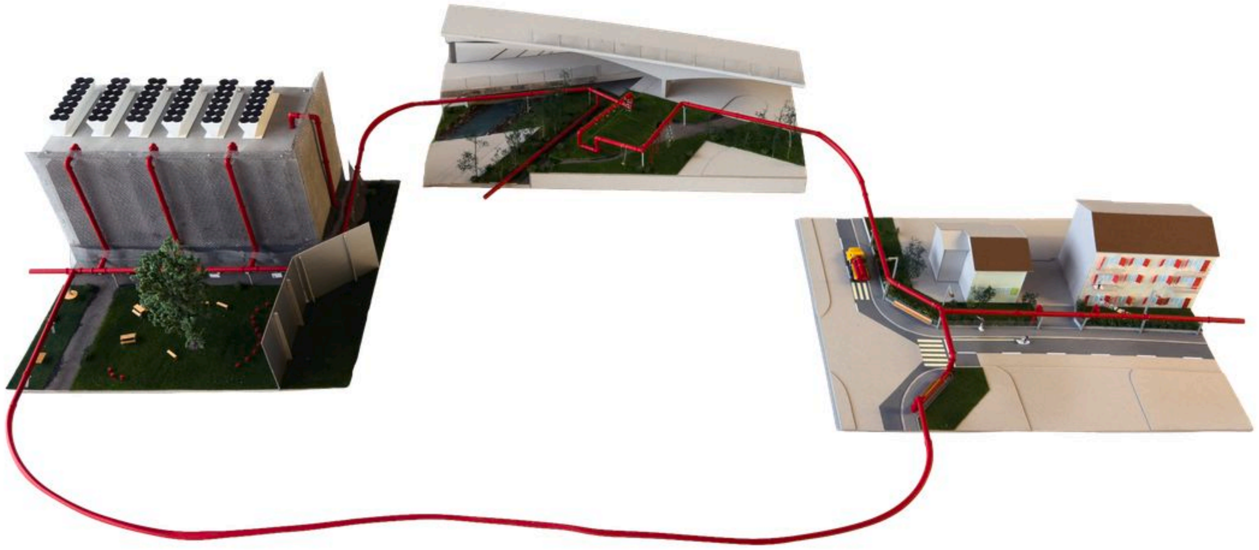
ETH Zurich Department of Architecture
ARCHITECTURE OF TERRITORY
Chair of Architecture
and Territorial Planning
Professor Milica Topalović

The Production of Cloud
Fall 2025

Heat in the Cloud: District Heating, Glattbrugg

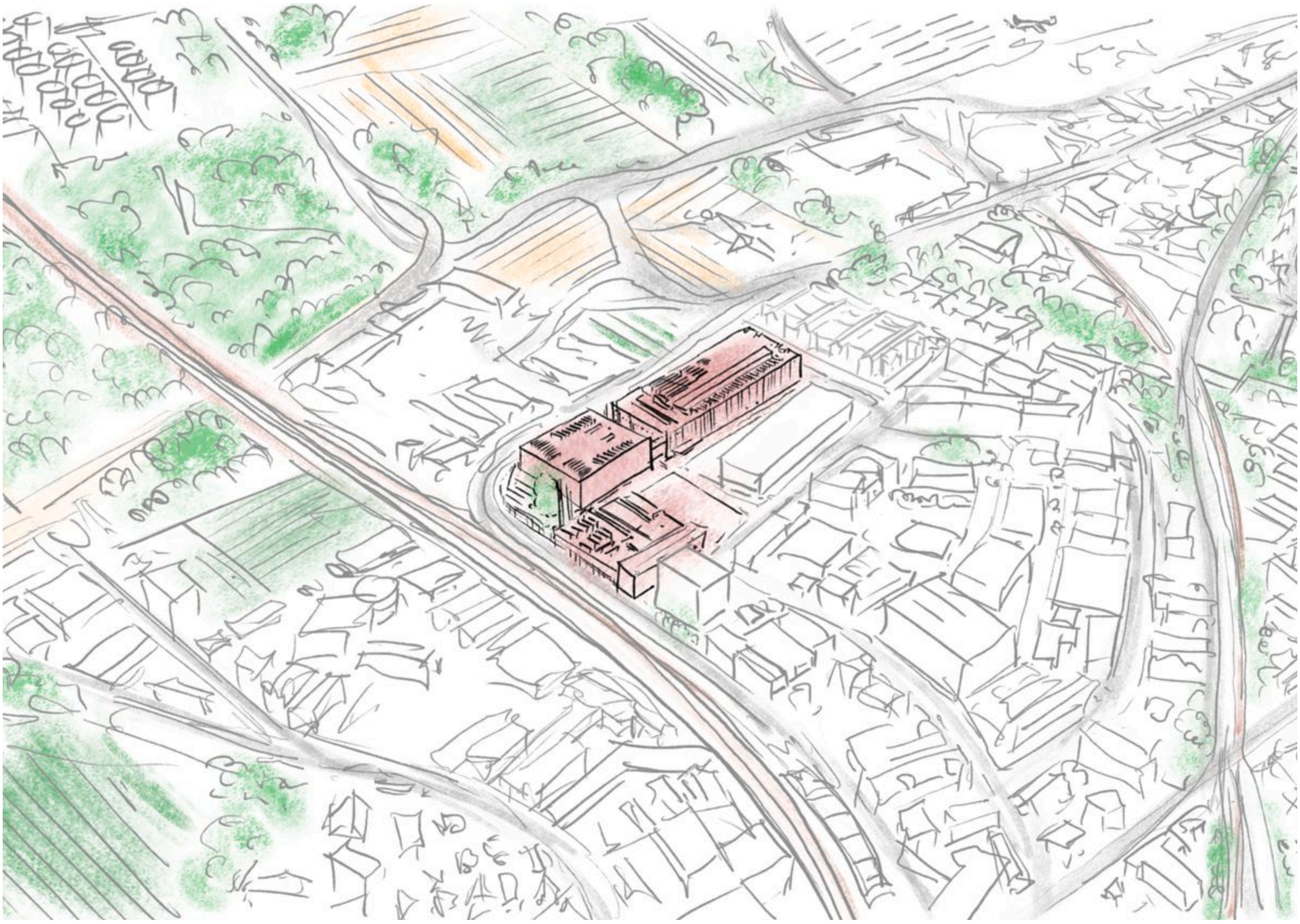
Serena Peier, Rebecca Grobotek, Matteo Bianchi, and Linus Ham



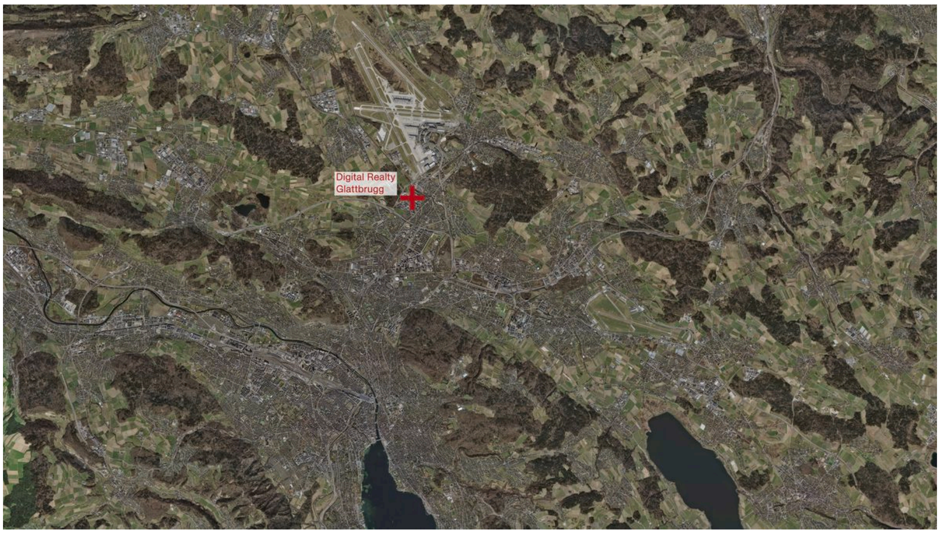
Data centres are powerful heat producers, yet they remain largely invisible in cities and their waste heat remains mostly unused. In Zurich's Glattbrugg district, stalled projects such as the Airport City energy network highlight the political and economic obstacles to conventional underground district heating systems.

This project maps these constraints and proposes an alternative in the form of an above-ground, flexible heat network that makes the warm pipes visible and re-routable alongside the change of data centres locations. By incorporating the pipes into public spaces in the form of seating, shelters, or paths, the proposal renders energy flows tangible and redefines data centres as civic infrastructure rather than isolated fortresses.

Contextualising Digital Realty: Scale and Setting

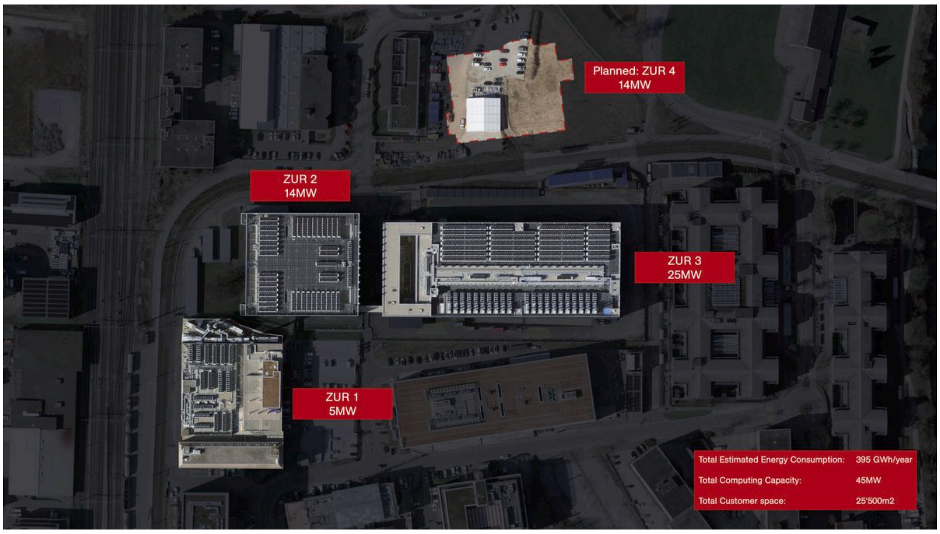


As the world's second-largest data centre operator, Digital Realty makes its scale tangible in Zurich—with one of Switzerland's largest data centre campuses, a powerful multi-megawatt footprint, and a network of locations that spans the globe.



