WP4

System integration Eavor Loop in district heating

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Executive summary

The system integration of the Eavor-Loop in the district heating network consists of 2 sub-work packages:

1. Physical connection to existing grid with the technical capacity of absorbing the Eavor-Loop heat
2. Simulation of heat demand profiles and temperatures to determine the feed-in capacity of the loop without a negative impact on the quality (temperatures) of the heat delivered to the customers.

The physical connection between the Eavor-Loop & heat grid consists of a connection point in the existing grid and a new connection pipeline between the Eavor project and the existing grid. The technical design has been modelled with Sishyd. The connection point has been identified by comparing the most logical (geographical) options, which resulted in one most logical connection point. For the technical design are based on the technical requirements received from the Eavor-Loop. One important output of the design is the diameter of the connection pipeline. With the concept design a concept budget could be made. The accuracy of the budget will increase in the upcoming project phases.

For the simulation of demand and temperatures two approached have been used. Ennatuurlijk has modeled the heat demand for the Eavor-Loop with historical data (hourly basis) of the heat grid and taken into account that there always needs to be a minimum capacity from other heat sources to avoid the cooling down of the transport grid to these other sources. The current temperature regime of the heat grid has mostly been treated as a given. The last years various attempts have been undertaken to lower the supply temperature, but the attempts were with various success. Still, lowering the supply & return temperature reduction will be an important point of attention and topic for further optimalisation. For a next phase of the project future scenario's for optimalisation can be considered in the project valuation.

Besides the historical simulation, another simulation has been done by TNO using the Design Toolkit software. With this software several scenarios have been explored to understand the impact of the Eavor-Loop in the heat grid temperatures. Overall, it shows that a temperature drop of the network mainly occurs in high heat-demand periods and that mainly the heat grid part "Kraaiven" is subjected to a potential temperature drop if no measures are taken. This simulation has done with theoretical model and therefore the results of this study have to treated with care.

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1. General

1.1. Introduction

In work package 4 (WP4) the feasibility of the Eavor-Loop feed-in in the Ennatuurlijk “Midden West Brabant” (MWB) heat grid has been executed. The feasibility study contains the technical boundaries as well as the hourly fit between the Eavor capacity and the hourly demand in the existing grid. For future optimalisation, several scenarios for future improvement have been done.

This study is based on the given the parameters (Appendix A) supplied by the Eavor project team and the current parameters of the ENN heat grid.

In the operation phase special attention is needed for the colder winter period when the supply temperature in the heat grid can be higher than from the Eavor-Loop to ensure the needed supply for customer demand.

For future improvements special attention is needed for the return temperature of the heat grid. With a lower return temperature, the absorbed amount of Eavor-Loop heat can be higher or less usage of heat pump dispatch.

1.2. WP4 Objectives & deliverables

The work package consists of three objectives and corresponding deliverables.

1. Physical connection (description, hydraulic design and technical constraints)
2. Concept budget (level 0)
3. Operating hours during the year, incl future scenarios

2. WP4 results physical connection

2.1. Description of approach

The intended location for the EOVOR project is located in the north of Tilburg near the sewage treatment plant. For the connection between the Eavor project site and the existing heat grid there are 2 possible options available as shown in Figure 1.

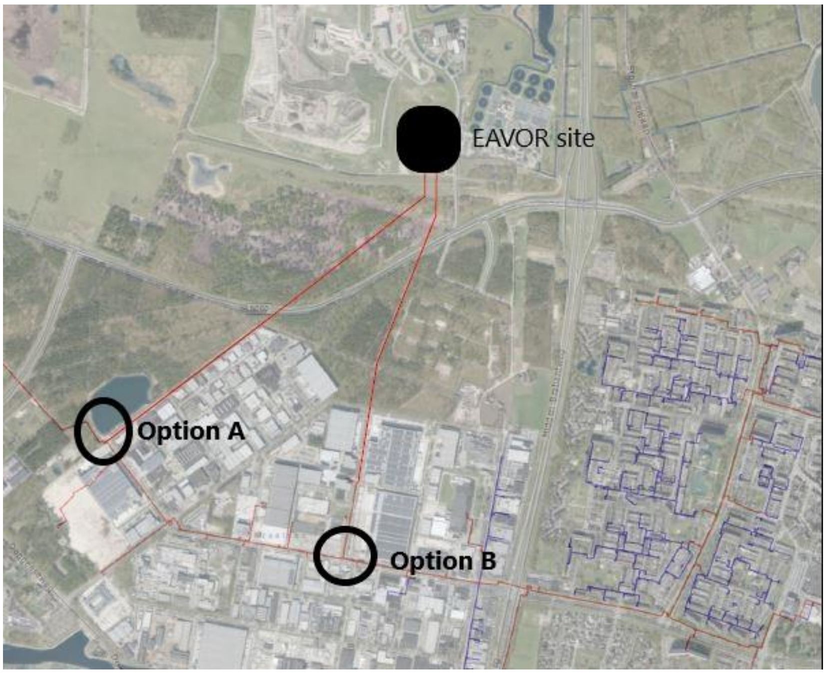


Figure 1 Grid connection options

Option A connects the pipeline from the Eavor project to an existing T-piece located on the Zevenheuvelenweg. This T-piece was installed for future expansion of the district heating network in the area but was never used. The diameter of the existing connection is DN150. The total length of the pipeline in this option is around 1930 meters.

Figure 2 Option A

Figure 3 option B

Option B connects the pipeline from the Eavor project to on one of the branches of the main existing pipeline (Figure 3). The diameter of this pipeline is DN80. The total length of the pipeline in this option is around 1910 meters.

With the capacity from the EAVOR project combined with the given parameters the existing pipeline of option B will not be sufficient enough. Therefore, the choice has been made to use option A.

2.2. Hydraulic design SisHyd

The following hydraulic design is proposed. It is expected that heat pumps will be used for further optimalisation, but these will be in the scope of the Eavor project and for this study the output is a given fact, based on the Eavor parameters as described in table 1.

For the hydraulic grid calculation, the calculation program SisHyd was used. In this calculation program, the existing district heating network in Tilburg is simulated. The simulation is based on the existing temperatures and capacities in the grid. This can lead to some parameters not directly corresponding to the desired technical principles.

2.3. Technical constraints

The following constraints are relevant for the project and determine the operating envelope. They are based on the ENN heat grid values and the parameters provided by the Eavor project (Appendix A).

