



# SWEET Call 1-2020: DeCarbCH

## Deliverable report

<b>Deliverable n°</b>	M6.3
<b>Deliverable name</b>	From 2000W to net-zero: the evolving frame conditions for thermal grid development in the city of Zurich
<b>Authors</b> The authors bear the entire responsibility for the content of this report and for the conclusions drawn therefrom.	Speich, Matthias Kammer, Adrian Eberle, Armin  ZHAW Zurich University of Applied Sciences Institute for Sustainable Development <a href="mailto:matthias.speich@zhaw.ch">matthias.speich@zhaw.ch</a>
<b>Delivery date</b>	03/2024

### Table of contents

<b>Summary</b> .....	<b>2</b>
<b>List of acronyms</b> .....	<b>3</b>
<b>1 Introduction</b> .....	<b>4</b>
<b>2 Material and Methods</b> .....	<b>5</b>
2.1 Analytical framework .....	5
2.2 Source material .....	8
<b>3 Results</b> .....	<b>9</b>
3.1 General context .....	9
3.2 Current frame conditions for the development of thermal grids in Zurich .....	10
3.2.1 Environment: politics, supply-side markets, demand-side markets .....	10
3.2.2 Public value account of thermal grid development .....	13
3.2.3 Governance, regulatory framework and instruments .....	16
3.2.4 Current state of infrastructure and planned developments .....	23
3.2.5 Business model and value network .....	32
3.2.6 Supporting resources .....	43
<b>4 Concluding discussion</b> .....	<b>44</b>
4.1 Learnings .....	44
4.2 Learning opportunities and outlook .....	47
<b>5 References</b> .....	<b>48</b>
<b>Appendix</b> .....	<b>52</b>



## Summary

As cities and municipalities in Switzerland commit to net-zero greenhouse gas by the middle of the century or earlier, aligning local energy policy, planning, and business models becomes imperative. This report examines Zurich's measures towards achieving its 2040 net-zero goal, with a focus on thermal grid planning, operation, and governance. Structured according to WP2's analysis framework, the report examines six dimensions: local and environmental factors, public value dimensions, governance, infrastructure status, business models, and supporting resources. Drawing from various sources including municipal bills, policy documents, media reports, and research findings, the report aims to document Zurich's accelerated transition to assist other municipalities facing similar challenges. Zurich's unique political landscape and resources make it an exemplary case, so that documenting and disseminating its policies helps other municipalities to manage their net-zero transition. Additionally, the report serves as a knowledge hub for researchers, aiding in project proposal development by identifying current city challenges and needs.

The city's strategy involves integrating various energy potentials and implementing regulatory, organizational, and financial measures to accelerate decision-making and implementation. Notable changes include continuous strategic energy planning, a new net-zero monitoring instrument, and governance adjustments for fast decision-making. The report identifies successes, such as high demand for financial support and progressing grid expansion. However, challenges like infrastructure planning complexities and limited influence on building owners remain. Zurich serves as both an extreme and critical case, offering insights into effective policies, organizational measures, and technical solutions for transitioning to net-zero. Learning opportunities include studying customer reactions to tariff incentives, the success of renewable products, and the impact on the local business ecosystem.



## List of acronyms

2000W	2000 Watt (Society / targets)
CHF	Swiss francs
ERZ	Entsorgung und Recycling Zürich
ewz	Elektrizitätswerk der Stadt Zürich
GHG	Greenhouse gas(es)
HVAC	Heating, ventilation and air conditioning
MCHF	Millions of Swiss francs
NZZ	Neue Zürcher Zeitung
Rp.	Rappen (=centime, 1/100 of a Swiss franc)
WVV	Wärmeversorgungsverordnung (ordinance on heat supply)



## 1 Introduction

**Background:** In Switzerland, thermal grids have become a key instrument of cities and municipalities to reduce GHG emissions from the building sector on their territory. To meet decarbonization goals and timelines, many municipal energy strategies foresee the development and expansion of thermal grids into new districts, as well as the densification and modernization of existing grids. This requires considerable investments as well as a substantial transformation of existing infrastructure. These changes, in turn, often entail organizational reconfigurations, business model adjustments and the development of new resources such as: policy, planning and legal instruments; data and knowledge pools; communication channels and platforms; etc. Indeed, as the strategic significance of thermal grids for energy and climate policy increased since about 2010, a quantitative growth of the number and size of grids has been accompanied by the development of new business units in utilities, increased quality standards and professionalism, expertise codified in guidelines and standards, etc. A number of political decisions (such as the Federal Council's adoption of the net-zero target by 2050 in 2019; various cantonal laws prohibiting the installation of new fossil fuel-based heating systems; or various cities adopting a more ambitious net-zero timeline than the federal government) led to favorable conditions for the development of thermal grids and have contributed to the momentum in the industry. Also, shifting perceptions of customers on energy independency and security generate a high willingness to connect to a thermal grid.

**Problem situation:** Despite these favorable developments, sizeable obstacles remain for a development of thermal grids in accordance with municipal decarbonization timelines. A shortage of qualified workers (such as engineers, technicians, construction workers) limits the capacity of cities, utilities, and engineering and construction firms to realize thermal grids according to schedule. Furthermore, planned developments foresee the integration of diverse energy sources at varying temperature levels, which often entails modernization of existing grids. This greatly expands the number of technical decisions to be taken, making it difficult to select the appropriate technical configuration of future thermal grid systems. In addition, such developments require further coordination between diverse actor groups: cities and utilities must coordinate with – or are at least partly dependent upon the choices made by – building owners (as customers to be acquired and retained, but also regarding building retrofit, efficient energy consumption and willingness to support demand-side management schemes), building professionals (as point-of-sale actors influencing building owners' choice of heating system, but also regarding the fit between primary-side and secondary-side installations, including the interface, i.e. the substations), potential excess heat providers such as data center operators, etc. These challenges make it difficult to formulate policy mixes that ensure alignment between municipal decarbonization strategies, utilities' business model, building owners' choices and complementary actors' routines. Importantly, the challenges of developing thermal grids are often situation-specific and locally embedded, making it difficult to devise policies and measures that are easily transferrable from one district, city or country to another (Paardekooper et al., 2022; Weisskopf et al., 2022).

**Aims and research questions:** The aim of this study is to give an overview of the governance of thermal grid development in the city of Zurich. Given the difficulty of formulating easily transferrable measures (see above), this study takes a broad view and aims at identifying the local determinants of thermal grid development, including their interaction with broader political, economic and social frame conditions. As a case study (Flyvbjerg, 2006), it aims to generate useful knowledge from the in-depth description of a single case. Potential addressees include decision-makers in other cities and regions in Switzerland and abroad, who can compare challenges and success factors in Zurich with their own region. For the actors involved in Zurich, a comparison with the development in other selected cities provides the opportunity to reflect current practices. Finally, for the research community, this case study helps develop a shared understanding of the organizational issues around thermal grids.

In a narrow sense, the purpose of this report within SWEET-DeCarbCH is to give a complete view of the organizational setup, the policy, planning and legal instruments, and other resources, such as data and knowledge pools, which form the frame conditions for the development of thermal grids in the city



of Zurich. However, we believe that such an analysis is much more valuable if this overview is embedded in its context. We therefore characterize the thermal grid infrastructure, as well as the organizational and instrumental elements enumerated above, as the current outcomes of a decades-long, ongoing, and path-dependent process in which they are shaped by evolving public policy goals, controversies and frames. Such a broad and dynamic perspective allows to answer not only which system is currently in place but also which functions this system is supposed to fulfill – in other words, to describe the spirit, rather than just the letter, of the current instruments. Such a perspective allows the assessment whether, or not, a particular policy mix, business model adaptation or individual measure can be expected to work well if transferred to a different context.

From these considerations, we propose the following research questions:

- How is the transition from the 2000W to the 2040 net-zero goal reflected in the organizational, regulatory and policy frame conditions for the development of thermal grids in Zurich?
- What can be learned from the past and current development of thermal grids in Zurich, now and in the coming years?

According to (Flyvbjerg, 2006), an effective strategy to yield generalizable insights from a case study is to select a case that stands out, e.g., a case with particularly favorable or unfavorable frame conditions. We consider Zurich as such an extreme, but also a critical case for the following reasons: with its high level of political support, its local expertise and its available financial resources, Zurich is taking a pioneering role in the transition towards net-zero. At the same time, technical, infrastructural and organizational complexity make the planning and implementation of thermal grids particularly challenging here.

## **2 Material and Methods**

### **2.1 Analytical framework**

The analytical framework (Figure 1) represents the geographically and sectorally defined socio-technical system through five constituent elements and eight linkages between them. Its purpose is to put the description of the constituent elements in relation to each other and identify misalignments between them. Analysis therefore takes place at two levels: internal consistency within the constituent elements, and consistency between them. The framework is based on the co-evolutionary business ecosystem perspective (Speich & Ulli-Beer, 2023), adapted here to accommodate the role of policy and regulation



more explicitly. The individual building blocks of the framework are analyzed separately, as per the description in Table 1.

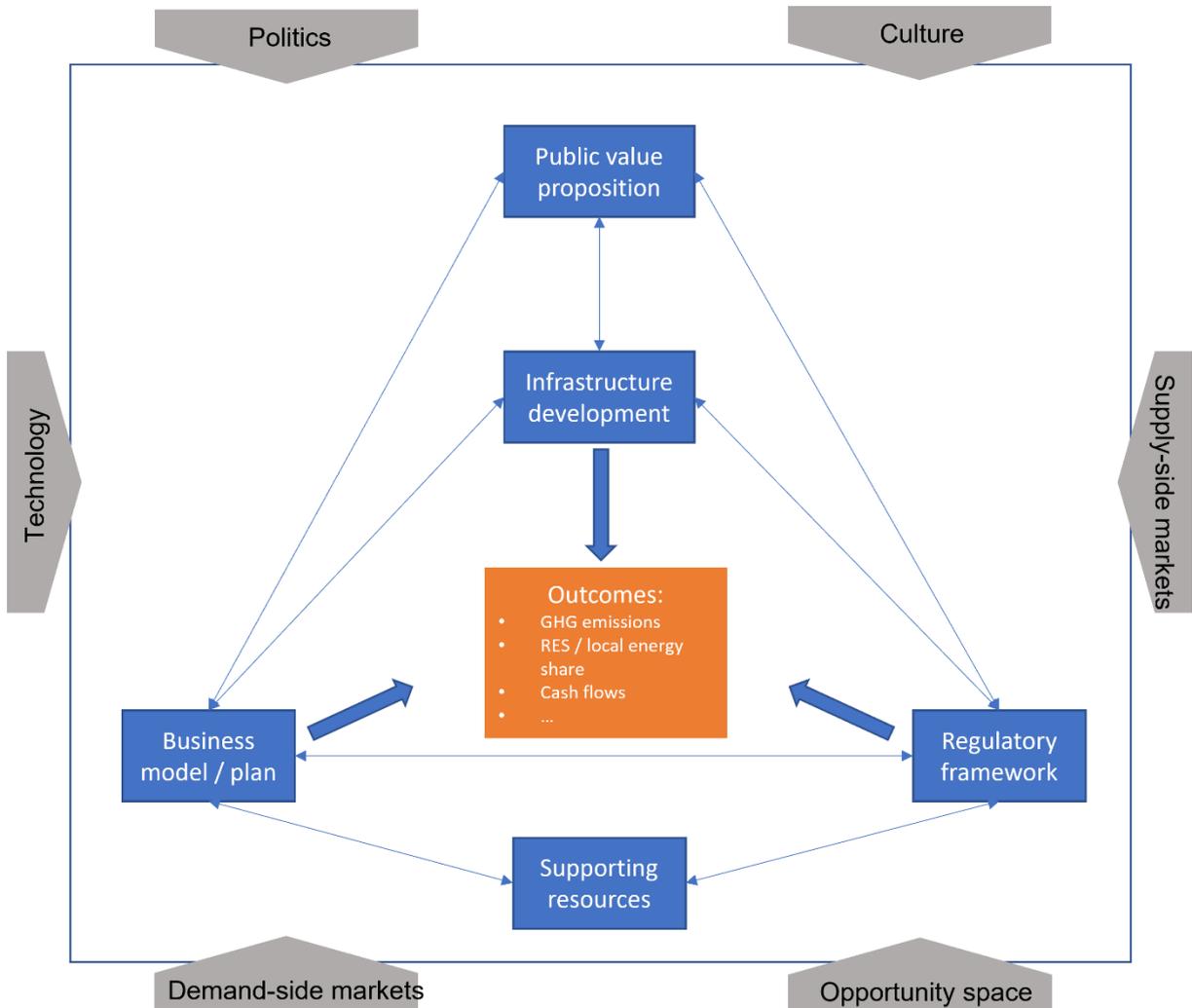


Figure 1: Analytical framework

Table 1: Description of the different elements of the analytical framework

Constituent element	Main components	Questions to assess internal consistency
Public value proposition	An account of the benefits expected from the proposed infrastructure development: how do these benefits justify the use of public funds and/or authority?	<ul style="list-style-type: none"> <li>• Are there trade-offs involved between the expected benefits?</li> <li>• Is there a common understanding of the public VP within the ecosystem?</li> <li>• Is the public VP contested by some actors?</li> </ul>
Infrastructure development	Target infrastructure, planned development timeline.	<ul style="list-style-type: none"> <li>• Is the proposed infrastructure development technically feasible?</li> </ul>
Business model / plan	Actors, activities and exchanges within the value	<ul style="list-style-type: none"> <li>• Are there unresolved conflicts of interest or</li> </ul>



	network; cost and revenue structure; pricing model; customer value proposition; planned investment and financing timeline; controlling processes.	of goals within the value network? <ul style="list-style-type: none"><li>• Does the pricing model adequately reflect the cost structure?</li></ul>
Regulatory framework	Laws and bylaws at all administrative levels, planning instruments and processes, financial instruments.	<ul style="list-style-type: none"><li>• Are there contradictions between laws at different administrative levels?</li><li>• Are planning and financial instruments in line with existing regulation?</li><li>• Do actor roles in the planning process match with those foreseen by regulation?</li><li>• Are the foreseen financial instruments permissible under existing regulation?</li></ul>
Supporting resources	Data and knowledge bases, decision-support tools, communication channels (e.g., platforms), networks, ...	<ul style="list-style-type: none"><li>• Are there redundancies between existing resources (e.g., several uncoordinated data collections)?</li><li>• Is there unexploited potential in the combination of existing resources?</li></ul>

The elements of the framework are discussed in the following order:

- An introduction and overview of the problem situation is given in Section 3.1.
- The main environmental dimensions (Figure 1) are discussed in Section 3.2.1.
- The public value account (Moore, 2014) of the city's current strategy for the heating transition (with a focus on thermal grid development) is established in Section 3.2.2.
- Section 3.2.3 presents the governance arrangement for thermal grid development in Zurich as well as the regulatory and policy instruments.
- Section 3.2.4 describes the current state of infrastructure development, as well as past developments and future plans.
- Section 3.2.5 discusses the business model and the value network, i.e., the involved actor groups and the economic interactions between them.
- Section 3.2.6 discusses the role of supporting resources, in particular the knowledge base around thermal grids.



## 2.2 Source material

This report is based on the analysis of secondary, publicly available sources. The large number of publications related to the topic precludes an exhaustive inventory of all relevant sources. Rather, the sources were selected to appropriately describe the elements of the analytical framework, using information saturation as a stopping criterion. In particular, the following materials have been used:

- Proceedings from the municipal council, and communications by the city council. These documents are publicly available on the city’s website. For proceedings of the municipal council, the entry for each bill contains several documents (e.g., text of the original bill, statement of the executive council, commissioned report, discussion protocol, etc.). To facilitate referencing, this document references each bill by its official number (e.g. “GR 2023/269”). A list of the referenced bills, with links to the corresponding webpages, is provided in the Appendix.
- Further political documents, such as the annual budgets and accounts, available from the city’s website
- Public energy policy documents: current and past versions of the documents that describe and/or form the city’s energy policy instruments, available from the city’s website.
- Communication and reporting material of the involved organizations: annual reports, websites, presentations.
- Official statistics (e.g., Statistical Yearbook of the city, data tables and geodata available as Open Government Data).
- Media reports, in particular from the two Zurich-based daily newspapers Neue Zürcher Zeitung (NZZ) and Tages-Anzeiger, but also smaller local outlets.
- Applied research literature related to the development of thermal grids, as well as energy policy in general, in the city of Zurich. For example, results from the research program Energieforschung Stadt Zürich, or studies commissioned by the city authorities to answer specific questions, have been considered. Also, relevant articles from Swiss trade publications were used.

This report is intended to be an information hub / point of entry for researchers and partners (from the SWEET-DeCarbCH project and beyond) which may not be familiar with the situation in Zurich. It therefore synthesizes and structures insights from the various sources listed above, providing an overview of the infrastructural, organizational and socio-political frame conditions for the further development of thermal grids in Zurich. This should help in the definition of proposed research projects, e.g., through the identification of current challenges. Also, we believe that this list of sources will be useful for additional research, e.g., keep track of new developments or research topics not covered in this report (Figure 2).

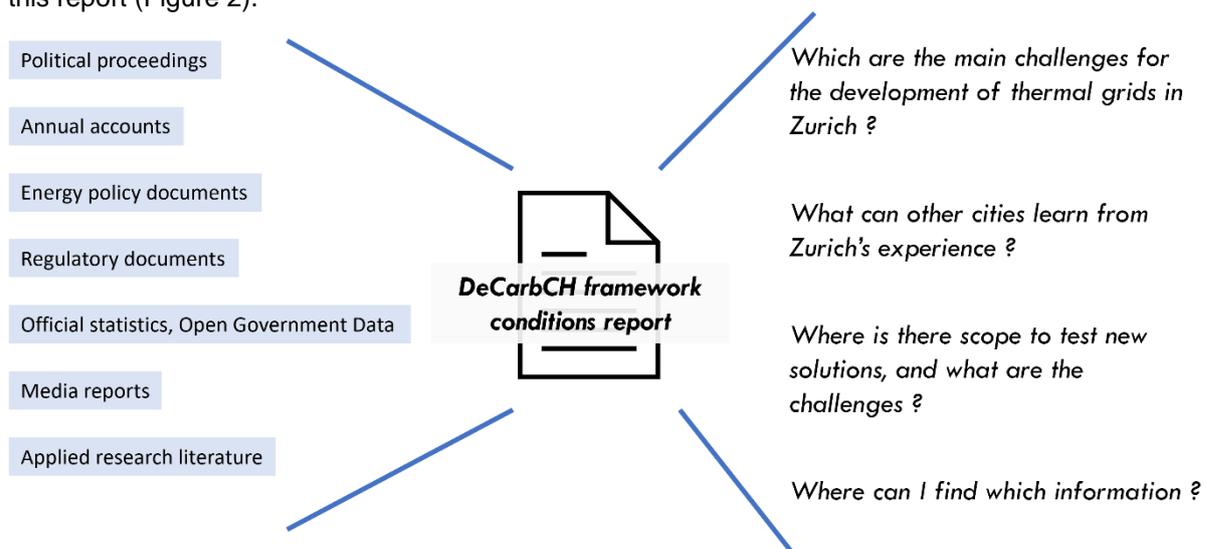


Figure 2: Intended function of this document as a synthesis of multiple data sources and as an information hub.



### 3 Results

#### 3.1 General context

Zurich is a city of currently 427'000 inhabitants located in Switzerland. It is the capital of the Canton of Zurich, the most populous of the 26 Swiss Cantons (i.e., member states), with approximately 1.5 million inhabitants. The city has an oceanic, temperate climate characterized by a distinct heating season between mid-September and mid-May.

In recent years, annual final energy consumption in the city across all sectors (heating, electricity and transport) amounted to 9'400 GWh (Figure 3), i.e., approximately 22 MWh/a per capita. This translates into annual GHG emissions of 4.3  $t_{CO_2eqv}$  per capita, of which approximately half originate from heating (Figure 4). While final energy consumption decreased by 10% between 1990 and 2020, the decrease in GHG emissions per capita was more pronounced, as these amounted to 6.17  $t_{CO_2eqv}$  in 1990 and reached a maximum of 6.75  $t_{CO_2eqv}$  in 2002. These changes occurred despite a simultaneous increase in population by 22%. The building sector has so far played an important role: this decrease is due to a large extent to improvements in building energy efficiency and to substitution of fossil-fuelled heating systems with decentral renewables-based systems and connections to thermal grids (Stadt Zürich, 2023a). Among other factors that influence these time series, economic activity has been cited: a decrease in GHG emissions in the early 1990s coincided with a recession, whereas the subsequent economic pick-up, from 1998 on, was accompanied by a renewed increase in GHG emissions (Tages-Anzeiger, 2002).

#### Endenergiebilanz 1990 bis 2020

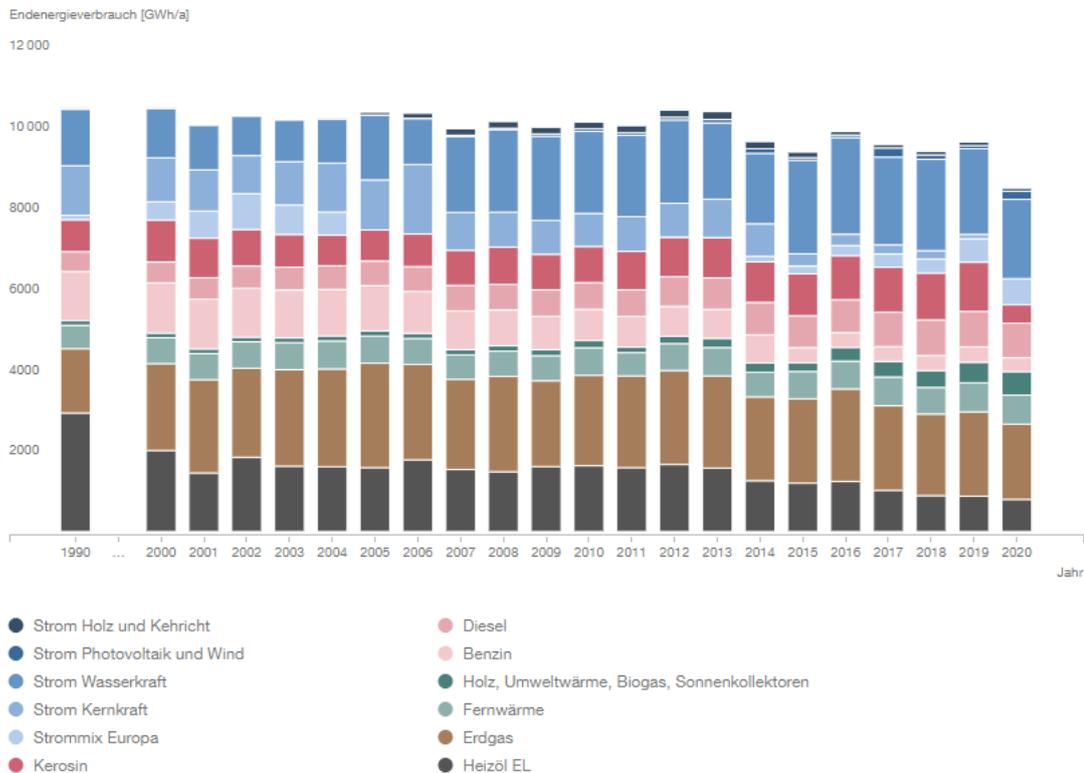


Figure 3: Final energy consumption in the city of Zurich across all sectors: heating (brown/green), transport (red) and electricity (blue). Source: Stadt Zürich (2023).

Under Switzerland's federal political system, cities have considerable autonomy in formulating their energy policy, as long as it is compatible with cantonal and federal policies (Hofmann & Richert, 2016). In Zurich, as in other Swiss cities, reducing GHG emissions is an important public priority and has



therefore greatly impacted the city's energy policy. Concretely, the city's voters have decided to adopt the goals of the 2000W-society in 2008 (striving for an average per-capita primary energy use of 2000 W, and annual per-capita GHG emissions of  $1 t_{CO_2eqv}$ , by 2050). In 2022, the target of net-zero GHG emissions by was adopted, which corresponds to a much more ambitious timeline: under the previous targets, the intermediary goal for 2035 still allowed for  $2.5 t_{CO_2eqv}$  per capita. A massive expansion of thermal grids, from one quarter to two thirds of the city's built-up area, was identified as a key measure to reach the 2040 net-zero goal (INFRAS & Quantis, 2020). The same report, which was commissioned by the city while preparing for the net-zero decision, also lists necessary accompanying measures: decarbonization of peak heat supply in thermal grids, phase-out of the natural gas distribution infrastructure, incentivization of building retrofit and heating system replacement.

