



Zonthermie warmtenet Loppersum

Ondersteuning gemeente Eemsdelta met een QuickScan zonthermie en
vervolgonderzoeksvragen

Zonthermie warmtenet Loppersum





Contents

- Introduction
- Quick scan of solar thermal energy and answers to questions
- Follow-up research ideas



Executive summary (1/2)

The municipality in Loppersum has a plan to realise a district heating network with air source heat pump (ASHP) to supply the heat. We performed a quick scan on the integration of solar thermal energy to the planned heat network. The minimum heat generation studied is 10% of the annual heat demand. The result shows that several cases are profitable to install solar thermal. Therefore, we recommend to do a feasibility study as continuation of this quick scan.

Method

- Monthly level simulation
- 2 types of solar thermal collector were considered: evacuated tube and flat plat.
- 2 levels of solar thermal output temperature were evaluated (45 °C and 70 °C). The 45 °C output is upgraded to 70 °C before delivered to heat network.

Scenarios

- The simulation has been performed to generate solar heat

equal to 10%, 20%, 40%, and 80% demand annually.

Results

1. 3 target buildings (Gemeentehuis, Kerkgenootschap, and Gemeentewerf) have enough capacity to generate up 80% of the district heating demand.
2. Heat storage necessities:
 - Heat storage is needed for the case where generation is higher than 10% demand
 - Heat storage sizes to achieve 90% solar thermal utilization are 87 MWh, 300 MWh, and 738 MWh for 20%, 40%, and 80% demand respectively.
3. Flat plate type gives better business case compared to evacuated tube
4. Solar thermal output temperature does not give notable impact to the business case



Executive summary (2/2)

Results (continued)

5. Unit cost (type: flat plat; 20 years period):

	without subsidy (EUR/GJ)	with subsidy (EUR/GJ)
Solar thermal cases		
10% demand	18	-2
20% demand (87 MWh storage: 90% utilization)	46	28
40% demand (300 MWh storage: 90% utilization)	29	10
80% demand (738 MWh storage, 90% utilization)	25	6

- As a comparison, the current ASHP unit cost:

	without Subsidy (EUR/GJ)	with Subsidy (EUR/GJ)
Baseline (ASHP) cases		
30 years period	28.0	18.1
45 years period	23.3	16.6

6. We identified the possible subsidies for this project, as listed in page 26.

7. Net Present Value (NPV) for solar thermal flat plate types with ASHP as baseline:

Temperature →	70 °C	45 °C
10% demand	€ 108 K	€ 108 K
20% demand	€ -258 K	€ -270 K
40% demand	€ 231 K	€ 227 K
80% demand	€ 856 K	€ 849 K

Key assumptions:

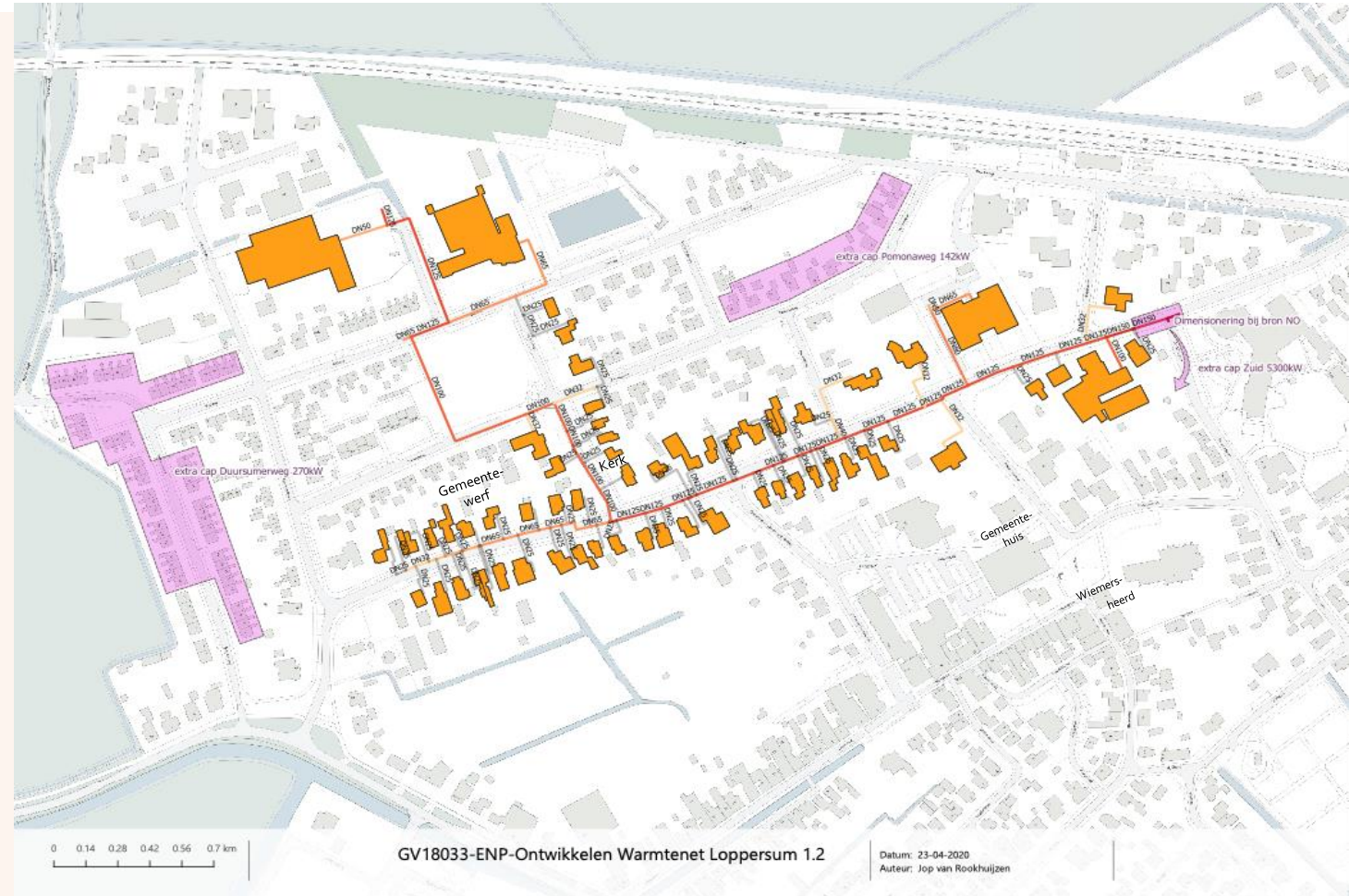
- Subsidy: 256 EUR/ton CO₂ saved for 15 years (reference: SDE++)
- Benefit: electricity saved (price: 120 EUR/MWh)
- Benefit: If there's storage, the capacity of the air source heat pump is reduced. The impact to this reduction is simulated as ASHP fixed cost (EUR/GJ) multiplied generated solar thermal energy (GJ).



Introduction: planned heat network

Gemeente Loppersum has a plan to build a district heating that connect:

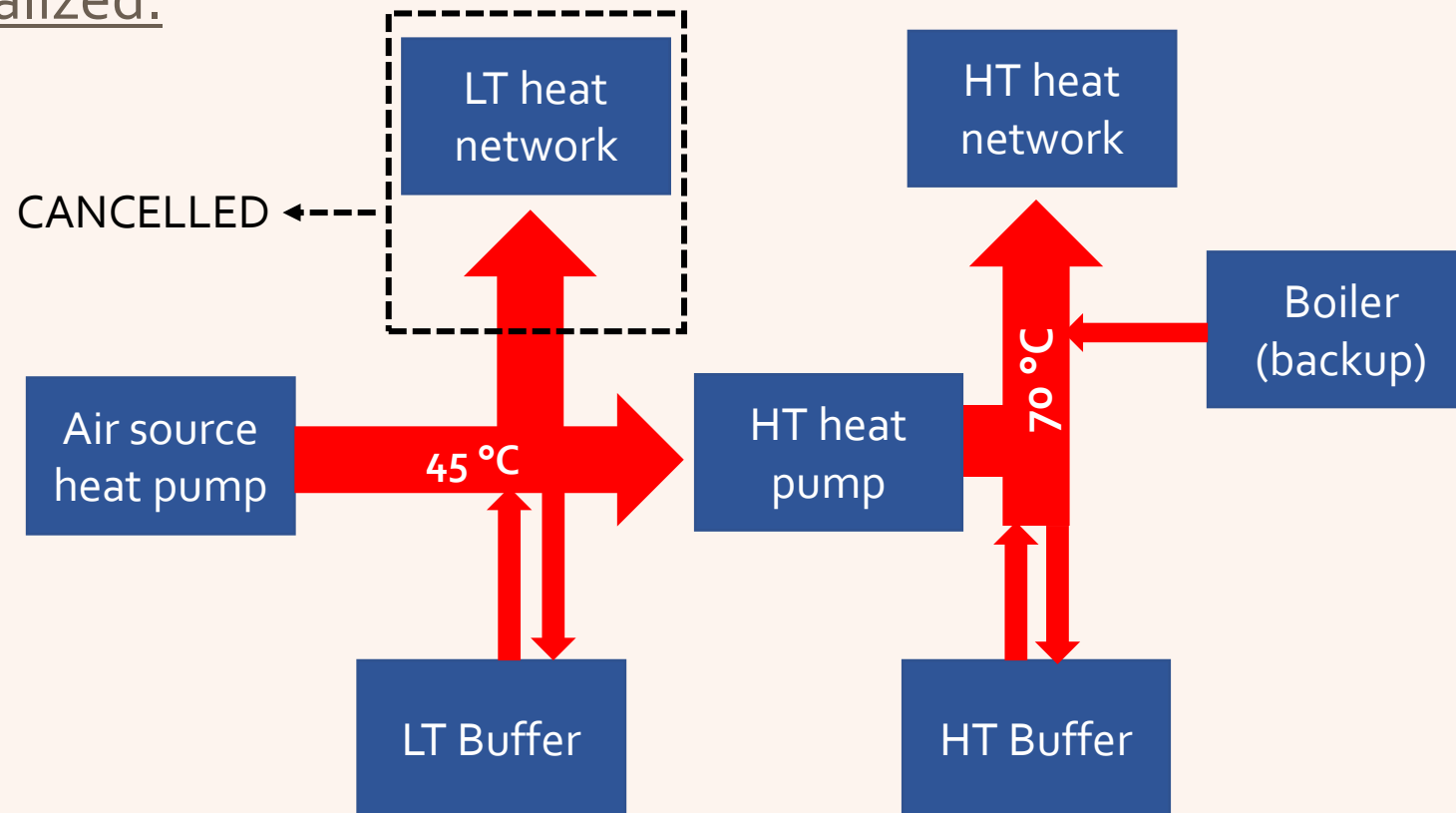
- **60-80 homes** (~4200 GJ/year)
- **4 non-residential buildings** (~2400 GJ/year):
 1. Gemeentewerf
 2. Kerkgenootschap Waardevol Leven
 3. Gemeentehuis
 4. Wiemersheerd





