Phasing Out Gas

Heating and Cooling Vienna 2040

City of Vienna

wien.gv.at/rausausgas

Contents

Consistent action for a climate-neutral Vienna!

Global warming, climate change and climate protection are buzzwords we encounter more and more frequently in everyday life. That is a good thing, too, because the fight against climate change constitutes a major challenge. However, actions speak louder than words!

For a long time already, the City of Vienna has been pursuing a consistent course that attaches utmost importance to all issues related to the climate and the environment. The first Climate Protection Programme (KLiP) of the City of Vienna was established in 1999; its manifold measures have led to a reduction in greenhouse gas emissions of 1.4 million tonnes annually over the past decades between 2009 and 2021. Since then, numerous programmes and projects to render Vienna even more climate-friendly have been added. In its Government Agreement, Vienna's "coalition of progress" has specifically committed itself to further advancing climate protection and, in particular, to setting concrete examples – hence acting as a model for all people of Vienna in order to win them over to embrace this cause.

The Vienna Climate Guide as a "road sign" pointing towards climate neutrality by 2040 was the first major strategic strategy resulting from this commitment. The Climate Guide aims to counteract the effects of climate change by means of concrete instruments and measures as well as to prepare for changed conditions where necessary. The Climate Guide comprises over 100 measures targeted at ensuring that Vienna will remain the world's most liveable city for many decades to come – for all of its inhabitants.

Thus, global warming, climate change and climate protection are not mere buzzwords for the City of Vienna but rather important mandates to act. This is also proven by the new catalogue of measures "Phasing Out Gas – Heating and Cooling Vienna 2040". This strategy sets the course for the energy transition in the field of space heating in Vienna – an endeavour so massive that calling it a "mammoth task" actually constitutes an understatement. Vienna's flats contain around 600,000 individual gas-fired heating systems, all of which will be gradually replaced by climate-friendly alternatives. This will not only have positive effects on the environment and climate but will also help us eliminate our dependence on external energy suppliers.

It will take some time until the 600,000th gas-fired heating system will have been replaced. However, the City of Vienna has already started this process. For this, I want to express my thanks to all municipal employees who have participated in developing the "Phasing Out Gas – Heating and Cooling Vienna 2040" strategy as well as those who will implement it. If future generations will be able to enjoy Vienna's high quality of life, we will know that our work has borne fruit.

Michael Ludwig
Mayor of Vienna

A socially equitable heat transition!

Our vision is clear: As of 2040, all buildings in Vienna will be heated and – where necessary – cooled using climate-neutral, emission-free and renewable technologies.

Fossil fuels for space heating will be history from 2040 onwards! Already today, Vienna has an edge in the energy transition process: Compared to Austria's other eight federal provinces, our city scores with the lowest final energy consumption per capita in the field of space and water heating.

However, almost 90 percent of CO_2 emissions in the building sector are currently caused by gas heating. Hence, "Phasing Out Gas" is like the moon landing – a complex challenge: Solutions must be found for 600,000 gas-fired units, approximately 474,000 of which are decentralised systems and for 260,000 gas stoves.

A comprehensive strategy based on the Vienna Climate Guide was developed in order to attain this goal: "Phasing Out Gas – Heating and Cooling Vienna 2040" defines the steps to achieve the phasing-out of fossil fuels for space heating.

This document provides a good overview both of the necessary technical prerequisites that are already available and of those that still need to be created as well as the necessary adjustments to the legal framework.

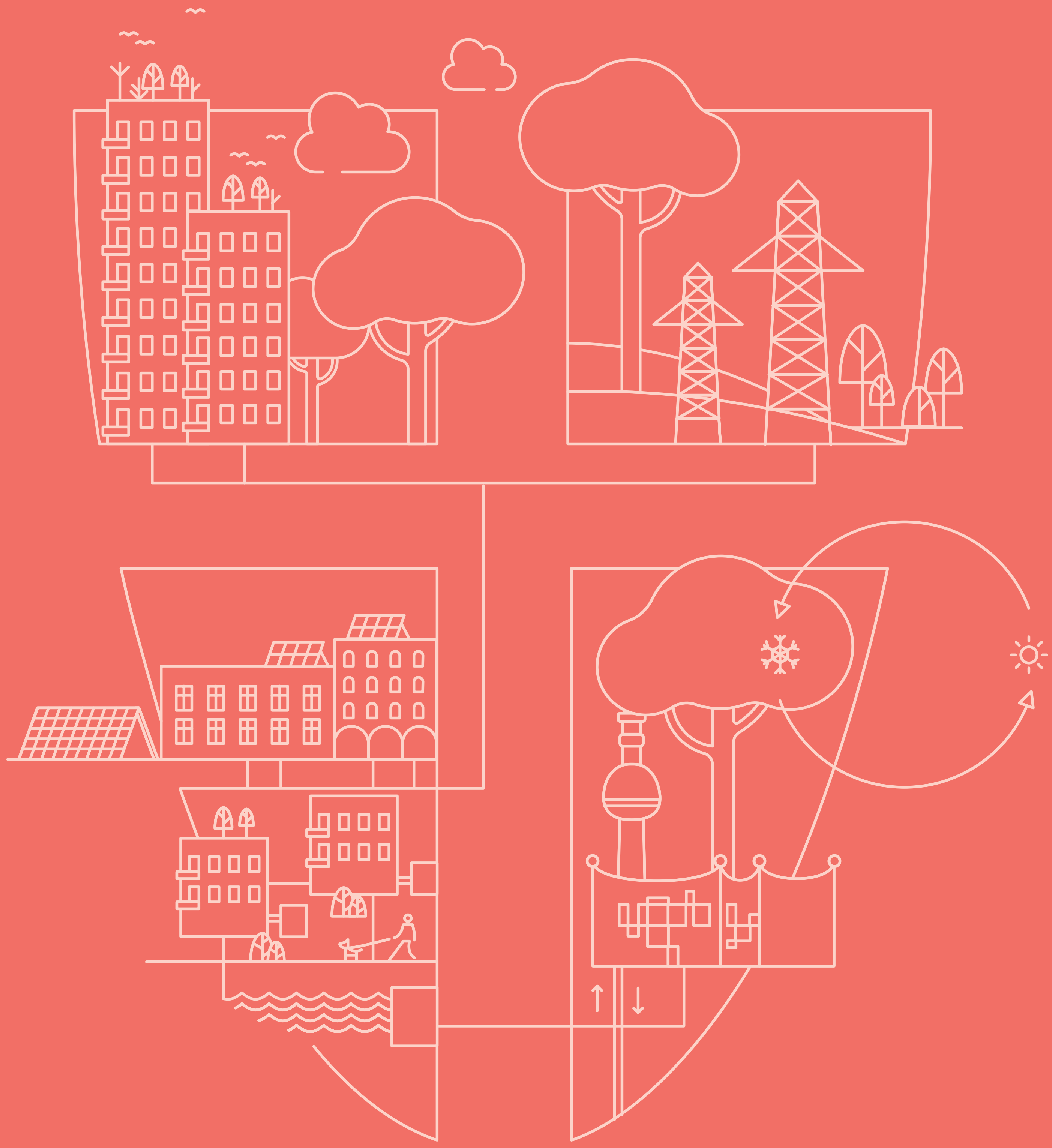
Numerous, partly already implemented innovative projects demonstrate the feasibility of this goal and foster confidence. In the coming years, we want to show how the journey towards climate-neutral heating will actually function by drawing on the example of 100 specific buildings. In any case, what is called for until 2040 is courageous action at all levels! Both at the federal and the provincial levels, clearcut legal provisions must be formulated, and durably earmarked subsidy schemes must be created. The switch to renewable energy sources can only come about as a socially equitable process – the people of Vienna must know precisely what to expect. This can only be achieved through foresighted planning, reliable support and effective communication!

The "Phasing Out Gas" programme was launched at the Executive Group for Construction and Technology of the City of Vienna and will be translated into action in the coming years with strong commitment and in co-operation with all relevant departments and enterprises of the City of Vienna – but above all together with Vienna's citizens and the business community. This "Viennese moon landing" can only succeed through the combined efforts of all parties concerned!

Jürgen Czernohorszky
Executive City Councillor for Climate, Environment, Democracy and Personnel

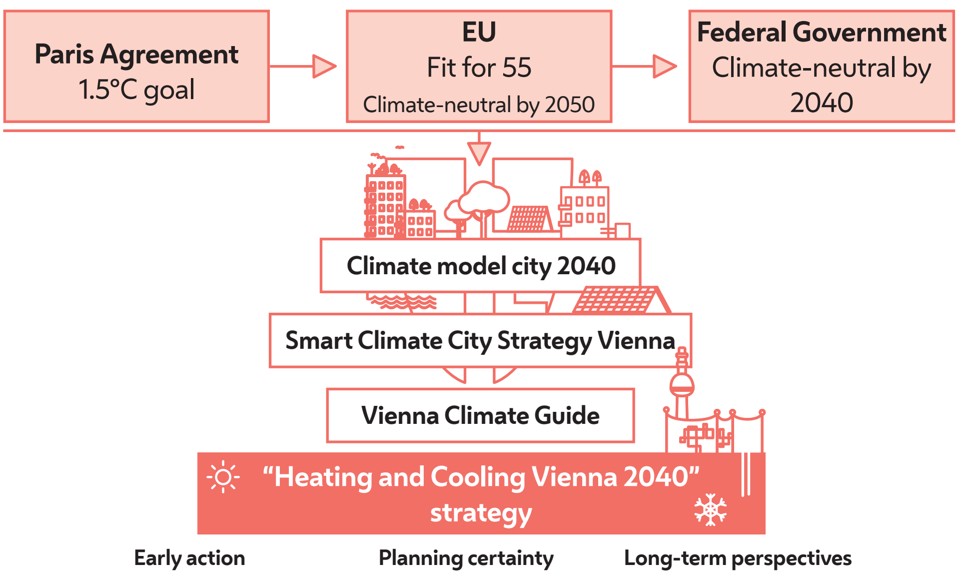
1

Goals to warm and cool your heart



After replacing wood-fired heating systems a century ago, first by coal- and later by oil- and gas-fired systems, we are now entering the **era of renewable energy**. Once more, the energy system is undergoing a transformation. This has consequences for all of us – for the city itself, for the Vienna Public Utilities and other enterprises active in the field of energy supply, for the construction and real-estate sectors, for project developers, for all industries engaged in refurbishment projects, and for end customers, flat owners and tenants.

By switching from wood and coal to city gas in the last century, Vienna has already shown that transitions in the municipal energy system are, in fact, doable and that we are able to adapt successfully to new conditions. While framework conditions have obviously changed, the challenge remains the same: An energy system characterised by dependencies must be replaced by another because of visibly emerging problems. In the past, a major reason for the switch to a different source of energy was massive air pollution; today, the reasons are greenhouse gas emissions and dependence on fossil fuel imports. Climate change and its effects show more and more clearly that we need to transition to renewable energy sources. Imports from crisis regions endanger security of supply and price stability. For the future, we need a system based on renewable, possibly regional energy free of greenhouse gas emissions.



This calls for long-term perspectives and systematic action. At the European level, the EU heads of state and government have agreed to reduce greenhouse gas emissions in the EU by at least 55 % (compared to levels of 1990) by 2030 and to make **Europe the world's first climate-neutral continent by 2050** ("European Climate Law"). Moreover, the "Fit for 55" climate package was presented in July and December 2021. It supports the attainment of the 2030 climate targets through proposals for adapting over one dozen current climate and energy legislation documents of the EU.

In its 2020 Government Agreement, **Vienna's city government** committed itself to the definite objective of attaining climate neutrality by 2040 and embodied this goal in the **Smart Climate City Strategy Vienna** adopted in 2022 by the City Council. It comprises the overarching goals regarding climate protection and adaptation to climate change to ensure quality of life for all inhabitants of Vienna as well as to permit the attainment of climate neutrality and climate resilience.

The **Vienna Climate Guide** summarises the key levers, measures and instruments required to achieve climate neutrality and climate resilience in Vienna. This document acts as a bridge between theory and practice. The Vienna Climate Guide defines a common vision and sets out the steps required to implement them. It describes which sectors have to be addressed (and how) in order to reduce Vienna's greenhouse gas emissions from currently about 5 million tonnes of $CO_{2\text{-eq}}$ to zero. The key sectors to be tackled in this context are buildings and transportation.

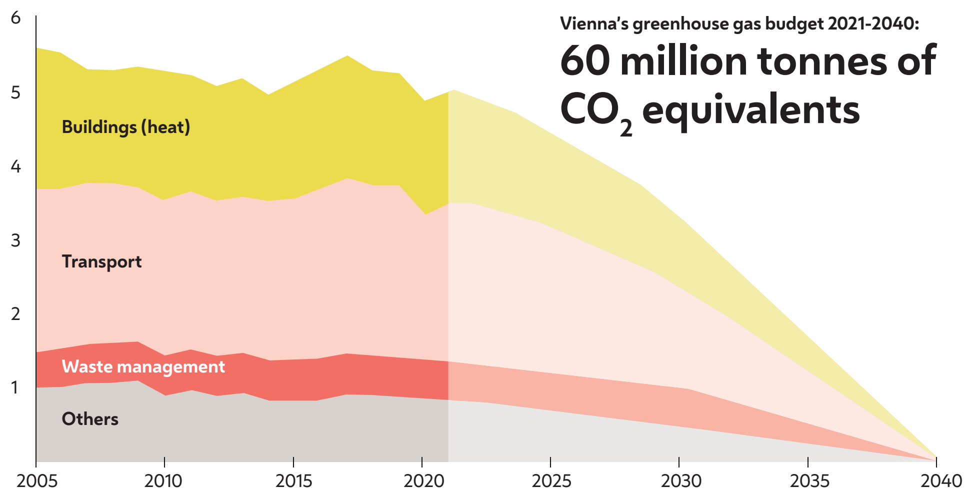


Figure 1
Total greenhouse gas emissions in Vienna by sectors in million tonnes of $CO_{2\text{-EQ}}$/year.[1]

The present strategy **"Phasing Out Gas – Heating and Cooling Vienna 2040" (acronym "WWK40")** looks at the building sector and sketches the road to attaining a climate-neutral city in line with the "quitting oil and natural gas" motto for the building sector. After all, this sector contributes substantially to Vienna's greenhouse gas emissions, which demands a comprehensive transformation of our buildings in order to attain the climate targets.

[1] M. Anderl, M. Gangl, S. Haider, S. Lambert, C. Lampert, K. Pazdernik, S. Poupa, W. Schieder, B. Schodl, M. Titz, M. Wieser, A. Zechmeister. Zechmeister. Bundesländer Luftschadstoff-Inventur 1990-2019. Regionalisierung der nationalen Emissionsdaten auf Grundlage von EU-Berichtspflichten (Datenstand 2021). Vienna: Environment Agency Austria, 2021. REP-0787.

WHAT DOES THE STRATEGY INCLUDE?

- Already available solutions
- Feasible combinations of different solutions
- Areas requiring further development
- Legal framework conditions that need to be created
- Ways to fund or subsidise the transition
- Underlying thematic basis of the "Phasing Out Gas" programme for implementing the "Heating and Cooling Vienna 2040" strategy

WHAT DOES THE STRATEGY NOT INCLUDE?

- **Concrete spatial specifications (of the future energy infrastructure)**
  The specific energy systems best suited for the individual buildings of Vienna will be identified in the coming years by drawing on the instrument of spatial energy planning.
- **Legal texts and funding guidelines**
  Proposals for laws and funding schemes will be developed in due course and applied in targeted fashion. This strategy highlights areas where adaptation is required to attain the goal of climate-neutral energy supply.
- **Implementation plan and time schedule**
  When and how the measures developed in the present strategy will be implemented is part of the "Phasing Out Gas" implementation programme.

2
Where do we stand today?

In recent decades, the legal framework as well as attractive funding models for building rehabilitation programmes (e.g. thewosan – integrated thermal energy renovation of residential buildings, rehabilitation of entire blocks, WieNeu+), the extension of district heating as well as the rapid implementation of the OIB (Austrian Institute of Construction Engineering) Guidelines and the nearly zero-emission standard for newly erected buildings entailed marked reductions of Vienna's greenhouse gas production. **Compared to the other federal provinces, Vienna boasts by far the lowest final energy consumption per capita for space and water heating.** Apart from the moderate floorspace per person (38 m² of useful floorspace per person[2]), this is also due to lower heating energy consumption per square metre – a consequence of Vienna's much more compact architecture as well as of the abovementioned measures. Correspondingly, Vienna is also among the top performers among federal provinces where CO_2 emissions per capita are concerned.

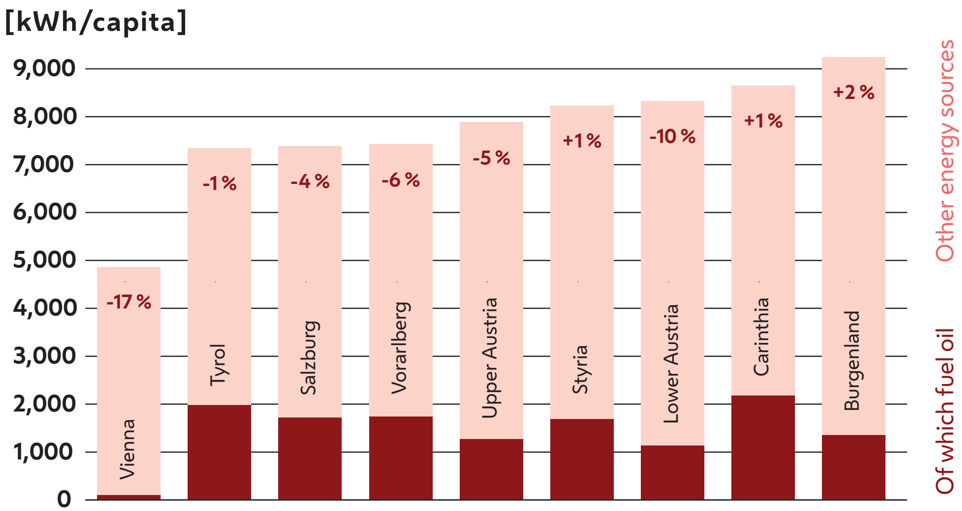


Figure 2
Per-capita final energy consumption of households for space and water heating in 2020 and changes since 2005.[3]

The building sector, i.e. space and water heating and space cooling, accounted for close to 30 % of Vienna's greenhouse gas emissions of relevance for the headline goals[4] in the period from 2014 to 2018. Fuel oil- and coal-fired heating systems play a minimal role in this. **Almost 90 % of the CO_2 emissions of buildings are currently caused by gas-fired heating systems.** Decentralised gas-fired boilers in flats or at workplaces amount to close of half a million, clearly outnumbering centralised gas-fired systems supplying one or several buildings.

To attain climate neutrality by 2040, reducing energy demand is crucial. In this respect, much has been achieved in Vienna over the past decades. CO_2 emissions of the building sector have decreased by 37 % since 1990 and by 20 % since 2005 – a bigger reduction than that attained in other sectors. In terms of per-capita emissions, reductions even tally at 51 % and 32 %, respectively.

[2] As of 2011: https://www.wien.gv.at/statistik/lebensraum/gebaeude/#:~:text=Die%20durchschnittliche%20Wohnnutzfl%C3%A4che%20pro%20Wohnung,Wien%20liegt%20bei%2038%20Quadratmetern

[3] UIV – Klimaschutz und Energiewende: Ein Bundesländervergleich. January 2022.

[4] Traditionally, the "headline goals" of the Smart City Strategy Vienna take account of all greenhouse gas emissions in Vienna with the exception of those of plants currently covered by EU emissions trading. Thus, emissions arising in connection with electricity consumption or district heating in buildings are not shown for the building sector but for the energy sector; however, the plants coming under the latter sector are almost exclusively within the remit of EU emissions trading.

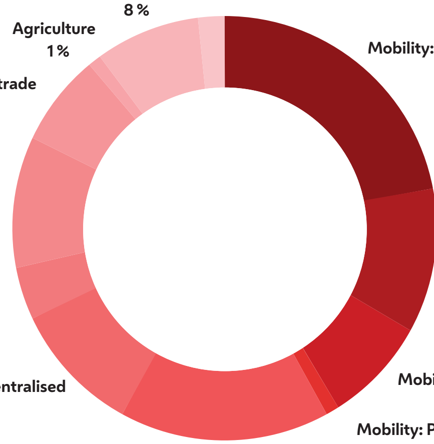


Figure 3
Vienna's greenhouse gas emissions of relevance for the headline goals; values for 2019.[5]

NO FOSSIL ENERGY SUPPLY FOR NEW BUILDINGS ERECTED IN VIENNA

The instrument of spatial energy planning was created already in 2018 to ensure that the absolute minimum of gas will be used in newly constructed buildings. By means of ordinances, these plans define "climate protection areas", where space and water heating systems of newly constructed buildings must be operated on the basis of renewable energy sources or district heating. In a growing city, the new-build sector can contribute significantly towards effective climate protection, since buildings constructed today will be there for many decades to come.