Although industry has historically played an important role in the city's development, sustained structural change since the 1960s has deeply transformed the representation of sectors in the city: in 2015, the industrial sector represented only 7% of jobs, whereas this share was more than 50% a century earlier (Stadt Zürich, 2018). Former industrial areas were replaced or converted into residential, commercial, office or mixed-use areas. As a result, process energy plays a marginal role in the city's energy mix today, and this report will focus on space heating and cooling.

## Treibhausgasbilanz 1990 bis 2020

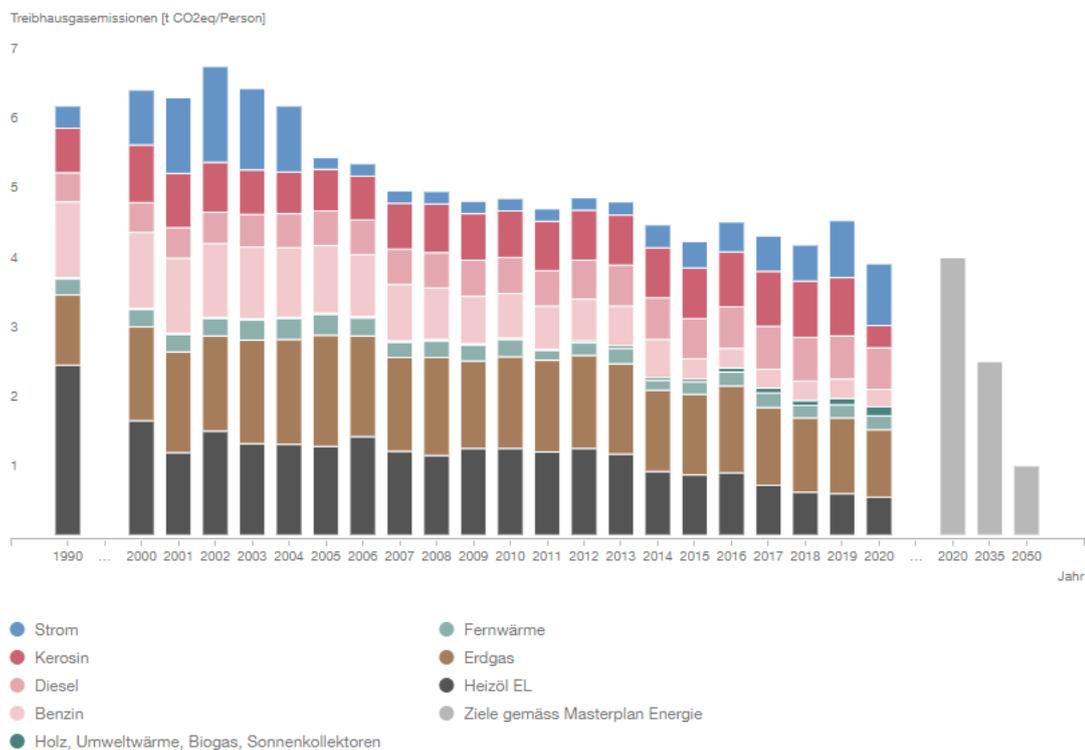


Figure 4: GHG emissions from the city of Zurich across all sectors: heating (brown/green), transport (red) and electricity (blue). Note: the future targets on the right side of the graph are no longer representative of the city's current targets (net-zero GHG emissions by 2040). Source: Stadt Zürich (2023).

### 3.2 Current frame conditions for the development of thermal grids in Zurich

#### 3.2.1 Environment: politics, supply-side markets, demand-side markets

The development of thermal grids in Switzerland is highly dependent on public policy – this is especially the case in municipalities like Zurich, where the utilities operating the grid are not legally independent from the administration, so that decision-making takes place to a large extent through political



processes. For important decisions, such as large investments or long-term emission targets, a popular vote is either mandatory or can be called through referendum. As a result, the city population is regularly asked to participate in the decision-making on infrastructure development, which gives the occasion to gauge political support for municipal policy. The results for a selection of heating-related popular votes (Table 2) show a consistently high support for ambitious climate and energy targets (such as the 2000W targets in 2008 or the 2040 net-zero target in 2022) and for the development of thermal grid infrastructure. Since 2018, voters have approved over a billion CHF in credits for the further development of thermal grids (in addition, the vote in September 2023 on the construction of a third combustion line at the Hagenholz waste incineration plant, which was accepted by 90.8% of voters, ensures additional heat generation capacities). Similar levels can also be found in votes at cantonal and federal levels: for example, the cantonal Energy Act, which was accepted by 62.6% of cantonal voters in 2021, received a share of 74.5% in the city of Zurich. Similarly, the federal climate policy act, which gives a legal basis to the federal net-zero target, was accepted at federal level with a share of 59.1%, whereas voters in the Canton and the city of Zurich approved the law by 62.5% and 77.4%, respectively. It is worth noting that also in the past, support for thermal grid development proposals was rather high – even the write-down of accumulated debts in 2001, to a large extent at the expense of the public budget, was accepted with a share of 68.4%.

Table 2: Selected municipal votes on thermal grids and energy-related topics. Data source: Voting database, City of Zurich.

Voting date	Voting matter	Votes in favor
23.03.1969	Credit of 21.5 MCHF to build a district heating network for the cantonal buildings (university, hospital, ...) in the Hochschulquartier district.	82.3% (Canton: 78.2%)
04.03.1973	First phase of grid construction (33.31 MCHF).	68.0%
30.06.1974	Credit of 90.2 MCHF for the expansion of the cantonal district heating network.	78.5% (Canton: 77.8%)
10.06.2001	One-time write-down contribution of 114 MCHF for the recovery and financing of the district heating supply system of the City of Zurich and annual operating contribution from 2002 onwards, provided that the operating income is not sufficient to cover the operating costs.	68.4%
30.11.2008	Establishment of the 2000W target in the municipal constitution.	76.4%
23.09.2018	Credit of 235 MCHF for the expansion of district heating.	83.3%
28.11.2021	Framework credit of 330 MCHF for the expansion of district heating.	84.1%
15.05.2022	Climate target net-zero by 2040.	74.9%
27.11.2022	Framework credit of 573 MCHF for the expansion of thermal grids.	84.0%

The attractiveness of thermal grids is dependent upon its competitiveness with alternative heating systems. Consumer prices for energy carriers have fluctuated greatly in the past, albeit with a different intensity and volatility for different energy carriers (Figure 5). While the aggregate Zurich consumer price index (base May 1993), which reflects the price of various consumer goods, was at 118 in August 2023 (i.e., the price of consumer goods increased by 18%), the sub-indices for energy were much higher, i.e.: 152 (electricity), 309 (natural gas), 365 (oil) and 196 (district heating). While some of this increase, especially for oil and natural gas, may be a result of the geopolitical situation in the last two years, some important fluctuations can also be seen in the past. Of note, the tariff for district heating was coupled to the oil price until 2022, but with a mechanism preventing excessive prices (see also Section 0). Therefore, the district heating price tracks the oil price somewhat, but does not fully reflect the oil price peaks. During such peaks, district heating therefore became a viable alternative to oil (e.g., Tages-Anzeiger, 2005). It is also worth noting that the electricity price increased only moderately in 2023, whereas other locations in Switzerland faced a much greater increase. This is due to the fact that the city's utility ewz owns



enough generation capacity in hydro- and wind power assets to cover the demand in its supply area (ewz, 2023b). This has insulated electricity consumers in Zurich from increasing market prices so far.

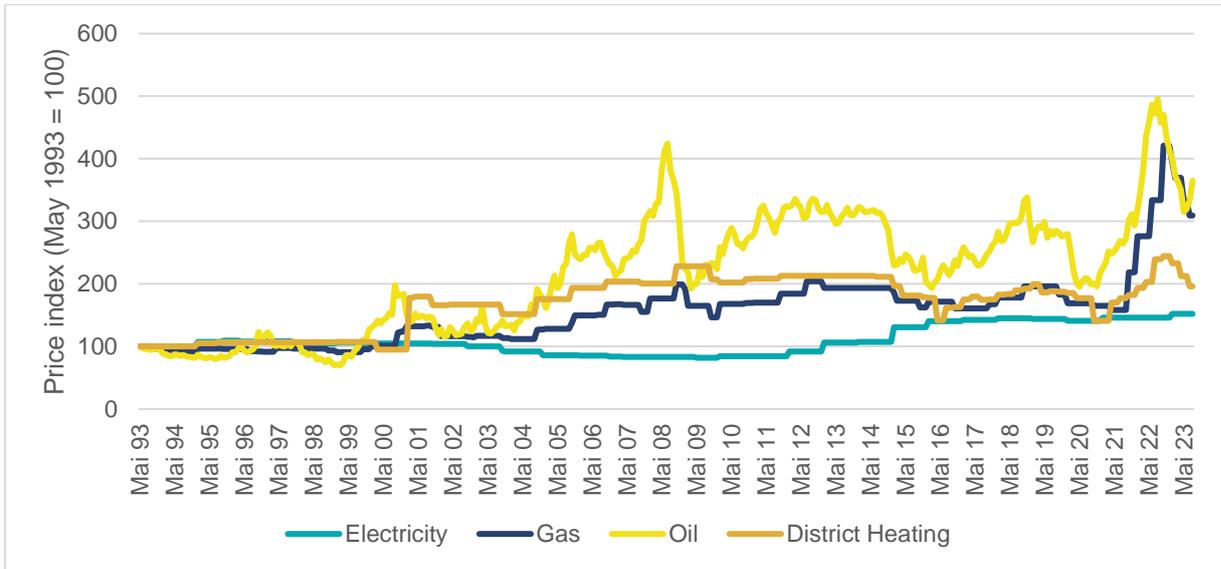


Figure 5: Development of selected energy prices in the city of Zurich, from May 1993 to present. Data source: City of Zurich, Zürcher Index der Konsumentenpreise.

On the demand side, notable environmental factors impacting the frame conditions for thermal grids are building structure and outdoor temperature. The evolution of the building stock is monitored by the city's statistical office. Two relevant trends have been identified (Rey, 2020): first, there is a densification of the building stock. Whereas new developments on areas not previously built-up were common until 2000, less than 10% of new dwellings belong to this category in recent years. Instead, dwellings are built as a replacement of old (residential or non-residential) buildings, with a densification rate of 70% (i.e., the ratio of new and demolished dwellings is 1.7). This increase in the number of dwellings was accompanied by an increase in the surface area of dwellings, as well as in the number of residents. Taken together, these changes point to an increase of heating demand per unit ground area, all else being equal. The second important trend is the higher share of residential dwellings in new developments: whereas in the period 1991-2002 only 47.6% of newly built floor area was built for residential purposes, this value increased to 63.6% in the period 2010-2020. As a result, the share of floor area used for residential purposes increased from 53% to 57%. Such changes are relevant for the development of thermal grids, as various uses of buildings (residential, office, commercial, public, etc.) differ in their load profile and (future) cooling requirements.

Regarding outdoor temperature, the annual number of heating degree-days has shown a slight negative trend (Figure 6). Due to climate change, further decreases can be expected in the future. The CH2018 project (CH2018 Project Team, 2018) provides downscaled projections from global climate simulations under different radiative forcing scenarios. Under the RCP 2.6 scenario, an average of 2934-3235 annual degree days can be expected for the period 2020-2049, which represents a decrease from the average value for the period 1981-2010 (3414 heating degree days) (for the period 2020-2049, scenarios with greater radiative forcing (RCP4.5 and RCP8.5) differ only slightly from the RCP2.6 projections). According to the same projections, the average number of cooling degree-days increases from 118 to 151-212 (RCP2.6), or even up to 245 (RCP8.5, upper estimate).

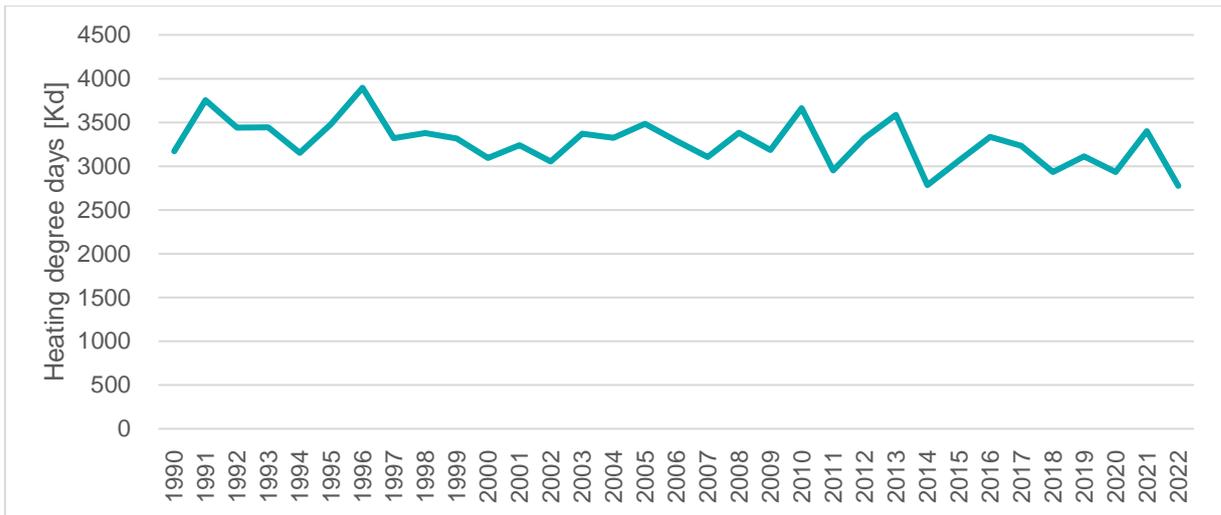


Figure 6: Heating degree days (target temperature: 20°C, heating limit: 12°C) calculated from the records of the meteorological station Zurich-Fluntern (Note: this weather station is located at 556 m asl, whereas many important residential and commercial areas of the city are located 100 m or more below. The number of heating degree days is therefore likely to be somewhat lower for most consumers).

### 3.2.2 Public value account of thermal grid development

This section aims at establishing a “public value account” of the current strategy to develop thermal grids in Zurich. The idea of a public value account originates from applied research on strategic management in the public administration, in particular public value theory (Moore, 1995, 2014). The core idea is that decision-makers in the public sector are bound by a different logic than private-sector managers: while the latter must generate profits to legitimize the survival of their organization, public-sector actions are legitimized by outcomes perceived as valuable by citizens. The cost of reaching these outcomes may be monetary, through the use of public funds, but also non-monetary. In particular, public organs can use authority to enact necessary changes, but this comes at the cost of restricting individual freedom. These costs must therefore be justified in relation to the public benefits that they are expected to bring. The idea of a public value account is to summarize and compare the various costs and benefits of a public-sector action or strategy by showing them in form of a ledger. Since the public is a heterogeneous collective of citizens that make subjective value judgments under uncertainty, it cannot be objectively established which arrangement of costs and benefits is optimal, so that a qualitative and heuristic approach is indicated (Prebble, 2021). In this report, we use a template from the Atlas of Public Management (2017) to represent these costs and benefits (Table 3). The positive side of the ledger (right-hand side) contains the intended beneficial outcome, stated as a mission assigned to public organizations through political processes. In addition, the positive side lists possible co-benefits (unintended positive outcomes), as well as those aspects which ensure that citizens’ requirements of justice and fairness are represented. The negative side lists the costs arising from the use of public finance and state authority, as well as unintended negative consequences.

When applying the public value framework, it is important to define who is in charge of the “account”, i.e., who is responsible for devising a sound and sustainable strategy (Bryson et al., 2017). In this case, given the governance arrangement in Zurich (Section 3.2.3.1), we define the city council as primarily responsible for the city’s energy strategy, in coordination with the relevant parts of the municipal administration, including the utilities. These bodies are, together, in charge of devising a strategy that fulfils the political mission of the 2040 net-zero target. This strategy must be justified to, and approved by the “authorizing environment”, i.e., citizens, policymakers, the media, etc. (Moore, 1995). For this reason, this section draws primarily on proceedings of the municipal council, where the city council is required to lay out the logic for proposed law changes, expenses or other measures. Conversely, municipal council members can themselves propose such changes at the address of the city council, or ask for information, clarifications or a detailed report on a given topic. This data source is complemented



by media reports to obtain a complete picture of the public value account as perceived by the authorizing environment. We stress that the statements presented here may not necessarily be considered expert opinion, as not all actors are familiar with the issues to the same degree. Furthermore, statements may be politically motivated. We therefore caution against an interpretation of these results as objective.

In the current phase, the public value account for the development of thermal grids in Zurich reflects the 2040 net-zero target as the primary driver of local energy policy (Table 3, uppermost right sector). The year 2040 has been characterized as an ambitious but realistic timeframe for the construction of thermal grids as per the municipal energy plan, considering the need to coordinate with other construction works of the city (Tiefbauamt / Energiebeauftragte, 2021). In accordance with this timeframe, several new elements of the city's strategy aim at accelerating decision-making, planning and construction processes. For example, the instrument of framework credits (Section 3.2.3.1) allows the city council to decide quickly on the release of financial resources for new developments. Also, the city's spatial energy planning is now a continuous process with regular updates (Stadt Zürich, 2022c), as opposed to the previous practice of revising spatial energy plans at intervals of a decade or more, which is still the current practice in most Swiss municipalities. At the construction level, new auxiliary regulations and a yearly revised implementation timetable facilitate the coordination with other civil engineering works, thus addressing an important cause of delays (Tiefbauamt / Energiebeauftragte, 2021). Also, detailed concepts for envisioned technical solutions are currently being elaborated (GR 2021/377). These concepts are part of an iterative process between technical planning and political realization: technical concepts are adapted if political realities, such as conflicts over space (see below) prevent their implementation. Citing advantages for the implementation speed, the city council sees it as its own responsibility to administer the political implementation process and the balancing of competing interests (GR 2023/41).

The stated co-benefits of the city's strategy (middle right sector in Table 3) concern public finances, the city's utilities as well as local businesses. As the city's utilities deliver part of their profit to the city's finances, either as a direct contribution in the case of the non-autonomous utilities ERZ and ewz, or in the form of dividends and taxes in the case of the autonomous utility Energie 360° (cf. Section 3.2.5.1), a growth in the activities of these utilities can be expected to increase these contributions to public finances. We note, however, that this is not the primary reason for expanding the activities of these utilities. In the case of ewz, which is active throughout Switzerland in the energy services market, the city council notes synergies, such as learning effects, between the utility's activities within and outside of the city (GR 2023/526). Finally, it was pointed out in the municipal council that infrastructure development in the city was carried out to a large extent by local businesses, who therefore profit from the increased volume of projects (GR 2021/502).

A component of fairness and justice (lower right sector in Table 3) is the requirement of financial self-sustainability for thermal grids (cf. Section 3.2.5.1), which is based upon the cost-recovery and user-pays principles (Kanton Zürich, 2022a). Furthermore, the city aims to promote transparency in costs by requiring utilities to provide a tariff sheet and to follow a harmonized tariff structure, as per the ordinance on heat supply (GR 2021/444). Nevertheless, some controversies arise regarding the interface between utilities and customers. For example, differences in tariffs between the grids (or, in the case of the connection fee, between buildings within a short distance from each other) have been characterized as arbitrary, so that a bill is seeking the introduction of a unique tariff for all thermal grids in the city (GR 2022/441). However, a minority in the municipal council questions the fairness of such a measure, citing concerns that averaging prices over grids with different production costs and different demand densities would lead to unwanted cross-subsidizations. Furthermore, there are concerns that such a measure could hinder the speed of rolling out thermal grids. Nevertheless, the bill was accepted, and the city council must now suggest such a model. Another fairness question concerns the right of building owners to connect to the grid even if this would be unprofitable for the utilities (GR 2019/514). This concerns mostly small buildings, sometimes with location-specific factors that worsen the business case. This reveals a tension between the cost-recovery principle and the question whether small-building owners should have a right to connect.



Despite large investment volumes, the direct public financial cost (upper left sector in Table 3) is limited, since the utilities implementing and operating the thermal grids are required to be financially self-sustainable (cf. Section 3.2.5.1). A risk remains, however, if the profitability of new infrastructure remains below expectations. Direct public spending, however, concerns complementary measures such as heating replacement subsidies and energy consulting for building owners. Both instruments are justified with regard to the necessary acceleration of fossil-fuel substitution to reach the 2040 net-zero goal. Regarding subsidies, the city's current expenses are described by the city council as addressing a temporary gap until additional funding programs are started by the canton or the federal government (GR 2023/343). This issue is described as time-critical: according to policymakers, the new cantonal energy law (cf. Section 3.2.3.2) is not sufficient to enact a complete substitution of fossil-fueled heating systems by 2040, as many of these systems are recent (GR 2021/362). The continued and increasing expenses for building energy consulting and coaching are justified with a high demand for such solutions in the wake of recent policy changes. The utility of this instrument has however been questioned by a minority of policymakers: the intended effect of raising awareness for energy-efficient solutions may already be achieved by the new policies, so that the coachings would be superfluous in this respect. Furthermore, the causal link between consulting and action by the building owners was questioned (GR 2022/305). The energy consulting offer provides value both for the public (through increased energy efficiency and lower emissions) and for building owners. As a result, building owners pay a share of the costs, while the rest is subsidized. A bill sought to increase the share to be paid by building owners, invoking fairness considerations (GR 2022/571). However, this bill was rejected, and the necessity to incentivize a fast replacement of heating systems was cited as an argument against by the city council in the debate.

Although the use of incineration waste heat is well-supported by voters and policymakers, there is concern that this discourages more sustainable options for waste management, such as increased recycling (Tages-Anzeiger, 2023). However, many policymakers see this as a dilemma rather than a reason to oppose this strategy altogether (GR 2020/565, GR 2023/16). Further unintended negative consequences (middle left sector in Table 3) include the disturbance of traffic, as well as noise emissions, from construction works (Tiefbauamt / Energiebeauftragte, 2021). Furthermore, since the 2040 net-zero goal requires a fast roll-out of thermal grids, a coordination with other public construction works, such as urban heat island mitigation measures, is not always possible, so that synergies are not always realized (Zürich24, 2023).

The social costs of using authority (lower left sector in Table 3) concern various aspects of the transition. As more thermal grids are being planned and realized, space requirements inevitably create conflicts with other uses of land (GR 2023/269). Participatory processes, which are sometimes carried out in similar situations, were said to delay such projects (GR 2023/269), as it is critical to secure the location early (GR 2022/602, GR 2023/114). Likewise, in the interest of timing, it was deemed essential that the coordination and balancing of interests remains in the responsibility of the city council (GR 2023/41). Another cost of authority concerns the decommissioning of natural gas grids: since it is uneconomical to have two competing infrastructures for heat distribution, the roll-out of thermal grids is accompanied by a decommissioning of natural gas grids. Therefore, building owners may face stranded assets. For this reason, a long-term communication is essential (eicher+pauli/INFRAS, 2022). Finally, a tension between speed and accountability was noted in the governance arrangement: since framework credits (Section 3.2.3.1) are a transfer of authority from the legislative to the executive power, a minority of policymakers were concerned that long-term decisions over large investment sums represent a lack of accountability or control (GR 2021/502, GR 2020/565).

Table 3: Public value account for the development of thermal grids in the city of Zurich in the current phase (net-zero target). The left column lists the (monetary and non-monetary) costs, and the right column the benefits and positive outcomes of the current strategy.