Introduction: Planned configuration

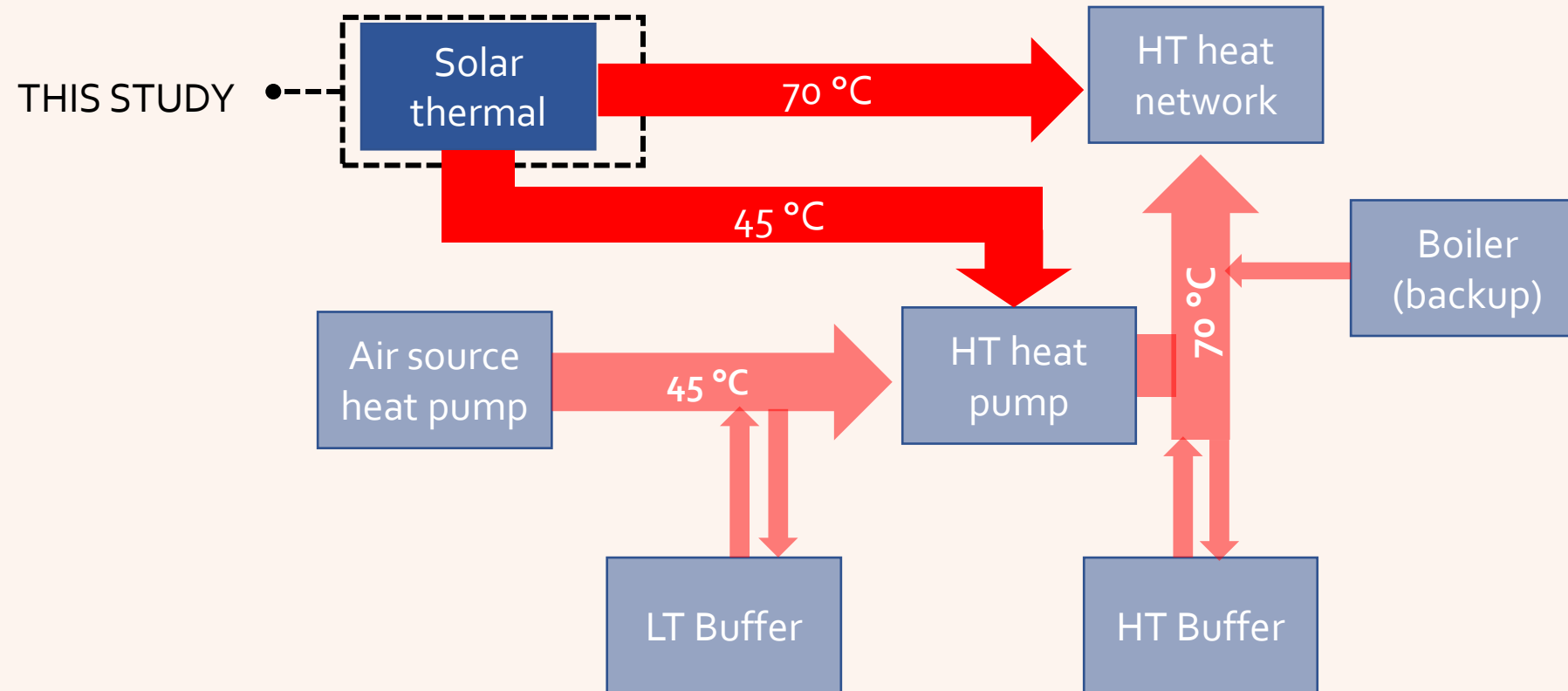
- Wiemersheerd (one of the building) does not join the the plan anymore.
- As it is the only low temperature demand, the entire LT grid will not be realized.





Introduction: This study

In this study, we investigate the supply of solar thermal generation to the High Temperature (HT) network with 70 °C as the final temperature to the target users.





Target buildings

There are three non-residential buildings where the solar thermal can be installed.

Building	
A	Gemeentewerf
B	Kerkgenootschap
C	Gemeentehuis



Quick scan questions

In this quick scan study, we answer below questions:

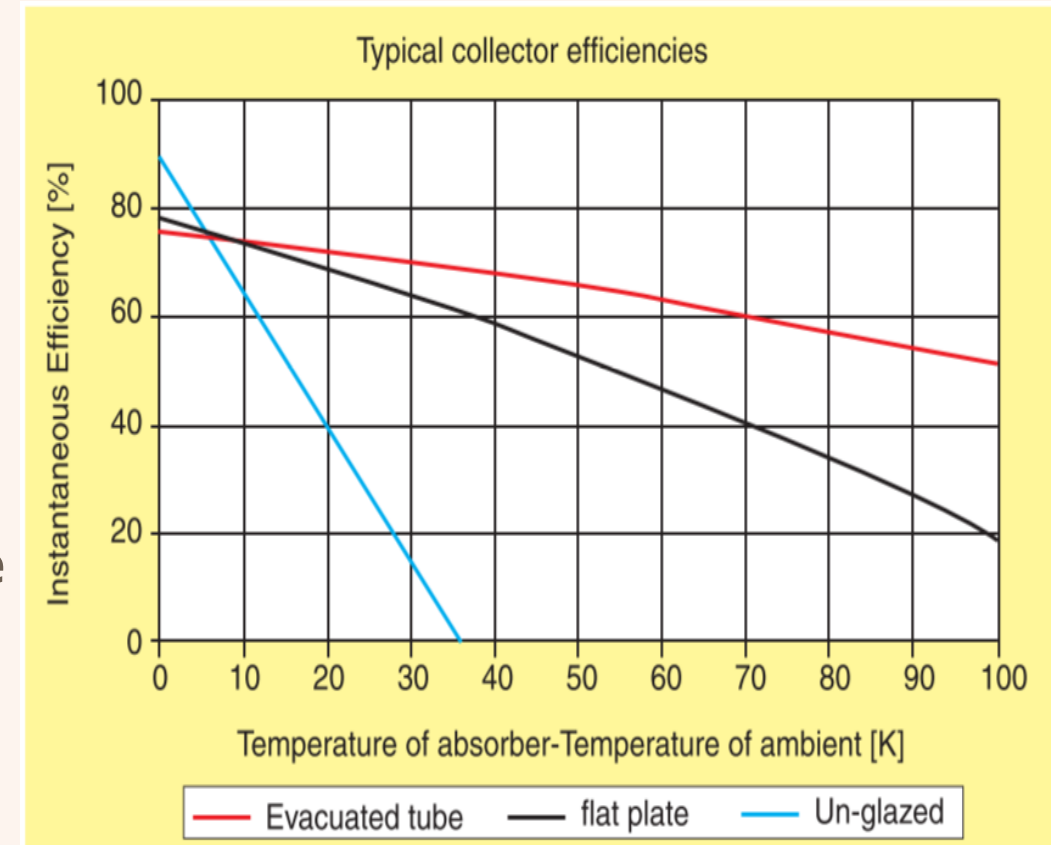
1. Is solar thermal heat generation of at least 10% of heat demand feasible?
2. How much surface area do you need for that?
3. What are the surface requirements and what additional facilities are needed to use this surface for solar thermal?
4. Is this surface area available?
5. Are additional (storage) facilities needed (buffers, thermal storage, etc.)? If so, with what size?
6. What facilities are needed to supply the heat to the envisaged heat network?
7. What are the approximate investment and operating costs? (with an accuracy of +/- 30%)
8. What is the approximate cost per GJ of heat? (with an accuracy of +/- 30%)
9. What subsidy options are available for development, realisation and operation?
10. Is solar thermal energy profitable to operate at the Loppersum heat network? If so, at what capacity and/or surface is solar thermal energy profitable?



Starting points

1. **Two types of solar collectors** are considered: evacuated tube and flat plate collector.
 - There are 3 commercially available types: evacuated tube, flat plate collector, unglazed collector.
 - Unglazed collector has too low efficiency for output temperature $> 30^{\circ}\text{C}$
2. Two levels of solar thermal output **temperature** are considered:
 - $70^{\circ}\text{C} \rightarrow$ feed directly to HT grid
 - $45^{\circ}\text{C} \rightarrow$ upgraded to 70°C by a heat pump, feed to MT grid

Two temperature level is simulated to capture the efficiency difference.





The technology comparison

	Flat plate 1	Evacuated tube 2
Efficiency @target $T = 45\text{ }^{\circ}\text{C}$	0.63	0.7
Efficiency @target $T = 70\text{ }^{\circ}\text{C}$	0.47	0.63
CAPEX [EUR/ m ²]	250	480
Weight ¹	16 kg/net m ²	38 kg/net m ²

¹ as a comparison: PV panel 10.3 kg/net m²

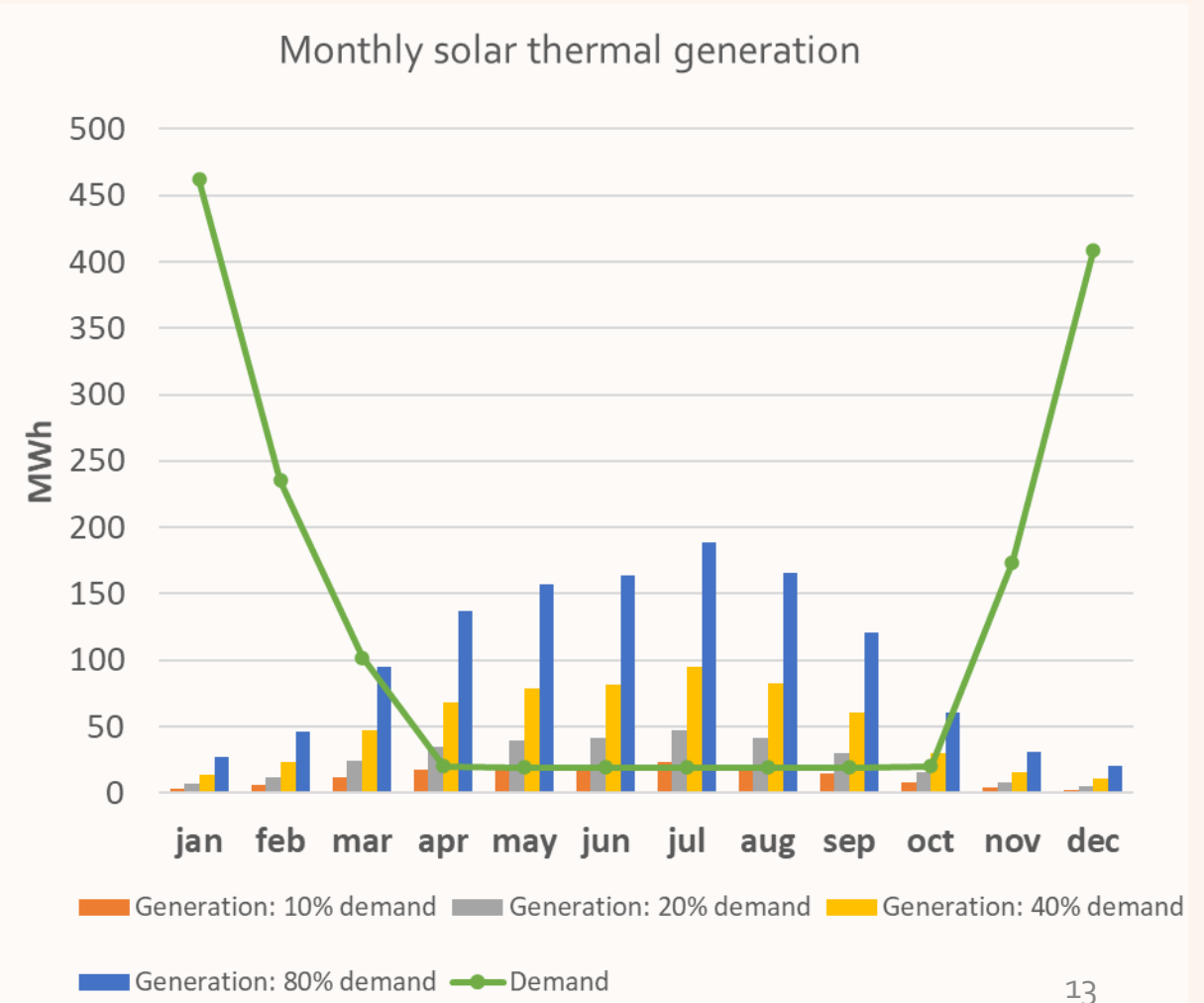




Q1: Is generating heat with solar thermal at least 10% of the heat demand feasible?

