Why Heating and Cooling Networks are a good solution

(or "the how and what about heating networks")

Part 1: Introduction

After a period in which heating networks were presented as the ideal solution for implementing the energy transition in Dutch urban areas and smaller residential areas (among other things to replace the use of natural gas), recent developments are growing doubt as to whether this is the case. The reactions of users to the often much higher energy prices than initially proposed and the decisions of a number of large energy suppliers to stop heating network projects because they cannot be carried out profitably, are understandable. However, as Berenschot pointed out in its recent research, there is no reason to present heating networks as a less relevant or even bad solution[1].

By 2030, 1.5 million Dutch homes and many other buildings must be made more sustainable and/or free of natural gas (NPLW[2]). There are now 3 main routes:

1. The individual heat pump, usually with outside air as the source;
2. The individual hybrid gas boiler, with green/H2 gas in the future;
3. A collective heating network.

> *Municipalities make plans for an area in consultation with residents, or sometimes on the initiative of residents. Municipalities will act as directors, area by area, to offer clarity to residents and building owners about the alternative to natural gas and the associated timeline.*
>
> The municipal council adopts the environmental plan and can set frameworks prior to the heating programme and implementation plan. These plans are also tailored to the characteristics of an area.
>
> Are there relatively dense buildings and a sustainable heating source? In that case, a heating network is often the most logical option to investigate. In almost all cases, a heating network is less of a burden on the electricity grid than an electric alternative.
>
> Are there fewer buildings? Municipalities can therefore also look at, for example, the possibilities of small-scale innovative low-temperature heating networks.
>
> If heating networks are not an option, fully electric heat pumps are the best alternative for well-insulated buildings (often buildings built from 1992 onwards).
>
> If both heating networks and fully electric heat pumps are not yet an option for the next 10 years, insulation in combination with a hybrid heat pump is an interim solution. In specific areas, a hybrid heat pump combined with insulation and sustainable gases may be the only possible final solution. But the availability of green gas is also expected to be very limited for the built environment towards 2050. The same applies to hydrogen. Waiting for green gas or hydrogen as a solution is therefore not an option.

Source: Local heating transition: the narrative (NPLW website)

At the moment, there is (a lot of) resistance to a solution with collective heating networks, because the tariffs are considered too high and people find the price too expensive. The proposed networks are usually conventional 3rd and 4th generation grids, which do not provide cooling and are installed by large commercial heating companies.

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1 https://www.nvde.nl/wp-content/uploads/2024/05/Finale-rapportage_Warmtenetten-in-vergelijking-met-andere-warmteoplossingen_24042024.pdf

2 https://www.nplw.nl/strategieuitvoering/verhaal-lokale-warmtetransitie/default.aspx#How%20go%20we%20our%20neighborhoods%20and%20villages%20heat?

The most important reason for the failure of many heating networks is probably the current legislative framework Warmtewet 1.0 (“Heating Act 1.0”) with maintaining the tariff for energy supply at the gas price, or the so called "no more than usual price" (= natural gas price) Also, the desire of politicians to exclude the private sector from the development of these networks as much as possible might not be helpful. This political desire to exclude the private sector is understandable because there is a need to maintain a certain degree of control over these systems which are a common good and have a utility function. In contrast to the distribution networks for natural gas and electricity, the quality of the heat supplied depends on the distribution network and the costs are therefore more difficult to distribute among all Dutch people, as is customary for natural gas and electricity. However, a return to full implementation in the hands of the public sector is probably not the most efficient solution either, even if on paper it can give greater confidence in the success of a project. Due to the complexity of this energy system, this is probably nevertheless a difficult and improper task for the government.

A point that unfortunately almost never comes up in the current discussion is why a heating network, or rather a "heating and cooling network", is a serious way to realize the energy transition in many urban areas and small residential areas. The reason might be that the focus is mainly on the (traditional) large-scale and central district heating and not on the alternative and small-scale approach that "decentralized" networks with their inherent advantages. The technical development that allows heating and cooling networks to operate 40-50% more efficiently, often referred to as the 5th generation networks (or 5th Generation District Heating and Cooling or 5GDHC), is still largely unknown.