Use of collectively owned assets and associated costs	Achievement of collectively valued outcomes
---	---



<p><b>Financial costs</b></p> <ul style="list-style-type: none"> <li>Limited impact of infrastructure development and operation on public finances due to <i>Eigenwirtschaftsbetrieb</i> model.</li> <li>Financial risk in case of stranded assets or insufficient profitability of grids.</li> <li>Use of public funds for subsidized heating replacement, energy counselling of building owners, as well as planning and coordination by the administration.</li> <li>Financial support for organizations displaced by infrastructure development.</li> </ul>	<p><b>Mission achievement</b></p> <ul style="list-style-type: none"> <li><u>Mission</u>: Accelerated development of thermal grids as a contribution to net-zero GHG emissions in buildings, through financial and governance instruments aimed at accelerating decision-making and implementation (framework credits, strategic energy planning, coordinated implementation plan).</li> </ul>
<p><b>Unintended negative consequences</b></p> <ul style="list-style-type: none"> <li>Reliance on waste incineration as a barrier to more sustainable waste management strategies.</li> <li>Disturbance of traffic and noise from construction works.</li> <li>Other important public construction projects may be delayed.</li> <li>Time constraints hinder the exploitation of synergies with other urban construction measures (e.g., urban heat island mitigation, development of cycling infrastructure).</li> <li>Different tariffs for different locations: perceived as unfair / arbitrary.</li> </ul>	<p><b>Unintended positive consequences</b></p> <ul style="list-style-type: none"> <li>Revenues for public finances through direct contribution, dividends and taxes.</li> <li>The city's utilities can valorize the acquired capabilities outside the city (in a market setting).</li> <li>Local businesses profit to a large extent from the new investments.</li> </ul>
<p><b>Social costs of using state authority</b></p> <ul style="list-style-type: none"> <li>Space requirements for new infrastructure components (e.g., energy centrals) create conflicts with other uses of land or buildings.</li> <li>Phase-out of the gas infrastructure leads to stranded infrastructure assets, as well as additional costs for building owners (for the latter, a compensation is provided).</li> <li>Potential lack of accountability in the framework credit scheme.</li> </ul>	<p><b>Justice and fairness</b></p> <ul style="list-style-type: none"> <li>Cost-recovery and user-pays principles applied in <i>Eigenwirtschaftsbetrieb</i> structure.</li> <li>Transparency of tariff models is guaranteed through targeted political measures (public district heating) and conditions for special concessions (thermal grids with a public mandate).</li> </ul>

### 3.2.3 Governance, regulatory framework and instruments

#### 3.2.3.1 Governance structure

Thermal grids in Zurich have so far been operated by three utilities: ERZ and ewz, which are legally part of the municipal administration, and Energie 360° AG, which is owned to 95.87% by the city (see Section 3.2.5.1). For the large majority of thermal grids (in terms of buildings connected and energy delivered), development is either directly or indirectly influenced by the city's municipal energy policy. For the grids considered as public district heating (Section 3.2.4.1), the decisions on construction, expansion and spending are subject to the political decision-making process (see below), whereas grids with a mission or special concession (Section 3.2.4.2) are administered independently by their utility, following the conditions given by the Ordinance on heat supply (see Section 3.2.3.2).

The city's decision-making organs are the city council (executive), municipal council (legislative) and the voting population. For the development of public district heating, the city council has a leading role: Decisions such as new constructions and investments are prepared in collaboration with the responsible departments of the city's administration. Depending on the spending volume, decisions must be



submitted to the municipal council (from 2 MCHF) or to a popular vote (from 20 MCHF). In the context of thermal grid developments, the city has made use of framework credits to accelerate decision-making. Framework credits are an instrument allowing a one-time investment decision on large projects. This is not yet a definitive spending decision, but allows spending decisions within this project (e.g., a new expansion phase) to be taken quickly. In recent years, voters in Zurich have approved several framework credits for the expansion of thermal grids, for a total volume of more than 1 billion CHF (cf. Table 2).

As part of an ongoing reorganization of thermal grid governance, it is foreseen to place most thermal grids under the control of ewz (GR 2023/581). This should conclude several efforts to simplify the organization of thermal grids in Zurich, as it was noted that the presence of three distinct utilities hamper a strategic course of action (econcept & BHP Hanser und Partner, 2017). Also, other considerations led the city to reconsider the organization of thermal grids, e.g., on the respective role of the public administration and private companies (GR 2021/417). In the past, an effort to improve coordination was the creation of a dedicated office, “Wärme Zürich”, responsible for coordinating between the three utilities, the city administration and building owners (GR 2021/178). However, since the reorganization decreases the need for inter-organizational coordination, this office will be discontinued (GR 2023/581).

### 3.2.3.2 Regulatory instruments

This section briefly outlines the main regulatory instruments that influence the framework conditions for thermal grids. As per the Swiss constitution and the federal CO2 law, reducing GHG emissions from the building sector falls under the responsibility of the cantons. In Zurich, the **cantonal energy law** was updated in 2021, with direct relevance to the heating sector. Among other regulations, the law prohibits the installation of new fossil-fueled heating systems. Exceptions can be granted where the life cycle costs of all non-fossil solutions exceed those of a fossil-based heating system by at least 5%. In the city of Zurich, there have so far been few applications for such exceptions, indicating that the cantonal energy law is having the desired impact (Stadt Zürich, 2023d). However, since the installation rate of non-fossil-fueled heating systems was low prior to 2021 (Lehmann et al., 2017), there are many recent fossil-fueled systems in operation, so that it has been estimated that the cantonal energy law alone will not be enough to reach the city’s 2040 net-zero goal (GR 2021/362).

At municipal level, the 2040 net-zero goal was introduced into the **municipal constitution** (Gemeindeordnung) in 2022. The time horizon of 2040 was selected following a comparison of expected socioeconomic impacts and feasibility for variants with a time horizon of 2030, 2040 and 2050 (INFRAS & Quantis, 2020). Concretely, the new articles in the municipal constitution (Art. 152 and 152a) require the city to implement all measures towards net-zero by 2035, with the explicit exception of the heating sector. Indeed, it was that the heating sector can reach this goal earliest by 2040. The reason lies in the long planning and construction timelines for thermal grids, due e.g., to the necessity to coordinate with other civil engineering works (Tiefbauamt / Energiebeauftragte, 2021) or to a workforce shortage for construction (GR 2021/177).

Despite the various strategic and planning instruments of municipal energy and climate policy (see Section 3.2.3.3 below), there was no legal basis for them at municipal level. In a bill introduced in 2019 (GR 2019/3), some members of the municipal council saw this as a significant gap. According to this bill, the planned roll-out of thermal grids places heat supply in the general public interest, requiring adequate regulation. As a result, the **ordinance for heat supply** (Wärmeversorgungsverordnung, hereafter WVV) was passed in 2021 (GR 2021/444). One of the initiators of the original bill described the WVV as the final puzzle piece of the municipal energy policy (GR 2021/444). Concretely, the WVV covers two areas: thermal grids and natural gas. Regarding thermal grids, the WVV explicitly states that the city may build and operate thermal grids. Furthermore, it specifies the criteria to obtain a mission or concession for a thermal grid (see also Section 3.2.3):

- The share of renewable heat or excess heat must be at least 70%, 100% after 2040.
- Heat pumps must be operated with 100% renewable electricity.



- The future share of heat supply in the supply area must match the share specified by the spatial energy planning.
- All interested building owners in the supply area must receive an offer for connection.
- A transparent price sheet must be made public.
- The price must follow the three-component model of connection costs, price per kW and price per kWh (see also Section 3.2.5.5).

Regarding natural gas, the WVV gives a legal basis to the aims of the natural gas strategy (see Section 3.2.3.3 below).

### 3.2.3.3 Planning process and auxiliary instruments

To characterize the planning framework relevant to the development of thermal grids, this report distinguishes between various planning and strategic instruments and two steering instruments: the Energy Masterplan and the Net-zero reporting (Figure 7). The role of the steering instruments is to periodically monitor key indicators, assess the existing measures across the city's departments and propose changes if necessary. While municipal energy and climate policy includes sectors not directly related to thermal grids (e.g., transport, waste management), this section focuses on the aspects of steering and planning instruments that have a direct relevance and is therefore selective in its treatment of these instruments. This section first characterizes the two steering instruments and then describes selected strategic and planning instruments.

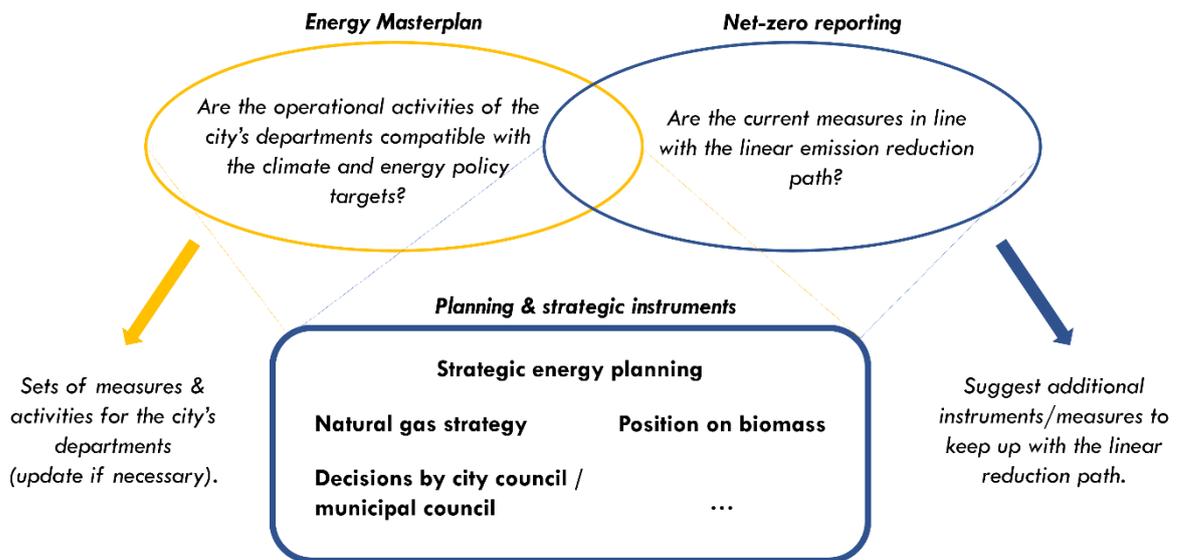


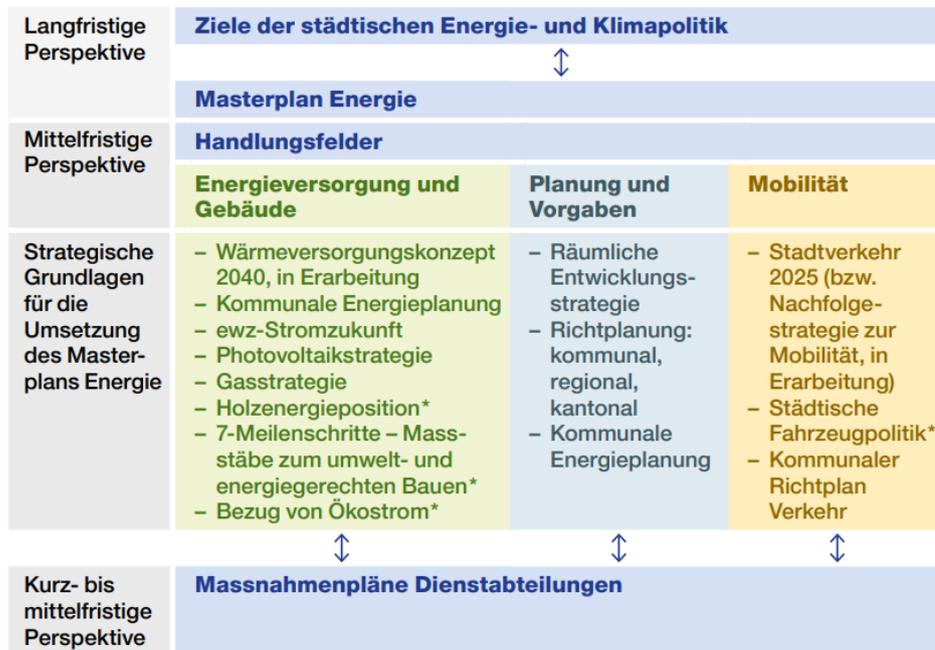
Figure 7: Role of two steering instruments for the energy and climate policy in the city of Zurich: the energy masterplan and net-zero reporting.

First launched in 2002, the **Energy Masterplan** aims at coordinating the existing and new energy policy measures across the city's departments (Tages-Anzeiger, 2002). The Masterplan is updated periodically (an update every four years is foreseen, although the adoption of the 2040 net-zero target prompted an update ahead of schedule in 2023) and formulates concrete, binding measures for the city's departments and their branches. A regular monitoring of GMG emissions and primary energy consumption, as well as the controlling of measures within the responsible units, form the basis to assess whether new measures or modifications are needed. Rather than acting as a stand-alone instrument, the Masterplan is based on the city's sector-specific instruments: its role is to align the concrete measures with the city's overarching climate and energy policy targets and with the relevant planning instruments (Figure 8).



As a long-term instrument, the Masterplan takes into account the evolving priorities and foci of municipal energy policy. For example, in 2012, sufficiency was introduced as a key principle, along with (energy) efficiency and the choice of low-carbon energy sources (Kägi, 2023), and the latest update (Stadt Zürich, 2023e) is oriented towards the 2040 net-zero target.

### Schnittstellen zu strategischen Grundlagen



\* Verwaltunginterne Grundlagen

Figure 8: Role of the Energy Masterplan: measures for the city's departments are defined by aligning overarching climate and energy policy targets with existing planning instruments. Source: Masterplan Energy 2023 (Stadt Zürich, 2023e)

Under the 2040 net-zero target, the municipal constitution (Gemeindeordnung) requires the city to define an emission reduction path (Absenkpfad) that reaches the 2040 target linearly or even faster. Furthermore, the city must report on the emission reduction progress annually and, if the reduction is not on track, define a set of corrective measures (Gemeindeordnung Art. 152a). This was done for the first time in 2023 in two separate documents: the **net-zero intermediate report** (Netto-Null Zwischenbericht) reports on the monitoring of direct GHG emissions in the buildings, transport and waste management sectors, whereas the **climate change mitigation plan** (Klimaschutzplan) lists the concrete targets and measures for these same sectors.

The monitoring of GHG emissions (Stadt Zürich, 2023f) shows that the direct GHG emissions amounted to 2.4  $t_{CO_2eq}$  in 2022, with the buildings sector representing a share of 56% (Figure 9). As already discussed above (Section 3.1), emissions from the building sector follow a negative trend, although inter-annual variation due to meteorological conditions is apparent. Projections of GHG emissions after 2022 (right side of Figure 9) are based on the expected impact of currently planned measures, sometimes involving expert judgment. For the building sector, besides a continuous reduction of GHG emissions due to fossil fuel replacement and energy saving measures (see below), further reductions are expected following the commissioning of the third combustion line in the waste incineration plant, as well as the assumed acknowledgment of imported renewable gas (e.g., biogas) as carbon-neutral on federal level.



The climate change mitigation plan (Stadt Zürich, 2023d) lists two areas for emission reduction in buildings: 1) the substitution of fossil-fuelled systems, including the roll-out of thermal grids, and 2) the reduction of energy demand for space heating. Since renewable energy sources for heating are limited, the full decarbonization of heat supply (area 1) is dependent upon energy demand reduction (area 2). In the first area, many of the listed measures are under the direct responsibility of the city administration and utilities: strategic energy planning (see below), development of the infrastructure for heat provision and distribution (see Section 3.2.3) and phasing-out of the natural gas distribution infrastructure and decarbonization of the remaining gas supply, accompanied by financial support and consulting. For the second area, the direct measures of the city are restricted to a large extent to financial support and consulting. In general, the report notes that building owners and users (including tenants and firms) have a decisive role in reaching the targets in both areas, since they take the decision on replacing heating systems, improving buildings' thermal performance, optimize the functioning of HVAC systems and reduce useful energy demand through sufficient behavior. The city only has a limited direct influence on these decisions (e.g., in the case of city-owned buildings or new developments), so that setting adequate frame conditions is reported as a key leverage point for the city.

### Entwicklung der Treibhausgasemissionen 2010–2040

(in t CO<sub>2</sub>-Äquivalente/Einw./a)

■ Gebäude ■ Mobilität ■ Entsorgung ■ Land- und Forstwirtschaft ■ Negative Emissionen ••• Absenkpfad

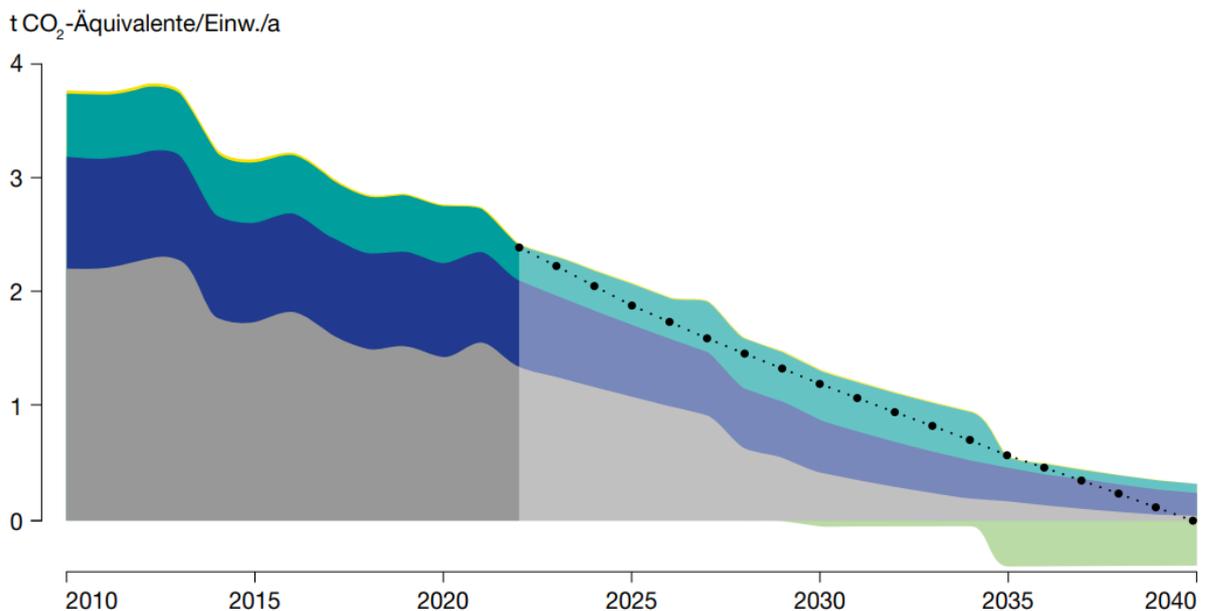


Figure 9: Annual direct per-capita GHG emissions in Zurich, historical (2010-2022) and estimated (2022-2040), along with a linear reduction path from 2022 to 2040. Source: Net-zero intermediate report 2022 (Stadt Zürich, 2023f).

The remainder of this section describes five of the city's strategic and planning instruments relevant to thermal grids (Figure 7): the municipal energy planning process, the heat supply concept, the natural gas strategy, the position on biomass energy, and the implementation plan for thermal grids.

In Switzerland, **spatial energy planning** is an instrument used by municipalities to ensure a sound use of available thermal energy potentials by assessing the spatial distribution of energy demand and the location of energy sources, and then defining areas where thermal grids are foreseen (Schubert, 2014). Depending on cantonal policy, municipalities may be mandated to establish such a plan (in Zurich, the cantonal administration requires such a plan from selected municipalities, including from the city of



Zurich). Most municipalities update their energy plans only periodically: typically, such a plan has a horizon of 15 years, after which an update is foreseen. In Zurich, spatial energy planning also adopts a long-term perspective. However, it is part of a process where new targets, projects and difficulties are taken into account, leading to more frequent partial or full updates (Stadt Zürich, 2022c). This marks a change from the past: the energy plan of 1992 was replaced in 2016 to ensure compatibility with the 2000W goals. Since then, the plan was updated in 2019 to account for further expansion of thermal grids, and again in 2022. This current version (Stadt Zürich, 2022c) contains updated limits of the areas where thermal grids are planned, based e.g., on new insights from feasibility studies. Also, the decision to phase out the natural gas distribution infrastructure where thermal grids are planned was taken into account in the new plan. The development of infrastructure according to the current plan is presented in Section 3.2.3.

The definition of supply areas for thermal grids in the energy plan is based on the **Energy Supply Concept 2050** (Stadt Zürich, 2014). This commissioned study includes the spatially explicit modeling of future energy demand, based on scenarios that reflect various assumptions on the pace and depth of building energy retrofit, as well as on the choice of energy sources for heating and electricity. Since the current concept is based on 2000W goals, it is no longer in line with current policy (net-zero 2040). Therefore, a new version is currently being elaborated and is expected for 2024.

The city's **strategy on natural gas** (Stadt Zürich, 2021) has the purpose to guide the city council's decision making regarding the role of natural gas. In accordance with overarching policy goals and legislation, the strategy sets out how the goals of reducing gas use, phasing out fossil gas and reducing the gas distribution infrastructure are to be reached. The strategy foresees that fossil gas shall no longer be used after 2040, for any purpose<sup>1</sup>. Since renewable gas, such as biogas and synthetic gas, is expected to remain scarce in the future, the strategy specifies that gas should only be used where no other non-fossil energy carriers are available. New connections to the gas grid are no longer possible, unless explicitly foreseen in the spatial energy planning due to a lack of alternatives. Another exception is as a temporary solution in planned supply areas for thermal grids, until a connection to the grid can be realized. The peak load of thermal grids is another explicitly mentioned exception. The strategy further foresees that the gas infrastructure will be decommissioned to a large extent in areas where thermal grids will be built (for a detailed overview of the modalities, we refer to the strategy document), which may lead to the entitlement of building owners for a financial compensation. To ensure an adequate supply of renewable gas in the areas outlined above, it is also foreseen that the city invests into facilities for the production and storage of renewable gas in Switzerland and abroad, possibly in the form of a shared investment.

The **position on wood energy** (Stadt Zürich, 2022b) sets out binding guidelines for the use of the scarce biomass resources. It follows the principle that the use of wood energy should be restricted as far as possible to thermal grids and industrial processes. Also, biomass-fueled thermal grids are foreseen only in areas where the energy demand density justifies the establishment of a thermal grid, but no other energy sources are available.

As mentioned before, timing is a critical issue to reach the 2040 net-zero goal (see Section 3.2.2). To accelerate construction, but also to minimize construction costs and adverse effects for the public, an **implementation plan for thermal grids** (Tiefbauamt / Energiebeauftragte, 2021) was put in place. The implementation plan acts as a link between spatial energy planning (where should new grids be built?) with the civil engineering office's coordination of construction works (when and how can construction take place?). At the center of the implementation plan is a timeline specifying when construction is scheduled for all planned thermal grids (Figure 10). Since the frame conditions often change, the plan is updated regularly in a process involving utilities and the civil engineering office. Several area-specific factors are considered for this schedule: past and planned construction activity in the concerned areas, uncertainty related to implementation and financing of planned grids, need for energy conversion plants

---

<sup>1</sup> On this point, the strategy goes further than the city's ordinance (WVV), which only covers space heating. By contrast, the gas strategy explicitly also includes transportation and industrial processes.



in addition to the grids. In addition, overarching factors are also taken into account, such as the human resources of utilities and the civil engineering office. Besides the schedule, the implementation plan also contains the following elements:

- Rules for cost-sharing for construction projects with multiple involved organizations: such rules were so far missing for thermal grids, so that negotiations delayed the implementation process.
- Updated technical norms for construction in the underground, regarding location of thermal grid pipelines and necessary distance from water pipelines.
- Updated rules for the procurement of engineering services in the context of piping engineering.
- A process description for the roll-out of a new thermal grid, reflected in the civil engineering office's software.
- An integrated strategy for communication with the public regarding the roll-out of thermal grids, its costs and benefits and its place within municipal policy.
- A clarification of the legal options that may be used to enforce the use of private ground to build pipelines (the report specifies that this should be used as a last-resort option where the use of public ground is impossible due to the presence of other infrastructure).
- A clarification that exceptions from the fossil-fuel ban under the new cantonal energy law are permissible in the case of temporary solutions before a thermal grid is ready, and that the city will grant such exceptions.