- Monthly generation for 10%, 20%, 40%, and 80% of demand has been simulated
- At generation equal to 10% demand, most of the heat (94% heat) can be utilized
- Monthly mismatch (excess generation) is a challenge for generation > 10% yearly demand

Generation	Mismatch (% of total generation)
10% demand	6%
20% demand	39%
40% demand	60%
80% demand	71%





Q2: How much surface area do you need for that?

- Table below shows the required surface areas of solar collectors to generate 10%, 20%, 40%, and 80% of yearly demand for different panel type and temperature.

Panel Type/Temp.	10% demand	20% demand	40% demand	80% demand
Evacuated tube 70 °C	317 m ²	635 m ²	1269 m ²	2538 m ²
Evacuated tube 45 °C	248 m ²	497 m ²	993 m ²	1986 m ²
Flat plat 70 °C	425 m ²	851 m ²	1701 m ²	3402 m ²
Flat plat 45 °C	280 m ²	561 m ²	1121 m ²	2243 m ²



Q3: Surface requirements and additional facilities for the surface

Surface requirements

- The optimal orientation of the roof is the essential requirement. To maximize the yield, the south orientation is desired.
- Consideration must be made with regard to the carrying capacity of the roofs and weight of the panels (see panel weight on slide no. 12)

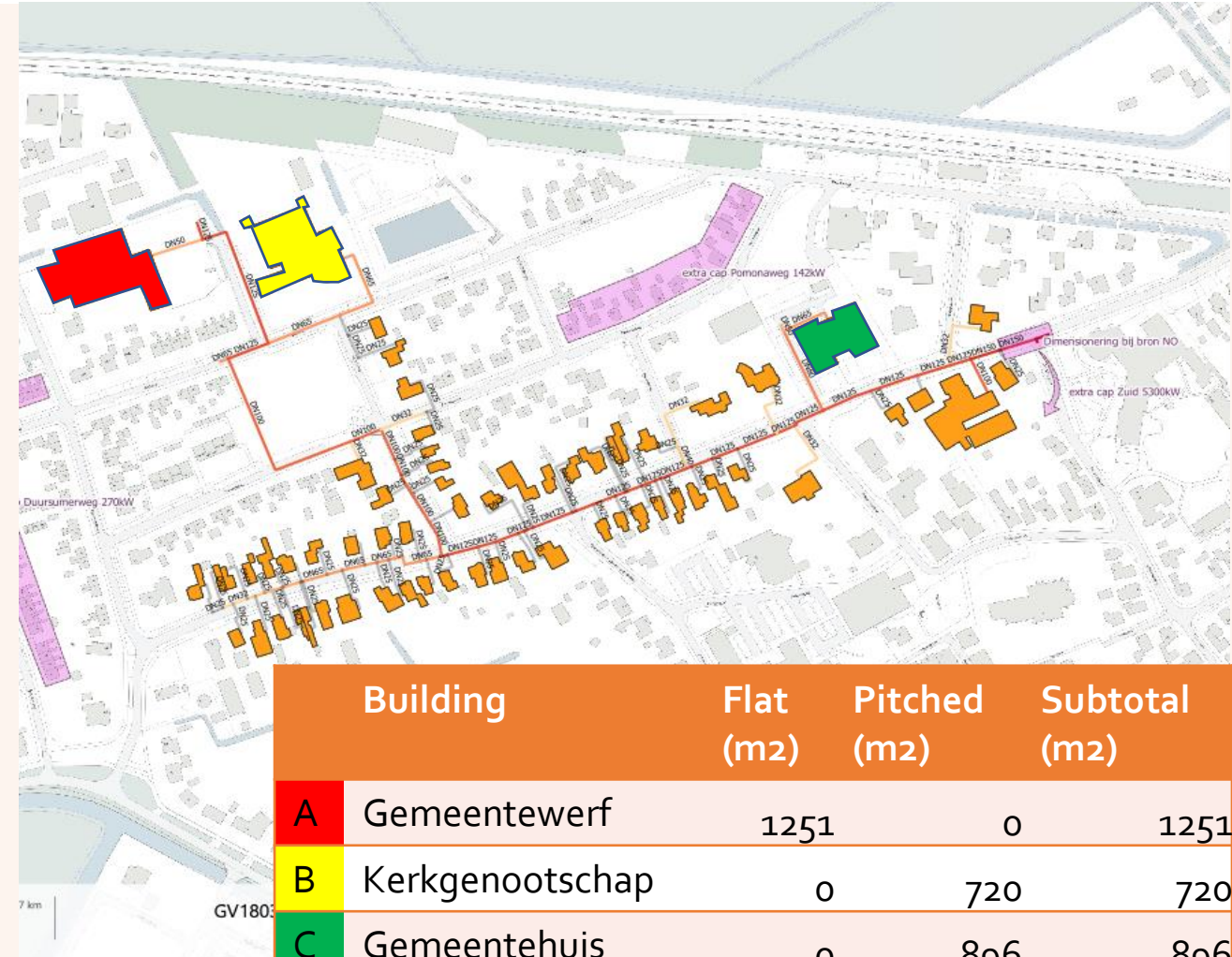
Additional facilities needed to use this surface for solar thermal

- mounting



Q4: Is this surface area available?

- We performed quick survey of roof area from the google maps (see below table)
- There is enough surface area to generate up to ~80% heat demand
- Because the heat transfer station will be located next to the Gemeentewerf, the Gemeentewerf and/or the Kerkgenootschap are the first most logical roofs to work with.



	Building	Flat (m2)	Pitched (m2)	Subtotal (m2)
A	Gemeentewerf	1251	0	1251
B	Kerkgenootschap	0	720	720
C	Gemeentehuis	0	896	896
	TOTAL		16	2867



Q5: Are additional (storage) facilities needed (buffers, thermal storage, etc.)? If so, with what size?

- Storages are needed for generation > 10% demand
- Table below shows the storage size to meet certain % utilization (solar thermal used / generated):

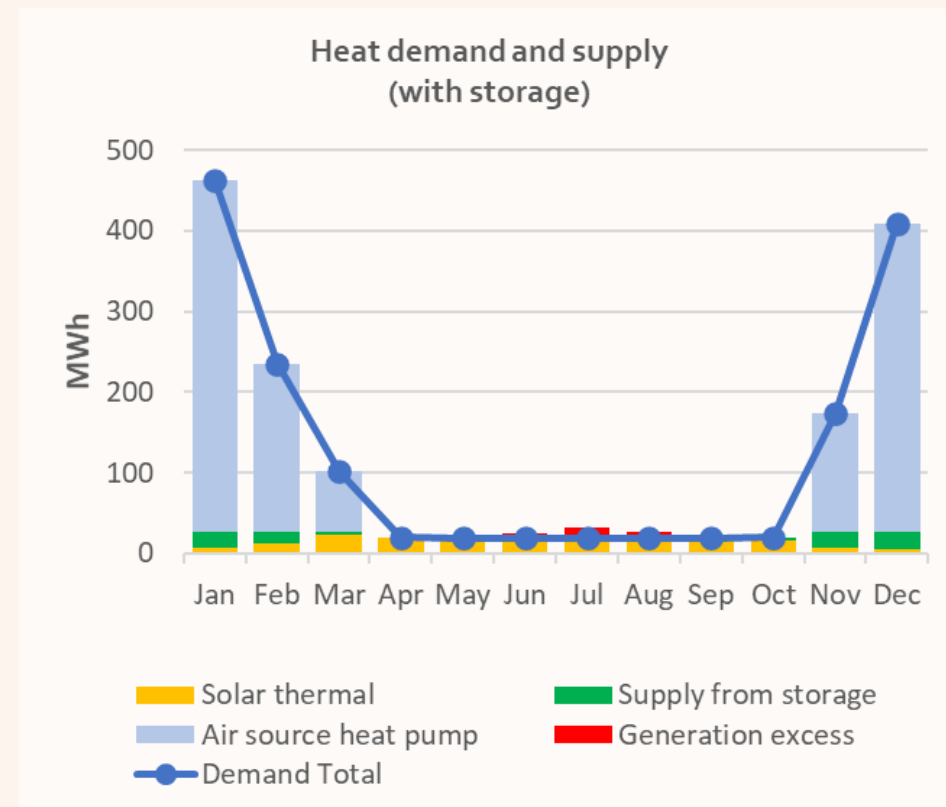
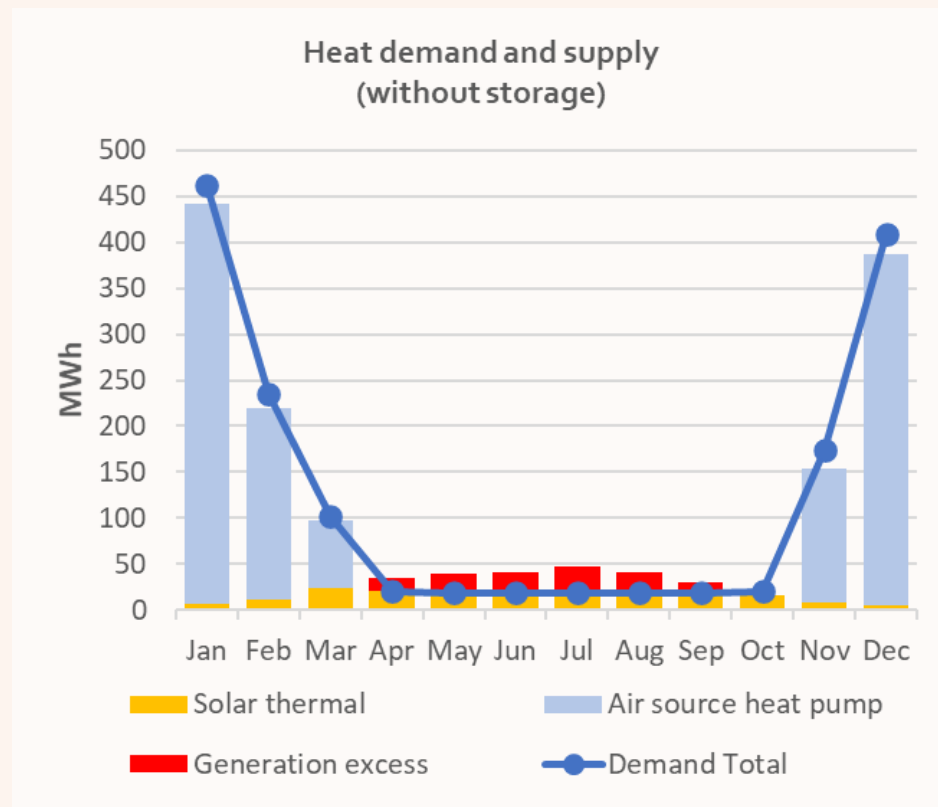
	80% utilization	90% utilization	100% utilization
10% demand	-	-	7.7 MWh
20% demand	56 MWh	87 MWh	117 MWh
40% demand	240 MWh	300 MWh	360 MWh
80% demand	629 MWh	738 MWh	900 MWh

- Available buffer size: **1.4 MWh** (40 m³ at 70 °C, $\Delta T = 30$ °C)
- More details studies on the hourly bases would be necessary to shows the storage requirement on hourly basis.



