6 Next step: Ecovat Arnhem

This chapter describes the design of the Ecovat Arnhem, and the expected efficiency.

The design of the next Ecovat is improved. This Ecovat is expected to be much more efficient than the Ecovat Uden, because:

- The Ecovat Arnhem will be thirteen times larger in volume. This means the surface to volume ratio is much more efficient, as shown in Table 14;
- The Ecovat Arnhem will be 30 meters deep. This is twice the depth of the Ecovat Uden. This means the destratification effect and the losses to the bottom will be less (compared to the stored volume);
- The Ecovat Arnhem has an improved design of the top to minimize natural convection. Also, the top has more insulation.

Table 14 Volume/surface ratio Ecovat Uden vs. Ecovat Arnhem

Ecovat	Unit	Uden	Arnhem
Diameter	m	11	30
Depth	m	16	28,8
Volume	m3	1.521	20.358
Surface	m2	743	4.128
Volume/Surface		0,489	0,203

To determine the efficiency of Ecovat Arnhem, we need to define the design of that Ecovat and its usage. After all, the system efficiency is a combination of the installed hardware and its usage during the year. This will be elaborated in the next chapters.

6.1 Description Ecovat Arnhem

6.1.1 *Dimensions Ecovat Arnhem*

The Ecovat in Arnhem has a diameter of 30,0 meters and a dept of 28,8 meters. These are the dimensions of the thermal storage capacity volume. So, the diameter including the structural wall is bigger and the total depth is bigger due to a concrete bottom. The prefab elements will be 3,14 meters wide and 3,6 meters high. So, the Ecovat has eight layers.

Table 15 Wall surface for each layer.

Layer	Wall parts per layer	Width of wall part [m]	Height of layer [m]	Wall surface of layer [m2]
1	30	3,14	3,600	339,12
2	30	3,14	3,600	339,12
3	30	3,14	3,600	339,12
4	30	3,14	3,600	339,12
5	30	3,14	3,600	339,12
6	30	3,14	3,600	339,12
7	30	3,14	3,600	339,12
8	30	3,14	3,600	339,12
Total			**28,80**	**2712,96**

.

Table 16 Volume for each layer

Layer	Layer suface [m2]	Volume [m3]	Concrete [m3]	Water [m3]
1	704	2.567	99	2.468
2	704	2.567	99	2.468
3	704	2.567	99	2.468
4	704	2.567	99	2.468
5	704	2.567	99	2.468
6	704	2.567	99	2.468
7	704	2.567	99	2.468
8	704	2.567	99	2.468
Total		**20.533**	**792**	**19.741**

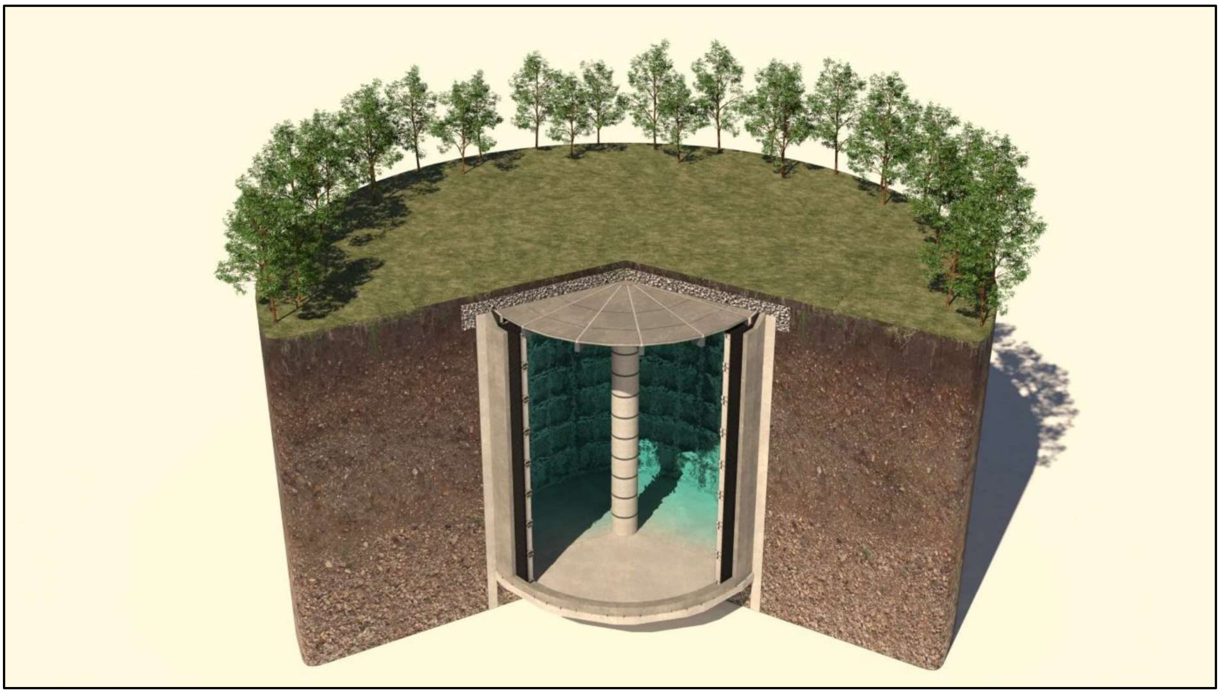

Figure 33 Visual of the Ecovat Arnhem (no houses nearby, only trees)

6.1.2 *Insulation Ecovat Arnhem*

In this chapter the new design of the top, walls and bottom is described.

Firstly, the top has a new design. Based on the findings and with external consultancy, a new design has been made that will reduce the impact of all problems that occurred with the top of Ecovat Uden. The new insulation of the top will be between 1,0 m. and 2,7 m. thick. The new design is not disclosed in this report but can be provided on request. The new theoretical thermal resistance is determined by a third party. The new design is not air tight (just like in the Ecovat Uden), which creates natural convection which will affect the thermal resistance. In the calculation of the new top, natural convection is already considered and simulated. The calculation used extreme conditions to test the sensitivity for the thermal resistance. The water temperature was 95^{0}C and the air temperature outside was -10^{0}C. By taking this into account a new thermal resistance is calculated, namely 24,6 m2*K/W. The absolute minimum of the top is 20,0 m2*K/W.

Secondly, the wall has similar design to the Ecovat Uden. Prefabricated wall parts will be used. This time the concrete will be cast in the mold with the insulation in the mold. This will create a strong attachment of the insulation to the wall parts. The same insulation blocks will be used as with the Ecovat Uden but they will be placed with a greater precision in order to minimize the thermal leakages. The thermal resistance of the new walls is shown in the tables below.