THE LOCATION OF THE DIGITAL REALTY CAMPUS IN GLATTBRUGG
Photograph: map.geo.admin.ch, edited by the authors, 2025.

The Digital Realty campus is located just north of Zurich in Glattbrugg, between the Glattbrugg railway station and Zurich Airport. It comprises three buildings: ZUR1, ZUR2 and ZUR3. A fourth facility, ZUR4, is already in the planning stage.



THE BUILDINGS OF THE DIGITAL REALTY CAMPUS IN GLATTBRUGG
Photograph: map.geo.admin.ch, edited by the authors, 2025.

DATA CENTER ZUR 2&3, DIGITAL REALTY GLATTBRUGG. Photograph: AOT, 2025.

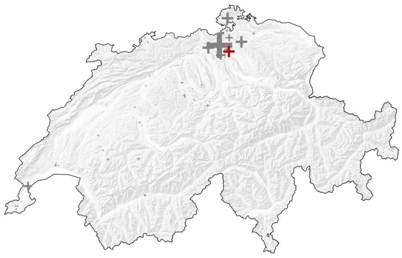
DATA CENTER ZUR 2&3, DIGITAL REALTY GLATTBRUGG. Photograph: AOT, 2025

DATA CENTER ZUR 2 DIGITAL REALTY GLATTBRUGG. Photograph: AOT, 2025.

The Digital Realty campus in Glattbrugg is among the largest data centres in Switzerland. Worldwide, Digital Realty operates more than 300 facilities, making it the second-largest data centre provider in the world.

THE DATA CENTRE LOCATIONS OF DIGITAL REALTY WORLDWIDE
Source: Digital Realty.

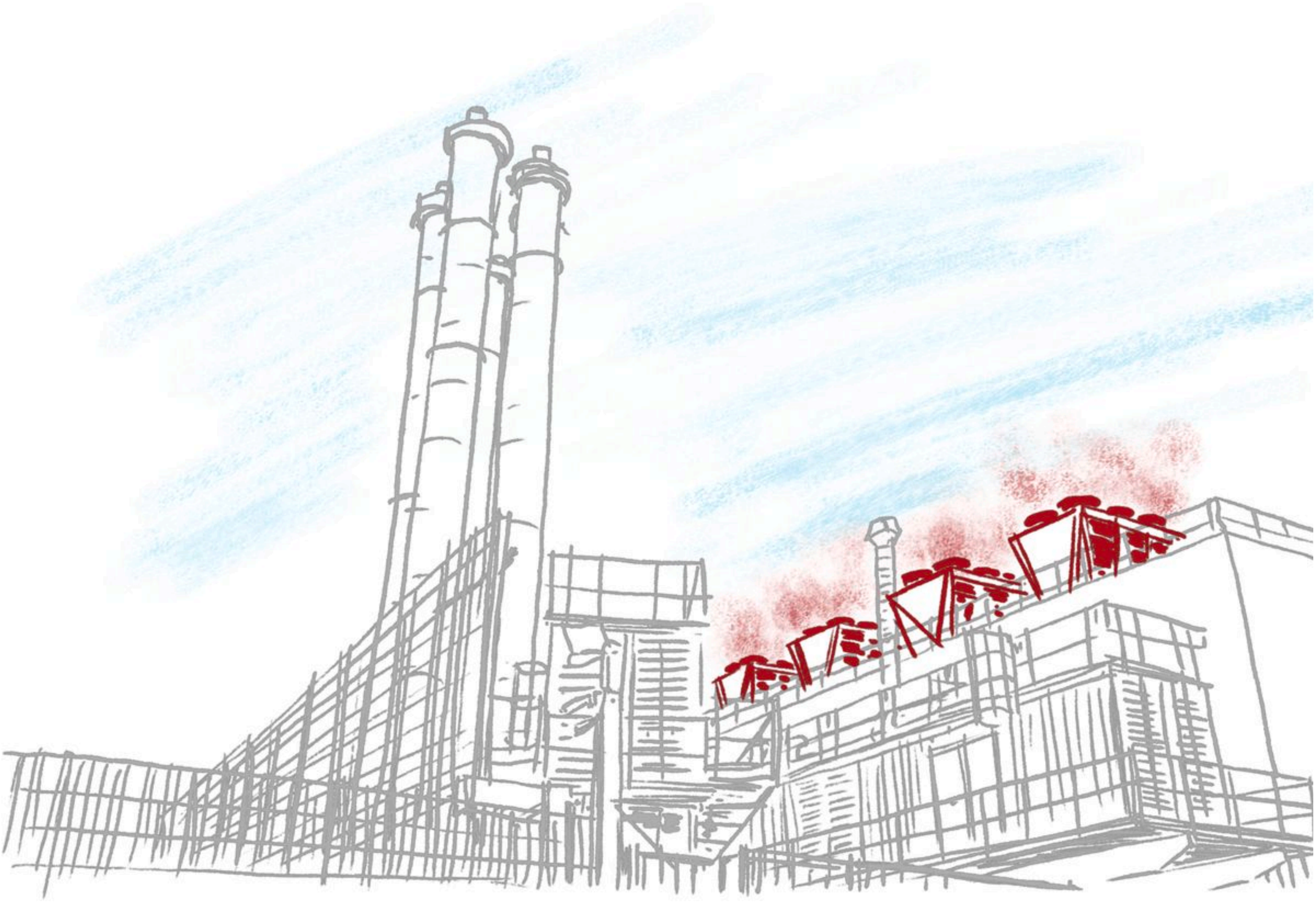
- ● Location of one or several data centres
- ● Location of Campus Glattbrugg



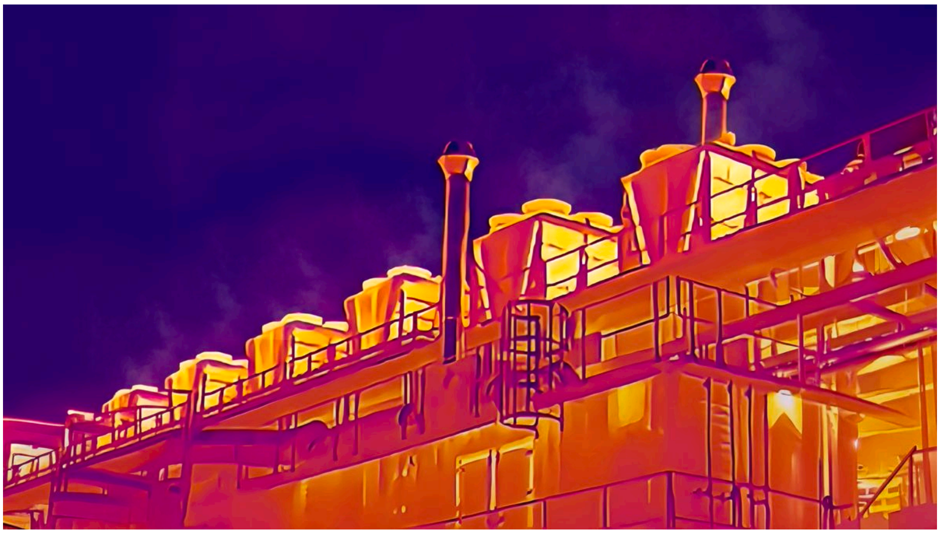
THE DIGITAL REALTY CAMPUS IN GLATTBRUGG AS ONE OF THE LARGEST DATA CENTRES IN SWITZERLAND
Source: AOT, 2025.

- + Swiss data centres by energy demand (MW)

Waste Heat of Data Centres: An Untapped Resource

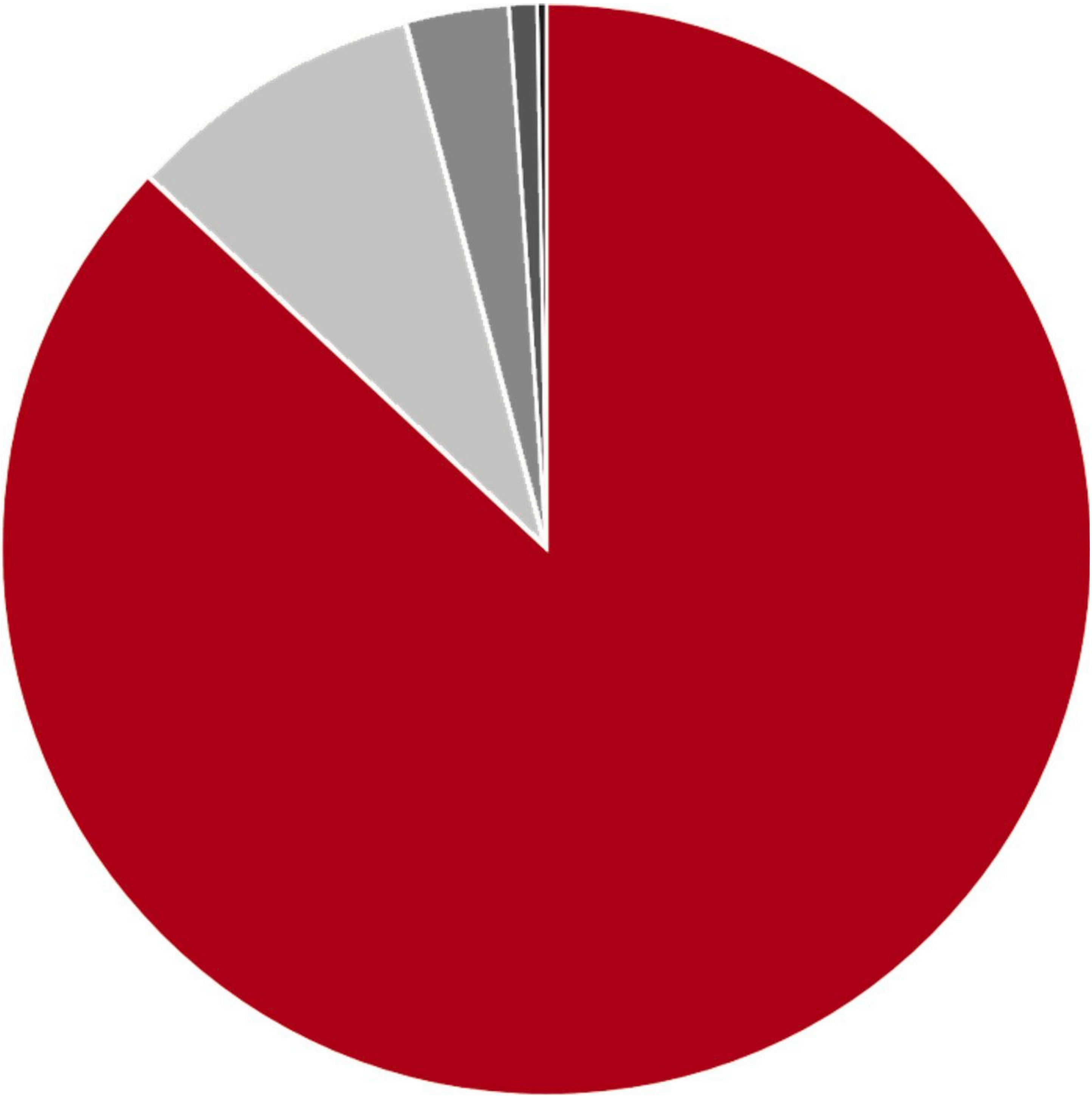


The heat of our digital infrastructure is invisible yet immense, and it escapes into the atmosphere. At Digital Realty Glattbrugg, as is the case almost everywhere else, this energy is lost, providing warmth only to the birds flying overhead.