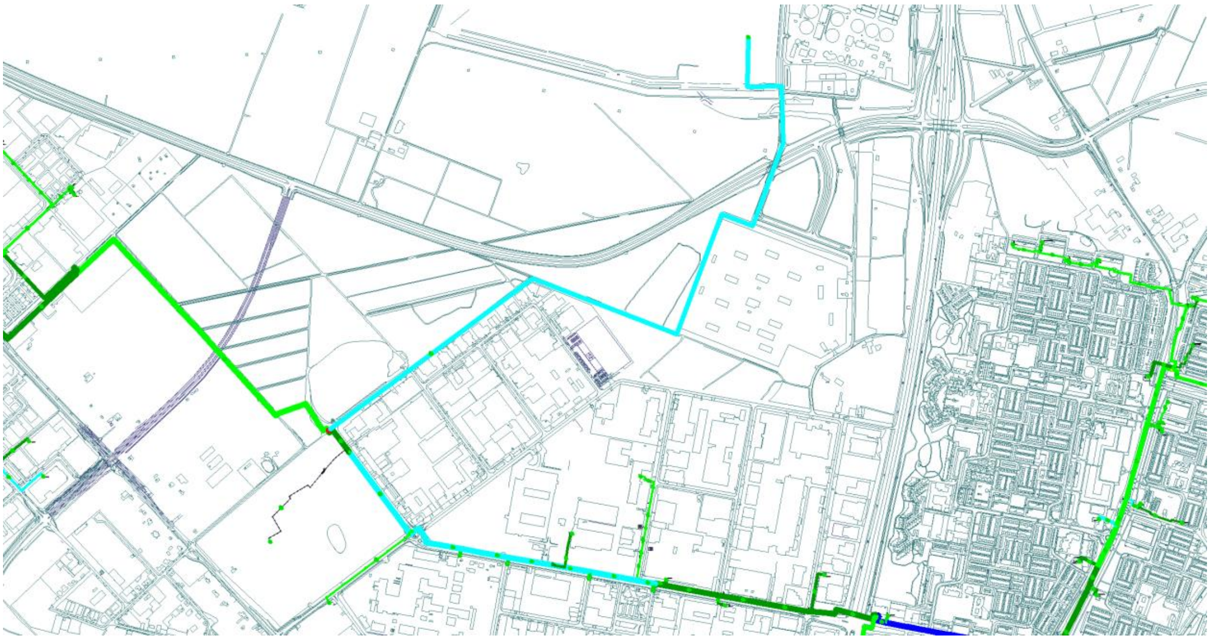
	Summer (Apr - Dec)	Winter (Jan - Mar)
Heat Grid Temperature (°C)	95	120
Eavor-Loop Outlet Temperature (°C)	89	102
Heat Exchanger Inlet Temperature (°C)	97	122
Heat Exchanger Outlet Temperature (°C)	66	66
Eavor-Loop Inlet Temperature (°C)	60	51
Working Fluid Flow Rate (kg/s)	70	30
P50 Thermal Duty (MW)	**9.1**	**7.1**

Table 1 Operating parameters (source; feasibility report Eavor)

Winter

Pipe diameter	**DN150**			**DN200**			**DN250**	
Length	1930	meter		1930	meter		1930	meter
Power	10	MW		10	MW		10	MW
Temp. Supply	120	°C		120	°C		95	°C
Temp. Return	65	°C		65	°C		65	°C
Heatloss	42,57	W/m		48,44	W/m		47,26	W/m
Total heatloss	82,1601	kW		93,4892	kW		91,2118	kW
Flow	163	m³/h		163	m³/h		163	m³/h
Speed	2,24	m/s		1,3	m/s		0,83	m/s
Pressure loss	332	Pa/m		81	Pa/m		25	Pa/m
Pressure loss supply	6,4	bar		1,56	bar		0,5	bar
Pressure loss return	6,2	bar		1,5	bar		0,48	bar
Pressure difference	12,2	bar		13	bar		12	bar
Pressure maintenance	5	bar		5	bar		5	bar
Input pressure Eavor	24	bar		20	bar		18,5	bar

Table 2 Results winter scenario for DN200 and DN250



In the winter scenario, the Eavor heat source will deliver a power of ~10MW with a temperature of 120°C to the existing district heating network. The return temperature in the calculation model is to approx. 65°C. This will result in a flow of approximately 163m³/h.

To determine the pipe diameter, a maximum speed of approx. 3-3.5m/s is maintained with a maximum pressure loss of 200Pa/m. Based on these principles, three diameters were examined in more detail, namely DN150, DN200 and DN250. Table 2 shows the results of the hydraulic calculation. These results show us that a DN200 for the winter situation is possible within the given parameters. The total pressure required to pump the power into the existing grid is approximately 20 bar. This pressure is made up of the pressure difference between the supply and the return, the pressure loss over the pipework and the static pressure in the existing network.

Summer

Pipe diameter	**DN150**			**DN200**			**DN250**	
Length	1930	meter		1930	meter		1930	meter
Power	10	MW		10	MW		10	MW
Temp. Supply	95	°C		95	°C		95	°C
Temp. Return	65	°C		65	°C		65	°C
Heatloss	36,12	W/m		41,1	W/m		40,1	W/m
Total heatloss	69,7116	kW		79,323	kW		77,393	kW
Flow	292	m³/h		292	m³/h		292	m³/h
Speed	4	m/s		2,3	m/s		1,5	m/s
Pressure loss	1088	Pa/m		265	Pa/m		83	Pa/m
Pressure loss supply	21	bar		5,1	bar		1,6	bar
Pressure loss return	20	bar		5	bar		1,5	bar
Pressure difference	33	bar		12	bar		14	bar
Pressure maintenance	5	bar		5	bar		5	bar
Input pressure Eavor	54	bar		23	bar		19,7	bar

Table 3 Results summer scenario for DN200 and DN250

In the summer scenario, the same requirements were used as in the winter scenario with the difference that the supply temperature from the Eavor heat source is 95 °C. The return temperature of approx. 65°C remains the same. This results in a higher flow in the winter scenario as it is shown in Table 3. These results show us that the DN200 pipe (in contrast to the winter scenario) with a speed of 2.3m/s and a pressure loss of 265 Pa/m is not suitable. This means that a diameter of DN250 must be assumed.

The results of the calculation are close to the established parameters. In practice, it may be that the temperatures or the total capacity of the Eavor project is different resulting in the possibility of a pipe diameter of DN200. For example, in the situation when the power is not 10MW but approx. 8.5 to 9 MW. For the purposes of this report, a pipe diameter DN250 is assumed.

A point of attention when applying a DN250 is the connection to the existing grid. As described earlier, the idea was to connect the pipeline to an existing T-piece. The branching pipe to which this pipe is coupled is a DN150 which results in high pressure and speed at this point. Given the age of the existing network (1981), the advice is to make a new connection on the existing DN400 pipeline.

2.4. Concept budget

For the physical connection a concept budget (level 0) is provided Table 4.

Cost estimate*	
Tie-in existing heatgrid	€ 20.000
Pipeline	€ 5.790.000
Engineering	€ 348.600
Profit & risk	€ 615.860
Total cost	**€ 6.774.460**

