DECARB CITY PIPES 2050

H/C plan

ROTTERDAM

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 893509

Table of Content

Introduction

In line with the Paris Agreement, European agreements and the Climate Act, the Netherlands wants to significantly reduce CO2 emissions in the coming decades. Therefore, Rotterdam wants to be gas free and climate neutral by 2050.

In recent years we have gained a lot of experience with the five 'district orrientedapproaches going natural gas-free'. The fourteen exploratory studies, in search of suitable districts for subsequent district orriented approaches, have also yielded valuable insights.

The energy transition is still in full swing. There is still much to be discovered and re-evaluated. We therefore make our decisions in the knowledge that much will probably still change. That's why we have chosen an adaptive strategy. We focus on steps that are possible now and avoid steps based on too many uncertainties in the future. In this way, today's choices lay a solid foundation for the future: they are regret-free or no-regret choices. It also gives us scope to respond to new developments, innovations and insights.

Currently, Rotterdam has 263,000 natural gas connections, which are mainly used for cooking, heating and hot running water. We must therefore start on time to ensure that all buildings in the city are natural gas-free before 2050. We will do this in phases, so that the city remains accessible during the heat transition and we can make optimal use of resources and people. To be able to make sufficient headway towards 2050, a number of components are required.

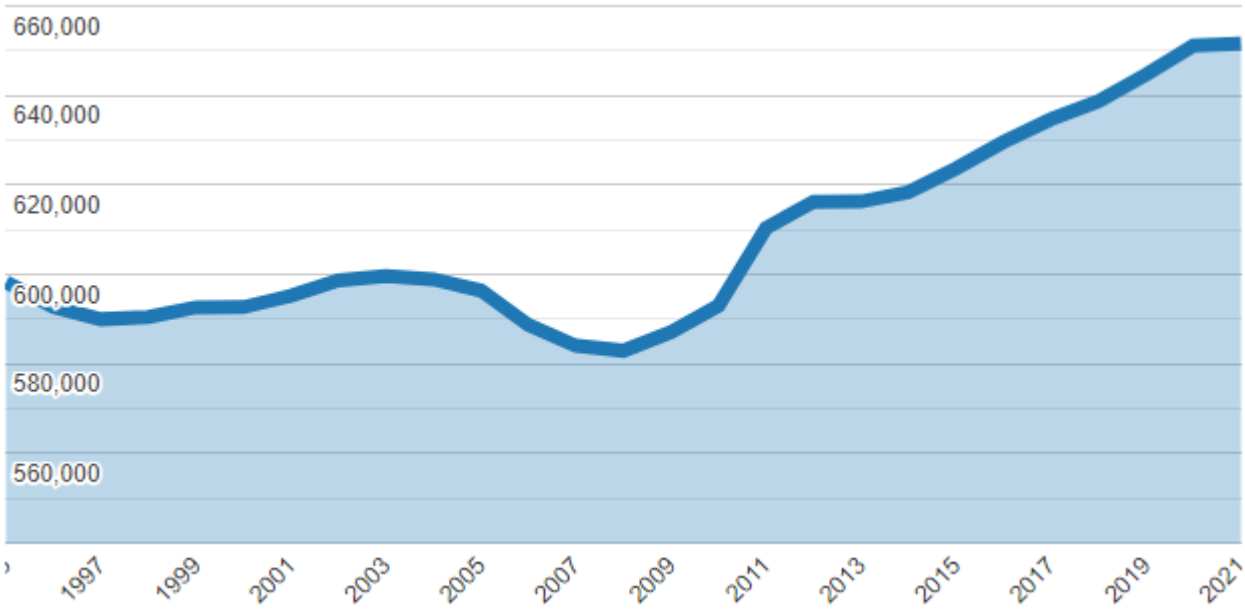
These will enable us to heat buildings with a clean heat alternative:

- The available technologies to provide a building with heat;
- The necessary infrastructure and spatial possibilities;
- The availability and development of sustainable heat sources;
- The degree of energy saving required to save CO2 and to make buildings suitable for a heat alternative.