THERMAL IMAGE OF ROOFTOP COOLERS ON A
DATA CENTRE (DIGITAL REALTY ZUR1, GLATTBRUGG)
Image: the authors, 2025.

Rooftop coolers on data centres often blend into the background and remain largely unnoticed. Even when they are visible, it is unclear what they do. In normal daylight, they appear almost motionless, as if nothing were happening. Yet thermal imaging reveals that data centres emit enormous amounts of heat through these systems.



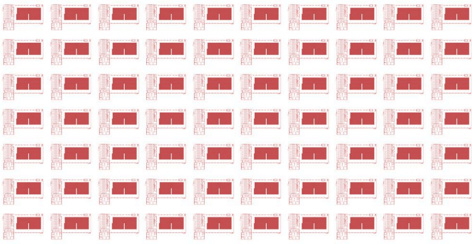
A 45 MW DATA CENTRE HAS A HEAT OUTPUT OF 51,694,500 WATT
Source: Schneider Electric, 2025.

87 % IT-equipment
9 % UPS with battery
2.9 % power distribution
1 % lighting
0.01 % people

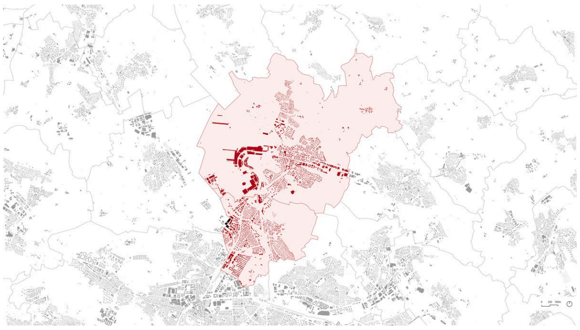
The amount of waste heat produced by a typical data centre is often underestimated. For instance, a facility with a computational capacity of 45 megawatts (MW), such as the Digital Realty data centres in Glattbrugg, can produce around 51.5 MW of thermal energy in the form of waste heat.

If this heat were recovered with ideal efficiency, it could meet the entire thermal energy demand of residential and non-residential buildings in Opfikon and Kloten. The same quantity of heat would be sufficient to operate around 70 public swimming pools, which illustrates the scale of this continuous energy stream.

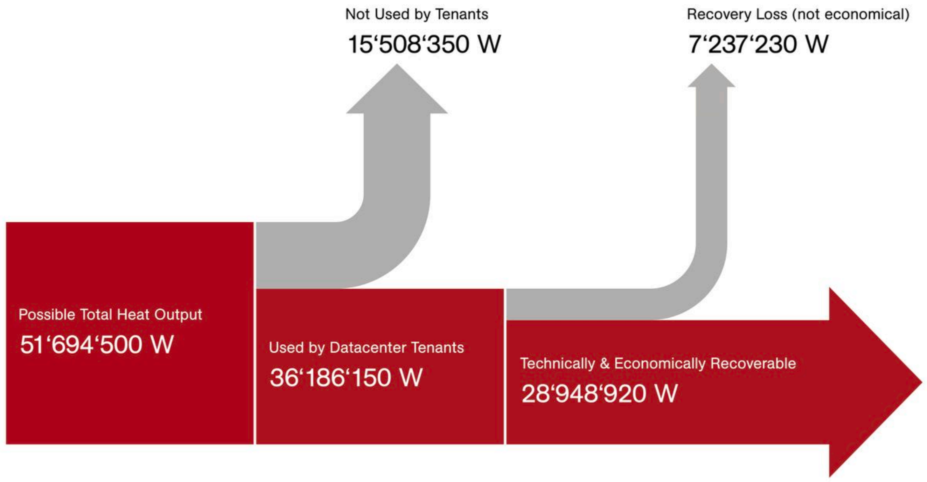
These comparisons demonstrate the extraordinary energy density inherent in data centre operations and their potential to contribute positively to broader urban infrastructure.



WASTE HEAT COVERS THE THERMAL ENERGY DEMAND OF 70 PUBLIC SWIMMING POOLS
Source: Energie Schweiz, 2024.



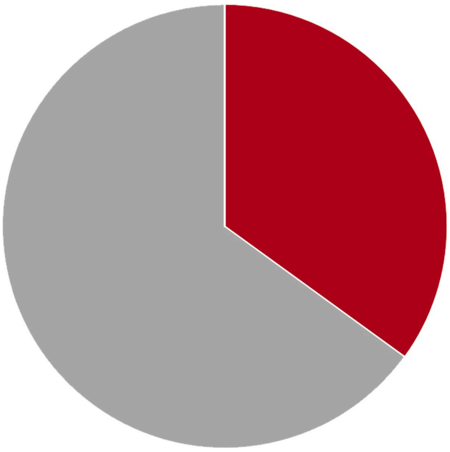
WASTE HEAT COVERS THE THERMAL ENERGY DEMAND OF OPFIKON AND KLOTEN.
Source: econcept, 2024.



ACTUAL USABLE WASTE HEAT OF A DATA CENTRE
Diagramme: the authors, 2025.

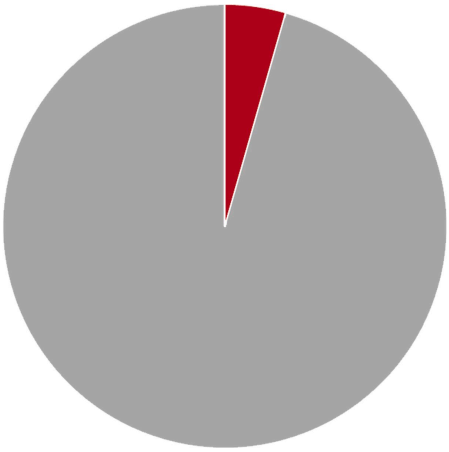
Approximately 30 % of the potential thermal output is never produced because tenants do not utilise the full installed IT capacity. Of the remaining waste heat, around 20 % cannot be recovered since extracting additional heat from the heat exchanger beyond this level would be disproportionately energy- and cost-intensive.

Even if only the recoverable share of this waste heat were used with ideal efficiency, it could cover the entire thermal energy demand for residential and non-residential buildings in Opfikon, as well as a portion of neighbouring Kloten. This quantity of heat would be sufficient to operate around 39 public swimming pools, demonstrating that even a small proportion of the original waste heat potential constitutes a significant continuous energy stream. This raises the important systemic question of how much of the available waste heat in our energy systems is currently being utilised, and how much is still being dissipated into the environment.



WASTE HEAT UTILISATION
SWITZERLAND 2019
Source: Bundesamt für Energie, 2019.

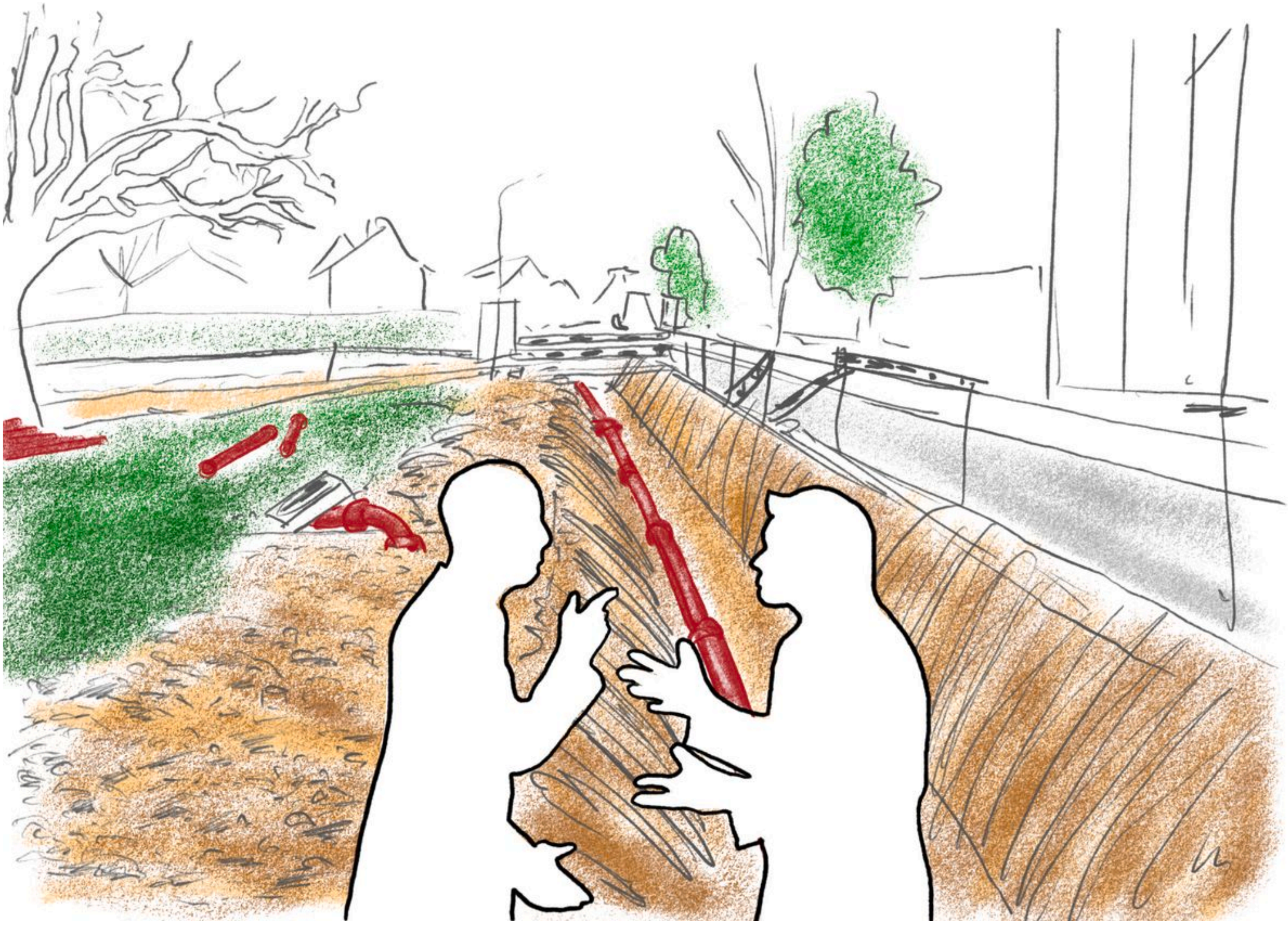
35 % used
65 % unused



WASTE HEAT UTILISATION
GLOBAL 2024
Source: Verneglobal Harnessing Data Center Waste Heat, 2024.