Table 4 cost estimate +/- 40%

**The investments are based on key figures and therefore an indication.*

3. WP 4 results operational hours

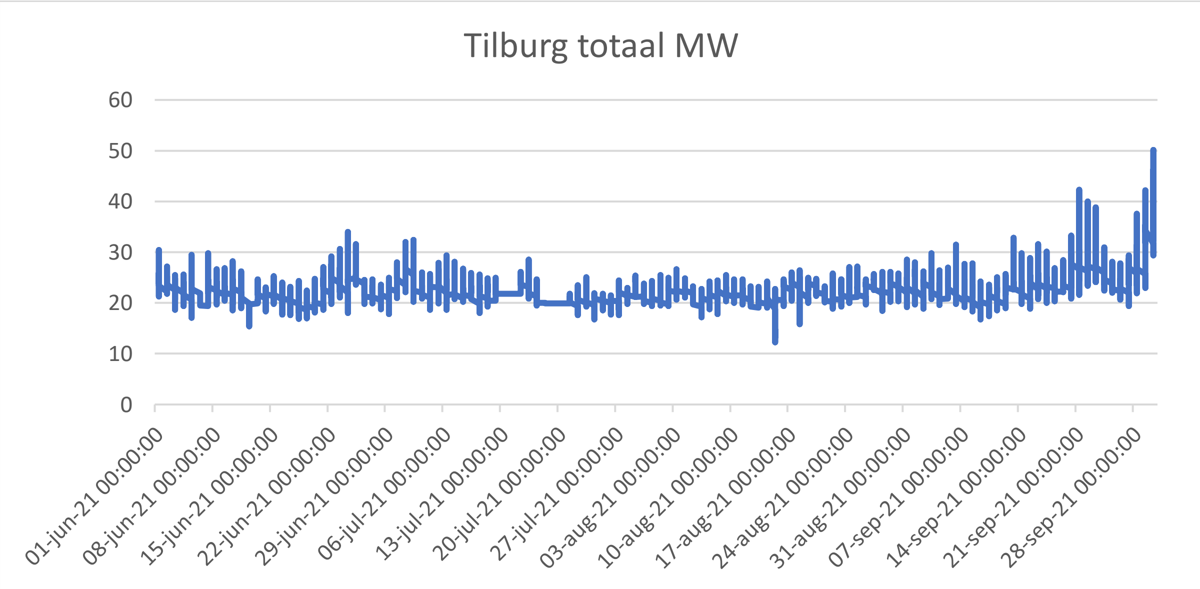
To determine the operational dispatch of the loop in the heat grid, a study has been done based on historical heat grid data and with the operational parameters provided by the Eavor project. The study is done with a dedicated xls file.

Below the possibilities for continuous production of the Eavor source when it is fed into Tilburg on the corner of Zevenheuvelenweg / Wolterbeekstraat.

A large part of Tiburg Noord can be reached from the connection point, but not the customers at the industrial estate on the Vossenberg. The low load of the whole of Tilburg North is in any case too small (regularly < 5MW). Fortunately, we can also reach the Tilburg Reeshof area via the city ring. This creates sufficient demand to absorb 10 MW in the summer as well. However, we must also take into account that there must always be a flow over the transport pipeline from Geertruidenberg to Tilburg. Otherwise, the transport pipeline will cool down. Effectively, at least 7 MW is always required, which is received at the Tilburg pumping station and must therefore also enter the city. In 2021 there were 20 hours when the low load of Tilburg fell below 17 MW. It will need some balancing in the hottest periods to be able to absorb the heat well, but it is just possible. The capacity for additional heat sources will be limited to 10 MW in the hottest summer months.

3.1. Results

The simulation gives the following results in summer.



In months outside of June to September the demand in Tilburg will be sufficient to absorb without capacity restrictions the heat produced by the Eavor-Loop.

3.2. Design Toolkit Simulations of Eavor-Loop in Tilburg primary network

The heating network of Tilburg has been made available via a shapefile (pipe network of primary heating network only) to be utilized in the Design Toolkit functionality as developed during the WarmingUp project (MOOI call). This shapefile has been converted to an ESDL-file that is required for the design toolkit. The resulting network consists of the primary heating network with consumers on a neighborhood level, see Figure 4 left graph. For purpose of this work, this network has been simplified: the consumers are clustered into 12 residential and 2 industrial areas, see Figure 4 right graph.

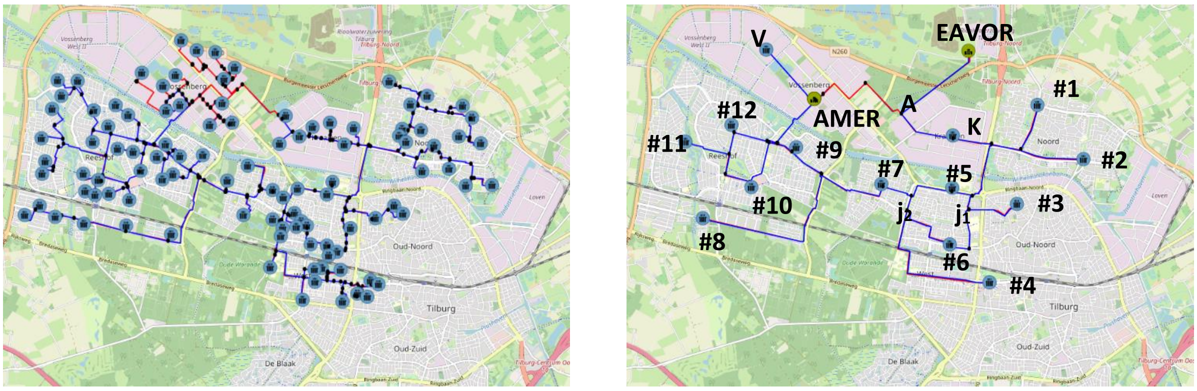


Figure 4: Left graph: detailed primary heating network of Tilburg. Right graph: simplified heating network of Tilburg with neighborhoods clustered in 12 residential areas. The industrial areas are clustered into Vossenberg area (V) and Kraaiven area (V). The Eavor-Loop is connected to the Tilburg primary heating network via tie-in point 'A'.

For each residential area (#1 - #12) an estimate of the number of households, N_a, and a typical heat demand, H_a, is made using the heating-demand profile-generator [1]. The typical heat-demand of a residential area is estimated by selecting a single 'representative neighborhood' within this area and calculate its heat-demand profile by the generator, H_n. By using the number of households in the selected neighborhood, N_n, the area heat demand is estimated via: $H_a = H_n * N_a / N_n$. In the profile-generator the year 2013 is selected. The shape of the heat demand profile of residential area's #1 to #7 and #9 are quite similar, as are the profiles of areas #8 and #10 to #12 [2].

The total annual heat demand of Tilburg is estimated as 470,000 MWh/y, or 53.6 MW on average. About 60% of this heat demand is required by the residential area (= 32.2 MW) and 40% by the industrial area (= 21.4 MW). The heat demand for each residential area estimated via the heating-demand profile-generator, H_a, is scaled such that the average total residential heat demand meets 32.2 MW, see Table 5. The heat demand of the industry is assumed to be constant throughout the year and is assumed to scale with its area size, i.e., about 7.2 MW by industrial area Kraaiven and 14.2 MW by industrial area Vossenberg, see Table 6.

[1] https://www.warmteprofielengenerator.nl/

[2] From the warmteprofiel generator the average heat demand is about 700 W for residential areas #8 and #10 to #12, corresponding to about 20GJ/y for a household (i.e. typical for Newbuild houses). For residential areas #1 to #7 and #9 the average heat demand is about 1500W, corresponding to about 47GJ/y for a household (i.e., typical for older existing build houses).

The total heat demand of Tilburg during the year is shown in Figure 5. During high demand season (Q1 & Q4) the average heat demand is about 79 MW and in low demand season (Q2 & Q3) the average heat demand is 28.0 MW. These values are judged sufficiently close to the estimates of the high- and low-demand of 75 and 32 MW, respectively, to assess the effect of installing the Eavor-Loop on the temperatures in the primary heating network.

Table 5: Number of households and average heat demand of residential areas #1 to #12.

