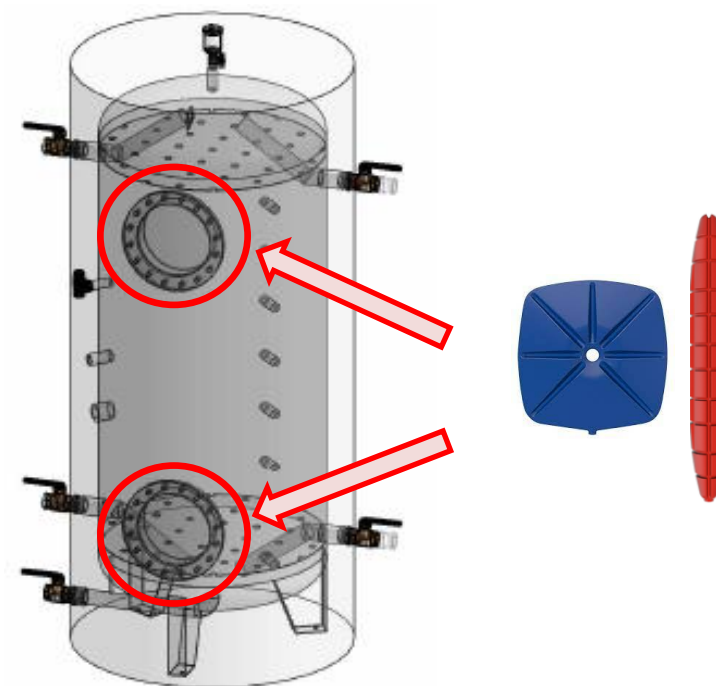
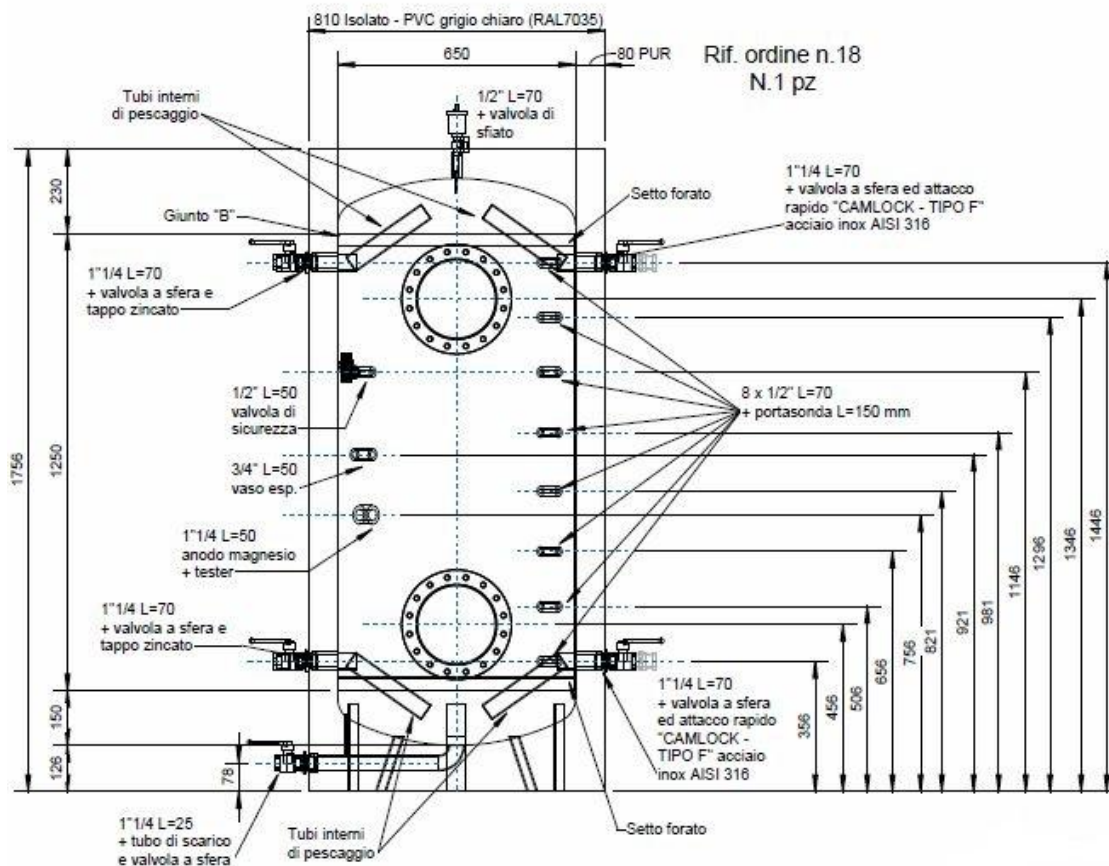