Table 17 Thermal resistance wall of layer 1, 2 and 3.

	Lambda [W/mK]	Thickness [m]	Thermal resistance [m2*K/W]
Concrete (structural wall)	1,600	1,000	0,63
Concrete (filling)	1,600	0,500	0,31
Foamglass	0,041	0,430	10,49
Total		**1,930**	**11,43**

Table 18 Thermal resistance wall of layer 4, 5 and 6.

	Lambda [W/mK]	Thickness [m]	Thermal resistance [m2*K/W]
Concrete (structural wall)	1,600	1,000	0,63
Concrete (filling)	1,600	0,500	0,31
Foamglass	0,041	0,340	8,29
Total		**1,840**	**9,23**

Table 19 Thermal resistance wall of layer 7 and 8.

	Lambda [W/mK]	Thickness [m]	Thermal resistance [m2*K/W]
Concrete (structural wall)	1,600	1,000	0,63
Concrete (filling)	1,600	1,000	0,31
Foamglass	0,041	0,250	6,10
Total		**1,750**	**7,04**

Thirdly, the bottom of the Ecovat Arnhem. Just as in the Ecovat in Uden, this will be a concrete bottom. For Arnhem this bottom will be without leakage. It has to be, since the ground water level outside the Ecovat Arnhem is lower than the water level in the Ecovat. Any leakages would thus result in a dropping water level in the Ecovat.

6.1.3 *Water level Ecovat Arnhem*

The design of the Ecovat in Arnhem is made to be completely watertight. The water level will thus not vary much in Arnhem. Only slightly due of the expansion of water.

6.2 Thermal performance of Ecovat Arnhem

In this chapter two use cases of the Ecovat Arnhem are calculated. Both cases assume the same installed hardware. The difference is in the usage of the Ecovat. In the first use case, the Ecovat is charged up to its full potential and is then not charged or discharged anymore for 6 months. This is similar to the way the Ecovat Uden was charged for the calculation of the thermal efficiency. In the second use case, the Ecovat Arnhem is simulated for twelve months with a varying state of charge (e.g. the amount of stored energy between 0 and 100%).

6.2.1 *Thermal performance Ecovat Arnhem use case 1: As with Ecovat Uden*

Just as with the Ecovat Uden, we can distinguish several parts of the Ecovat in Arnhem and identify different insulating parts, see Figure 34. In the next chapter the thermal losses are determined when the Ecovat is used similarly as in Uden.

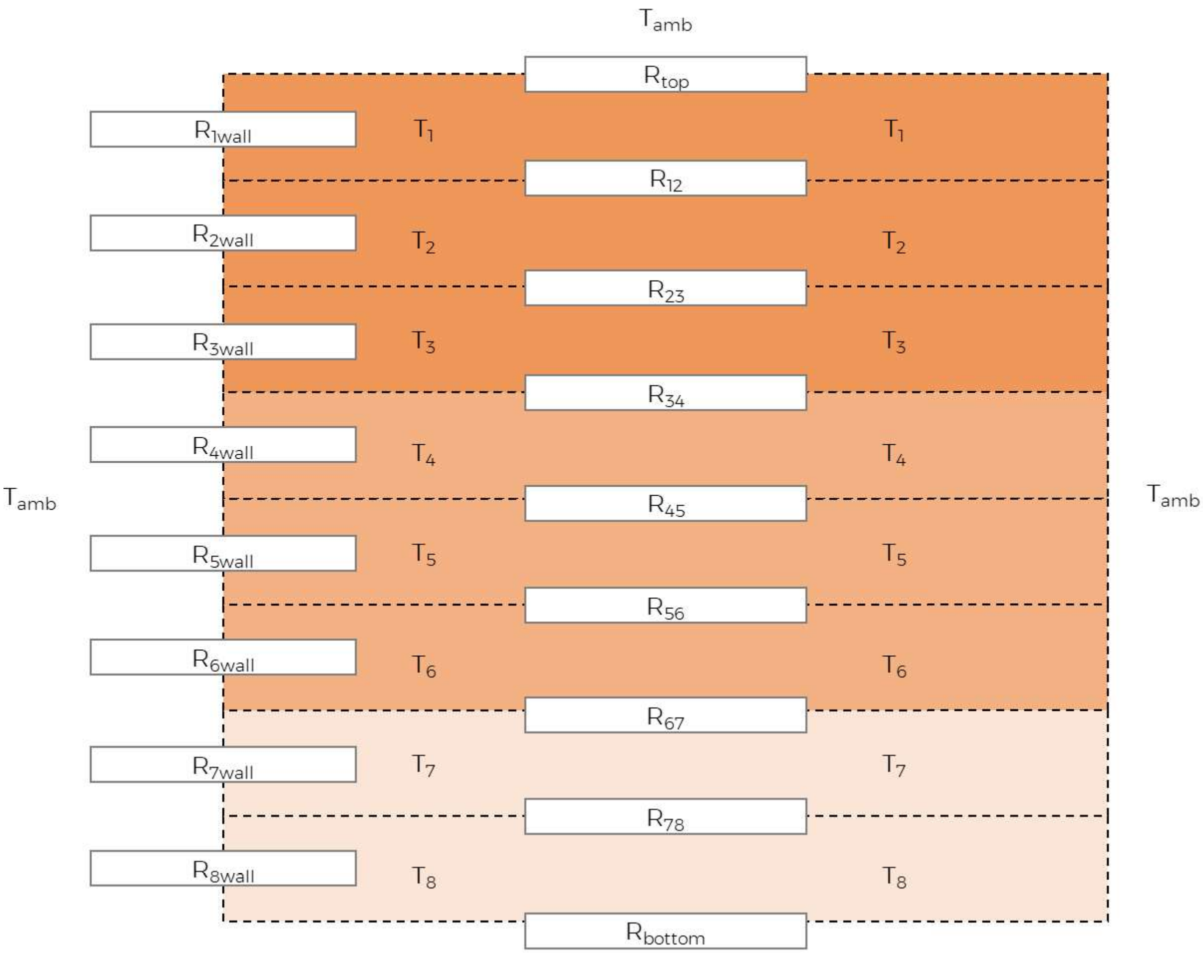

Figure 34 Thermal resistance of all parts the Ecovat Arnhem

Based on the findings in the Ecovat in Uden and the new design for Arnhem we defined the thermal resistance for the Ecovat Arnhem as shown in Table 20. Note that:

1. For the top, the new design has been thoroughly calculated by a third party, as explained in chapter 6.1.2. This means a thermal resistance of 24,60 [m2*K/W];
2. The reduction of the measured thermal resistance of the walls in the Ecovat Uden was 34,7% compared to the theoretical optimum. As explained in chapter 5.3, the thermal resistance of the new walls in Arnhem should be better. However, we cannot be certain of this, so 34,7% reduction is assumed for Arnhem as well;
3. The thermal resistance between layers is the same as in Ecovat Uden, since this use case has still standing water as well. The only difference is that the layers are slightly higher (3,6 meters compared to 3,3 m.), so the thermal resistance will be slightly higher too;
4. The bottom is mostly based of the thermal resistance of half of water layer 8 and concrete. The water part is given the same reduction as the with the thermal resistance between layers.