These technological developments in recent years make this more local, and small-scale, approach possible. This development is not only about heat supply, but also about cold supply, whereby the goal is not to continuously send as much heat as possible in one direction, but also to use any locally produced heat in conjunction with temporary heat and cold storage. The approach is not 'top-down' from a large source to a large number of customers, but 'bottom-up' from the end user, in order to meet his energy needs locally as much as possible and to retain and exchange all energy flows as much as possible and then to exploit the added value of connecting multiple end users.

The five separate topics with titles: "Legislation and regulation", "Thermal energy sources and networks", "5th Generation District Heating and Cooling (5GDHC)" and "Private Public Partnership" and "XChains", provide a non-technical explanation of "the how and what" behind the heating networks and the role that XChains wants to play in them.

The appendix contains a list of reasons why a municipality or building users would opt for a particular solution. The idea is that in many cases a 5GDHC solution provides a better answer to these aspects than other solutions. In a way, this is more true if there are ambitions in several aspects of this table.

ANNEX: Assessment frameworks

Nr	Criterium	Toelichting	Grootheid	Parameter
1	Betaalbare energierekening; maandlasten variabel/vast	De maandelijkse energierekening in GJ plus jaarlijkse vaste kosten (W/K/E/G)	GJ-tarief + opslag W/K/T	€/maand
2	Concurrerende aansluitvoorziening; capex investering	Aansluitbijdrage BAK voor warmte, tapwater en koude	€/aansluiting en/of €/kW	€
3	Benodigde investering bij de eindgebruiker	Welke eisen worden gesteld voor mogelijke aansluiting, maatregelen aan de gebouwen	€/m2 BVO	€
4	Eerlijke verdeling van kosten energie voor burgers/bedrijven	Socialisering kosten binnen Gemeente per doelgroep en per locatie	GJ-tarief + opslag W/K/T	€/maand
5	Integrale afweging kosten op lange termijn visie	TCO totaal netto contant gemaakt ter verantwoording keuze	€,nc/jaar	€
6	Geen overwinsten laten wegvloeien uit de regio	Aantoonbaar en gecontroleerd (ACM) realistisch rendement versus bijbehorend risico	project ROI	%
7	Het voorkomen van uitsluiting, lock-in	Hoe voorkom je dat de (rijke) koplopers beschikbare voorzieningen opmaken ?	Epiek, geluid, bronnen	% van totaal
8	Stabiliteit energiekosten door externe factoren	Zo veel mogelijk onafhankelijk van geopolitieke invloeden en ongewenst manipulaties	% lokaal opgewekt	GJ,lokaal
9	Betrouwbare levering Elektriciteit en Warmte (en Koude)	De beschikbare (duurzame) infrastructuur heeft een beperkte capaciteit en groeimogelijkheden	aansluitruimte	kW
10	Flexibilisering levering Elektriciteit en Warmte (en Koude)	Hoe veel spreidingsmogelijkheid voor betere benutting van de infrastructuur buiten de piekuren ?	Epiek/Egemiddeld	ratio
11	Inzet van (multi-)bronnenstrategie	Duurzame bronnen zijn schaars en nemen ruimte in beslag, redundantie is gewenst	Vermogen en energie	GJ/kW
12	Benodigde professionals en middelen/grondstoffen	Met welk concept/werkwijze wordt beschikbaar materiaal en arbeidskracht optimaal ingezet ?	uren/kg per kgCO2	T/MI