- Literature review to define the best operating conditions for experimental tests to assess the performance of the storage system;



- Design and development of a 500-litre latent thermal storage prototype with **Pacetti Srl**: definition of technical characteristics.

500-litre latent thermal storage prototype from **Pacetti Srl**

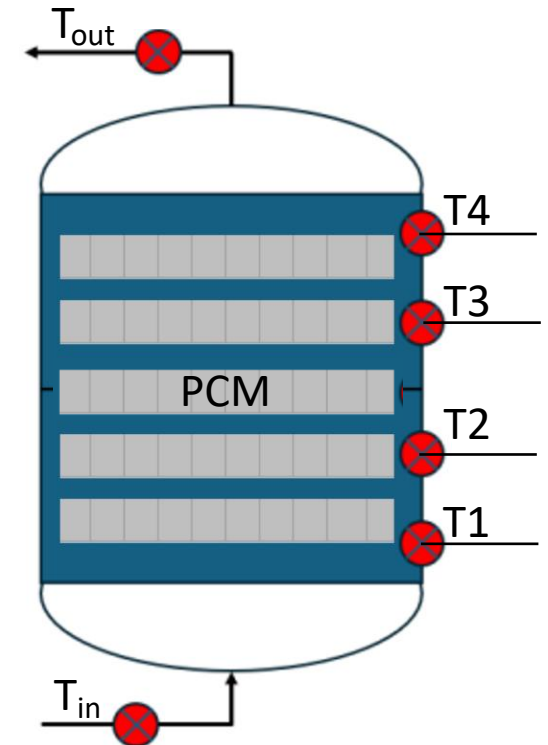


3D View - Vista 3D

Design and testing of a first latent thermal energy storage prototype

The PCM is embedded within an innovative polypropylene macro-encapsulation system, the **HeatSel**. The tank was loaded with **56 HeatSel modules**.

Parameter	Unit	Value
Dimensions	mm	185×185×32
V_out HeatSel	l	0.4
Weight PCM HeatSel	kg	0.47
Number of HeatSel	-	56
%mass filling	-	42
%vol filling	-	36



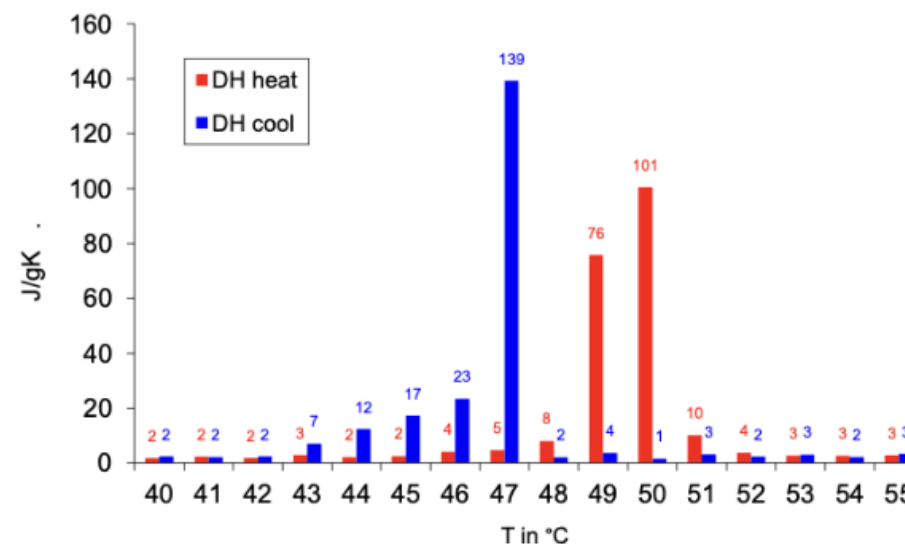
Design and testing of a first latent thermal energy storage prototype

