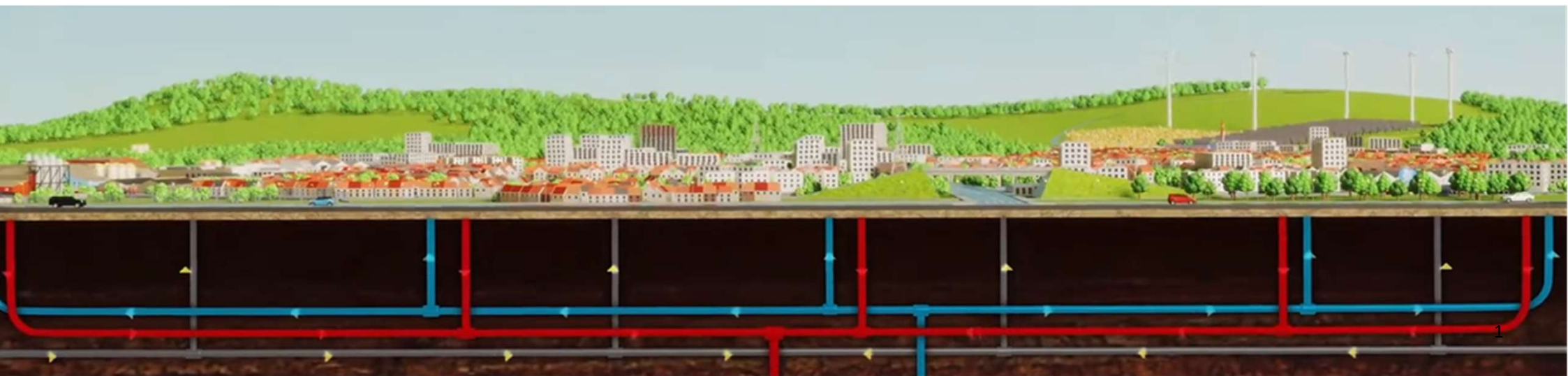




The story of 5DHC Networks



Energy Transition - Objectives

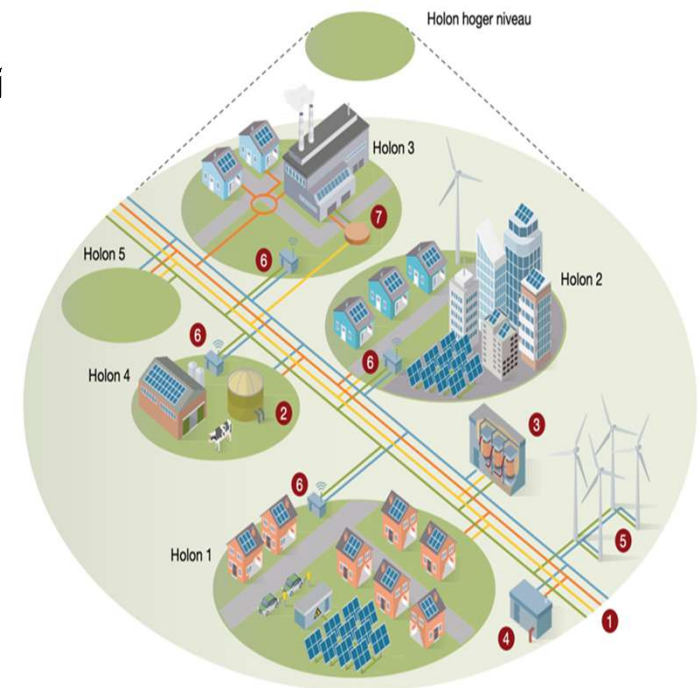
Creating a sustainable society by realising local energy supplies in the built environment whereby these facilities:

- are optimised towards the existing infrastructures,
- have been provided with an economic scalability as a characteri
- limit the demands on the (public) space and
- will become independent of fossil sources.