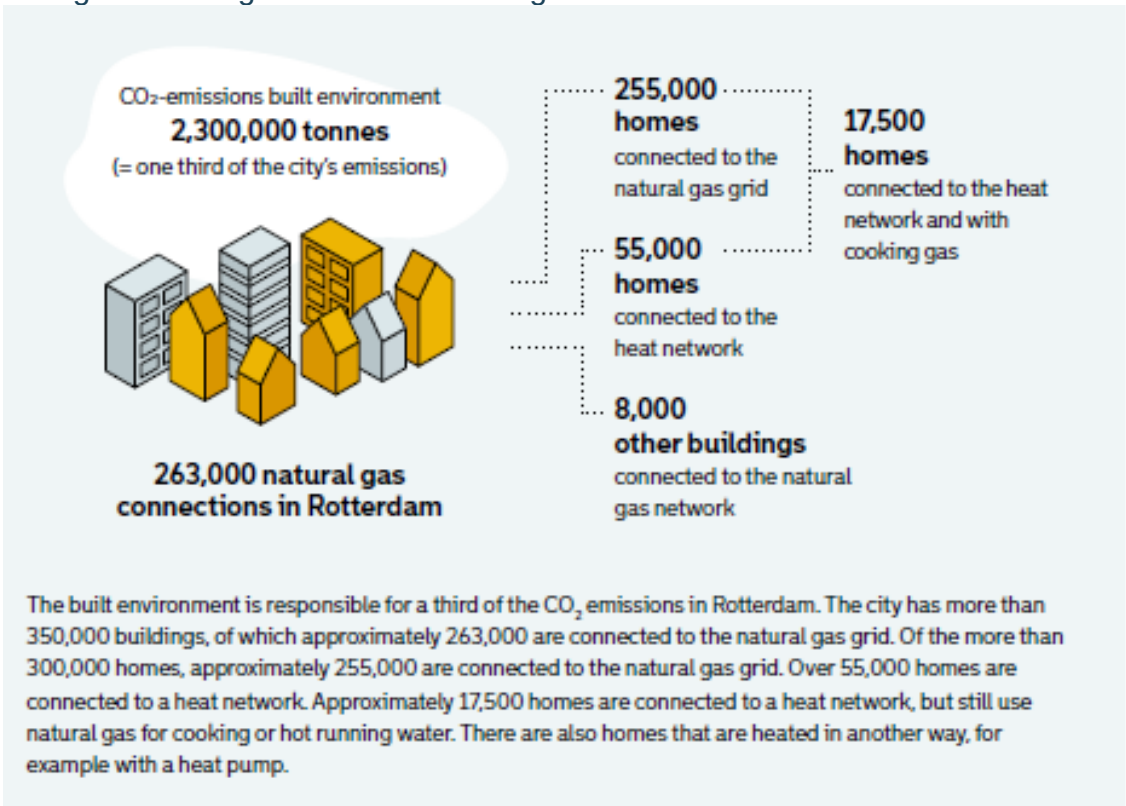
Each alternative to natural gas requires different adjustments and investments. This has consequences for the efforts that users and heat and electricity suppliers must make. We aim to achieve the most suitable and affordable solution for all parties.

Facts & figures: the context

Number of inhabitants : growth from 9% to 651,631 inhabitants in 2021
Data for the years 1995 to 2021 :



The challenge of making Rotterdam natural gas-free in numbers :



Current energy infrastructures for district heating:

Available heat sources

To make buildings natural gas-free we need clean energy, both now and in the future. The most important clean energy sources in the Rotterdam region are industrial residual heat , geothermal energy, aquathermal energy, clean electricity from the sun and wind and sustainable gases (including hydrogen). The availability of these energy sources has been analysed on behalf of the municipality. Naturally, we are taking into account the energy demand from the region, as agreed in the Regional Energy Strategy.