Thermisches Netz	Status Energieplanung	EVU	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Albisrieden	Prüfgebiet	ewz EDL																					
Altstetten Nord / Höngg	Prioritätsgebiet	ewz EDL																					
Altstetten Ost	Prioritätsgebiet	ewz EDL																					
Cool City	Prüfgebiet	ewz EDL																					
Enge	Prüfgebiet	ewz EDL																					
Hardau Sihlfeld (Nord)	Prioritätsgebiet	ewz EDL																					
Hardau Sihlfeld (Süd)	Prüfgebiet	ewz EDL																					
Höngg Zentrum	Prüfgebiet	ewz EDL																					
Seefeld	z.T. Prüfgebiet	ewz EDL																					
Altstetten West	Prioritätsgebiet	E360																					
Lengg	Prioritätsgebiet	E360																					
Tiefenbrunnen	Prioritätsgebiet	E360																					
Tiefenbrunnen - Erweiterung (Marina)	Prüfgebiet	E360																					
Wollishofen Manegg	Prüfgebiet	E360																					
Oberstrasse Guggach Ost	Prioritätsgebiet	ERZ FW																					
Unterstrass Guggach West	Prioritätsgebiet	ERZ FW																					
Wipkingen	Prioritätsgebiet	ERZ FW																					
Industriequartier	Prioritätsgebiet	ERZ FW																					
Aussersihl	Prioritätsgebiet	ERZ FW																					
Affoltern	Prüfgebiet	ERZ FW																					

Figure 10: Implementation plan for the roll-out of thermal grids in Zurich. Dark blue indicates construction of the grids, light blue indicates densification, i.e. the connection of buildings to the grid. Source: implementation plan document (Tiefbauamt / Energiebeauftragte, 2021)



### 3.2.4 Current state of infrastructure and planned developments

There are around 40 thermal grids in the city of Zurich, which differ greatly in terms of size and energy sources, but also in terms of governance (Stadtrat, 2017). The city distinguishes between 1) public district heating, the development of which is determined by public authorities; 2) thermal grids with a public mission or a specific area concession, which benefit from some financial and organizational advantages if they fulfill some conditions related to the city's energy and climate goals, and 3) thermal grids without a special concession or mission (Stadt Zürich, 2022c). This section reviews the development, current state and plans for each of these categories. We note that the availability of data does not allow a treatment of all categories at the same level of detail.

#### 3.2.4.1 Public district heating

The **public district heating** currently consists of two distinct grids (Figure 11): the high-temperature grid operated by the city's waste utility ERZ, primarily fed by excess heat from the Hagenholz waste incineration plant (in the north and center of the city), and since 2020, the new grid Altstetten-Höngg, which uses waste heat from the Werdhölzli sewage treatment plant (in the west of the city). The ERZ grid includes several originally independent grids: the Zürich-Nord grid, which was developed around the waste incineration plant; the Hochschulquartier grid, which was integrated through a connecting line in 1972; and the Industriequartier grid, which was fed by the Josefstrasse waste incineration grid before its decommissioning in 2021. Since then, the Industriequartier grid has been integrated into the ERZ grid through the connecting line built in 2021. This grid operates with a supply temperature between 90°C and 120°C, and a return temperature around 50°C (ERZ, 2013). The main heat source, the Hagenholz waste incineration plant, is located in the north-east of the city, right before the city border. This plant can currently process up to 240'000 t of waste per year (this capacity will increase to 360'000 t/a with the construction of a third incineration line) (Stadtrat, 2019). The capacity of the waste incineration plants is coordinated within the canton of Zurich, based on historical waste quantities and scenario-based estimates of future quantities. As current estimates foresee an increase in the amount of waste (due in particular to population growth, increased economic activity, as well as increased building retrofit or demolition – see also Section 3.2.1 for the latter topic), an increase in the capacity of the canton's incineration plants was deemed necessary (Adam & Morf, 2018). In this planning process, the capacity increase at the Hagenholz plant was made conditional on the successful integration of the Industriequartier grid, in order to ensure that the heat generated can be used to the full extent (Adam & Morf, 2018). Besides the waste incineration plant, the ERZ grid includes three other heating plants: the Aubrugg CHP plant, which uses biomass and replaced a fossil-fuel based plant in 2011, as well as two fossil-fuel based plants used mainly as a back-up. In 2022, waste incineration provided 50% of the heat, whereas biomass accounted for 17% (ERZ, 2023). The share of waste heat decreased after the decommissioning of the Josefstrasse incineration plant in 2021: before that, waste heat accounted for approximately 63% of heat sold by ERZ. With the construction of the third incineration line, the share of waste heat is expected to increase again. However, other measures will likely be necessary for the grid to reach the net-zero target by 2040 (ERZ, 2023).

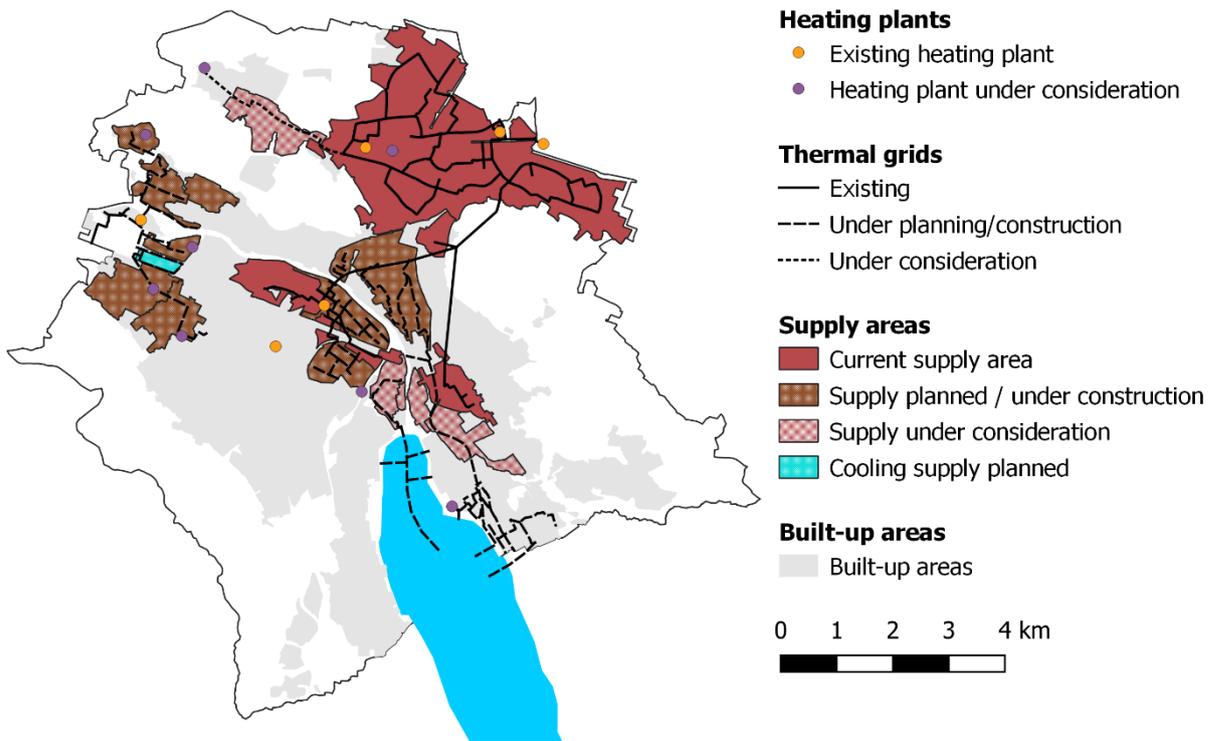


Figure 11: Extant and planned infrastructure for public district heating in the city of Zurich. Data source: Energy planning report (Stadt Zürich, 2022c), Canton of Zurich (background elements).

The ERZ network currently supplies 700-800 GWh/a of heat to customers (Figure 14). In currently supplied areas, the density of connections is already in the range of 63%-79%, depending on the area. For this reason, only a small number of new connections is expected. On the other hand, the city expects that some customers will be lost: for example, when old buildings are demolished and replaced by new buildings, owners may prefer a decentral heating (and cooling) solution (Stadt Zürich, 2022c). Also, due to building retrofit, it is expected that overall heat demand in the area will decrease. In the areas where grid expansion is foreseen or ongoing, the city sees particularly favorable conditions for heat supply with a high-temperature grid: since they are primarily residential areas, there should be a demand for heat all year round (for domestic hot water) and little need for cooling. In addition, options for building energy retrofit are limited in these areas (due e.g., to heritage conservation aspects), so that overall heat demand is expected to decrease less than elsewhere (Stadt Zürich, 2022c). In total, considering all these changes, the foreseen annual heat sales on the ERZ grid for 2050 is roughly equivalent to the current value (Table 4).

Table 4: Current and estimated/targeted characteristics of the areas of the ERZ district heating grid. Note: the target values published at the time of writing are not yet in line with the 2040 net-zero goal and may be



updated in the next iterations of the city's energy planning process. Data sources: Energy planning report (Stadt Zürich, 2022c), Statistik Stadt Zürich.

Area	Status	Connection density 2015	Target connection density 2050	Energy sales 2022	Estimated energy sales 2050
Zürich-Nord	Existing	63%	70%	444 GWh/a	331 GWh/a
Zürich-West (formerly: Industriequartier)	Existing	79%	85%	97 GWh/a	68 GWh/a
Hochschulquartier	Existing	73%	70%	150 GWh/a	80 GWh/a
Aussersihl	Under construction	-	63%	-	45 GWh/a
Gewerbeschule	Under construction	-	60%	-	58 GWh/a
Unterstrass, Oberstrass, Wipkingen	Under construction	-	70%	0.36 GWh/a	90 GWh/a
Guggach	Under construction	-	60%	-	15 GWh/a
<b>Total heat sales on the ERZ grid in Zurich (excluding Opfikon and Wallisellen)</b>				<b>692 GWh/a</b>	<b>687 GWh/a</b>

Since the ERZ grid has been managed as public infrastructure from the beginning, its development over time can be retraced with the help of publicly available data. There are nevertheless gaps in the available data: values for the Hochschulquartier and Industriequartier areas were not reported for many years, so that aggregate values for the whole ERZ network are only available for the period after 2004. Therefore, the following figures (Figure 12, Figure 13, Figure 14) show the indicators for each sub-grid for the period where data is available, and a sum for the whole ERZ grid for the period after 2004.

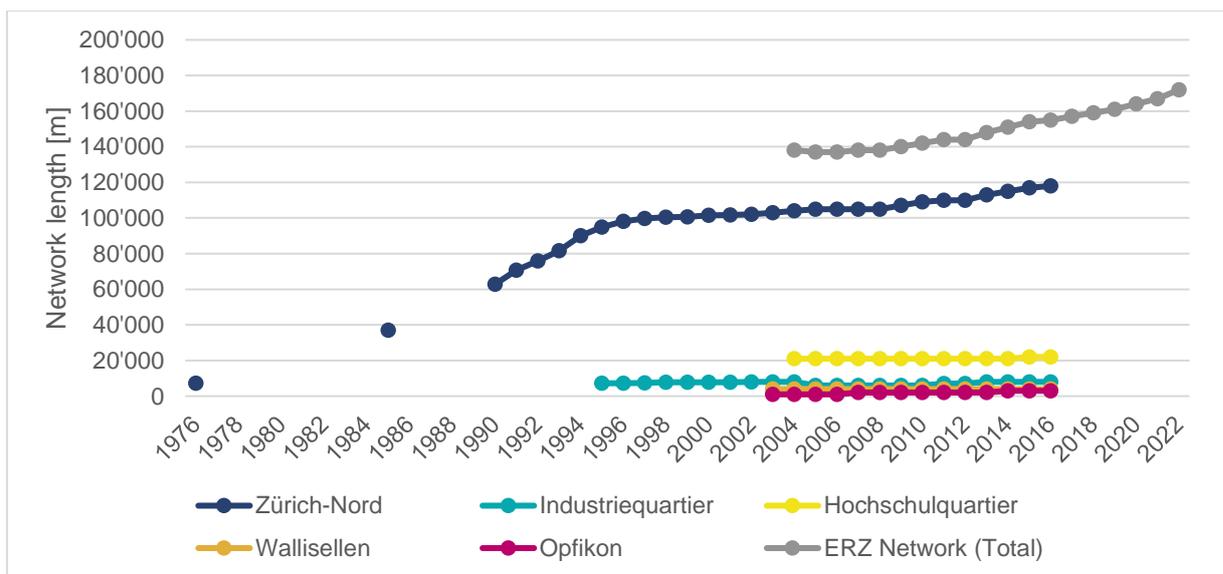


Figure 12: Temporal evolution of the waste incineration district heating network in Zurich (network length). Due to gaps in available time series, values for the total network (grey line) are only shown from 2004 on. Data sources: Statistical Yearbook of the City of Zurich, ERZ annual reports, NZZ.



The length of the network, expressed in m of double lines and including both main and service pipes (Figure 12), shows a sustained increase in the Zürich-Nord grid since the grid's beginning in the 1970s until the mid-1990s. After that, development plateaus, until an increase becomes noticeable again after 2010. For the years in which values for them are reported individually, the grids in the Hochschulquartier and Industriequartier areas show little change. Also, development of the grids in the neighboring municipalities Wallisellen and Opfikon, which started in 2003, remains limited. In recent years, aggregated over the whole ERZ network, the development of network length accelerated somewhat.

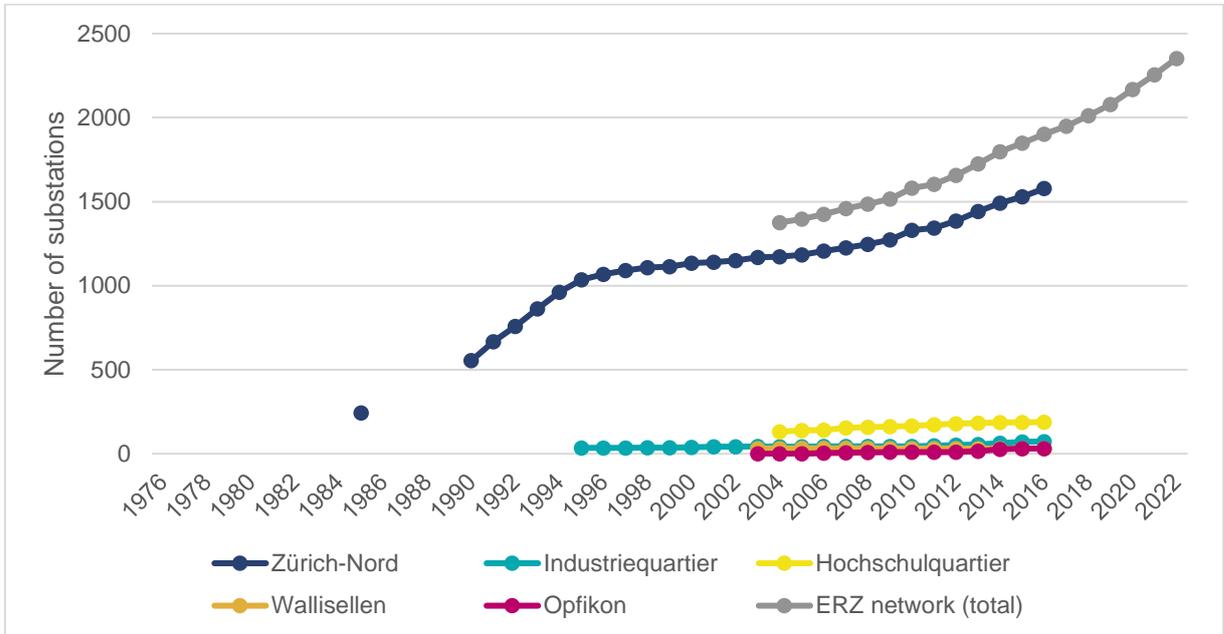


Figure 13: Temporal evolution of the waste incineration district heating network in Zurich (number of substations). Due to gaps in available time series, values for the total network (grey line) are only shown from 2004 on. Data sources: Statistical Yearbook of the City of Zurich, ERZ annual reports.

The number of substations (Figure 13) shows a similar development until the mid-1990s. After that, an annual increase remains noticeable in the following years. At the level of the entire network, the connection rate has accelerated, with nearly 100 new connections per year in recent years. This corresponds roughly to the connection rate in the growth phase of the early 1990s.

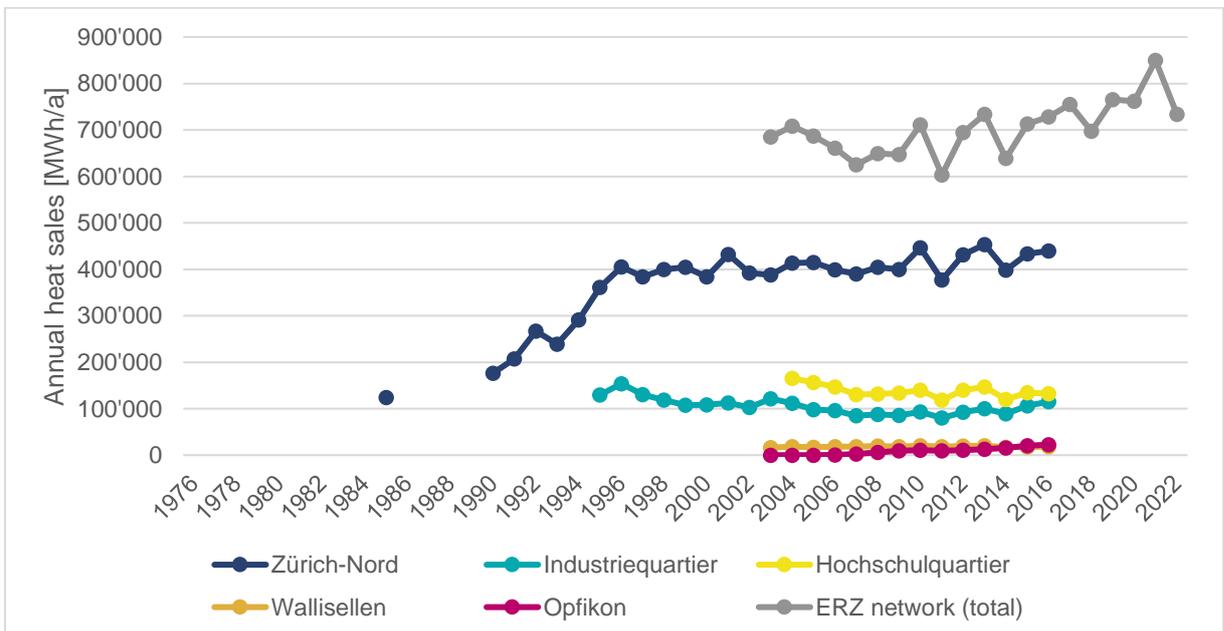




Figure 14: Annual heat sales on the waste incineration district heating network. Due to gaps in available time series, values for the total network (grey line) are only shown from 2004 on. Data sources: Statistical Yearbook of the City of Zurich, Statistik Stadt Zürich.

Annual energy sales (Figure 14) show greater year-to-year fluctuations, as energy demand is also determined by meteorological conditions. In Zürich-Nord, the sustained increase until the mid-1990s can be observed also here. After that, annual heat sales remain nearly constant for many years, despite an increase in the number of connections (see above). At the level of the entire grid, the increasing number of connections is nevertheless reflected in the development of the recent years. It is also worth noting that heat sales in the Hochschulquartier and Industriequartier areas is disproportionate to the relatively small number of connections. Indeed, these areas include many large buildings, including e.g., hospitals, university buildings and the main train station. By contrast, the Zürich-Nord grid covers extended residential areas and includes many single-family houses as customers (Schmid, 2023).

Besides the ERZ network, public district heating also includes the Altstetten-Höngg grid, located in the western area of the city (Figure 11). This grid is primarily fed from the Werdhölzli sewage treatment plant, with energy being harvested both from the processing of sewage sludge and from the sewage water itself through heat pumps. For the delivery infrastructure, both high-temperature and low-temperature grids are being planned and built. Construction started in 2019, and the enlargement of the supply area and subsequent densification is expected to proceed, in several expansion phases, until 2035. In the future, the city's energy planning expects annual energy sales of 118 GWh/a of heat and 32 GWh/a of cold (Stadt Zürich, 2022c). All of the city's three utilities are involved in the supply or distribution of energy: while ERZ operates the sewage treatment plant, ewz was tasked by the city to plan and realize the grid in collaboration with Energie 360°. Through a cooperation agreement, ewz and Energie 360° have delimited the areas where either utility will realize and operate the grid. This distribution of tasks was presented by the city as a way to ensure a fast development of the infrastructure, allowing a timely substitution of natural gas, which is the main energy source for heating in the area (GR 2020/559). A notable element is the inclusion of the newly built ice hockey stadium Swiss Life Arena, for which the energy supply facilities (also operated by ewz) have been designed to exploit synergies between heating and cooling, e.g., through the feeding-in of waste heat from ice production into the grid (Boschung, 2021).

As can be seen on Figure 11, the city and its utilities are currently considering the realization of new grids as part of the public district heating. The areas currently under evaluation include the inner city (referred to as "City" in the planning documents) to the north of the lake's end, as well as the historical districts Niederdorf and Oberdorf. In both cases, it is foreseen to use ambient energy from the lake and/or the Limmat river. The inner city is characterized by a high share of office buildings, so that a substantial cooling demand is expected (Zieger, 2023). Based on a preliminary study, ewz expects annual sales of 95 GWh of heat and 26 GWh of cold (Zieger, 2023). Due to the large size of a possible future grid, the search for an appropriate location for the energy conversion plant has been challenging: owners of suitable sites have shown little interest in selling their land (GR 2023/114) and the current choice of location has been contested politically, as it displaces cultural and socio-economic activities that are seen as valuable for the inner city (GR 2022/602, GR 2023/114).

#### 3.2.4.2 Thermal grids with a public mandate or special concession

Besides public district heating, the second organizational category of thermal grids in Zurich are those with a **public mandate or special concession** (Figure 15). Unlike the grids presented above, such projects are initiated by utilities as part of their regular business activities, rather than by political decision-making. To steer the development in line with municipal energy policy, operators of these grids benefit from special conditions if their project fulfils a list of environmental and organizational criteria (cf. Section 3.2.3).

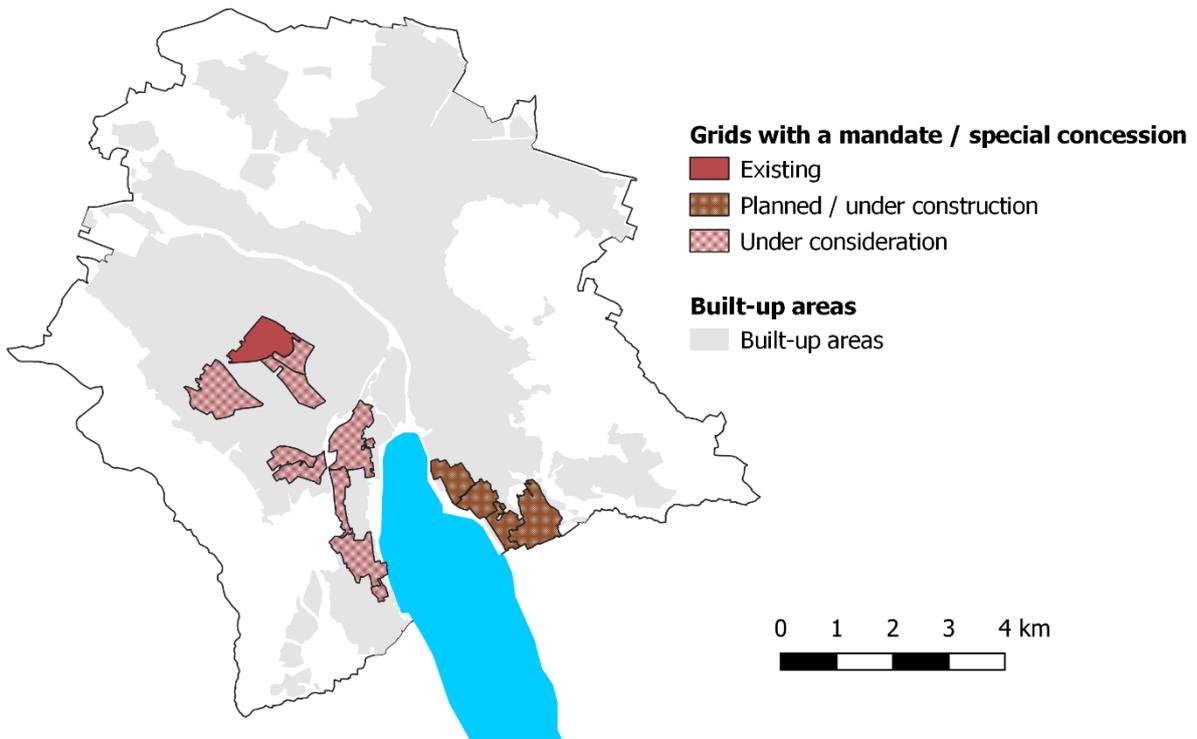


Figure 15: Extant and planned thermal grids with a public mandate or special concession in the city of Zurich. Data source: Energy planning report (Stadt Zürich, 2022c), Canton of Zurich (background elements).

