USES4HEAT

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Mapping the ground beneath the greenhouse

Baseline, monitoring plan and basic engineering for the USES4HEAT seasonal heat storage demonstrator in Andel, the Netherlands

How do you heat about 12 hectares of orchid greenhouse without natural gas? USES4HEAT's answer is to store the heat of summer underground, in an aquifer thermal energy storage (ATES), and use it in winter. The project's baseline report, led by Fondazione Bruno Kessler (FBK), is the first step: it describes the climate, the underground, the technical design and the permit path of the Andel demonstrator, and sets the baseline against which the project will be measured.

A new home for the demonstrator

The baseline report updates an earlier version from December 2024, which was written for the original demonstration site in Riva del Garda (Italy). The demonstrator is now in Andel, a village in the municipality of Altena, in Noord-Brabant, a province with a strong food and ornamental-plant sector. Most of its greenhouses still rely on natural gas boilers or combined heat and power (CHP) units, while taxation on gas keeps increasing to push users towards low-carbon heat.

The host is Butterfly Orchids. Its existing 3.5 ha greenhouse runs on gas boilers, CHP, heat pumps and a low-temperature ATES (5–25 °C) with four wells, with PV panels for LED lighting. It is also connected to a nearby swimming pool. The company will add 12 ha of greenhouse with no gas connection, interconnected with the existing one by a pipeline, about 400 m from the village.

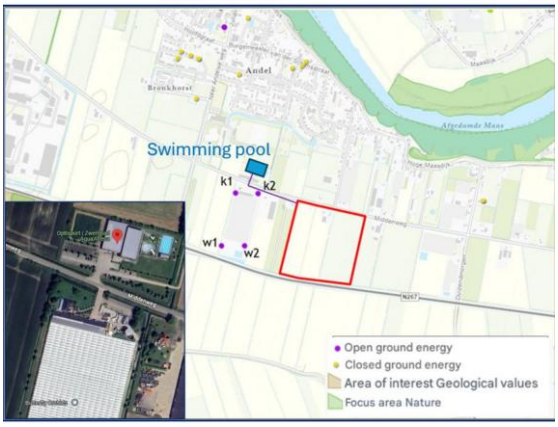

Figure 1. *The demo area in Andel: the new greenhouse (red), the existing greenhouse, the swimming pool and the existing LT-ATES wells (k1, k2, w1, w2). Source: USES4HEAT baseline report.*

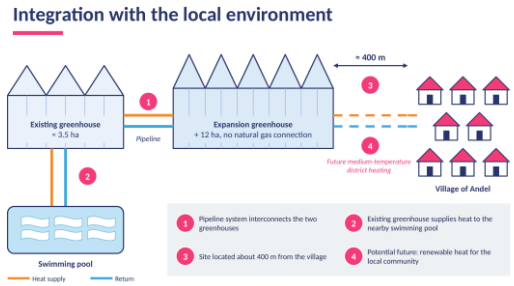

Figure 2. *Integration of the demonstrator with its local environment: the existing and new greenhouses, the swimming pool and the village of Andel.*

Figure 3. *Orchid cultivation inside the greenhouse.*

Heat in winter, sun in summer

Andel has a temperate oceanic climate (Cfb). From October to April the average temperature stays below 15 °C, while summers are mild with occasional peaks above 30 °C that call for cooling. Heating degree days, a standard measure of heating demand, fell from 2,774 in 2021 to 2,349 in 2024, with an average of about 2,475, whereas the equivalent measure for cooling is marginal.

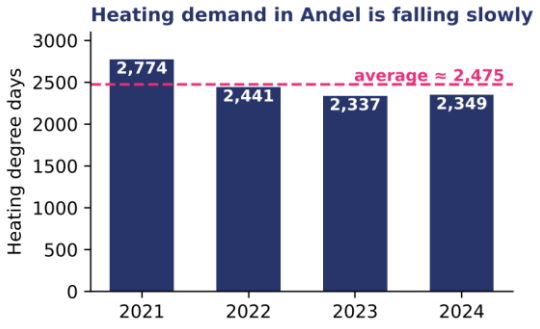

Figure 4. *Heating degree days in Andel, 2021–2024 (base temperature 18 °C). Source: USES4HEAT baseline report.*

The sun supplies the opposite profile. Peak irradiance exceeds 800 W/m² in June and July, and monthly irradiation passes 100 kWh/m² from April to September, reaching about 180, 200 and 190 kWh/m² in May, June and July. This mismatch between summer supply and winter demand is the case for seasonal storage.

Figure 5. *Monthly solar irradiation in Andel, 2021–2024, with the average in red. Source: USES4HEAT baseline report.*

What lies below

Two test drillings, one in the future warm-well area and one in the cold-well area, characterised the subsurface and gave the input for well design and for the permit request. Below an 8 m clay top layer lie sand aquifers separated by clay layers down to a sandy-clay base at about 120 m. The natural groundwater is at 12 °C and flows southeast at about 18 m per year.