Industrial residual heat

There appears to be sufficient sustainable heat available in the vicinity of Rotterdam. The potential supply of heat in our region is almost twice as large as the expected future demand for heat. There is a above all a lot of residual heat: in the harbour alone, there is currently much more residual heat available than we use. Residual heat – increasingly from sustainable sources – will therefore form an important part of Rotterdam's sustainable heat mix.

Geothermal energy

Geothermal heat is also abundantly available in the Rotterdam region. This is important because for a robust and reliable heat system it is important to use multiple sources for supply of heat networks.

Clean electricity from the sun and wind

Rotterdam has sufficient sustainable heat sources, but at the same time, there is a shortage of clean electricity in our region. Moreover, we expect the demand for electricity in the city and port to grow strongly due to, among other things, electric driving and the production of green hydrogen for industry. So we will also need clean electricity from outside the

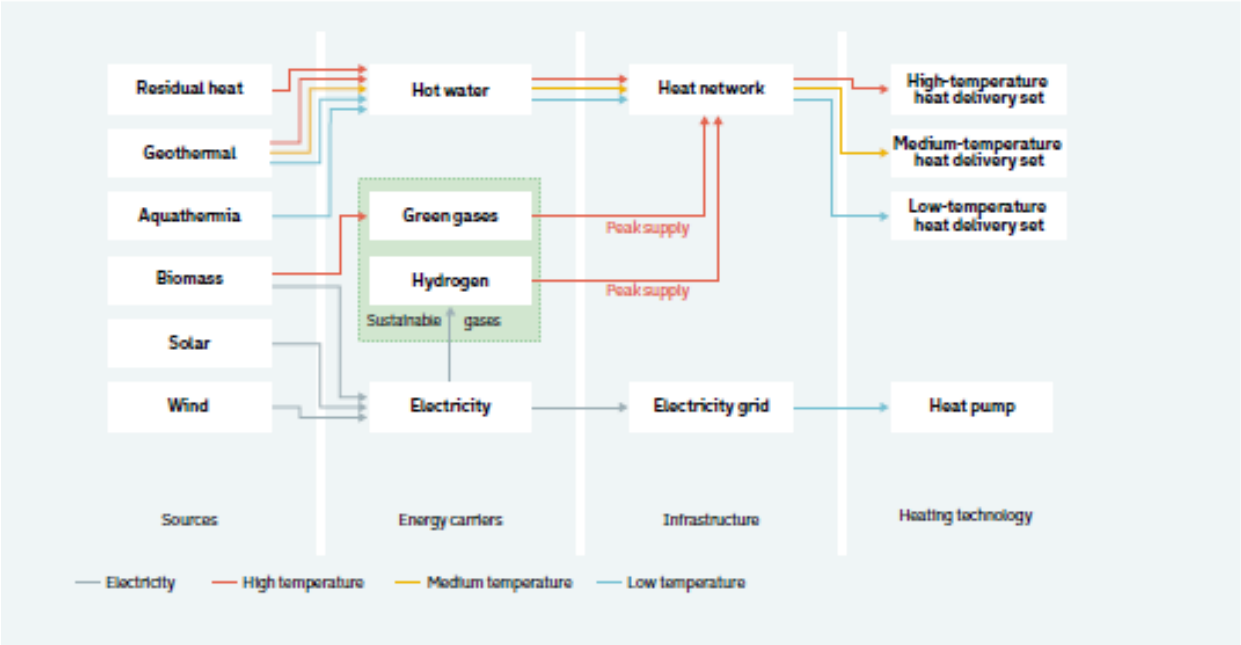
municipality, for example from offshore wind farms. To prevent a further increase in electricity demand, we are not encouraging electric heating with heat pumps. It is more efficient to use heat networks, because then we can use the available residual heat from the port. We want to make optimal use of this. Where a heat network is the most affordable and efficient solution, we will try to avoid electric heating solutions.