Although any utility can access this scheme, all existing and planned grid of this category belong to the city's utilities ewz and Energie 360°. Currently, one operational grid belongs to this category: the Hardau grid, which is operated by ewz and uses heat from the groundwater. This grid currently has a heating power of 8 MW (Kanton Zürich, 2023). This grid is expected to deliver 33 GWh/a by 2030 in its current supply area, and an extension is currently being considered in two directions (Stadt Zürich, 2022c).

Table 5: List of thermal grids with a public mandate or special concession in the city of Zurich. Source of inventory: energy planning report (Stadt Zürich, 2022c).

Grid name	Operator	Energy sources	Status	Power and/or energy sales	Reference for additional information
Hardau (current supply area)	ewz	Groundwater	Operational	8 MW	(Kanton Zürich, 2023)
Hardau (extensions)	ewz	Groundwater and waste heat	Under consideration	-	-
Seefeld	ewz	Lake water	Under construction	<b>Heating:</b> 22.3 GWh/a <b>Cooling:</b> 1 GWh/a	(ewz, 2023a)
Tiefenbrunnen	Energie 360°	Lake water	Under construction (further extensions under consideration)	About 400 buildings	



Lengg	Energie 360°	Lake water	Under construction	<b>Heating:</b> 22 MW, 48 GWh/a <b>Cooling:</b> 9 MW, 23 GWh/a	(Energie 360°, 2022)
Enge	ewz	Lake water	Under planning	<b>Heating:</b> 37 GWh/a <b>Cooling:</b> 6 GWh/a	(Zieger, 2023)
Wollishofen	Energie 360°, to be transferred to ewz	Lake water	Under planning	-	(NZZ, 2023)
Albisrieden	-	Biomass	-	-	-
Binz Nord	-	Waste heat, ambient heat from ground	-	-	-
Binz Süd	-	Lake water	-	-	-

### 3.2.4.3 Thermal grids with a public mandate or special concession

In addition to the public district heating and grids with a special mandate or concession, there exist some grids that have been realized **outside of such frameworks** (Figure 16). The energy planning report (Stadt Zürich, 2022c) lists an inventory of those grids with annual energy sales greater than 5GWh. This list was completed here with additional information on the operator, energy sources, and grid size, expressed as power or annual energy sales (Table 6). Most of these grids are operated by the utilities ewz and Energie 360° on an energy service provision basis. However, some grids are operated directly by their primary users, i.e., the ETH Zurich and the housing cooperative FGZ. For this category of grids, there is no target or growth estimate on the side of the city (Stadt Zürich, 2022c).

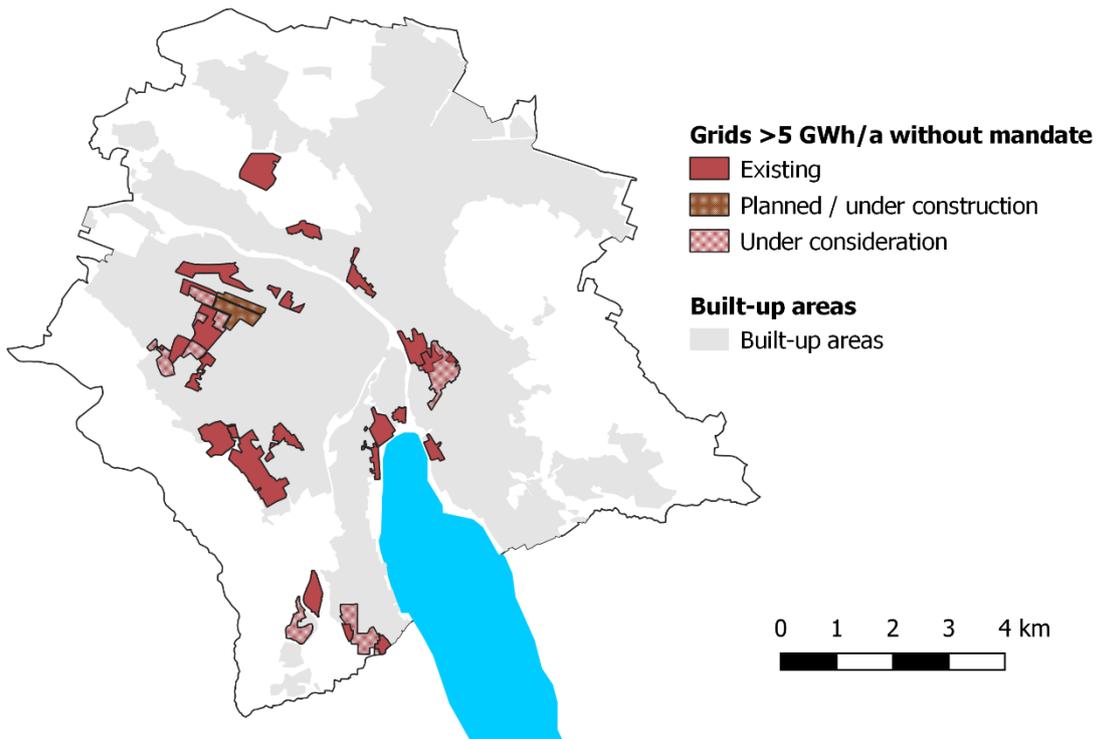


Figure 16: Extant and planned thermal grids without a public mandate or special concession in the city of Zurich. Data source: Energy planning report (Stadt Zürich, 2022c), Canton of Zurich (background elements).

Table 6: List of thermal grids without a specific area concession in the city of Zurich. Source of inventory: energy planning report (Stadt Zürich, 2022c), regional structure plan (Kanton Zürich, 2023).

Grid name	Operator	Energy sources	Status	Power and/or energy sales	Reference for additional information
Manegg		Groundwater		4.5 MW heating, 3 MW cooling	
Aargauerstrasse	ewz	Groundwater, excess heat from external data center (Swisscom)	Operating since 2012, extension under consideration	4 MW / 14 GWh/a	(Stadt Zürich, 2017)
City-West/Herdern		Groundwater	Operating		
Baslerstrasse		Excess heat, groundwater	Planned		
Hohlstrasse		Groundwater	Planned		
Friesenberg	Housing cooperative FGZ	Excess heat from external data centers	Operating	27 GWh/a heating, 8 GWh/a domestic hot water	(Kolb, 2017)
Albisrieden		Excess heat from a city-	Operating (grid retrofitted in 2016)	4 MW	



		owned data center			
ETH Hönggerberg	ETH Zurich	Excess heat, geothermal energy	Operating since 2016	8 MW heating, 6 MW cooling	(Häusermann & Mast, 2017)
Flurstrasse	ewz	Excess heat			
Wiedikon / Binz	ewz	Excess heat from external data centers (Swisscom)	Operational since 2013	2 MW	
Wipkingen	ewz	Sewage water	Operating since 1999	1.25 MW	(Romesch, 2004)
ETH Zentrum		Excess heat from waste incineration			
Moos	ewz	Drinking water	Operational since <2002, extension under consideration		
Escherwiese	ewz	Lake water		4.3 GWh/a heating, 2.6 GWh/a cooling, 0.9 GWh/a freecooling	(ewz, 2023a)
Mythenquai/Enge	ewz	Lake water			
Falkenstrasse	ewz	Lake water		3.1 GWh/a heating, 1.1 GWh/a cooling, 0.3 GWh/a freecooling	(ewz, 2023a)
Fraumünster	ewz	Lake water	Operational, capacity doubled in 2022	3.6 GWh/a heating, 2.4 GWh/a cooling, 0.6 GWh/a freecooling	(ewz, 2023a)
Hochschulgebiet Zentrum		Lake water, ambient air			
Triemli	ewz	Biomass		10 MW heating, 3 MW cooling	
Käferberg	ewz	Biomass	Operational since 2018	4.5 GWh/a	
Leimbach	Energie 360°	Biomass	In consideration		

#### 3.2.4.4 Planned infrastructure developments

As seen above, a massive expansion of thermal grids is a pillar of the city's energy policy. This growth is accompanied by a series of measures to increase the system's total efficiency. A key challenge is to replace the remaining share of fossil fuels in the thermal grids. The following technical measures are under consideration:



- A coupling of existing grids is foreseen, to take advantage of synergies between individual grids (Bürgi, 2023). A technical long-term concept is currently in elaboration, in parallel to the ongoing reorganization (Section 3.2.3.1).
- An expansion of the heat generation capacity from biomass has been proposed, although the various challenges of biomass use (resource scarcity, space requirements, logistics, air and noise pollution, potentially low acceptance by residents) are noted (GR 2021/377).
- The integration of thermal energy storage was described as indispensable (GR 2021/377), although uncertainty remains over the concrete solutions to be used. For example, both centralized and distributed storages are considered (Bürgi, 2023).
- In the ERZ network, it is foreseen to lower the temperature from currently 113°C to 104 °C to increase energy efficiency (Stadtrat, 2018). This requires some improvements to existing infrastructure to ensure an adequate transportation capacity. Also, the

### 3.2.5 Business model and value network

A generic value network map for thermal grids in Swiss cities (Figure 17) was proposed by Speich & Ulli-Beer (2023). This subsection describes the main actor groups (operators of thermal grids, building owners and managers, HVAC professionals, as well as the municipal departments involved in operative activities) and the economic relationships between them for the specific situation in Zurich (tariff models, connection options, relationships within the HVAC industry, as well as financial support and energy consulting offers available to building owners). The following actor groups present on Figure 17 will not be described in detail: spatial planners (unlike in most other Swiss cities and municipalities, energy and spatial planning are carried out by the city administration itself, with limited involvement of external firms), engineering and construction firms on the supply side (these actor groups are rarely mentioned in the reviewed material), as well as fuel and energy providers (for those cases where the main energy source is operated by a different organizational unit than the grid itself, i.e., the waste incineration and sewage plants, the energy input still comes from units of the city's waste management utility ERZ. There is little information available on the modalities of energy transfer to the grid).

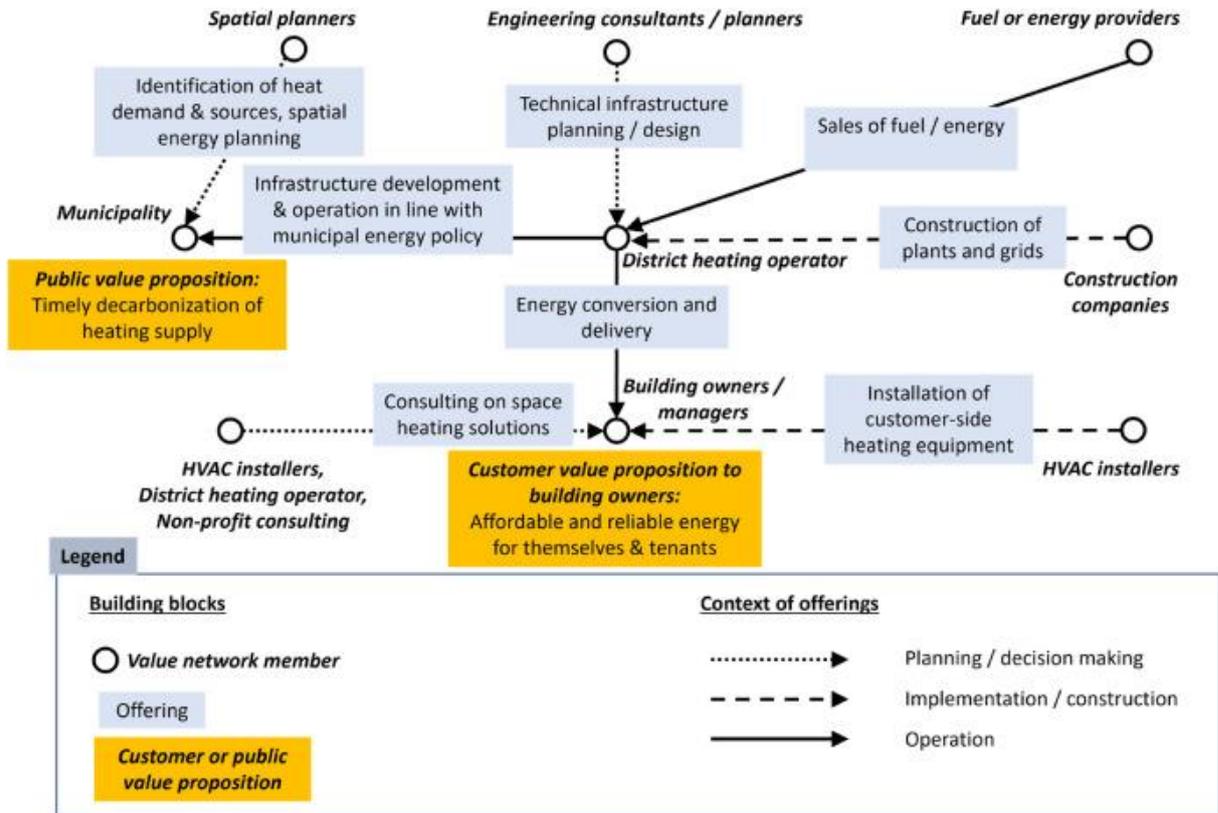


Figure 17: Generic value network around a thermal grid. Source:(Speich & Ulli-Beer, 2023)

### 3.2.5.1 Thermal grid operators

At the center of the value network is the **operator of the thermal grid**. At the time of writing, thermal grids in Zurich were mostly operated by three different utilities, each of which is legally part of the city's administration or under ownership of the city (currently, a reorganization process is under way, following the city executive's decision to transfer a large part of the existing grids under the control of the utility ewz (GR 2023/581). Since the specifics of this reorganization process, which is tied to the consideration of a physical interconnection of different grids (cf. Section 3.2.4.4), are not yet known, this report focuses on the status quo, with mentions of the effects of the reorganization where these are already known).

The district heating grid using heat from waste incineration is operated by the city's waste management utility **Entsorgung und Recycling Zürich (ERZ)**. ERZ is a non-autonomous entity that is part of the city's department for civil engineering and waste management (Tiefbau- und Entsorgungsdepartement). The district heating business unit is one of the profit centers (Eigenwirtschaftsbetriebe) within the organization. In the Canton of Zurich, public utilities must, or may, be organized as profit centers, depending on their activity (Kanton Zürich, 2022a). For the operators of thermal grids, the profit center status is facultative. Nevertheless, it has been decided that this status applies to the ERZ district heating business unit. Organizations with this status must strive for a positive balance and may not cross-subsidy each other's activities. This means that the development and operation of the ERZ district heating grid is not funded through the public budget, but from the utility's earnings. Following the write-off of accumulated debt in 2001 (cf. Section 3.2.1), a new financing model was installed (Figure 18).

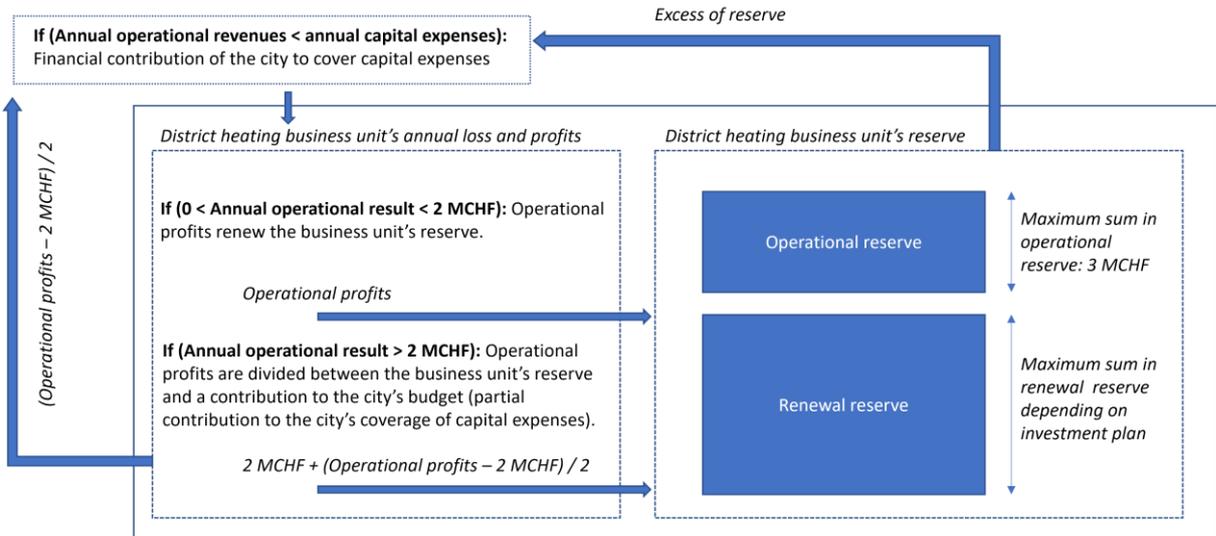


Figure 18: Financing concept of the district heating business unit of ERZ, as described in GR 2003/215.

In 2022, the district heating business unit of ERZ had 73 employees, out of 1014 employees for ERZ in total (ERZ, 2023). The district heating unit grew considerably in recent years, as it had 51 employees in 2013 (Figure 19)<sup>2</sup>. A further increase is planned: the financial plan for 2024-2027 foresees the creation of 11 full-term equivalents in the business unit, for the operation and maintenance of the new infrastructure. As part of the planned reorganization, the entire district heating business unit of ERZ will be transferred to ewz.

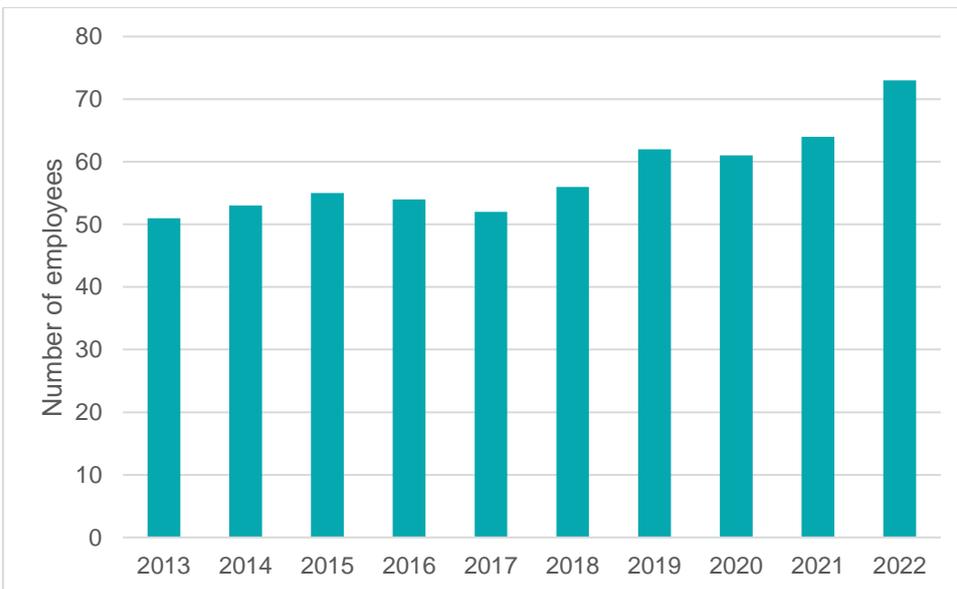


Figure 19: Number of employees in the ERZ district heating business unit. Data source: ERZ annual reports.

The city's electric utility **ewz** is also a non-autonomous entity that is part of the city's administration. It belongs to a different department than ERZ, i.e. the department of industrial services (Department Industrielle Betriebe). Although its primary public mission is to provide electricity to the city (econcept & BHP Hanser und Partner, 2017), ewz has also developed a business unit for energy services. This business unit realizes and operates thermal grids as well as decentral heating and cooling installations, both in Zurich and elsewhere in Switzerland. The utility thus fulfils a mandate (Leistungsauftrag) from the city: due to increasing political will to use renewable and low-carbon energy sources, and following

<sup>2</sup> We note that no information on the distribution of tasks and required skills for these jobs was available.



successful initial projects by ewz (such as the Wipkingen thermal grid, cf. Table 6), the city formulated such a mandate in 2002. While the purpose of this mandate is to enable the city's energy strategy on its own territory, it foresees the provision of energy services on a market basis outside the city, as an additional revenue source. Furthermore, the mandate explicitly mentions innovation and low environmental impact as two areas where ewz should strive for leadership. Like ERZ, ewz follows the profit center model, so that the activities of each business unit must be financially self-sustaining.

The third of Zurich's utilities, **Energie 360° AG**, is a legally autonomous company, unlike ERZ and ewz. The city currently holds 95.87 % of its shares. Energie 360° acts as Zurich's natural gas provider and was privatized in 1998, following the expectation of regulatory changes on the gas market and a subsequent greater need for flexibility for gas providers. Although Energie 360° still has a monopoly on natural gas provision in Zurich and other municipalities, it has made the provision of energy services a strategic priority (econcept & BHP Hanser und Partner, 2017), anticipating a shrinking of the natural gas market. It is active throughout Switzerland on the market for energy services in various sectors such as heating, cooling and transportation. As an autonomous entity, Energie 360° makes no direct payments to the municipal finances. On the other hand, it is a source of revenues for the city through dividends and taxes. As part of the planned reorganization, the larger thermal grids operated or built by Energie 360° will be transferred to ewz. On the other hand, smaller grids will remain with Energie 360°, and the company will continue to build and operate collective connections (cf. Section 3.2.5.6) within the city.

### 3.2.5.2 Building owners and building, real estate and HVAC professionals

On the demand side, a structural analysis of the city's building park (Jakob et al., 2012) revealed a great heterogeneity of building types and owners. Residential uses accounted for 57% of the total floor area, of which more than half (35% of total) belongs to multi-family houses. Of the non-residential uses, offices make up the largest part, with 19% of total. Other relevant uses are commercial activities as well as single-family houses. Compared to the rest of Switzerland, the building park in Zurich is somewhat older: over 20% of buildings are older than 1920. The period 1947-1974, characterized by rapid growth and favorable economic conditions, accounts for a large share of buildings. Buildings from that period have a relatively low energy efficiency. However, the retrofit rate is relatively high for this category, although many retrofits only concern individual components (e.g., windows, roof insulation) rather than taking a whole-building perspective. The latter would entail a much greater potential for energy savings (Domschat, 2023).

Table 7: Distribution of real estate ownership in the city of Zurich (2009). Source: Jakob et al. (2012)

Owner category	% number of owners	% number of buildings	% total floor area	% residential floor area	% non-residential floor area
Individual people	31%	30%	20%	28%	9%
Several individual people	22%	22%	17%	23%	9%
Finance and real estate firms, etc.	15%	13%	27%	15%	43%
Housing cooperatives	13%	15%	11%	17%	3%
City of Zurich	9%	11%	10%	7%	14%
Associations / foundations	4%	4%	6%	4%	7%
Retirement funds	3%	3%	3%	5%	2%
Other public owners	3%	3%	7%	2%	14%
<b>Total</b>	<b>68'663 owners</b>	<b>53'899 buildings</b>	<b>34'325 m<sup>2</sup></b>	<b>19'541 m<sup>2</sup></b>	<b>14'785 m<sup>2</sup></b>



The structural analysis also considered the distribution of ownership (Table 7). This breakdown shows that residential buildings are mostly owned by individual people or cooperatives, whereas a large share of non-residential buildings was owned by finance and real estate firms (Jakob et al., 2012). The spatial distribution of building types and ownership is also heterogeneous: the areas where thermal grids were operational or planned at the time of the analysis (2009) accounted for 49% of all buildings, but for 61% of total floor area. This indicates that thermal grids were primarily built and planned in denser areas, although many dense areas are not yet covered by a thermal grid (Lehmann et al., 2020). Also, the areas of the ERZ grid, as well as the lake surroundings (where in the meantime, thermal grids have been built or are planned over large areas, cf. Section 3.2.3) contain a greater share of buildings owned by financial or real estate companies than the rest of the city (Jakob et al., 2012).

