#	Vraag	Antwoord
1	Will there be a overall compairison between the 4 types of energy storage solutions during this series?	Hi! This was covered during the first webinar. Check out the recordings of the first and second webinars here: https://topsectorenergie.nl/nl/kennisbank/webinarreeks-warmteopslag/ Also, the fact sheets that Bas talked about that are still to be published can also be used for an overall comparison.
2	How much water do you need for a MWh. Is that related to the size?	Morten's slides indicate the cubic metres (m3) you need per MWh for a few projects. Apart from volume, temperature is also important.
3	are te solar collectors PT or PVT ?	The solar collectors in theese projects are purely thermal collectors. It could also be used with pvt
4	Is PTES interesting for the Netherlands, with its relatively high groundwater levels?	We expect that this couldn't be applied on all places. In each project, you should check how large a heat storage system should be and what kind of options you have and which could be applied. And also what the function of the heat storage is. How long does heat need to be stored, for example.
5	The system in Tibet looks quite large, was it connected to the small village we saw on the pictures? Where is the heat delivered to?	Yes, Morten said it is delivered to the village. Apparently covering 90% of their yearly heat demand. The other 10% is covered by electric boilers.
6	why is the groundwaterlevel in the netherlands an issue? is it heatloss?	Answered live
7	What is the most efficient Diameter to depth according to heat losses?	In general - the deeper the better. But there is always a limit to the depth - either geotechnical og geometrical
8	What is the purpose of the middle diffuser? top and bottom are clear	The middle diffuser is mainly used when attaching a heat pump to the system. But it also helps to get rid of mixed temperature water from the boundary layer between hot and cold.
9	Have wind energy and big heat pumps been used to provide heat for these storage systems?	Yes. The danish district heating plants are very actively taking part in the electricity market by using HP and electrical boilers. The more storage capacity they have available the more flexible they can act in the electricity market and earn money (produce cheap heat) on that.
10	Is there a min. required depth of the PTES to ensure temperature stratification?	The storages I have experience has a water depth of 10 m and upvards. I can not tell exactly the minimum required depth to ensure stratification
11	What is the heat loss (approx.) per 24 hrs (of course depending on the dimensions/volume) of the PTES? Maybe you can give some examples of existing PTES systems.	Morten gave an example of a PTES in Dronninglund that has a yearly heat loss of around 10%. Obviously it will depend on the temperature of the heat storage and the temperature outside how much heat loss there is on a daily basis.

12	What are reasons for choosing PTES instead of HT-ATES when implementing HT energystorage in the NL?	It depends from site to site and from the amount of heat, which needs to be stored. For HT-ATES you need proper aquifers which are between strong clay layers. If they are not present, you can check if PTES will be an option. So from case to case, you have to judge what is the bst solution from a technical, legal and financial perspective. An interesting aspect that Morten mentioned was the possible function of PTES as a day or week-buffer. So not as seasobnal storage.
13	How does the size of the pit storage and the temerature of the water relate to the round trip efficiency?	A bigger storage will have relatively lower heat loss because the surface area related to the volume is smaller. The temperature of the water has a large impact on the round trip efficiency. The example from Dronninglund cool down the water to 5-10°C during the winter by a heat pump. This is one of the reasons for the high efficiency. A lot of the heat you loose to the surrounding soil is regained during the winter because it ""flows"" back into the cold water inside the storage"
14	How do you select the optimal depth/height of the PTES? What considerations regarding ground water table to atke account of?	If we have the possibility we stay above the ground water table. In Dronninglund the bottom of the storage is 1 m above the ground water table. If you can not avoid the ground water you need to evaluate the flow velocity of the ground water and evaluate the heat loss. Special precautions can be taken against this. (insulation of sides and bottom of storage or sheet piles around the storage to reduce ground water flow)
15	What is the benefit of using this kind of tank instead of usual tanks made from steel and other coupounds with good gesture of temperature and pressure	Its mainly a cost factor. PTES is generally 5 times cheaper than steel tanks depending of the size.
16	Is EPDM not an option as a variable-temperature resiliant long life lining material? (to expensive?)	EPDM could be an option. The main drawback to my knowledge is that you can not weld EPDM. That is right, EPDM is not weldable and very soft so it is not possible to use as sealing barrier in a Pit. Therefore the developement in PP-HTR and PE-HTR going forward."
17	What is the effect of storage on the cost of heat?	The storage will be have to paid back and therefore provide an immediate cost to the heat. But it also enables all the other heat sources to operate more efficiently and at their best times (lowest heat cost). So the overall heat price goes down. The magnitude is case specific.
18	What potential do you see in PTES combined with CHP? Because in NL we will need to increase decentralized electricity production in the winter....	Jonas I. S.: "We see that it would be possible and a great idea to use a storage together with a CHP plant. It would enable the operator to ramp up the production of electricity when prices are high and storing the excess heat in the storage. It would also enable the CHP plant to operate with a very constant load and the excess production of heat in the night or during the middle of the day could be stored in the storage and used for the peak demands in the morning and evening."