Sustainable gases

Sustainable gases, such as hydrogen and biogas, can also serve as fuel for heat. But their availability is limited in the short term and they are also very expensive. We prefer, therefore, not to use them for heating, but rather as a raw material for industry, as a fuel for industrial heat, for heavy and long-distance transport, energy storage and grid stability. These activities are more difficult to solve with other renewable energy sources. Indirectly, however, the combustion of sustainable gases in industry does produce residual heat for a heat network.

So, we do not expect sustainable gases, such as hydrogen, to become a viable alternative to natural gas for heating homes. The following applies to all sustainable energy sources: we will use high-quality sources as much as possible for a high-quality demand and we will be very economical with scarce sources. Biomass will therefore mainly be used for food and animal feed, construction materials and chemicals rather than as fuel. Our choices are explained in the municipal visions on hydrogen and sustainable biomass.

Available alternative heat sources to natural gas :



Process

The scope of our H/C plan is buildings with a natural gas connection (industry cluster harbour not included). The goal of the analysis is to identify promising districts for new district oriented approaches and to identify the preferred (most affordable) alternative heating solution per neighbourhood. For our analysis we involved housing corporations, grid operator, concession holders (heating companies), technical department City of Rotterdam, bordering municipalities (if relevant)

The steps we took are:

- Selection of exploration districts (2019): In 2018, we started a district orriented approach to natural gas-free heating in five districts.
- Exploratory study in 14 districts (2020)
    - District analysis: local characteristics and relevant tasks;
    - Technical analysis: insights into the heat system;
    - Business cases: insights into costs and benefits:
    - Planning: coordinating the work in buildings, in the topsoil and in the subsoil.
- Selection of promising districts (WHEN map) (2021)
- Improvement of the WHAT map (2021)
- In progress: improvement oft he WHAT map (2022) where we further analyse the heating and cooling demand, insulation, heating an cooling solutions, temperature, transport pipes, heating and cooling sources and storage.

Framework, principles, data & analysis

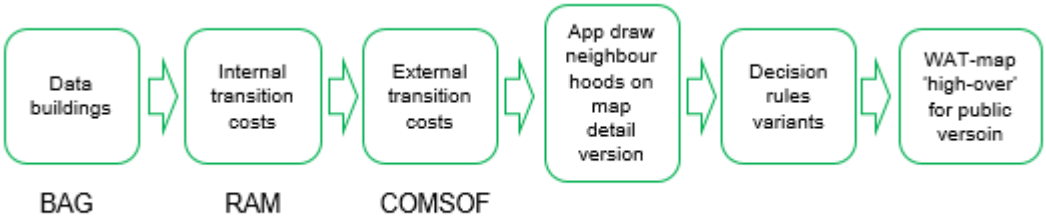
The Rotterdam WAT map 2021 is part of the Rotterdam Transition Vision Heat 2021.

This map shows per neighbourhood:

- the most affordable alternative to natural gas at the lowest total costs (also known as social costs).
- How much cheaper this preferred alternative is compared to the second cheapest alternative.

We took an agile approach :

- Agile: goals not laid down in detail in advance, iterative, adjust gradually, biweekly meetings. Roughly chronologically:



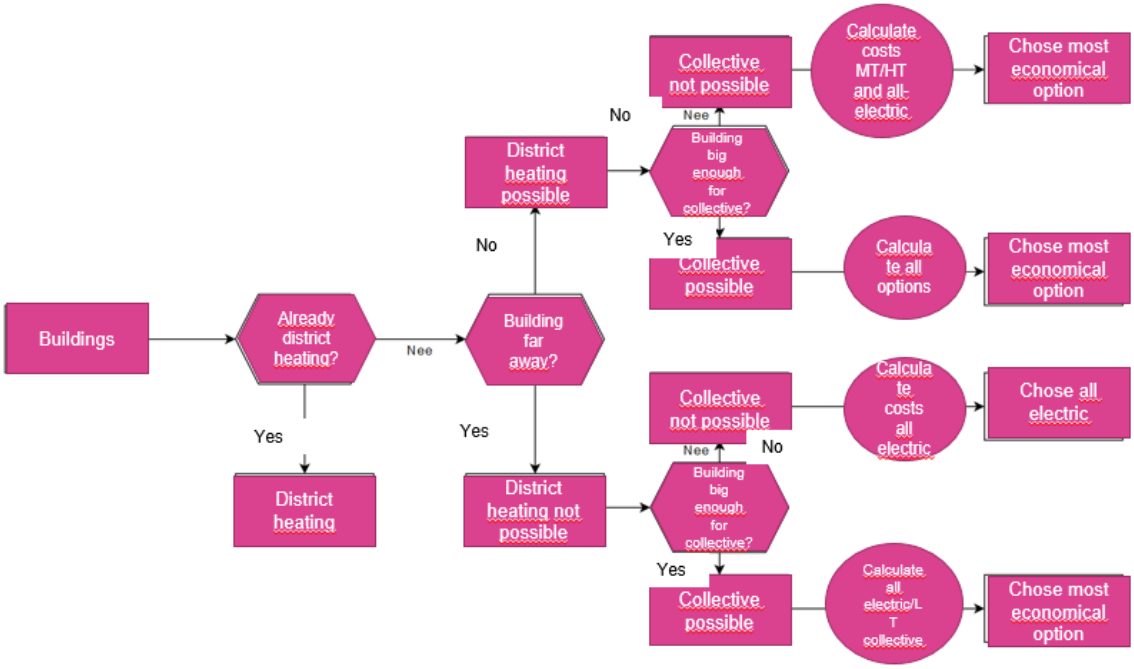
Data we used:

- **Buildings:** basic administration data, m2, energylabel, surface windows/doors/roof/facade, isolationlevel
- **Network connection**: gasgrid, heat network or both
- **Heat demand:** current use on street level
- **Costs district heating:** COMSOF-analysis results
- **Results:** per building the optimal internal and external transition costs

Rotterdam Natural Gas Free Model (RAM) calculates per home the optimal internal (within the building) and external (energy system) transition costs

ComSOF external transition costs district heating network: connection costs per home/cluster + costs per meter of pipe