13	Vermindering energiegebruik	Hoeveel externe energie is uiteindelijk nodig voor W/K/T en hoe snel reduceert dit ?	Extern	GJ
14	Vermindering CO2 uitstoot	Wat is de CO2 belasting van de benodigde energie, evt. ook materialen en producten	CO2/GJ,geleverd	kgCO2
15	Opvoeren van de realisatiesnelheid	Het huidige temp is veel te laag, hoe opschalen en lock-ins te voorkomen ?	% CO2/reductie per jaar	kGCO2/jaar
16	Een mooie en gezonde stad	Wat is het toekomstbeeld en hoe draagt het gekozen E-concept daaraan bij ?	milieukosten/esthetiek	€sk/score
17	Ontplooiingskans en groeipotentieel	Genoeg en betaalbare energie om (door) te ontwikkelen en ontplooien	energie/inwoner	GJ pp
18	Economisch aantrekkelijke stad	Gunstig vestigingsklimaat voor bedrijven, werkgelegenheid	bruto lokaal product	€
19	Esthetisch aantrekkelijke stad	Bruikbaarhied van ruimte, frisse lucht, estethiek	referentiebeelden	score
20	Biodiversiteit en waterbeheer	Welke koppelkansen biedt het E-concept op andere duurzaamheidsambities ?	score	++/+/0/-/--
21	Kringlopen sluiten grondstoffen/water/energie	Lokaal hergebruik maakt de regio onafhankelijker en efficienter	percentage	%
22	Collectiviteit, sociale cohesie	Bijdragen aan maatschappelijke verantwoordelijkheidsgevoel, draagvlak en participatie	% burgers betrokken	%
23	Ruimtebeslag bovengronds	Hoeveel ruimte is nodig voor het E-systeem en hoe zichtbaar is het ?	oppervlakte/volume	m2 / m3
24	Rumte in de bodem (openbaar), maar ook privaat	De bodem vervult vele functies, hoe is de inpasbaarheid van het E-concept	tracé/volume	geo/m3
25	Ruimte op en benutting van daken	Ook daken vervullen meerdere functies, hoe draagt E-conceptbij aan max benutting?	% oppervlakte	%/m2
26	Verkeershinder, belemmeringen	Wegwerkzaamheden veroorzaken hinder en economische schade	meter maal tijd	m*dagen
27	Tijdfasering en (mee)groeipotentie	Hoe aanpasbaar is het E-concept op ontwikkelingen in de stad en gebouwen	score	++/+/0/-/--
28	Inpasbaar in hogere ambities (17 SDG's)	Gemeente heeft meerdere doelen en ambities, welke concessies/prioritering ?	score	++/+/0/-/--
29	Noodzaak om het proces te initiëren en regisseren	Hoeveel regie is nodig en wat is het belang van voldoende deelname (bij collectief systeem)?	score	++/+/0/-/--
30	Op welke elementen wil de Gemeente invloed ?	Kan de overheid bij het E-concept voldoende invloed uitoefenen ?	kpi's	ja/nee
31	Bevordering marktwerking, PPS	Zoveel mogelijk de markt betrekken maar wel randvoorwaarden stellen	aandeel privaat	%
32	Inpassing in regelgeving en NL-/EU-beleid	Hoe goed past het E-concept in vigerende kaders en verwachte ontwikkelingen	score	++/+/0/-/--
33	Toekomstige trends - flexibiliteit/veerkracht	In welke mate is het E-concept of welke onderdelen zijn no-regret opties en aanpasbaar	risico LCC	€/2020-2050
34	Innovaties, toegepasing lokale kennis in productie	In hoeverre helpt het E-concept de Stad/regio in profilering als innovatieve incubator	score	++/+/0/-/--
35	Veiligheid stoffen	In hoeverre veroorzaakt het E-concept risico's voor brand, explosie, giftige gassen, transport	score	++/+/0/-/--
36	Veiligheid overig	In hoeverre veroorzaakt het E-concept risico's voor straling, bodem, drinkwater	score	++/+/0/-/--