But also, to ensure that they:

- remain affordable and therefore accessible to all,
- promote biodiversity, usability and aesthetics,
- avoid unnecessary environmental burdens, and
- lead to a healthy and comfortable living environment.

The objective is to be part of the climate goals to have realized by 2023 500,000 new connections of existing buildings (homes) to a heating (and cooling) network.



Source: Visualisatie werking holarchisch energiesysteem
<https://energy.nl/publications/holarchisch-energiesysteem/>

Energy Transition - 5GDHC can achieve these goals

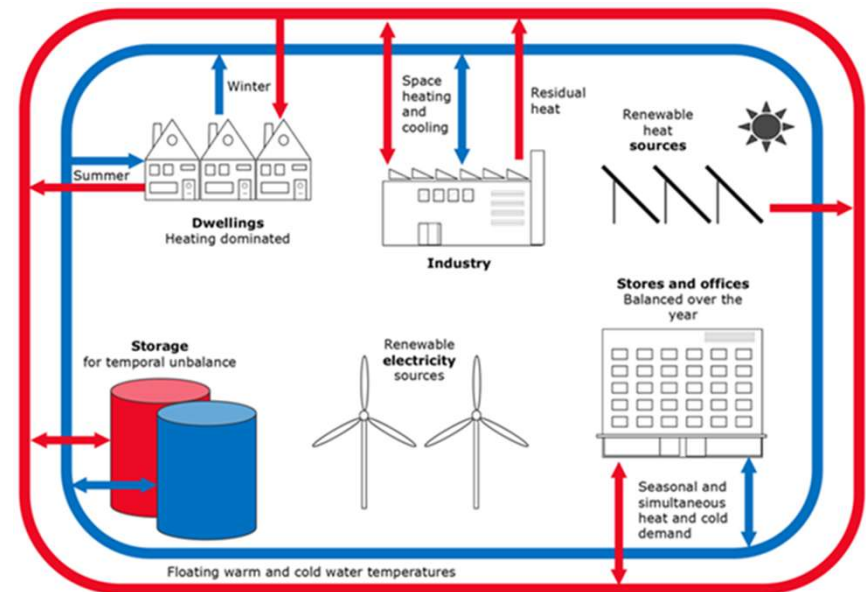
5GDHC ("5G District Heating and Cooling") networks offer an efficient way to replace natural gas as an energy source for heating and reduce CO2 emissions.

This efficiency is due to:

- local exchange of individual excess heat and cold;
- local (temporary) storage of collective excess heat and cold;
- making use of local green energy sources and of available residual heat/cold.