ID	Total house holds	Representative Neighborhood	Average heat demand
1	3500	Heikant Oost	5.6
2	1600	Lijnse Hoek Oost	2.6
3	1200	Kasteel West	1.6
4	4450	Bomenbuurt Midden	6.9
5	750	Het Zand Noord Oost	1.3
6	2250	Westermarkt	3.9
7	1800	Kruidenbuurt Zuid	2.5
8	1800	Koolhoven Noord	1.0
9	2100	Gesworen Hoek Zuid	2.6
10	1600	Campenhoef Midden	1.4
11	1500	Dalem Noord II	1.0
12	2350	De Kievit Noord Oost	1.7
	25000	**Total Residential**	**32.2**

Table 6: Average heat demand of industrial area Kraaiven (K) and Vossenberg (V).

ID	Industrial area	MW
K	Kraaiven	7.2
V	Vossenberg	14.2
	Total Industrial	**21.4**

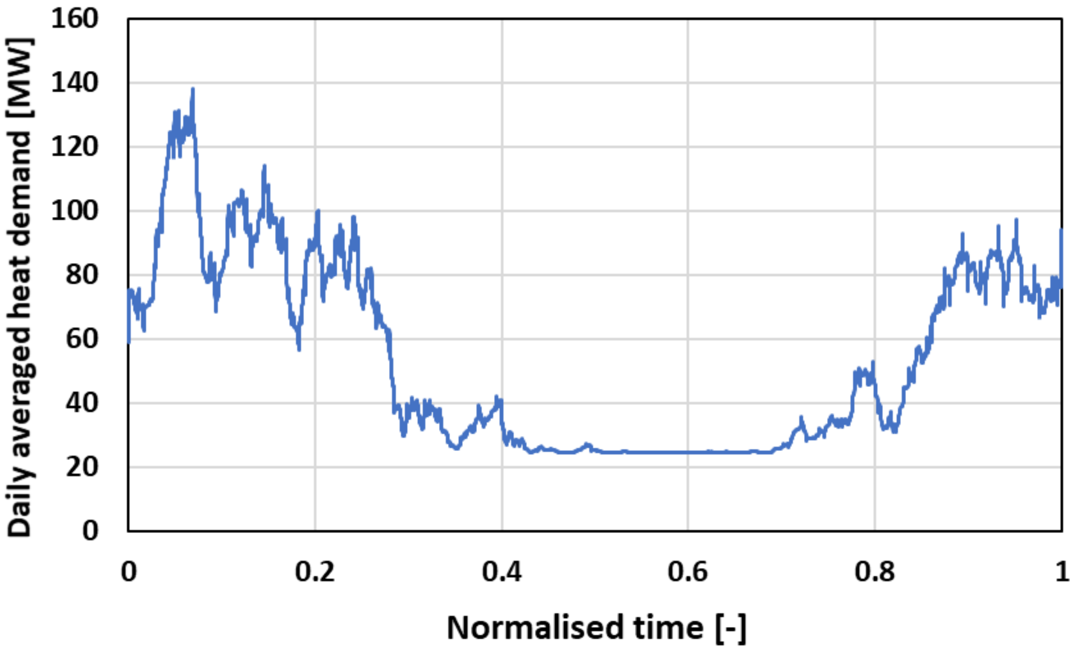


Figure 5: Total heat demand of Tilburg during the year including residential and industrial users.

The required heat is currently supplied by the Amer centrale, which ties in at the South-East side of industrial area Vossenberg (see Figure 4). During low-demand season the supply temperature of the primary heating network is 95 °C and in high-demand season the supply temperature increases to 120 °C. In consultation with the heating curve by the Amer centrale is approximated in a piece-wise linear manner, see Figure 6. The return temperature is set to 65 °C throughout the year.

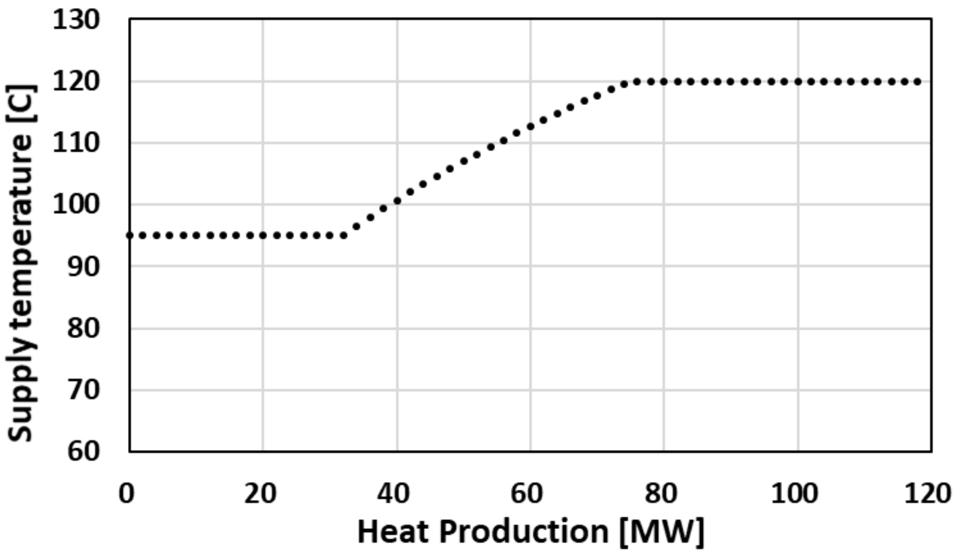


Figure 6: Amer heating curve: supply temperature as a function of heat production by the Amer centrale.

The Eavor-Loop is modeled as a heat production source with constant heating power and supply temperature. The tie-in point of the Eavor-Loop in the primary heating network of Tilburg is at the West-side of industrial area Kraaiven (option A, Figure 7). In total 5 scenarios have been simulated (see Table 7).

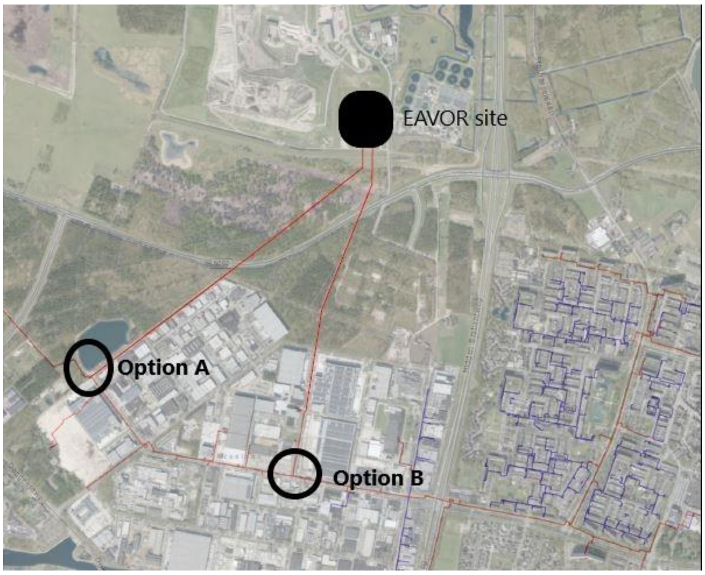


Figure 7: Options for tie-in points of Eavor site. Option A has been selected in the simulations.

Table 7: Scenarios assessed in the simulations, the performance of the Eavor-Loop is provided by Eavor.