Q5 (continued)

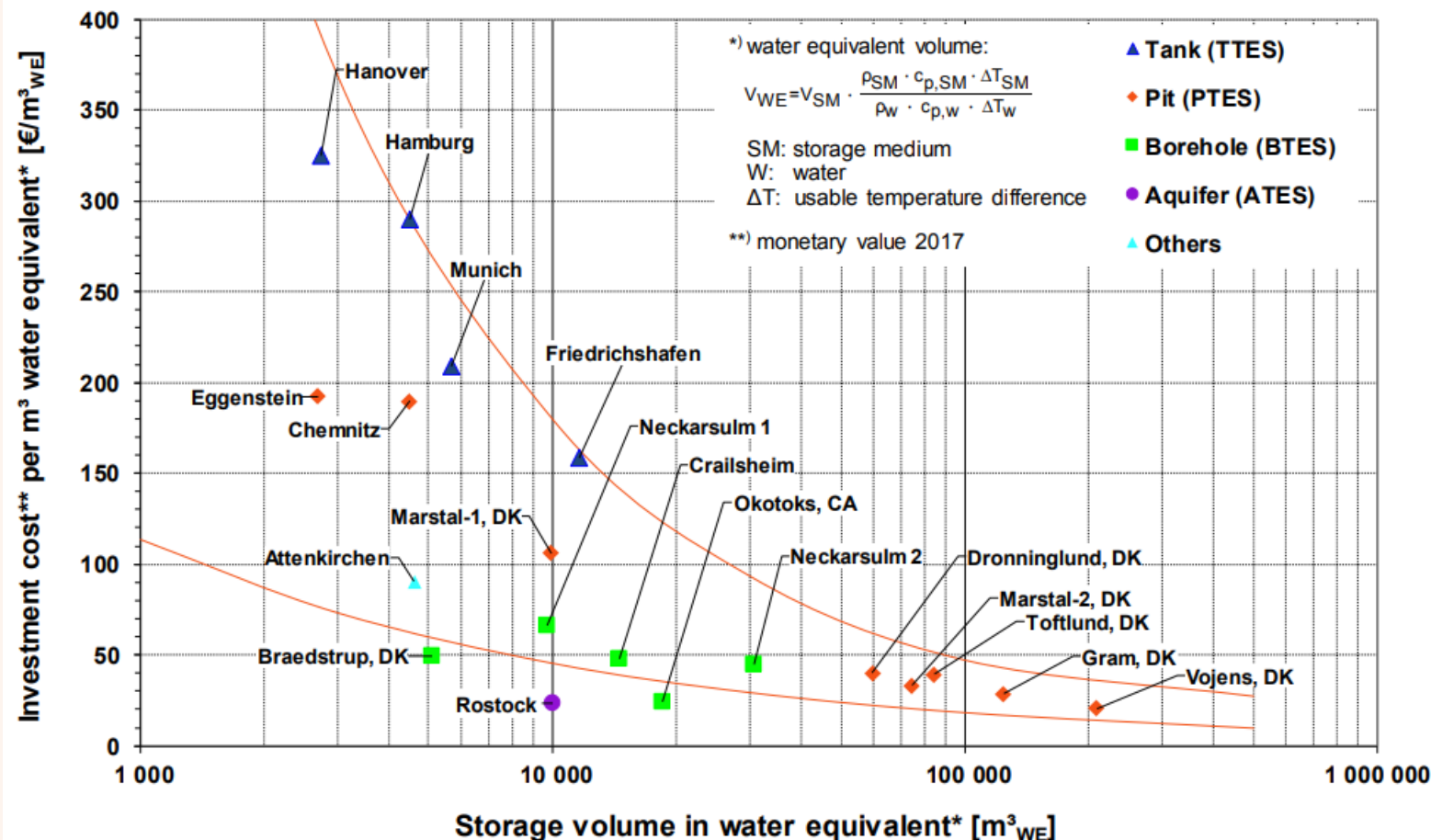
- Figure below shows the comparison of heat supply with and without storage for the case of generation = 20% yearly demand.
- Heat utilization: 61% without storage, 90% with 87 MWh storage.





Q5 (continued)

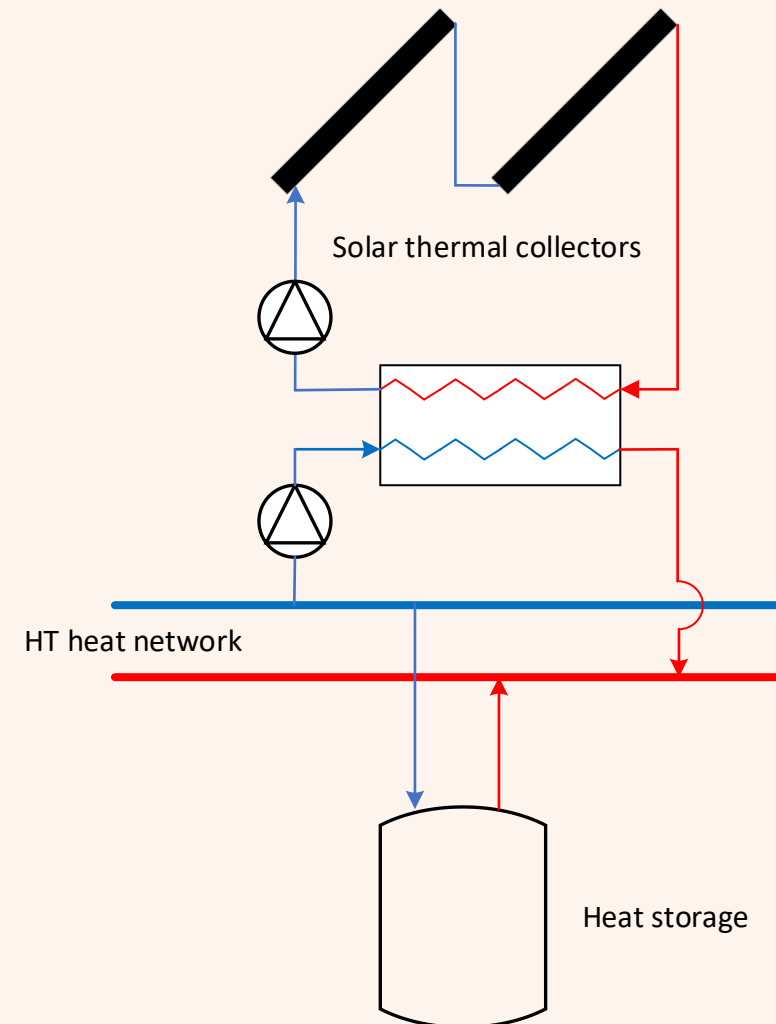
- As a reference, the figure below shows different options of thermal storage and their cost at different system scale



Q6: What facilities are needed to supply the heat to the envisaged heat network?



- Solar collectors
- Pumps and control system
- Pipe connection to the HT heat network
- Optional: Heat storage
- Optional: heat pump (if the solar thermal output temperature is set at $< 70\text{ }^{\circ}\text{C}$, heat pump is needed)
- Heat exchanger



Q7: What are the approximate investment and operating costs?



Investment cost components:

- Solar collectors (including control)
- Pipe connection to the HT heat grid
- Optional: Heat storage
- Optional: if the solar thermal output temperature is set at $< 70\text{ }^{\circ}\text{C}$, heat pump(s) are needed.
- Electrical connection for internal pump, control, and optional heat pump
- Heat exchanger (for a closed loop system)

Operational cost components:

- Operation & maintenance
- Electricity use (in cases where additional heat pump is needed)



Q7 (continued)

1. Solar collector cost as function of scale

Size (m ²)	Evacuated tube (EUR/m ²)	Flat plate (EUR/m ²)
1	550	300
100	500	250
1000	400	200
5000	400	200

2. Operational and maintenance cost (yearly)
= 1.5% investment cost
3. 100 m pipeline needed at 200 EUR/m
4. Other cost (heat exchanger, engineering, and installations): 30% total investment

5. Thermal storage as a function of scale

Size (MWh)	Cost (EUR/MWh)
0.1	10000
10	8571
70	5714
140	2286
350	1143
700	857
3500	571



Q7 (continued)

Investment cost

Type →	Evacuated tube		Evacuated tube		Flat plate		Flat plate	
Temperature →	70 °C		45 °C		70 °C		45 °C	
10% demand (no seasonal storage)	€	220 K	€	180 K	€	150 K	€	110 K
20% demand (87 MWh storage)	€	940 K	€	870 K	€	810 K	€	740 K
40% demand (300 MWh storage)	€	1,240 K	€	1,100 K	€	1,020 K	€	870 K
80% demand (738 MWh storage)	€	2,160 K	€	1,880 K	€	1,730 K	€	1,430 K

Operational cost [EUR/year]

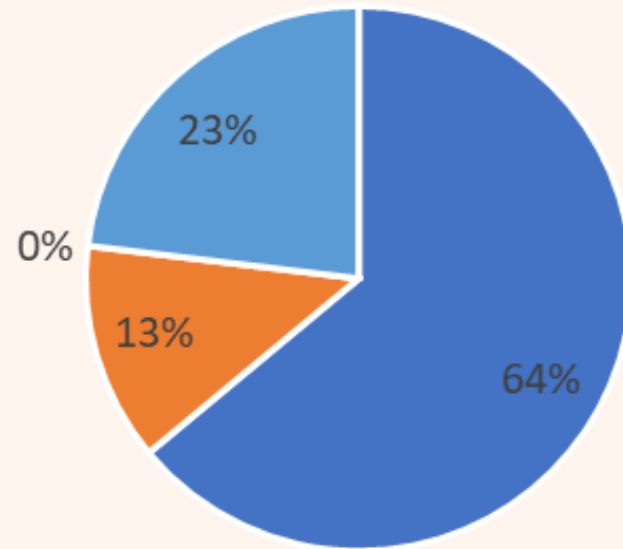
Type →	Evacuated tube		Evacuated tube		Flat plate		Flat plate	
Temperature →	70 °C		45 °C		70 °C		45 °C	
10% demand (no seasonal storage)	€	3 K	€	6 K	€	2 K	€	5 K
20% demand (87 MWh storage)	€	14 K	€	19 K	€	12 K	€	17 K
40% demand (300 MWh storage)	€	19 K	€	28 K	€	15 K	€	25 K
80% demand (738 MWh storage)	€	32 K	€	52 K	€	26 K	€	45 K