Table 20 Thermal resistance of several parts of the Ecovat Arnhem.

Part	Assumed thermal resistance [m2*K/W]	Remarks
Top	24,60	1
Wall1	7,18	2
12	2,38	3
Wall2	7,18	
23	2,38	
Wall3	7,18	
34	2,38	
Wall4	6,03	
45	2,38	
Wall5	6,03	
56	2,38	
Wall6	6,03	
67	2,38	
Wall7	4,60	
78	2,38	
Wall8	4,60	
Bottom	1,82	4

Based on the thermal resistance of the parts in Table 20 and Figure 34, we can simulate the thermal losses over 26 weeks. The layer temperatures of the simulation are shown in Figure 35.

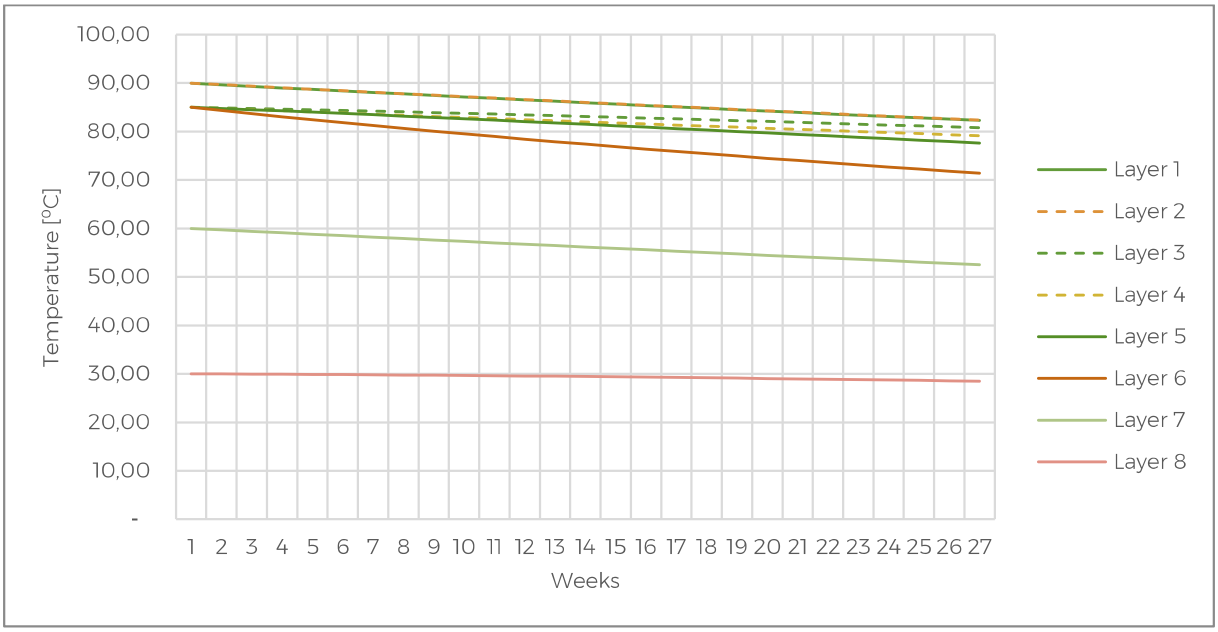

Figure 35 Best case temperature of layers of Ecovat Arnhem for six months

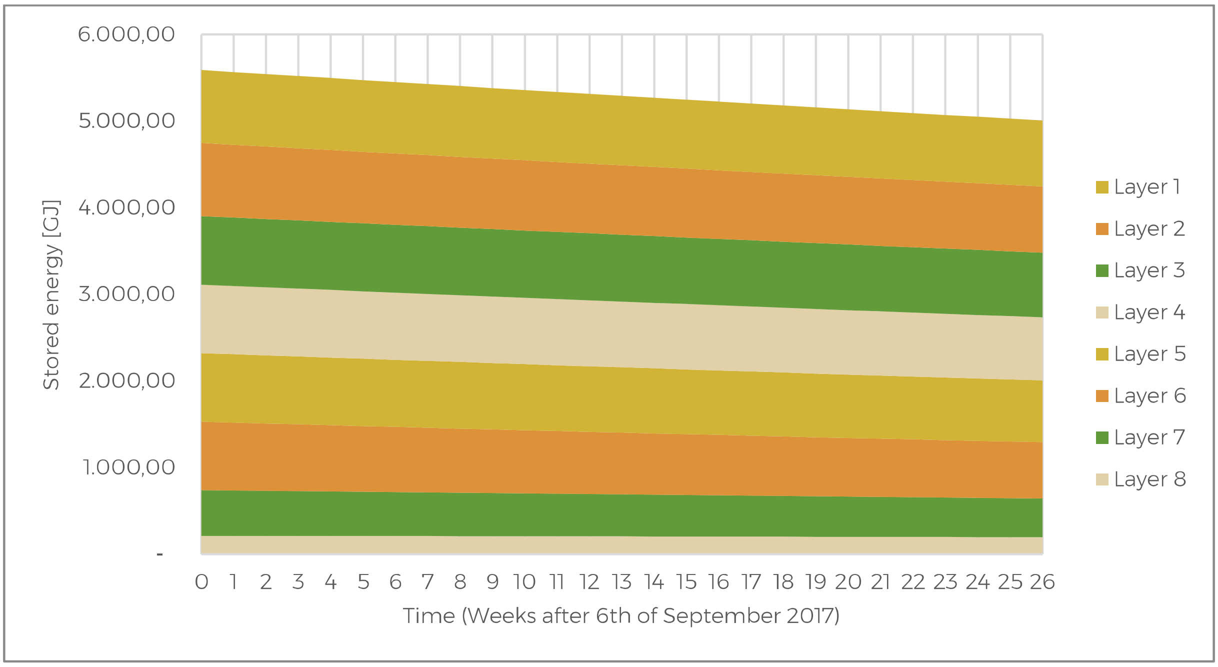

Figure 36 Stored heat Ecovat Arnhem use case 1

As show in the table below, ca. 584 GJ was lost over six months. Compared to the stored heat at the start this is a thermal loss of 10,44%. Thus, an efficiency of 90,56%.