ID	Eavor-Loop		Remarks
	Heat production	**Supply temperature**	
0	-	-	Base case without Eavor-Loop tied in
1	6.3 MW	98 °C	Eavor-Loop running at natural convection (mass flow of 47 kg/s)
2	7.7 MW	90 °C	Eavor-Loop running at forced convection (mass flow of 75 kg/s, pump power ~76 kW)
3a	5.2 MW	120 °C	Eavor-Loop boosted by 1MW heat pump to increase supply temperature (300 RT on the cold side).
3b	7.3 MW	120 °C	Eavor-Loop boosted by 2MW heat pump to increase supply temperature (570 RT on the cold side).

3.3. Design Toolkit Results

The primary heating network of Tilburg forms roughly a ring with several branches to supply the various areas. In the base case scenario, the heat supply is split and flows via the North and South part of the ring. These two streams 'meet each other' at the stagnation point [3]. The flow distribution between the North and South part, and the heat-demand-distribution of all consumers (residential and industrial) determine the location of the stagnation point. The flow distribution itself depends also on the heat-demand-distribution of all consumers and on the dimensions of the network (diameter, lengths and hydraulic wall-roughness). Changes in the heat-demand and heat-production

[3] The stagnation point is the location in the network where the streams meet, and the flow is essentially zero.

characteristics affect the flow distribution. The flow distribution for the base case (ID = 0) is shown in Figure 8.

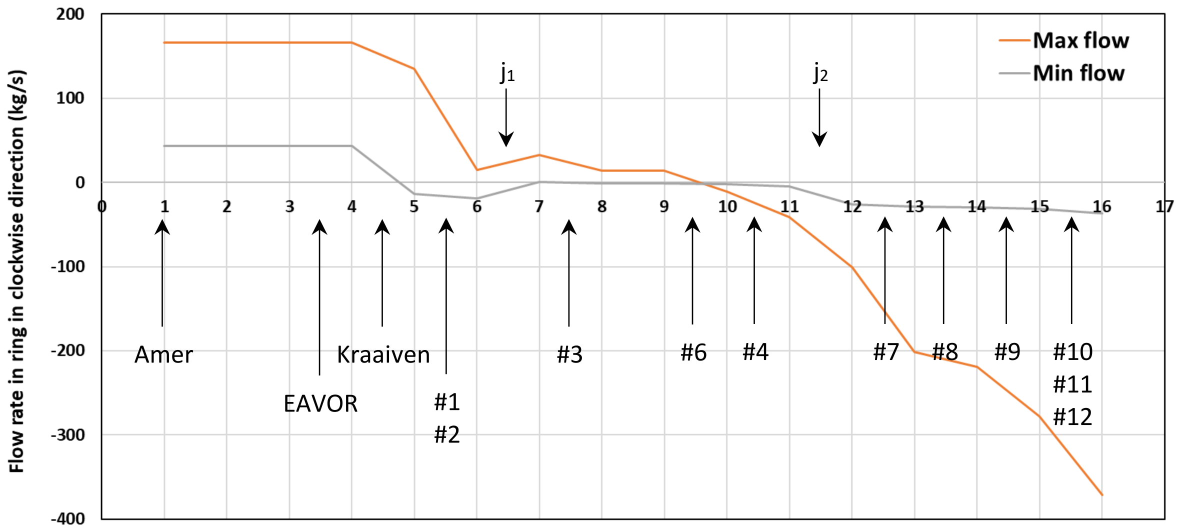


Figure 8: Flow rate in the ring of the Tilburg primary heating network for maximum flow conditions and minimum flow conditions for the base case (case 0). Positive flows represent flows in clockwise direction. The horizontal axis shows location points in the ring. The IDs: 'j1' and 'j2' are the tie-in point of the 'sub-ring' going from demand #5 #6, and back. j1 is east of the subring and j2 is west of the subring

The maximum flow in the ring occurs when the heat demand is maximum, or about 140 MW. In this situation 167 kg/s is flowing into the ring from the Amer tie-in point in clockwise direction, 372 kg/s in counterclockwise direction, and 62 kg/s towards Vossenberg. The stagnation point is approximately near 'consumer #6'.

The minimum flow in the ring occurs when the heat demand is minimum, or about 24 MW. In this situation 43 kg/s is flowing into the ring from the Amer tie-in point in clockwise direction, 36 kg/s in counterclockwise direction, and 114 kg/s towards Vossenberg. There are now 2 stagnation points: a strong one at Kraaiven and a weaker one at 'consumer #3'.

The temperature of the supply flow is equal for all consumers, but varies throughout the year, see Figure 9.

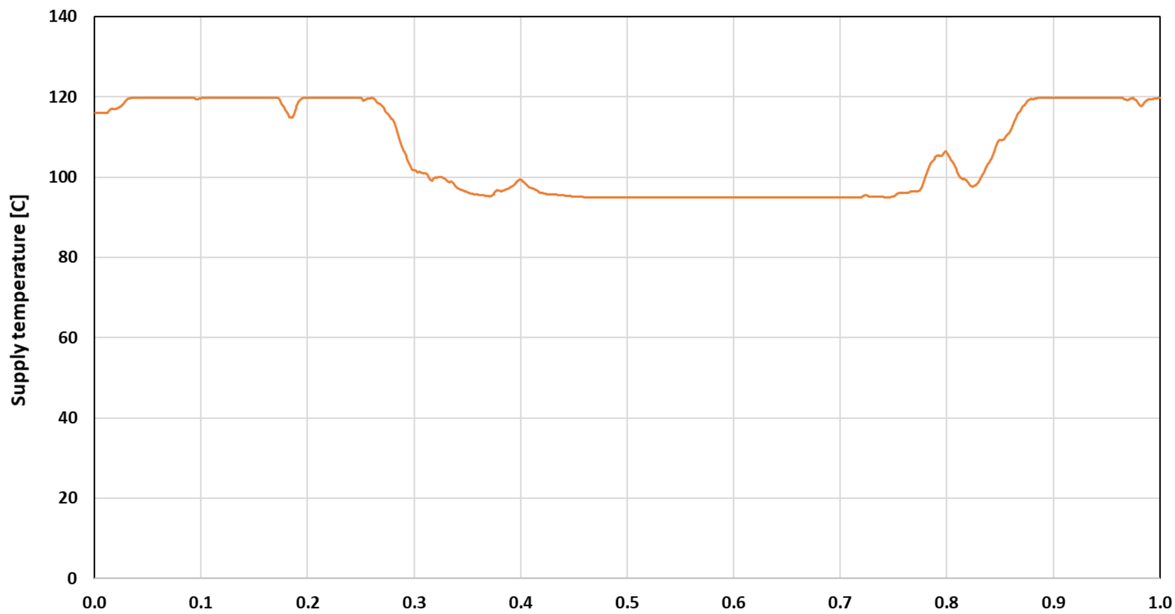


Figure 9: Supply temperature in the primary ring of the Tilburg heating network through the year.

The flow distribution is of importance since it determines how the Eavor-Loop affects the supply temperature in the ring. Typically, in high heat-demand periods, the flow from the Eavor-Loop mixes with the flow from the Amer (thereby changing the supply temperature) and flows in the clockwise direction in the ring network, up to the stagnation point. Beyond the stagnation point the flow is fed by the Amer alone, via the ring in the counterclockwise direction. During low heat-demand periods the Eavor-Loop significantly affects the flow, and each case behaves differently.