WHAT ARE CLIMATE PROTECTION AREAS?

- They are based on Article 2b of the Building Code for Vienna ("Spatial Energy Plans") and defined by ordinance.
- They impact the choice of space and water heating systems of new buildings but do not affect existing structures.
- Space and water heating of new buildings in climate protection areas must be provided by means of renewable energy sources or district heating.
- Fossil fuels are banned.
- This concerns all new buildings, e.g. subsidised and privately financed housing, offices, shops, public buildings, schools.

[5] M. Anderl, M. Gangl, S. Haider, S. Lambert, C. Lampert, K. Pazdernik, S. Poupa, W. Schieder, B. Schodl, M. Titz, M. Wieser, A. Zechmeister. Bundesländer Luftschadstoff-Inventur 1990-2019. Regionalisierung der nationalen Emissionsdaten auf Grundlage von EU-Berichtspflichten (Datenstand 2021). Vienna: Environment Agency Austria, 2021. REP-0787.

Resolutions concerning the first climate protection areas were taken by the Vienna City Council in June 2020. So far, such areas were defined and approved for 19 of Vienna's 23 municipal districts and will be available for all districts by the end of 2023. In recent years, many newly constructed buildings have demonstrated that fossil fuels are no longer necessary for space and water heating; rather, renewable energy solutions have become state of the art. At the federal level, a ban on the use of fossil fuel-based energy systems in newly constructed buildings is currently being developed under the Renewable Heat Act (acronym "EWG").

EXISTING BUILDINGS AS A CHALLENGE – VIENNA IS DIFFERENT

However, new structures make up only a very small part of Vienna's building stock. The overwhelming majority of buildings are older structures supplied with natural gas, which will have to be adapted to the new framework conditions over the next 17 years until 2040. The fossil energy systems of these buildings will have to be replaced; the structures may also require thermal refurbishment. Moreover, Vienna's condensed building stock creates challenging conditions for the use of renewables-based heat, such as heat pumps, but also biomass.

Vienna is a city with a great number of decentralised gas-fired heating systems. Of currently approximately 600,000 gas boilers in Vienna, around 474,000 are decentralised units. The conversion of these decentralised gas-fired heating systems will nearly always require the centralisation of heat distribution in the building, since this is the best and most cost-effective way to attain decarbonisation. Around 79,000 of these 474,000 units are installed in buildings already provided with district heating. In addition, approximately 260,000 gas stoves in Vienna likewise require conversion to renewables.

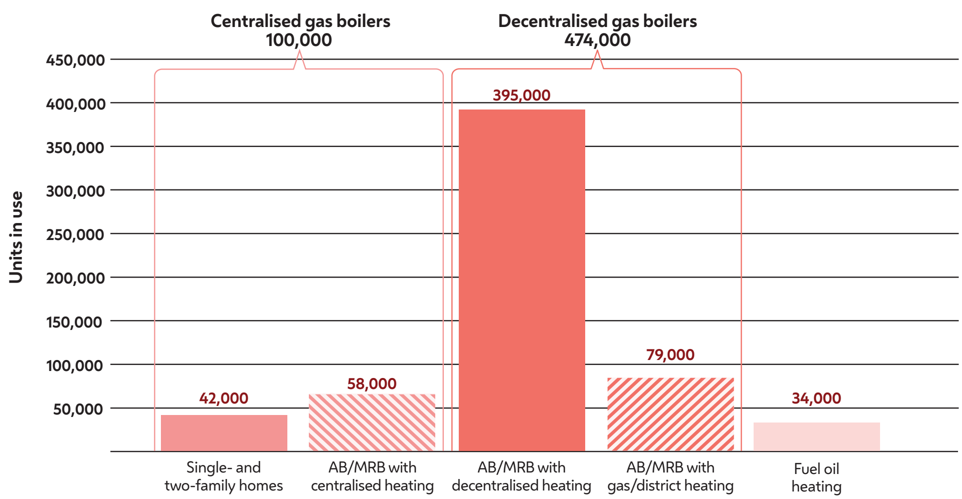


Figure 4
Fossil heating systems in Vienna's current building stock.[6]

[6] Source: City of Vienna, Vienna Public Utilities.

Figure 4 shows that 42,000 centralised gas units are located in single- and two-family homes, while 58,000 are installed in centrally heated apartment buildings and multi-storey residential buildings (AB/MRB). Of the 474,000 decentralised gas boilers, 395,000 are situated in decentrally heated apartment buildings and multi-storey residential buildings. 79,000 decentralised gas units are to be found in buildings supplied with gas and district heating (this means that a district heating system was installed in these buildings at a later date but not all dwellings are connected to it).

DECENTRALISED HEATING SYSTEMS

Gas-fired heating systems for individual flats, gas heaters, gas boilers, gas-fired radiators, single heaters, electric heaters, …

Every unit in use has one or several appliances for space and water heating. These are not connected to other units in use.

HEAT NETWORKS

District heating networks, local heat networks, low-temperature heat networks

In this case, heat is jointly generated by one supplier in central spots for several buildings with different owners. A heat network distributes heat for space and water heating in the supply area. The individual units in use are provided with heat transfer stations.

CENTRALISED HEATING SYSTEMS

Gas- or oil-fired central heating systems, district heating, renewables-based solutions, …

Heat for space and water heating is generated in one place of a building or housing estate for all units in use (flats, commercial premises, …). The heat is distributed via risers installed e.g. in staircases or via chimney flues.

If these dwellings are grouped into forms of housing under law, it becomes clear that the overwhelming majority of the population live in rental or co-operative flats, i.e. are not the owners of their homes. This situation is of relevance for the decarbonisation push, since, according to the current legal status, tenants – while not entitled to determine which energy system is available to them in their flat – must agree to a voluntary switch of the heating system planned by the building owner before this can be implemented in the unit they live in.

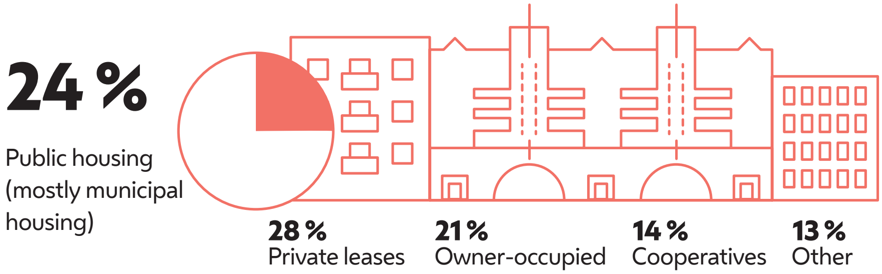


Figure 5
Types of housing.[7]

A STATUS-QUO ANALYSIS: DECARBONISATION TYPES (DCT) OF THE CITY OF VIENNA

Across Vienna, fossil fuel-fired (in particular gas-fired) heating systems are operated in various building types governed by different framework conditions. Within the city limits, all imaginable housing and building types can be found – from allotment gardens or single family homes to housing estates with low-density development or highly condensed inner-city districts, mostly with Gründerzeit-era buildings.

To attain the goal of supplying all buildings in Vienna with renewable heating and cooling by 2040, various technical options and potential solutions must be considered. From a current perspective, the technical solutions that will be used to heat and cool a large part of the buildings are district heating and heat pumps. In the medium term, the electricity required for district heating and heat pumps is to be generated by means of renewables in Austria, mainly with wind power plants and photovoltaic plants. Biomass heating systems will also be drawn upon, albeit to a limited extent.

WHAT ARE DECARBONISATION TYPES (DCT)?

- Clusters of buildings sharing similar traits with regard to decarbonisation
- They interlink the status quo with potential solutions
- The following characteristics are considered:
  - Type of building (single- and two-family homes, apartment buildings and multi-storey residential buildings)
  - Age of building (built pre-2001 or post-2001)
  - Use of building (residential or non-residential)
  - Condition (thermally refurbished, not refurbished, new building constructed post-2001)
  - Heating system (centralised, decentralised)
  - Energy source (gas, oil, gas plus district heating)
  - Gas used for cooking (yes, no)

[7] wien.gv.at/statistik/pdf/wienin-zahlen-2022.pdf

Figure 6
Various parameters for defining decarbonisation types.

To clarify which technology can be drawn upon and to what degree as well as which potentials exist, the city's building stock was classified according to different types called **"decarbonisation types"**.

This classification permits creating clusters of similar building types, thus allowing for the development of conversion possibilities for each type and an assessment of costs. In its turn, this permits the identification of potential solutions for the various decarbonisation types, which then may be varied by typologies and other parameters, such as a cluster's location within the city.

In addition to the housing type, development density, too, significantly impacts the possibilities of choosing an energy source. In particular, densely populated neighbourhoods can be supplied via grids, i.e. central district heating or low-temperature heat networks. For buildings in less densely developed zones, renewables-based solutions may be considered. Figure 7 presents the development density of Vienna's municipal area. The densely populated inner districts shown in dark purple are clearly discernible.

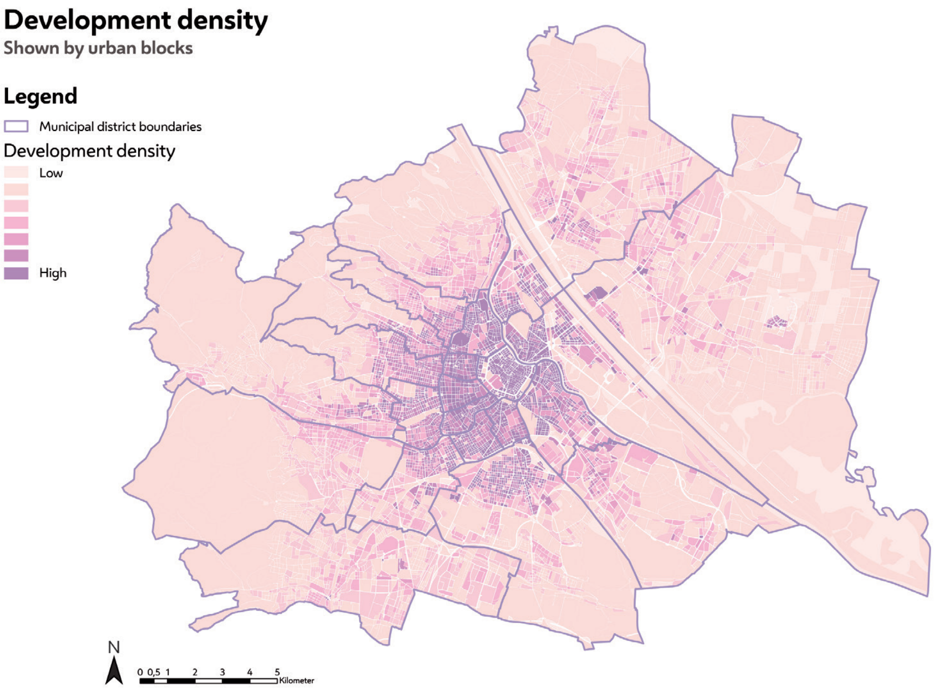


Figure 7
Average development density (as per July 2022).[8]

[8] GEL-SEP, Municipal Department 20.

Figure 8
Top view of some municipal districts – left: districts 1, 6 and 7; right: district 22 (Dittelgasse) – for an overview of actual development densities.
Source: C. Fürthner

The following nine characteristic decarbonisation types are defined on the basis of these parameters:

	Building type	Refurbishment status	Energy source	Centralised/ decentralised	Number of units in use
1	Apartment buildings and multi-storey residential buildings (AB/MRB)	Not refurbished	Gas	Decentralised	306,000
2	Apartment buildings and multi-storey residential buildings (AB/MRB)	Not refurbished	Gas	Centralised	36,000
3	Apartment buildings and multi-storey residential buildings (AB/MRB)	Not refurbished	Oil	Centralised	31,000
4	Apartment buildings and multi-storey residential buildings (AB/MRB)	Thermally refurbished/ new and not refurbished	Gas and district heating	Centralised and decentralised	79,000
5	Apartment buildings and multi-storey residential buildings (AB/MRB)	Thermally refurbished/ new	Gas	Centralised	22,000
6	Apartment buildings and multi-storey residential buildings (AB/MRB)	Thermally refurbished/ new	Gas	Decentralised	89,000
7	Single- and two-family homes (SFH/TFH)	Not refurbished	Gas	Centralised	36,000
8	Single- and two-family homes (SFH/TFH)	Thermally refurbished/ new	Gas	Centralised	6,000
9	Single- and two-family homes (SFH/TFH)	Not refurbished	Oil	Centralised	3,000
Sum total					608,000

Figure 9 shows these nine decarbonisation types in combination with the number of units in use in Vienna. The bigger a field of the chart, the higher the number of units in use that belong to this decarbonisation type.

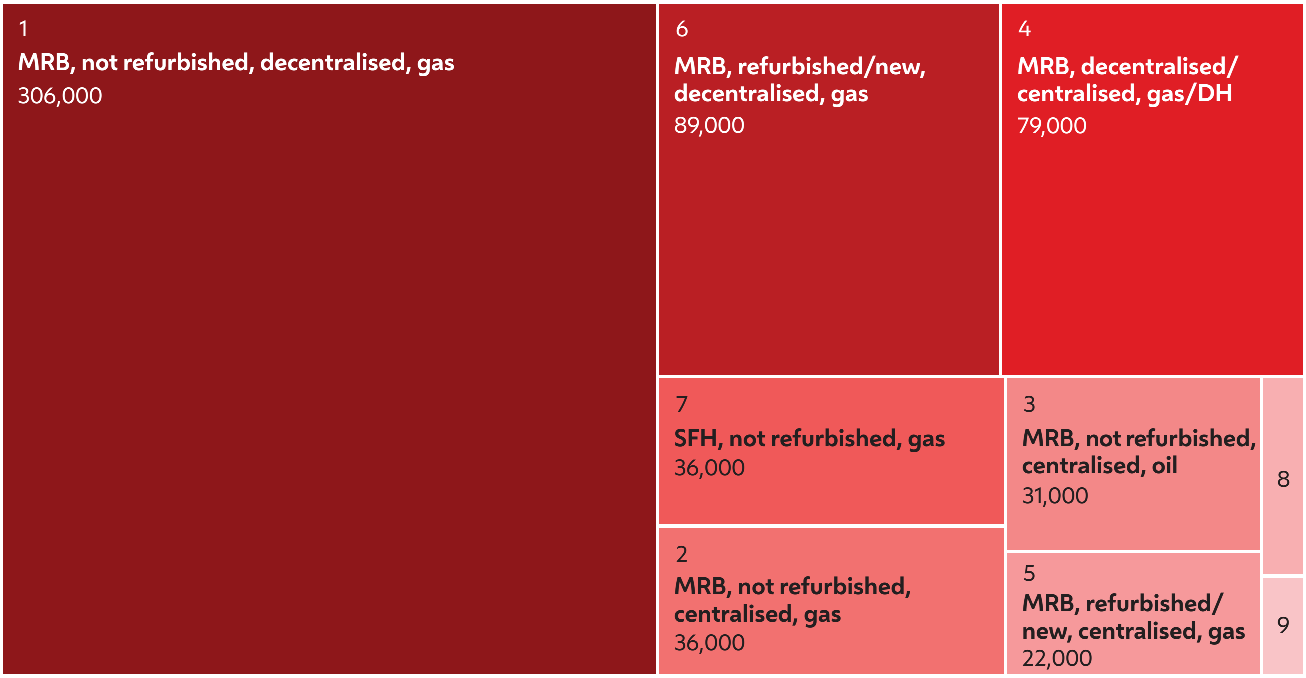


Figure 9
Distribution of decarbonisation types in Vienna by number of units in use.[9]

It is evident at first glance that **decarbonisation type 1** occurs by far most frequently in Vienna. Thus, around 474,000 units in use are located in multi-storey residential buildings that have not yet been refurbished and whose housing units are heated with decentralised gas-fired systems.

Which solution can be considered for which decarbonisation type is dependent on many background conditions. These are broken down in the next chapters on the basis of **"elements"** and then described in greater detail.

SITUATION IN THE SUMMER MONTHS OVER THE PAST DECADES

With the exception of the past few years, cooling was mainly an issue of importance for commercial properties in Vienna, not so much for residential buildings. The good structural condition of the buildings, together with night-time ventilation, was often sufficient to keep indoor temperatures at an acceptable level even during hot spells. As a result of climate change, though, the number of hot days in Vienna has been steadily increasing in recent years (see Figure 10 on climatological threshold days); hence, active cooling is increasingly necessary in residential buildings as well.

[9] City of Vienna, Vienna Public Utilities.

Modern residential buildings, such as the Mühlgrundgasse MGG-22[10] projects, show how innovative energy concepts can provide heating and cooling for housing units. The combination of geothermal energy and thermal component activation[11] enables year-round energy-efficient temperature control, as the heat accumulated during the summer months is stored temporarily underground for the winter period.

In offices, hotels and similar buildings, internal sources of heat as well as comfort requirements are so pronounced that active cooling is often called for. Currently, such buildings may in a few cases be connected to the centralised district cooling system. However, as a rule, these structures are cooled by means of conventional air-conditioning systems or cooling units installed e.g. on the roof. These systems present the drawback that waste heat is not recovered but released into the environment, which heats up the air even more and facilitates the formation of urban heat islands, significantly reducing open-air quality for the population.

It must be expected that the demand for cooling and, consequently, the demand for cooling energy will increase in the future. To make sure that Vienna will remain one of the world's most liveable cities, it is important to focus, not only on the supply of buildings with heating and cooling, but also on measures for climate change adaptation. Therefore, the City of Vienna has developed the **Vienna Heat Action Plan**[12], which contains key measures to combat urban heat phenomena. This plan is updated on an ongoing basis to take account of new developments.

[10] wien.gv.at/stadtentwicklung/energie/beispiele/energieprojekte-energieeffiziente-gebaeude.html

[11] The concrete ceiling is used for releasing heat and cooling the building.

[12] digital.wienbibliothek.at/wbrup/download/pdf/3955617?originalFilename=true

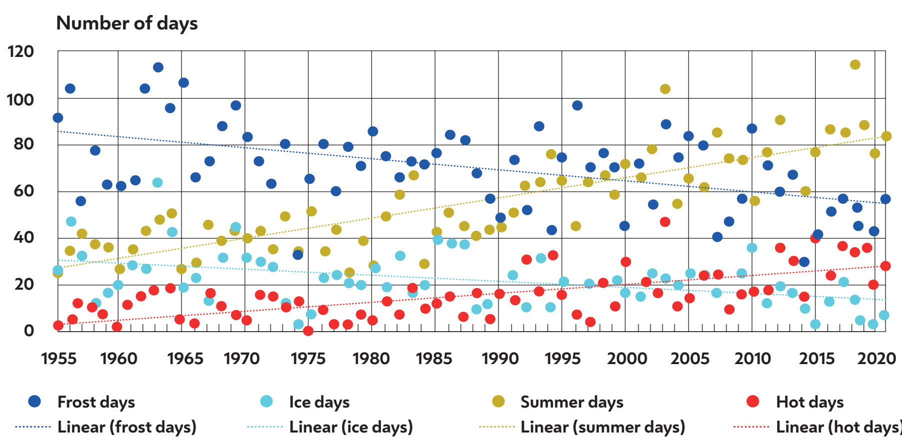
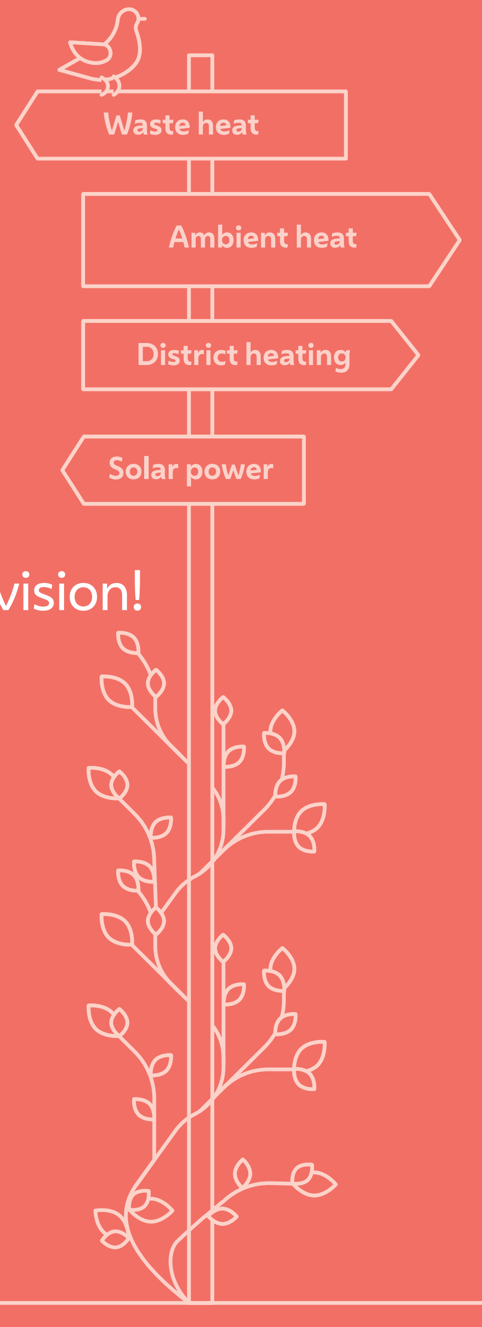


Figure 10
Climatological threshold days.[13]

[13] wien.gv.at/statistik/lebensraum/tabellen/eis-hitze-tage-zr.html

3
How do we go about it?

"Heating and Cooling Vienna 2040" – a vision!