3 % used
97 % unused

Ambition Meets Reality: The Unfinished Story of the Energy Network Airport City

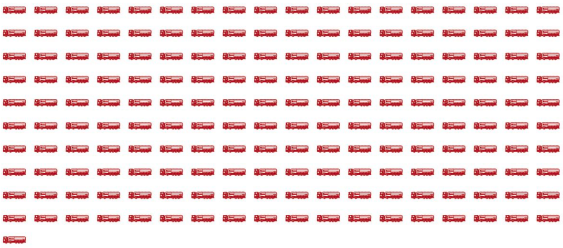


What began as a pioneering energy vision ended as a cautionary tale. The Airport City heat network aimed to utilise data centre waste heat in Opfikon, but despite the involvement of key players and ambitious intentions, the project is currently on hold.

The original project area covered Airport City in Opfikon, located near three data centres. The aim was to capture the heat produced by Digital Realty's facilities and use it to provide heating, hot water and cooling to customers. This would enable the system to save up to 15,000 tonnes of CO_2 per year. This is equivalent to around 5.6 million litres of heating oil, or the contents of 181 large tankers, each with a capacity of approximately 31,000 litres. The aim was to use local energy more sustainably and reduce emissions.

Four key stakeholders were involved in this initiative: Digital Realty, the waste heat provider; EBL, with extensive experience of building district heating networks; Energie Opfikon AG, responsible for supplying the city with water and electricity; and the Managing Director of Airport City Zurich, representing the interests of the airport region and ensuring coordination between local stakeholders. Together, they formed the basis for a forward-looking, regionally anchored energy system.

ENERGIEVERBUND OPFIKON
Source: EBL, 2024.



5.6 million litres of heating oil are
181 large tank trucks with a capacity
of approximately 31,000 liters each.

MANUEL VILAÇA
Energy Efficiency Manager Digital Realty. Source: LinkedIn, 2025.

TOBIAS ANDRIST
CEO Genossenschaft Elektra Baselland. Source: Alpiq, 2025.

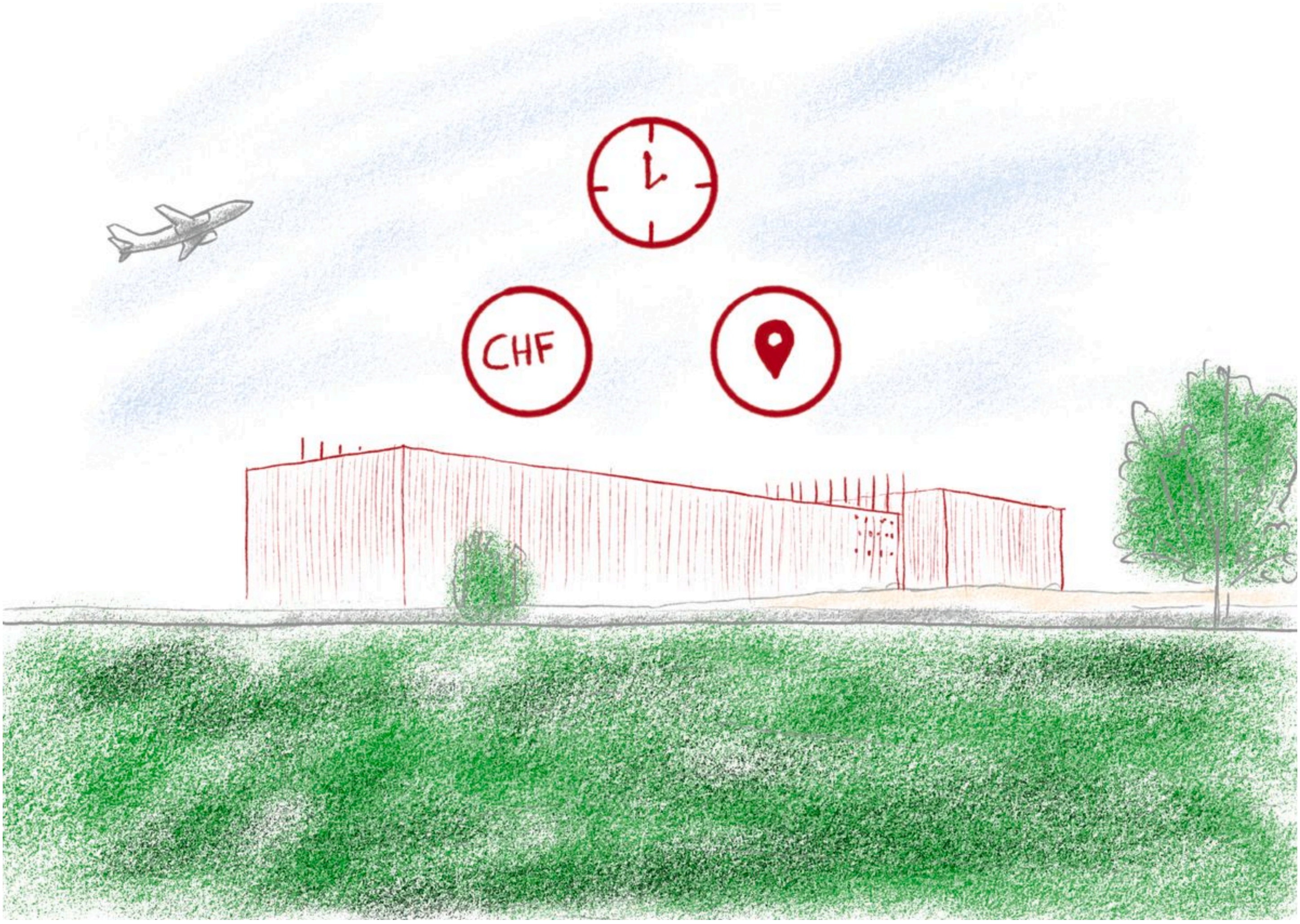
JANEZ ŽEKAR
Managing Director Energie Opfikon AG. Source: LinkedIn, 2025.

CHRISTOPH LANG
Managing Director Airport City Zurich. Source: Airport City Zürich, 2025.

The Unfinished Story of the Energy Network Airport City, the authors, 2025.
https://youtu.be/j48v3dfWEQ0

From interviewing the stakeholders, we learned that large-scale district heating only really makes sense in dense urban areas where many buildings can share the same network. These networks should be planned, built and operated by public bodies rather than private companies to ensure long-term reliability and fairness. New data centres, with their enormous heat output, should be required to feed some of their waste heat into these systems. However, the crucial question of who will ultimately pay for the necessary infrastructure remains unresolved. Meanwhile, data centres themselves remain largely invisible to most citizens, operating out of sight even as they quietly reshape local energy systems.

Misaligned Incentives: Volatile Heat and Inflexible Grids

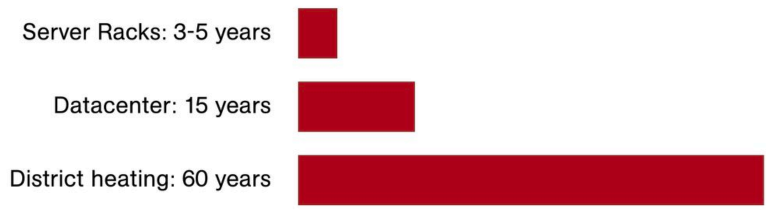


While IT and data centre assets have a short lifespan and construction costs account for only a small proportion of the total investment, district heating networks demand high upfront investment, long payback times, and stable partners—yet operators can relocate, go bankrupt, or simply opt out, in a legal landscape not built for this dependency.

“On the one hand, the lifespans do not match, in other words, IT has a much shorter lifespan than a heating network; that is the first problem, and the second problem that arises from this is the different time periods involved.”

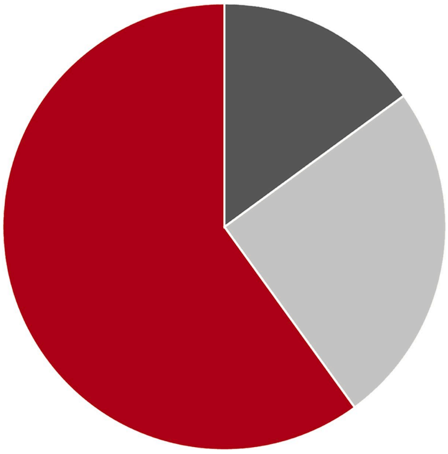
Martin Neukom, President of the Cantonal Government and Head of the Department of Building of the Canton of Zurich.

This mismatch he describes becomes particularly tangible when looking at the typical lifespans of district heating networks, data centre buildings, and server racks side by side.