The flow distribution of Case 1 is shown in Figure 9 for the situation of maximum heat demand and minimum heat demand. In case heat demand is maximum (about 140 MW), about 141 kg/s is flowing into the ring from the Amer tie-in point in clockwise direction, 371 kg/s in counterclockwise direction, and 62 kg/s towards Vossenberg. The Eavor-Loop adds about 46 kg/s going in the clockwise direction, so that the total flow towards Kraaiven is larger than in the base case (about 10%). The counter-clockwise flow from Amer is similar to the base case. Consumers ‘Kraaiven’, ‘#1’ and ‘#2’ will receive the mixed Amer-Eavor supply at a temperature of about 110 °C (i.e., a temperature drop of about 10 °C compared to the base case). At j_1 the mixed flow is mixed again with the flow from the Amer (via #5) going in counter-clockwise direction and reaches a temperature of about 115 °C (i.e., a temperature drop of about 5 °C compared to the base case). Consumer #3 will receive this. The stagnation point is approximately near ‘consumer #6’ and will receive a supply temperature of about 117 °C (i.e., a temperature drop of about 3 °C compared to the base case). All other consumers are fed by the Amer and will receive the same supply temperature as in the base case.

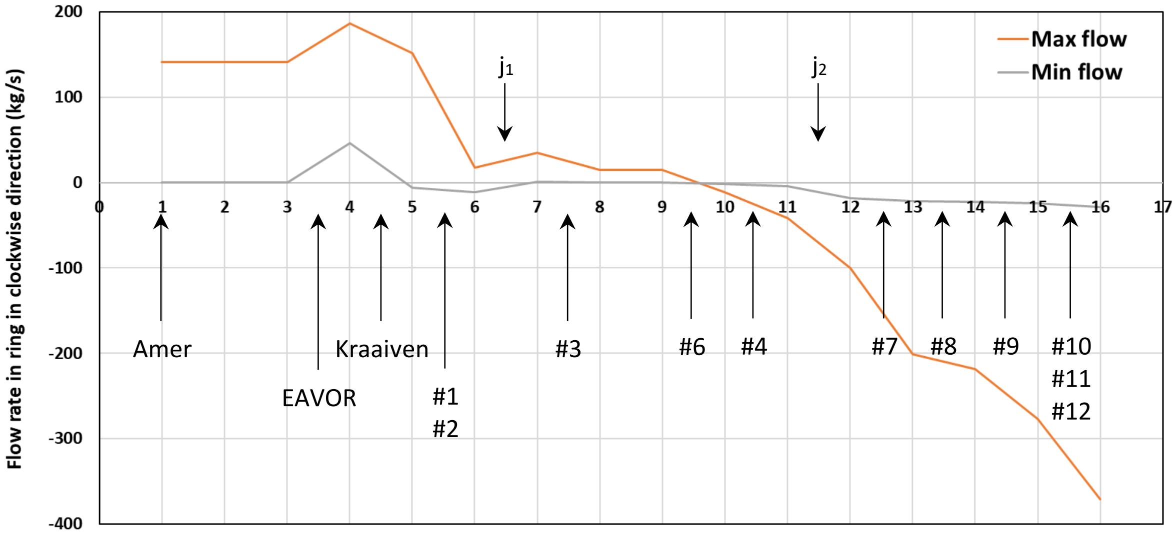


Figure 10: Flow rate in the ring of the Tilburg primary heating network for maximum flow conditions and minimum flow conditions for case 1. Positive flows represent flows in clockwise direction. The horizontal axis shows location points in the ring. The IDs: 'sr1' and 'sr2' are the tie-in point of the 'sub-ring' going from demand #5 #6, and back. Sr1 is east of the subring and Sr2 is west of the subring

During minimum heat-demand (about 24 MW) the flow between the Amer tie-in point and the Eavor tie-in point is almost zero. Thus, the Eavor-Loop is feeding Kraaiven almost completely (90% of the required heat), and the Amer is feeding all other consumers (in counter-clockwise direction). This means that the supply temperature of Kraaiven is about 98 °C (i.e., a temperature rise of about 3 °C compared to the base case in low-demand period), and all other consumers receive a supply of 95 °C.

The change in temperature of the supply flow is now varies between the consumers, and this change varies throughout the year, see Figure 11. For the consumers closest to the Eavor-Loop tie-in point the impact is largest up to about 12 °C in high-demand period.

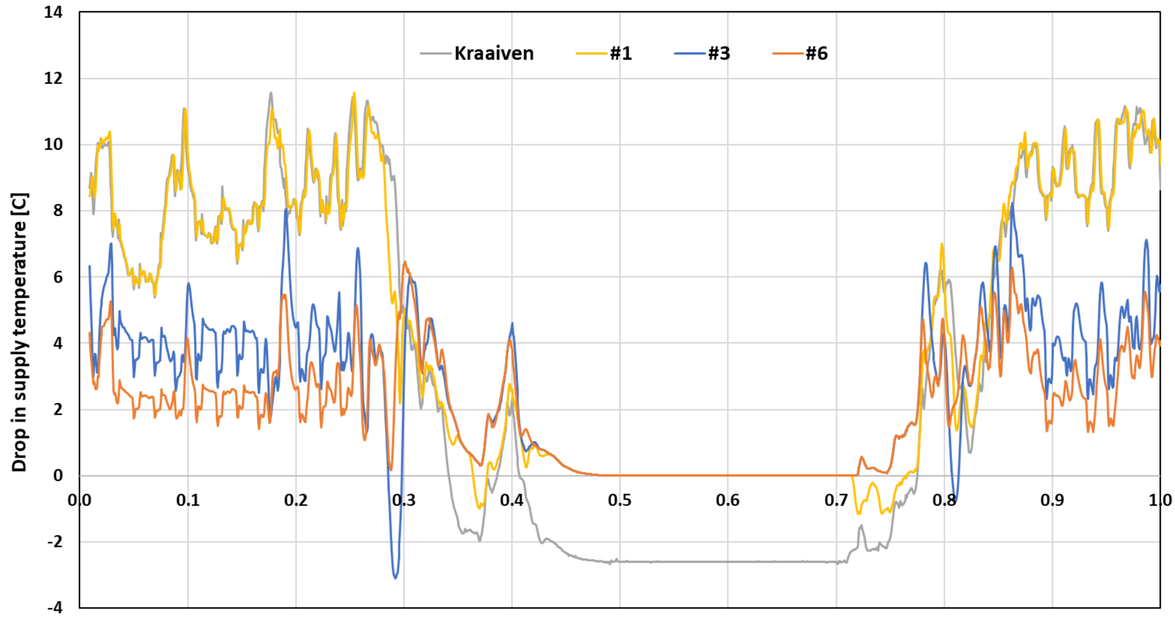


Figure 11: Supply temperature in the primary ring of the Tilburg heating network through the year for case 1.

Considering case 2, where the Eavor-Loop internal-flow is boosted by a pump to increase the heating power output at the cost of supply temperature, the impact on temperature is larger. In this case the flow distribution during the high heat-demand period is much alike that in case 1, but the temperature impact is for consumers Kraaiven, #1 and #2 much larger (up to about 20 °C, see Figure 13).