3.1 The “Heating and Cooling Vienna 2040” vision at a glance

- 100 % renewable energy sources for heating and cooling.
  It is our vision for 2040 to heat and, where necessary, to cool all buildings in Vienna using climate-neutral, emission-free and renewable technologies. Fossil fuels are not needed anymore for heating and cooling.

- Densely built-up urban areas in particular are supplied by means of centralised district heating.

- By 2040, centralised district heating has been decarbonised and is powered by renewable energy sources and waste heat.

- Less densely built-up areas are suited for renewables-based low-temperature heat networks and renewables-based building solutions. The focus is on heat pumps; in individual cases, biomass-based systems are used.

- Local renewable potentials are maximised and integrated into the nearest energy systems.

- The relevant investments have greatly benefited Vienna’s economy and triggered an innovation push for Vienna’s enterprises.

- In 2040, Vienna remains one of the most liveable cities and, at the same time, is one of the first climate-neutral cities in the world.

- Many buildings have been adapted to climate change.

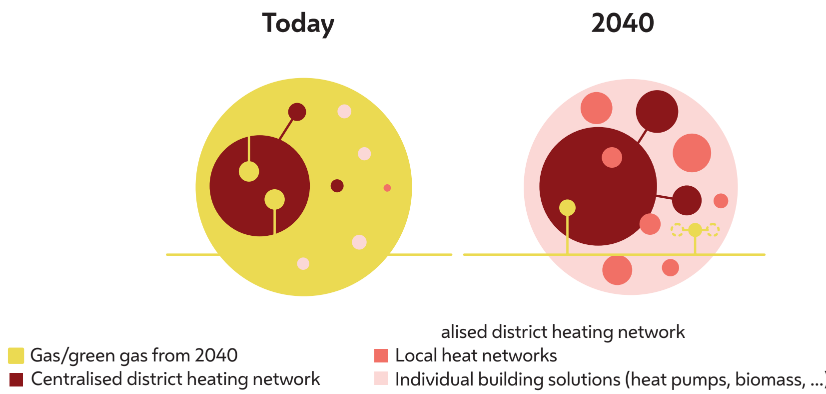
- The costs of transformation were equitably distributed across the various social groups; in 2040, all inhabitants of Vienna benefit from lower and more stable energy costs on a permanent basis.

- A sufficient number of skilled personnel were trained to handle the transformation process. In the long term, many people were (re-) integrated into the labour market.

- Green gas is used by industry and power plants.

Our **future vision** is shown in the right-hand part of Figure 11: The centralised district heating network mainly supplies the densely built-up urban areas and is rendered more close-knit especially in areas where district heating is already available. Thus, district heating will supply a large part of the building stock in urban areas with high heat demand density. In addition to being extended, district heating will also be decarbonised so that no fossil fuels will be needed

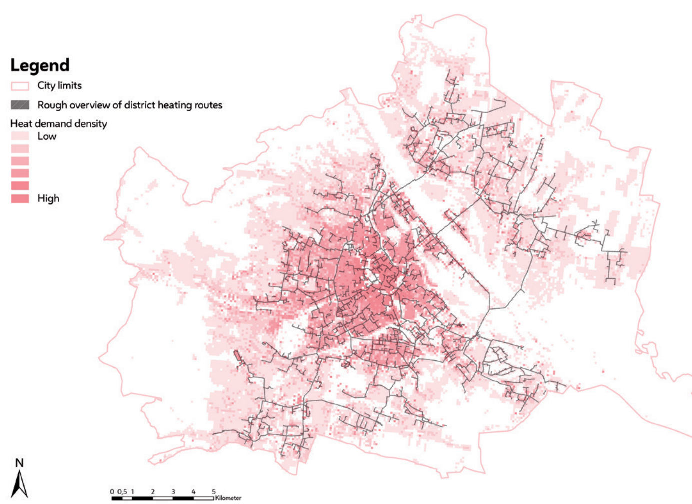
Figure 11
Heating and cooling – today and tomorrow.[14]



anymore for its generation in 2040. Local heat networks will be created for areas and neighbourhoods in those parts of Vienna which are not suitable for the centralised district heating network despite their high thermal density. Renewables-based space heating systems are used for new structures as well as existing buildings in areas with lower heat demand density. There are also a few industrial enterprises and power plants operated with gas; they run on green gas and generate electricity and heat.

This vision is based on the current heat demand density in the individual urban areas and on the network of existing district heating routes. In the past, the district heating network was built to accommodate areas with high heat demand. Figure 12 gives a rough overview of existing district heating routes and (graduated) current heat demand densities: The darker a zone, the higher its heat demand. Thus, these areas are also basically suited for network-based heat supply. In addition to heat demand density, however, other technical, economic and legal restrictions will need to be taken account of in network expansion.

Figure 12
Heat demand density and rough overview of district heating routes.[15]



[14] Heating/Cooling Outlooks 2030/2050 (Decarb City Pipes 2050 and Municipal Department 20).

[15] Municipal Department 20, Vienna Public Utilities.

VIENNA'S GOALS TO BECOME A CLIMATE MODEL CITY BY 2040

Based on the Government Agreement of 2020 and the Smart Climate City Strategy Vienna

- *Final energy consumption for space and water heating as well as cooling in buildings will decrease by 20 % per capita by 2030 and by 30 % per capita by 2040.*

- *The associated CO_2 emissions will decrease by 55 % per capita by 2030 and will attain zero in 2040 at the latest. Developers' competitions for subsidised housing projects drive social innovations and generate new solutions for climate protection and climate adaptation.*

- *By 2040, the phase-out of fossil fuel-based energy sources for space and water heating as well as cooling will be completed.*

- *Green gas including hydrogen from renewable energy sources is to be used for cogeneration plants or other energetically efficient purposes instead of space and water heating.*

- *Over the next two years, a strategy for the gradual conversion of fossil fuel-based heating systems in existing buildings to district heating and renewables-based forms of heating by 2040 will be developed.*

- *Fossil fuel-fired heating systems will be completely eliminated by 2040.*

3.2 Renewable energy sources – an overview

The choice of a specific solution as the most suitable for a given location depends on numerous factors. In the future, renewables-based energy solutions will be combined as best possible so that appropriate solutions will be available for all circumstances. To make sure that this goal will not be limited to isolated flagship projects, easily replicable solutions must be implemented while gradually increasing the conversion rate. A great variety of renewable energy sources and waste heat are available for this purpose.

ELECTRICITY FROM RENEWABLE SOURCES FOR THE HEAT TRANSITION

In the future, Vienna will be mainly heated and cooled with decarbonised district heating and heat pumps. Both technologies require electricity to function. Due to the great number of buildings that will be switched from gas-fired supply to heat pump solutions, it is currently expected that the annual electricity consumption for space and water heating will rise from 1.8 TWh at the moment to 2.7 TWh, corresponding to an increase by 50 %[16, 17].

[16] G. Aue, A. Burger. Wärme & Kälte, Mobilität, Strom: Szenarien für die Dekarbonisierung des Wiener Energiesystems bis 2040. Vienna: Compass Lexecon, on behalf of Wien Energie GmbH, 2021.

[17] The study assumes intense renovation activities.

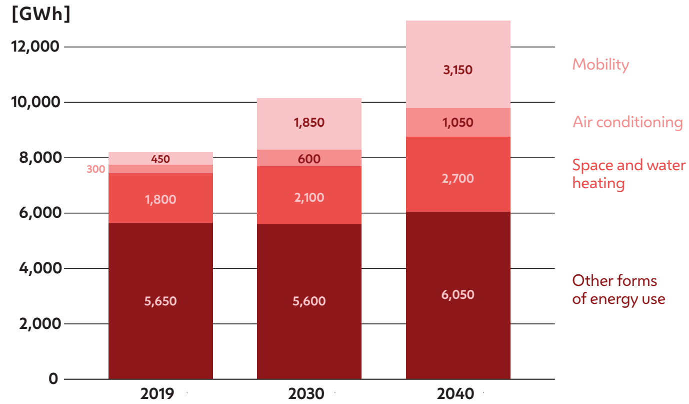


Figure 13
Annual electricity consumption by types of use [GWh]; own chart.[16]

Decarbonised district heating, too, will require more electricity to function, since heat pumps, large-scale heat pumps and deep geothermal energy will account for a major portion of district heating in the future. In this field, an increase by 0.50 TWh to 0.85 TWh is expected, which corresponds to roughly 10 % of Vienna's total electricity demand[16].

In a climate-neutral Vienna, this electricity must, of course, originate in renewable resources. Due to the urban fabric, which permits only a very limited degree of wind power utilisation, and the planned phasing-out of fossil fuels in electricity generation, Vienna's electricity production will decrease until 2040 despite the ongoing solar energy campaign. Photovoltaics (PV) will play an important role for Vienna, since this technology can be easily integrated into existing buildings. Vienna's solar energy campaign launched in 2021 already serves to increase the installed PV capacity from currently about 100 MW_p to 800 MW_p by 2030. Here, the focus is on using already sealed surfaces.

While wind energy will assume an important role in Austria's power generation, its significance for Vienna's electricity production will be minor. Being very densely built up, Vienna offers practically no suitable locations for wind power plants; possibilities for extending hydropower generation in Vienna are likewise extremely limited.

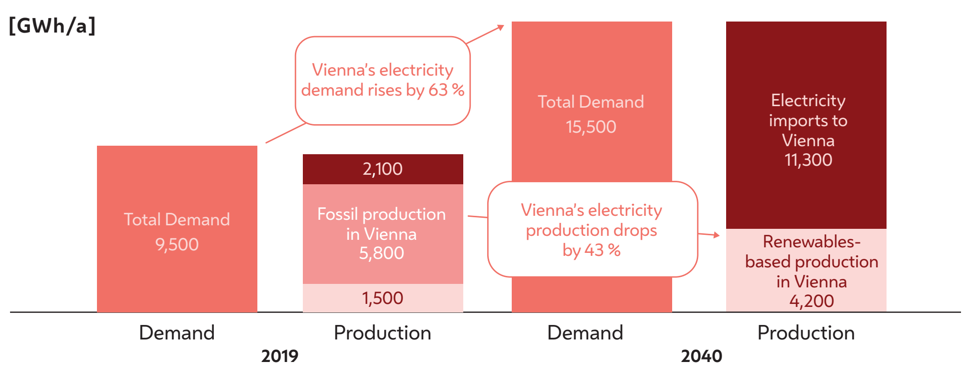


Figure 14
Vienna's electricity demand and its coverage [GWh/a].[16]

Therefore, Vienna will co-operate with the surrounding region. As a metropolis with high energy consumption, Vienna must make use of the surplus power from renewables generated in its environs and act as an energy reservoir. To be able to distribute the increasing electricity volumes in Vienna's power grid safely and securely also in the future, the network must be continuously upgraded and expanded.

RENEWABLE AMBIENT HEAT

Locally available ambient heat constitutes a key component of future energy supply. In urban areas, heat pumps can be deployed to extract geothermal heat as well as heat from air and groundwater for heating one or several buildings. In addition, solar thermal energy offers a valuable supplement.

By tapping deep geothermal energy, heat available at great depth[18] can be directly fed into the central district heating grid. In this way, renewable energy sources at the urban periphery can be drawn upon to supply densely populated parts of Vienna.

WASTE HEAT AS A SOURCE OF RENEWABLE ENERGY

The direct exploitation of available waste heat is essential for phasing out fossil energy sources and switching to district heating at a large scale. Due to the high temperatures generated, waste heat from high-temperature applications, e.g. waste incinerators or cogeneration plants (i.e. combined heat and power, CHP)[19], can be directly fed into the district heating grid. Low-temperature waste heat, e.g. from sewers or wastewater, can be used for space and water heating with the aid of heat pumps. Other sources of waste heat include office buildings, supermarkets, businesses and data centres or server rooms. Waste heat should best be used onsite by coupling energy demand as early as possible with locally available sources and taking account of these requirements already in planning (for example, when choosing heat generation solutions for residential neighbourhoods). The seasonal storage of waste heat, e.g. in geothermal probe fields, makes it possible to use summer heat surpluses as sources of heat in the winter months.

In the future, Vienna's electricity demand for space cooling will likewise augment significantly (according to a Compass Lexecon study, by 240 %, i.e. from around 300 GWh in 2019 to over 1 TWh in 2040[20]). The increased use of individual cooling and air-conditioning devices for this purpose would also result in the release of larger waste heat volumes into the environment, leading to even higher urban temperatures during the summer months. This development must be counteracted by means of alternative solutions, such as district cooling networks (chiefly for service buildings) or the seasonal cooling of buildings by means of geothermal probes. At the moment, many waste heat flows are still released unproductively into the environment. Appropriate specifications are called for to make sure that waste heat will be made effective use of.

[18] At a depth of approx. 3,000-6,000 m below ground.

[19] The use of cogeneration allows for a marked reduction of resource consumption. Thermal power plants convert heat partly into electrical energy. Combined heat and power (CHP) enhances efficiency from roughly 40 % to up to 86 %. As a result of this high efficiency, Vienna's modern power plants have a much lower fuel demand, which lessens their impact on the environment.[20]

[20] G. Aue, A. Burger. Wärme & Kälte, Mobilität, Strom: Szenarien für die Dekarbonisierung des Wiener Energiesystems bis 2040. Vienna: Compass Lexecon, on behalf of Wien Energie GmbH, 2021.

LIMITED USE OF BIOMASS IN THE CITY

So far, the use of biomass (e.g. wood pellets, wood chips or logs) for heating single-family homes, apartment buildings or multi-storey residential buildings in Vienna is minimal. In addition, biomass makes a small contribution to district heat production. Neither is it expected that biomass will play a more important role in heating Vienna's buildings in the future. This is because biomass can be annually replenished only to a certain degree and, hence, is not sustainably available in unlimited quantities. Moreover, climate change negatively impacts some domestic wood species. Last but not least, bioenergy should be used closer to its place of origin – i.e. in rural areas – for reasons of logistics. Also, biomass is an energy source of superior quality and with a high energy content that, consequently, should not be primarily used in the low-temperature range but rather for more high-end applications.

If heat pumps or connection to the district heating network are not possible for valid reasons, the use of biomass for heating individual buildings does, however, constitute a suitable alternative. In particular, biomass is well suited for applications requiring a high volume of energy for a small space, since it is characterised by relatively high energy density and can also generate high-temperature heat.

In multi-storey residential buildings not served by district heating, biomass-fired systems could be used for centralised heat supply in specific cases. Here, the advantage would lie in efficient centralised waste gas purification as compared to a great number of individual heating systems.

GREEN GAS FOR INDUSTRY AND POWER PLANTS

At the moment, it may be assumed that the available quantities of green gas will be still limited in 2040 and even beyond, entailing correspondingly high prices. The reasons for this lie in the high demand for green gas for many different areas of application (e.g. chemicals, steel, aviation and navigation) and the respective production and supply structures, which are still in the development stage. Against this background, the already scarce quantities of green gas will not be used for low- or medium-temperature applications and, thus, **not for space and water heating of individual buildings** in Vienna.

Vienna will remain dependent on gas-fired plants in the future for reliable operation and coverage of peak loads in electricity and district heating supply. For this purpose, the use of green gas is advantageous because of its high energy density and suitability for seasonal storage. Hence, the use of green gas in Vienna is planned only for sectors where no alternatives exist, e.g. in CHP plants, for high-temperature applications in industrial production or, temporarily, in some areas of public transport.

It is very important for Vienna to ensure that green gas will be available in sufficient quantities and at acceptable prices for use in the areas mentioned above. Incentives must be created to safeguard the best possible use of the existing potentials in Vienna and to enable the development of green gas production and utilisation.

JOINT IMPLEMENTATION

In the coming years, measures to decarbonise the building stock, to adapt to climate change and also in the field of mobility will need to occupy public space. To be able to take account of as many aspects as possible when realising individual projects and to proceed in a co-ordinated, holistic manner, a competent co-ordination office must be set up to make sure that all of the abovementioned aspects are duly considered when implementing a project. This can help to cut down on the investment costs, duration of works and levels of noise caused by construction measures.

WHAT IS THIS "GREEN GAS"?

The term "green gas" refers to all renewable gaseous energy carriers derived from sustainable sources. This is a highly concentrated energy carrier well suited for storage and high-temperature processes. Green gases include:

- **Biogas** – methane produced from biomass or waste.
- **Green hydrogen** – hydrogen generated from green electricity and water or, conversely, biomass and waste by means of electrolysis. This process entails significant conversion losses.
- **Synthetic methane** – an artificial gas presenting the same chemical properties as natural gas is generated from renewable sources.

3.3 What can building owners do already today?

The following overview is to show persons interested in switching from fossil to renewables-based heat supply what can be done already today and how such projects can be implemented.

These measures provide information and support in project realisation.

INFORMATION

You want to obtain information on which forms of renewable energy solutions work for you, and how?

Check the following publications for an overview (German)!

- **Phasing Out Gas use in existing buildings**
  digital.wienbibliothek.at/wbrup/download/pdf/3289554?originalFilename=true
- **"AnergieUrban" project report**
  oegut.at/de/projekte/energie/anergie urban leuchttuerme.php
- **Information about geothermal energy in Vienna**
  erdwaerme-wien.info/
- **Renewable energy potentials – thematic map of Vienna**
  wien.gv.at/stadtentwicklung/energie/themenstadtplan/
- **Heat pumps drive decarbonisation of urban building stock**
  wien.gv.at/kontakte/ma20/publikationen/ind[illegible]html

CONSULTATION

How can the transition function? What possibilities exist? How can permits be obtained?

These and many other questions are answered by the consultation services of the City of Vienna!

"Hauskunft"

- Consultation on thermal building rehabilitation
- Consultation on heating system conversion
- Consultation on subsidies
- Consultation documentation
- Information on subsidised refurbishment concept
- hauskunft-wien.at/ (German)

Competence Centre for Renewable Energy

- Consultation on renewable energy technologies
- Consultation on related procedures for obtaining permits
- Consultation on renewable energy communities Consultation on subsidies
- erneuerbare-energie.urbaninnovation.at (German)

SUBSIDIES

What subsidies exist?
How can I find relevant information?
Are there any consultation services?

Both the Federal Province of Vienna and the Federal Government offer subsidies for projects aimed at phasing out fossil energy supply and support this with extensive consultation services.

See "Consultation" infobox

Subsidies granted by the Federal Province of Vienna

- Up to 35 % of the costs for converting existing heating systems to renewable energy-based systems are eligible for subsidisation. For details, please consult the Vienna Building Rehabilitation Ordinance (German): ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrW&Gesetzesnummer= 20000091
- Subsidisation of thermal and energy refurbishment projects
- Subsidisation of heat networks (anergy networks) combined with heat pumps for up to three structures
- Comprehensive information on energy-relevant subsidies granted by the Federal Province of Vienna in this field wien.gv.at/stadtentwicklung/energie/foerderungen/finden.html (German)

Subsidies granted by the Federal Government for phasing out oil and gas use

- The switch from fossil fuel supply to renewables-based solutions is subsidised. For more details, please consult this website (German): umweltfoerderu at/privatpersonen/raus-aus-oel.html

IMPLEMENTATION

Where can I find concrete implementation models? Which solution is the right one for my building? Which companies are suitable partners for me?