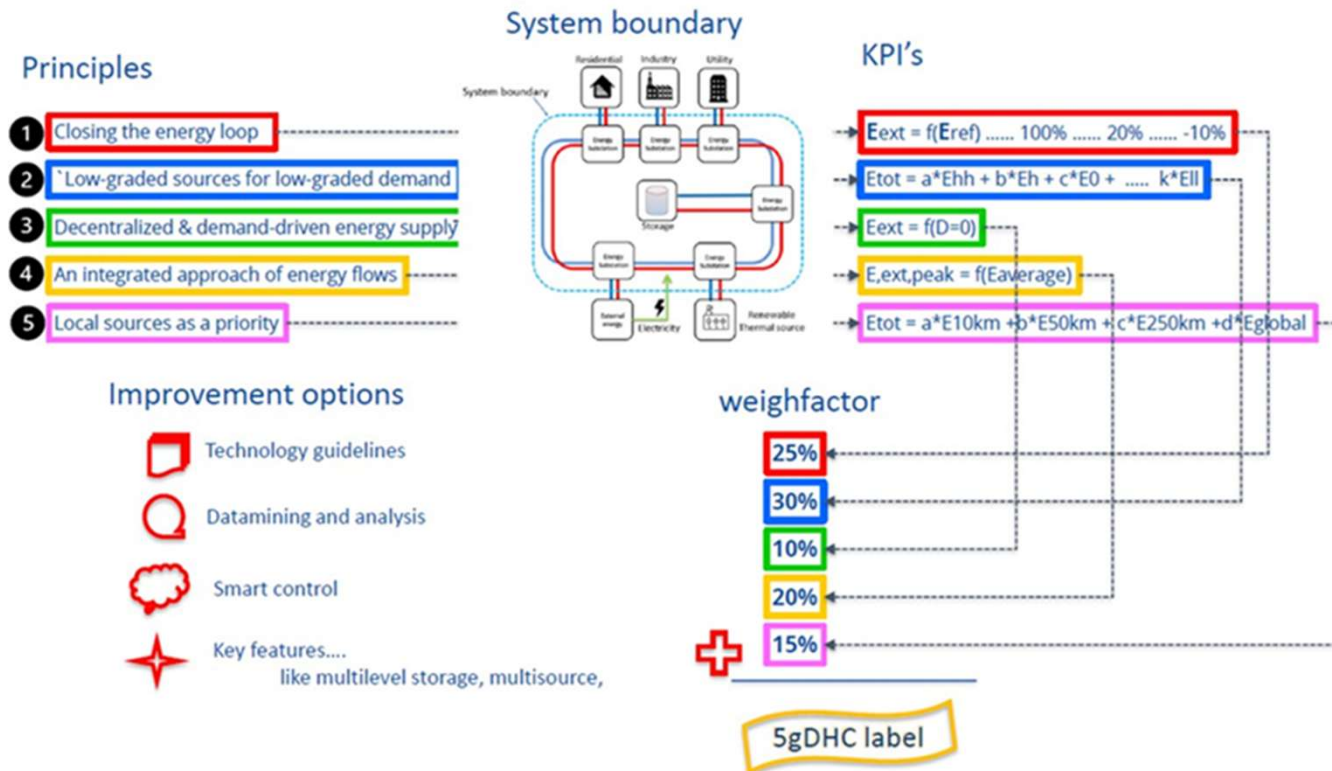
In addition to phasing out fossil gas as a source of heating and cooling, 5GDHC solutions also aim to reduce the pressure on the local and national electricity grid, avoid noise pollution from air source heat pumps, and prevent emissions of NOx and particulate matter from biomass.

The 5GDHC solutions contribute to the prevention of "urban heat islands" and promote an aesthetic and liveable city. In other words, a 5GDHC network aims to make better use of local energy without introducing new forms of environmental disadvantages.



5GDHC – Methodology

- After four generations that started with a district heating network that pumped water at very high temperatures (often steam) through the city, proposes the D2Grids working group five principles, each of which is represented in a KPI, in order to identify the ideal 5GDHC network.