A survey by Lehmann et al. (2020) revealed that, although thermal grids covered a lower share of the city's territory than in other Swiss cities, the readiness of building owners to connect was comparatively high: for the buildings where thermal grids were available, 64% chose this option for a heating system replacement in the surveyed period. This figure was somewhat lower in Basel (54%) and St. Gallen (57%). However, in Winterthur, where connections are mandatory, this figure is substantially higher (90%). Over the years, disconnection of buildings from thermal grids was very rare, indicating high customer satisfaction (Bättig, 2001; Tages-Anzeiger, 2005). Jakob et al. (2012) further noted that buildings owned by cooperatives and public organizations (such as the Canton of Zurich or the federal government) were connected more often to the district heating grid (although this did not apply to the buildings owned by the city itself).

The decision-making of residential building owners in Zurich regarding heating system choice was investigated by Lehmann et al. (2017). Although this study focused on decentral heating options rather than thermal grids, it nevertheless offers insights into the factors that influence building owners' decisions. A key finding was that building owners often seek advice from HVAC installers (this was the case for two thirds of private owners and half of professional owners) or heating system providers. Real estate managers were also found to have an influential role (Bruni et al., 2018). This was found to be problematic insofar as these actors do not have specific skills for consulting, as opposed to engineering firms or architects. Also, there is little incentive for them to spend much effort on consulting, since they are usually not paid for that. An implication is that non-specialized actors were more likely to recommend systems for which little consulting is required, such as gas boilers or connecting to a thermal grid. By contrast, systems seen as more complex, such as heat pumps, were recommended less often. Decision-making on energy retrofit was also studied in Zurich (Rieder et al., 2014): research focused both on the motivations of building owners and on their perceived barriers. Four key motivations impacting the decision-making of building owners were identified:

- Environmental motives.
- Focus on yield and utilization.
- Conservation and increase of value.
- Provision of affordable housing.

The relative importance of these motivations differs between actors. For example, environmental motives are more central for individual owners and users of self-owned office spaces, whereas a yield focus is more central for professional owners. Provision of affordable housing is central for the city administration, as well as for cooperatives, some of which have a public welfare purpose. Besides these key motivations, research has identified five groups of relevant barriers and drivers for energy retrofits:

- Regulatory frame conditions: some regulatory requirements may incentivize retrofits, but the complexity of requirements in various domain represents a substantial barrier.



- Requirements of building users: a high housing demand disincentivizes energy retrofits, whereas high comfort requirements by potential users are an incentive. The relative importance of such effects varies with location and user segment.
- State of the building: older and lower-quality buildings are more likely to be thoroughly modernized.
- Economic factors, especially 1) the opportunity cost of energy-efficiency measures versus other investments and 2) (uncertainties related to) expected return on investment.
- Informational barriers: if building owners, but also professionals, only have a limited knowledge of possible options, opportunities for environmentally and economically beneficial interventions may be missed.

Based on these insights, it has been suggested to combine policy measures that enlarge the building owners' *objective* scope of action (such as incentives and new financing instruments) and measures that enlarge their *perceived* scope of action and/or reduce uncertainties (such as energy consulting, or decision-making tools such as a yield calculator).

### 3.2.5.3 Tenants

With policies aiming at increasing the building retrofit rate, adverse effects on tenants were feared: depending on the depth of the intervention, building retrofits may lead to substantial rent increases or the eviction of tenants. The city therefore commissioned a report assessing the effects of the 2040 net-zero goal on tenants (Infras, 2021). According to this report, it is expected that the intense activity in the construction sector will continue, as Zurich remains an attractive place to live and work. Therefore, building retrofits and replacement will take place at a sustained rate regardless of municipal climate policy. The authors estimated that in a business-as-usual scenario, one-third rented dwellings will be impacted by deep retrofits or building replacements by 2040. In a scenario following the 2040 net-zero goal, about one half of apartments is expected to be impacted. The authors note that these estimations do not cover simple replacements of the heating system without improvements to the building envelope. However, they note that this may lead to increased costs for the tenants if their building is connected to a thermal grid with high energy costs (cf. Section 3.2.5.5).

To mitigate these effects, the authors of the study suggest minimizing distributive effects of financial support instruments: the financing of energy efficiency measures from the CO<sub>2</sub> levy was mentioned as closest to the "polluter pays" principle, whereas financing these measures from taxes would have the least effect on lower-income tenants. By contrast, financing by building owners themselves was expected to have higher adverse social effects, as the costs would be passed to a great extent to the tenants. Regarding connections to thermal grids, the authors suggest improving the offers for temporary solutions, possibly with financial support (cf. Section 3.2.5.6) and monitoring the energetic and financial impact of connections and retrofits, possibly as part of new financial instruments.

### 3.2.5.4 Financial support of building owners

As discussed in Section 3.2.3.3, building owners have a decisive role in reaching the net-zero goal in time, since they take the decision to replace their heating system or improve building energy performance. The encouragement of such measures through financial support is therefore a key lever for energy policy. In Zurich, building owners are eligible for financial support both from the Canton and the city, through various instruments, as summarized by a factsheet from the city (Stadt Zürich, 2023c):

- For the replacement of heating systems with non-fossil solutions (concretely: air-water heat pumps, shallow geothermal heat pumps, water-water heat pumps or the connection to a thermal grid), the Canton and the city both offer subsidies, which are cumulated. For thermal grids, the connection fee is subsidized by a base sum of at least CHF 12'000 (CHF 22'000 for connections > 500 kW), plus CHF 120 for each kW.



- If a new heat distribution system must be installed, this is eligible for a subsidy of CHF 3'200, plus CHF 80 for each kW.
- Building owners who replace their gas- or oil-fueled system before the end of its expected lifetime (25 years) receive a compensation of CHF 4'000, plus the investment costs that have not yet been amortized.
- Building energy retrofits are eligible for subsidies: the instruments of the Canton and the city offer financial support for building envelope retrofits, as well as for more holistic modernizations according to the Minergie standard.
- Under cantonal law, investments with the purpose of energy efficiency and reduced environmental impact can be deducted from taxes.

The payment of a compensation for replacing fossil-fueled heating systems, combined with financial support for a new system and consulting on its optimization, was introduced in October 2022 (GR 2021/362). It is currently set up as a pilot project, with a cap of 13.5 MCHF. In the first year of its application, the experience has been positive: the reserved amount of money will probably be exhausted (additional financing of 6.5 MCHF has been requested by the city council and granted by the municipal council; cf. GR 2023/343), and in more than half of received applications, the heating systems to be replaced are less than 15 years old. This indicates that this instrument is effective in accelerating the phase-out of fossil-fueled heating systems. The city is therefore currently considering a follow-up program (Stadt Zürich, 2023b).

Besides financial support of energy efficiency and heating system investments, the second set of instruments used by the city to influence building owners is an energy consulting and coaching offer. In 2009, the city set up a pilot project with coaching offers on energy-related topics to building owners (cf. GR 2012/222). The stated aim was to integrate expert knowledge into the planning and realization of construction and renovation projects by private building owners in order to encourage the adoption of efficient solutions. The coaching consists of the supervision of the preliminary study, project planning and/or realization phases by independent experts from private engineering or architecture firms. These experts are mandated by the city for this role, following a public procurement process. The city acts as a first point of contact for interested building owners and offers an initial consulting service. For building owners who wish more in-depth consulting, the city organizes the contact with external experts. In addition, a steering committee of city-internal and external experts (including representatives from the utilities ERZ and ewz) is responsible for quality control, and a pool of experts from the city's various departments helps devise solutions to address conflicting goals regarding energy, building and aesthetics.

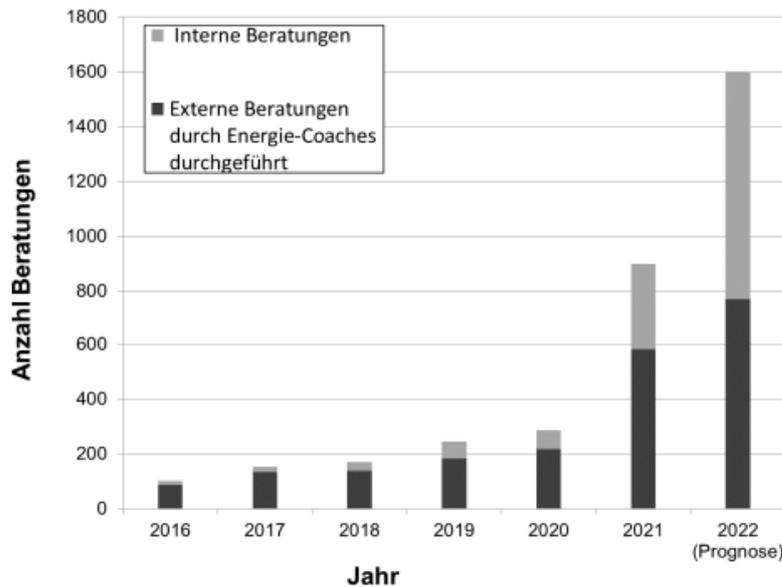


Figure 20: Annual number of energy coachings performed by the city (internal) and by mandated external experts (Source: GR 2022/305)

Following a positive assessment of the pilot project's impact, the municipal council approved the request to establish the energy coaching as a permanent activity, with an annual budget of CHF 970'000. More than half of this sum is expected to go towards services provided by external actors, i.e., the energy coachings and the development of new tools and offers. While the city covers part of the costs for the coaching, building owners are expected to contribute. The concrete share to be covered by building owners depends on the concrete project, also considering the energy impact of the implemented measures.

In 2021, a marked increase in the demand for energy coachings was noted (Figure 20). This was attributed to a general increase in awareness of climate change, but also concretely to the prospect of a ban on fossil-fueled heating systems under the Canton's new energy law. As a result, the municipal council approved to increase the annual budget for energy coaching to 2 MCHF (GR 2022/305). At the same time, a bill introduced by municipal council members requested an increase of the building owners' contribution to the coaching costs: the share to be covered by building owners should be no less than 40%, instead of the current value of approximately 20% (GR 2022/571). However, this proposal was rejected, as the incentivization of building owners was deemed important.

### 3.2.5.5 Tariff models

Tariff models for thermal grids in Switzerland generally have a similar structure and mostly comprise three main components: a one-time connection fee, a tariff per kWh and a tariff per kW<sup>3</sup>. Despite the similar structure, important differences exist in the calculation of the individual components, resulting in great differences in annual heating costs for customers (Preisüberwacher, 2023). Also in Zurich, the different grids currently have different tariffs, although they have been harmonized to follow the three-component structure outlined above (the WVV requires that all thermal grids with public mandate or concession structure their prices accordingly, cf. Section 3.2.3.2). For the ERZ district heating network, the tariff model was recently updated, with some key differences to the previous model (established in 2000): first, under the previous tariff model, the price per kWh was coupled to the oil price, whereas the new model makes the price per kWh dependent upon energy recovery costs and price indices; second, fixed costs are weighted higher than before in comparison to variable costs; and third, the new tariff

<sup>3</sup> Some operators only charge a tariff per kW or per kWh, and some include additional price components (Preisüberwacher, 2023)



model includes a penalty for high return temperatures as an incentive for customers to optimize the functioning of substations and demand-side installations.

Prior to 2022, the price per kWh ( $P_1$ ) was set as follows:

$$P_{1,pre-2022} = \begin{cases} 1.4 * 30 - (30 - P_{oil}) * 0.5, & \text{if } P_{oil} < 30 \\ 1.4 * P_{oil}, & \text{if } 30 \leq P_{oil} \leq 45 \\ 1.4 * 45 + (P_{oil} - 45) * 0.5, & \text{if } P_{oil} > 45 \end{cases},$$

where the oil price  $P_{oil}$  is expressed in CHF/100l. Under this model, the price of heat increases linearly with the price of oil, with a less steep slope when  $P_{oil}$  is below or above a certain threshold. This model took advantage of the low costs for waste heat, allowing the operator to absorb high oil prices and thus offer a priceworthy alternative in times of high oil prices (cf. Section 3.2.1). By contrast, when oil prices are low, the price of heat falls less steeply in order to ensure a cost-effective operation (Tages-Anzeiger, 2005). A downside of this model for the utility is that annual revenue fluctuates rather strongly. For example, oil price fluctuations impacted revenues from energy sales in the years 2015 and 2016 (Figure 22), so that almost no contribution to public finances could be made in those years (econcept & BHP Hanser und Partner, 2017). The new model no longer ties the heating price to the oil price: instead, the energy price depends on the costs of recovering heat from the waste incineration plant (currently 1.4 Rp./kWh, Stadt Zürich, 2022a), as well as the development of three price indices: the Zurich energy price index (cf. Section 3.2.1), the Zurich index for housing prices and the national consumer price index. These developments are factored into the energy price as follows:

$$P_{1,2022} = 65 * \left( 0.15 \frac{P_{waste\ heat}}{P_{waste\ heat,2021}} + 0.35 \frac{I_{housing}}{I_{housing,2021}} + 0.25 \frac{I_{energy}}{I_{energy,2021}} + 0.25 \frac{I_{consumer}}{I_{consumer,2021}} \right) * f_{temp}.$$

The factor  $f_{temp}$  depends on the average return temperature, which is determined periodically from the measurements at the district heating meter:

$$f_{temp} = 100\% + \min (T_{return} - T_{return,max}, 20\%),$$

where  $T_{return,max}$  is the maximal authorized return temperature as per technical conditions (the online price sheet mentions a  $T_{return,max}$  of 50°C). For example, if the meter readings show an average return temperature of 62.4°C, the price per kWh  $P_1$  for that building will increase by 12.4% (as can be seen in the equation above,  $f_{temp}$  is capped to an increase of 20%).

As mentioned above, the new tariff model gives more weight to the kW-dependent price component ( $P_2$ ) in order to reflect the high infrastructure costs. Also, this choice is meant to incentivize a decrease of connection power, so that more buildings can connect and the grid can be operated at lower costs (Stadt Zürich, 2022a). Indeed, whereas the previous tariff model calculated  $P_2$  as a square-root function of the connection power, the new model uses a piecewise linear relationship, with a particularly steep increase of CHF 42 per additional kW up to 250 kW (Figure 21). As a result,  $P_2$  may more than double under the new model: for a connection power of 250 kW,  $P_2$  was CHF 5'285 under the previous model and CHF 11'400 under the current model, which corresponds to an increase of 116%. At the same time,  $P_1$  decreased somewhat: in 2023,  $P_1$  was 10.5% lower than under the old model, which represents a decrease of CHF 4'590 for a building with an annual energy use of 600 MWh. In sum, the tariff model change leads to an increase of 3.25% across all customer segments (Stadt Zürich, 2022a).

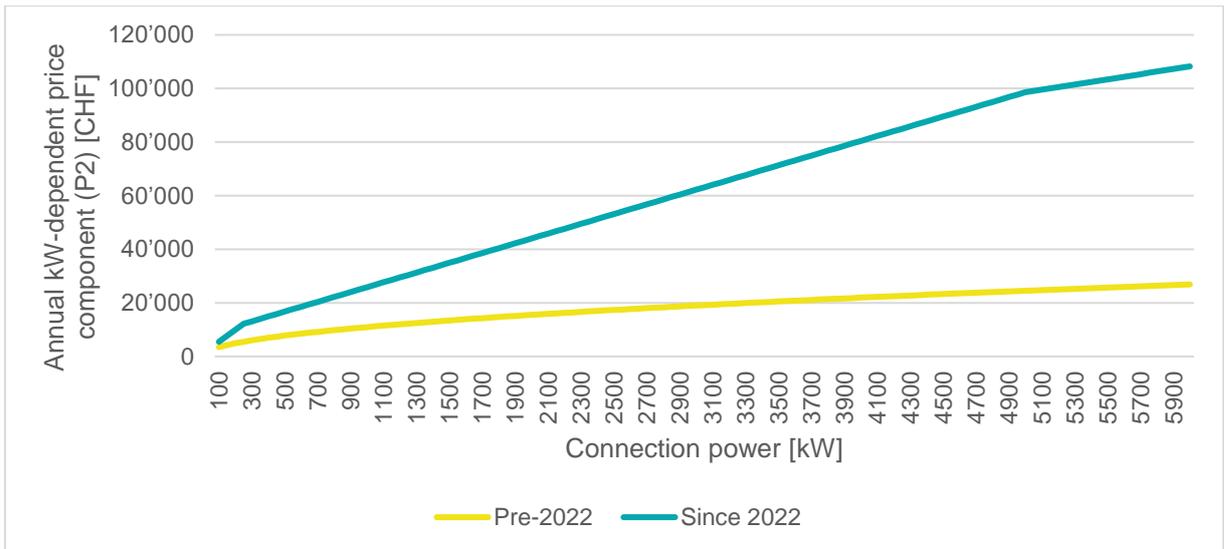


Figure 21: Comparison of the kW-dependent price component in the pre-2022 and current tariff models for the ERZ grid.

A comparison of the annual costs under the old and the new model (for the latter, these estimates are hypothetical, as the tariff change occurred in 2022 only) for the period 2010-2019 (Figure 22) shows that under the new model, costs fluctuate much less from year to year. Figure 22 is a screenshot from a spreadsheet provided by the city when the tariff change was announced (Stadt Zürich, 2022a). According to the accompanying text, the greater stability of the new model is a direct consequence of decoupling from the oil price.

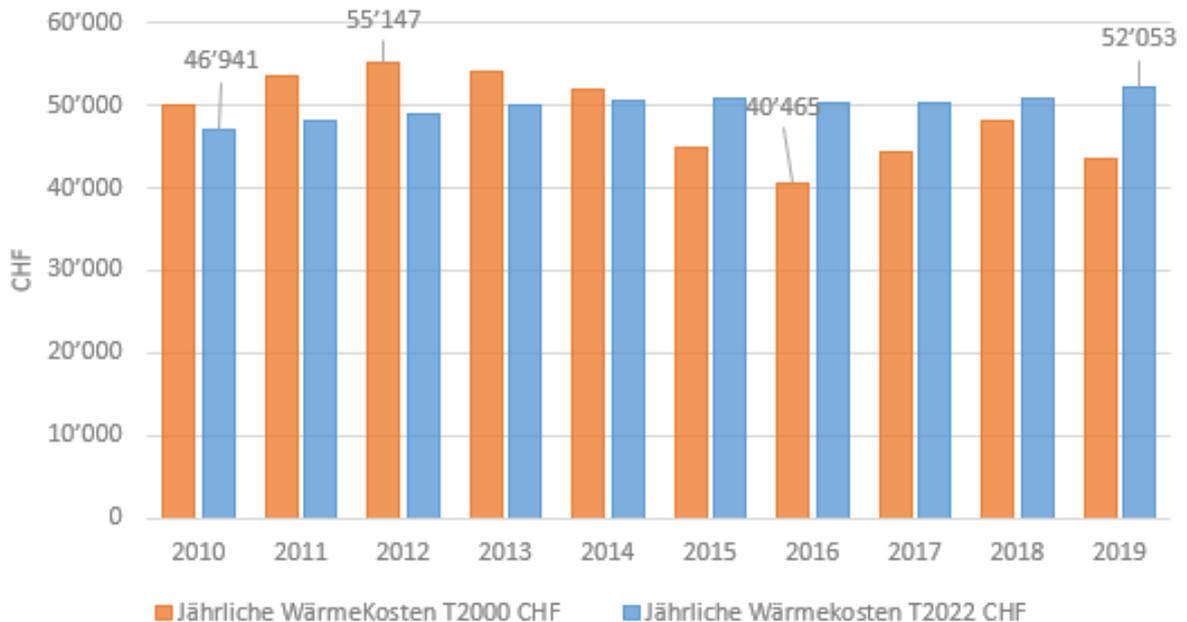


Figure 22: Ex-post comparison of annual heating costs for the ERZ district heating grid under the previous (orange) and new tariff model (blue). This calculation assumes a building with an annual energy use of 600 MWh for heating and connected power of 250 kW, with no penalty for high return temperatures. Source: spreadsheet provided by Stadt Zürich (2022).

As mentioned above, the different thermal grids in Zurich have their own tariffs, reflecting location-specific factors such as energy and infrastructure costs. A comparison of the ERZ grid with some of the grids operated by ewz (Table 8) reveals important differences in the annual costs for customers: in grids



such as Hardau (with groundwater as energy source) or Seefeld (lake water), customers pay twice as much or more compared to a building with the same connected power and energy use connected to the ERZ grid. The comparison further reveals important differences in the price per kW ( $P_2$ ): the prices in the ewz grids are three to five times higher than under the current ERZ tariff model, and up to ten times higher than under the pre-2022 ERZ tariff model. The prices per kWh ( $P_1$ ), on the other hand, are all in a similar range, except for Hardau, where they are substantially higher.

The new energy law in the Canton of Zurich prohibits the installation of new fossil heating systems, unless the life-cycle costs of renewable heating systems exceed those of a fossil system by at least 5%. To assist building owners in assessing whether the new rule applies to their case, the Canton provides a spreadsheet allowing a cost comparison. This allows a comparison of the costs for thermal grids with renewable and fossil heating systems (Table 8). For a building with the same demand characteristics, both heat pumps and fossil-fueled boilers lead to higher costs than the ERZ grid, but lower costs than the lake water-based grid Seefeld.

In some cases, customers have the option to choose a 100% renewable option, with a higher price per kWh: for example, in the Altstetten/Höngg grid, choosing the 100% renewable product leads to a  $P_1$  of 8.2 Rp./kWh instead of the 7.5 Rp./kWh of the standard product (75% renewable). Some of the price sheets also list the prices for cooling:  $P_1$  amounts to 3.7 (Altstetten/Höngg) and 6.1 Rp./kWh (Klausstrasse), whereas  $P_2$  amounts to 131 and 107 CHF/kW, respectively.

Table 8: Tariffs for selected thermal grids in Zurich, and costs for decentral heating systems for reference. Calculations in the two rightmost columns assume a multi-family building with 50 apartments, a subscribed power of 250 kW and an annual heat consumption of 600 MWh. Also, the connection fee is not considered in these calculations, whereas figures for decentral heating systems do include investment costs. Data source: spreadsheet provided by Stadt Zürich (2022) for ERZ, online price sheets for ewz (date of last access: November 2023), spreadsheet provided by the Canton of Zurich (Kanton Zürich, 2022b) for decentral heating systems.

Grid	Price per kW (CHF/KW)	Price per kWh (Rp./kWh)	Resulting effective energy price (Rp./kWh)	Annual energy costs per apartment (CHF/a)
ERZ (pre-2022)	23.6	7.3	8.3	994
ERZ (since 2022)	46.5	6.5	8.4	1'013
Altstetten / Höngg	146.0	7.5	13.6	1'630
Hardau	202.0	11.5	19.9	2'390
Seefeld	230.0	6.8	16.4	1'966
Seefeld / Klausstrasse	230.0	8.2	17.8	2'134
Air-water heat pump (COP 2.5)	-	-	12.9	1'547
Ground-source heat pump (COP 3.5)	-	-	12.1	1'451
Natural gas	-	-	14.6	1'757
Oil	-	-	16.0	1'919

The remaining component of the tariff model, the connection fee, is also calculated differently in different grids. While the price sheets for some ewz grids list concrete prices as a function of connection power (Altstetten/Höngg, Seefeld), others do not specify any price, and the ERZ price sheet provides a formula for an indicative price, while specifying that the effective price will be calculated as part of the quote. For example, for a connection power of 250 kW, the price sheets for Altstetten/Höngg and Seefeld indicate a connection fee of CHF 101'928. Since subsidies are available (see below), the price to be paid by the customer is reduced to CHF 59'928 (for the same connection power, the indicative price given by the



ERZ formula amounts to CHF 74'633). Assuming an interest rate of 5% and a period of amortization of 40 years, this adds an annuity of CHF 70 to the annual costs per apartment (rightmost column of Table 8).