A refurbishment concept is the first step towards implementation, as it shows which measures are required to ensure the supply of your building with renewable energy.

These websites also list companies offering high-quality refurbishment services (German).

- **Subsidised refurbishment concept**
  wien.gv.at/wohnen/wohnbaufoerderung/ahs-info/pdf/sanierungskonzept.pdf (German)
- **Quality Platform of Refurbishment Partners**
  vxn--qualittsplattform-sanierungspartner-b7c.wien/ (German)
- **Flagship projects – innovative energy projects of the City of Vienna**
  The City of Vienna is a worldwide leader in the application of novel energy technologies. Viennese flagship projects can be consulted in a data base, on the wien.at city map or in an app specially dedicated to Viennese flagship projects. Numerous projects show impressively how the future-oriented planning of sustainable energy supply can be practically implemented.
  wien.gv.at/stadtentwicklung/energie/beispiele/

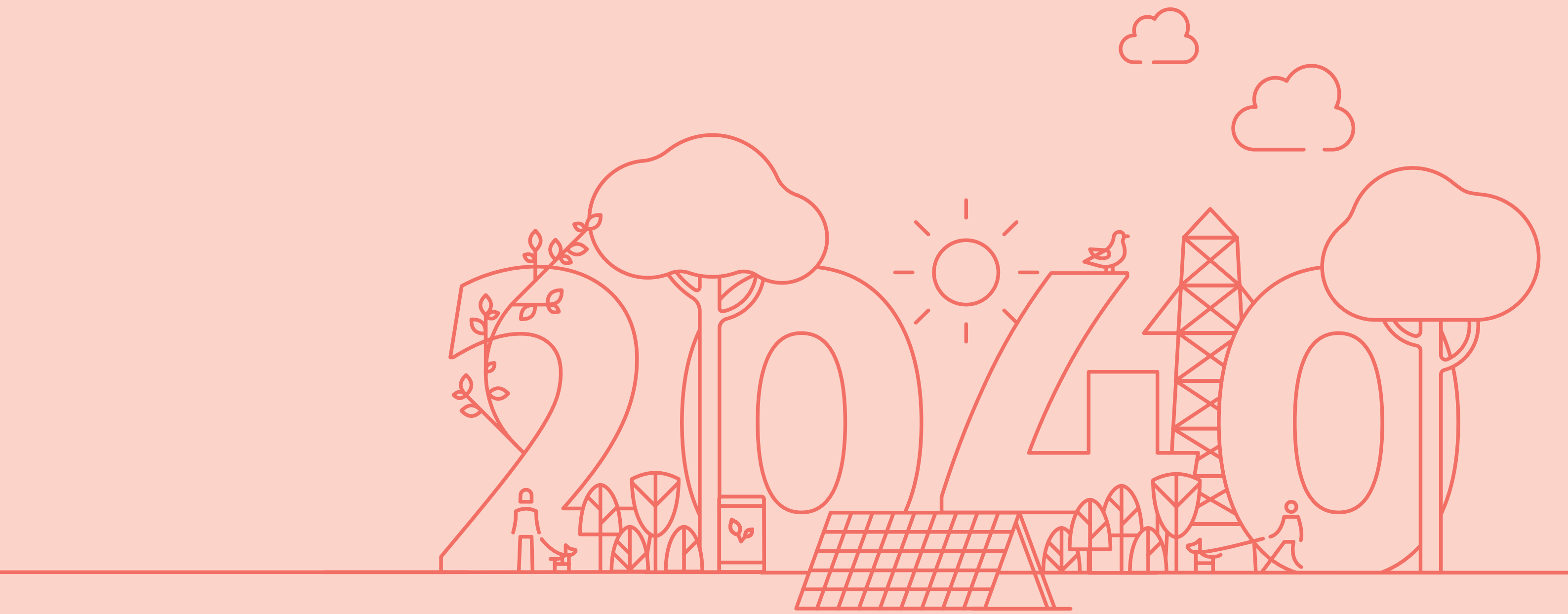
4
The path to “Heating and Cooling Vienna 2040”

Elements of climate-neutral heating and cooling for Vienna in 2040

Thermal refurbishment &
circular economy
Centralisation of heating
systems in buildings
Heat pump solutions
Interim solutions
Adaptation to heat
and climate change
Heat networks
Super-efficient buildings

4.1 The path to “Heating and Cooling Vienna 2040” – an overview

How can this fundamental transition from one system to another be achieved, and which aspects and interest groups must be involved and taken aboard? Obviously, 2040 is not very far away. For this reason, many activities must be launched simultaneously and, if possible, at once. Some framework conditions and fields of action can be adapted more quickly and easily while others require patience and first need to be launched before they can be expanded over time.



At the same time, the heat transition must contribute to social equity, as we all are affected by climate change. This also means supporting those who cannot shoulder the costs of the heating revolution on their own.

Before initiating a system transformation of this magnitude, it is essential to first create a common starting point and basis of **relevant data**. This data pool must be updated on an ongoing basis.

The already existing **technical solutions** are a key springboard of our vision for 2040 in orderto attain our goal of climate-neutral space heating and cooling by the date we have set ourselves. A great number of innovations that provide the foundation for our strategy have been developed in this field over the past few years. These innovations are already available – as examples realised in Vienna show – and can be quickly implemented. The principal options include district heating and heat pumps, effectively complemented by heat from photovoltaics and solar energy systems.

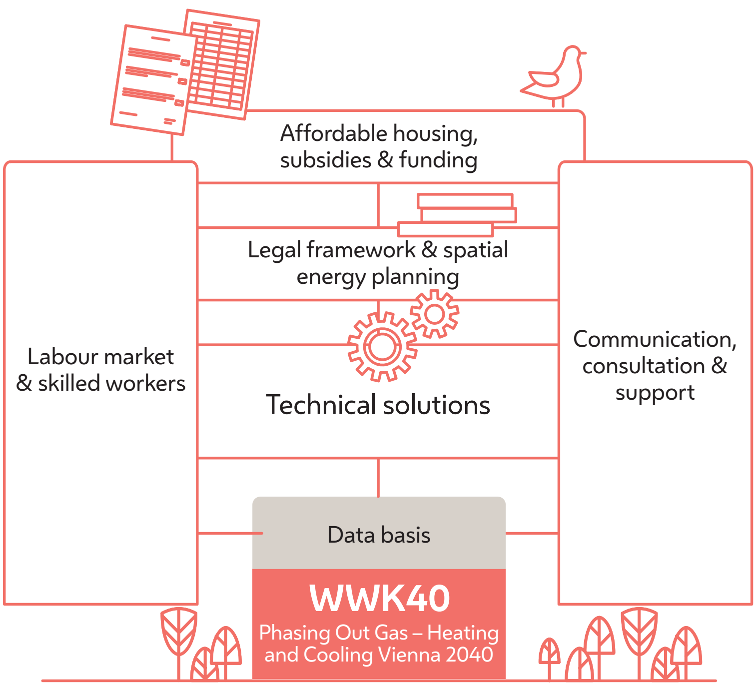
To be able to implement the existing technical solutions in a socially equitable and binding fashion, the key aspects must be given an appropriate legal **framework**, as only this will make it possible to define requirements in a legally effective manner and safeguard the actual implementation of the necessary changes. Depending on the various ownership rights and titles, different fields of legislation must be urgently adapted to ensure that the time schedules set for building decarbonisation will be attained.

Quite obviously, the heat transition entails costs. Since **affordable housing** is an issue that the City of Vienna continues to pursue as a crucial item on its political agenda, suitable **financing models and subsidies** must be developed to bring about the heat transition.

Together with the legislative framework, **spatial energy planning** ensures the necessary planning certainty, inter alia for flat users, building owners, energy suppliers and network operators. It is a valuable aid for unifying diverse fields, options and viewpoints as well as for providing a co-ordinated, balanced spatial overview of energy supply possibilities for the entire municipal area.

Moreover, a greater number of well-trained **skilled workers** will be required to ensure that the heating system conversion will actually be successful. Targeted basic and advanced (re-) training initiatives, the strengthening of certain industries and fields of specialisation, qualification programmes as well as the prevention and active counteracting of the skills shortage are essential here. The “side effect” will be an enormous employment and value creation boost for Vienna’s labour market and economy, also beyond municipal borders. The provision of skilled workers is an issue that must be pursued and taken account of throughout the entire heat transition process.

To be able to actively target and reach all stakeholders, full and clearcut **communication** is vital and must be comprehensively co-ordinated continually – like the training of skilled personnel – throughout the entire process, as this is the only way to ensure that all players will act in concert. The groups concerned are many and varied; therefore, different approaches must be developed and tested for each group. In addition, low-threshold, independent consultation services to inform the population must be offered and continuously expanded. Good practices of offerings that are already in place include Hauskunft, the Competence Centre for Renewable Energy and the Urban Renewal Offices.

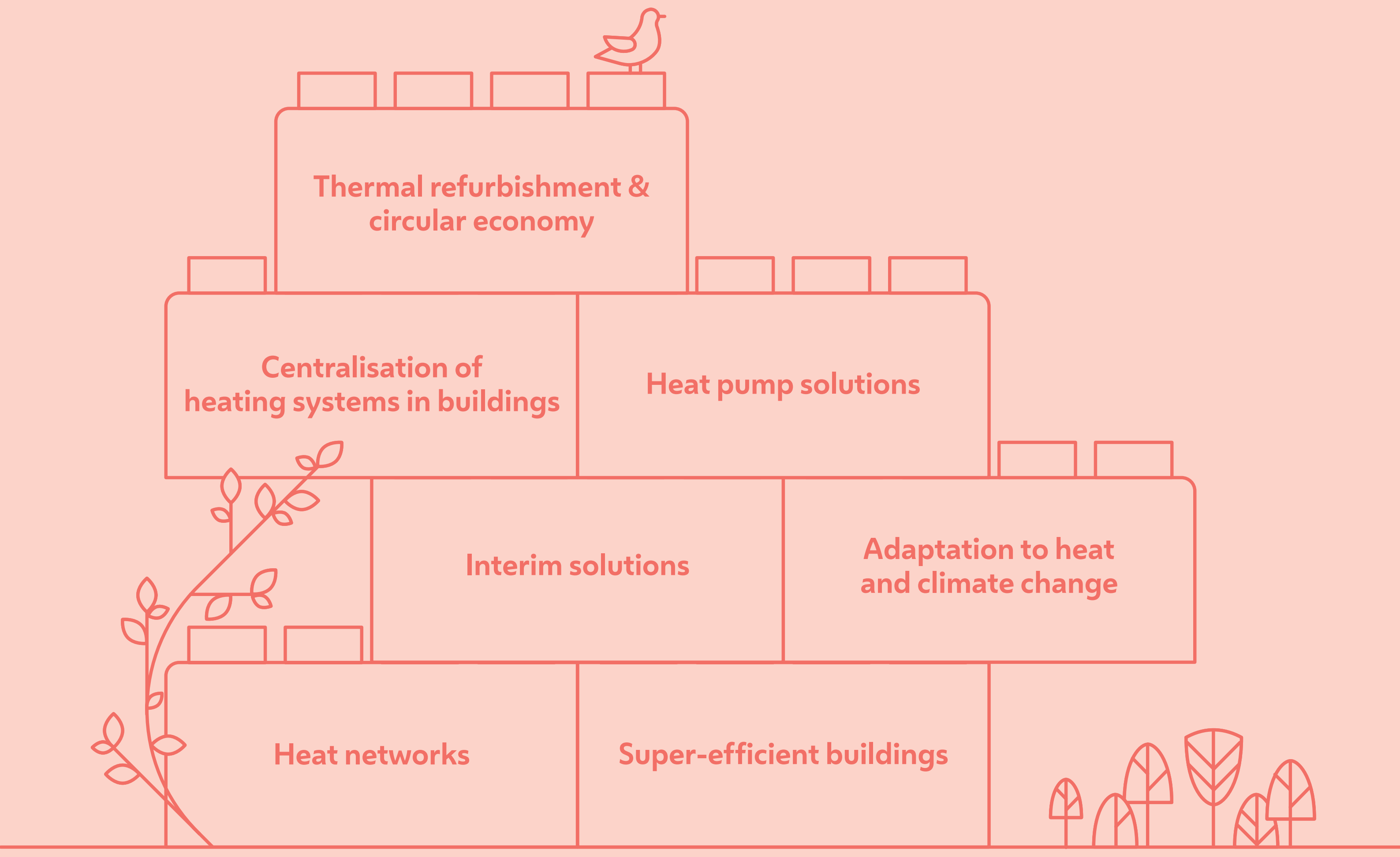


FROM THEORY TO PRACTICE

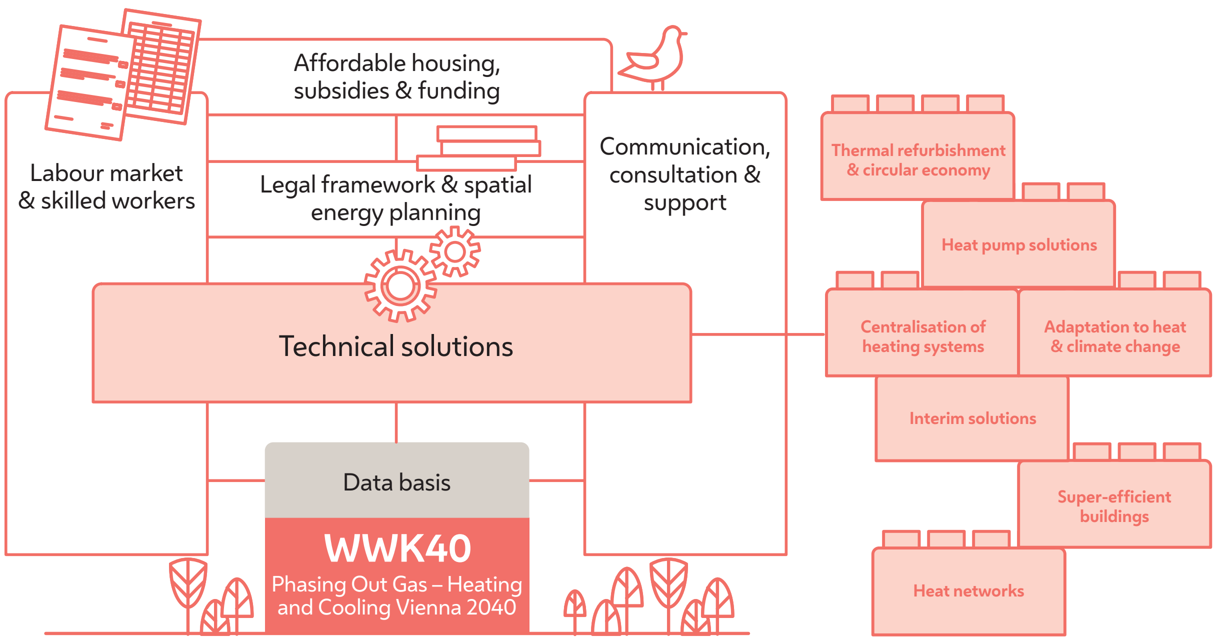
Since 2020, a large team of experts of the City of Vienna, the Vienna Public Utilities and various scientific disciplines has been busy laying the basis for a road towards climate-neutral Vienna. The programme **"Phasing Out Gas"**, which serves to implement the "Heating and Cooling Vienna 2040" vision, was already launched to ensure that this strategy will become reality. It is headed by the Executive Group for Construction and Technology and pursues the goal of co-ordinating the heat transition on behalf of the City of Vienna and advancing all crucial aspects of this endeavour. This is dealt with in greater detail in Chapter 5. This programme pools all efforts that will be taken by the City of Vienna together with all citizens in order to truly phase out oil and gas consumption by 2040.

4.2 Technical elements

To make this technical vision reality, detailed information about the buildings in our city is essential, as is a comprehensive overview of the changes that must be implemented and the possible solutions available for this purpose. Therefore, this chapter is dedicated to the different technical elements required to make each single building climate-proof and to become climate-neutral by 2040. What counts in this effort is not the application of each element for each building but rather an effective combination of different elements to achieve optimum results on a case-by-case basis.



Chapter 2 (Where do we stand today?) presented the role of decarbonisation types. This chapter once more refers to them to explain which measures can be carried out to reduce energy consumption and allow for the use of renewables-based forms of energy. The overview of decarbonisation types (see Chapter 2) shows that type 1, i.e. not yet refurbished apartment buildings and multi-storey residential buildings with decentralised gas supply, constitute the biggest category. These buildings are difficult to decarbonise, since each unit in use has its own, individual heating system. The focus of this chapter will be on this decarbonisation type 1, as the methods and solutions that will be applied to it are also suitable – in modified form – for the other eight decarbonisation types.



ELEMENT 1

Efficiency, thermal refurbishment and circular economy

Key elements enabling the attainment of building decarbonisation by 2040 include the reduction of energy consumption and an increase in energy efficiency. However, it must be assumed that not all refurbishment measures listed in this chapter can be implemented in all buildings.

Saved energy is the most environmentally friendly and cheapest form of energy – it does not even have to be supplied!

THERMAL REFURBISHMENT – COMPREHENSIVE REHABILITATION VS. INDIVIDUAL MEASURES

Thermal refurbishment is one way of increasing the energy efficiency of buildings.

Even if it will not be possible to completely rehabilitate all buildings by 2040 in addition to converting their heating systems, thermal refurbishment plays an important role in this context. It increases the energy efficiency of the building stock by reducing heat losses, which entails much lower energy consumption for heating. This lower energy demand paves the way for the use of renewables-based energy. Any conversion of heating systems by phasing out fossil fuels will be significantly easier and less costly to realise and maintain if the possibilities of thermal building refurbishment are made used of simultaneously; for this reason, the possibilities of thermal building improvement should always be evaluated together with potential solutions for converting the heating system.

Refurbishment measures not only reduce the demand for district heating and electricity but also help to lower the required flow temperature. To be able to use heat pump solutions and low-temperature district heating, the flow temperature should ideally be decreased to roughly 50°C. In most cases, this permits the continued use of the existing radiators, cutting down on refurbishment costs. Whether or not existing radiators can remain in use depends on their performance capacity. When converting heat supply, water heating, too, must be considered. In case of centralised water heating, appropriate Legionella bacteria prevention must be carried out, and higher flow temperatures may become necessary. Alternatively, heat transfer stations or electric water heating devices can be installed directly in the individual flats.

The rehabilitation of a building may take the form of either comprehensive thermal refurbishment or partial refurbishment.

- In case of buildings for which no large-scale rehabilitation measures can be carried out, there exists the possibility of realising various **individual measures** to reduce energy consumption and enable the conversion to renewables-based energy systems. Which measures are the most suitable depends on the respective decarbonisation type. It makes sense to integrate these individual measures into a refurbishment concept and gradually implement a comprehensive rehabilitation programme.

- In case of **comprehensive rehabilitation**, the entire building envelope is thermally refurbished; normally, the façades as well as the ceilings of the top storey and cellar are rehabilitated and insulated; the windows, too, are replaced. Moreover, it is possible to install some form of external sun protection and to eliminate thermal bridges. Measures inside flats, such as converting heat distribution from radiators to surface-based systems (e.g. underfloor, wall or overhead heating), can be implemented in vacant flats or in inhabited flats if the tenants agree to this.

Figure 15
Possible thermal refurbishment measures.