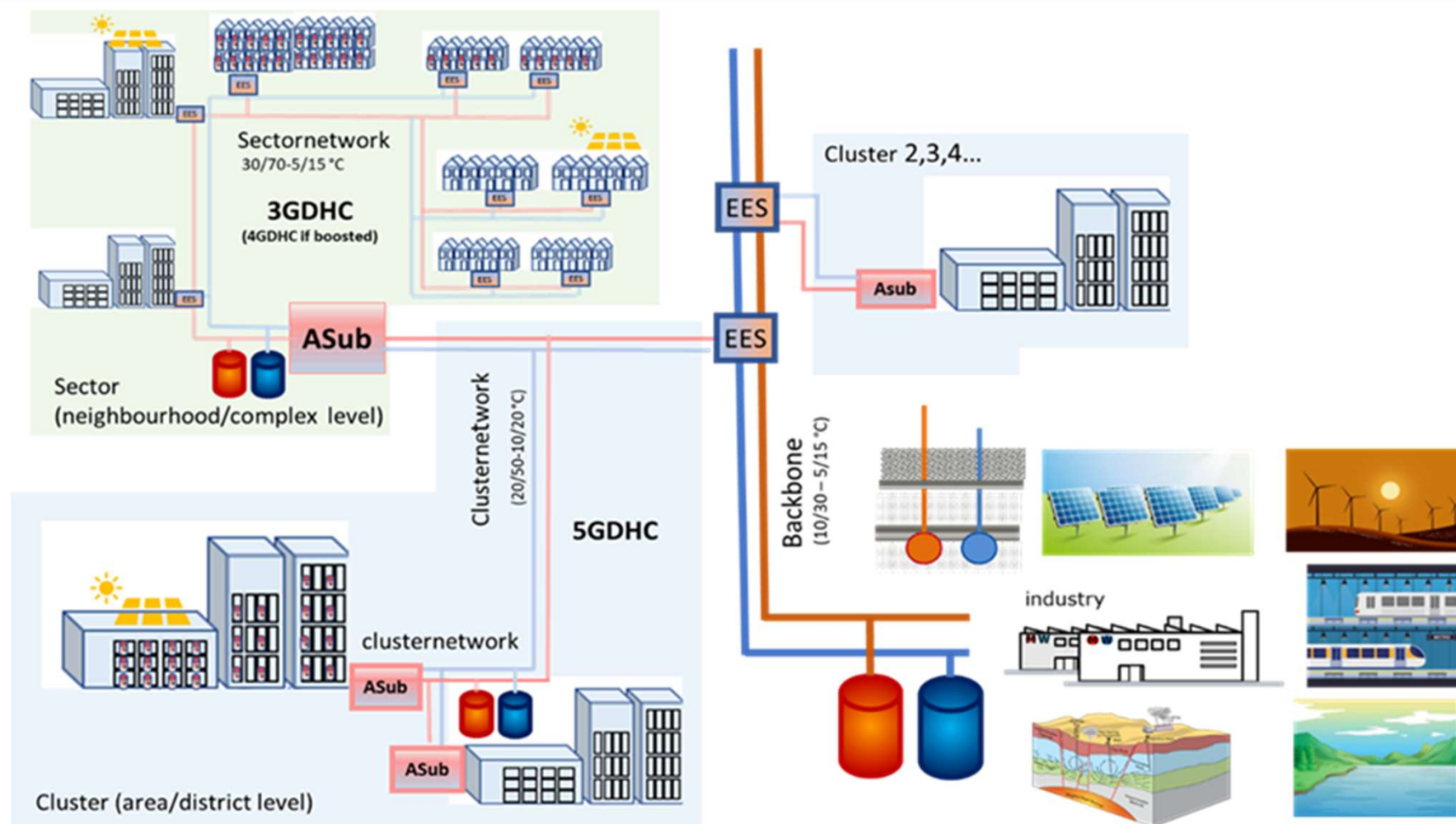
5GDHC – Definition of the 5 principles

The five principles for the ideal 5GDHC network are:

1. **Closing the energy loop:** Preventing energy losses through an optimized system that allows an exchange of heat and cold between end users, first at the building level, then within the district and eventually at the city level.
2. **Use of low-grade sources for low-grade demand:** Ensure that the supply of low-grade sources is aligned with the demanded quality level of demand.
3. **Decentralized and demand-driven energy supply:** Circulating energy within the system only when and where it is needed and as close as possible to the end user.
4. **Integrated approach to energy flows:** Linking heating and cooling to other energy flows to avoid energy waste in all sectors and reduce peak loads.
5. **Local resources as a priority:** Avoiding large investments and energy losses during transport, and stimulating the local economy.

Even if the ideal 5GDHC network (all KPIs reach 100%) does not exist in reality, the results will show the best routes and scenarios that can improve the overall performance of the local energy system. It should also be noted that some measures may improve performance on one principle but may be counterproductive on another.