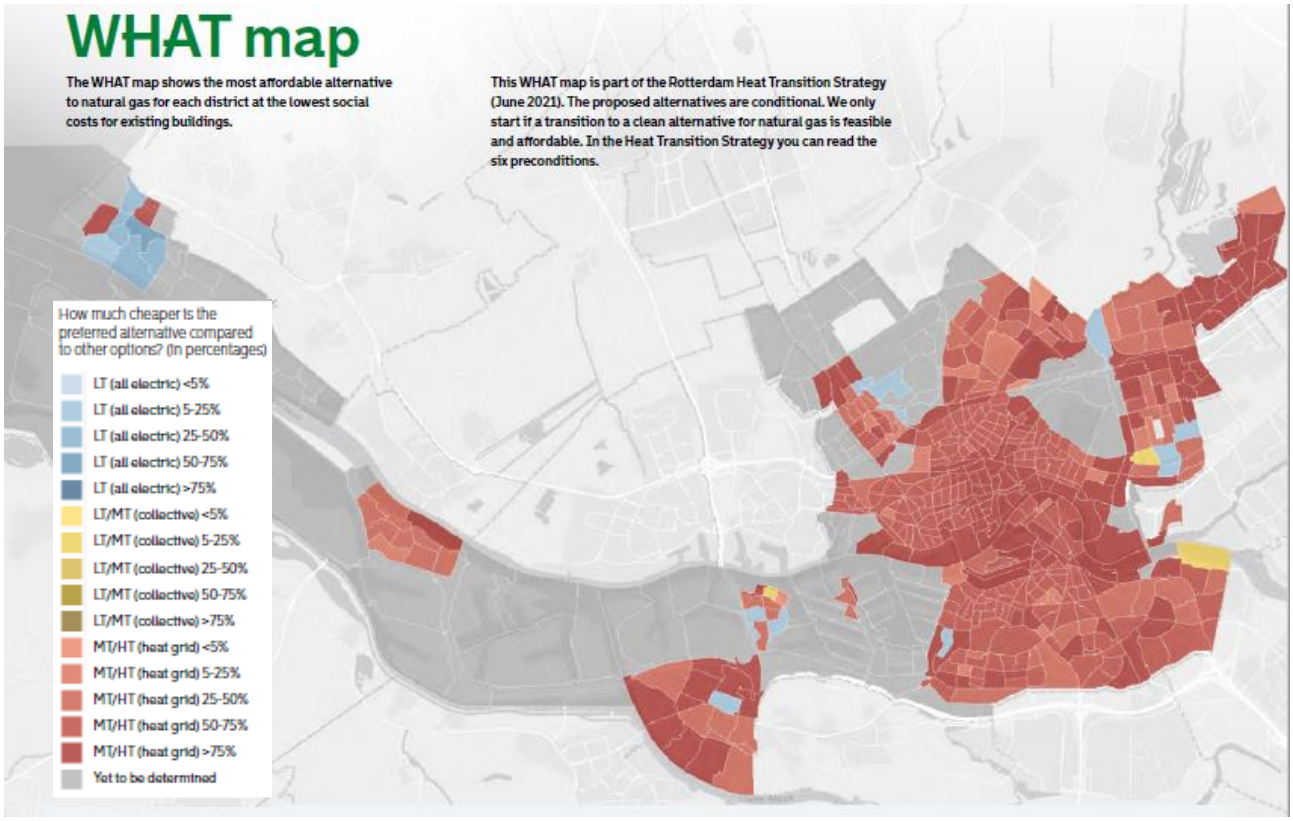
The decision rules (see picture below) we used :



The calculation made uses a big set of assumptions and principles, examples of these assumptions and principles used for the WHAT map calculations are:

- District average
- 30 year average
- Average energy consumption per type of building
- Heat supply is assumed not to have a limit, there is enough waste heat from the port of Rotterdam and high potential for geothermal heat.
- Avoid electrification (based on clean energy strategy – Regional Energy Strategy Rotterdam The Hague)
- For DH cost efficient insulation is assumed for each household, average costs at buildingslevel for this kind or insulation are used.
- Cost of DH bases on average cost per meter DH
- For LT / electrical solutions individual Heatpumps are assumed and the current electrical grid does not need reinforcemend (assumption) .

H/C planning



The WHAT map shows the most affordable alternative to natural gas for each district at the lowest social costs for existing buildings. The proposed alternatives are conditional, it gives direction to the most likely options, but is not yet a decision. The transition is only started if the clean alternative is feasible and affordable. The six precondition, as mentioned in the Heat Transition Strategy, are:

1. Compensation for implementation costs and sufficient implementation capacity of the municipality;
2. Sufficient investment and implementation funds as well as sufficient implementation capacity of housing corporations;
3. Solutions for the unprofitable portion and pre-financing of the construction of collective heat solutions;
4. Additional financing and subsidies for private individuals, tenants and home owners associations;
5. Sufficient powers for municipalities in terms of legislation and regulations; and
6. (Im)possibilities in spatial planning.

A heat network is the cheapest option

As the WHAT map indicates, in large parts of the city collective heating solutions are an attractive alternative to natural gas in terms of affordability for residents, landlords and businesses. A medium or high temperature heat network is the cheapest alternative for the majority of Rotterdam's districts. The initial analysis by the Netherlands Environmental Assessment Agency and the Openingsbod (opening offer) from grid operator Stedin confirm this.