The example of decarbonisation type 1 (i.e. non-refurbished apartment buildings or multi-story residential buildings with decentralised gas supply, which is the most frequent type in Vienna) shows clearly which refurbishment measures can be carried out. Ideally, all of the following measures can be realised:

1 Insulating the top storey ceiling

2 Insulating the exterior wall facing the street
(possibly on the inside because of monument protection requirements)

3 Insulating the cellar ceiling

4 Insulating the exterior wall facing the inner courtyard/firewall

5 Replacing or renovating the windows

Optionally:

6 Surface-based heating system instead of radiators (e.g. underfloor, wall or overhead heating)

SUSTAINABLE AND RESOURCE-CONSERVING REHABILITATION BASED ON THE CIRCULAR ECONOMY MODEL

"Circular economy" is an economic model that ensures that resources (e.g. excavated soil, materials, construction products, components, buildings) are used, repurposed, shared, leased, reused, repaired, processed and recycled as long as possible. The primary objective lies in significantly extending the useful life of the resources deployed and in reducing waste to an absolute minimum. Towards this purpose, the circular economy decouples value creation from the consumption of finite resources and, hence, is the central instrument for bringing about a sustainably built environment. Moreover, the circular economy contributes significantly to attaining the climate targets, since recycling- and life cycle-oriented construction methods also help to reduce grey emissions. The Smart Climate City Strategy Vienna stipulates that circular planning and construction to maximise resource conservation should be standard in new-build and refurbishment projects from 2030. This means that thermal refurbishment, too, must implement the core principles of the circular economy – reduction, durability, reuse and recycling. Resource conservation according to the tenets of the circular economy means inter alia that a building or individual building components can be completely dismantled at the end of their useful life and that the individual construction materials can be reused or recycled. One objective lies in using renewable construction materials in order to reduce grey emissions, i.e. the emissions resulting from manufacturing these products. For example, by reducing the use of glued bonds, individual layers of components can be replaced more easily when they have reached the end of their useful life. The materials used should be selected – in addition to being easy to combine, free of hazardous substances and easily separable – also with regard to their carbon footprint. Yet, apart from the technical/structural level and that of the materials used in construction, flexible layout design and, consequently, flexible ways of building utilisation play an important role as well. Buildings that are suited to different forms of use and can be repurposed and put to secondary uses without major material input are able to react to changing needs and, therefore, have a longer service life. In Vienna, this quality is clearly borne out by the oft-mentioned Gründerzeit-era buildings, since they are flexibly modified to this day and prove suitable for the most diverse requirements.

ELEMENT 2

Centralisation of heating systems in buildings

The centralisation of heating systems in buildings will constitute a key element on the road to renewables-based energy systems in the existing building stock, as it enables the conversion of such buildings to district heating powered by renewables or to renewables-based individual building solutions.

The most widespread systems currently used in Vienna are decentralised space and water heating solutions for individual flats. These units in use moreover accommodate approximately 260,000 gas stoves as well. Single-flat gas heating systems are installed in close to 500,000 units in use; around 306,000 of these were classified as belonging to decarbonisation type 1. Converting these units in use to renewables-based solutions or district heating (nearly) always necessitates the installation of central heat distribution ("centralisation") in the buildings. In a few exceptional cases, decentralised renewables-based solutions can be implemented if centralisation is not feasible, although this usually involves high maintenance costs and efforts.

POSSIBILITIES TO PREPARE FOR HEATING SYSTEM REPLACEMENT

If construction works in a building are already scheduled, a pipe system for the new heating installation can be included relatively easily and cost-efficiently. This avoids consequential costs, and future conversion will be easier. When switching to the new energy supply system, the centralised heating system “only” needs to be connected to the individual flats.

The spots for installing risers, the central heating system and other necessary technical facilities inside the building depend on the individual structure. The following possibilities exist:

- **Staircase**
  Gas, water and power lines are often accommodated in riser ducts and distributed from there to the individual units in use. If there is enough space, additional heat distribution pipes can be added or installed in the masonry. The individual units need only to be connected to the centralised system at the moment of actual conversion. As a rule, the existing heat distribution system inside the unit in use is directly connected to the riser installed in the staircase. Alternatively, a heat transfer station can replace the fossil fuel-based boiler. The advantage of a heat transfer station inside the flat is that it allows for a lower flow temperature, since the water is heated directly in the flat with a freshwater module; thus, regular heating for Legionella prevention is not required.

- **Addition of lift**
  If a lift well is added in the course of a building refurbishment or attic conversion, heat distribution can also be considered when constructing the new lift well. Connection to the individual flats’ distribution system proceeds along the same lines as with distribution from the staircase.

- **Flue shafts**
  Existing flue shafts offer another possibility for distributing heat inside buildings. Here, the advantage lies in the fact that they are situated inside the individual units in positions that allow for direct connection to the existing pipe system. Instead of the gas boiler, a heat exchanger is installed or the unit is directly connected to the network. As a rule, the necessary structural modifications inside the individual units are only slight. If a heat exchanger is used, Legionella prevention for hot water can likewise be waived.

- **Façade**
  If there is no space for installing heat distribution pipes inside the building, they can be integrated into the façade in the course of thermal refurbishment. This permits keeping construction works inside the building to a relative minimum; possibly, too, the existing distribution system inside the individual units can be used.

- **Light well**
  If it proves impossible to integrate heat distribution pipes inside the building, light wells, too, can be used for this purpose. Here, it is important to insulate the pipelines very well to reduce heat losses, since a large portion of the distribution pipes will not be located inside the heated building envelope.

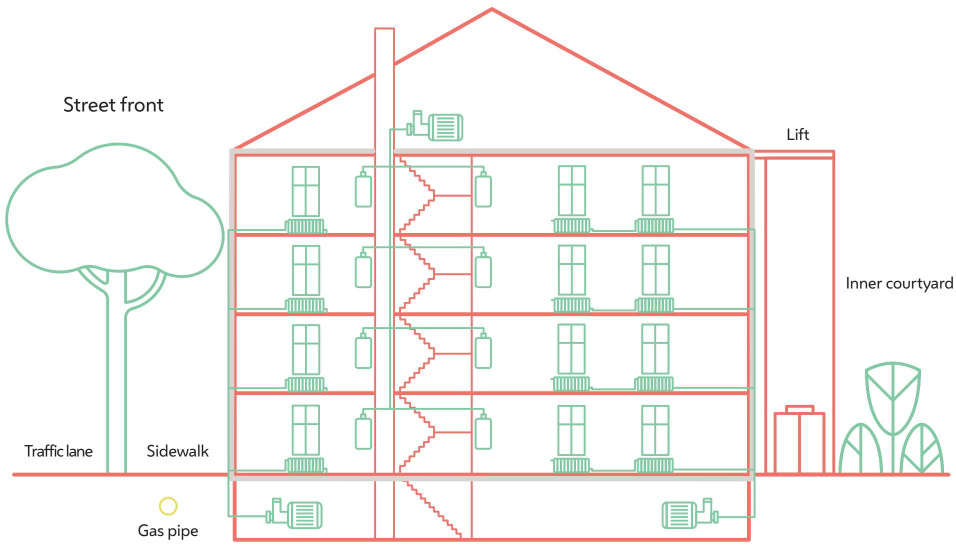


Figure 16
Centralised heat distribution – different potential solutions.

ELEMENT 3

Interim solutions

Every structural intervention in buildings can be used for conversion!

It is important to centralise energy supply in buildings to permit their later conversion to a renewables-based energy system. Hence, it is a good idea to prepare for future centralised heat distribution whenever there are construction works in the staircase, a lift is added or other works are carried out inside a building.

When a gas boiler or single-flat gas-fired system has reached the end of its useful life, it is important to avoid useless investments. If the flat or building owner has to purchase a new boiler, this entails significant costs. Since, normally, boilers do not break down precisely when a building is up for (thermal) refurbishment or the heating systems inside all flats in the building are about to be converted, creative solutions are called for to avoid lock-in effects. These solutions must guarantee continued heat supply and be flexible enough to ensure that the unit can be connected to the building's central energy system at a later date.

GAS BOILER LEASING AS AN INTERIM SOLUTION

Leasing models like those used for motor vehicles could provide a suitable way out. In this case, companies (plumbers, energy suppliers, …) lease out a gas-fired device (e.g. a used but functional gas boiler) and handle its installation, maintenance and smooth operation. When the whole building is converted to a centralised system, the leased device is uninstalled and the flat is connected to the central heating system. The leased boiler can then be used for another flat as an interim solution.

SHARED BOILERS AS AN INTERIM SOLUTION

A much simpler solution that was already implemented several times by the housing developer SOZIALBAU AG is provided by "shared boilers". In this case, a central gas boiler is installed on the roof of the building; the individual units are then heated via unused flue shafts. In this system, water is heated by electric boilers in the individual flats, combined with a photovoltaic installation. If a gas-fired device becomes defective, the flat is connected to this central energy supply system. This interim solution also provides a basis for converting the building to a renewables-based energy system, since the newly built distribution layout via flue shafts can be used for the renewables-based energy supply system. Housing estates operated by SOZIALBAU AG that were already converted to heat pump solutions show how this approach works.

Figure 17
Shared gas boiler as an interim solution.

Heat networks

Heat networks can assume a decisive role in decarbonising Vienna's heat supply. Especially in densely built-up neighbourhoods, where little space for using local sources of heat is available, the decoupling of source and sink via a heat network will often be necessary. As a result, sources of heat located at the urban periphery can be efficiently developed at a large scale and used for supplying inner-city areas. Moreover, synergies in a neighbourhood (e.g. waste heat) can be tapped and resource input can be optimised.

CENTRALISED DISTRICT HEATING PROVIDED BY WIEN ENERGIE GMBH

With an approximate length of 1,200 km, Vienna's district heating network is one of the longest worldwide and already supplies heat to around 430,000 dwellings in the city. This status quo makes district heating a key element in the further decarbonisation of the Austrian capital.

- Eco-friendly: Using waste heat from other processes makes district heating an eco-friendly energy source. Total decarbonisation by 2040 as planned will render district heating CO_2-neutral. However, at the moment, the share of fossil fuels in district heat generation is still quite high.

- Standard solutions: Heat is provided centrally for the entire building via a district heating substation. Hence, no additional devices need to be installed in flats or buildings – this also means that no additional maintenance costs for tenants and owners will be incurred.

ROLE OF DISTRICT HEATING FOR SUPPLY

District heating will assume a crucial role in supplying Vienna's existing building stock. In particular in densely built-up urban quarters, where there is little space for energy supply via renewable sources and many buildings date from the Gründerzeit era, hence posing complex challenges for rehabilitation, district heating offers an environmentally friendly solution. Moreover, it can be installed in existing buildings with minimally invasive measures – also in zones subject to special protection regulations, such as monument protection. Newly built areas are to be heated with locally available, renewable energy sources. In the case of multi-building energy supply solutions, local low-temperature heat networks are the method of choice. Connection to the central district heating network can generate synergies.

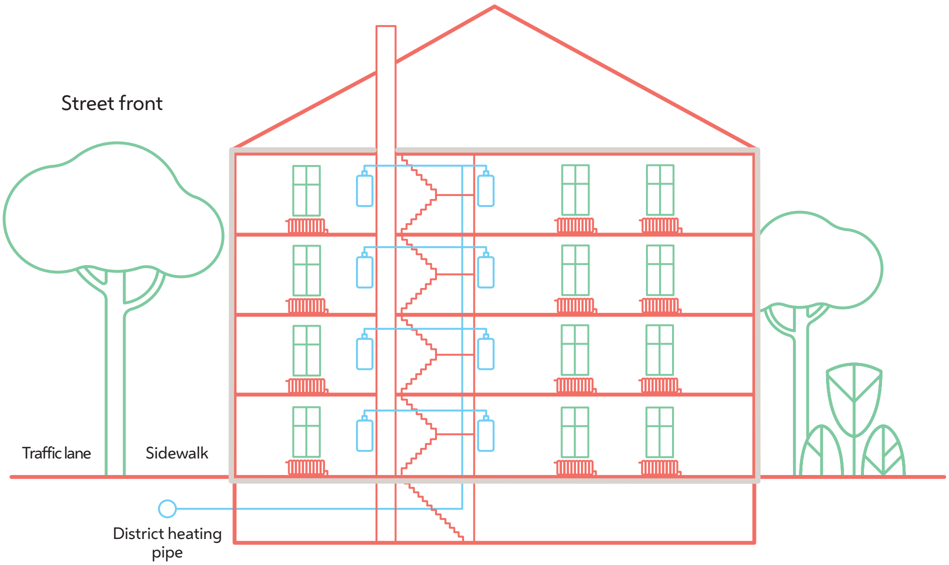


Figure 18
Supply with district heating via flat stations.

According to a study commissioned in 2021 by the district heat provider Wien Energie GmbH, district heating will supply around 56 % of the heat required for space and water heating in Vienna by 2040. This means that, after a run-up phase until 2027, around 95 MW of heating power will be additionally connected to the district heating network every year. In 2040, district heating production will therefore exceed 7.5 TWh.

DECARBONISATION OF DISTRICT HEATING

The entire district heating complex must be decarbonised until 2040; hence, from that year onwards, it will be exclusively fed by renewable energy sources. In order to provide fully decarbonised district heating, a number of technologies can be drawn upon. Climate-neutral district heating is to be primarily supplied by means of geothermal energy and large-scale heat pumps:

- Deep geothermal energy will tap thermal water resources and feed the energy of the hot water directly into the district heating network;
- large-scale heat pumps will, inter alia, feed the portion of industrial and commercial waste heat that is available throughout the year into the district heating network;
- heat from surface water bodies and sewers can be used for district heating by means of heat pumps.

According to the study "Wärme & Kälte, Mobilität, Strom: Szenarien für die Dekarbonisierung des Wiener Energiesystems bis 2040"[21] commissioned by Wien Energie GmbH, around half of the district heating volume produced today originates from cogeneration plants (CHP plants) operated with gas. By 2040, the share of district heating provided by CHP plants will have markedly decreased, since other renewable sources will be drawn upon. However, part of the district heating provided (close to 1 TWh) will originate from CHP plants operated with green gas. Above all in winter and during months with little availability of solar or wind energy, CHP plants fulfil an important role. The use of green gas for this purpose is particularly efficient, since heat and power are generated in conjunction, hence making the best possible use of the scarce available quantities of green gas.

Thermal waste treatment, too, will continue to make a significant contribution to attaining climate neutrality by 2040. Three approaches make it possible to produce CO_2-neutral district heating and cooling in this manner:

- **Reduction of incinerated fossil fractions**
  This can be remedied by means of waste avoidance and all measures aimed at stepping up the recycling of fossil volumes.

- **Innovative evolution of CO_2 separation techniques (carbon capture)**
  In the future, CO_2 from the waste gas of waste incinerators is to be captured and, hence, will be no longer released into the environment. It can then be used for manufacturing climate-neutral products. Moreover, it may also be possible in the future to store the thus obtained concentrated CO_2 underground and, in this way, remove it permanently from the atmosphere.

- **Compensation**
  Any residual CO_2 emissions can be compensated by e.g. afforestation programmes and similar measures.

The funding and economic viability of the abovementioned measures must be assessed against the background of increased CO_2 taxation. In the future, investments in CO_2-related measures will entail a reduction of taxation on CO_2 emissions.

In Vienna, waste incineration is a key measure towards climate protection already today. On a worldwide scale, most waste still is dumped or landfilled without prior treatment, which results in methane emissions that are hazardous to the climate and far exceed the CO_2 emissions caused by incineration. The City of Vienna will therefore speak out on an international level to advocate a systematic and thorough ban on the dumping of untreated waste.

[21] G. Aue, A. Burger. Wärme & Kälte, Mobilität, Strom: Szenarien für die Dekarbonisierung des Wiener Energiesystems bis 2040. Vienna: Compass Lexecon, on behalf of Wien Energie GmbH, 2021.

Figure 19 shows a possible composition of energy sources that will be used in district heating in the future.

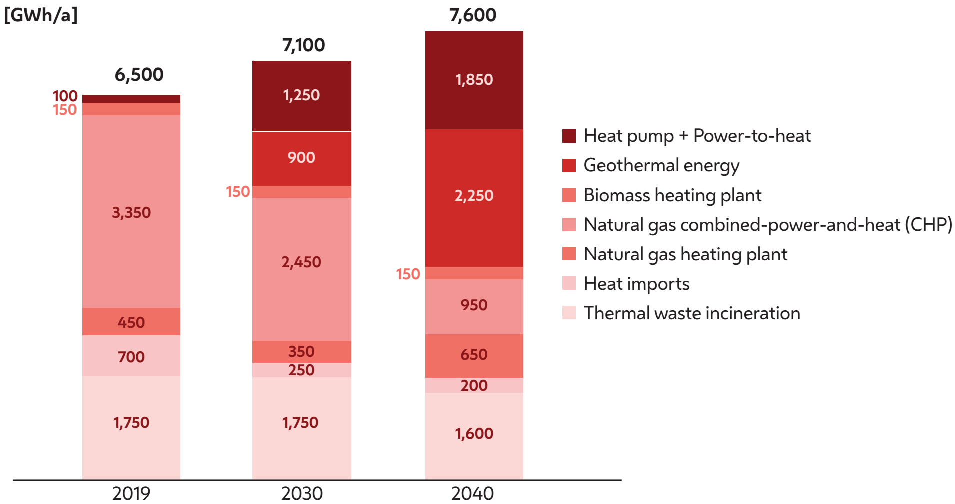


Figure 19
Vienna's district heating demand and its coverage in [GWh/a].[22]

The use of fossil fuel-based energy is being gradually reduced. In the future, deep geothermal energy in particular will play a vital role in district heating production. By the same token, large-scale heat pumps and green gas will contribute significantly to covering demand.

HEAT STORAGE FOR THE HEAT TRANSITION

Heat reservoirs for short-term, long-term or seasonal heat storage are important elements for decarbonised district heating production. Until 2040, their capacity is to be increased to 190 GWh. For many years already, Wien Energie GmbH has been operating short-term reservoirs for decoupling electricity market-driven production in CHP plants from heat demand in the district heating network and reducing peak loads currently met by gas-fired heating plants. High-pressure water tanks are used for this purpose. Additional heat reservoirs will be distributed across Vienna in the future to balance peak loads in the network. Moreover, it is planned to integrate seasonal reservoirs that may take the form of deep drilling or pit storage. Details addressing these solutions can be found in the decarbonisation study commissioned by Wien Energie GmbH: "Wärme & Kälte, Mobilität, Strom: Szenarien für die Dekarbonisierung des Wiener Energiesystems bis 2040"[22]. Heat storage, however, requires space – such reservoirs cannot always be accommodated underground; hence, they will need to be integrated into the cityscape.

[22] G. Aue, A. Burger. Wärme & Kälte, Mobilität, Strom: Szenarien für die Dekarbonisierung des Wiener Energiesystems bis 2040. Vienna: Compass Lexecon, on behalf of Wien Energie GmbH, 2021.

FURTHER DENSIFICATION AND EXTENSION OF THE DISTRICT HEATING NETWORK

The current network must be further developed to ensure that centralised district heating will indeed be able to cover a significant portion of the heat demand of Vienna's buildings.

- On the one hand, the existing network will be further **condensed**; areas close to the network will be connected to it. Above all densely built-up inner-city neighbourhoods are very likely to be connected to the district heating network in the future.

- On the other hand, existing network capacities will be **extended** to permit supplying additional buildings in areas with already installed district heating connections. For this purpose, the capacities of area substations[23], primary and secondary pipes will be increased; attention must also be paid to supra-regional capacities and capacities for the production of decarbonised district heating.

In 2023, spatial energy planning is to define specific district heating areas in order to obtain a clear picture of those areas where heat networks should be principally available by 2030/2040.

FRAMEWORK CONDITIONS FOR DISTRICT HEATING SUPPLY

To be able to supply the largest possible number of buildings with district heating or other renewables-based energy systems by 2040, several framework conditions must be in place:

- The Federal Government is to adopt the Renewable Heat Act (acronym "EWG"). This will permit the implementation of an analogous act of the Federal Province of Vienna and support the objectives of the City of Vienna. The EWG stipulates mandatory centralisation in areas supplied with district heating. Combined with sound spatial energy planning, this ensures a high level of planning certainty and security of investment, also for the parties that build and operate district heating networks.

- Sound spatial energy planning as well as the planning of district heating network upgrades help to facilitate the connection of the largest possible number of buildings. This is to be coupled with simultaneous thermal refurbishment of these buildings, if possible, and a highly efficient, economically and socially optimised extension and densification of the existing district heating infrastructure.

- Spatial energy planning provides security in planning by establishing where district heating supply will be possible in the future and, conversely, where other heat networks or individual solutions should be implemented.

- Buildings must be converted to centralised systems to be able to deliver district heating for space and water heating.

[23] Area substations connect the (high-temperature) main network to (medium- temperature) local networks.

- Clearcut procedures for building owners – from the submission of applications to the ex-post installation of district heating connections – must be in place.

- High new connection rates and rapid conversion of all flats in these buildings reduce pipe infrastructure doubling.