LIFESPAN MISMATCH BETWEEN IT HARDWARE,
DATA CENTRES AND DISTRICT HEATING NETWORKS.
Source: ASHRAE Technical Committee

Data centres are also less secure sources of heat than public infrastructure such as waste incinerators or wastewater treatment plants. As their buildings represent only a small proportion of total data centre costs worldwide, it is comparatively easy for operators to change strategies without facing significant sunk-cost pressure. Consequently, several disruptive scenarios are always possible: a data centre operator could go bankrupt; a specific facility could be sold to a different owner; a site could be sold or repurposed for another use; or entire operations could be relocated to another country. While these may be relatively minor decisions for the operator, they can have a significant impact on any district heating network that relies on waste heat from that site.



BREAKDOWN OF DATA CENTRE COSTS: A WORLDWIDE AVERAGE
Source: McKinsey, 2025.

- 60 % IT-equipment
- 25 % power, electrical equipment, cooling
- 15 % building and land

THE ECONOMIC TIMES tech

Data-center operator Cyxtera files for bankruptcy

Data-center operator Cyxtera Technologies Inc filed for U.S. bankruptcy protection in New Jersey on Sunday, two years after the company went public, as it struggles to pay down debt and faces a severe funding crunch.

Miami, Florida-based Cyxtera is a provider of co-location services, which allows companies to keep their privately-owned servers and networking equipment in a third-party data center, such as ones owned by Cyxtera.

In March, the company entered into an agreement with its lenders to extend its $120.1 million revolving credit facility and extended its maturity to 2024.

DATA CENTRE OPERATORS CAN GO BANKRUPT
Source: The Economic Times, 2023.

Digital Realty Sells 33-Year-Old Airport Data Center

July 11, 2025 | 2:22 p.m. ET | Jarred Schenke, Atlanta (https://www.bisnow.com/author/jarred-schenke-5711) (mailto:jarred@bisnow.com)

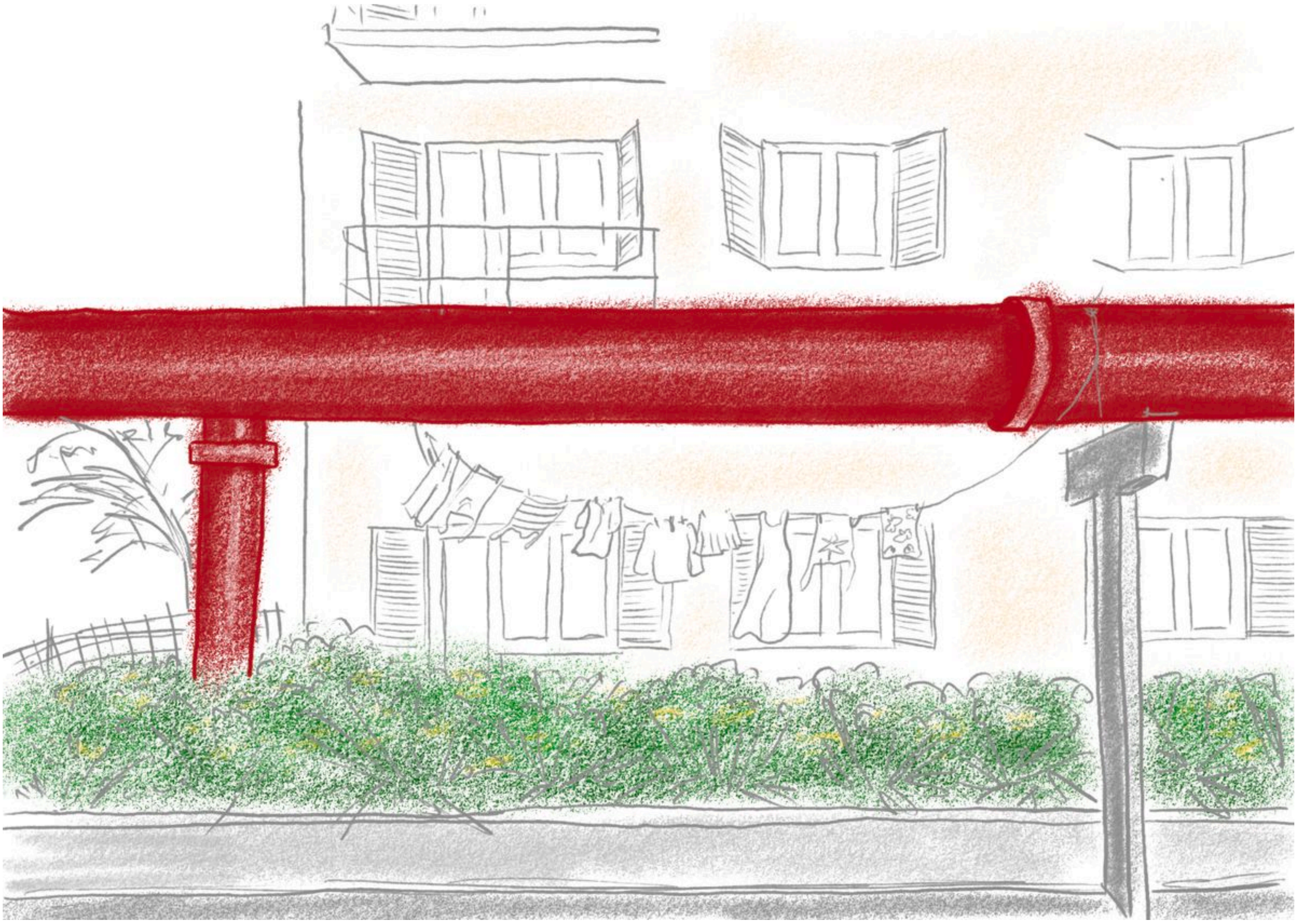
A California investment firm picked up a data center built in 1992 near Atlanta Hartsfield-Jackson International Airport.

An affiliate of Menlo Park, California-based Menlo Equities (https://www.bisnow.com/tags/menlo-equities) purchased 760 Doug Davis Drive in Hapeville for $65.5M from Digital Doug Davis LLC, an entity

OPERATOR SELLS DATA CENTRE
Source: Bisnow, 2025.

DATA CENTRE OPERATOR (LIKE DIGITAL REALTY) MIGHT DECIDE TO CHANGE THE LOCATIONS
Source: Digital Realty, 2025.

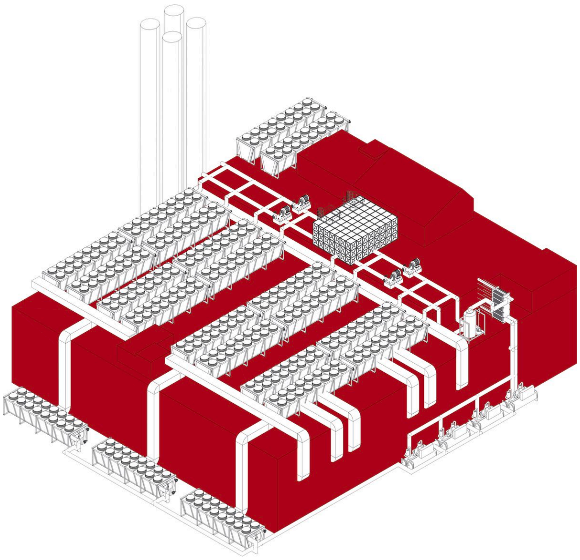
Designing an Alternative: An Above-Ground District Heating Network



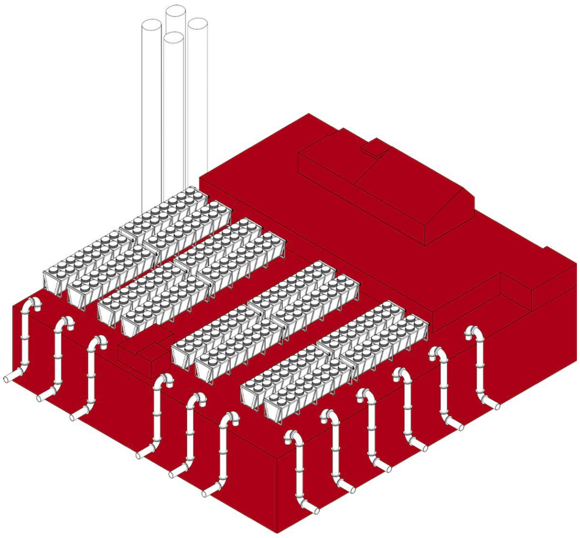
When heat sources are uncertain, flexibility is essential. Above-ground pipelines provide a cheaper, quicker and more adaptable means of connecting fluctuating energy producers, such as data centres, to the urban infrastructure, making energy flows visible and responsive.

Today, data centres largely remain black boxes within the urban fabric, with their technical systems hidden from view. Taking inspiration from the Plug-In City Study by Warren Chalk, Peter Cook, and Dennis Crompton (1964), it is possible to envisage inverting this logic and relocating all of the data centre's infrastructure to the exterior. This would transform the data centre into a visible urban machine rather than a sealed container.

However, such a fully "inside-out" data centre remains a speculative vision and is unlikely to be realised in practice. In this project, however, the invisible becomes legible through waste heat and the overhead district heating pipes that carry it. This makes the data centre perceptible in the city, not by exposing its servers, but by tracing the energy it releases.

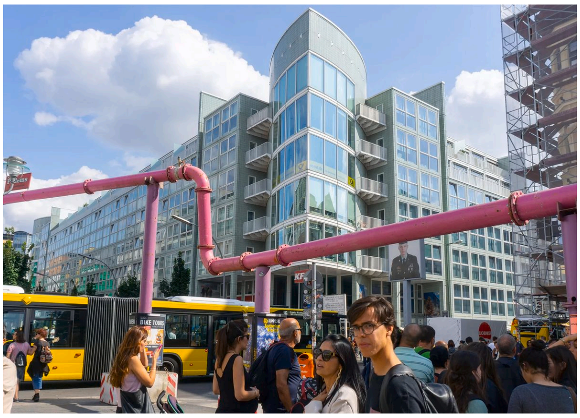


AXONOMETRY OF A DATA CENTRE WITH VISIBLE INFRASTRUCTURE (INSIDE OUT)
Drawing: the authors, 2025.