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Part 2: Laws and regulations

Everyone agrees that the current (heat) legislation from 2014 is outdated and has undesirable effects: linking the energy tariff for heating supplied from a heating network to the natural gas price is no longer relevant if natural gas is no longer the alternative for the heating supply. The comparison should be made with a (more expensive) alternative that meets the same sustainability requirements. The only logic exists for a situation in which the supplied heating is produced centrally using gas (a method that by definition does not fit into the energy transition objectives).

The new legislation ("Wet Collective Warmte", "WcW" or Collective Heating Supply Act) therefore puts an end to this link by introducing a maximum rate based on costs. The "Wet Gemeentelijke Instrumenten Warmtetransitie" ("WGIW" or Municipal Heating Transition Instruments Act) was adopted by the 2nd Chamber on 23-4-2024. This bill gives municipalities the opportunity to make local rules to carry out the transition from natural gas to sustainable forms of energy. The municipality decides when the natural gas network will be removed in certain districts[3].

The government supports the development of new projects with the "Warmtenetten Investeringssubsidie" or WIS (Heating Networks Investment Subsidy) scheme: "On request, the Minister will grant a subsidy to a company for a project aimed at the construction of an efficient heating network, if the heating network a) meets the requirements for energy-efficient district heating and cooling and b) ensures the supply of heat to more than 250 small-user connections (KVA) spread over more than 5 buildings". The subsidy amounts to a maximum of € 20,000,000 per project (> 3,330 kva) for the difference between the eligible costs and the operating profit and is a) < 45% of the eligible costs and b) < € 6,000 per kva[4]. The outgoing government wants to increase the budget for the Heating Investment Subsidy from 400 million to 920 million euros (spring memorandum 2024).[5]

Despite the good intentions, the consequences of the existing Heating Act 1.0 are not yet helping to stimulate the introduction of heating networks and after a positive start in recent years, the energy transition in this area has suffered a significant blow. The threat and conditions for a new heating law and the resistance to the current connection fees and GJ tariffs may lead to their project development coming to a halt. This dent has been further exacerbated by the fact that two major energy suppliers (Vattenfall and Eneco) have each halted an important project as part of the energy transition process. The reasons given were the uncertainty surrounding the setting of future energy tariffs and that they are unable to guarantee an acceptable energy tariff that makes their investment in the heat production and network profitable. In doing so, they probably assume that the "acceptable" energy tariff will be the maximum cost-based tariff they can demand. It should be noted that the business cases are based on their "old" inefficient technology with high losses (from 30% in winter to 70% in summer).

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3 https://www.tweedekamer.nl/kamerstukken/wetsvoorstellen/detail?cfg=billdetails&qry=bill%3A36387

4 https://zoek.officielebekendmakingen.nl/stcrt-2023-11052.html

5 https://nos.nl/artikel/2516514-honderden-miljoenen-extra-aan-subsidie-voor-warmtenetten

Even if it becomes clear in the future whether this is the case, we can already ask ourselves how the Netherlands Authority for Consumers and Markets (ACM) calculates "a cost-based rate" for a district, or in other words what is included by ACM in its definition of a project. Certainly for the larger energy suppliers, a project definition is more difficult to define because their costs partly consist of central "overheads" that are more difficult to allocate per project, but also because some of them apply a national and therefore not a project-related, energy tariff.

Another uncertainty problem is that in the project definition and profitability calculation, the number of connections is also essential in terms of dimensioning of any central heat production facility, capacity and the total network. Fewer connections than planned will lead to higher costs per connection or result in losses for the project developer, unless the developer can possibly expand the initial “warmte kavel” (heat plot) and thus take advantage of any over-dimensioning.

Finally, the new legislation creates uncertainty for the current heat suppliers regarding their future role. Even if a transition period is foreseen for existing projects, the need for a public majority share in the future projects with more than 1500 individual residential connections also creates uncertainties for these suppliers. A possible side effect may be that these publicly organized projects may lead to the introduction of less efficient solutions because a part of the market, innovation and risk-taking are eliminated. Municipalities, and certainly the mostly smaller municipalities, do not have the experience, manpower and knowledge to develop and operate these networks and they often lack the opportunity to provide the desired financing (which is possible if the State steps in) and to bear the additional investment risk through, for example, the Guarantee Fund of 250 million for the period up to 2030[6]. This is a fund to start up new heating networks, where the amount mentioned should be enough to cover 80 to 90 percent of the costs of the construction phase. With a guarantee fund, it is possible to start financing with 10% equity (instead of the current 30%) and a lower return requirement on that equity[7].

The guarantee fund therefore ostensibly solves a financing problem, but because a “warmte bedrijf” (heating company) is not part of a core task of a municipality, locally organised heating companies can lead to inefficient business operations and therefore high (operating) costs. The business cases are often very sensitive to higher annual costs, much more sensitive than an additional investment in infrastructure. Even if private companies can contribute their experience through a joint venture, the proposed organisational structures are complicated and often unclear in terms of risk allocation, so full public control deters many companies from joining such a joint venture.

The new law clearly does not solve all problems, but within the law there are possibilities to implement the energy transition decisively, provided that some flexibility is guaranteed in the implementation. This flexibility can be applied on two levels:

- Although it is positive that the realisation of heat plots with fewer than 1500 connections gives greater freedom in implementation and management, in order to create the necessary interest, flexibility in the application of the law is needed with regard to a possible desired expansion of the heat plot once the original plot has been successfully realised. These expansions can provide the necessary incentive for private companies to offer innovative solutions, which are often risk-bearing and project-oriented.