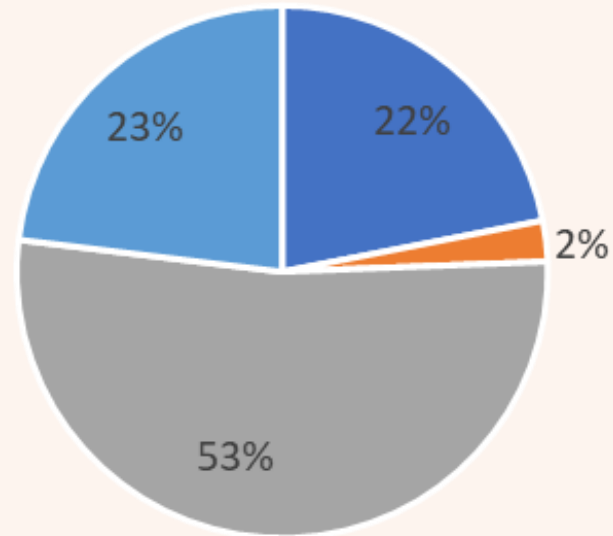
Q7 (continued)

Investment cost

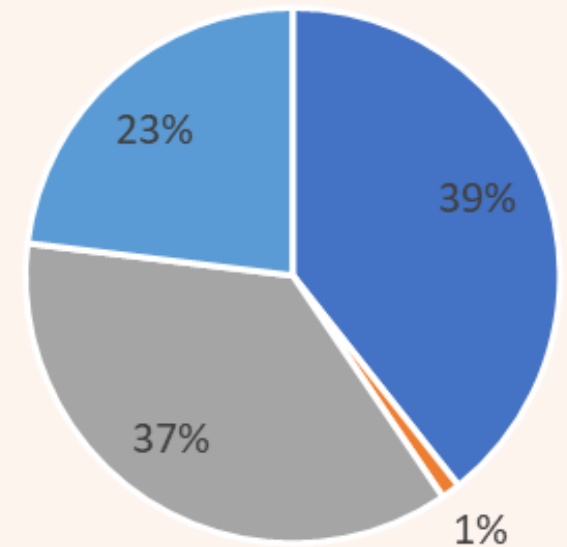
Generation = 10% demand



Generation = 20% demand



Generation = 80% demand



■ Solar thermal ■ pipes ■ Storage ■ Others



Q8: What is the approximate cost per GJ of heat?

Solar thermal cost (EUR/GJ of heat) (20 years financial period)

Type →	Evacuated tube		Evacuated tube		Flat plate		Flat plate	
Temperature →	70 °C		45 °C		70 °C		45 °C	
Subsidy →	No	Yes	No	Yes	No	Yes	No	Yes
10% demand (no seasonal storage)	25	7	25	7	18	-1	18	-2
20% demand (87 MWh storage)	54	35	54	35	46	27	47	28
40% demand (300 MWh storage)	35	16	36	16	29	10	29	10
80% demand (738 MWh storage)	31	12	31	12	25	5	25	6

As comparison, here is the existing cost per GJ heat¹

Period	Without subsidy (EUR/GJ)	with subsidy (EUR/GJ)
30 year	28.0	18.1
45 year	23.3	16.6

- ¹this value is calculated from Tebodin data (shared by the municipality)
- Note: Storage unit cost is higher on a small scale



Q9: What subsidy options are available for development, realisation and operation?

#	Name	Amount	Requirement	Status
1	SDE++	x	x	Currently closed
2	Green Deal	x	The plan encounters obstacles in its implementation. And the national government can play a role by removing these obstacles. (and may more requirements)	Open
3	Hernieuwbare Energietransitie (HER+)	Max budget of the whole subsidy is € 50 million. https://zoek.officielebekendmakingen.nl/stcrt-2020-14196.html#d17e1642	https://www.rvo.nl/subsidie-en-financieringswijzer/hernieuwbare-energietransitie/beoordelingscriteria-hernieuwbare-energietransitie	Open until 31 March 2022;
4	Investeringssubsidie duurzame energie (ISDE)	X	This one is only for the already built and running companies, they can cover some costs for a solar thermal option like a boiler. The solar thermal device should be listed on a special list.	Open



Q9 (continued)

#	Name	Amount	Requirement	Status
5	Subsidieregeling Coöperatieve Energieopwekking (SCE)	https://zoek.officielebekendmakingen.nl/stcrt-2021-11075.html	You are an association of owners (VvE) or an energy cooperative that focuses on generating renewable energy from solar PV, wind or hydropower. The subsidy is for both small and large consumer connections. The production installation must be owned by the subsidy recipient. Financial lease is also regarded as property for the SCE scheme. You are also required to include a feasibility study with your grant application.	Open
6	Subsidies duurzaamheid en innovatie Noord- Nederland (SNN)	There is no standard subsidy. You can check on https://www.snn.nl/ondernemers to see which one is interesting. At the moment I don't see any interesting subsidies from this fund	SNN is a partnership of the three northern provinces (Groningen, Friesland and Drenthe) and the municipalities of Groningen, Leeuwarden, Assen and Emmen. SNN implements subsidy schemes on behalf of the government, individual provinces or municipalities.	Open



Q9 (continued)

#	Name	Amount	Requirement	Status
7	NOM	• subordinated loan of €50,000 to €200,000 (NOM Booster Finance): a loan for promising, young companies operating within the Top Sectors or provincial spearheads (chemistry, creative industry, energy, high-tech systems, logistics, life sciences, horticulture, agrifood, water , biobased economy, sensor technology and healthy aging); • subordinated loan of € 200,000 to € 1.5 million (NOM Mezzanine loan): a loan intended to strengthen the financial structure of companies; • share capital/subordinated loan of €200,000 to €2.5 million (NOM Growth or Acquisition Financing): a combination of share capital and subordinated loan intended to allow companies to grow further or to facilitate an acquisition.	The NOM is an investment company focused on the northern provinces, conditions differ per amount	Open
8	Subsidieregeling warmtetransitieprojecten provincie Groningen (WTPG)	a maximum of 50% of the eligible costs, up to a maximum of € 2 million per project; never more than the unprofitable top of the project.	The aim of the subsidy scheme for heat transition projects in the province of Groningen (WTPG) is to stimulate the implementation of area-oriented projects that lead to the use of climate-neutral and natural gas-free heat in the context of the heat transition of the built environment in the province of Groningen.	Open



Q9 (continued)

#	Name	Amount	Requirement	Status
9	Fonds Nieuwe Doen Groningen	The amount of the loan differs per case. The fund also offers the option of taking out so-called light financing for loans of €5,000 to €50,000.	The fund is open to companies, governments, institutions and organizations such as foundations and cooperatives. Private individuals cannot take out a loan from the fund. The fund provides loans for initiatives in the field of quality of life, care and energy: quality of life: investments in social accommodations with associated household effects such as village houses and sports clubs; healthcare: investments in healthcare and welfare-related real estate with associated household effects; energy: investments in the field of energy saving and sustainable energy generation.	Open



Q10: Can solar thermal energy be profitably exploited in the Loppersum heat network?

Business case logic

Costs:

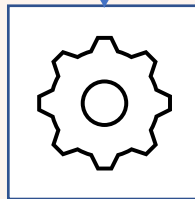
- a. Investment cost
- b. Operational cost

Benefit:

- a. Electricity reduction of air source heat pump (electricity price: 120 EUR/MWh)
- b. Subsidy, counted as CO₂ reduction (CO₂ price: 256 EUR/ton for 15 years)¹
- c. Solar thermal in combination with storage reduce the size of air source heat pump needed. This benefit is counted as fixed cost ASHP (10.54 EUR/GJ) * delivered heat (GJ)

Assumptions:

- Interest rate: 2%
- Lifetime: 20 years
- Does not consider re-investment



Output: NPV

Positive NPV means it is profitable compared to air source heat pump

¹ SDE++



Q10 (continued)

Results: Net Present Value (NPV), 20 years period

Type →	Evacuated tube		Evacuated tube		Flat plate		Flat plate	
Temperature →	70 °C		45 °C		70 °C		45 °C	
10% demand	€	23 K	€	23 K	€	108 K	€	108 K
20% demand	€	-423 K	€	-432 K	€	-258 K	€	-270 K
40% demand	€	-40 K	€	-54 K	€	231 K	€	227 K
80% demand	€	314 K	€	289 K	€	856 K	€	849 K

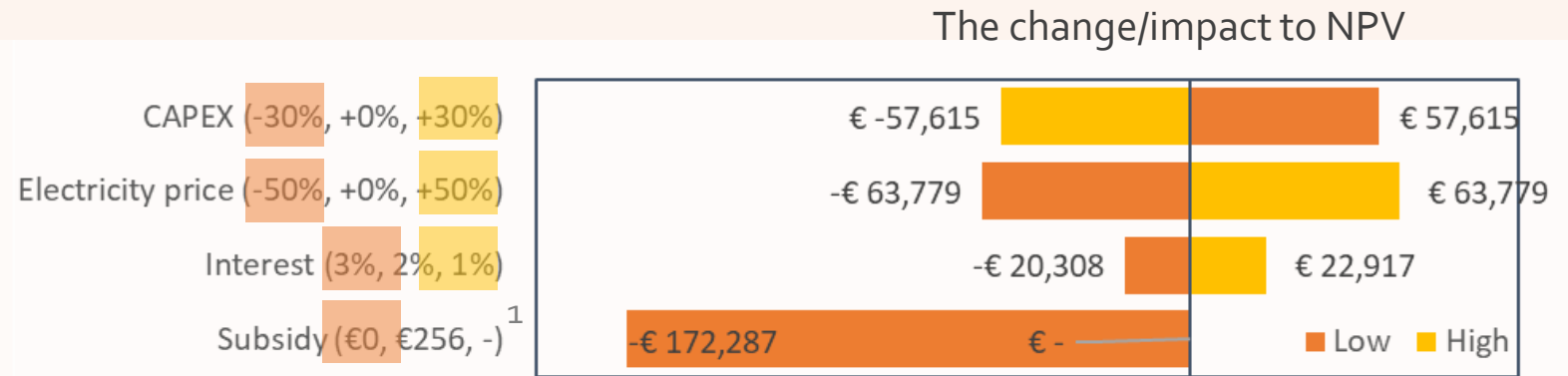
Positive NPV means it is profitable compared to air source heat pump



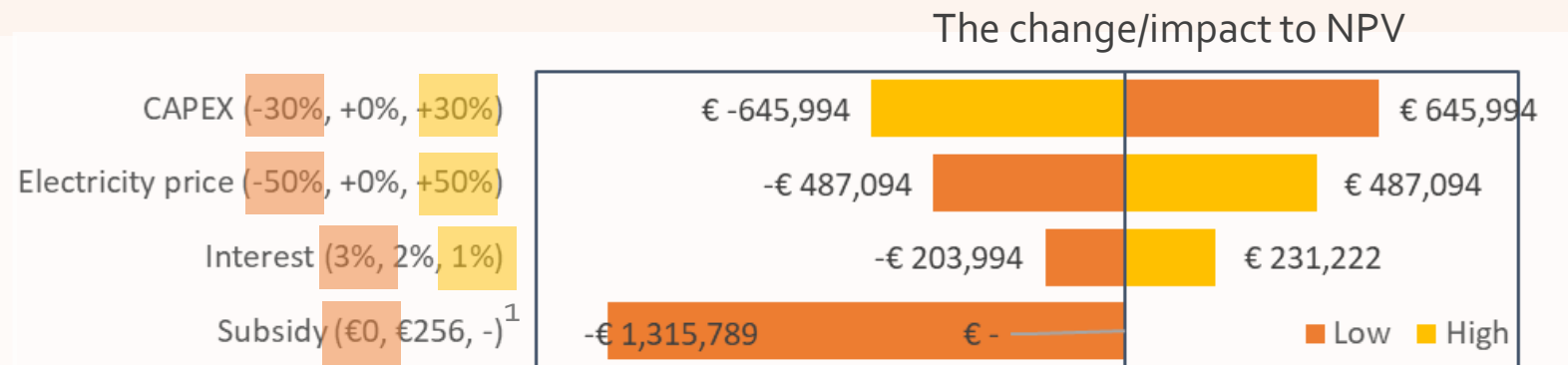
Q10 (continued)

Sensitivity analysis

Case: 10% demand (flat plate)
NPV: 108 K



Case: 80% demand (flat plate)
NPV: 856 K



¹ unit = €/ton CO₂.