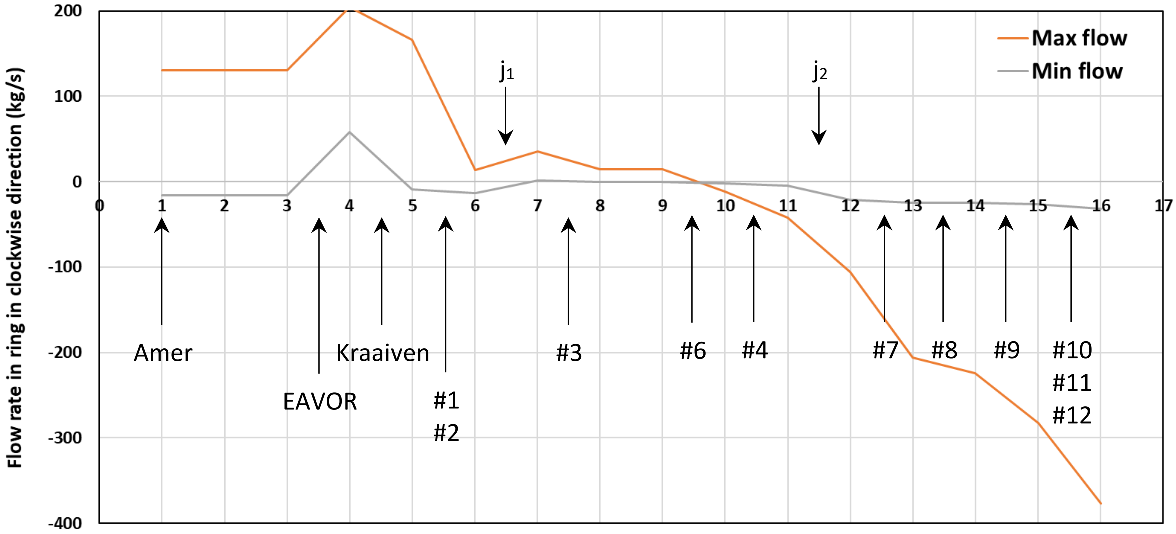


Figure 12: Flow rate in the ring of the Tilburg primary heating network for maximum flow conditions and minimum flow conditions for case 2. Positive flows represent flows in clockwise direction. The horizontal axis shows location points in the ring.

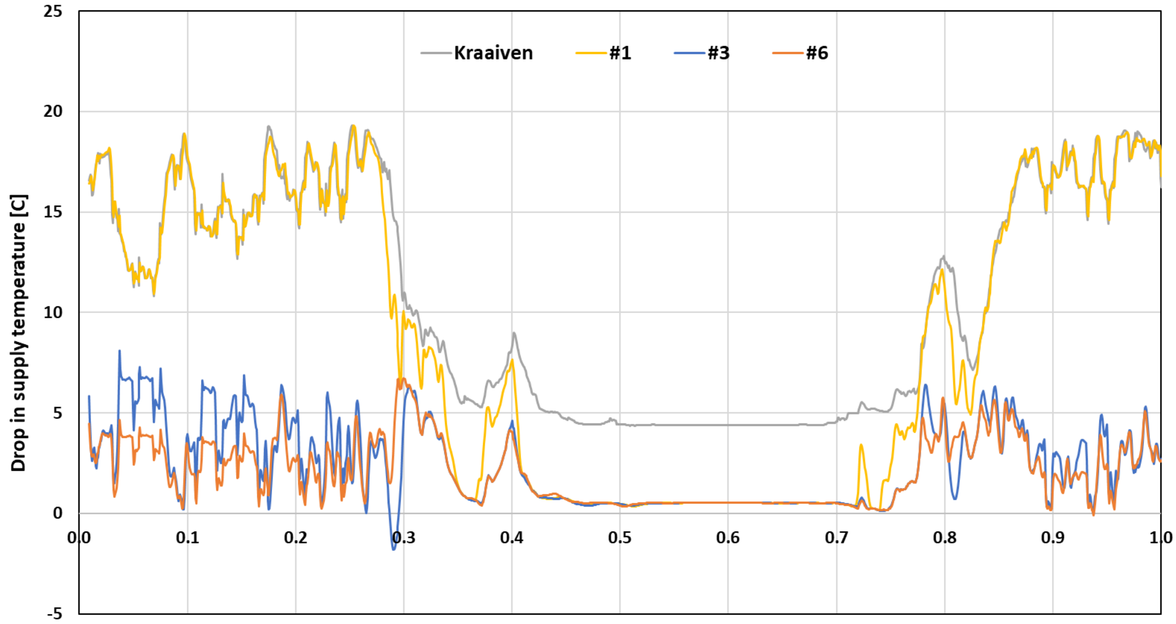


Figure 13: Supply temperature in the primary ring of the Tilburg heating network through the year for case 2.

During the low demand period, the flow distribution is more affected by the Eavor-Loop: the flow from the Eavor-Loop now flows both in clockwise direction towards Kraaiven (57.8 kg/s) and counter-clockwise direction towards Amer (15.7 kg/s). The flow to Amer mixes with the Amer feed to a temperature just below 95 °C (i.e., a temperature drop less than 1 °C compared to the base case in low-demand period), and feeds all consumers fully (except for Kraaiven). Kraaiven is fed by Eavor and the counter-clockwise mixed flow and receives a supply temperature of about 91 °C (i.e., a temperature drop of about 4 °C compared to the base case in low-demand period).

For cases 3a and 3b the flow distributions are both much alike case 1, both in high and low heat-demand period, see Figure 14 (case 3b). The main difference with case 1 is that the Eavor-Loop supplies a heat with equal temperature to that of Amer in high heat-demand period, such that the temperature impact is small. During the low heat-demand period the Eavor-Loop supplies a temperature higher than that of the Amer, which mainly affects Kraaiven. Kraaiven receives a supply temperature of about 110 °C and 120 °C for case 3a and 3b, respectively (i.e., a temperature rise of about 15 °C and 25 °C, respectively, compared to the base case in low-demand period). See Figure 15 (case 3b). Consumers #1 and #2 will also experience a higher supply temperature in the mid heat-demand periods, but this effect is practically absent in low heat-demand period.

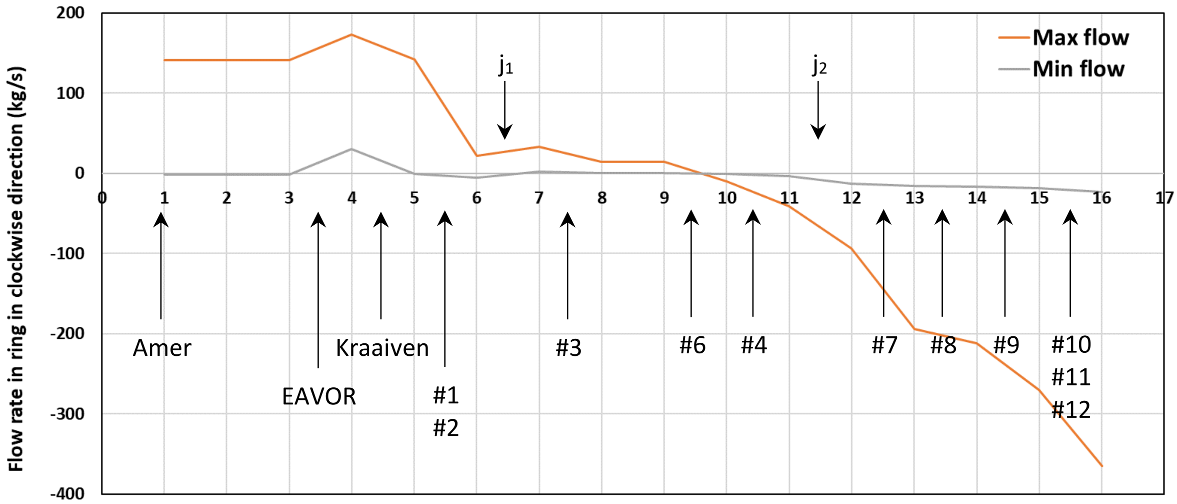


Figure 14: Flow rate in the ring of the Tilburg primary heating network for maximum flow conditions and minimum flow conditions for case 3b. Positive flows represent flows in clockwise direction. The horizontal axis shows location points in the ring.