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6 https://www.binnenlandsbestuur.nl/whitepaper/investeringen-warmtenetten

7 https://www.g40stedennetwerk.nl/bouwstenen-financiering-warmtenetten#:~:text=Waarborgfonds%20warmtenetten%20met%20spelregelkader,in%20de%20investering%20van%20warmtenetten.

- With regard to larger heat plots, flexibility is desired in the possibility of adapting the current complex structure so that the private sector has a direct influence on the implementation and day-to-day management of the operation. Furthermore, it should be clear that the main construction and operation contracts (commitment of costs and risk responsibility) that are signed prior to the establishment of the local heating company in which the public sector has the majority stake can only be adjusted if both parties agree.

In short, the new law brings clarity, but some flexibility is needed in its application to be sure that heating networks can still be realized in the future.

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Part 3: Thermal energy sources and networks

The success of a heating network and therefore the success of the energy transition depends to a large extent on a good combination of the right energy source and an efficient network with possible storage. As far as the sources are concerned, there are many possibilities, ranging from large central sources (biomass, geothermal energy) to decentralized sources by using, for example, solar collectors or heating pumps. Of course, each chosen solution has its own specific advantages and disadvantages[8].

It is clear that the current large and traditional energy sources for district heating (natural gas or even worse coal) do not fit within the energy transition objectives. However, it is also doubtful whether the use of biomass on a large scale is an ideal solution, especially if this solution is based on the use of wood pellets coming from Norway or Canada. Even if this solution may still be economically interesting at the moment, it does little to improve the total CO_2 balance, for example, if transport is also included in the comparison.

Geothermal energy (deep or shallow)[9] can be an ideal solution, but many uncertainties and often many more expensive studies are still needed to determine whether the source can deliver the desired capacity. And even then, there is always a large residual risk in terms of permits, actual capacity and related construction costs.

With the exception of the use of the soil by means of aquifers, the costs of the centrally set up (large-scale) shallow and deep geothermal heating sources are such that their realisation is only feasible if a large number of connections can be realised. Once this number has been reached, expansion of the number of connections is usually impossible without major new investments in the heating sources to further increase their capacity. The same is more or less true when it comes to the construction of the network because everything is delivered from a central point. A planned expansion of the system at a later date requires a certain amount of over-dimensioning of the pipes or a new substantial investment in larger pipes at that time. These investments are particularly high in the case of networks based on high water temperature due to the need to provide adequate insulation.

Industrial residual heating is an ideal source as long as the amount of heating supplied matches the demand for heating and the necessary investments to connect this source to the local heating network can be repaid within an acceptable rate. Assuming that the heating network project makes the necessary investments to disconnect the heat, it should be possible to supply this heating free of charge or at a low rate. Residual heating is a by-product that would otherwise be lost and thus increase the ambient temperature undesirably. In addition to the well-known industrial residual heat, data centers and other buildings where cooling is a necessity (offices, shops, restaurants/bars, theater, sports complexes, hospitals, etc.) also generate the necessary

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8 https://www.zuid-holland.nl/publish/pages/25675/418_pzh_afwegingskader_digitaal_def.pdf

9 In line with the principles given for the SDE++ scheme 2021, a depth limit of 500 metres, in line with the depth to which the Mining Act applies, is also used here. https://www.pbl.nl/sites/default/files/downloads/pbl-2020-conceptadvies-sde-plus-plus-2021-geothermie_4110.pdf

"residual heat" or "cooling heat". Again, it is better to supply this heat to a heating network so as not to further increase the outside temperature in the built environment.

In addition to sources such as surface water, sewage thermal, transport/metro, conversion heating (see Re-UseHeating manual[10]), solar heat (via solar collectors) and air heat (via air-based heat pumps) can make an important contribution as decentralized and local sources because they are realized in an individual (per building) or limited collective way. While the efficiency of solar collectors depends greatly on the amount of "solar light", that of heat pumps depends on the outside air temperature. In addition to both requiring electricity to function connection, the air source heat pumps are not silent, and if they are used for cooling in the summer, they also heat the outside temperature.