Table 21 Stored heat at start and after six months.

Layer	Stored heat Week 1 [GJ]	Stored heat Week 27 [GJ]
Layer 1	843,86	762,95
Layer 2	843,86	762,95
Layer 3	791,12	746,57
Layer 4	791,12	729,30
Layer 5	791,12	713,47
Layer 6	791,12	647,86
Layer 7	527,41	448,76
Layer 8	210,96	195,22
Total	**5.590,56**	**5.007,05**

6.2.2 *Thermal performance Ecovat Arnhem use case 2: As expected*

In the second use case, the Ecovat Arnhem is simulated for twelve months with a varying state of charge (e.g. the amount of stored energy between 0 and 100%). This chapter will explain the varying state of charge and the thermal losses.

The varying state of charge is a result of the availability of the thermal production sources and the heat demand. For Arnhem the heat demand is produced by solar thermal collectors (ca. 50% of the heat demand) and by heat pumps (also ca. 50% of the heat demand). The heat pumps are consuming electricity (and producing heat) by following the load curve of wind in the Netherlands. By combining the availability of the solar thermal for each hour and the availability of the heat pumps for each hour, with the demand for heat for each hour, we have a resulting state of charge (SoC) of the thermal storage capacity. Figure 37 shows the SoC for an average year (a year has 8760 hours).

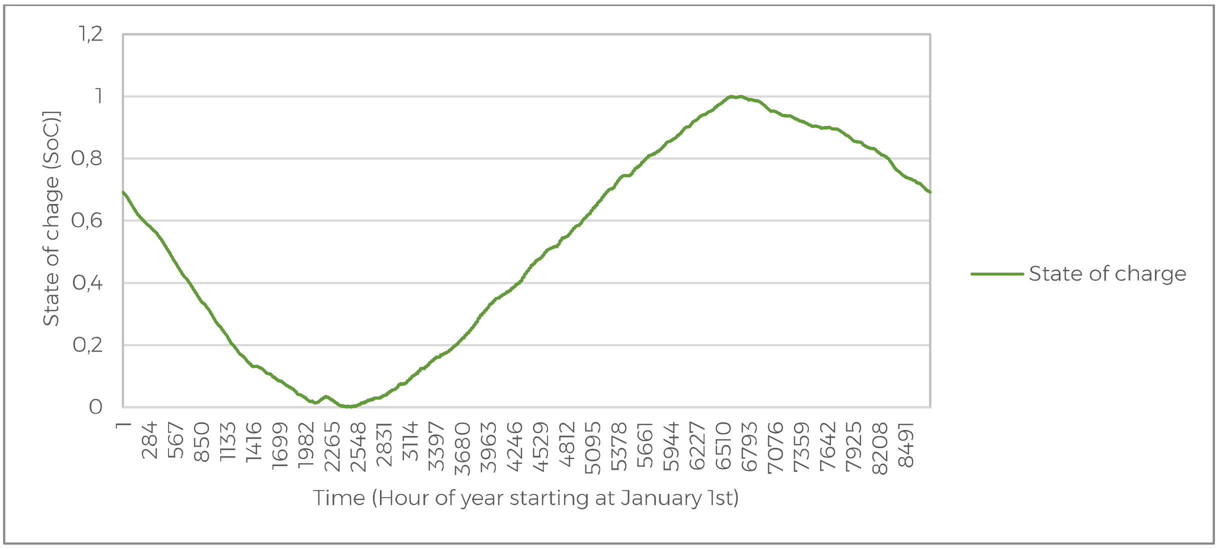

Figure 37 State of charge (SoC) of the Ecovat Arnhem when charged as expected.

Given the SoC for any given time of year, the maximum and minimum SoC need to be described. From the charging cycles model (not elaborated in this report) we know that the required storage capacity for Arnhem, given the estimated heat demand, is 1.387 MWh. So, the difference between the maximum and minimum SoC (SoC_max and SoC_min) is 1.387 MWh (4.991 GJ). This is visible in Table 22.

Table 22 Storage capacity Ecovat Arnhem use case 2.

Layer	Maximum temperature [ºC]	Minium temperature [ºC]	Volume [m3]	Weighted average heat capacity[4] [kJ/(m3*K).]	Storage capacity [GJ]
1	85	45	2.567	4.110	422
2	85	30	2.567	4.110	580
3	80	5	2.567	4.110	791
4	80	5	2.567	4.110	791
5	80	5	2.567	4.110	791
6	80	5	2.567	4.110	791
7	60	5	2.567	4.110	580
8	30	5	2.567	4.110	263
Total			**20.533**		5.010

By combining the varying SoC and the maximum and minimum temperatures per layer, the varying temperature for each layer is calculated. See Figure 38. In this calculation it is assumed that each layer is charged according to the SoC profile. This could also be done differently, if the Ecovat steering software

[4] Based on 99 m3 of concrete per layer and 2.468 m3 of water per layer. Heat capacity of water is 4.186 kJ/(m3*K) and concrete is 2.210 kJ/(m3*K).

would find a more optimal profile. For example, discharging lower layers to SoC_min first before discharging upper layers. For now, the profile as presented in Figure 38 is regarded as a possible profile.