#### **3.2.5.6** Connection options

As a further measure to accelerate the roll-out of thermal grids, collective connections (in German: Gemeinschaftsanschlüsse) are promoted by the city. This solution consists of building a secondary grid connecting several buildings to the primary thermal grid. This solution offers several advantages to building owners: since the secondary grid can be operated temporarily with another energy source (e.g., natural gas), building owners have more flexibility regarding the timing of connection. Also, costs and construction intensity on public ground can be reduced (Tages-Anzeiger, 2021). In Zurich, this option is offered by Energie 360°.

#### **3.2.6** Supporting resources

The organizational, regulatory and policy developments described in this report rely on a set of supporting, public or common resources. In particular, one type of resources will be highlighted here: the knowledge base resulting from application-oriented and problem-oriented research.

To steer the complex process of the net-zero transition, an extensive knowledge of technical and social aspects is essential. To address the uncertainty around the proposed strategy, as well as around concrete measures, the city regularly commissions reports and studies on specific topics. For example, the general feasibility of the net-zero transition (INFRAS & Quantis, 2020), the choice of a suitable strategy to decommission the natural gas grid while minimizing negative impacts for the public and for residents (eicher+pauli/INFRAS, 2022) or the choice of an adequate organizational form for the city's utilities (econcept & BHP Hanser und Partner, 2017) were objects of such reports. Of note is the research program "Energieforschung Stadt Zürich", where various implementation-oriented research projects were funded between 2010 and 2020 to help realize the goals of the 2000W society. In retrospect, this research program generated valuable outcomes: basic results (such as a structural analysis of the building park in Zurich, or a mapping of the relevant barriers and drivers to energy efficiency) influenced the design of various policy instruments (Banfi Frost & Dettli, 2023).



## 4 Concluding discussion

### 4.1 Learnings

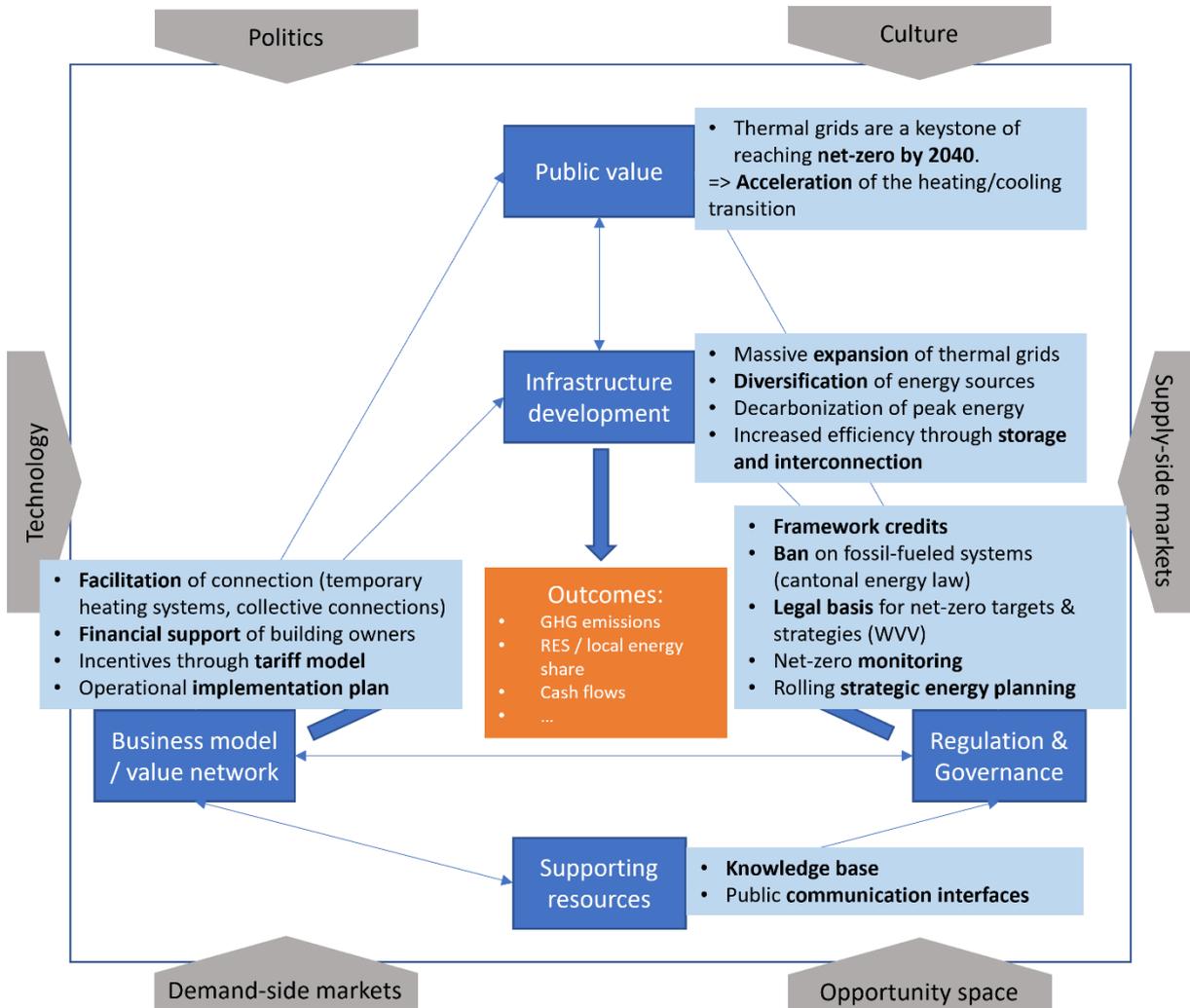


Figure 23: Overview of measures taken by the city of Zurich to accelerate the decarbonization of heating and cooling through the development of thermal grids.

As cities and municipalities adopt net-zero goals with an ambitious timeframe, local energy policy, planning and business models must be aligned with this timeline. In recent years, the city of Zurich has taken various measures to ensure such alignment, as summarized on Figure 23. Upon setting the 2040 net-zero goal, Zurich identified the massive expansion of thermal grids as a key measure to reach this goal for the building sector. At the same time, this development was deemed particularly time-critical, so that several recent developments (regulatory, organizational, etc.) are aimed at accelerating decision-making and implementation. The aim of this report was to structure the inventory of these measures to facilitate learning from the specific case of Zurich. While only an initial assessment of these measures is possible (see below), taking stock of these developments shows which measures are politically and operationally feasible in the context of a major city. The availability of rich qualitative and quantitative data gives the opportunity to understand the rationale behind these measures.

The city's strategy foresees an expansion of thermal grids on two thirds of the city's territory, deploying several localized energy potentials (mainly waste incineration excess heat, sewage water excess heat, as well as ambient heat from the lake and groundwater). The expansion of thermal grids, as well as the substitution of fossil fuels within extant grids, require considerable investments. To increase the efficiency of the whole system, further improvements, such as thermal energy storage and an



interconnection of thermal grids, are foreseen. The organizational model in Zurich foresees that these developments are self-financed by the responsible business units. However, since the city's utilities are legally part of the municipal administration, these investments are subject to political control. The current **governance** arrangement reflects the need for fast decision-making: the planned investments take the form of framework credits, i.e., a global sum for large projects which was approved by popular vote. Concrete spending decisions within a framework credit are at the discretion of the city's executive (city council) and must not be approved again by the municipal council or the voters. Currently, the framework credits for the development of thermal grids cover more than one billion CHF. This is accompanied by a closer monitoring in the strategic energy planning process: whereas spatial energy planning was previously done approximately every 15 years, it is now a continuous process, so that new developments can be accounted for quickly. Furthermore, the city has developed a new instrument to track progress of decarbonization: the net-zero monitoring takes stock of the measures planned throughout the city's administration and reviews whether they are in line the 2040 net-zero goal. If not, the city is obligated to formulate corrective, sector-specific measures. At the operational level, a coordinating role of the city council for the selection of infrastructure sites aims at accelerating decision-making. An important operational instrument is the implementation plan: by setting up a coordination process with the city's civil engineering department, this instrument reduces the coordination costs for individual projects and enables a long-term planning of grid construction. These governance changes are accompanied by changes in **regulation**: the ordinance for heat supply (WVV) gives a legal basis to the city's strategies. This makes the content of these strategies binding not only for authorities, but also for building owners. At the cantonal level, the new energy law prohibits the installation of new fossil-fueled heating systems since September 2022.

These changes impact the **business model** of the utilities, as well as the economic exchanges between utilities, building owners and building professionals. On the supply-side, utilities can build upon their capabilities and capacities, which they have developed over a long time. The district heating business unit of ERZ has been in charge of the high-temperature grid for several decades. Likewise, ewz has valorized low-temperature energy sources, such as sewage water, low-grade excess heat or ambient heat, since pilot projects in the late 1990s. The city's policy of mandating ewz to develop this business field, with projects both in Zurich and elsewhere, has allowed the utility to develop its capabilities in this domain, so that it can now realize the large projects planned in Zurich. Finally, Energie 360° also has developed capabilities in the energy services domain in commercial activities throughout Switzerland. These complementary capacities have been described as a success factor in previous projects. A concrete example is the promotion of community connections (Gemeinschaftsanschlüsse) by Energie 360°: by offering building owners more flexibility on the timing of connection, this solution facilitates customer acquisition and thus helps accelerate the roll-out of thermal grids. On the demand-side, various interventions aim at influencing building owners' decision-making. The city offers three types of direct financial support: 1) energy consulting, 2) investments into energy efficiency and heating system replacement, and 3) early replacement of fossil-fueled heating systems. These instruments also reflect the necessity to accelerate the heating transition: energy consulting offers (1) aim at ensuring that building owners receive qualified advice. Indeed, studies have shown that building owners often take advice from less qualified actors, leading them to choose sub-optimal options. The financial support (2) aims not only to match offers by the cantonal and federal administrations, but also to close a temporal gap until these instruments are rolled out. Finally, the support of early heating system replacement (3) was deemed necessary to reach the 2040 net-zero goal, since many fossil-fueled systems are still quite recent. Utilities, on their side, seek to steer decision-making through incentivizing elements of tariff models. Concretely, incentives are set to keep the subscribed power low (so that the utility can connect more buildings) and to optimize the performance of secondary-side systems.

Although these developments are recent, some initial observations on their success can be made. On a policy level, both coercive and supportive measures seem to reach the intended impact: although the cantonal energy law allows for justified exceptions to the ban on fossil-fueled systems, the number of applications for such exceptions is very low. The financial support offers for energy consulting and heating system replacement are in high demand, and many recent fossil-fueled heating systems have



been replaced. A direct causal link between consulting and decision-making has, however, been questioned by some policymakers. Regarding the roll-out of thermal grids, implementation is so far proceeding according to schedule, and the demand for new connections is greater than expected.

On the other hand, this report has also highlighted some challenges and open questions of the selected approach: on the infrastructure side, the search for suitable locations is difficult within the city, and conflicting land uses may pose a trade-off between speed of decision-making and perceived fairness. Also, planned improvements to the infrastructure, such as thermal energy storage or the interconnection of thermal grids, are not yet laid out in detail (e.g., in public planning documents), as the optimal planning of such systems is a complex task. Another challenge concerns the evolution of energy demand: while the city has ample scope to steer the development of infrastructure, its influence on building owners' decision-making is limited to consulting and financial support. However, unless demand is reduced, the available excess and renewable heat potentials will not be enough. Indeed, current policies and economic frame conditions are not conducive to net-zero in buildings. Furthermore, some open questions concern the economic effects of the energy transition on private households and firms: although the effects of building retrofit and thermal grid development are expected to be limited for tenants (compared to parallel trends in the real estate sector), the deployment of thermal grids nevertheless leads to higher energy costs. The acceptance of such costs and their perception by tenants and private building owners is not yet known. The introduction of a single tariff across all thermal grids, which is currently discussed, also raises the question of fairness and potentially unwanted distributive effects. Finally, there is a potential conflict between the economics of thermal grids from the utility's point of view and the perceived right of small building owners to access the grid. Finally, on a longer timescale, the reliance on waste incineration raises the question whether this strategy reduces opportunities for recycling and circularity.

To summarize, although many of the presented measures are recent and cannot be evaluated yet, this report allows some conclusions to be drawn, which can assist further cities and municipalities in managing their transition towards net-zero. Recall that Zurich was selected both as an extreme case and a critical case (Flyvbjerg, 2006) in that it has high political support, ample financial resources and a high level of local expertise for its energy transition, but also high technical and organizational complexity. As an extreme case, it presents a unique set of policy and organizational measures. As a critical case, it allows to identify issues that are likely even more problematic under less favorable settings ("if this is a problem here, it will likely be a problem elsewhere") – or, conversely, successful solutions that are likely to be successful in less complex settings ("if this works here, it will likely work elsewhere"). Here, the first type of conclusions concern policy and organizational measures, whereas the second type of conclusions concern technical solutions.

As an extreme case, the following conclusions can be drawn:

- Among the ambitious policies in Zurich are far-reaching supportive measures (financial support, including compensations for early heating system replacement). These measures have so far achieved their intended effect. This suggests a high willingness of building owners to change their heating system, despite non-financial barriers (e.g., time and effort). Monitoring this decision-making in the next years will give insights into the concrete motivations of building owners under these new policy settings.
- The increase in demand for energy consulting, which coincides with the drafting and acceptance of the cantonal energy law, suggests that fossil-fuel bans should be accompanied by suitable consulting offers.
- On the supply-side, this case study demonstrates that critical capabilities may need a long time to be built. This is evidenced by the decades-long experience of ewz in valorizing low-grade heat potentials, which now enables the utility to realize such large-scale projects. Conversely,



this helps explain why the uptake of such technologies is slow, despite large potentials (Hangartner & Hurni, 2022).

As a critical case, the case of Zurich highlighted following trade-offs:

- Speed of decision-making and perceived fairness: the prioritization of fast decarbonization has led to a trade-off with perceived fairness, e.g., regarding the selection of sites. In areas where political support for decarbonization is not as strong as in Zurich, this may become critical.
- Grid economics and perceived fairness: economic fairness is at the heart of several identified controversies (single tariff decision, decision to connect small buildings, effects on tenants). In municipalities where support for decarbonization is not as strong and/or thermal grids are smaller, this may be an issue for the acceptance of thermal grids by customers or citizens. This is in line with Chambers et al. (2021), who highlighted the distribution of costs as an underappreciated challenge for decarbonization.
- Public benefits of subsidies and administrative action: as noted above, financial support measures have so far had a beneficial impact. Also, instruments such as rolling energy planning or net-zero monitoring likely facilitate the management of decarbonization. However, other municipalities may not have the means or political support for such expenses. An integrated strategy for managing heating supply and demand may be useful to plan and justify such actions.

From a technological point of view, Zurich may act as a critical case due to its complexity (e.g., several different energy sources at different temperature levels). Therefore, viable concepts for the interconnection of thermal grids can form a blueprint for application in other areas.

#### **4.2 Learning opportunities and outlook**

The collaboration of Zurich in SWEET-DeCarbCH gives the opportunity to study the effect of its policies over time. From a socio-economic and organizational perspective, the following questions are of interest:

- How do customers react to incentivizing tariff elements (return temperature penalty, higher subscription price)?
- How successful are 100% renewable products? What can be learned about the willingness of customers to pay for higher environmental value?
- What is the success of specific measures to acquire customers (voluntary increase of the connection fee, special agreements with customers in areas to be densified, temporary solutions)?
- How does the new energy policy impact the local business ecosystem (development of skills among installers, engineers, etc.; decision-making of building owners)? cf. Lehmann et al. (2017)



## 5 References

- Adam, F., & Morf, L. (2018). *Überprüfung der Kapazitäts- und Standortplanung der thermischen Verwertung von Abfällen im Kanton Zürich 2012-2035*. Retrieved from [https://www.zh.ch/content/dam/zhweb/bilder-dokumente/themen/umwelt-tiere/abfall-rohstoffe/abfallwirtschaft/publikationen/ergebnisbericht\\_kapazitaetsplanung\\_kva\\_2012-2035\\_anpassung\\_2018.pdf](https://www.zh.ch/content/dam/zhweb/bilder-dokumente/themen/umwelt-tiere/abfall-rohstoffe/abfallwirtschaft/publikationen/ergebnisbericht_kapazitaetsplanung_kva_2012-2035_anpassung_2018.pdf)
- Atlas of Public Management. (2017). Public Value Account. Retrieved from <https://www.atlas101.ca/pm/concepts/public-value-account/>
- Banfi Frost, S., & Dettli, R. (2023). *Energieforschung Stadt Zürich*. Retrieved from [https://www.seval.ch/app/uploads/2023/09/WK2\\_Seval-Kongress-2023-Energieforschung-Zuerich.pdf](https://www.seval.ch/app/uploads/2023/09/WK2_Seval-Kongress-2023-Energieforschung-Zuerich.pdf)
- Bättig, I. (2001). Fernwärme : ein Auslaufmodell? *Wohnen*, 76(6). <https://doi.org/https://doi.org/10.5169/seals-106991>
- Boschung, P. (2021, October 14). Swiss Life Arena in Zürich-Altstetten: Der «Löwenkäfig» wird eröffnet. *Baublatt*. Retrieved from <https://www.baublatt.ch/bauprojekte/swiss-life-arena-in-zuerich-altstetten-der-zsc-loewenkaefig-wird-eroeffnet-33404>
- Bruni, S., Hanisch, C., Mantei, V., & Dewald, C. (2018). *Rolle der Immobilienbewirtschaftenden bei energetischen Erneuerungen im Stockwerkeigentum*. Retrieved from [https://energieforschung-zuerich.ch/media/topics/report/FP-2.10\\_Forschungsbericht.pdf](https://energieforschung-zuerich.ch/media/topics/report/FP-2.10_Forschungsbericht.pdf)
- Bryson, J., Sancino, A., Benington, J., & Sørensen, E. (2017). Towards a multi-actor theory of public value co-creation. *Public Management Review*, 19(5), 640–654. <https://doi.org/10.1080/14719037.2016.1192164>
- Bürgi, R. (2023). Für Stadt und Land. *Faktor Thermische Netze*, 12–16.
- CH2018 Project Team. (2018). CH2018 - Climate Scenarios for Switzerland. In *National Centre for Climate Services*. <https://doi.org/10.18751/Climate/Scenarios/CH2018/1.0>
- Chambers, J., Zuberi, M. J. S., Streicher, K. N., & Patel, M. K. (2021). Geospatial global sensitivity analysis of a heat energy service decarbonisation model of the building stock. *Applied Energy*, 302, 117592. <https://doi.org/10.1016/j.apenergy.2021.117592>
- Domschat, F. (2023). *Thermische Sanierungskonzepte für 60/70er-Jahre Bauten* (p. 14). p. 14. Retrieved from [https://forumenergie.ch/images/fez/anlaesse/fez/uptodate/2023/pdf/FEZ\\_UpToDate07\\_Folien\\_Domschat\\_20230710.pdf](https://forumenergie.ch/images/fez/anlaesse/fez/uptodate/2023/pdf/FEZ_UpToDate07_Folien_Domschat_20230710.pdf)
- econcept, & BHP Hanser und Partner. (2017). *Organisation der Energieversorgung Stadt Zürich. Expertenbericht zum Postulat 2016/321*. Retrieved from [https://www.econcept.ch/media/projects/downloads/2018/04/201805\\_Beilage\\_STRB\\_Nr.\\_310\\_2018.pdf](https://www.econcept.ch/media/projects/downloads/2018/04/201805_Beilage_STRB_Nr._310_2018.pdf)
- eicher+pauli/INFRAS. (2022). *Ergänzungsstudie Direktumstieg Gas-Fernwärme Stadt Zürich*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/energie/Startseite/energiepolitik/BE20220322\\_SchlussberichtErgaenzungsstudieDirektumstieg.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/energie/Startseite/energiepolitik/BE20220322_SchlussberichtErgaenzungsstudieDirektumstieg.pdf)
- Energie 360°. (2022). *Energieverbund Lengg*. Retrieved from [https://gesundheitscluster.ch/files/20220920\\_Energie360\\_VeranstaltungGCL.pdf](https://gesundheitscluster.ch/files/20220920_Energie360_VeranstaltungGCL.pdf)
- ERZ. (2013). *Bewährt, sauber und sicher – Zürich Wärme*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/zed/Deutsch/erz/fernwaerme/ZW\\_Bewaehrt\\_sauber\\_sicher-ZuerichWaerme\\_1311.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/zed/Deutsch/erz/fernwaerme/ZW_Bewaehrt_sauber_sicher-ZuerichWaerme_1311.pdf)
- ERZ. (2023). *Tätigkeitsbericht 2022*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/zed/Deutsch/erz/wissen/tb/erz\\_taetigkeitsbericht\\_2022.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/zed/Deutsch/erz/wissen/tb/erz_taetigkeitsbericht_2022.pdf)
- ewz. (2023a). *Seewasserverbunde Zürichsee*. Retrieved from <https://www.ewz.ch/de/geschaeftskunden/immobilien/referenzen-projekte/seewasserverbunde-zuerichsee.html>
- ewz. (2023b). *Trotz stabiler ewz-Energiepreise – nationale Netznutzungskosten führen zu Tariferhöhungen*. Retrieved from [https://www.ewz.ch/de/ueber-ewz/newsroom/medienmitteilungen/2023/ewz\\_Tarife\\_2024.html](https://www.ewz.ch/de/ueber-ewz/newsroom/medienmitteilungen/2023/ewz_Tarife_2024.html)
- Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, 12(2), 219–245. <https://doi.org/10.1177/1077800405284363>
- Hangartner, D., & Hurni, A. (2022). *Liste "Thermische Netze" - Auswertungsbericht 2021*. Retrieved from <https://pubdb.bfe.admin.ch/de/publication/download/10878>