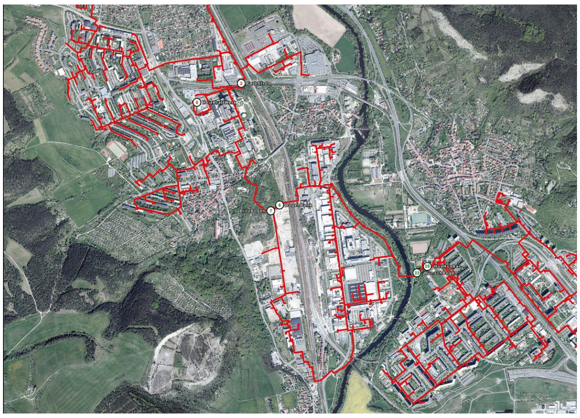
AXONOMETRY OF A DATA CENTRE MADE VISIBLE THROUGH OVERHEAD DISTRICT HEATING PIPES
Drawing: the authors, 2025.

AACHEN UNIVERSITY HOSPITAL
Photograph: Roland M Schwerdtfeger.



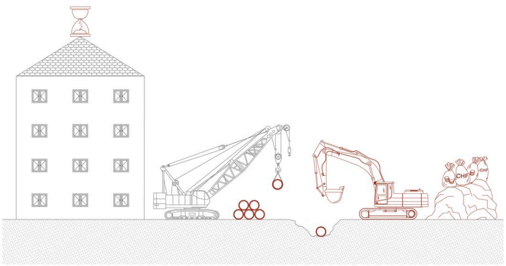
PINK PIPES IN BERLIN
Photograph: Brian Scantlebury, 2017.

PINK PIPES IN BERLIN
Photograph: Unknown.

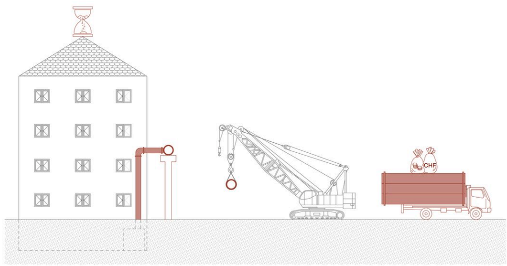


MAP OF THE DISTRICT HEATING PIPES IN JENA
Source: Adern von Jena, 2007.

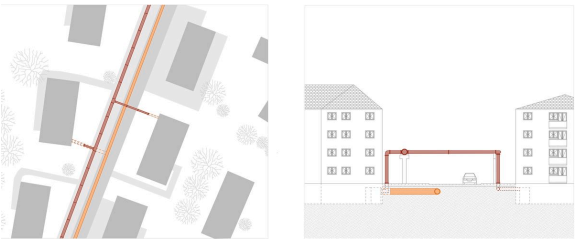
THE VEINS OF JENA
Photograph: Unknown, 2007.



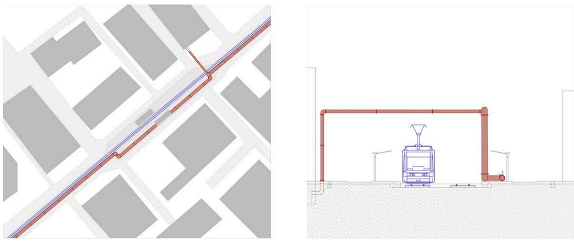
BEFORE: CONSTRUCTION COSTS AND TIME EXPOSURE ARE HIGH AND PIPES ARE DIFFICULT TO REPOSITION
Drawing: the authors, 2025. Source: Oppermann. Fernwärme Schlussbericht, 2022. Ashworth. “Comparison table.” 2023.



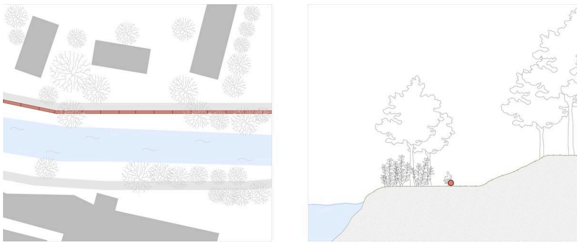
AFTER: CONSTRUCTION COSTS AND TIME EXPOSURE ARE REDUCED BY 60 % AND PIPES CAN BE EASILY REPOSITIONED
Drawing: the authors, 2025. Source: Oppermann. Fernwärme Schlussbericht, 2022. Ashworth. “Comparison table.” 2023.



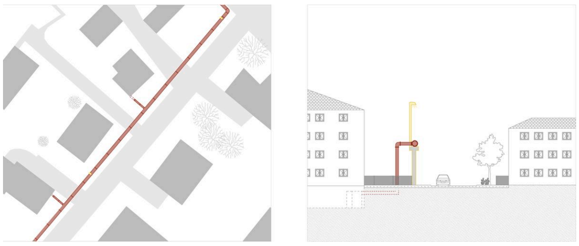
RULE 1: ALONG THE EXISTING UNDERGROUND GAS PIPELINE NETWORK
Drawings: the authors, 2025.



RULE 2: ALONG THE EXISTING RAILWAY TRACKS
Drawings: the authors, 2025.



RULE 3: ALONG PUBLIC PLACES LIKE PARKS AND PLAYGROUNDS
Drawings: the authors, 2025.



RULE 4: IF POSSIBLE, PLACED ON PUBLIC INFRASTRUCTURE
Drawings: the authors, 2025.

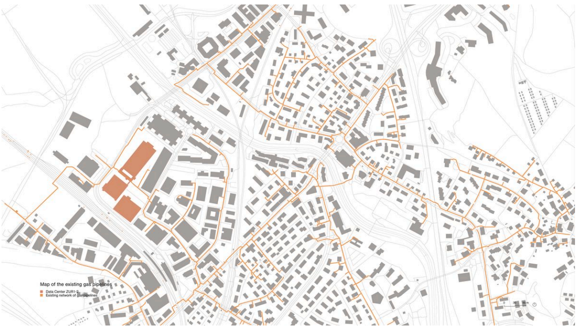
The proposed project in Opfikon showcases the application of recently developed planning regulations for district heating systems, with the Digital Realty campus serving as the primary heat source. To determine the most suitable layout and routing for the new energy network, the existing infrastructure and relevant local indicators were thoroughly mapped and analysed.

The analysis begins with an overview of residential buildings in Opfikon that currently rely on fossil fuels for heating. The map also shows the existing gas network, highlighting the pipes laid beneath the streets that supply heat to many of these homes. This gas infrastructure is scheduled for decommissioning by 2050, rendering the transition to renewable district heating both necessary and timely.

Public transport is a key consideration in this planning process, given that Opfikon is closely linked to Zurich Airport and the wider Zurich transport network. Public spaces, such as parks and recreation areas, were also included as important indicators to help visualise the urban landscape and identify suitable routes for new infrastructure.

Combining these layers of information makes it possible to identify key nodes and determine a feasible above-ground piping pathway. This mapping forms the basis of a proposal for a new district heating system that is sustainable, visible, and connects key buildings and community facilities.

BUILDINGS HEATED WITH FOSSIL FUELS
Drawing: the authors, 2025. Source:
Leitungskataster Canton of Zurich, 2025.

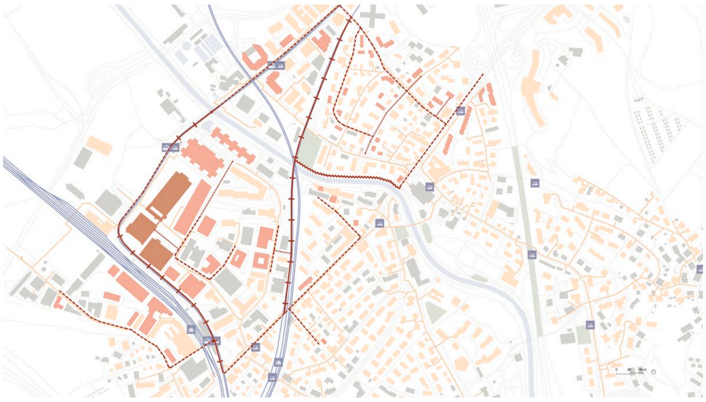


EXISTING GAS PIPELINE NETWORK
Drawing: the authors, 2025. Source:
Leitungskataster Canton of Zurich, 2025.

RAILWAY TRACKS AND STOPS
OF PUBLIC TRANSPORT
Drawing: the authors, 2025. Source:
Leitungskataster Canton of Zurich, 2025.

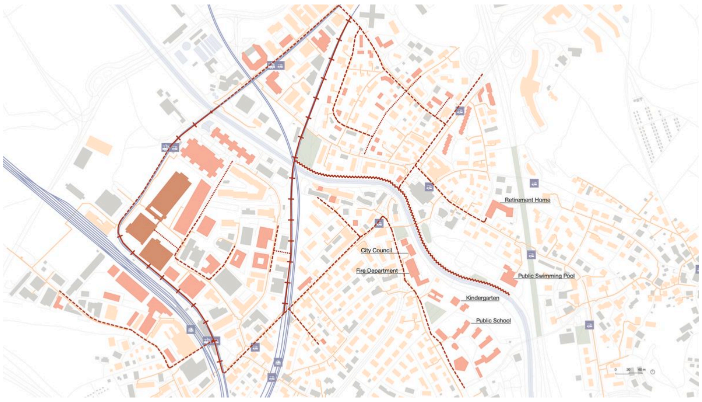
PUBLIC SPACES AND
LOCAL RECREATION AREAS
Drawing: the authors, 2025. Source:
Leitungskataster Canton of Zurich, 2025.

OVERLAY ALL INDICATORS
TO REVEAL INTERSECTIONS
Drawing: the authors, 2025. Source:
Leitungskataster Canton of Zurich, 2025.



PROPOSAL FOR AN ABOVE-GROUND DISTRICT HEATING NETWORK
Stage 1: covering interested customers
Drawing: the authors, 2025.