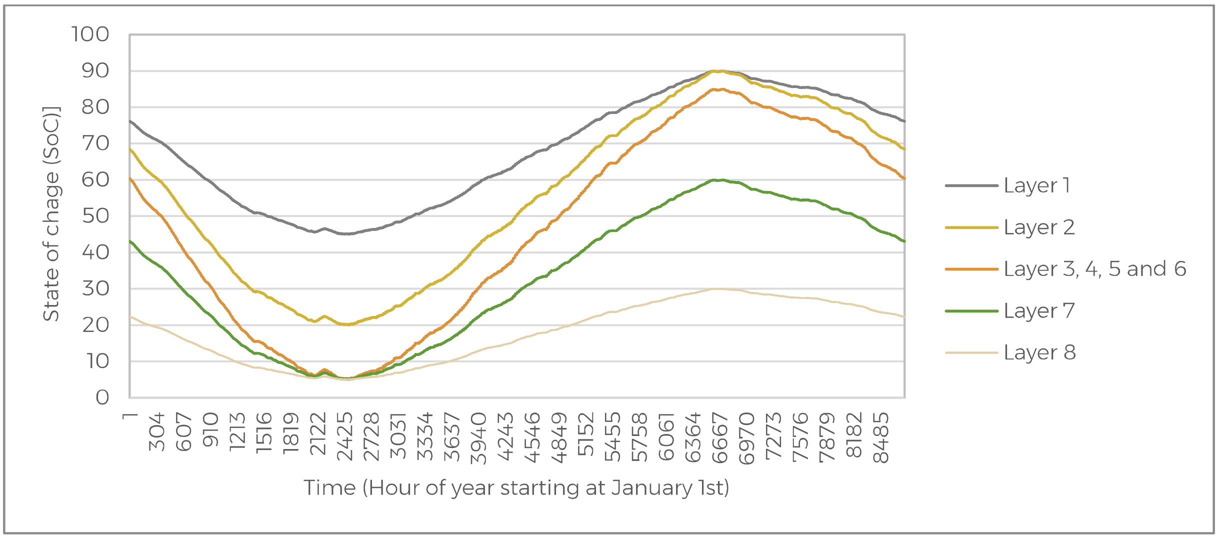

Figure 38 The varying temperature during one year for the Ecovat Arnhem in use case 2

Based on these different SoC during a year, the thermal losses are calculated. See Figure 39. Most heat is lost at the wall, then the bottom and then the top. This makes sense since the wall has the largest surface and less insulation as the top. The bottom is gaining some heat for a part of the year (roughly between hour 1100 and 3600) since the temperature in layer 8 (5°C) is lower than the temperature of the soil (10°C). The sum of all losses is presented in

Table 23. The total loss is 621,8 GJ. Compared to the storage capacity, this would mean a loss of 12,4%. Below the impact of this loss on the overall system efficiency is elaborated as well as the sensitivity of several worst-case scenarios.

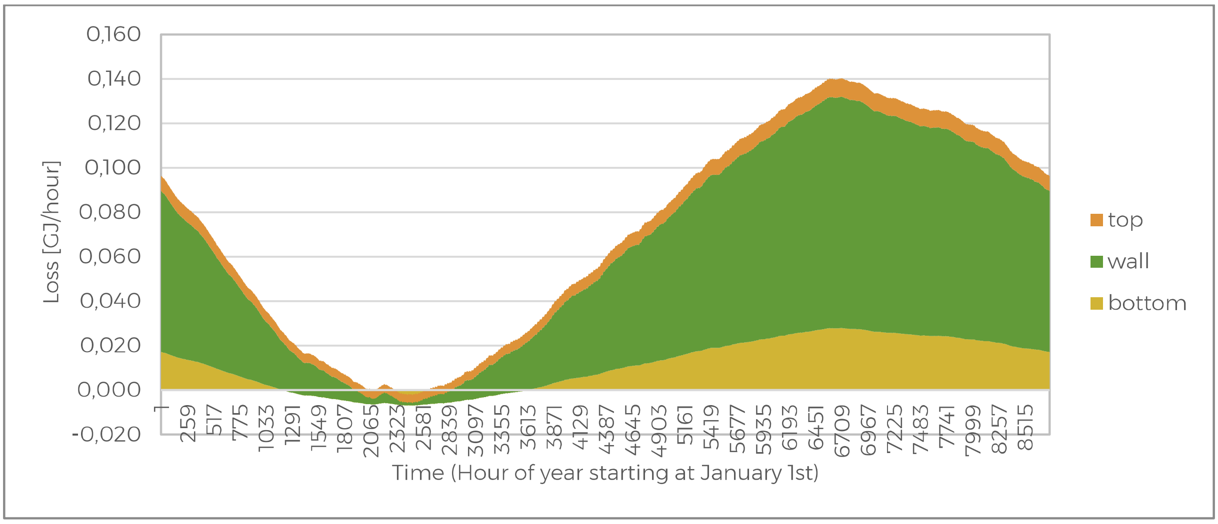

Figure 39 Thermal losses during one year for the Ecovat Arnhem in use case 2.

Table 23 Annual thermal losses Ecovat Arnhem use case 2.

Layer	Loss [GJ]
Top	52,4
1	86,6
2	68,5
3	53,8
4	64,1
5	64,1
6	64,1
7	54,1
8	18,3
Bottom	95,9
Total	**621,8**

Table 24 System efficiency Ecovat Arnhem use case 2.

	GJ	%	Comments
Heat demand	11.396	80,7%	Currenct project size based on 559 apartments + 9.940 m2 mixed use space
Losses district heating	2.100	14,9%	Assumption Ecovat: Fixed loss, regardless of amount of transported heat. Loss district heating is indicative for illustration purpose and context of Loss Ecovat. Loss district heating does not influence the loss Ecovat.
Losses Ecovat	622	4,4%	Table 23.
Production total	14.118	100,0%	
Production solar thermal	7.059	50,0%	Assumption Ecovat: Production 1,76GJ/m2. Surface is 4.011 m2. This space is available on the roofs in the area.
Production heat pumps	7.059	50,0%	
Electricity consumption heat pumps	2.353		Assumption Ecovat: COP 3.