- Subsidy has significant influence on the economic feasibility



Project team relevant experience

- I. These two project are specifically on the application and integration of the solar thermal systems in the built environment. The team member from Witteveen+Bos (Saleh Mohammadi) has worked on below projects:
 1. **deZONNET project**
 2. **KoWaNeT Project**
- II. In other projects, solar thermal energy has frequently been researched as on the of the energy systems solution scenarios and its applicability and techno-economic feasibility has been compared with other renewable based heating systems. For example:
 - **Oranjekwartier**



Conclusion

- There is enough roof area on the 3 target buildings to install solar collectors to meet 80% demand annually.
- The solar collector type has a significant impact on the solar panel efficiency and business case.
 - Flat plat gives better economic benefit than evacuated tube
- Solar thermal is best implemented when:
 - no seasonal storage is needed, or
 - In case storage is needed, a large-scale installation would reduce the unit cost of storage and collectors
- It is profitable to install solar collector to meet 10% demand, 40% demand, and 80% demand. The key assumptions:
 - 120 EUR electricity price
 - Subsidy: 256 EUR per ton CO₂ for 15 years
- Subsidy has a significant impact on the profitability of the solar thermal installation



Follow-up questions

- Since subsidy is a significant factor on the profitability of the solar thermal, we advise to look deeper into the subsidy scheme.
- We recommend to perform hourly simulation to examine the generation and supply mismatch and daily storage requirement.
- The integration and optimization of the solar system must be done on the **whole system level** in order to create solution with sound business case.
- Integration of the **PVT** inserted of solar thermal collectors could be interesting as the it also produce electricity. Further study on the impact of PV side can be conducted on the next stage.
- **ATES or Aquifer Thermal Energy Storage** is a low temperature seasonal storage which use the sub-surface area to store heating and cooling energy. There is a possibility to integrate solar thermal energy with the ATES system to re-charge the storage over the summer months. Due to the seasonal nature of the solar radiation, this storage medium could provide better and more economical solution as storage for this system. More comprehensive study on the applicability of this system would be required.
- With integrating the solar thermal system with ATES, there will be extra **cooling load** that could be supplied to the required cooling demand in the area. Further study on the application of cooling system is an interesting topic if ATES used as storage.
- An exploration can be done to check **other users** in the neighborhood that could be integrated with the solar thermal system in order to improve the business case.
 - For example, google map shows that there is an **open swimming pool** nearby that can be a customer in the summertime for the heat from the solar thermal system, could be directly feed by the panels without heat pump

samen *versnellen*



www.wtcgroningen.nl





Slimme inzet warmtepomp en e-boiler in een warmtenet

Kerschoten Apeldoorn

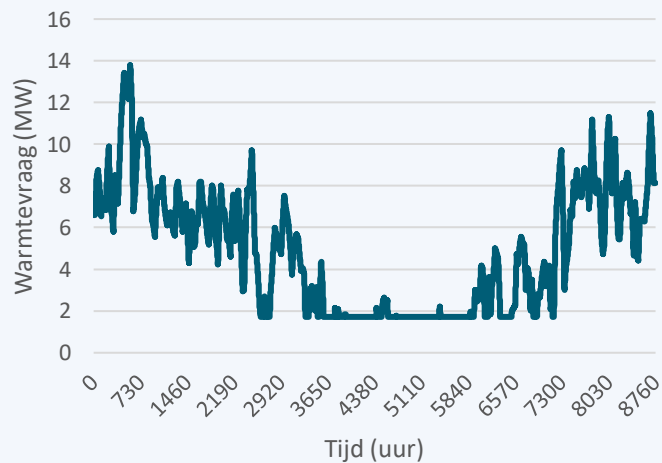
16-06-2021

Warmtebronnenonderzoek Kerschoten

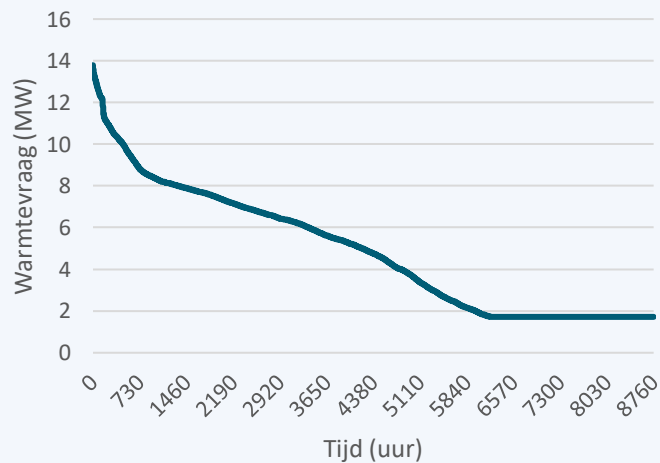
- Welke warmtebronnenmix is er mogelijk met effluent (uitstroom) **RWZI** als basislast?
 - Voor **fase 1** en **fase 2** van het warmtenet?
- Wat zijn de mogelijkheden voor warmteopslag?
- Welke warmtebronnen kunnen richting 2040 aardgas vervangen als pieklast?



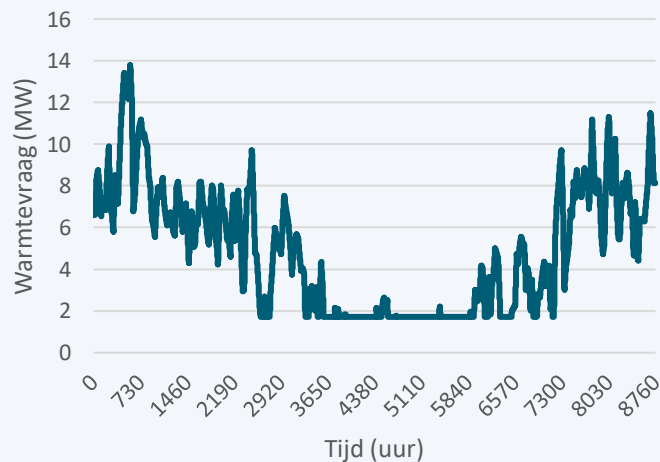
Warmtevraagprofiel Kerschoten 2019



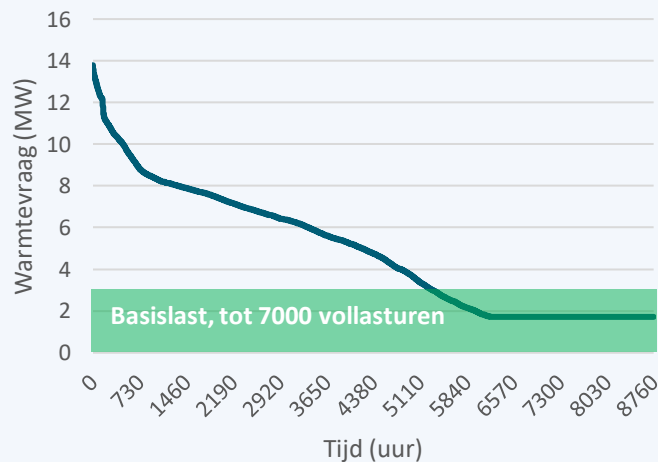
Jaarbelastingduurkromme



Warmtevraagprofiel Kerschoten 2019



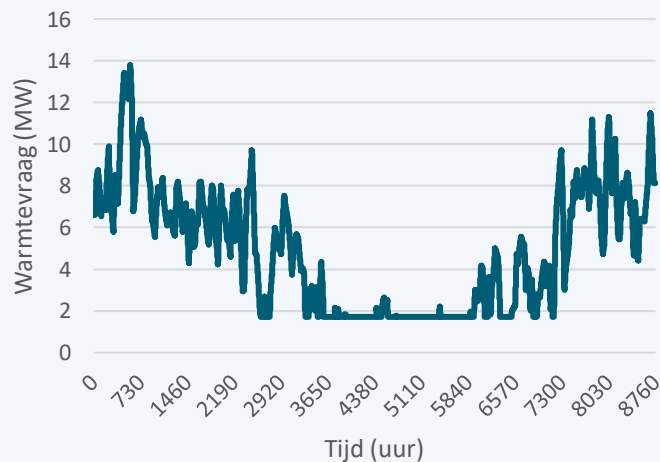
Jaarbelastingduurkromme



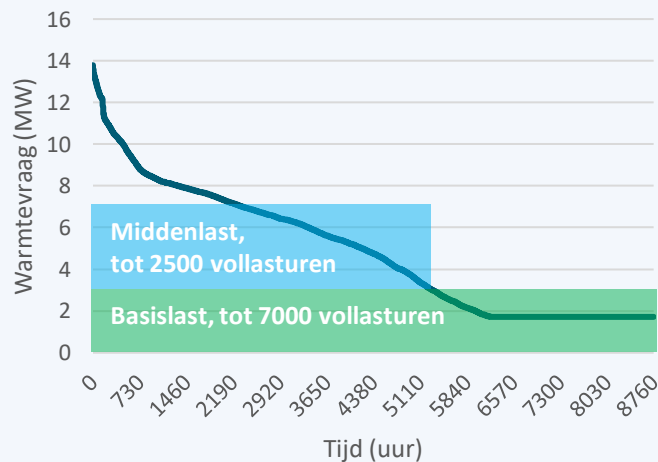
Basislast:

- Lage energielasten (€/GJ)
- Hoge investering (€/kW)
- Bijvoorbeeld:
 - Warmte uit effluent
 - Geothermie
 - Restwarmte (WKK)