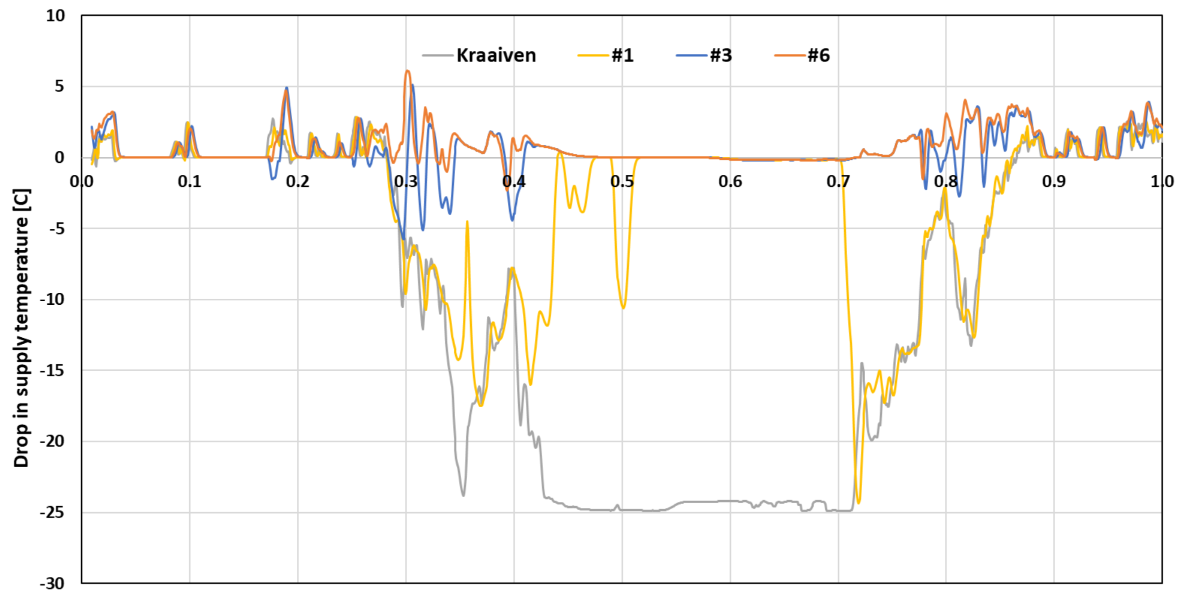


Figure 15: Supply temperature in the primary ring of the Tilburg heating network through the year for case 3b.

3.4. Conclusions and recommendations

The primary heating network of Tilburg has been modelled in Design Toolkit to assess the impact of connecting the Eavor-Loop as heat supplier on the supply temperature of the network. 4 cases have been simulated:

- Case 0: base case without the Eavor-Loop tied-in
- Case 1: Eavor-Loop tied-in at location A, Eavor-Loop running at natural convection
- Case 2: Eavor-Loop tied-in at location A, Eavor-Loop running at boosted convection
- Case 3: Eavor-Loop tied-in at location A, Eavor-Loop boosted by using a heat pump (3a: 1 MW, 3b: 2 MW)

The impact of the Eavor-Loop on the supply temperature varies per case and between the low and high heat-demand period.

In the high heat-demand period the flow distribution of case 0 is little affected by the presence of the Eavor-Loop. The flow from the Eavor-Loop mixes with the flow from the Amer and flows clockwise in the direction of Kraaiven. The temperature drop experienced by Kraaiven in high heat-demand season is up to about 20 °C for case 2, up to about 12 °C for case 1 and almost absent for case 3a and 3b.

In the low heat-demand period the flow distribution is much affected by the Eavor-Loop. For case 1 and case 2, since in this period the supply temperature of Amer and Eavor-Loop are quite close, the impact on the supply temperature is quite small (up to about 4 °C for case 2) and only occurring at Kraaiven. For case 3a and 3b the supply temperature of the Eavor-Loop is much higher than that of Amer, hence a temperature rise is observed (up to about 15 °C and 25 °C for case 3a and 3b, respectively). This temperature rise is mainly occurring for Kraaiven.

Overall, it shows that negative impacts on the supply temperature (i.e., a temperature drop) by the Eavor-Loop mainly occur in high heat-demand periods, and that mainly Kraaiven is subjected to these impacts. This is due to the fact that tie-in point of the Eavor-Loop is upstream of Kraaiven (in the base case).

The simulations have been performed with estimates of heat-demand profiles and Amer heating curve. Variations herein can impact the flow distribution and/or supply temperatures. It is recommended to use actual values to obtain a more accurate impact assessment.

From a technical point of view, the tie-in point of the Eavor-Loop should be upstream of the consumers that are least affected by a supply temperature reduction. This will reduce the negative impact of a drop in supply temperature by the Eavor-Loop.

There are many more scenarios possible to operate the Eavor-Loop, some of which may impact the supply temperature little, but are more sustainable (i.e., more use of the Eavor-Loop heat). E.g., combining natural buoyancy operation (case 1) during high heat-demand period with forced-flow (case 2) during low heat-demand period may impact the supply temperature little, while improving the total heat generated by the Eavor-Loop (about 7 MW).

4. Future scenarios

Ennatuurlijk is currently investigation if the primary supply and return temperature of the heat grid can be reduced. The aim is to year-round reduce the supply temperature to below 100 °C and the return temperature to below 60 °C.

This will reduce the transport capacity of the heat grid, so first capacity bottlenecks must be resolve.

At this moment it is not clear yet, if these temperature reductions are a feasible option.

Appendix A. Operating parameters Eavor-Loop

Operating & Process Conditions

Parameter	Unit	Value
Application	N/A	Direct / District Heating
Heat Network Inlet Temperature	°C	90.0
Heat Network Outlet Temperature	°C	65.0
Eavor-Loop™ Outlet Temperature	°C	88.8
Eavor-Loop™ Inlet Temperature	°C	62.6
Heat Pump Size	MW	1.0
Heat Pump Electrical Requirement	kW	380.9
Temperature Upstream of Heat Exchanger	°C / km	93.3
Temperature Downstream of Heat Exchanger	°C	66.0
Eavor-Loop™ Working Fluid Flow Rate	kg /s	75.0
Total Thermal Duty	MW_{th}	8.6
Circulation Pump Required	Y / N	Y
Circulation Pump Size	kW	75.0