5GDHC – Description of a modular system overview



5GDHC – Description of a modular system Pipeline network

5GDHC networks can be set up modularly consisting of the following pipeline networks:

- **Backbone:** This 2-pipe thermal pipeline network has one pipe for heating and one pipe for cooling and connects the individual cluster networks through an exchange station. There are no active (generating) power plants in the backbone, only sources with low (source) temperatures. In case, there is deep geothermal or industrial waste heat is available, it is possible that the backbone also contains a hot pipe.
- **Cluster network:** Like the backbone, this is a 2-pipe thermal pipeline network that is connected to the backbone via an energy exchange station and supplies heat and cold to the end users (offices, flats, utilities and sector networks) via active substations. The cluster network is a 5th generation thermal network in which pipes also act as reservoirs for heat and cold, and in which a dynamic temperature regime prevails.
- **Sector network:** This is a 4-pipe thermal pipeline network that provides several buildings/connections with heat and cold from one centrally located (underground) station that is connected to a cluster network and can possibly be linked to a local heat or cold storage. The configuration of a sectoral network can be defined as a 3rd generation network (use of high temperatures without end-user amplification) or a 4th generation network (use of lower temperatures with end-user amplification for domestic hot water and possibly for). A sectoral network is preferably not located in the public space, but within the thermal building envelope.

With a possible exception of sector network pipes (in the case of a 3rd generation network), a form of standardization can also be implemented here because larger diameters (especially for cold water) are less of a problem from a heat loss point of view. They can however contribute to providing a kind of buffer capacity.

5GDHC – Description of a modular system Network nodes

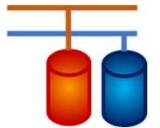
(continued) the following modular "nodes":

- **Booster Exchange Stations (BES):** These are the heat pumps installed at the end user's premises where the temperature of the water is raised to the required level of the tap water. They can become a multi-purpose end-user device that is also stimulated to deal with peaks in space heating and/or indoor air heating or cooling. Given the numbers, standard solutions are used for homes as much as possible to reduce costs (some over-dimensioning may be cheaper than specific solutions).
- **Active Substations (Asub):** These substations form a hydraulic separation between the sector and cluster network and exchange thermal energy by means of a heat pump. The temperature of the cluster network water is actively brought (with the help of energy and intervention of the network operator/software) to the temperature required for the functional use in the buildings (space heating, space cooling and/or preparation of domestic hot water). For each connection, an indoor or adjacent substation is realized based on the required capacity of the building in question. From the substations, the individual end users can be connected to a 4-pipe thermal network, depending on whether heating or cooling is contracted.
- **Energy exchange stations (EES):** At these stations, thermal energy is exchanged between the backbone and the cluster network. Both water circuits are hydraulically separated.

5GDHC – Description of a modular system Other elements

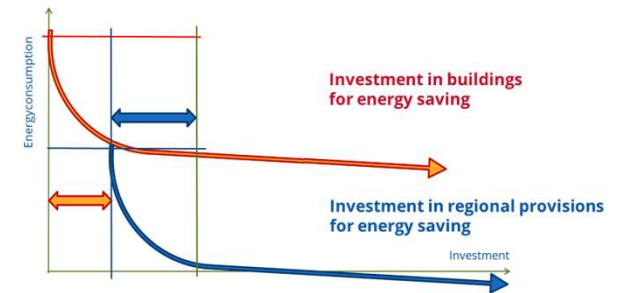
(continued) and a number of other elements:

- **Buffers:** These can take the form of a geothermal solution (heat and cold storage) or newly constructed storage vessel with a standard construction solution
- **External energy sources:** Various solutions are possible for this –
 - *Heat* in the form of geothermal energy (including thermal energy storage), solar collectors, and surface and sewage heat, but also industrial residual heat and data plants insofar as they are not directly added to the network
 - *Local green electricity:* solar panels and wind energy
- **Management systems:** These are usually linked to the buffers and consist of heat pumps and system pumps to regulate the water flow (EES and Asub) that are centrally controlled.