Warmtevraagprofiel Kerschoten 2019



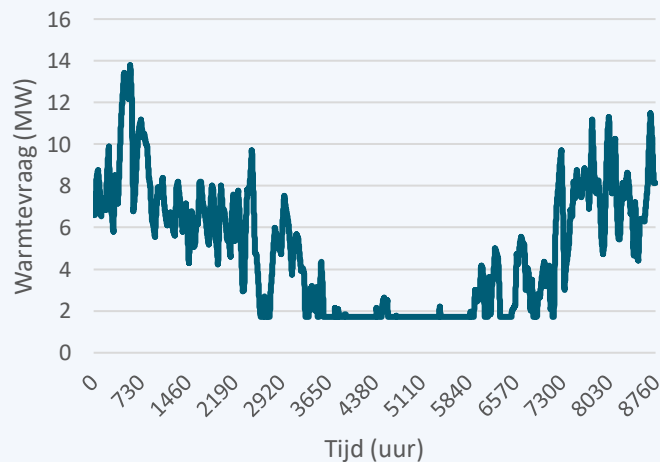
Jaarbelastingduurkromme



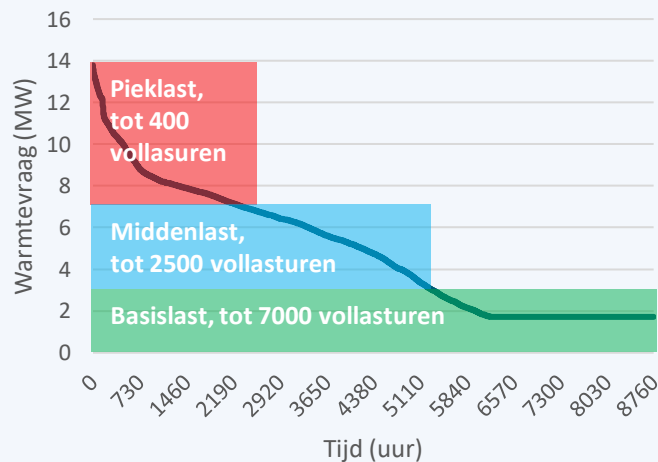
Middenlast:

- Gem. energielasten (€/GJ)
- Gem. investering (€/kW)
- Bijvoorbeeld:
 - Luchtwarmtepomp
 - Biomassaketel

Warmtevraagprofiel Kerschoten 2019



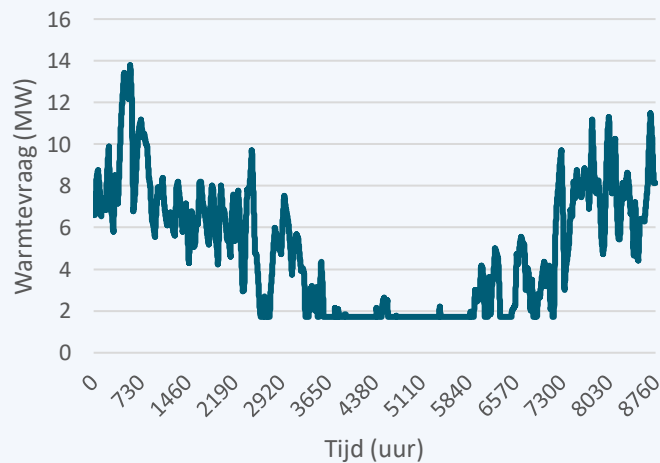
Jaarbelastingduurkromme



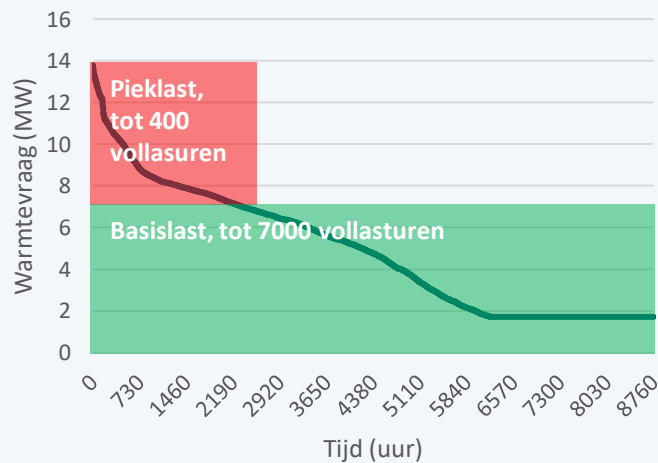
Pieklast:

- Hoge energielasten (€/GJ)
- Lage investering (€/kW)
- Bijvoorbeeld piekketel op:
 - Aardgas
 - Groen gas
 - Waterstof

Warmtevraagprofiel Kerschoten 2019



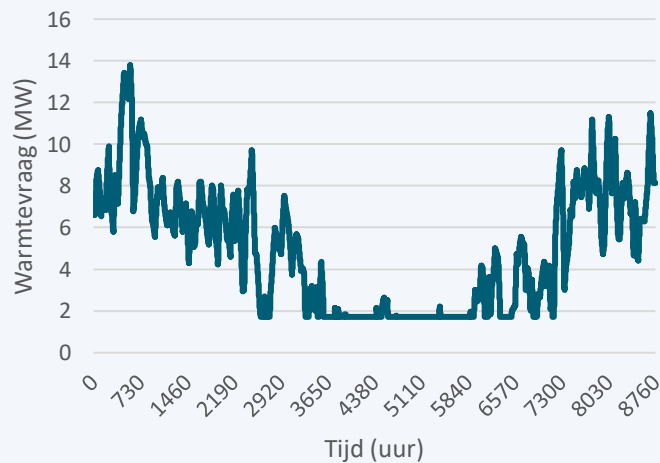
Jaarbelastingduurkromme



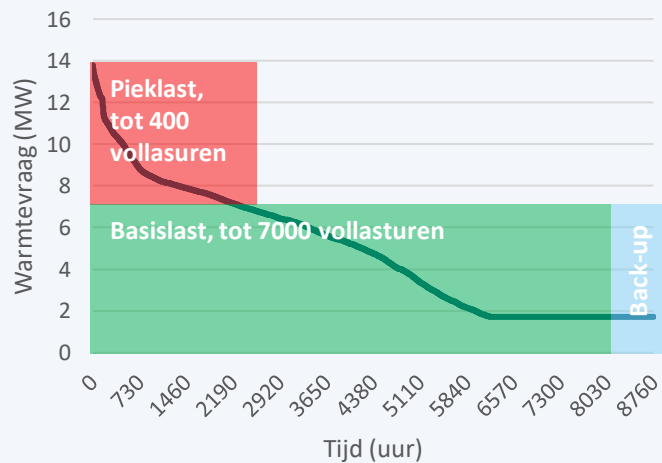
Variatie:

- Geen middenlast

Warmtevraagprofiel Kerschoten 2019



Jaarbelastingduurkromme



Vergeet niet de
back-up bron:

- Gasketel
- E-boiler

Fasen onderzoek

Fase 1: **voorselectie** potentiële bronnen en interviews

Fase 2: **verdieping** warmtebronnen en warmte-opslag

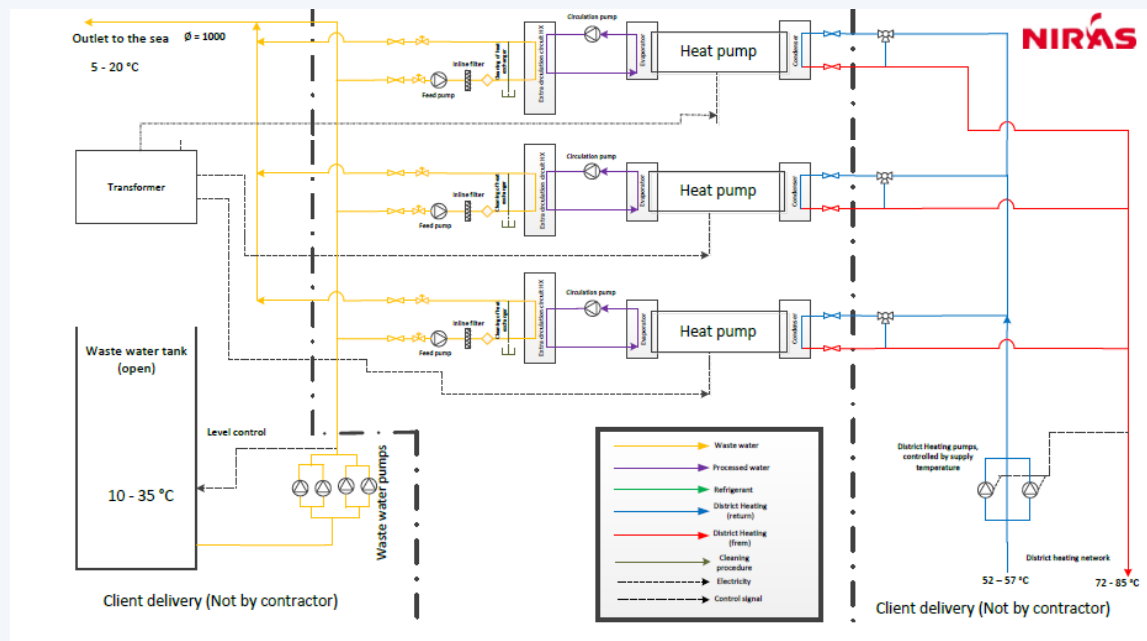
Fase 3: Analyse **warmtebronnenmix**

Voorselectie potentiële bronnen

- WKO
- Warmtebuffer (Ecovat concept)
- Warmte uit effluent RWZI (TEA)
- Riothermie (TEA)
- Biogas-WKK's RWZI
- TEO Kanaal Noord
- Geothermie
- Restwarmte bedrijven
- Zonthermie
- Power2Heat
- Luchtwarmtepompen
- Piekketels op aardgas, waterstof, groengas, biomassa

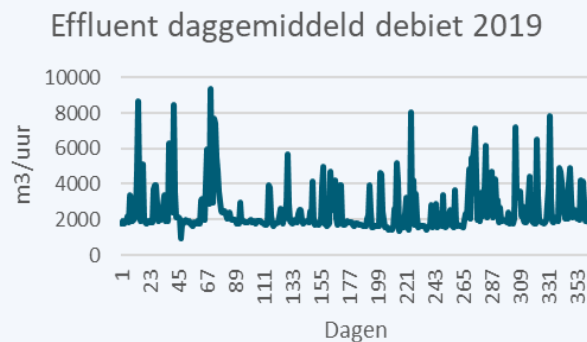
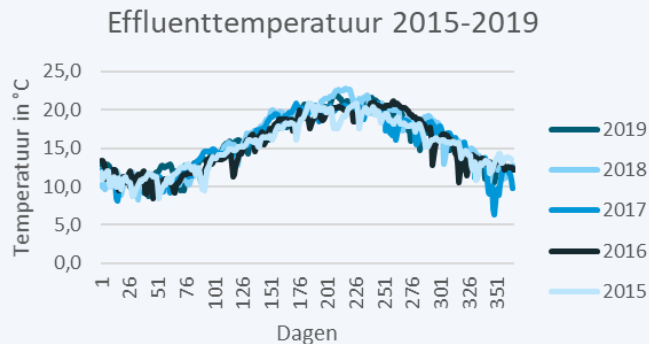
Voorbeeld: effluentwarmte RWZI Kalundborg Denemarken