- Data centres ZUR1, ZUR2, and ZUR3
- Households interested in a district heating connection
- Buildings currently heated with fossil fuels
- Public places and parks
- River Glatt
- Railway tracks
- Existing gas pipeline network
- New proposed overground district heating network, stage 1

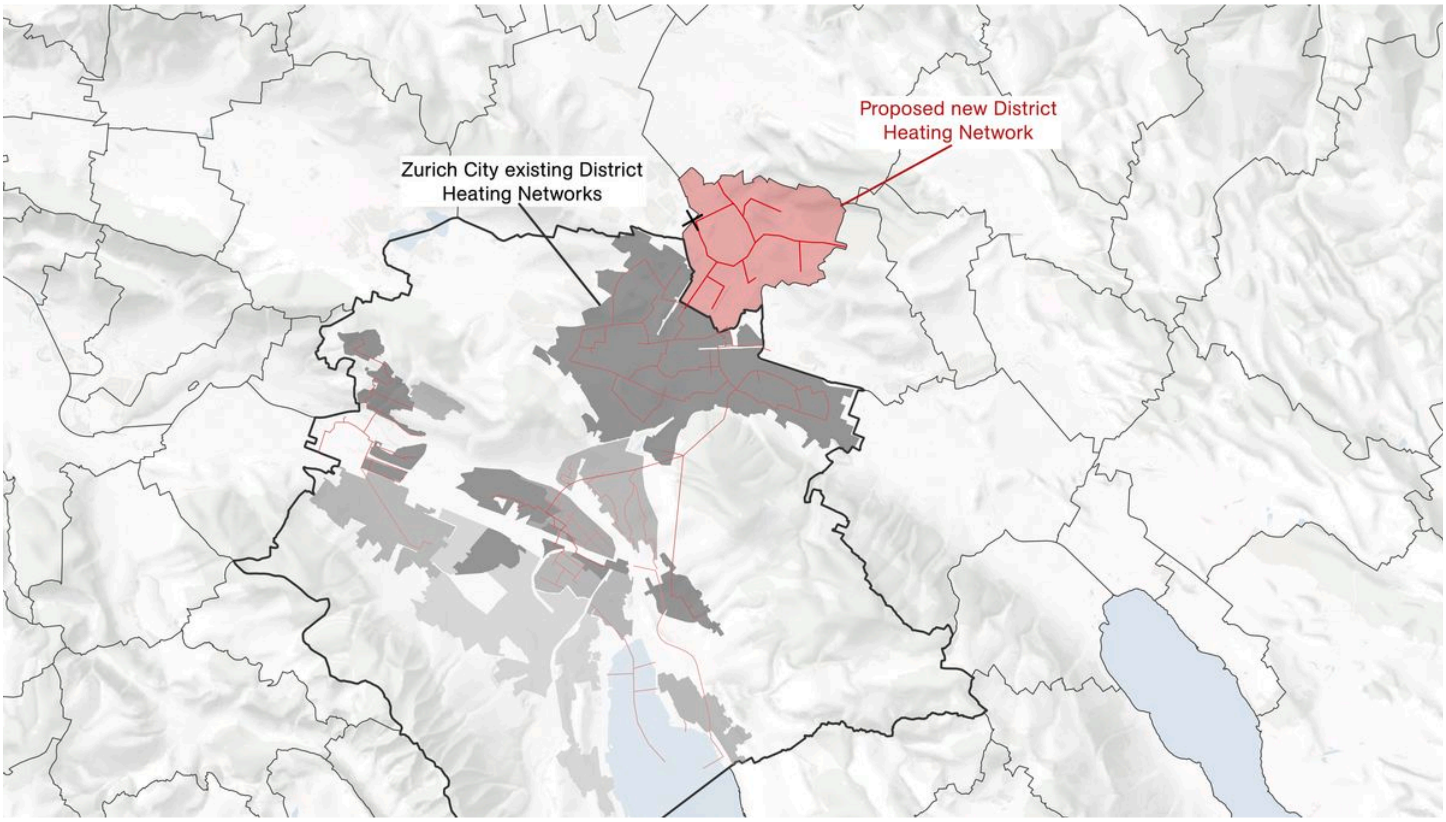


PROPOSAL FOR AN ABOVE-GROUND DISTRICT HEATING NETWORK
Stage 2: covering public institutions
Drawing: the authors, 2025.

- Data centres ZUR1, ZUR2, and ZUR3
- Households interested in a district heating connection
- Buildings currently heated with fossil fuels
- Public places and parks
- River Glatt
- Railway tracks
- Existing gas pipeline network
- New proposed overground district heating network, stage 2

PROPOSAL FOR AN ABOVE-GROUND DISTRICT HEATING NETWORK
Stage 3: replacement of all fossil fuel heating systems
Drawing: the authors, 2025.

- Data centres ZUR1, ZUR2, and ZUR3
- Households interested in a district heating connection
- Buildings currently heated with fossil fuels
- Public places and parks
- River Glatt
- Railway tracks
- Existing gas pipeline network
- New proposed overground district heating network, stage 3



PROPOSED NEW DISTRICT HEATING NETWORK AS AN EXTENSION OF ZURICH'S DISTRICT HEATING NETWORK
Drawing: the authors, 2025. Source: EWZ, 2025.

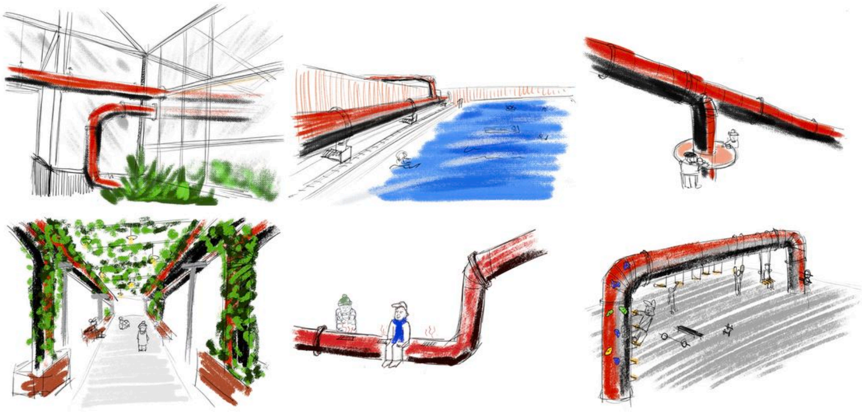
- Proposed new district heating network
- Existing district heating Zurich
- District heating Zurich under expansion
- District heating Zurich in planning
- Location of Digital Realty data centre

This network is being rolled out in stages. Initially, it will connect buildings that have already expressed an interest in joining the Airport City energy network. These buildings will serve as pioneering examples for other potential customers. The second stage will see public institutions, including schools, retirement homes, swimming pools and municipal facilities, integrated into the system. This approach is supported by expert input, including from Janez Zekar, who discussed the concept in an interview.

Ultimately, the network will extend to residential buildings that currently rely on fossil fuels for heating. As the gas network is phased out by 2050, these homes will require an alternative energy solution, so it is crucial that they are included in order to create a fully renewable local heating infrastructure.

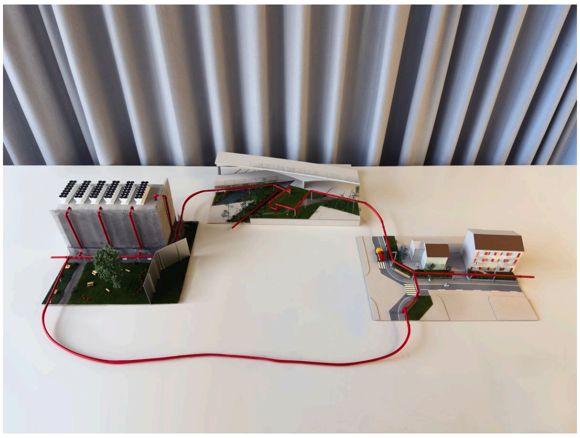
The proposed project aims to link Opfikon's new heating system with Zurich's existing district heating networks. This connection would extend Zurich's district heating infrastructure beyond the city's borders, creating a more resilient and sustainable energy landscape across the region.

Urban Heat Infrastructure

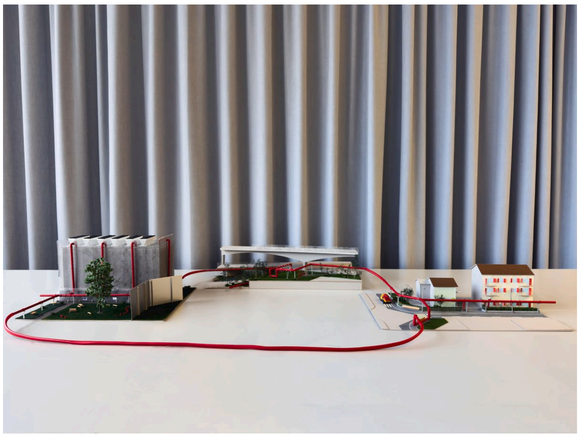


How does the urban heat infrastructure impact its surroundings?
Drawings: the authors, 2025.

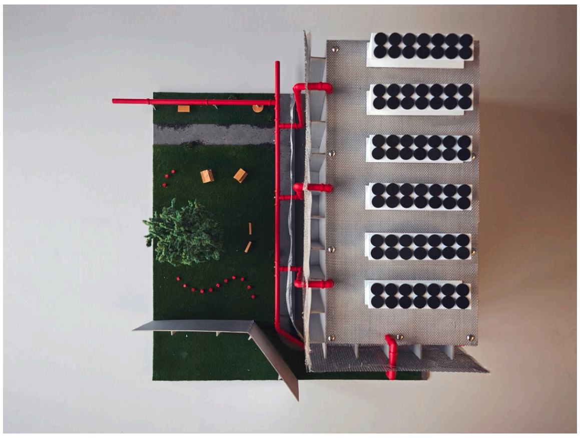
The above-ground pipes emerge from technical invisibility to become part of the public realm. As visible lines running through the city, they create seating areas, gathering spaces, and walkways. This allows the heat network to interact directly with the public, who can experience it as a spatial, social, and energetic infrastructure.



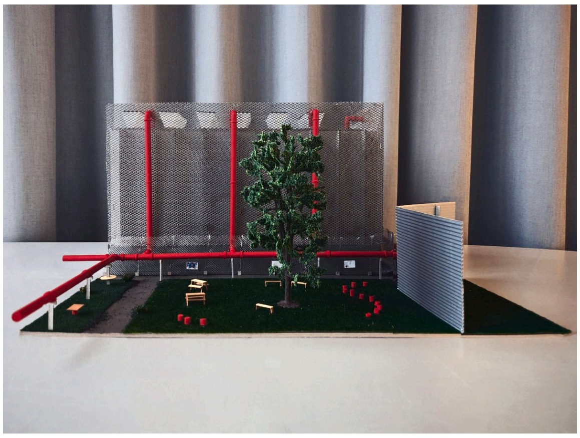
THREE MODELS OF WASTE-HEAT USE: SOURCE, THERMAL NETWORK, AND END-USERS, ELEVATED VIEW
Photograph and model: the authors, 2025.