This in itself is not surprising. In an urban environment, collective systems are often the socially cheapest alternative to natural gas. About one-fifth of the buildings in Rotterdam are already connected to district heating; we have been using heat networks since the 1950s. Further economies of scale mean that costs are lower and also more fairly distributed. Heat would then be distributed to homes via a heat network. The advantage of a heat network is also that it is suitable for using other sources of heat in the future, making it a no-regret investment.

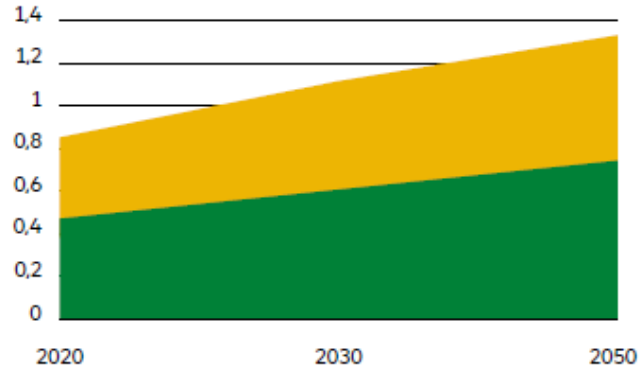
Another sustainable alternative to natural gas is electric heating (all-electric). This is an individual solution per house, which is relatively expensive. Most existing houses in Rotterdam must be heavily insulated for this type of heating, making this solution, on balance, often more expensive.

Cooling

Due to the heating transition, the demand for collective heating is rising sharply. This is therefore a matter of considerable technical, organisational and legal attention. Less attention is paid to the expected increase in demand for cooling, although this will also require changes to our energy system. It is difficult to estimate the extent of the demand for cooling. The expected increase is partly due to climate change; the average temperature in 2050 is expected to rise from around 1.4°C to 3.3°C compared to now, and the number of summer days when it is warmer than 25°C will increase from 21 to possibly 35 days in 2050. In addition, new-build homes, but also existing homes, are increasingly well insulated, which increases the demand for cooling. The necessary cooling demand for existing and calculated new-builds in 2050 is 47 per cent higher for residential buildings and 5 per cent higher for non-residential buildings than in 2020. In addition to the necessary cooling, the demand for comfort cooling is increasing. What is a comfortable temperature differs from resident to resident. Age and health, but also the personal comfort of the resident plays a role in this. As we tackle the issue of cooling and as more cooling becomes available, the demand for comfort cooling will increase. This makes it difficult to identify the level of comfort demand. There are various technical solutions for meeting the increased demand for cooling. As with heating, the first step is to reduce the demand for cooling. These include sun blinds, green-blue roofs or greening the city.