Development of a **62-litre modular LTES** prototype filled with **water** and **macro-encapsulated PCM modules**. Thermal insulation layer: 5 cm of glass wool



ATS50

Hydrated salt, from Axiotherm GmbH



Melting range [°C]	Solidification range [°C]	Specific heat capacity [kJ/(kg*K)]	Heat storing capacity [kJ/kg]	Thermal conductivity [W/(m*K)]
49-50	43-47	3	228	0.6

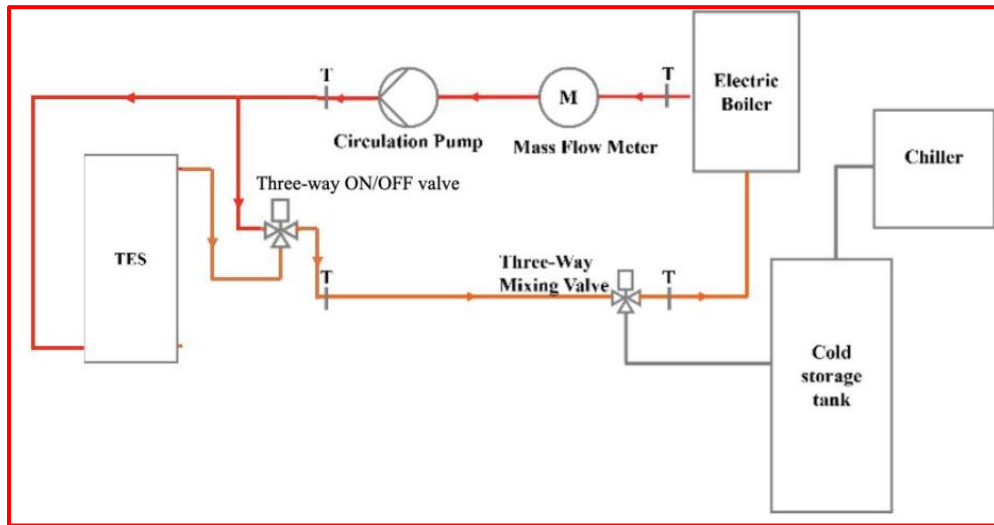
Test Methodology

Analysis of the **thermal performance of the LTES during the discharging process** and **comparison with an equivalent STES** (same tank filled with water only):

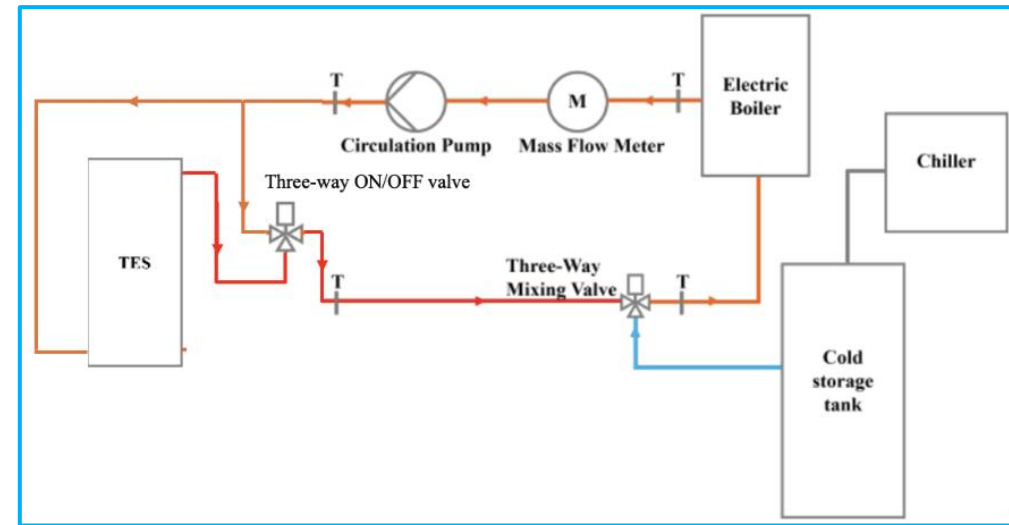
- 1) The TES is charged previously with hot water at T_0
- 2) The TES is discharged with chilled water at T_{in}
- 3) Discharge process concluded when $T_{TES} = T_{in}$