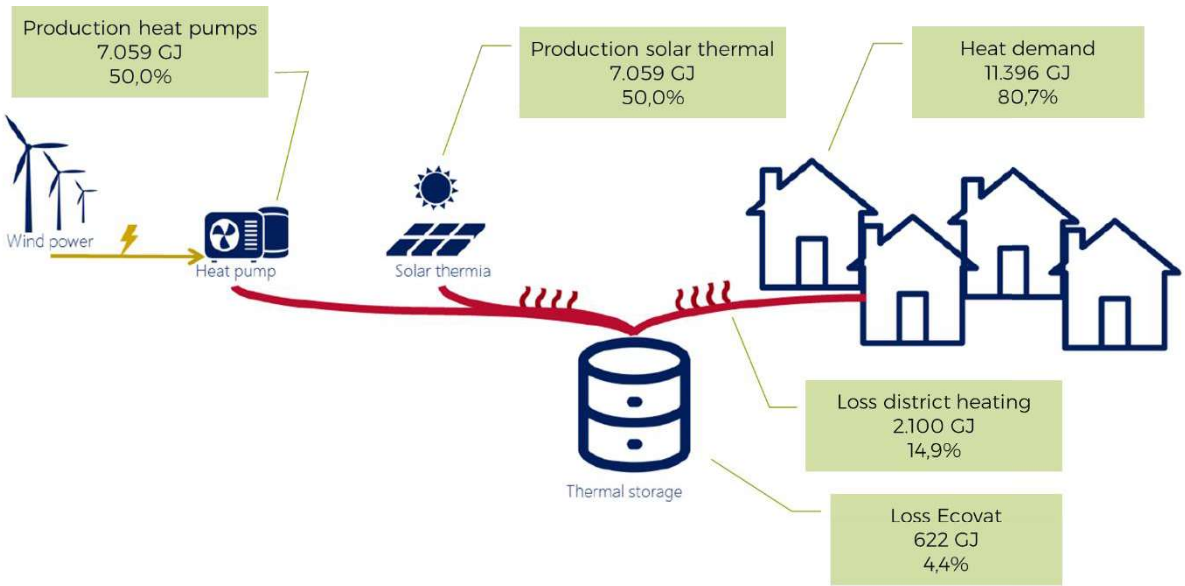

Figure 40 Baseline system performance Ecovat Arnhem

For the total business case of Arnhem, it is important to know the sensitivity of the business case when the Ecovat would perform less than the performance presented in this chapter. If the Ecovat would lose more heat, this would result in more heat production from the heat pumps. The heat demand is kept as a constant (11.396 GJ), as well as the losses in district heating (2.100 GJ) as well as the solar thermal production (7.059 GJ). The solar thermal production is likely not increased when the Ecovat would be less efficient, since these will already be installed. Producing more heat with the already installed heat pumps near the Ecovat, would seem as the most sensible way to compensate any extra losses. So, the only outcome of a less efficient Ecovat, would be more electricity consumption for the heat pumps.

Table 25 shows four sensitivity calculations on the electricity consumption of the heat pumps by a less efficient Ecovat. All four efficiency reductions show a very small increase in electricity consumption between 0,7% and 1,7%. This basically means the total business case is not very sensitive for any reductions of the efficiency of the Ecovat Arnhem. All four sensitivities are explained in the following paragraphs. After these paragraphs, in Table 26, the sensitivity is expressed in terms of loss compared to storage capacity and loss compared to delivered heat.

Table 25 Sensitivity analyses on electricity need Ecovat Arnhem use case 2.

Sensitivity	Annual thermal loss Ecovat [GJ]	Electricity consumption [MWh]	Electricity consumption [%]	Comments
Use case 2 baseline	*622*	*2.353*	*100,0%*	*As presented in Table 24.*
1. Lower thermal resistance top	677	2.370	100,7%	50% lower thermal resistance of top. So, 12,3 instead of 24,6 m2*K/W.

2. Lower thermal resistance bottom	669	2.369	100,7%	50% lower thermal resistance of water then obtained in Uden. So, 1,22 instead of 1,82 m2*K/W.
3. Ground temperature lower	677	2.371	100,8%	8^{o}C instead of 10^{o}C.
4. Lower thermal resistance wall	741	2.393	101,7%	20% lower thermal resistance for all walls.
5. Combining 1 and 2	721	2.386	101,4%	

First the thermal resistance of the top is reduced with 50% from 24,6 to 12,3 m2*K/W. This is merely to test the sensitivity, but this reduction is not realistic. The reasons why the top of Ecovat Uden performed poorly, have been mitigated with the design of Ecovat Arnhem. Also, the natural convection within the top of Ecovat Arnhem has already been taken into account in the calculation of the thermal resistance of 24,6 m2*K/W. The total electricity need is increased with 0,7%.

Secondly, the thermal resistance of the bottom is reduced with 50% from 1,82 to 1,22 m2*K/W. This is merely to test the sensitivity, but this reduction is not realistic. The assumed thermal resistance of 1,82 m2*K/W is based on 0,63 m2*K/W of the concrete bottom and 1,19 m2*K/W of 1,8 meters of water column. The latter has a thermal conductivity of 1,51 W/(m*K) (obtained from measurements of Ecovat Uden). However, this could be higher when the water at the bottom is more turbulent. So, the thermal conductivity is raised to 3,02 W/(m*K). This results in a 50% lower thermal resistance of 0,60 m2*K/W. Adding the concrete, this results in a total thermal resistance of the bottom of 1,22 m2*K/W. The total electricity need is increased with 0,7%.

Thirdly, the ground temperature is lowered. Most locations in the Netherlands have an average ground temperature of 10^{o}C. There are some exceptions though. For the location in Arnhem this is not year measured. By lowering the ground temperature with 2 degrees, the total electricity need is increased with 0,8%.

Fourthly, the walls have a 20% lower thermal resistance then assumed. It is important to note that the assumed thermal resistance already takes into account a reduction of the thermal resistance compared to the technical specifications of the supplier of the insulation. The thermal resistance (of the top 3 layers) is 11,0 m2*K/W based on the specifications. However, in Ecovat Uden we calculated a reduction of 34,7% and this is therefore assumed for Ecovat Arnhem as well. The 20% reduction for the sensitivity is thus an extra reduction on the assumed thermal resistance of 7,18 m2*K/W (for the top 3 layers,) resulting in a thermal resistance of 5,74 m2*K/W. The total electricity need is increased with 1,7%. Again, the design of the wall has hardly changed so a reduction of 34,7% in the specifications is regarded as the expected performance.

Fifthly, two sensitivities can be combined such as 1 and 2. The resulting electricity need is increased with 1,4%. This fifth sensitivity is regarded as the worst-case scenario for the Ecovat Arnhem.

Table 26 Sensitivity analyses in terms of storage capacity and delivered heat use case 2.

Sensitivity	Annual thermal loss Ecovat [GJ]	Thermal loss Ecovat compared to stroage capacity [%]	Thermal loss Ecovat compared to delivered heat [%]
Use case 2 baseline	622	12,4%	5,46%
1. Lower thermal resistance top	677	13,5%	5,94%
2. Lower thermal resistance bottom	669	13,4%	5,87%
3. Ground temperature lower	677	13,5%	5,94%
4. Lower thermal resistance wall	741	14,8%	6,50%
5. Combining 1 and 2	721	14,4%	6,33%