- 3 x 3,3 MW_{th}



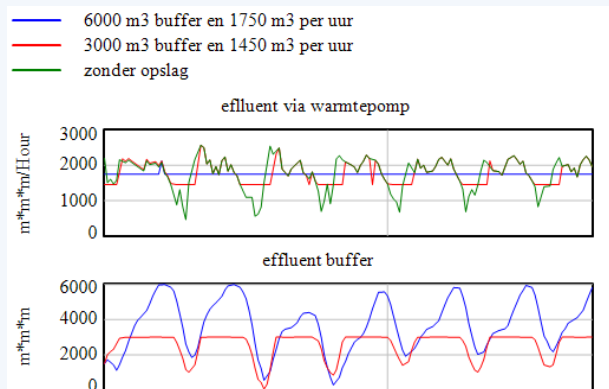
Warmtepomp met effluentwarmte RWZI

- Mooie basistemperatuur, nooit kouder dan 8°C → seizoensopslag niet nodig
- Daggemiddelde debiet van circa 1.750 m³/uur



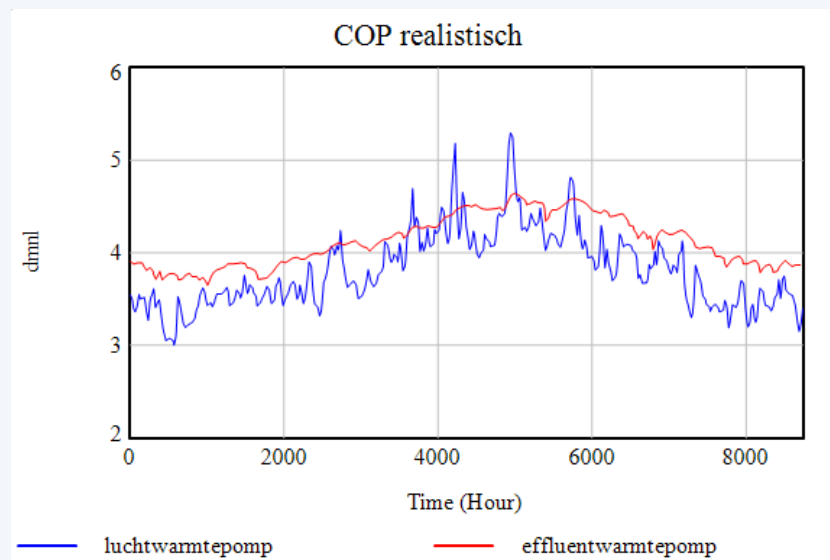
Warmtepomp met effluentwarmte RWZI

- Effluent debiet tussen 2.000 m³/uur (overdag) en 900 m³/uur (nacht)
- Evt. ongebruikte 4 x 3000 m³ tanks inzetten als effluentbuffer
 - Evt. ook tank(s) isoleren en deksel erop als heetwaterbuffer



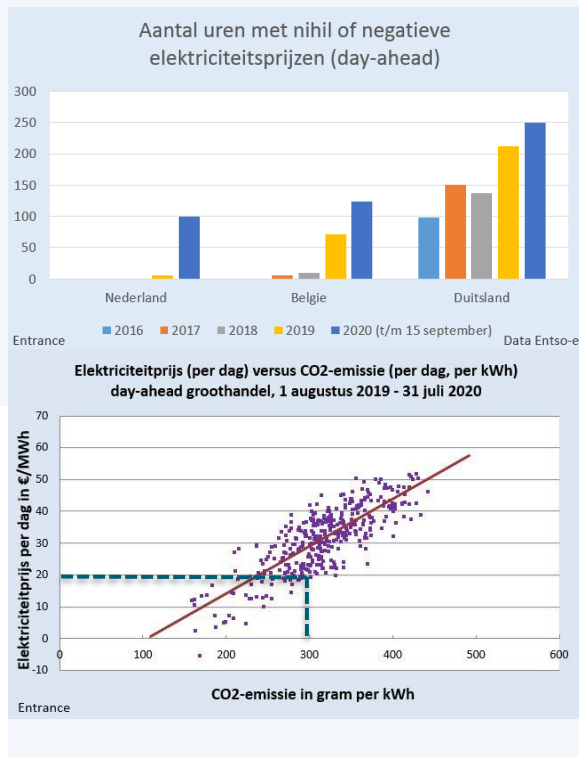
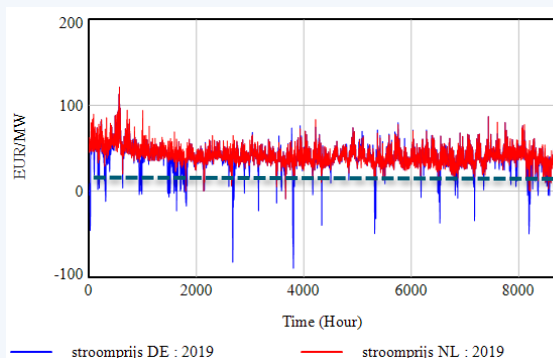
Energieprestatie en duurzaamheid

- CO₂-uitstoot:
 - 21 kg/GJ in 2020
 - 6 kg/GJ in 2030
- Seasonal COP 4
 - Aanneame 65% van Carnot rendement
 - Met dezelfde aanname zou een luchtwarmtepomp 3,6 halen, dus niet eens zo'n groot verschil



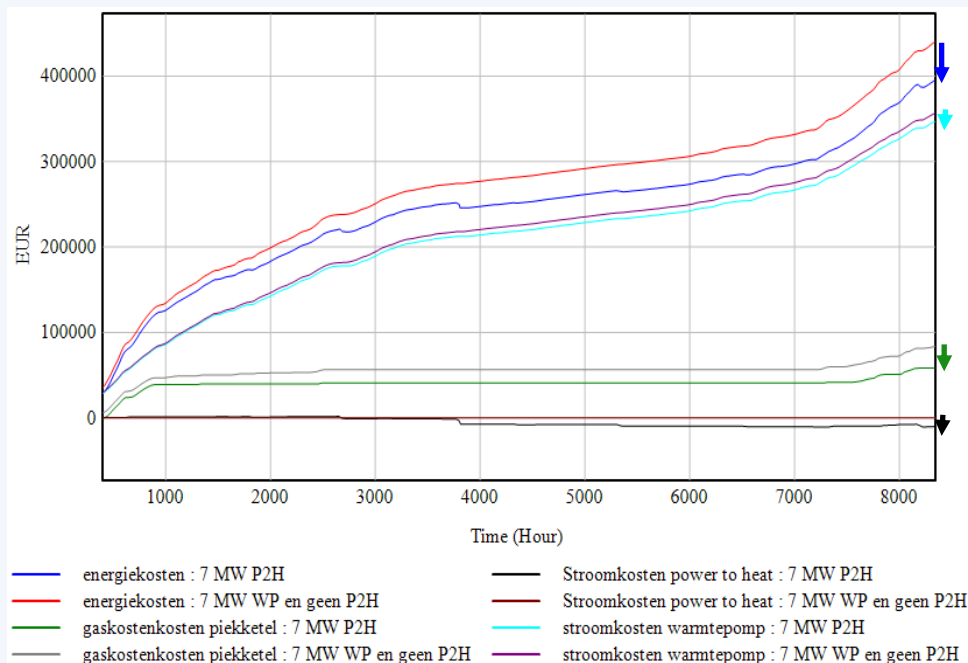
Back-up bron

- Gasketel en E-boiler vergelijkbare investering
- Echter E-boiler buffert tevens warmte wanneer:
 - Stroom (bijna) gratis en schoon is.
 - Op koude dagen wanneer stroom goedkoper is dan piekgasketel



Resultaat inzet e-boiler voor power to heat (P2H)

- E-boiler maakt 360 vollasturen en 6% van de totale warmtevraag
- Besparing van €50.000/jaar op energie-inkoop opgebouwd uit:
 - €9.000 besparing warmtepomp
 - €30.000 besparing aardgas
 - €11.000 inkomsten e-boiler



Resultaat verdieping warmtebronnen

Bronnen → ↓ Criteria	warmte uit effluent RWZI	geothermie	Lucht- warmtepomp	biomassa- ketel	piekketel op aardgas	piekketel op groen gas	piekketel op waterstof	Power2Heat e-boiler
type bron	basislast	basislast	middenlast	middenlast	pieklast	pieklast	pieklast	Back-up & goedkope uren
realistisch thermisch vermogen (MWth)	7,0	3,5	5,0	5,0	10,0	10,0	10,0	7,0
Vollasturen	5500	7000	2000	2000	400	400	400	360
CO2-uitstoot per GJ 2020 (kg/GJ)	21	14	23	5	66	25	91	28
CO2-uitstoot per GJ 2030 (kg/GJ)	6	4	7	5	66	25	27	8
investeringskosten (EUR/MW)	€ 1.400.000	€ 5.000.000	€ 940.000	€ 500.000	€ 60.000	€ 60.000	€ 60.000	€ 60.000
energielasten (EUR/GJ)	€ 2,8	€ 1,8	€ 3,1	€ 10	€ 6	€ 19	€ 25	€ -1
totale bronkosten (EUR/GJ)	€ 10	€ 20	€ 16	€ 20	€ 11	€ 24	€ 29	€ 3,4

Analyse warmtebronnenmix

	Combinatie 1	Combinatie 2	Combinatie 3	Combinatie 4
basislast 2 ^e tranche	7 MW effluentwarmte	7 MW effluentwarmte	5 MW effluentwarmte	5 MW effluentwarmte
middenlast 2 ^e tranche	-	-	5 MW luchtwarmtepomp	5 MW biomassaketel
pieklast 2 ^e tranche	10 MW piekketel	10 MW piekketel	7 MW piekketel	7 MW piekketel
overig/back-up 2 ^e tranche	7 MW piekketel	7 MW e-boiler	5 MW e-boiler	5 MW e-boiler
gecombineerde brongkosten basis (€/GJ)	10,5	10,5	12,0	13,5
gecombineerde brongkosten slim (€/GJ)	n.v.t.	10,2	11,8	13,3
CO ₂ -uitstoot basis in 2030 (kg/GJ)	11,9	11,9	7,3	6,7
CO ₂ -uitstoot slim in 2030 (kg/GJ)	n.v.t.	10,1	7,5	6,5

Analyse verduurzamen piekketel richting 2040

	effluentwarmte + piekketel aardgas	effluentwarmte + piekketel groengas	effluentwarmte + piekketel waterstof
vollasturen piekketel basis (uren)	400	400	400
vollasturen piekketel slim (uren)	270	20	0
gecombineerde bronkosten basis (€/GJ)	10,5	11,7	12,3
gecombineerde bronkosten slim (€/GJ)	10,2	11,1	11,2
CO ₂ -uitstoot basis per GJ in 2030 (kg/GJ)	11.9	8.0	8.2
CO ₂ -uitstoot slim per GJ in 2030 (kg/GJ)	10.1	6.5	6.4

Conclusies

- Effluentwarmte biedt goede basis voor basislast
- E-boiler als back-up bron met slimme inzet zeer aantrekkelijk
- Pieklast ingevuld door aardgasketel
- Verduurzaming piekketels richting 2040 kan door groengas en waterstof



A close-up photograph of a blue globe with black grid lines. The words "your hand" are written in a cursive script across the globe's surface. To the right, a portion of a yellow globe is visible. The background shows green foliage.

www.witteveenbos.com