- Four values of the water mass flow rate:
- **30 kg/hr** (0.32 vol/hr)
 - **60 kg/hr** (0.97 vol/hr)
 - **90 kg/hr** (0.32 vol/hr)
 - **180 kg/hr** (0.97 vol/hr)

- $T_0 = T_{sup_PCM} + \Delta T$
 $T_{in} = T_{inf_PCM} - \Delta T$
 Two ΔT considered:
- **5 K**
 - **10 K**

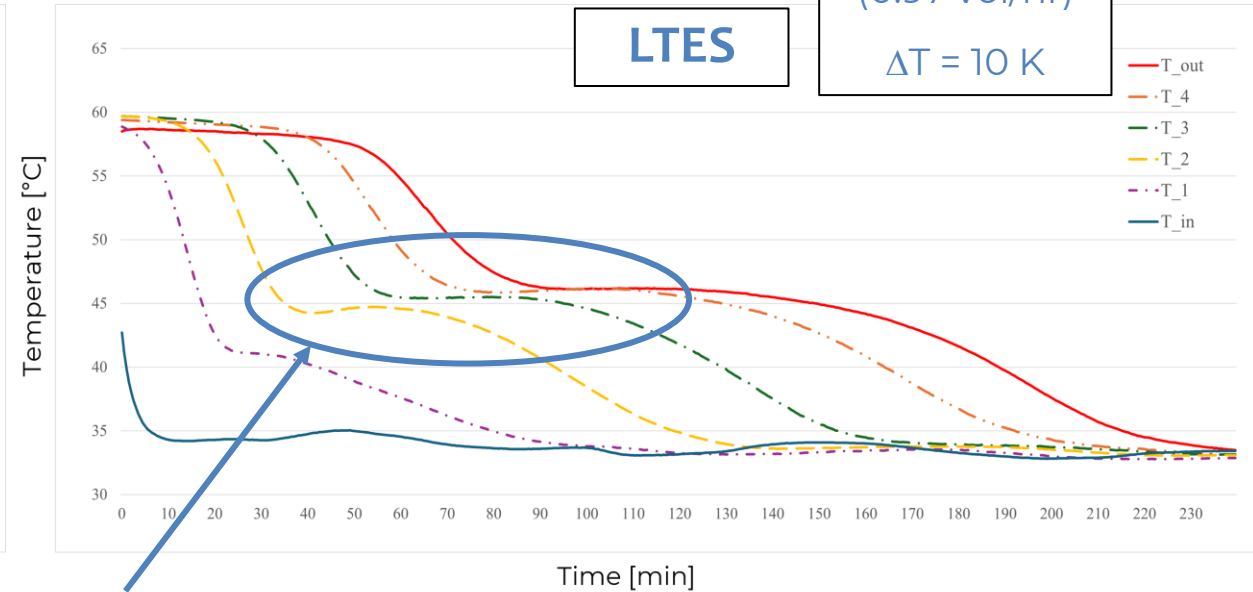
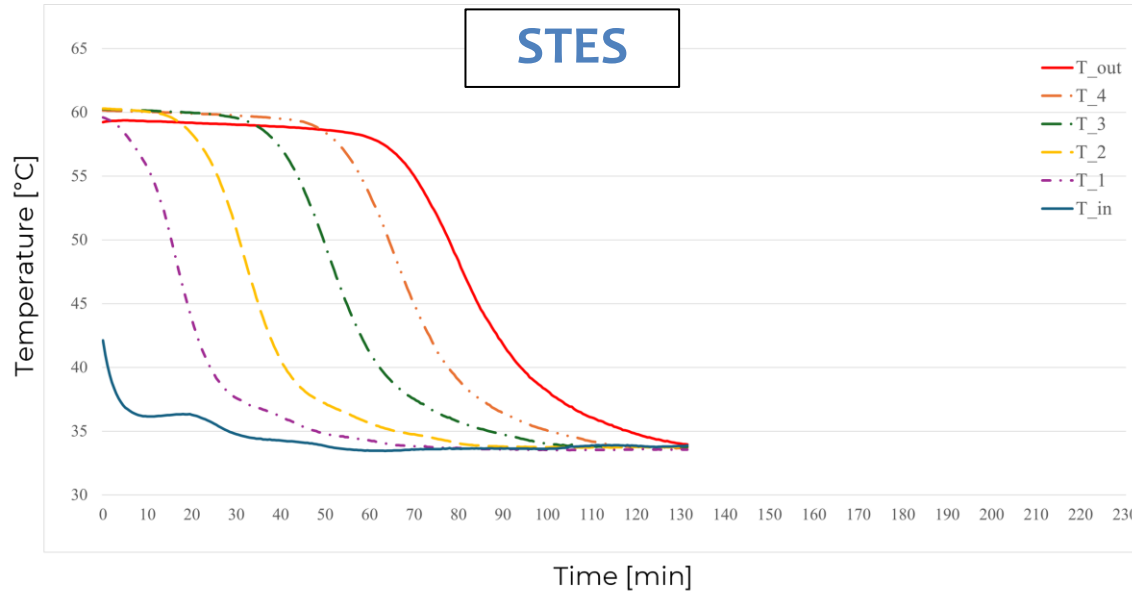