USING SYNERGIES

To be able to supply all buildings with renewables-based energy, it is important to combine several technologies. Buildings or neighbourhoods supplied with district heating can tap synergies and interact with other systems, e.g. low-temperature heat networks and heat pump solutions. These potential synergies include the following:

- A district heating area provides optimised (additional) heating for an area supplied by a low-temperature heat network.

- Low-temperature heat networks can reduce peak loads in the district heating network.

- Buildings can feed waste heat into the district heating network by means of heat pumps.

EXISTING LOCAL HEAT NETWORKS

Currently, a few fossil fuel-based local heat networks exist for supplying housing estates or neighbourhoods in Vienna. They are characterised by central units operated with natural gas or fuel oil and distribute heat for space and water heating via a pipe system. As a rule, the units have no additional energy system; this makes it relatively easy to convert these networks to renewables-based energy systems, as only the central unit needs to be converted. In such cases, biomass may be a suitable solution, since larger units of this kind can be provided with appropriate waste gas purification features. Of course, other renewables-based solutions, such as geothermal energy or connection to the district heating network, may offer an alternative if framework conditions allow.

LOW-TEMPERATURE HEAT NETWORKS (ANERGY NETWORKS)

Local low-temperature heat networks (also called “anergy networks”) can heat and cool several buildings or urban blocks. The temperature level of the water circulating in these networks is low and, hence, entails only minimal losses. The temperature is increased by means of heat pumps and provided as heating energy. One advantage of these networks lies in their suitability for integrating different sources of heat. These different sources of low-temperature heat can be used by every building that is part of the network.

Inter alia, the following sources can be used:

- Geothermal energy from geothermal probes
- Air heat exchangers
- Solar thermal energy
- Waste heat of e.g. shops or offices
- Wastewater heat

Figure 20
Example of a low-temperature heat network.

One great advantage of low-temperature heat networks lies in the fact that they permit the tapping of synergies between buildings in line with their characteristics and type of use: For example, a plot with lots of greenery and space for geothermal probes can provide geothermal energy, while a building with a large, contiguous roof surface can accommodate photovoltaic panels (PV) or hybrid collectors (PVT) and thus provide electricity for operating the heat pump. Such networks are particularly effective if there is demand for both heating and cooling. By the same token, surplus heat generated during the summer months can be seasonally stored in geothermal probes. As a result, a building can be cooled and the size of the geothermal probe field can be reduced.

Decentralised heat networks and low-temperature heat networks are an important solution especially in those densely built-up neighbourhoods where district heating solutions will not be possible. Spatial energy planning will provide a map of areas suitable for this type of heat networks. However, a challenge lies in finding and appointing contractors to build and operate such pipe-based heat supply networks. The relevant framework conditions need still to be clarified.

DISTRICT COOLING

Beside the use of ground-source or groundwater heat pumps, district cooling is one possibility of cooling buildings without further heating up the ambient air in the city. The heat extracted must then be introduced into the district heating network. Due to the fact that cooling is relatively costly and requires distribution via the pipe network, district cooling is above all suitable for areas with a high density of service buildings and where no alternatives are possible. District cooling delivers cold water with a temperature of 7°C to the connected buildings. These can cool the units in use by means of fan coils, ventilation systems or cooling ceilings without releasing waste heat into the environment or causing further heating-up of the city during the summer months.

Heat pump solutions

In recent years, heat pumps have emerged as genuine allrounders. Their suitability for manifold combinations and adaptability to local conditions above all enable these devices to heat and cool many different building types.

Basically, heat pumps function by increasing heat from a relatively low temperature level to one that is high enough to heat and, conversely, cool a building. A range of different media can be drawn upon for heat extraction; air and geothermal energy are most frequently used as sources. Wastewater heat, industrial process heat and groundwater, too, can serve for heating and cooling buildings. In Vienna, it is planned to use primarily ground-based sources of heat. The higher efficiency of geothermal energy solutions vis-à-vis air-to-water heat pumps also has a positive impact on power network development, since less electrical energy is needed on very cold days. Moreover, the noise emitted by air-to-water heat pumps proves an additional challenge in urban areas.

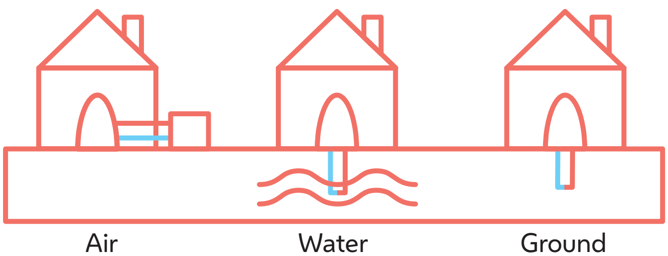


Figure 21
Sources of heat for heat pumps.

COOLING IN THE SUMMER MONTHS

A key advantage of heat pumps lies in their ability to cool buildings during the summer months. Ground-source heat pumps are particularly recommended, since the waste heat resulting from the cooling of buildings is not released into the environment. As a result, the city is not heated up further; rather, the waste heat is transferred to the ground for seasonal storage, to be used during the winter months.

TAPPING VARIOUS SOURCES OF ENERGY

- **Geothermal probes** are suitable for all building types from single-family homes to multi-storey residential buildings. The probes are drilled at depths of up to 300 m and use the internal heat of the earth to heat the building. In the summer, the heat is transported from the building via the probes back into the ground; the probe field regenerates, and the heat is stored underground for the next winter season. At the same time, the building is cooled without releasing heat into the environment.

- **Groundwater heat pumps** – precisely as the name indicates – use groundwater as a source of heat. Large-scale applications by professional energy supply companies are preferable to small-scale ones. These should be entered into a database for all of Vienna to prevent potential negative impacts on groundwater quality and ensure the best possible exploitation of this source of heat. A groundwater management concept for Vienna could serve as a valuable basis to permit effective co-ordination of the use of this energy source. To enable groundwater exploitation, a plot must have a certain size, as the two wells required (supply well and return well) take up some space. Groundwater bodies in Vienna tend to be too warm compared to the undisturbed groundwater bodies outside the built-up municipal territory; as a result, more heat should be extracted from the groundwater than returned to it.

- **Air-source heat pumps** are above all suitable for single-family homes but are used for multi-storey residential buildings as well – also in combination with other sources of heat. Their advantage lies in the fact that they are very efficient in the summer months; however, they are inefficient on very cold days. Reversibly deployed, air-source heat pumps also allow for the possibility of cooling a building. However, the waste heat should not be released into the environment but rather stored in the hot water or fed back into a heating system, e.g. the district heating network. In this way, the heat is used efficiently and does not contribute to the further heating-up of the city. Above all larger systems allow for this possibility.

TECHNICAL FRAMEWORK CONDITIONS FOR THE EFFICIENT USE OF HEAT PUMPS

- The effective use of heat pumps is enhanced by a certain level of energy efficiency of buildings and a centralised system. Buildings that have not been thermally refurbished may have an excessive heat demand; this necessitates a very high flow temperature, which renders the use of heat pumps quite difficult. Although recent years have seen some progress in the development of heat pumps, their deployment has its limits. For example, flow temperatures over 50°C markedly reduce the efficiency of heat pumps. Here,multi-stage heat pump systems could provide a solution.

- In any case, flow temperatures should be as low as possible to ensure the efficient deployment of air-source heat pumps. The use of air-source heat pumps is moreover limited because of the noise emitted by them, as the necessary outdoor units that extract heat from the ambient air need ventilators to function. In densely built-up neighbourhoods, this may make it difficult to obtain an operating permit. Particularly low-noise models can offer a way out without infringing on the rights of neighbours. To keep sound emissions as low as possible, it also makes sense to set up shared building utility rooms and to check the potentials of shared heat supply for several buildings.

- Another aspect concerns space requirements: In addition to the heat exchangers, the heat pump itself as well as a buffer tank and hot water tank must be installed. They can be accommodated either inside the building, on the roof or on available outdoor surfaces.

Figure 22
Geothermal probes for heat supply.

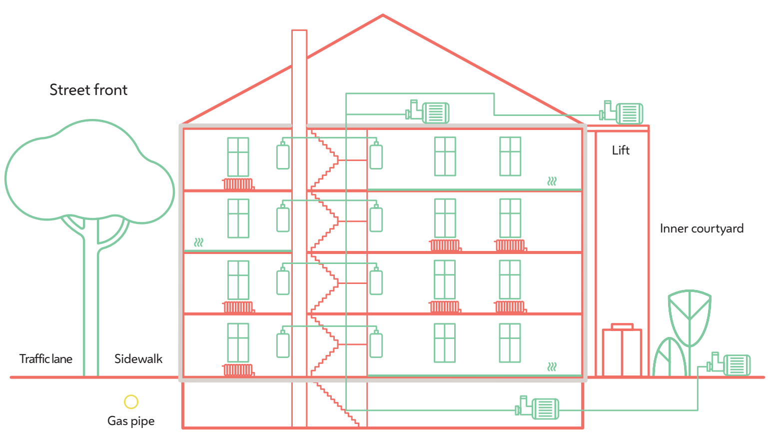


Figure 23
Potential locations for installing air-source heat pumps.

Decarbonisation type 1 buildings have three possibilities to decarbonise their heating systems (which will be centralised in the future):

1. Use of groundwater heat and geothermal energy with geothermal probes and heat pump – these can be installed in the inner courtyard or on the sidewalk in front of the building (if the inner courtyard does not offer sufficient space)
2. Use of ambient air with an air-source heat pump – this may be installed e.g. in the cellar, attic or on the lift well
3. Connection to the district heating system

As a first step, the possibility of refurbishing the building and centralising heat distribution should be evaluated in any case.

GEOTHERMAL PROBES IN PUBLIC SPACE

Since heat pumps combined with geothermal probes are most efficient and offer the advantage of also being able to cool a building, the subject of geothermal probes in public space is intensively discussed. In case of buildings where no (or no sufficient number of) probes can be installed on the property itself, e.g. because of a lack of sufficient green spaces or of adequately dimensioned access for drilling machinery, public space can be drawn upon for this purpose. It is very important to ensure that no structural components that are part of the geothermal probe remain in public land up to a depth of 1.80 m.

Especially for densely built-up areas that cannot be connected to the district heating network, this offers a potential solution to implement innovative renewables-based energy concepts. If several buildings situated side by side phase out their fossil fuel-based gas supply, low-temperature heat network pipes may be laid in public space, thus tapping synergies and combining different sources of heat. More detailed information regarding this aspect can be found under Element 4 "Heat networks".

ELEMENT 6

Adaptation to heat and climate change

In view of rising temperatures and more and more frequent hot days and tropical nights, another important element on the road towards our objectives for 2040 lies in suitably adapting buildings to heat.

Cities are particularly affected by increasing hot spells and extreme temperatures. Due to the high percentage of sealed surfaces, cities heat up easily but are slow to cool down. Hence, vulnerable parts of the population – which include elderly persons, children and socially disadvantaged groups – must be specifically protected against this hazard. These groups find it more difficult to adapt to climate change and rising temperatures; hence, they must be paid more attention to.

Not only sectors such as public space, healthcare or our mobility system but also our buildings and our behaviour in our homes need to be adapted to climate change.

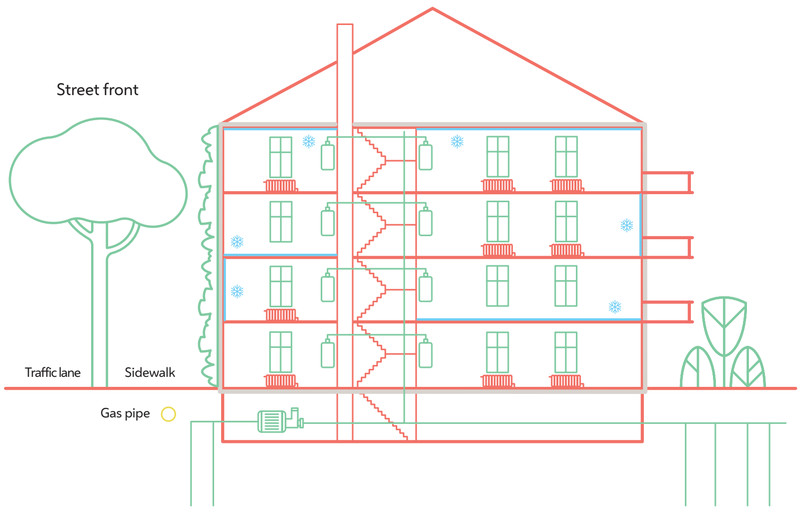


Figure 24
Measures to improve the adaptation to heat.

The installation of **external sun protection** devices is the most effective way to keep our buildings cool and the penetration of heat into buildings and dwellings low, as this method is much more effective than interior shading. Solutions that correspond to monument protection requirements and do not adversely affect the cityscape are already available. Balconies, too, can be used as shading elements.

Other effective measures include **night ventilation** and the correct daytime airing of dwellings. During the night hours, all windows must be opened to permit cool air to enter the building, while sun protection devices reduce the heat caused by solar radiation in the daytime.

The use of **heat pumps** is an active measure for the cooling of buildings, as they not only heat buildings in the winter but also cool them in the summer months. Cold water flows through the pipes and thus dissipates heat. In buildings where heat pumps are not an option, one possibility for space cooling lies in the installation of cooling ceilings.

Split-system air conditioners are not a socially responsible way of cooling buildings in the city, as the ambient air of the city is heated up even more by the heat released from the air-conditioned rooms. As a result, it is cooler inside but the outside air becomes even hotter for other citizens.

To avoid any further heating-up of the city, the **waste heat** of rooms can be fed into the district heating network or a local heat network. Another possibility for the summertime cooling of buildings connected to the district heating network lies in the ex-post installation of geothermal probes.

Building **insulation** offers advantages not only during the winter months: In summer, it affords protection against the too rapid and intense building-up of indoor heat. Top-storey ceiling insulation likewise offers some relief.

Furthermore, buildings can contribute to the adaptation to climate change by creating new green spaces. The **greening** of façades and roofs reduces indoor temperatures. Shading and evaporation keep the exterior wall temperatures down. Trees in inner courtyards and on the streets contribute to cooling the ambient air and provide shade. All of these measures make a valuable contribution to a good microclimate.

ELEMENT 7

Super-efficient buildings

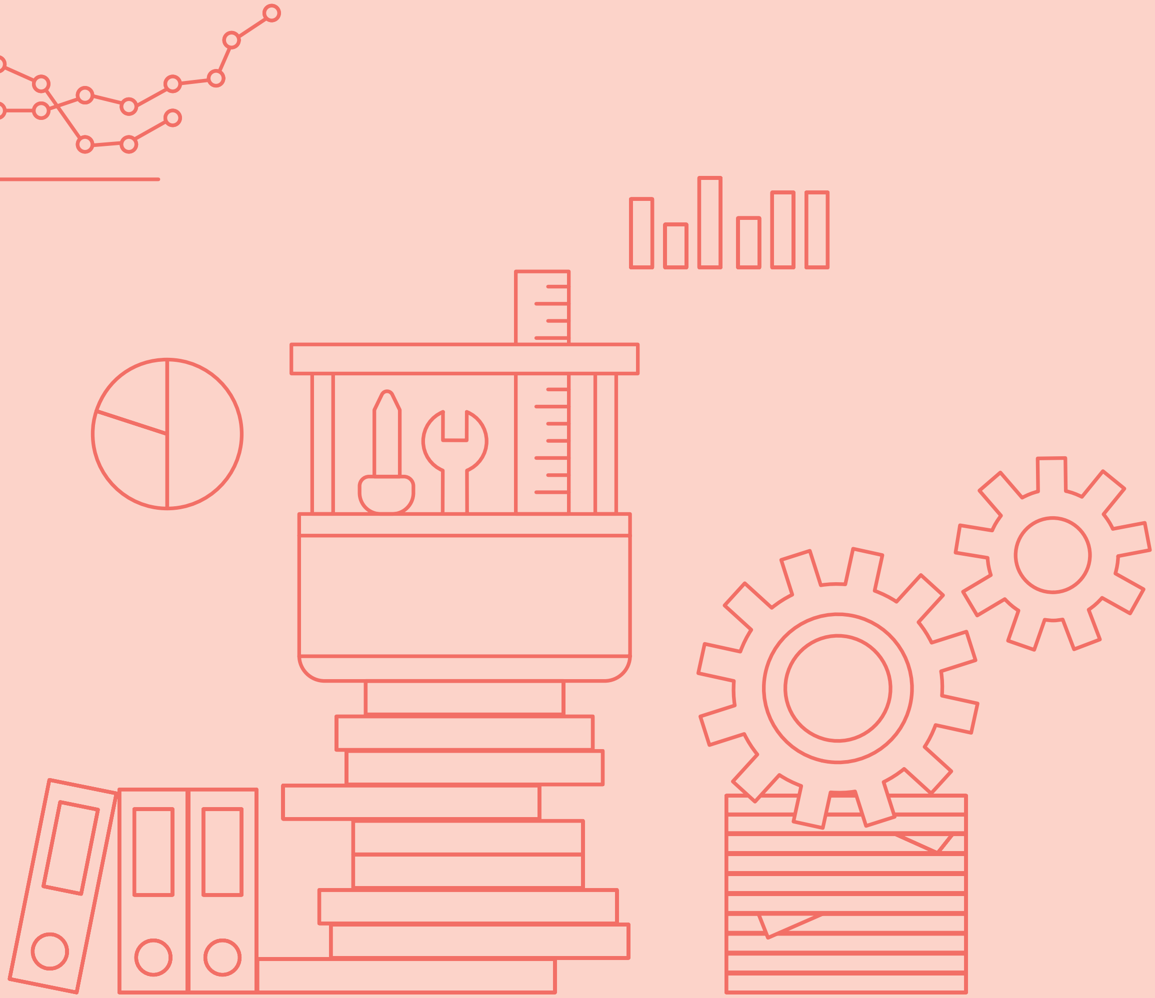
Super-efficient buildings are implemented since they were first developed in the late 1990s. This building type is characterised by an extremely low heat demand of less than 15 kWh (m^2a). However, this level of energy efficiency can only be attained with suitable insulation of the exterior walls, the top-storey ceiling or roof and the cellar ceiling. Special attention must be paid to ensuring the recyclability of all components and the use of eco-friendly materials. In addition, planning and construction must reliably prevent the formation of thermal bridges. The airtightness of the building envelope is particularly relevant for minimising heat losses. By the same token, high quality standards must be met by the windows installed: On the one hand, they must let only minimal heat volumes escape; on the other hand, solar heat gains must be enabled. The use of controlled ventilation with heat recovery for dwellings can further increase the energy efficiency of a building.

If a building can be thermally refurbished at this level, the resulting heat demand is very slight. In case of such buildings, heating can be provided via the controlled ventilation of the dwelling; alternatively, individual small electric radiators can provide the required heat. This eliminates the need for the relatively time-consuming and costly installation of a central heating system in the flats.

Measures against overheating during the summer months must be considered in plans for this building type as well.

4.3 Instruments

"How do we go about it?" is probably the most vital question arising before any major change. The complexity of decarbonising Vienna with its innumerable buildings and enormous variety of framework conditions calls for careful planning to ensure that the right measures will be taken at the right moment. Therefore, this chapter lists instruments to attain and influence the set objective by 2040. These instruments are continuously evolved to safeguard that they will provide the best possible support when implementing the different elements.



INSTRUMENT 1

Spatial energy planning

By embodying **spatial energy plans in Article 2b of the Building Code** for Vienna, a basis for spatial energy planning was created to support the extension of district heating and the use of renewables-based energy sources in new buildings.

The next step will be to extend spatial energy planning to existing buildings and heating systems. In this context, the importance of the analysis of the building stock will increase and, based on this analysis, the various possibilities of converting the energy supply of different building types will be assessed. Depending on locally available sources of energy (availability/non-availability of district heating, potentials for renewables), parameters relating to the structural physics of each building (completed [partial] thermal refurbishment/non-refurbished building, appointments of flats, possibly also monument protection-/protection zone-related considerations) as well as other relevant aspects, appropriate framework conditions must be developed, e.g. in such fields as planning, law and subsidy policies.

These parameters result in different potential solutions across the city, whose development can be supported by spatial energy planning and advanced in co-ordinated fashion. Basically, **three options** for solutions can be distinguished:

1. The first option comprises the further development of the pipe infrastructure, above all of **district heating**. The further expansion and densification of the district heating network is the backbone of tomorrow's climate-friendly building supply.

2. Another potential solution is provided by the locally available **renewable energy sources for the energy supply of individual buildings**. Wherever heat supply by means of heat networks is impossible, individual buildings will be supplied with the energy sources available onsite.