19	What is the status on modelling these fairly complicated systems? Did you use digital twin to fine tune the systems?	Jonas I. S.: "The modelling of a storage is always a complex task. There exist several commercial softwares that does this which can be used in feasibility studies to find the correct size of it. When it comes to operation there is also software programs that assists the operators in real time how to operate the storage. EMD and Danfoss has such softwares. Another point is that when a heat pump is connected to the storage the modelling becomes a lot more complicated and therefore it is often useful to get inputs based on experience and existing cases. Companies like Bobach Solution has this knowledge."
20	Thank you very much for an insightful presentation, very informative.	Thank you for attending.
21	Is electricity cheap in Denmark? Surprised to see electric boilers rather than heat pumps.	Jonas I. S.: "Electricity is sometimes cheap. It varies a lot but we usually have cheaper electricity during winter (More wind) and during summer (More sun). However, the main advantages of electric boilers compared to heat pumps are their quick response (They can quickly turn on and produce heat which is needed), maintenance is cheap and low, the CAPEX is significantly lower and we have seen prices around 50 - 70,000 EUR/MW for electric boilers."
22	how do you ensure that temperature stratification remains intact in the pit, and avoid convection, by the input and offtake of water at verious levels and at different time scales?	Jonas I. S.: "The diffusers are designed to avoid turbulence so if a larger charge/discharge capacity is needed the diffusers are larger. The main parameter is the velocity of the water exiting the diffuser. We need to keep that low and therefore, if the charge/discharge capacity (MW) is larger we need to transport larger amounts of water which yields a larger diffuser. Furthermore, if it was not clear from the presentations, the water level inside the PTES remains constant at all times. Therefore, when water is pumped out, the same amount is pumped in."
23	Are the observation data over time of the temperatures and energy loss pubicly available ? Can you share a link?	Jonas I. S.: "Yes, they are. Note that all the reports and articles use data when the former lid design was in use. Currently, there are no published report with the new lid, however they will come. Please have a look at the following references: https://www.solar-district-heating.eu/wp-content/uploads/2019/10/Dronninglund-evaluation-report-2015-2017_20190531.pdf https://www.solar-district-heating.eu/wp-content/uploads/2019/10/Marstal-evaluation-report-2015-2017_2019.05.28.pdf https://www.sciencedirect.com/science/article/pii/S0038092X22009252"

24	There is more wind energy in winter. Could a smaller storage heat a bigger town with wind energy not solar energy?	Jonas I. S.: "Yes, that would most certainly be possible. The question is then about the conversion from electricity to heat. Depending on the demand and the surrounding system either electric boilers or a heat pump would be the best cases. The electric boiler has significantly lower CAPEX and OPEX compared to the OPEX, however it produces heat from electricity in approximately 1:1 ratio (99% efficiency) whereas the heat pump cooling the bottom of the storage and heating the top would have a COP of around 3.5, i.e., a ratio of 3.5 heat to 1 electricity."