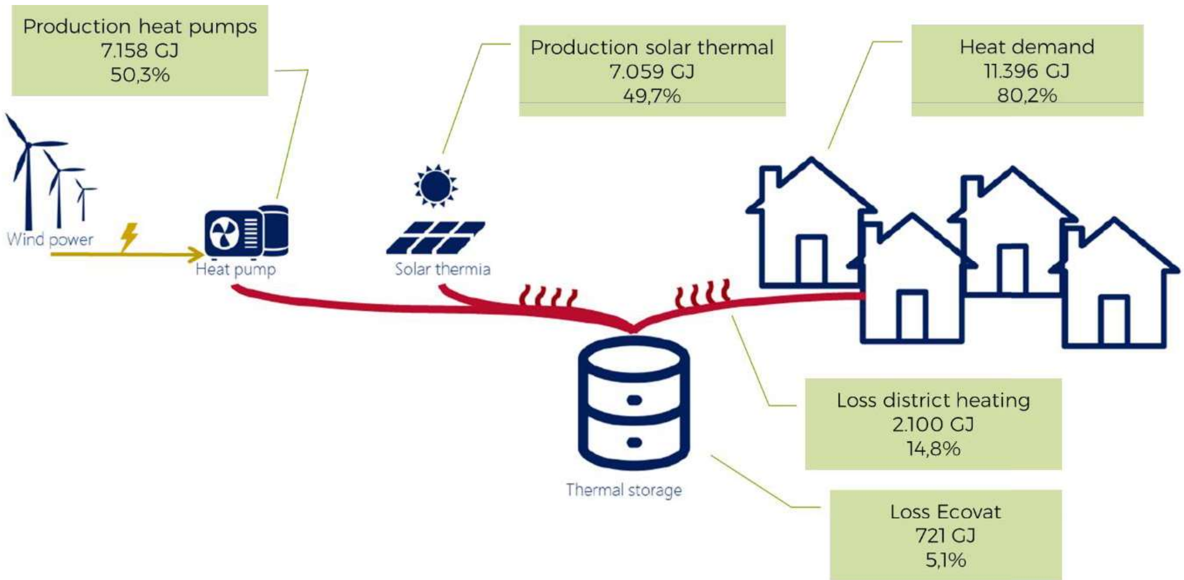

Figure 41 Worst case system performance Ecovat Arnhem

6.3 Conclusion Ecovat Arnhem

The design of the next Ecovat is improved. This Ecovat is expected to be much more efficient than the Ecovat Uden. The thermal loss of the Ecovat Arnhem is expected to be 584 GJ over six months when fully charged. This is 10,44% of the full storage capacity. When used for twelve months, and with a varying state of charge, the thermal loss is expected to be 622 GJ which is 4,4% of the total produced heat and which is 12,4% of the thermal storage capacity of the Ecovat Arnhem. This is regarded as the baseline. In a sensitivity analysis, the worst-case is calculated. This results in a thermal loss of 721 GJ, which is 5,1% of the total produced heat and which is 14,4% of the thermal storage capacity of the Ecovat Arnhem. For more details, see chapter 6. Figure 4 shows the baseline system performance.

This Ecovat is expected to be much more efficient than the Ecovat Uden, because:

- The Ecovat Arnhem will be thirteen times larger in volume. This means the surface to volume ratio is much more efficient, as shown in Table 27;
- The Ecovat Arnhem will be 30 meters deep. This is twice the depth of the Ecovat Uden. This means the destratification effect and the losses to the bottom will be less (compared to the stored volume);
- The Ecovat Arnhem has an improved design of the top to minimize natural convection. Also, the top has more insulation.

Table 27 Volume/surface ratio Ecovat Uden vs. Ecovat Arnhem

Ecovat	Unit	Uden	Arnhem
Diameter	m	11	30
Depth	m	16	28,8
Volume	m3	1.521	20.358
Surface	m2	743	4.128
Volume/Surface		0,489	0,203

6.4 Discussion on stratification Ecovat Arnhem

In the calculations it is assumed that the turbulence in the Ecovat Arnhem will be like Ecovat Uden. However, it is possible that the turbulence will be higher due to charging and discharging with the heat exchangers. Arnhem will use two types of heat exchanger, namely coils and diffusers. Both will influence the turbulence and thus the stratification. This means more exergy (heat quality) is lost due to mixing of different temperatures in the Ecovat Arnhem. If the temperatures after mixing are still useable then this will not result in energy losses. If the temperatures after mixing are too low to be used, then heat pumps must add extra electricity later to make this heat useable again. The amount of electricity needed for this is hard to quantify. Commonly in TTES systems a thermocline is used to enhance the stratification and minimize the exergy losses. This thermocline is a layer of water with a thickness of one meter. This layer separates two volumes of water of different temperatures and has the characteristic to do so for long periods of time.

Figure 42 shows an example of such a thermocline in a thermal energy storage tank by the company Araner.

To conclude, the design of the heat exchangers (coils and/or diffusers) determine the amount of turbulence and thus the mixing of different temperatures, and thus the extra electricity needed for heat pumps to upgrade the temperature levels. For the design of the heat exchangers, Ecovat will consult experts such as Araner and Wim van Helden (AEE INTEC).

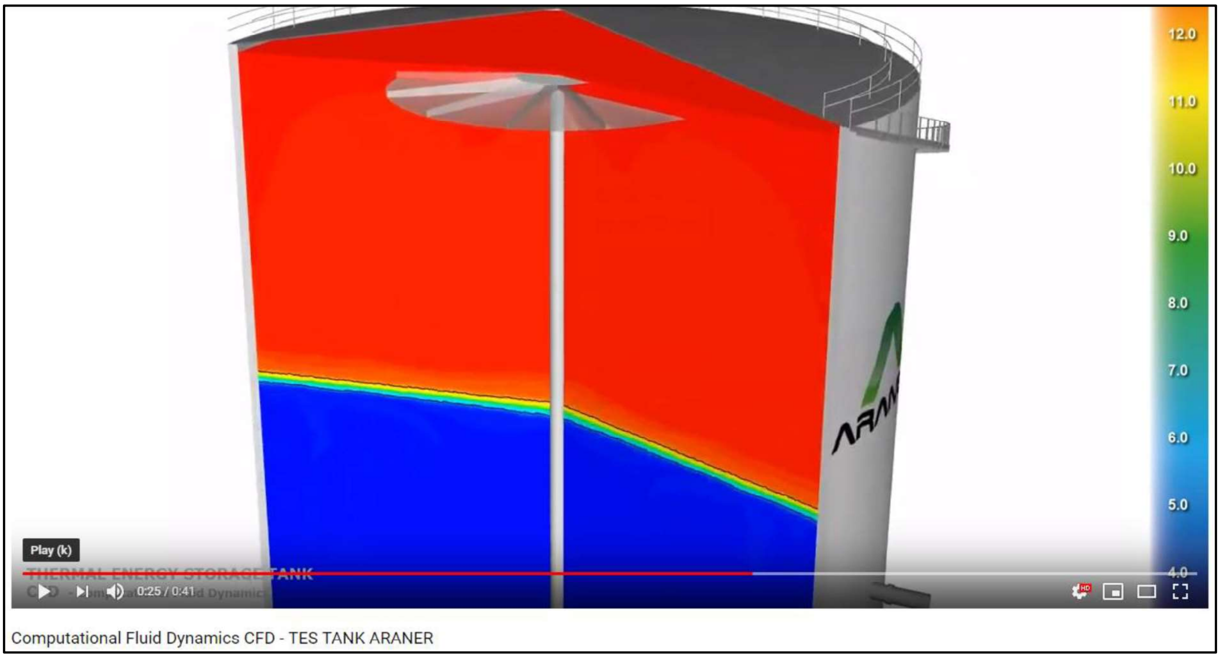

Figure 42 Snapshot of a video of charging a tank rapidly with diffusers.
https://www.youtube.com/watch?v=JCb-9A21r5w

7 References

Mangold, D., & Deschaintre, L. (2015). *Seasonal thermal energy storage. Report on state of the art and necessary further R+D.* International Energy Agency.