Charging process



Discharging process

Discussion of the preliminary results



A plateau within the PCM solidification range (43-47 °C)

- Thermal energy released
- Average heat transfer rate
- Discharge process duration

$$Q_{TOT,D} = \int_{t_{start}}^{t_{end}} \dot{m} c_p (T_{in} - T_{out}) dt$$

$$\dot{Q}_{TOT,D} = \frac{Q_{TOT,D}}{\Delta t_D}$$

$$\Delta t_D = t_{end,D} - t_{start,D}$$

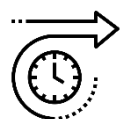
	Δt_D [min]	$Q_{TOT,D}$ [kWh] (±12.3%)	$\dot{Q}_{TOT,D}$ [W] (±12.3%)
STES	132	2.4	1098
LTES	240 (+82%)	3.6 (+50%)	902 (-18%)

Discussion of the preliminary results

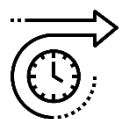
$\Delta T = 10\text{ K}$							$\Delta T = 5\text{ K}$						
HTF Mass flow rate [kg/hr]	Δt_D [min]		$Q_{TOT,D}$ [kWh] ($\pm 12.3\%$)		$\dot{Q}_{TOT,D}$ [W] ($\pm 12.3\%$)		HTF Mass flow rate [kg/hr]	Δt_D [min]		$Q_{TOT,D}$ [kWh] ($\pm 12.3\%$)		$\dot{Q}_{TOT,D}$ [W] ($\pm 12.3\%$)	
	STES	LTES	STES	LTES	STES	LTES		STES	LTES	STES	LTES	STES	LTES
30	248	377 (+52%)	2.3	3.3 (+41%)	566	524 (-7%)	30	187	393 (+111%)	1.3	2.5 (+88%)	424	379 (-11%)
60	132	240 (+82%)	2.4	3.6 (+50%)	1098	902 (-18%)	60	114	256 (+125%)	1.5	2.7 (+75%)	801	623 (-22%)
90	100	188 (+89%)	2.5	3.7 (+49%)	1485	1174 (-21%)	90	76	193 (+153%)	1.6	2.8 (+77%)	1235	863 (-30%)
180	58	116 (+102%)	2.5	3.8 (+50%)	2648	1967 (-26%)	180	53	120 (+129%)	1.7	2.9 (+71%)	1910	1428 (-25%)

- The PCM ability to store both sensible and latent heat strongly influences the system thermal performance
- The thermal energy released increases up to 88% if a LTES is considered
- The discharging time increases up to 150% longer, but in the best-case scenario the average heat transfer rate decreases by only 11%

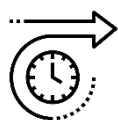
The next steps involve:



Definition of the parameters useful for the development of the tool



New tests will be conducted to simulate **the thermal charging and discharging cycles** typical of a Renewable Energy Community and to investigate the influence of the Heat Transfer Fluid operating conditions



Analysis of the new 500-litre thermal storage tank prototype, with the capability to study different configurations (e.g., different PCMs at different heights), better thermal insulation