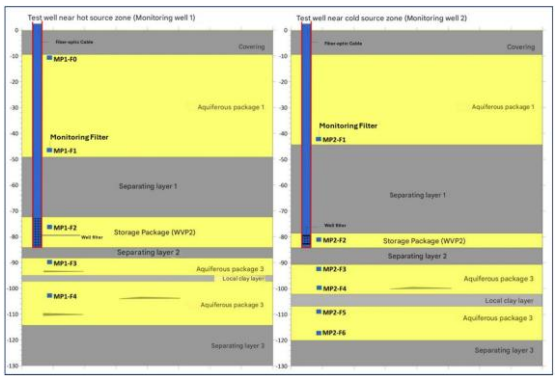

Figure 6. *Underground layers at the two test wells (warm zone, left; cold zone, right). Aquifers in yellow, clay separating layers in grey. Source: USES4HEAT baseline report.*

The target storage package lies at 72–84 m below the surface at the warm cluster (about 12 m thick) and at 79–84 m at the cold cluster (about 5 m thick). Fresh groundwater ends at about 125 m, where brackish water begins.

Why store heat now?

Renewable electricity made up about 53% of Dutch generation in 2024, but grid congestion persists, especially in winter, and electricity prices can be up to 100% higher than in summer. The USES4HEAT concept turns this into an advantage: heat pumps run when electricity is cheaper and the heat is stored for winter.

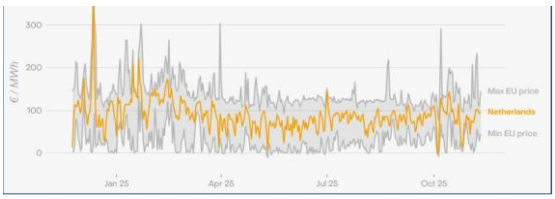

Figure 7. *Wholesale day-ahead electricity prices in the Netherlands, November 2024 to November 2025. Source: USES4HEAT baseline report (EMBER).*

In summer (about May to November) heat is taken from the greenhouse and from surface water, lifted by heat pumps to about 50 °C (up to 55 °C) and injected into the warm wells, together with PVT heat. In winter the warm wells supply the greenhouse directly or through the heat pumps, and the cooled water returns to the cold wells.

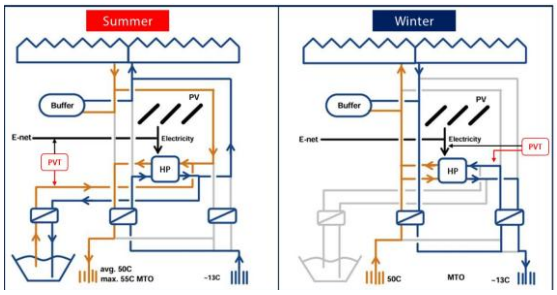

Figure 8. *Energy system in summer (left) and winter (right). Source: USES4HEAT baseline report.*

The storage: four warm wells, six cold wells

The medium-temperature ATES (MT-ATES) is an open-loop groundwater system with a warm zone of four wells, spaced about 20 m apart in the southeast corner of the site beside the technical room, and a cold zone of six wells, about 11 m apart, in the northwest corner. The two clusters are kept apart by about three times the radius of the heated zone, to preserve the cold source.

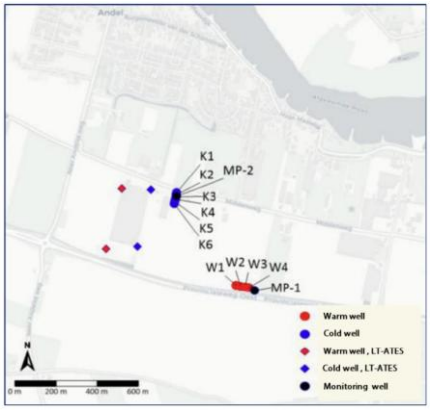

Figure 9. *Planned warm (red), cold (blue) and monitoring (black) wells, with the existing LT-ATES wells. Source: USES4HEAT baseline report.*

Boreholes will be 90 m deep and 500 mm wide, with a soil sample taken every metre during drilling. The warm wells have a 280 mm liner and a stainless-steel filter at 73–83 m; the cold wells have a 250 mm PVC liner and a filter at 80–83 m. Each borehole also holds three observation wells (piezometers) to monitor groundwater above, below and in the storage aquifer.

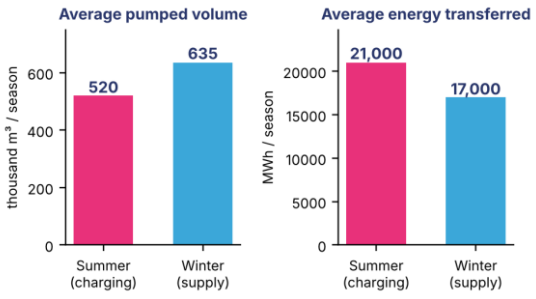

Figure 10. *Design water volume and energy transferred per season (average). Source: USES4HEAT baseline report.*

At up to 390 m³/h, the system is designed to transfer about 21,000 MWh per summer and 17,000 MWh per winter. A

study by IF Technology expects a thermal recovery efficiency of about 40% in the first five years, rising progressively to about 60% by the tenth cycle as the aquifer warms up.