TenneT. (2018). *Flexibility Roadmap NL.*

Appendix 1: Ecovat portfolio

	layers (#)	depth (m)	diameter (m)			
			30	36	42	48
Volume {m3)			Volume (m3)			
	8	28,8	**20.347**	29.300	-	-
	9	32,4	22.891	32.962	-	-
	10	36,0	25.434	**36.625**	49.851	-
	11	39,6	27.977	40.287	54.836	71.622
	12	43,2	30.521	43.950	**59.821**	78.133
	13	46,8	33.064	47.612	64.806	84.644
	14	50,4	35.608	51.275	69.791	**91.155**
	15	54,0	38.151	54.937	74.776	97.667
Usable heat capacity (dT = 50K)			Usable heat capacity (MWh/cycle)			
	8	28,8	**1.184**	1.705	-	-
	10	36,0	1.480	**2.131**	2.901	-
	12	43,2	1.776	2.558	**3.481**	4.547
	14	50,4	2.072	2.984	4.061	**5.305**
Natural gas equivalent (AEQ)			Natural gas equivalent (m^3/cycle)			
	8	28,8	121.197	174.524	-	-
	10	36,0	151.496	218.154	296.932	-
	12	43,2	181.795	261.785	356.319	465.396
	14	50,4	212.095	305.416	415.705	542.962
Storage temperature			0-90 °C			
Efficiency 6 months			89,5-90,1%	93%	95%	95%
Technical life expectancy			> 100 years			
Storage medium			natural water (H2O)			

Appendix 2: EPS specifications

Wednesday, March 16, 2011, Time 13:32

WinTherm32 Version 2.30.27
Instrument Program Version 72
Instrument Serial Number: 876

Sample Name: week11-Policel Gouda
Thickness: 49.409mm
Thickness obtained : from instrument

TEST RUN

Calibration used : User Type
Calibration File Id: 50mm_IRMM_876

Number of transdusers per plate: 1
Number of transdusers used per plate: 1

Number of Setpoints: 1

Block Averages for setpoint 1 in SI units

	Tupper [°C]	Tlower [°C]	Qupper [µV]	Qlower [µV]	Lambda [W/mK]
-ne-	8.53	20.13	-8504	-289	0.1707
-ne-	0.58	20.04	-3438	420	0.05762
-ne-	-0.00	20.11	-1442	997	0.03483
-te-	0.02	19.97	-1244	1039	0.03281
-te-	0.01	20.01	-1185	1180	0.03385
-te-	0.01	20.01	-1164	1195	0.03377
-pe-	0.01	20.01	-1159	1202	0.03379
-pe-	0.01	20.01	-1155	1205	0.03378
-pe-	0.02	20.02	-1154	1205	0.03377
-pe-	0.02	20.02	-1156	1205	0.03378

Wednesday, March 16, 2011, Time 14:15

Setpoint No. 1
Setpoint Upper: 0.00 °C
Setpoint Lower: 20.00 °C
Temperature Upper: 0.02 °C
CalibFactor Upper: 0.011806
Results Upper: 0.03369 W/mK
Temperature Lower: 20.02 °C
CalibFactor Lower: 0.011374
Results Lower: 0.03386 W/mK
Percent Difference: 0.52%

Thermal Equilibrium Criteria:
Temperature Equilibrium: 0.20
Between Block HFM Equil.: 49
HFM Percent Change: 2.00
Min Number of Blocks: 4
Calculation Blocks: 3

Results Table – SI Units

Mean Temp	Upper Cond	Lower Cond	Average Cond
10.02	0.03369	0.03386	0.03378

Appendix 3: Foamglass insulation

Product Data Sheet

FOAMGLAS® T4+

Pagina: 1 Datum: 01.05.2011 Vervangt: 28.06.2010 www.foamglas.be/nl

FOAMGLAS® T4+

Verpakkingsgegevens (per pak)

Lengte x breedte [mm]	600 x 450							
Standaard dikte [mm]	40	50	60	70	80	90	100	110
Aantal platen	12	10	8	7	6	6	5	5
Vierkante meter [m²]	3.24	2.70	2.16	1.89	1.62	1.62	1.35	1.35

Lengte x breedte [mm]	600 x 450							
Standaard dikte [mm]	120	130	140	150	160	170	180	
Aantal platen	4	4	4	3	3	3	3	
Vierkante meter [m²]	1.08	1.08	1.08	0.81	0.81	0.81	0.81	

Product Data Sheet

FOAMGLAS® T4+

Pagina: 2 Datum: 01.05.2011 Vervangt: 28.06.2010 www.foamglas.be/nl

1. Producteigenschappen volgens EN 13167 [1)]

Volumemassa (± 10 %) (EN 1602) : 115 kg/m³
Dikte (EN 823) ± 2 mm : van 40 tot 180 mm
Lengte (EN 822) ± 2 mm : 600 mm (halve blokken met lengte 300 mm zijn ook beschikbaar)
Breedte (EN 822) ± 2 mm : 450 mm
Warmtegeleidingscoëfficient (EN ISO 10456) : $\lambda_D \leq 0{,}041$ W/(m·K)
Brandreactie (EN 13501-1) : Euroklasse A1
Weerstand tegen puntlast (EN 12430) : PL ≤ 1.5 mm
Drukweerstand (EN 826 annex A) : CS ≥ 600 kPa
Buigsterkte (EN 12089) : BS ≥ 450 kPa
Haakse treksterkte (EN 1607) : TR ≥ 100 kPa

[1)] Het CE-merk van conformiteit is een verklaring van conformiteit met de verplichte essentiële eisen van CPD, zoals vermeld in EN 13167. Binnen het CEN Keymark certificaat werden alle vermelde eigenschappen gecertificeerd door een goedgekeurde, genotificeerde en geaccrediteerde derde partij.