Energy Transition - Comparison with traditional district heating

- 5GDHC concepts are demand-driven, so that the temperature jump happens as much as possible with the end user and the transport energy losses are substantially lower, even with limited insulation around the transport pipes;
- 5GDHC networks can be developed on a small scale and then expanded into larger systems without the efficiency of the initial system being compromised by a (temporary) significant over- or under-dimensioning;
- 5GDHC systems are more flexible and reliable for energy supply, because they use multiple (local) sources and storage modules, and because they are largely self-sufficient;
- 5GDHC arrangements contribute to creating a better financial balance between investing in energy savings (insulation of houses/buildings and ventilation) and investing in area facilities (closing cycles and using existing residual heat);
- 5GDHC systems are better adapted to a future in which due to climate change, there is potentially less need for heat, but a growing demand for cooling. Due to this growing demand for cooling, the business case is much less dependent on falling heat demand, because both heat and cold are 'sold' with the same infrastructure.



5GDHC – Advantages

By definition, a 5GDHC network provides the following practical benefits:

- Decentralised installations allow end-users to plug in when they are ready, and adapt the power station to their (changing over time) needs;
- Significant heat gains can be achieved from low-temperature sources and the heat flow from the back of the heat pump is kept in the system;
- Cooling is integrated into one system

In addition, several scientific studies have shown that:

- Lowering the heat distribution temperatures leads to an annual saving of 40% on electrical energy (from 10.4 kWh/m² to 6.2 kWh/m²)
- Switching from 3GDH to 4GDH saves 4.5% primary energy and 2.7% on system costs
- Implementation of a 5GDHC system:
 - leads to a 42% cost savings and 56% reduction in CO₂ emissions compared to individual heating, ventilation and air conditioning (HVAC) systems
 - compared to a conventional gas-fired district heating system, primary energy consumption is reduced by 58% (USA) and 84% (Germany), CO₂ emissions by 35% and 78% and energy costs by 53% and 57%.
- The integration of PV generation into the 5GDHC system led to a reduction in electricity consumption of about 30%.

5GDHC – Barriers and opportunities

As is often the case, is also here a major barrier here the willingness to adopt an innovative solution.

In the case of the innovative 5GDHC system, this system requires a decentralized and, at first glance, more complex approach and it is relatively easy to expand the network in small steps without having to immediately connect all individual potential users for economic reasons.

These more technical and economic barriers translate into a political barrier that is driven by the fear that the municipality will lose control if it does not participate directly in the implementation and that it must first build up the technical knowledge for this. The direct consequence is that its realization is postponed and the indirect consequence is that local initiatives get stuck in a political quagmire because (national and/or local) politics adjusts their objectives.

However, the innovative aspect of 5GDHC systems also offers opportunities because the possibility of a step-by-step expansion can be done by bringing together the various local parties: resident cooperatives and individual owners, but also shops, offices, schools and other utility buildings, and any small local industrial activities. All these parties benefit from being able to secure cheap cooling and heating, but also from giving up their excess heat, cold and any green generated electricity. A 5GDHC system makes it possible to easily exchange energy at the local level.

5GDHC – Conclusion

Making the urban built environment natural gas-free within the next 25 years is a major operation in the field of buildings and infrastructure in the Netherlands. To achieve this, a different approach is needed. This “new” approach should ensure that the process is speeded up and costs are reduced. This means:

- Make sure that cold and heat can be exchanged;
- Save on network construction costs (reduce piping costs and simplify integration into the street)
- Work as much as possible with prefabricated (possibly underground) substations;
- Introduce plug-and-play connections for (green) sources and residual heat;
- Establish "Plug-and-play" connections with communication protocols to end-users;

The 5GDHC systems have built-in resilience and flexibility (adapting to future changes..), noting that the decentralized installations allow end-users to connect when they are ready, and adapt the power substation to their (changing over time) needs.

In other words, they avoid the need for a centrally planned approach that can only be adapted to a lesser extent when local circumstances change: **5GDHC gives the initiative to the local parties.**



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