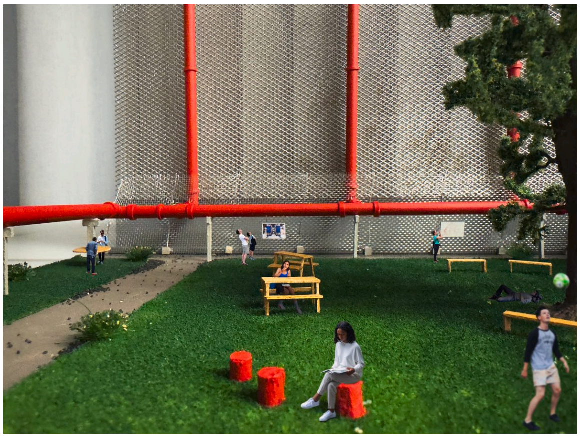
THREE MODELS OF WASTE-HEAT USE: SOURCE, THERMAL NETWORK, AND END-USERS, SIDE VIEW
Photograph and model: the authors, 2025.



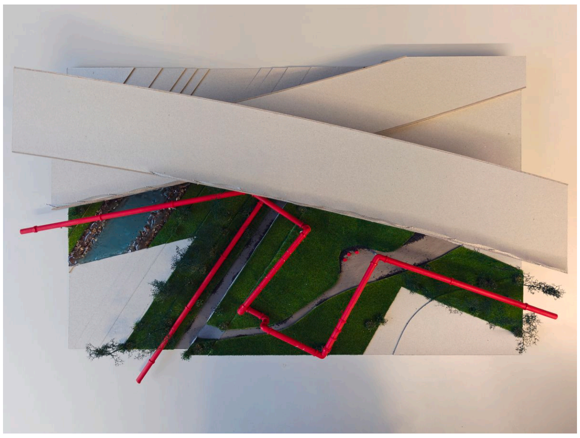
THE WASTE HEAT SOURCE, TOP VIEW
Photograph and model: the authors, 2025.



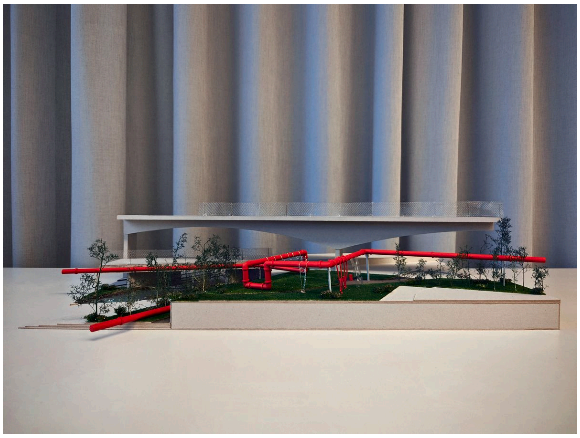
THE WASTE HEAT SOURCE, ELEVATION
Photograph and model: the authors, 2025.



THE WASTE HEAT SOURCE, COURTYARD
Photograph and model: the authors, 2025.

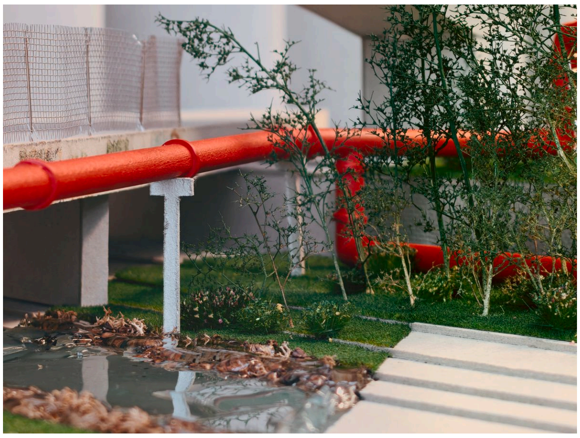


THE THERMAL NETWORK
THROUGH THE CITY, TOP VIEW
Photograph and model: the authors, 2025.



THE THERMAL NETWORK
THROUGH THE CITY, ELEVATION
Photograph and model: the authors, 2025.

THE THERMAL NETWORK
THROUGH THE CITY, PLAYGROUND
Photograph and model: the authors, 2025.



THE THERMAL NETWORK
THROUGH THE CITY, RIVER WALK
Photograph and model: the authors, 2025.

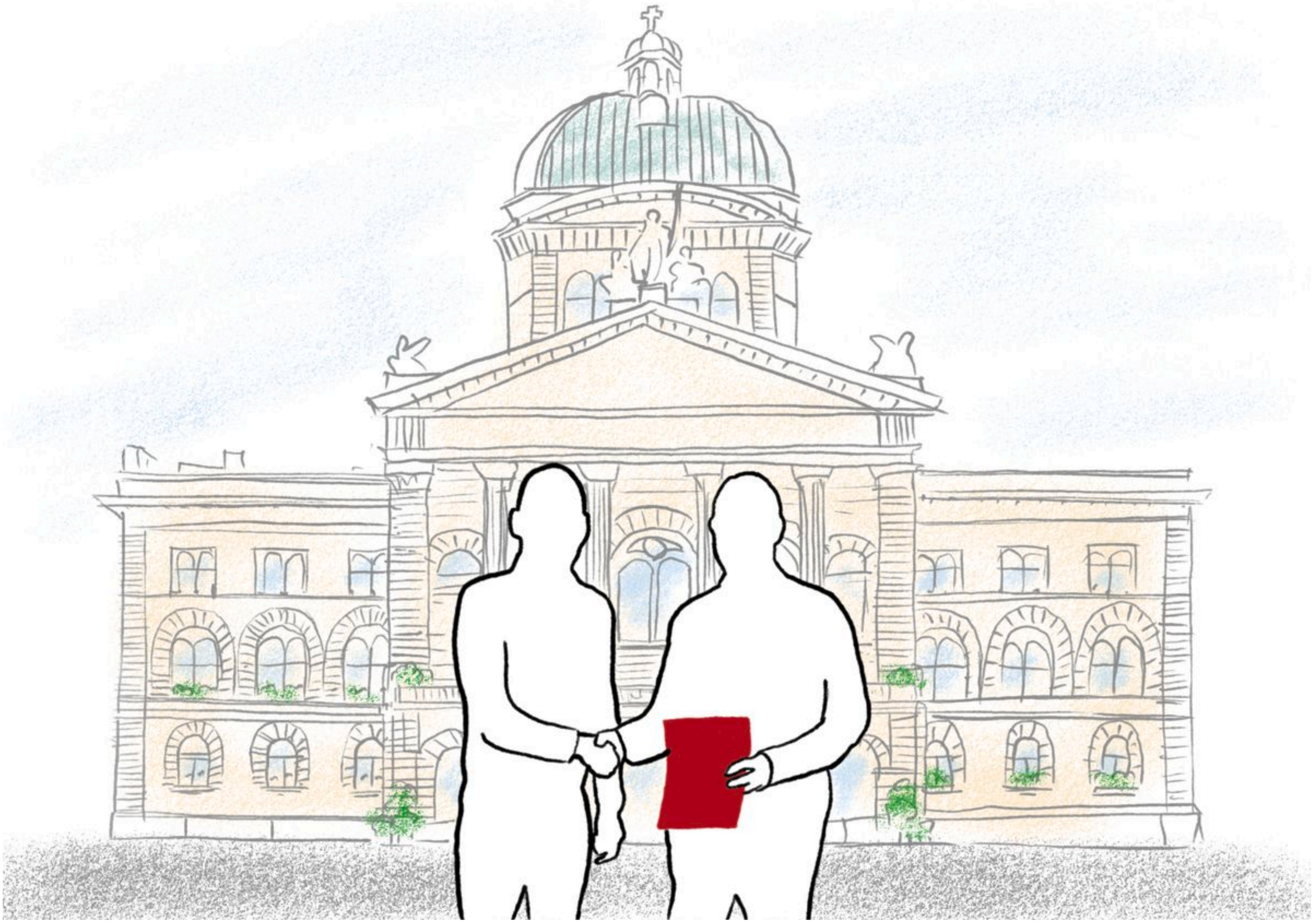
THE THERMAL NETWORK'S
END USERS, TOP VIEW
Photograph and model: the authors, 2025.

THE THERMAL NETWORK'S
END USERS, SIDE VIEW
Photograph and model: the authors, 2025.

THE THERMAL NETWORK'S END
USERS, RESIDENTIAL HOUSE
Photograph and model: the authors, 2025.

THE THERMAL NETWORK'S END USERS,
RESIDENTIAL NEIGHBOURHOOD
Photograph and model: the authors, 2025.

Rethinking Regulations: How to Enable Waste Heat Utilisation



Moving from soft incentives to binding obligations, stronger laws would require data centres to disclose their waste heat and present concrete reuse plans. They would also require data centres to co-finance the necessary infrastructure. This would make waste heat, formerly ignored, a reliable pillar of urban energy planning rather than a lost opportunity.

In Switzerland, there is no single national law governing the use of waste heat from data centres. Instead, regulation is set at the cantonal level. This work therefore examines the Canton of Zurich as a Swiss data centre hotspot, with its own special building regulations that address waste heat from buildings and industrial processes.

According to Zurich's regulations, waste heat generated in buildings, particularly from cooling systems and commercial or industrial processes, must be utilised wherever it is technically, operationally and economically feasible (§ 30a Sec. 1). If more than two gigawatt hours of waste heat per year cannot be used internally in new or substantially renovated buildings, it must be made available to third parties in a suitable form at cost price (§ 30a Sec. 2).

CITY OF ZURICH MUNICIPAL COUNCIL
Photograph: Tagesanzeiger, 2024.

But are the current laws really sufficient? Daniel Heierli, member of the Cantonal Parliament of Zurich and the Green Party, summarises the current situation pointedly:

"Simply giving away waste heat for free is not sufficient; if it is offered at a low temperature and in an arbitrary location, hardly anyone will make use of it, even at no charge–it is as unattractive as a worn-out sofa left on the sidewalk with a 'free to take away' sign."

Against this backdrop, the project proposes the introduction of additional legal instruments targeting data centres specifically, without claiming to have legal expertise. Firstly, data centre operators should be required to publish details of the waste heat they produce and submit a plan explaining how this heat could be used outside the data centre (§ 30a, Sec. 3, proposed). Secondly, if new infrastructure is required to utilise this waste heat, data centres should contribute a clearly defined and fair share of the investment costs. The city should set and guarantee cost-sharing rules for at least ten years (§ 30a, Sec. 4, proposed).

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