What is WKO?

In order to limit CO_2 emissions, reduce energy costs, and ultimately reduce 95% natural gas use, Wageningen University & Research has commissioned the construction of a **Heat and Cold Storage** (WKO) with associated wells and loops. Meanwhile, the construction of the heat and cold storage wells and induction loop by Heijmans and Haitjema is in full swing.

But how does such Heat and Cold Storage work? Why do the wells need to be drilled so deep? Can a well run out? And is it groundwater or tap water that we pump around? We asked Sjaak ter Brugge, project leader at Facility Services of WUR who, as part of his Energy Advisor REA (Register Energy Advisor) training, wrote a thesis including a business case for a thermal storage system for campus North. This WKO plan has been further developed into a campus-wide WKO induction loop and wells. As a result of this, the final go was given for the construction.

Heating and cooling

There will soon be a total of 18 interconnected **wells** spread over the campus, **nine** of which are **hot** and **nine cold**. These are a kind of batteries, where we store heat or cold deep underground. In fact, we store heat or cold released from buildings for reuse, instead of blowing it away into the air.

We pump reletavely hot water up to the building when there is a need for heat. The water temperature of the hot well is between 14 and 16 degrees Celsius. The building has a heat exchanger (counter-flow device, **TSA**), which transfers the heat from the groundwater to the water in the internal building installation. This transports the hot water to a heat pump. This pump then extracts the heat and thereby cools the water back to about 5 degrees (our kitchen refrigerator uses the similar principle; however, that heat is lost in the kitchen). The heat pump thus boosts the water to a temperature of approximately 55 degrees for heating the building. The cooled water flows back to the TSA, which in turn pumps it back into the cold well.

As soon as there is a need for cooling, the process runs in the opposite direction. We then pump up the water from the cold well at 7-8 degrees and pass it on to the building systems via the TSA. As a result, the building gives off heat to the cold water, which increases in temperature to approximately 17 degrees. This is then pumped back to the hot well via the TSA. Thus the heat pump is not needed in this circulation process.

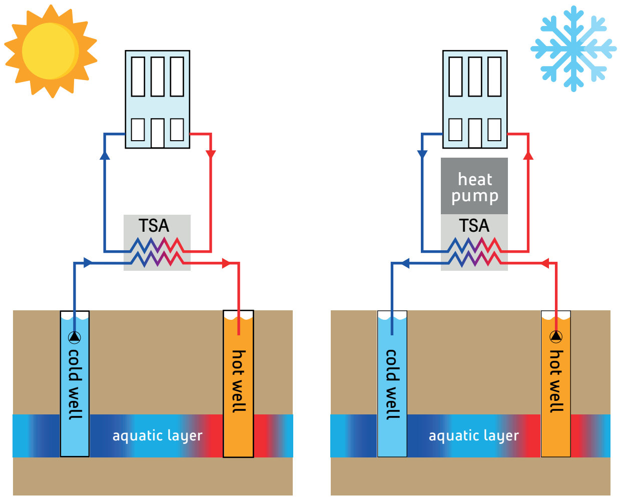


Fig. 1 Schematic presentation of a WKO system.

Deep wells

The wells are located deep underground, at approximately 90 m. At that depth you are no longer in the **upper aquifer**. In the deeper (second or third) aquifers, the water hardly moves, only about 1 m per year. This makes this layer very suitable for hot or cold water storage. We create a bubble with a diameter of about 50 m with hot or cold water. The normal groundwater temperature is about 12 degrees, but we store water of about 6 degrees in the cold well and about 17 degrees in the hot well. Although the movement of the water is minimal, there is a risk that the water will move somewhat.

Therefore all cold and all hot wells are placed in line (streets) with each other. This way they can hardly influence each other. Thus the WKO is an open system with the groundwater.