3. The third option is a mix of the first two solutions and combines inner-city energy potentials at the building level with pipe-based energy supply. The idea is to create **local heat networks** that supply a neighbourhood or urban block with locally available energy.

In the course of the “Phasing Out Gas” implementation programme at the Executive Group for Construction and Technology of the City of Vienna, a suitable set of instruments for spatial energy planning for the building stock must be developed and appropriately embodied bindingly in law. This also includes the formulation of corresponding procedures, processes and organisational adjustments in order to facilitate the foresighted planning of network infrastructure expansion and permit the co-ordinated exploitation of renewable energy sources and waste heat in the city.

Moreover, spatial energy planning can give rise to vital **points of contact with other areas of specialisation**. A particularly important aspect in this connection may lie in the combination with building refurbishment to make optimum use of the available energy options and supply as many households as possible. Special subsidies could also be developed for the effective support of energy system conversions; together with spatial energy planning, this would pave the way for optimum results. Finally, planned structural measures in public space could be yoked to spatial energy planning by e.g. combining the redesign of streets with the extension of the energy infrastructure. Infrastructure projects or other large-scale construction sites in public space could be made targeted use of for the expansion of heat networks and the construction of plants to tap local energy sources. For example, geothermal probes could thus be integrated or PV plants could be built in public space, thereby cutting down on investment costs and construction-site noise emissions.

INSTRUMENT 2

Legal framework

In the context of the 2020 "Heat Strategy", the Federal Government and the federal provinces agreed to define a joint framework for heat supply decarbonisation. Numerous working group meetings covering a variety of topics discussed the framework conditions for the switch to climate-friendly heat supply. This resulted in a draft for the Renewable Heat Act (acronym "EWG") as the key legal basis in this field. This is a federal law that stipulates precisely when and how fossil fuels for space heating are to be discontinued. In due course, Austria's federal provinces must then enact relevant administrative laws which comprise accompanying regulations and provisions that are necessary to effectively implement the stipulations of the EWG in accordance with the applicable enforcement regimes. In this connection, a major challenge lies in the fact that the EWG had not yet entered into force in 2022 (and, in fact, had not done so by January 2023). Yet, the relevant provincial laws can only be enacted after the EWG was adopted by the National Council and duly promulgated. This results in a lack of certainty and in time constraints, since regulatory measures must be taken in due time to be able to attain the goal by 2040. Especially since the precise contents of the EWG have not yet been agreed on, various eventualities must be anticipated as best possible, and transitional or "emergency" solutions must be developed.

In conjunction with the enactment of the necessary regulations under provincial law, it must first be decided to which regulatory regime these should be allocated. The applicable provisions of the Building Code for Vienna and the Structural Engineering Ordinance already contain comprehensive specifications that ensure the extensive deployment of renewable energy sources – also in the field of heat supply – at least for new-build projects, additions and modifications as well as larger building renovations. In the context of preparations for the amendments to the Vienna Building Code planned for 2023, it is currently being evaluated how these provisions can be tightened to contribute to the decarbonisation of the building stock.

Regulations fostering decarbonisation could be integrated into the regime of heating and air-conditioning legislation or a still to be created provincial law.

It is indispensable for the enforcement of the upcoming regulations to obtain an in-depth overview of data that give a precise idea of where (i.e. in which premises) fossil fuel-fired heating systems are operated in Vienna. Hence, as a first step, a legal basis allowing for the collection and processing of data is laid so that these data can be made available to the authorities in the form of a database.

Adaptations of other specific administrative laws at the federal level will also become necessary, e.g. of the Gas Act or the different housing-related laws, such as the Freehold Property Act, Tenancy Act or Limited-Profit Housing Act. On the one hand, the conversion of energy systems must be simplified; on the other hand, the coverage of the resulting costs must be equitable and socially viable. The legislative competence in this field lies with the Federal Government. Hence, the problems and need for legal amendments arising in connection with the decarbonisation of the building sector must be put forward to the Federal Government at an early date and in systematic fashion.

Due to the great complexity of abandoning fossil fuel-fired heating systems in a metropolis like Vienna and taking account of the abovementioned uncertainties regarding the contents and moment of entry into force of the EWG, several questions arise, e.g.:

- If the planned EWG is not adopted: Which of the EWG provisions of relevance for Vienna can be decided upon by Vienna as a federal province and/or municipality on its own? Which legal regulations can Vienna adopt at the provincial level?

- According to the currently available draft, the scope of the EWG is limited to space and water heating. Gas stoves are still used in many flats. Which legal regulations can Vienna adopt with regard to gas stoves?

- Often, the conversion of a heating system is only feasible if the building is adequately insulated, etc. Is it possible to stipulate a mandatory obligation to refurbish a building in certain cases? If so, what sort of regulation could this be?

- The adaptation of heating load standards allows for a configuration of heating and cooling systems that reflects the state of the art and reduces investment costs when switching to a renewables-based energy system. How can this be stipulated in a legally binding manner?

- The current EWG draft provides for the use of green gas also for space heating. However, as far as can be gauged today, green gas will not be available in quantities sufficient to cover all applications currently running on natural gas. The production of green gas (hydrogen and synthetic methane) entails significant conversion losses; hence, additional legal regulations are necessary.

- Spatial energy planning in a wider sense plays an important role here, also because a high degree of planning certainty must be ensured for the parties subjected to the related provisions. For this reason, it must be clarified what form the legal framework of spatial energy planning for the current building stock should take.

- Is a legal obligation to exploit waste heat or a ban on the transfer of heat caused by space cooling to the outside environment conceivable, and what form could this take?

Key legal questions in connection with spatial energy planning for the current building stock:

- How can the incentives for connection to an existing heat network be boosted?
- How can a high connection rate to the existing and (future) expanded district heating network or to another heat network be attained?

Enforcement: For authorities, enforcing the regulations for the phasing-out of fossil fuels will constitute a major challenge. Hence, resources must be earmarked and set aside at an early date to be able to cope in particular with the following tasks:

- Data collection and compliance with the duty of notifying the Federal Government

- Notification of the parties concerned of their obligation to convert their energy systems; official granting of any exemptions

- Monitoring and potential implementation of coercive measures to enforce the obligation

- Conducting of administrative court procedures

- Additional time input of various authorities for the approval of admissible renewables-based systems due to the rising number of applications

INSTRUMENT 3

Affordable housing, subsidies and financing

Financial investments are unavoidable to attain the decarbonisation of Vienna as well as our goal of becoming a climate model city. As a first step, planning certainty and security of investment must be established on the basis of jointly adopted goals and procedures for all groups concerned, thereby enabling them to prepare and plan construction projects, co-ordination measures, etc. as early as possible. Legislative adjustments and relevant statements must be reliable. At the same time, it is essential to provide incentives and assistance that on the one hand influence the investment and decision-making behaviour in a way that is compatible with our climate targets. On the other hand, this assistance must balance and prevent social inequalities and lighten the burden on citizens. The decarbonisation types described in Chapter 2 were used to assess the investment volume.

The following table is to provide an overview of the costs of individual measures for buildings. These costs are only estimates – actual implementation costs may differ. Potential subsidies are not included but may markedly reduce costs for the parties concerned.

The following section deals in greater detail with decarbonisation type 1, since this is the most frequent one with regard to the number of units in use. This type covers buildings that have not yet been (comprehensively) thermally refurbished, are currently supplied with gas and have no centralised heat distribution system.

Cost estimate for decarbonisation type 1[24] **Apartment building, decentralised gas supply, not refurbished, built before 2001**		Investment costs in €/unit in use (approx. 70 m^2)
Centralisation	Conversion measures for centralising the heating system – risers	3,000
Individual improvement – electric stove	Conversion measures in the flat for the installation of an electric stove instead of a gas stove (including additional costs for power current connection but without the stove itself)	2,500
Individual improvement – district heating transfer station	Conversion measures in the flat for the connection of one housing unit to the district heating network/ central heat pump (without installation of radiators but with water heating in the flat by means of space heating system)	3,000
Heat pump – air-to-water – centralised	Installation of an air-source heat pump instead of fossil fuel-fired central heating (gas/oil) including all required conversion measures in the central heating station (without measures inside the flat but including all necessary measures involving risers and hydraulic compensation)	9,000
Heat pump – brine-to-water – centralised	Installation of a ground-source heat pump instead of fossil fuel-fired central heating (gas/oil) including all required conversion measures in the central heating station (without measures inside the flat but including all necessary measures involving risers and hydraulic compensation)	12,500

Cost estimate for decarbonisation type 1[24] Apartment building, decentralised gas supply, not refurbished, built before 2001		Investment costs in €/unit in use (approx. 70 m²)
Partial refurbishment	Partial refurbishment (drawing on subsidy for heat demand reduction – "Delta subsidy") aimed at reducing the heat demand by at least 40 %	16,800
Comprehensive rehabilitation of heating and energy system	Comprehensive rehabilitation of heating and energy system to attain a nearly zero-energy building level	28,000

This assessment is to provide a rough idea (quantity structure) of the expected financing volume that will be required to attain the objective of decarbonised heating and cooling in Vienna by 2040.

The present strategy also determines the expected total costs that will be incurred from a present-day perspective. It should be considered that these "total costs" are not necessarily "additional costs", as standard maintenance likewise triggers ongoing costs for the exchange of heating systems and building refurbishment.

To assess the financing requirements, various elements were combined for all carbonisation types and then assigned a monetary value. How often an option will be implemented in the future is contingent on many different factors and cannot be defined or predicted from today's perspective. The total costs are estimated on the basis of a combination of individual cost items with the quantity structure for the decarbonisation types. These calculations are guidelines that can only be regarded as a "snapshot", given the currently highly dynamic situation of the construction sector. Correspondingly, the estimates given here reflect one of many possible situations.

Total financing requirements for decarbonising the building stock	Investment costs relating to building [€ bn, based on 2021 prices][25]
Heating system conversion (without costs for local heat networks and expansion of district heating network)	9,302
Comprehensive rehabilitation of heating and energy system	14,261
Partial refurbishment	5,704
Sum total	**29,267**

[24] Outcomes of WP4 – "Heating and Cooling Vienna 2040" (estimated costs as per 1 January 2022). Prices have significantly increased since then.

[25] Estimated costs as per 1 January 2022. Prices have significantly increased since then.

COSTS OF HEAT TRANSITION (FOR BUILDINGS)

This overview gives an idea of the sums that must be invested until 2040 in order to convert all buildings still supplied with fossil fuel-fired energy to renewables-based solutions. The figure comprises thermal refurbishment measures and the switch to renewables-based energy solutions. This will affect around 608,000 units in use in approximately 74,000 buildings. 608,000 units in use equal around 34,000 conversions or refurbishments annually, resulting in an annual investment volume of close to € 1.6 billion over the coming years.[26] For a general idea as well as for comparison: € 2 billion corresponds to roughly 2 % of Vienna's gross regional product. As mentioned above, only part of this amount of € 2 billion constitutes "additional costs" over a business-as-usual scenario, since large amounts are invested every year in building rehabilitation and building utilities.

To ensure that these investments can be implemented in socially equitable fashion, subsidies are called for and must be planned in due time and communicated to building owners and residents.

Investments in the expansion, densification and decarbonisation of Vienna's district heating network are not included in this calculation. For further relevant information, the study commissioned by Wien Energie GmbH and conducted in 2021 by Compass Lexecon should be consulted (*"Wärme & Kälte, Mobilität, Strom: Szenarien für die Dekarbonisierung des Wiener Energiesystems bis 2040"*). This study does not cover the investment costs for the creation of local heat networks including the required heat pumps and deep drilling. Neither does it comprise the costs of power grid upgrading. Models will have to be developed in the future for the dismantling of the gas network as well as for the remaining gas network[27].

SUBSIDIES FOR THE HEAT TRANSITION

The conversion must be affordable for all inhabitants of Vienna so as to ensure social equity. This means that the relevant subsidy schemes must be stepped up while optimising their orientation at the corresponding target groups. Low-income households must not only be aided financially; rather, information, consultation and support throughout the entire process of energy system conversion are required. Moreover, it will be important to clearly define the roles of tenants and landlords or building owners. The problem of the user/investor dilemma must be taken into account, and suitable solutions to resolve it must be found.

[26] Outcomes of WP4 – "Heating and Cooling Vienna 2040" (estimated costs as per 1 January 2022). Prices have significantly increased since then.

[27] The remaining gas network is needed for supplying industrial applications with green gas.

WHAT MUST BE KEPT IN MIND REGARDING THE FURTHER DEVELOPMENT OF SUBSIDY SCHEMES?

- Long-term budget planning co-ordinated with the implementation plan and the related gradual increase of the subsidy budgets for thermal refurbishment and heating system conversion

- Creating possibilities to pre-finance measures for infrastructure upgrading in order to reduce costs for "pilot converters" and ensure the economic viability of network expansion
- Additional subsidies and support for multi-plot initiatives (gas-free urban blocks and streets) that wish to phase out fossil fuel-fired systems co-operatively
- Well-considered subsidies precisely targeted at specific social groups are needed
- Improved co-ordination of federal and provincial subsidies
- Further development of subsidies for measures aimed at the phasing-out of cooking gas

INSTRUMENT 4

Communication, consultation and support

WE ALL ACT IN CONCERT

The heat transition can only succeed with broad-based support by the general public, citizens and building or flat owners, as it is they who can make the vision of a climate-neutral city transform from idea into reality. Only they can bring about changes in their homes and working environments. The issues of climate change, energy autonomy and self-produced energy are more and more at the focus – they are no longer matters of concern for experts only but also involve the population at large as well as civil society. A common understanding of how the climate neutrality of buildings can be achieved by 2040 is a prerequisite for the concerted action of all parties and the key motivation for citizens to convert their dwellings into climate-proof homes in a spirit of optimism and positivity towards the future.

To be able to attain the goal for 2040, all city dwellers – no matter whether home owners, tenants or building administrators – must be willing to engage with new solutions and place their trust in the new technologies. Many pilot ventures and flagship projects whose renewables-based, already implemented approaches – now considered state of the art – have served as examples indicate that Vienna's citizens look to the future with courage and are ready for a fossil-free era.

It will be the task of the City of Vienna to support the various stakeholders with proactive information and communication measures. A combination of information, independent consultation services, subsidies and a dash of creativity is to significantly support the switch to renewables-based heating and cooling by 2040. This safeguards planning certainty for owners as well as energy service providers, and the principles of spatial energy planning can be implemented in co-ordinated fashion across the city.

CONSULTATION FOR THE HEAT TRANSITION

To efficiently support the process and render the transition to a renewables-based heating system as easy as possible, the City of Vienna offers several assistance services already today; this commitment must be pursued by further expanding the service range.

Since autumn 2020, citizens interested in making their house or flat climate-proof can contact "Hauskunft" – the central consultation point of the City of Vienna – for all questions touching on rehabilitation or heating system replacement. The services of Hauskunft will be expanded on an ongoing basis and adapted to the needs of citizens so as to offer the best possible support on the road towards climate-neutral heating and cooling, since this is the only way to jointly attain the goal by 2040 (see Chapter 3.3).

The Competence Centre for Renewable Energy is a centre of excellence for all issues touching on renewable forms of energy and likewise offers consultation for citizens. In addition, a consultation point for energy communities will be set up at the Competence Centre for Renewable Energy. Renewable energy communities offer a good possibility for citizens to generate and consume electricity and heat on a shared basis. For example, a well-located roof surface of an apartment building can be used jointly to generate photovoltaic electricity, which is then distributed among the residents. These consultation points are complemented by the established format of Urban Renewal Offices offering onsite assistance and support in Vienna's neighbourhoods.

INSTRUMENT 5

Labour market and skilled personnel

In addition to pursuing goals of energy and climate policy, "Heating and Cooling Vienna 2040" will also trigger a strong impulse for Vienna's labour market, since building rehabilitation and refurbishment as well as heating system conversion will require a sufficient number of well-trained craftspeople, plumbers, planners, technicians, etc. in the near future. This raises the important question of how the energy transition can be rapidly implemented from a labour market angle: On the one hand, the ecological transformation offers great opportunities for the creation of additional jobs in Vienna. On the other hand, a lack of skilled personnel and resource bottlenecks in the industries concerned jeopardise the implementation of the intended objectives.

The City of Vienna always aims to combine its environmental and climate policy activities with socio-political measures. In particular, long-term strategies – such as the present "Phasing Out Gas – Heating and Cooling Vienna 2040" strategy – offer the opportunity of reintegrating persons at the margins of Vienna's labour market by means of specific basic and advanced training courses. To obtain reliable facts and figures regarding this crucial instrument, a study will be commissioned in the context of the implementation programme as a co-operation of

Municipal Department 23 – Economic Affairs, Labour and Statistics and the Vienna Employment Promotion Fund (waff).

The objective of the study will lie, on the one hand, in analysing the status quo and, on the other hand, in producing a demand analysis covering the challenges and opportunities for Vienna's labour market. The study is to serve as a basis for the formulation of economic, social and labour-market policy measures and will provide a foundation for further transformation processes.

A key role will be played by the waff Skills Centre.

WAFF SKILLS CENTRE – FOCUS ON DECARBONISATION AND THE SAFEGUARDING OF A SKILLS BASE

The programme of Vienna's provincial government stipulates that a strategic labour market instrument is to be set up at waff as a skills centre for Vienna. The key tasks of the skills centre will lie in compiling quantitative and qualitative analyses of the demand for skilled personnel in Vienna, in preparing strategic options for action to resolve relevant problems and in developing effective measures. Hence, the skills centre will not be a training centre for skilled personnel but rather a competence centre charged with developing problem-solving strategies in concert with various decision-makers and stakeholders. The abovementioned study is to provide a vital empirical basis towards this goal. The official inauguration of the skills centre will take place in 2023 with the presentation of the first status report on the skilled personnel situation of Vienna.

Already now, it is clear that a crucial focus of the waff Skills Centre will lie – in addition to the demand for skilled personnel in the fields of healthcare, nursing and social services on the one hand and digitalisation on the other hand – on the training policy and labour-market policy challenges arising in connection with the **Vienna Climate Guide** (Chapter "Climate protection: Vienna becomes climate-neutral") and, specifically, on the provision of skilled personnel for the implementation of the "Phasing Out Gas – Heating and Cooling Vienna 2040" strategy.

A fundamental challenge lies in the identification of potentials for recruiting additional human resources and, in particular, skilled personnel.