Water-based heat pumps in combination with aquifers or surface water are generally more efficient and cause almost no noise to the environment, but rely on water with a given minimum or maximum temperature to provide heating or cooling, respectively. For individual buildings or small collectives, a heat pump can also be connected to a horizontal or vertical soil exchanger. Horizontal soil exchangers are a pipeline network at a depth of approximately 1 m with a relatively large surface area and are more often used, for example, in sports fields, with the additional advantage that these winters can be kept free of ice and, in combination with aquifers, they can serve as seasonal storage of energy. Vertical soil exchangers usually involve closed probes up to about 20 m deep, also for individual houses[11]. The design and cost of closed soil exchangers for individual homes can be determined with the ATES tool[12]

None of these energy sources (thermal energy, residual heat, surface water, solar collectors) require large investments that can only be amortized taking into account large numbers of connections. In fact, all these facilities can be realized in a "scalable" way. By setting them up as a heating and cooling network and combining them with insulated buffers for heat or cold storage[13] and locally produced electricity, they can, in certain ideal cases, function completely autonomously. Furthermore, by merging several such small projects, the security of supply for all these projects in such a combined project can be increased.

In short, small-scale projects that make use of the various existing sources in the vicinity often form an attractive alternative compared to the relatively capital-intensive large-scale heating networks, in which the so-called connection risk is mainly reduced.

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10 https://api.euroheat.org/uploads/Re_Use_Heat_Handbook_For_Increased_Recovery_of_Urban_Excess_Heat_c050f4a3fe.pdf

11 https://bodemenergie.nl/soorten-bodemenergie/ in https://www.rvo.nl/onderwerpen/bodemenergie-aardwarmte/gesloten-systemen/bodemwarmtewisselaars

12 https://wkotool.nl/

13 The difference with shallow geothermal energy or ATES is that water with higher temperatures can be stored in the insulated buffers.

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Deel 4: 5th Generation District Heating and Cooling (5GDHC)

The above-mentioned small-scale solution to realize the energy transition in the urban environment and small residential areas is defined among professionals as a 5GDCH network or system and distinguishes itself from previous generations by its use within a closed network in which the "circulation" and "exchange" of hot (30 to 40 degrees) and cold (10 to 20 degrees) water in combination with insulated buffers takes place simultaneously. These buffers serve to store a temporary surplus of heat or cold and possibly create extra heat if there is a surplus of green electricity from local solar panels and/or wind turbines. The stored heat (or cold) can be used as soon as the demand for heat (or cold) exceeds the generation from renewable sources.

The 5GDHC systems function best when there is a lot of local exchange between heating and cooling demand and many local sources can be realized. Depending on the quality and quantity of industrial residual heating and cooling generated heat present in the project in question and the demand for heat, the desired buffer capacity can be calculated and the need for new heat (and any cold) sources can be determined. As a result, almost by definition, every project is different because the mix of buildings, wells and other facilities or companies with residual heat is almost never the same: the better the mix, the less there is a need for external energy sources. In other words, every project even with the same number of home connections has a different investment profile and therefore a different heat rate.

As mentioned above, the biggest advantage of 5GDHC networks is that they can be set up as small-scale projects because most of the components are dimensioned "pro rata" to the local production of and demand for heating and cooling. Only the dimensioning of the "backbone" (the main circular tube network) depends on the size of the “warmte kavel” (heat plot) and a certain overdimensioning may be necessary to allow for future substantial plot expansions[14]. The backbone is connected to the cluster network via an exchange station, which itself is connected to the end users via a second substation directly or via a sector network.

In addition to the pipe network (backbone, cluster network and sector network) with connection stations, a heat buffer with a possible (extra) heat pump is often added to the 5GDHC network to store heat, since heat production and use are usually not synchronized. Finally, in order to make the 5GDHC system as independent as possible from the national grid, green electricity (solar panels and/or wind turbines) can also be generated locally.

This set-up of the 5GDHC systems is based on a modular approach and thus the possibility to use existing standard components, which has a great advantage in limiting the initial investments and thus on the final tariff that the consumer will have to pay for the energy supplied.