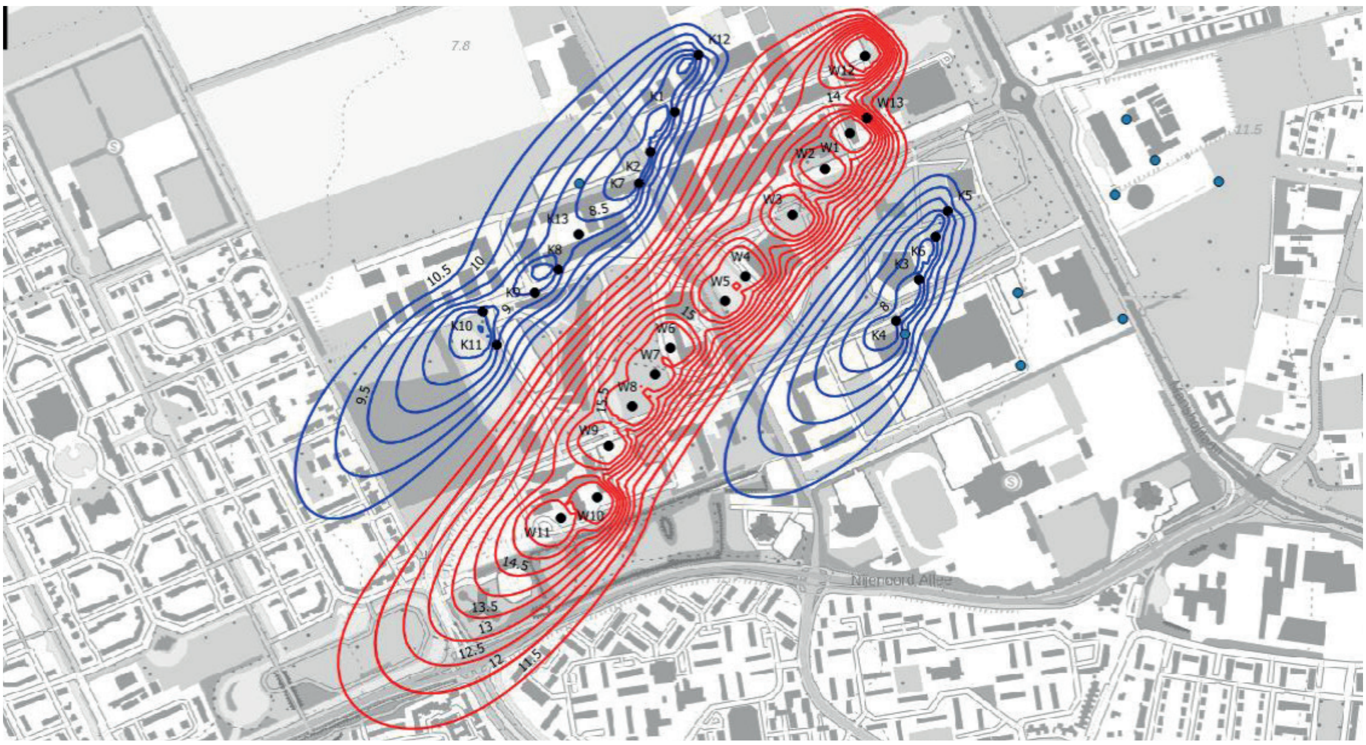
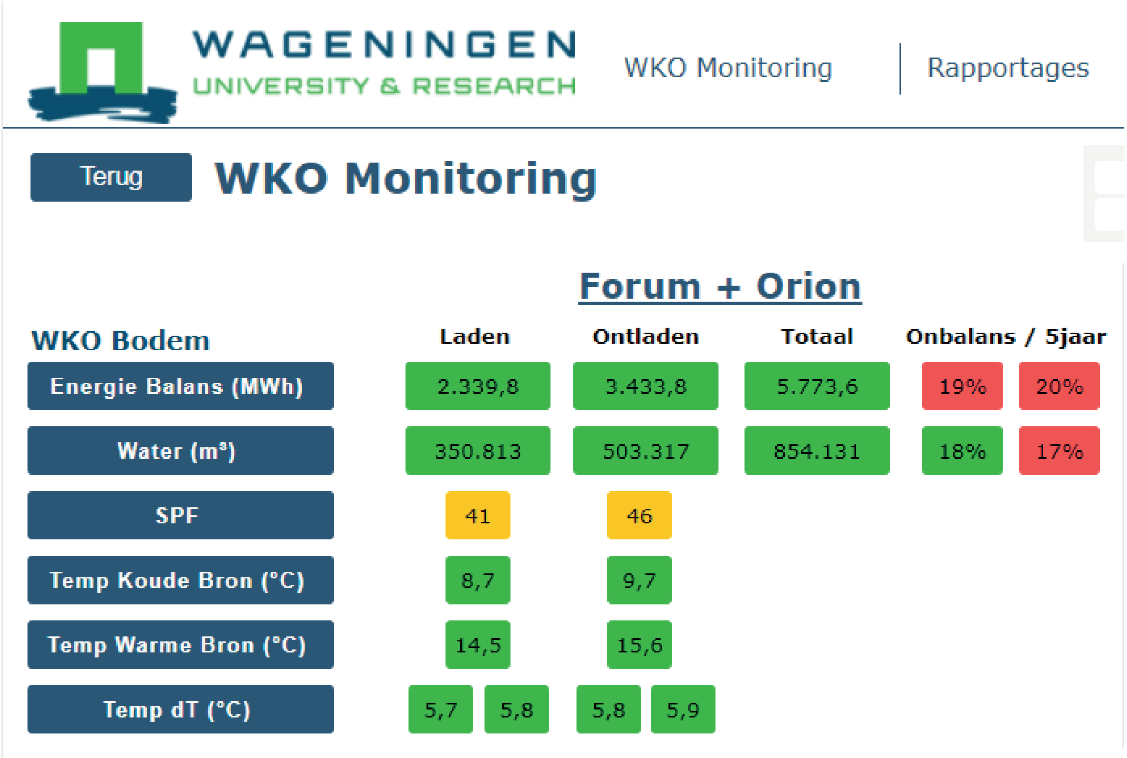