The following target groups/aspects are of special importance in this respect:

- Young people, with a view to their decisions in favour of specific fields of education and training as well as their career choices

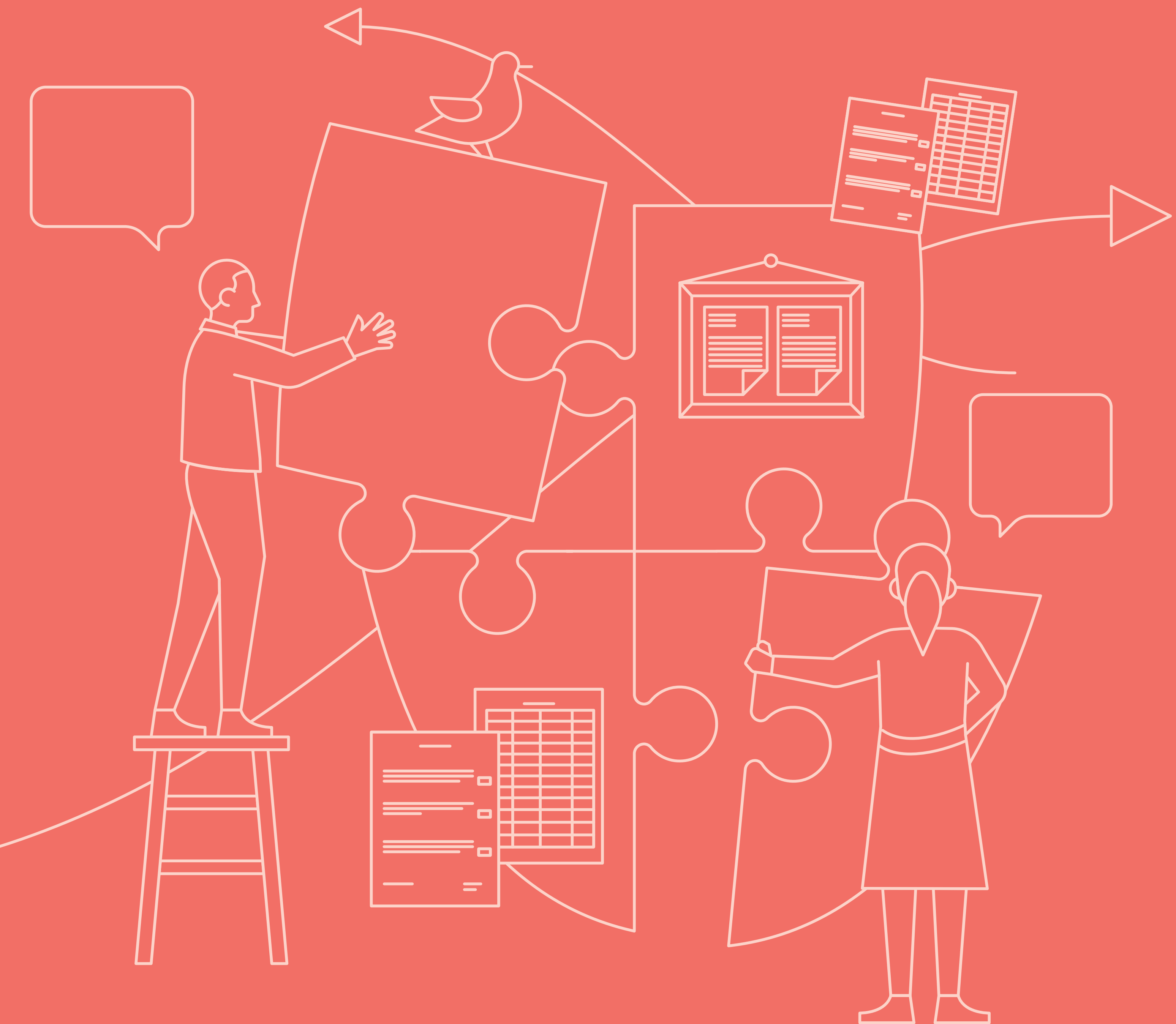
- The potential of persons who have completed no more than compulsory schooling (if at all) and could be motivated to obtain second-chance educational qualifications or to (substantially) upgrade their skills

- Another important group comprises the employees of enterprises handling concrete projects in the context of ecological transformation
- Persons who are currently active in fossil fuel-based industries and whose scope of activities will decline could find new lines of work in occupations concerned with renewable energy sources
- Foreigners (EU citizens or third-country nationals) who are to be recruited for jobs in the field of ecological transformation

In particular with regard to the training for highly qualified jobs, the typically long time required for such curricula must be taken account of. The provision of additional training infrastructure, too, needs some "lead time". Hence, in order to ensure the availability of skilled personnel in the future, the necessary training policy measures must be taken at an early moment.

However, Vienna alone will be incapable of coping with all labour market challenges, since a large share of this responsibility also lies with the Federal Government. The setting of curricula for vocational schools and the number of places at higher vocational colleges – to mention just two examples – are issues that must be tackled at the national level. It will be essential to adapt training programmes as quickly as possible to the new demands of the labour market and the challenges of the future. Working with renewable energy systems, thermal refurbishment projects or the installation of photovoltaic systems can no longer be viewed as an "add-on" but must become part and parcel of basic training. If the climate targets are to be attained, the skilled personnel of tomorrow must also learn in detail about the technologies of tomorrow to be able to apply them effectively.

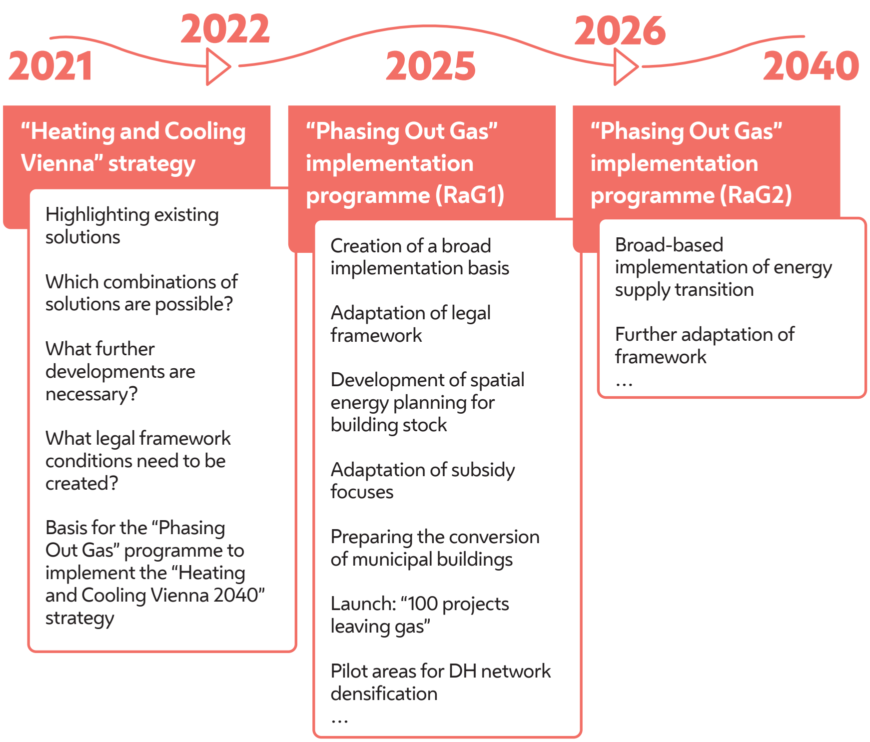
5
The “Phasing Out Gas” implementation programme



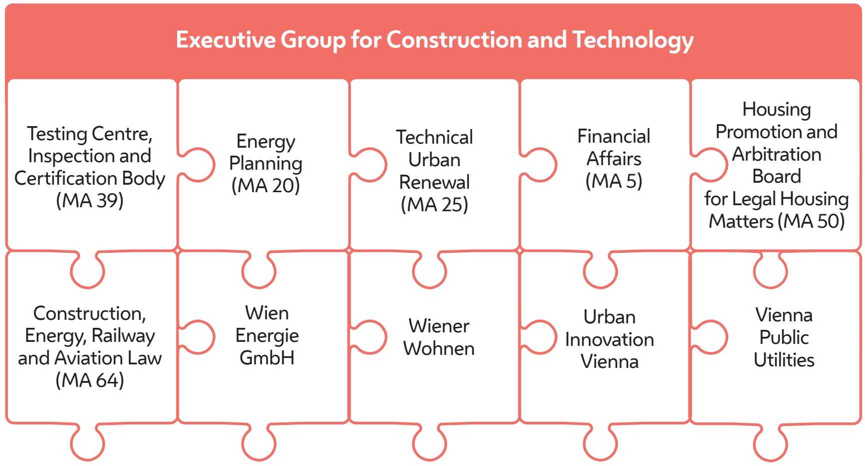
FROM STRATEGY TO IMPLEMENTATION

The present strategy describes the major areas of action necessary to make Vienna a CO_2-neutral climate model city. Of course, a mere strategy is not enough to transform a big metropolis from a city running on fossil fuels into one supplied with renewable energy. Therefore, the Executive Group for Construction and Technology of the City of Vienna launched the implementation of "Heating and Cooling Vienna 2040" already in 2022 with the programme "Phasing Out Gas" (acronym "RaG").

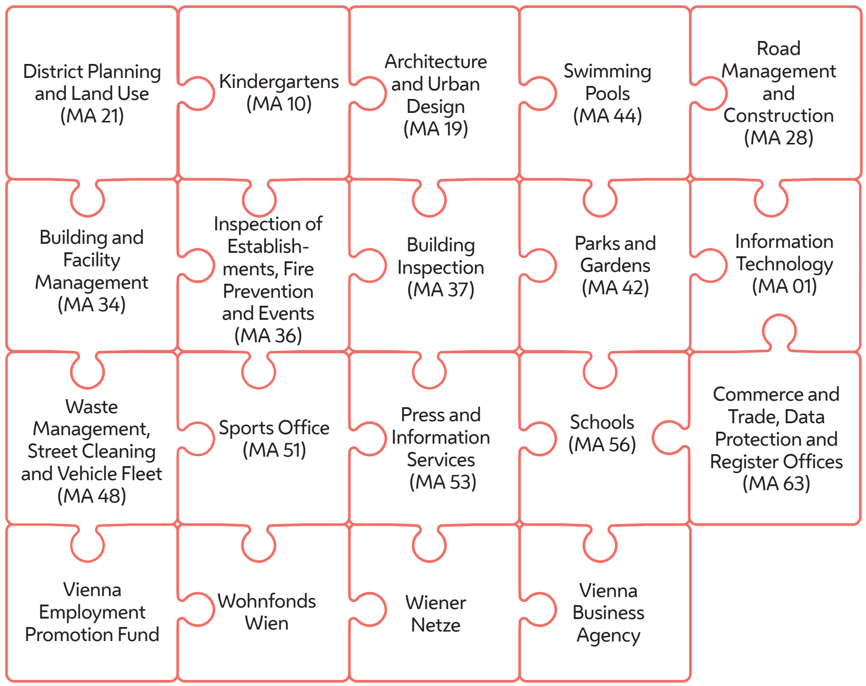
It is planned to structure this programme into two phases. Until 2025, the underlying thematic basis identified by the strategy is to be laid so that a broad-based conversion of Vienna's building stock can begin in 2026.



The RaG 1 programme phase is strategically managed and co-ordinated by the Chief Executive Office – Executive Group for Construction and Technology of the City of Vienna. Numerous municipal departments (acronym "MA"), enterprises and companies of the City of Vienna are involved in the programme. This broad-based team is necessary to ensure that the complex challenge of decarbonising the municipal energy supply can be dealt with comprehensively and holistically.



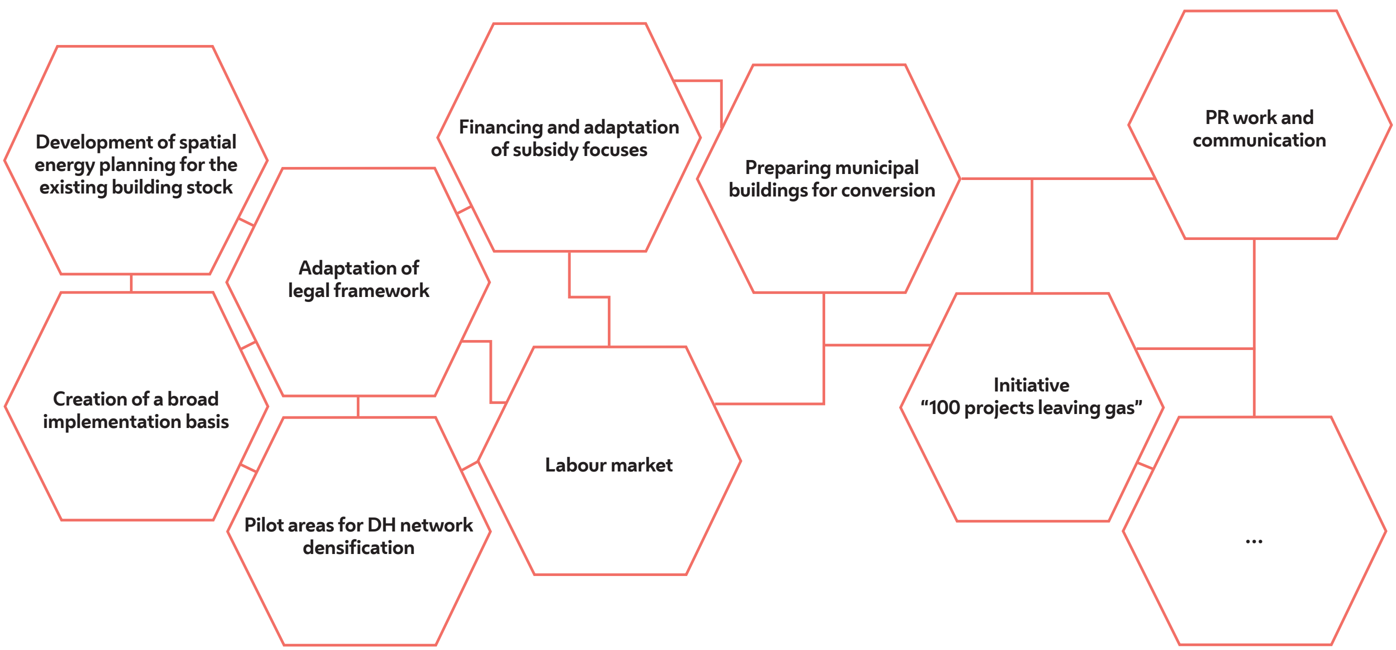
Other important municipal departments, enterprises, companies and funds of the City of Vienna include e.g.:



Vienna's energy supply is largely dependent on fossil fuels. Three quarters of gross domestic consumption originate from fossil energy sources. The demand for space heating - and, hence the demand caused by buildings – accounts for over one third of final energy consumption. If the process heat and electricity needed for the electrical equipment within buildings are also taken into account, the essential role of the building sector for the attainment of the climate and energy goals becomes evident. This is where the heat transition comes into play: In the future, space and water heating as well as energy for air conditioning and cooking (gas stoves) will be provided by means of closed-loop, eco-friendly forms of energy.

In Vienna only, around 600,000 households currently supplied with fossil fuel-based energy must be converted over the next 18 years. Most of them are today supplied by gas at single-flat level; a small part has centralised gas heating for the entire building, and a few tens of thousands of households are still heated with fuel oil. If this number is broken down to day-by-day conversions, this means that 100 households must be converted every weekday over the next 18 years.

To tackle this challenge, intensive work is being carried out to create the necessary basis for the heat transition. In particular, this calls for an adaptation of the legal and subsidy framework. Moreover, the current lack of skilled personnel must be counteracted to permit coping with the structural modifications. To co-ordinate the public tasks arising in connection with the heat transition, the "Phasing Out Gas" implementation programme was established at the Chief Executive Office – Executive Group for Construction and Technology of the City of Vienna.



For example, the programme serves to clarify the concrete financing requirements arising from the heating conversion above all of residential, but also of non-residential buildings as well as of municipal administrative buildings.

PR and communication strategies will be developed, on the one hand, to communicate the projects of the City of Vienna for attaining the climate goals and, on the other hand, to support acceptance of the measures on the part of citizens.

A study will highlight those areas of the labour market that need to be strengthened to ensure access to a sufficiently large pool of skilled personnel.

Other phases will be aimed at optimising the subsidies available for the attainment of the overarching goal as well as at adapting the relevant provincial laws.

Spatial energy planning for the current building stock is to identify those parts of the city that can be connected to the district heating network as compared to those parts where locally available energy sources should primarily be drawn upon.

In the context of the programme, pilot projects conducted in properties operated by Wien Energie GmbH and Wiener Wohnen as well as in municipal buildings and properties of low-profit and private project developers and building owners are to be initiated. These pilot projects are to serve as venues for testing and evaluating viable technical solutions to permit the rollout of the most suitable measures across the whole city.

In particular, the initiative "100 projects leaving gas" will help to obtain an overview of the specific requirements of variously appointed buildings dating from different periods. Technical solutions to rehabilitate buildings highly efficiently and convert them to sustainable forms of energy do exist. Now the task lies in establishing which methods best combine economic viability with benefits. An effective monitoring system is to document the success of the energy transition.

The programme interacts closely with other projects of relevance for the climate target of the City of Vienna, e.g. closed-loop or urban renewal campaigns such as WieNeu+ and WirSanWien.

Finally, the critical success factors of the "Phasing Out Gas 1" programme will serve to prepare the large-scale rollout in the context of "Phasing Out Gas 2" (starting in 2026). The rollout will draw on the basis established for the energy transition as well as on the key findings of the first programme phase.

Vienna tackles the challenge proactively.

Vienna does not wait for an uncertain energy future to arrive.

We shape the energy future to become a CO_2-neutral climate model city.

Glossary

CLIMATE-NEUTRAL
The basic principle of climate neutrality lies in quantifying and containing all climate-damaging activities, e.g. by directly avoiding, reducing and compensating greenhouse gases (source: University of Natural Resources and Life Sciences, Vienna: klima-neutralität.boku.ac.at/en/was-ist-klimaneutralitat/).

COMBINED HEAT AND POWER (CHP)
CHP (combined heat and power) is the combined simultaneous generation of electrical energy and heat, e.g. in a cogeneration plant.

COOLING
This refers to temperature control inside a building. Cooling may be passive (e.g. by means of external sun protection devices, ventilation) and active (e.g. air conditioning by means of split-system air conditioners). Heat pumps can be used for either active (with reversible heat pumps) or passive cooling (natural cooling; only the circulation pump is used).

"DELTA SUBSIDY"
This term defines measures aimed at reducing heat demand by a certain value (source: ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrW&Gesetzesnummer=20000091, German).

DISTRICT HEATING
District heating is the central supply of heat consumers by means of a large-scale network for the provision of space and water heating and/or process heat. As a rule, the thermal energy is transported in insulated underground pipe systems via a heated medium (usually water or steam).

EMISSION-FREE
This means that a process does not cause greenhouse gas emissions.

FLOW TEMPERATURE
This refers to the temperature of the water introduced into e.g. radiators or underfloor heating systems (source: energie-lexikon.info/vorlauftemperatur.html, German).

GREEN GAS
Green gas is also called "renewable gas". So far, gases from renewable sources include:
- Biomethane produced from biogas, landfill gas, gas from purification plants, wood gas or other sources
- Hydrogen produced by means of electricity from renewable energy sources
- Synthetic gas produced from renewable energy sources
- Other renewable gases (source: e-control: e-control.at/konsumenten/was-ist-gas-aus-erneuerbaren-quellen, German)

HIGH-TEMPERATURE
High-temperature process heat refers to temperatures in excess of 500°C.

HOUSING ESTATE
As a rule, a housing estate is composed of at least one residential building and one or several other residential buildings, which may have multiple storeys, and/or other facilities characterised by a common structure, such as children's playgrounds, shared amenities, green spaces, a footpath network, car parks, etc.

LOW-TEMPERATURE
Low-temperature heat can be used in anergy, local and district heating networks.
Low-temperature networks have larger pipe cross-sections and lower distribution losses. Flow temperatures of approximately 55°C are used to release low-temperature heat to indoor premises via radiators. In case of surface heating systems, the flow temperature can be lowered to a minimum of 25°C (source: geothermie.de/bibliothek/lexikon-der-geothermie/n/niedertemperatur.html#:~:text=Ein%20Niedertemperaturheizsystem%20ist%20ein%20auf,der%20Regel%2090%20%C2%B0C, German).

LOW-TEMPERATURE HEAT NETWORK/ANERGY NETWORK
This is a pipe network in which a heat transfer medium – usually water – circulates at a temperature range of about 5°C to 18°C throughout the year. Due to these low temperatures, anergy networks are characterised by markedly lower losses than traditional local heat networks. Anergy networks are often used in combination with energy storage by means of geothermal probes. The network temperatures offer optimum basic conditions for efficient heating by means of heat pumps but may also be used directly for free cooling. Anergy networks can serve to exploit synergetic interactions between different building categories (e.g. service buildings and residential buildings). It is important to observe a good energy balance of heating and cooling. For example, excessive heating during the winter months can be compensated with solar energy surpluses during the summer season.
To cover peak loads, such networks can also be coupled very effectively with district heating (ideally with return flow). Buildings supplied by anergy networks should be provided with surface heating systems to make efficient use of the low temperature level (source: Thematic concept "Spatial energy planning": digital.wienbibliothek.at/wbrup/download/pdf/3598198?originalFilename=true, German).

NEIGHBOURHOOD
In this context, the term describes an area that its inhabitants perceive as being part of their everyday living environment. Usually, this comprises a zone that accommodates all facilities that can be easily reached on foot. However, the extension of a neighbourhood also depends on natural boundaries (source: gbstern.at/, German).

PVT PLANT
This is an installation that combines photovoltaics and solar thermal energy generation, hence producing electricity and heat simultaneously.

URBAN BLOCK/BLOCK OF BUILDINGS
An urban block comprises a space encompassed on all sides by streets, natural or structural boundaries (source: regioplaner.de/struktur-daten/grenzen, German).

WASTE HEAT
Waste heat is heat resulting from processes as a by-product. This includes above all the waste heat of waste incineration plants, highly efficient CHP plants, industrial and commercial processes (supermarkets, computer centres, …).

WASTEWATER HEAT
Wastewater heat contained as a by-product in urban wastewater (e.g. from kitchens or bathrooms) or wastewater from industrial processes is used for water heating.

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Phasing Out Gas

Heating and Cooling Vienna 2040