Apart from the direct economic benefits of the 5GDHC solution, the indirect benefits in conjunction with the overall energy transition objectives should not be forgotten:

- The need for all buildings to be well insulated as part of the 5GDHC project fits in well with the government's already set objectives. This insulation brings benefits both in the cold and in the warm season.

[14] The entire network, and in particular the backbone, also serves as a kind of buffer.

- The fact that the pipe network does not operate at significantly higher or lower temperatures than the existing ground temperatures prevents not only expensive insulation but also a gradual heating of the soil (and drinking water pipes) around the pipe system.
- Reducing (or even eliminating) heat released in the outdoor air as a result of cooling buildings prevents the already rising outdoor air temperatures from rising further in urban areas due to climate change.
- The ability to cool homes via the 5GHDC network may lead to a higher demand for cooling than for heating in the near future. Since there will always be a demand for generating hot drinking water, a higher demand for cooling will not unbalance the total.

With the exception of the last point, the 5GDHC advantages can be seen as interesting positives compared to the current district heating systems. On the last of the above points, the 5GDHC system actually differs from a classic heating network, since a classic system cannot easily meet the cooling needs. This need must then instead be met with an additional installation of an air conditioner (or a "reverse" air-based heat pump) with all the additional additional electricity demand, noise problems and investments.

Despite these major advantages, only a few of these pure 5GDHC networks have been realized in Western Europe so far. The main reason is that a conventional system (central generation with high temperature distribution) provides greater certainty with regard to the desired heat supply and that investments associated with these conventional systems are usually more interesting for current energy suppliers who are not equipped to handle small-scale projects. Furthermore, the unfamiliarity of mostly the smaller interested parties in heating networks (smaller municipalities and housing corporations) is linked to their lack of risk-taking capital, another reason why virtually no 5GDHC projects have been developed in the Netherlands so far.

It is therefore important that more attention is paid to tackling small heat plots, communicating about how and why heating networks and in particular 5GDHC networks are the best technical solution for the energy transition in residential areas with at least 500 to 1000 homes.

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(or "the how and what about heating networks")

Part 5: Private-public partnerships

Also in the realisation of heating networks, cooperation between private and public parties is unavoidable within the Dutch economic system, since all installations and systems are provided by the private sector and the construction is carried out by the private sector. The question, however, is how this cooperation can best be structured, taking into account the fact that, in general, a large part of the infrastructure is a community property that is built on public land, and the private sector is better at managing projects as long as the right (financial) incentives are in place.

A collaboration in which the private sector has a major interest in the management requires good agreements in advance and opportunities for both parties to end the collaboration prematurely if the other party does not comply with the agreements. These agreements go hand in hand with a clear contractual division of responsibilities and construction and operating risks as well as a sharing of the financial risks in terms of the returns or losses resulting from the economic use of the property. By granting concessions to companies created specifically for this purpose, the public sector can transfer these responsibilities and take a stake in these companies and can also share in future expected profits.

In order to increase competition, the utilities have been split into an infrastructure company and a supply company as multiple supply companies can use the same infrastructure. In the case of heating networks, the quality of heat or cold supplied is strongly entangled with the quality of the network and how this network is operated. While there might be such a disconnect possible for the traditional high temperature networks, for a 5GDHC network this is impossible as the network can also be used as a buffer. In other words, there is no real need to set up a separate "warmte bedrijf" (heating company) in addition to an "infrastructure company" and both can be combined into a concession company or "special purpose vehicle" (SPV).

The SPV is set up as soon as all parties (private and public) agree on the project definition and energy tariff, the main construction and future operation & maintenance contracts with the implementing companies, the method of financing and the SPV governance.

- The project definition, including the duration of the concession period, describes in detail all project aspects and forms the basis on which the most important construction contracts are recorded and thus the investment volume is determined, but also the operating and maintenance costs as well as the future revenues and necessary subsidies to make the project profitable. As a result, it is also possible to set the energy tariff for the concession period, based on the principle that only an inflation correction is applied.

- Once the project definition has been established, the tenders can be made for the construction and operation & maintenance contracts with the aim of a clear division of responsibilities and risks between the SPV and the contractors, but also what quality should be delivered and at what price with preference on a "turnkey & fixed price" basis. The most important heating and cooling supply contracts could equally be concluded at this point of time.