Fig. 2 Underground heat and cold streets on campus with resp. the hot and cold wells (in addition to the 18 wells mentioned, also 6 future wells).



WKO Bodem	Laden		Ontladen		Totaal	Onbalans / 5jaar	
Energie Balans (MWh)	2.339,8		3.433,8		5.773,6	19%	20%
Water (m³)	350.813		503.317		854.131	18%	17%
SPF	41		46				
Temp Koude Bron (°C)	8,7		9,7				
Temp Warme Bron (°C)	14,5		15,6				
Temp dT (°C)	5,7	5,8	5,8	5,9			

Fig. 3 Current WKO dashboard Forum + Orion.

During the season, the cold well slightly heats up and the hot well slightly cools down. As a result, over time the temperature of the pumped up water may vary a bit. However, the absolute temperature difference between the two zones remains fairly constant. You can also see this in the "Temp dT (°C)" on the dashboard of the current Forum + Orion WKO installation.

There are pumps in both the hot and cold wells that pump the water into the cold and heat loops depending on the heat or cold demand of the connected buildings. Large **expansion vessels** in the Energy Building behind Gaia ensure a stable water pressure in the loops.

What do we use the WKO for?

The WKO is intended for **energy-efficient climate control** of the buildings and greenhouses on Wageningen Campus.

In addition, the WKO can also store **residual heat** from process installations such as cooling machines, etc.

The energy demand and surplus on campus is quite a puzzle, because we are not dealing with just office buildings. In general, greenhouses need cooling. But the greenhouses for (sub) tropical crops, some climate chambers and buildings with many laboratories (and therefore a lot of heat loss due to the necessary ventilation) require more heat. Older buildings on campus also require more heat than they provide. In principle, the yearly energy demand and supply is reasonably balanced. In case of a disturbed balance we are able to correct this with, for example, the **coolers at Orion**. These are able to cool or heat additional water if necessary. Already a number of buildings are connected to independent WKO wells. The added value of the induction loop is that we can exchange shortages and surpluses of individual locations with each other instead of blowing excess heat into the air or using additional gas heaters, thereby achieving better energy efficiency.

Since the original groundwater temperature is about 12 degrees, in a completely new WKO system normally, you first have to heat the wells to about 17 degrees or cool them down to 6 degrees before use. However, because several on-campus wells are already in use for a few years, we can develop the newly drilled wells more easily by extracting heat or charging cold from the start.

Sustainability and savings

The WKO ultimately provides WUR with enormous **energy savings** without significant CO_2 emissions. Although the pumps do use electricity, WUR has its own **green electricity supply**. The WKO loop and wells will be delivered in 2021, their lifespan is about 30 years. In contrast the installations in the buildings have a replacement cycle of about 15 years. That is why not all buildings are immediately connected.

All the necessary branches for future connections are already integrated in the loops, but we will only connect them to the building installations as soon as the current heating installation is due for replacement. Still, some buildings will be connected immediately, because this will immediately save a lot of money, the current heat pump (using natural gas) is due for replacement anyway, or because the building is still under construction. All buildings are expected to be connected within **five years**.

Fig. 4 The objective is that in 5 years' time all buildings on campus will be connected to the WKO induction loops.

With this, WUR invests in sustainability (no more natural gas) and a significant reduction in energy use. Earning back the investment (expected to be well within 15 years) is therefore not the only objective.

WKO construction

WUR commissioned Heijmans Infra and drilling company Haitjema to carry out the work for the construction of the WKO loop and wells. They started in October 2020. The induction loop and wells are expected to be completed in the spring of 2021. **Well drilling** is ongoing; parts of the loop are installed by means of horizontal directional drilling (**HDD**); in open excavations the **valves** and **connections** between the loop and the wells are installed; and in a few buildings the technical room is prepared for the connection with the WKO loop. Curious how this works? We are happy to tell you!

In a series of articles, we take you through the technology behind this drastic on-campus activity. In addition, environment manager Astrid Neefs of Heijmans made a vlog in which she gives you an insight into the various activities and techniques applied.