Heat pumps with a low-GWP refrigerant

The HIREF XVA1281W DX units (1.5 MW each) use refrigerant R515B, which has a low global warming potential (GWP 299). Two units are connected in series on the user side and in parallel on the source side, so each system delivers 3 MW; the project has two such systems, 6 MW in total. In summer the heat pump cools the greenhouse and sends the excess heat to the storage; in winter it draws on the warm zone, whose water is much warmer than natural groundwater, which raises its efficiency (the coefficient of performance, COP, is the heat delivered per unit of electricity).

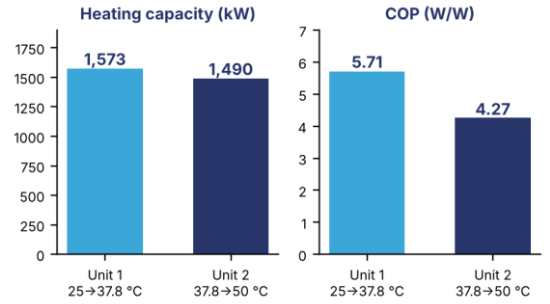

Figure 11. *Preliminary simulation of the two units in series under worst-case winter conditions (source 12/6 °C). Source: USES4HEAT baseline report.*

Figure 12. *Heat pump unit: control cabinet.*

Figure 13. *Heat pump units with members of the project team.*

Solar panels that make power and heat

ENDEF will install hybrid photovoltaic-thermal (PVT) panels, which produce electricity and heat, on the south-facing half (855 m²) of the 1,710 m² roof of the technical building. The first layout has 120 collectors in 5 rows of 24, each 2.7 m² and 600 W, for 72 kW and 324 m² of solar area. They sit on a 30° structure (40° final tilt), spaced to guarantee at least four hours of unshaded winter sun. With 63.6 kg per collector, the extra roof load is only 8.9 kg/m².

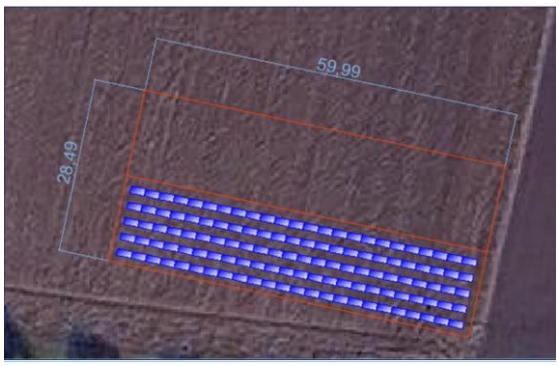

Figure 14. *Top view of the planned PVT field on the roof of the technical room. Source: USES4HEAT baseline report.*

Preliminary simulations estimate 74,484 kWh of electricity per year at Andel, peaking at 11,180 kWh in June. Electrical connection is planned through two Huawei SUN2000-36KTL-M3 inverters, with 15 panels per string.

Figure 15. *Monthly electricity production of the PVT field. Source: USES4HEAT baseline report.*

The permit: three deviations

Groundwater energy rules in North Brabant allow ATES at 5–25 °C and to a maximum well depth of 80 m. The MT-ATES exceeds these limits, so a special permit is needed for three deviations: storage up to 55 °C, full perforation of the storage layer beyond 80 m (otherwise injection rates in the thin cold aquifer would fall), and injecting more heat than is recovered in the first years. Simulations show a surplus of about 250% at first, falling to about 170% after ten years.

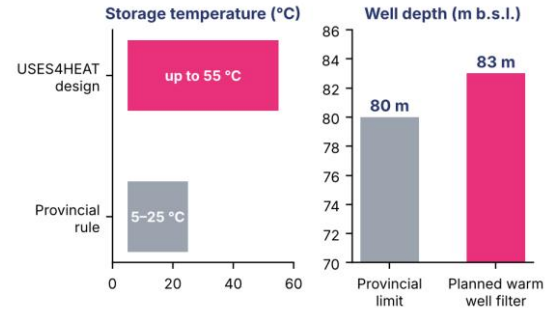

Figure 16. *Current provincial limits compared with the MT-ATES design. Source: USES4HEAT baseline report.*

The environmental and risk assessments and monitoring plan were reported to the authority, and its feedback was positive. The demonstrator will also inform policy for MT-ATES in the Netherlands and across Europe.

Risks and next steps

The report reviews thirteen project risks, from procurement and permits to heat pump performance, and rates all of them as low, with mitigation measures. Because the heat pump and PVT technologies are

modular, the concept can be demonstrated even if one technology underperforms.

The report is the reference for the next phases: the development of the technologies and then the construction and operation of the demonstrator. Next come final design of the wells and surface installation, drilling, installation of the heat pumps and PVT field, and integrated operation.

The report was prepared by FBK with DTESS, IF, ANDEL, HIREF, ENDEF, Energenius, AGS, Hydra, UNIGE and KTH within the USES4HEAT project.
More information: www.uses4heat.eu

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