- Häusermann, M., & Mast, M. (2017). *Fallbeispiel Anergienetz ETH Hönggerberg*. Retrieved from <https://pubdb.bfe.admin.ch/de/publication/download/8836>
- Hofmann, B., & Richert, J. (2016). *Effektivere Mehrebenenpolitik im Bereich Wärme* (No. 8). Retrieved from [https://www.sccer-crest.ch/fileadmin/FILES/Datenbank\\_Personen\\_Projekte\\_Publikationen/Publications/Working\\_Papers/Work\\_Package\\_1/Hofmann\\_Richert\\_2016\\_Effektivere\\_Mehrebenenpolitik\\_im\\_Bereich\\_Waerme.pdf](https://www.sccer-crest.ch/fileadmin/FILES/Datenbank_Personen_Projekte_Publikationen/Publications/Working_Papers/Work_Package_1/Hofmann_Richert_2016_Effektivere_Mehrebenenpolitik_im_Bereich_Waerme.pdf)
- Infras. (2021). *Netto-Null Treibhausgase in der Stadt Zürich: Auswirkungen auf Mieterinnen und Mieter*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/gud/Deutsch/UGZ/ugz/umweltpolitik/dokumente/Schlussbericht\\_NettoNull\\_Auswirkungen\\_auf\\_Mietende\\_\\_\(Infras2021\).pdf](https://www.stadt-zuerich.ch/content/dam/stzh/gud/Deutsch/UGZ/ugz/umweltpolitik/dokumente/Schlussbericht_NettoNull_Auswirkungen_auf_Mietende__(Infras2021).pdf)
- INFRAS, & Quantis. (2020). *Netto-Null Treibhausgasemissionen Stadt Zürich. Grundlagenbericht*. Retrieved from [https://www.infras.ch/media/filer\\_public/b9/12/b912a919-19cf-471c-94da-c60f58345908/grundlagenbericht\\_netto-null\\_200915\\_final.pdf](https://www.infras.ch/media/filer_public/b9/12/b912a919-19cf-471c-94da-c60f58345908/grundlagenbericht_netto-null_200915_final.pdf)
- Jakob, M., Gross, N., Honegger-Ott, A., Unterhollenberg, S., & Nägeli, C. (2012). *Der Gebäudepark in der Stadt Zürich. Grundlagenbericht im Hinblick auf die Identifikation und Bildung von Clustern*. Retrieved from [https://energieforschung-zuerich.ch/media/topics/report/Bericht\\_Gebaeudepark\\_in\\_der\\_Stadt\\_Zuerich\\_FP-2.1.pdf](https://energieforschung-zuerich.ch/media/topics/report/Bericht_Gebaeudepark_in_der_Stadt_Zuerich_FP-2.1.pdf)
- Kägi, S. (2023). *FEZ UpToDate: Suffizienz ein MUSS für Netto-Null?* (p. 45). p. 45. Retrieved from [https://www.forumenergie.ch/images/fez/anlaesse/fez/uptodate/2023/pdf/FEZ\\_UpToDate04\\_Foli en\\_Kaegi\\_20230413.pdf](https://www.forumenergie.ch/images/fez/anlaesse/fez/uptodate/2023/pdf/FEZ_UpToDate04_Foli en_Kaegi_20230413.pdf)
- Kanton Zürich. (2022a). *Eigenwirtschaftsbetriebe*. In *Handbuch über den Finanzhaushalt der Zürcher Gemeinden*. Retrieved from <https://www.zh.ch/de/steuern-finanzen/gemeindefinanzen/finanzhaushalt-gemeinden/handbuch-finanzhaushalt.html>
- Kanton Zürich. (2022b). *Heizkostenrechner*. Retrieved from <https://www.zh.ch/de/planen-bauen/bauvorschriften/bauvorschriften-gebäude-energie/heizungsersatz.html>
- Kanton Zürich. (2023). *Regionaler Richtplan Stadt Zürich. Richtplantext*. Retrieved from [https://maps.zh.ch/system/docs/are\\_rp/RegRicht/rsztext.pdf](https://maps.zh.ch/system/docs/are_rp/RegRicht/rsztext.pdf)
- Kolb, M. (2017). *Fallbeispiel Anergienetz Friesenberg der Familienheim-Genossenschaft Zürich*. Retrieved from <https://pubdb.bfe.admin.ch/de/publication/download/8836>
- Lehmann, M., Meyer, M., Kaiser, N., & Ott, W. (2017). *Umstieg von fossilen auf erneuerbare Energieträger beim Heizungsersatz*. Retrieved from [https://energieforschung-zuerich.ch/media/topics/report/FP-2.8\\_Forschungsbericht.pdf](https://energieforschung-zuerich.ch/media/topics/report/FP-2.8_Forschungsbericht.pdf)
- Lehmann, M., Odermatt, B., Buser, B., Moser, C., & Ott, W. (2020). *Städte-, Gemeinden- und Kantonsvergleich zum Heizungsersatz*. Retrieved from [https://energieforschung-zuerich.ch/media/topics/report/FP-2.8.1\\_EFZ\\_Layout\\_Synthesebericht\\_komplett.pdf](https://energieforschung-zuerich.ch/media/topics/report/FP-2.8.1_EFZ_Layout_Synthesebericht_komplett.pdf)
- Moore, M. H. (1995). *Creating Public Value. Strategic Management in Government*. Cambridge & London: Harvard University Press.
- Moore, M. H. (2014). Public Value Accounting: Establishing the Philosophical Basis. *Public Administration Review*, 74(4), 465–477. <https://doi.org/10.1111/puar.12198>
- NZZ. (2023). *Fernwärmemonopol? Künftig soll es in der Stadt nur noch einen grossen Wärmenetzanbieter geben*. Retrieved from <https://www.nzz.ch/zuerich/ewz-wird-bald-der-groesste-anbieter-fuer-fernwaerme-in-zuerich-ld.1741408>
- Paardekooper, S., Lund, H., Thellufsen, J. Z., Bertelsen, N., & Mathiesen, B. V. (2022). Heat Roadmap Europe: strategic heating transition typology as a basis for policy recommendations. *Energy Efficiency*, 15(5), 32. <https://doi.org/10.1007/s12053-022-10030-3>
- Prebble, M. (2021). Public Value Is Unknowable; Public Authority Makes Every Government Decision a Wicked Problem. *Administration & Society*, 53(10), 1582–1602. <https://doi.org/10.1177/00953997211022685>
- Preisüberwacher. (2023). *Marktbeobachtung Fernwärme Schweiz. Bericht des Preisüberwachers*. Retrieved from [https://www.preisueberwacher.admin.ch/dam/pue/de/dokumente/studien/marktbeobachtung\\_fernwaermetarife\\_schweiz.pdf](https://www.preisueberwacher.admin.ch/dam/pue/de/dokumente/studien/marktbeobachtung_fernwaermetarife_schweiz.pdf)
- Rey, U. (2020). *Bauliche Verdichtung aktuell*. Retrieved from Präsidialdepartement Stadt Zürich website: [https://www.stadt-zuerich.ch/prd/de/index/statistik/publikationen-angebote/publikationen/webartikel/2020-04-07\\_Bauliche-Verdichtung-aktuell.html](https://www.stadt-zuerich.ch/prd/de/index/statistik/publikationen-angebote/publikationen/webartikel/2020-04-07_Bauliche-Verdichtung-aktuell.html)
- Rieder, S., Arnold, T., & Gärtner, S. (2014). *Synthese der Grundlagenprojekte im Themenbereich Gebäude*. Retrieved from [https://energieforschung-zuerich.ch/media/topics/report/Bericht\\_Synthese\\_Themenbereich\\_Gebaeude\\_FP-2.7.pdf](https://energieforschung-zuerich.ch/media/topics/report/Bericht_Synthese_Themenbereich_Gebaeude_FP-2.7.pdf)



- Romesch, L. (2004). *Wärmegewinnung aus Abwasserkanälen*. Retrieved from <https://www.ikt.de/website/down.php?f=10>
- Schmid, S. (2023, March 24). *Wärmeversorgung: Zürich heizt aus der Ferne ein*. *Baublatt*. Retrieved from <https://www.baublatt.ch/bauprojekte/waermeversorgung-zuerich-heizt-aus-der-ferne-ein-34101>
- Schubert, S. (2014). The Need for Local Thermal Energy Planning. *Journal of Urban Technology*, 21(3), 21–36. <https://doi.org/10.1080/10630732.2014.940700>
- Speich, M., & Ulli-Beer, S. (2023). Applying an ecosystem lens to low-carbon energy transitions: A conceptual framework. *Journal of Cleaner Production*, 136429. <https://doi.org/10.1016/j.jclepro.2023.136429>
- Stadt Zürich. (2014). *Konzept Energieversorgung 2050. Kurzbericht*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/energie/Startseite/energiepolitik/EK2050\\_Kurzbericht\\_final.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/energie/Startseite/energiepolitik/EK2050_Kurzbericht_final.pdf)
- Stadt Zürich. (2017). *Mit Computern heizen*. Retrieved from [https://sprachwerk.ch/wp-content/uploads/2020/01/Faktenblatt\\_E\\_Aargauerstrasse\\_161220-1.pdf](https://sprachwerk.ch/wp-content/uploads/2020/01/Faktenblatt_E_Aargauerstrasse_161220-1.pdf)
- Stadt Zürich. (2018). *Industrie und Gewerbe*. Retrieved from [https://www.stadt-zuerich.ch/portal/de/index/portraet\\_der\\_stadt\\_zuerich/digitale-zeitreise/industrie-und-gewerbe.html](https://www.stadt-zuerich.ch/portal/de/index/portraet_der_stadt_zuerich/digitale-zeitreise/industrie-und-gewerbe.html)
- Stadt Zürich. (2021). *Gasstrategie Stadt Zürich*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/energie/Startseite/energiepolitik/Gasstrategie Stadt Zürich.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/energie/Startseite/energiepolitik/Gasstrategie%20Stadt%20Zuerich.pdf)
- Stadt Zürich. (2022a). *Fernwärmetarif 2022*. Retrieved from [https://www.stadt-zuerich.ch/ted/de/index/entsorgung\\_recycling/fernwaerme/preise/fernwaermetarif2022.html](https://www.stadt-zuerich.ch/ted/de/index/entsorgung_recycling/fernwaerme/preise/fernwaermetarif2022.html)
- Stadt Zürich. (2022b). *Holzenergieposition Stadt Zürich. Grundsätze und Umsetzungshilfe*. Retrieved from <https://www.stadt-zuerich.ch/content/dam/stzh/gud/Deutsch/UGZ/ugz/umweltpolitik/dokumente/holzenergieposition.pdf>
- Stadt Zürich. (2022c). *Planungsbericht Energieversorgung. Überarbeitung 2022*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/portal/Deutsch/Stadtrat %26 Stadtpraesident/Publicationen und Broschueren/Stadtratsbeschuesse/2022/Dez/1542 Beilage %26 Planungsbericht Energieversorgung Überarbeitung.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/portal/Deutsch/Stadtrat%20Stadtpraesident/Publicationen%20und%20Broschueren/Stadtratsbeschuesse/2022/Dez/1542%20Beilage%20Planungsbericht%20Energieversorgung%20Überarbeitung.pdf)
- Stadt Zürich. (2023a). *Energie in Zahlen*. Retrieved from [https://www.stadt-zuerich.ch/gud/de/index/umwelt\\_energie/energie-in-zahlen.html](https://www.stadt-zuerich.ch/gud/de/index/umwelt_energie/energie-in-zahlen.html)
- Stadt Zürich. (2023b). *Hohe Nachfrage nach Förderung für den Heizungsersatz*. Retrieved from <https://www.stadt-zuerich.ch/gud/de/index/departement/medien/medienmitteilungen/2023/juli/230705b.html>
- Stadt Zürich. (2023c). *Ins Klima investieren lohnt sich. Energie-Fördergelder für Hauseigentümer\*innen* (p. 4). p. 4. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/energie/Startseite/beratung-froerderung/Fördergelder für Hauseigentümerinnen.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/energie/Startseite/beratung-froerderung/Foerdergelder%20fu%20Hauseigentuerinnen.pdf)
- Stadt Zürich. (2023d). *Klimaschutzplan. Ziele und Massnahmen zur Reduktion der direkten Treibhausgasemissionen auf netto null bis 2040*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/gud/Deutsch/UGZ/ugz/umweltpolitik/dokumente/netto-null/Klimaschutzplan Stadt Zuerich\\_2023.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/gud/Deutsch/UGZ/ugz/umweltpolitik/dokumente/netto-null/Klimaschutzplan_Stadt_Zuerich_2023.pdf)
- Stadt Zürich. (2023e). *Masterplan Energie der Stadt Zürich*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/dib/Deutsch/Energieversorgung/Publicationen und Broschueren/Masterplan\\_Energie\\_2023\\_FINAL.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/dib/Deutsch/Energieversorgung/Publicationen%20und%20Broschueren/Masterplan_Energie_2023_FINAL.pdf)
- Stadt Zürich. (2023f). *Netto-Null-Zwischenbericht 2022. Direkte Treibhausgasemissionen auf Stadtgebiet*. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/gud/Deutsch/UGZ/ugz/umweltpolitik/dokumente/netto-null/Netto-Null-Zwischenbericht Stadt Zuerich\\_2022.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/gud/Deutsch/UGZ/ugz/umweltpolitik/dokumente/netto-null/Netto-Null-Zwischenbericht_Stadt_Zuerich_2022.pdf)
- Stadtrat. (2017). *Energiebeauftragter, 2000-Watt-Ziel-konforme Energieverbunde, Ergänzung der kommunalen Energieplanung mit Gebietskonzessionen und Gebietsaufträgen, Anpassung der Gebührenordnung zum Sondergebrauchsreglement, Genehmigung Musterkonzession*. Retrieved from [https://www.stadt-zuerich.ch/portal/de/index/politik\\_u\\_recht/stadtrat/geschaefte-des-stadtrates/stadtratsbeschuesse/2017/Jul/StZH\\_STRB\\_2017\\_0611.html](https://www.stadt-zuerich.ch/portal/de/index/politik_u_recht/stadtrat/geschaefte-des-stadtrates/stadtratsbeschuesse/2017/Jul/StZH_STRB_2017_0611.html)
- Stadtrat. (2018). *ERZ Entsorgung + Recycling Zürich, Fernwärme Zürich-Nord, NetzEntlastungsleitungen 2019–2021, Objektkredit* (p. 2). p. 2. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/portal/Deutsch/Stadtrat %26 Stadtpraesident/Publicationen und Broschueren/Stadtratsbeschuesse/2018/Sep/StZH\\_STRB\\_2018\\_0802.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/portal/Deutsch/Stadtrat%20Stadtpraesident/Publicationen%20und%20Broschueren/Stadtratsbeschuesse/2018/Sep/StZH_STRB_2018_0802.pdf)
- Stadtrat. (2019). *Weisung des Stadtrats von Zürich an den Gemeinderat: ERZ Entsorgung + Recycling*



- Zürich, *Kehrlichheizkraftwerk, 3. Verbrennungslinie, Erhöhung Projektierungskredit*. Retrieved from [https://www.gemeinderat-zuerich.ch/dokumente/442680341f7946dd9718e5c5f1a66b23-332?filename=2019\\_0543](https://www.gemeinderat-zuerich.ch/dokumente/442680341f7946dd9718e5c5f1a66b23-332?filename=2019_0543)
- Tages-Anzeiger. (2002, October 23). *Zürichs Antwort auf Rio und Kyoto*. p. 17.
- Tages-Anzeiger. (2005, September 20). *Der derzeitige hohe Ölpreis macht Fernwärme lukrativ*. p. 13.
- Tages-Anzeiger. (2021, November 19). *Zürich zahlt Millionen für Fernwärme – und bekommt Baustellen, Rotlichter und Stau*. Retrieved from <https://www.tagesanzeiger.ch/zuerich-zahlt-millionen-fuer-fernwaeirme-und-bekommt-baustellen-rotlichter-und-stau-647651431588>
- Tages-Anzeiger. (2023, August 21). *Hagenholz: Braucht es die dritte Verbrennungslinie wirklich?* Retrieved from <https://www.tagesanzeiger.ch/abstimmungen-in-zuerich-hagenholz-braucht-es-die-dritte-verbrennungslinie-wirklich-326871567265>
- Tiefbauamt / Energiebeauftragte. (2021). *Umsetzungsplan thermische Netze - Regelwerk* (p. 47). p. 47. Retrieved from [https://www.stadt-zuerich.ch/content/dam/stzh/portal/Deutsch/Stadtrat %26 Stadtpraesident/Publikationen und Broschueren/Stadtratsbeschluesse/2021/Apr/STRB Nr. 0382\\_2021%2C Beilage 1.pdf](https://www.stadt-zuerich.ch/content/dam/stzh/portal/Deutsch/Stadtrat_%26%20Stadtpraesident/Publikationen%20und%20Broschueren/Stadtratsbeschluesse/2021/Apr/STRB_Nr.0382_2021%2C%20Beilage%201.pdf)
- Weisskopf, T., Streit, D., Deschaintre, L., & Robineau, J.-L. (2022). *Beschleunigung des Ausbaus Thermischer Netze. Projektbericht*. Retrieved from <https://pubdb.bfe.admin.ch/de/publication/download/11019>
- Zieger, M. (2023). *Thermische Energie aus Seen und Flüssen*. *Aqua & Gas*. Retrieved from [https://www.aquaetgas.ch/energie/fernwaerme/20230131\\_ag2\\_thermische-energie-aus-seen-und-fluessen/](https://www.aquaetgas.ch/energie/fernwaerme/20230131_ag2_thermische-energie-aus-seen-und-fluessen/)
- Zürich24. (2023, May 8). *Nur bei der Hälfte der Bauprojekte wird die Hitzeminderung einbezogen*. Retrieved from <https://zuerich24.ch/articles/189865-nur-bei-der-haelfte-der-bauprojekte-wird-die-hitzeminderung-einbezogen>



## Appendix

Table 9: Bills of the municipal council referenced in the text

Number and reference (hyperlink)	Title	Type
<a href="#">2023/581</a>	Departement der Industriellen Betriebe und Tiefbau- und Entsorgungsdepartement, Neuorganisation der städtischen Wärmeversorgung, neue einmalige Ausgaben für den Kauf von drei Projekten von Energie 360° AG und deren Projektierung; neue einmalige Ausgaben für die Integration des Geschäftsbereich Entsorgung + Recycling Zürich, Fernwärme ins Elektrizitätswerk der Stadt Zürich; Aufhebung des Eigenwirtschaftsbetriebs Entsorgung + Recycling Zürich, Fernwärme; Teilrevision Anhang 1 Finanzhaushaltverordnung; Einführung einer neuen Produktgruppe im Elektrizitätswerk der Stadt Zürich; Abschreibung einer Motion	Weisung
<a href="#">2023/526</a>	Elektrizitätswerk, Bau von Anlagen des Geschäftsfelds Energielösungen des Elektrizitätswerks, Rahmenkredit von 200 Millionen Franken	Weisung
<a href="#">2023/343</a>	Umwelt- und Gesundheitsschutz Zürich, Förderprogramm Heizungsersatz und Heizungsoptimierung in der Stadt Zürich, Zusatzkredit	Weisung
<a href="#">2023/269</a>	Energiezentrale im ehemaligen Unterwerk Selnau, Prüfung alternativer Standorte, ganzheitliches Konzept für die Energiewende und eine lebenswerte Stadt, Beurteilung der bestehenden Angebote im Unterwerk und möglicher Planungsstopp sowie Zusammenarbeit mit der IG Selnau bei der Prüfung von Alternativen	Interpellation
<a href="#">2023/114</a>	CoolCity Energiezentrale, geprüfte alternative Standorte, raumplanerische Interessenabwägung für den Standort Selnau, Mietzinsfolgen für das Haus Konstruktiv, Wirtschaftlichkeit und Nachhaltigkeit des Projekts und Beurteilung des Ausfallrisikos	Schriftliche Anfrage
<a href="#">2023/41</a>	Vorlage planungsrechtlicher Massnahmen zur Bezeichnung geeigneter Standorte für Wärmespeicher oder andere Energieanlagen zur fossilfreien Spitzenlastdeckung der Wärmenetze, vorgängige Potenzialabklärung über die Dimension und Vorantreiben bereits bestehender Projekte	Motion
<a href="#">2023/16</a>	Entsorgung + Recycling Zürich, Kehrlichtheizkraftwerk, dritte Verbrennungslinie 2K5, neue einmalige Ausgaben	Weisung
<a href="#">2022/602</a>	Nutzung der Energiezentrale ewz-Unterwerk-Selnau, Standortevaluation für Cool City, Einfluss der getätigten Investitionskosten bei der Umnutzung von städtischen Gebäuden und Planungssicherheit für Kulturinstitutionen in städtischen Gebäuden sowie Unterstützung des Museums Haus Konstruktiv und des Impact Hubs bei der Suche nach einem neuen Standort	Schriftliche Anfrage
<a href="#">2022/571</a>	Energie-Coaching, moderate Erhöhung der Kostenbeteiligung der Kundschaft	Postulat
<a href="#">2022/441</a>	Einführung eines Einheitstarifs für den Anschluss und Bezug von Fernwärme gemäss Energieplan	Motion
<a href="#">2022/305</a>	Umwelt- und Gesundheitsschutz Zürich, Energie-Coaching, Zusatzkredit	Weisung
<a href="#">2021/505</a>	Elektrizitätswerk, Vorinvestitionen Energieverbund Höngg-Zentrum, Objektkredit	Weisung
<a href="#">2021/502</a>	Elektrizitätswerk, Ausbau der thermischen Netze des Elektrizitätswerks, Rahmenkredit	Weisung



2021/471	Elektrizitätswerk, Teilprojektierung Energieverbund CoolCity, Projektierungskredit	Weisung
2021/417	Rekommunalisierung der Versorgungsnetze für die Wärme- und Kälteversorgung und der mit diesen verbundenen Energiedienstleistungen von Energie 360° AG und ihrer Tochtergesellschaften	Motion
2021/377	Postulat von Markus Kunz, Michael Kraft und 2 Mitunterzeichnenden betreffend Bericht zur Reduktion der CO <sub>2</sub> -Emissionen und zur Realisierung eines CO <sub>2</sub> -freien Energiemix der städtischen Betreiber von Fernwärmenetzen und Energieverbunden, Bericht und Abschreibung	Weisung
2021/362	Dringliche Motion der SP-, Grüne- und GLP-Fraktionen und der Parlamentsgruppe EVP betreffend Fonds für die Förderung des Umstiegs von Öl- und Gasheizungen auf eine CO <sub>2</sub> -freie Wärmeproduktion, Bericht und Abschreibung, Einführung neuer Fördermassnahmen, Objektkredit	Weisung
2021/178	Departement der Industriellen Betriebe und Tiefbau- und Entsorgungsdepartement, Geschäftsstelle Wärme Zürich, Nachtragskredit	Weisung
2021/177	Umwelt- und Gesundheitsschutz und Energiebeauftragte, Klimaschutzziel Netto-Null 2040, Teilrevision Gemeindeordnung, Bericht, Abschreibung einer Motion und dreier Postulate	Weisung
2021/119	Stadtkanzlei, Abschreibungsanträge Postulate, Geschäftsjahr 2020	Weisung
2020/565	ERZ Entsorgung + Recycling Zürich, Ausbau der Fernwärmeversorgung in den Quartieren Wipkingen, Oberstrass, Unterstrass, Aussersihl sowie den Gebieten Guggach und Zürich-West/Sihlquai im Zeitraum 2022–2040, Rahmenkredit von 330 Millionen Franken und Vorfinanzierung mit 40 Millionen Franken	Weisung
2020/559	Nahwärmeverbund im Gebiet Zürich Altstetten, Hintergründe zur Vergabe eines Teilgebiets an die Energie 360° AG, Beurteilung der Rechtsgrundlagen für die Wärmeversorgung durch Energie 360° AG und das ewz und Gründe für den Verzicht auf eine Ausschreibung des Teilgebiets sowie Haltung zur Gasversorgung aus klima- und energiepolitischer Sicht	Schriftliche Anfrage
2019/514	Ausbau der städtischen Fernwärmeversorgung, Faktoren, Kriterien und gesetzliche Entscheidungsgrundlagen für den Anschluss von Gebäuden in den Prioritätsgebieten an die Fernwärme	Schriftliche Anfrage
2019/3	Ausarbeitung einer Energieversorgungsverordnung	Motion
2018/138	Berücksichtigung der Raumbedürfnisse neuer Technologien im Energiebereich am Werkstandort Josefstrasse	Postulat
2018/137	Multifunktionale Auslegung des Fernwärmenetzes im Zusammenhang mit der Planung und Projektierung der Fernwärmeverbindungsleitung	Postulat
2018/136	Abdeckung der Spitzenlast der Fernwärmeversorgung ohne fossile Energieträger	Postulat
2018/135	Anschluss von möglichst vielen Gebäuden in den künftigen Fernwärmegebieten	Postulat
2017/220	ERZ Entsorgung + Recycling Zürich, Erweiterung der Fernwärmeversorgung in der Stadt Zürich und Errichtung einer Vorfinanzierung von 50 Millionen Franken, Objektkredit	Weisung
2014/337	ERZ Entsorgung + Recycling Zürich, Verbindungsleitung zwischen den Fernwärmegebieten Zürich-Nord und Zürich-West, Projektierungskredit	Weisung
2012/222	Umwelt- und Gesundheitsschutz, Energie-Coaching, Bericht über die Pilotphase, Antrag auf Weiterführung	Weisung
2007/633	Umnutzung des Kehrlichtheizkraftwerkes Josefstrasse für die Fernwärme Zürich-West, Beteiligung an einer Betriebs AG	Weisung



<a href="#">2003/237</a>	KHKW Josefstrasse, Zukunft der Fernwärmeversorgung	Schriftliche Anfrage
<a href="#">2003/215</a>	Fernwärme, Übernahme der kantonalen Fernwärme durch die Stadt Zürich	Weisung
<a href="#">2000/496</a>	Fernwärme, Sanierung und Finanzierungsmodell	Weisung