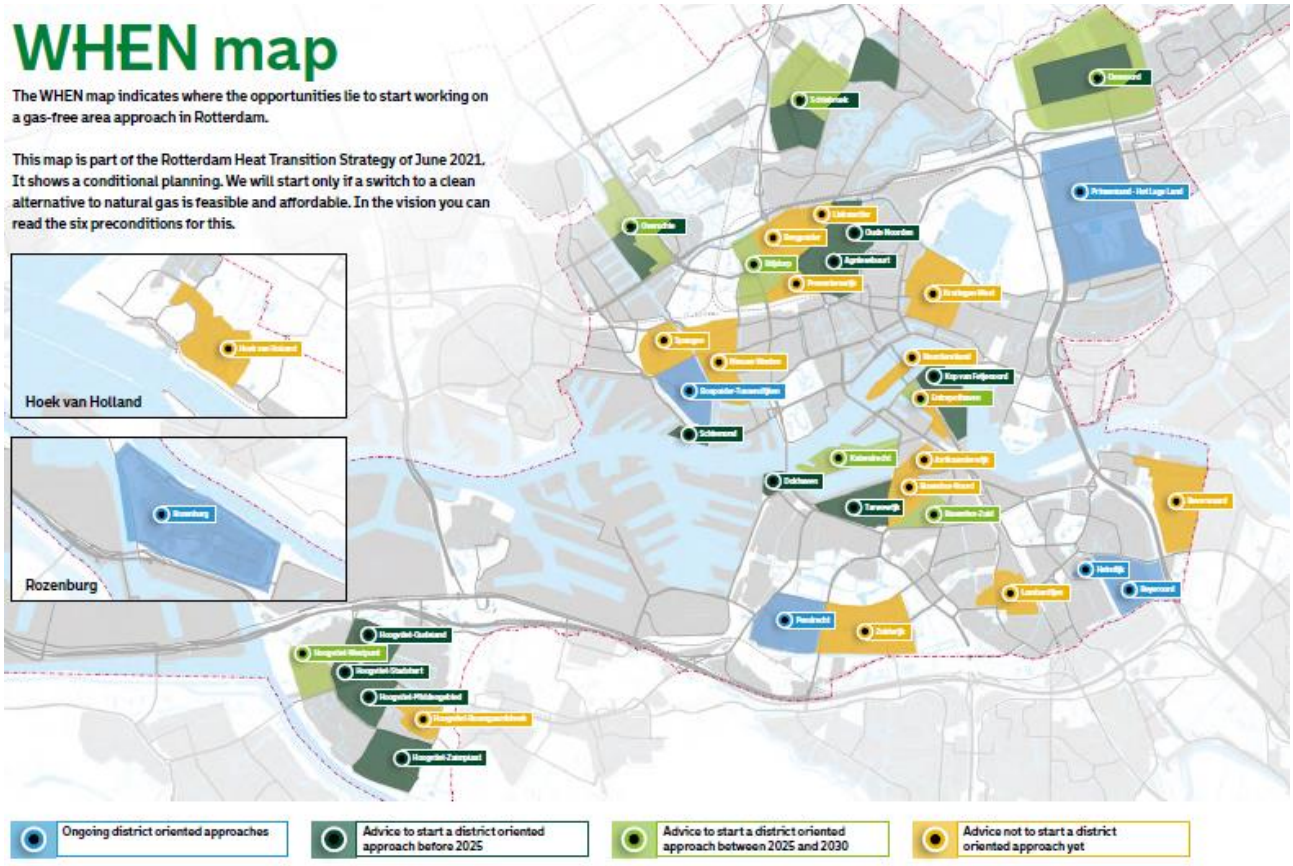
Sustainable cooling can be generated by means of a heat pump, cooling from the ground or surface water stored in a GCHE or distributed via a collective cooling network.
The last two technical solutions are already being applied in Rotterdam. We want to minimise the use of air conditioning because of the negative impact it has on the environment, which it heats up, the noise it produces and the increasing demand for electricity.

Cooling demand (in PJ / yr) for utilities (yellow) and housing (green):



Promising areas for an integrated gas-free approach

In 2018, we started a district oriented approach to natural gas-free heating in five districts. Based on our experiences in these, we drew up the first version of the WHEN map in early 2020. On this map, we have designated fourteen districts where we believe a subsequent district oriented approach to natural gas-free energy is possible. We call these district the exploration districts.



Next step: Rotterdam Heating Cooling Strategy

Scope: Working towards a collaboration between stakeholders with which we develop an adaptive strategy about the heating and cooling system. This strategy concerns efficient solutions for cross-district aspects of the heating and cooling system; sources, transport pipelines, storage, conversion, temperature and offtake.

Goal: An adaptive strategy on the heating and cooling system that is shared and supported by all stakeholders.

Who involved: Stakeholders (heat companies, Warmtebedrijf Rotterdam (=HeatCompanyRotterdam), The Regional Energy Strategy Rotterdam The Hague (RES), (potential) heat producers, housing associations, representatives of (potential) heat consumers and network company) and the Municipality of Rotterdam.

Steps: In the project Rotterdam Heating and Cooling Strategy we analyze what system is needed to make the WHAT map possible. Our adaptive strategy is about how we work together with stakeholders towards this system. (In addition, this analyses can change over the years due to developments or new insights)

DECARB CITY PIPES 2050

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 893509