- Shareholders must ensure that there is sufficient financing (equity in the form of equity and any subordinated loans, and debt) to guarantee the construction of the network and other parts of the overall 5GDHC system. The repayment of these assets follows from the net proceeds of the SPV and the payment of dividends.
- Finally, the shareholders appoint the board of directors, but leave the day-to-day management of the company to the CEO who is assisted by a rotating team of specialists depending on the stage the company is in (construction, operation). Since most projects are small-scale, it is more efficient that the SPV does not appoint its own staff, but outsources this to one of the parties on a performance-based basis with a fixed price with any inflation adjustment.

Once all these elements have been determined and agreed, the development phase ends and the construction phase (Financial Close) starts and the SPV begins its work as a concessionaire.

Why Heating and Cooling Networks are a good solution

(or "the how and what about heating networks")

Part 6: XChains

XChains has been set up with the aim of realising a large number of small-scale 5GDHC projects (including the realisation of any required sustainable energy sources), whereby XChains initially has a role as a project developer and sets up specific Special Project Vehicle (SPV) for each individual project together with the public sector.

XChains ensures that the most important construction contracts are licensed before Financial Close is reached, thus giving the SPV a good level of cost certainty. During construction, XChains will take care of the necessary project management, with an emphasis on the correct execution of the construction contracts, obtaining the outstanding permits, and the possible outsourcing of smaller construction components. After construction, XChains also takes care of the management of the operation and maintenance responsibilities with certain activities carried out by XChains or other subcontractors appointed by the SPV.

In addition to the above-mentioned tasks, XChains proposes to finance the construction financing by means of a subordinated loan, in order to guarantee a faster start once the main connections have been secured. In other words, XChains starts without obtaining the consent of all individual small-scale users with a connection. After the commissioning activities have been completed at the end of the construction phase, these subordinated loans are financed with low-cost bank loans. Since this refinancing is only possible if the construction is successfully completed, XChains indirectly bears part of the construction risk.

As with most projects, the success of a 5GDHC project depends on a good preparation phase. During this phase, a good analysis of the technical possibilities and solutions is important, but obtaining the cooperation of all the larger parties involved in the project is essential. In contrast to a traditional heating network, a good exchange of heat and cold between all parties connected to the 5GDHC network is the key element in obtaining a financially attractive project because it helps to reduce dependence on energy (electricity) from outside the local system.

It is also important that all those who can be connected participate in the project and thus join. This means that in neighbourhoods with homes with a poorer energy label, a programme of insulation must be implemented at the same time, and that for homes with an air source heat pump already installed, possibilities are being investigated to convert or replace this heat pump[15] without or with minimal additional investments for the owners concerned.

Even if the insulation program and the retrofit program of air source heat pumps are not a direct component of the 5GDHC financing (i.e. these investments are the responsibility of the homeowners), XChains can play an important role in the coordination and implementation of both the insulation program and the heat pump retrofitting or replacement program. Since, planning of connections often does not coincide with the need to replace old boilers, XChains can advise owners on the installation of air source heat pumps so that a simple conversion can be carried out as soon as the property in question can be connected to the 5GDHC network.

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[15] Depending on the age or the air source heat pump and therefore its residual value, these pumps can be sold again after a possible repair in a market where the production of new heat pumps lags behind demand (circular economy).

In addition to providing technical advice, planning and coordination of the implementation of these two programmes, XChains may also contribute to their pre-financing. This proactive and integrated approach should ensure that grounds for refusing a connection to the 5GDHC project are removed as much and as quickly as possible, because in the end everyone wins if a project can move quickly from the development phase to the realization phase. Speed in development is important to motivate the participating parties (removing opposition), but also to keep them motivated. The combination of a 5GDHC system, which, unlike a classic heating network, can be realized in small modular phases, with the pre-financing provided by XChains (no long bank financing commitment process) makes this possible.

As a private company, it is important to XChains that projects are profitable and that is one of the most important incentives for XChains to ensure that the execution and operation (including maintenance) are carried out as efficiently as possible. By means of professional project management, it ensures that the systems supplied by third parties give the performance that has been agreed upon and that the re-financing can take place as soon as possible after the end of the realization phase.

Finally, XChain's project-oriented design avoids cross-subsidization between projects, which means that energy tariffs are project-related.