

Pipe Dreams

A research by design perspective on
the energy transition in Brussels

Jonas Benjamin Görden

or true transition?

Thesis submitted to obtain the academic degree of
Master in Urban Design and Spatial Planning

Under the Supervision of Prof. Fabio Vanin (PhD)

Academic year 2023-2024

Vrije Universiteit Brussel
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Abstract

This thesis explores the ongoing efforts of cities to reduce their greenhouse gas emissions through the example of Cureghem, a district in Brussels. The concept of Positive Energy Districts is examined as a tool for the energy transition in cities. Looking at the spatial and social dimensions of this transition, the research highlights the limitations of current techno-centric approaches and underlines the need for integrated design strategies that combine collective action with climate adaptation. Some adverse effects of current approaches are discussed, in particular the 'performance gap' regarding energy-efficient buildings. The social implications of large-scale energy infrastructure projects are discussed and illustrated by a concrete case in Rotterdam. Through a research by design methodology, including historical and morphological analysis, spatial design and photographic survey, different approaches are explored through street designs, collages, mapping and scenarios. Concluding the design research, this thesis argues for an integrated approach to urban energy transitions that prioritises local resilience and community engagement. Gaps in understanding how social factors affect district energy demand are identified.

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I Acknowledgements

Working on an in-depth piece about the implications of the energy transition, like the one you are reading now, has been something of a dream of mine for some time. To make it a reality, I have relied on a whole host of people, from experts to committed friends, who have generously shared their time and knowledge.

My deepest appreciation and gratitude goes to the experts who gave me the opportunity to learn from their insights and experiences. In particular, I would like to thank Professor Julien Blondeau for sharing his expertise on heat networks, Hanne Mangelschots for welcoming me at Architecture Workroom Brussels and for her original take on Positive Energy Districts, Kris De Decker for his dedicated writing in Lowtechmagazine which has taught me so much and for taking the time to elaborate his unique perspective, and Martine Mvengou for welcoming me at Bruxelles Environnement.

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Thank you all.



II Introduction

Brussels has been ahead of the curve a number of times in history. It already made the switch to gas street lighting in 1819, beating *La Ville Lumière* by a whopping 40 years.¹ It was also the destination of the first railway line on the main continent, opening in 1835 connecting it with neighbouring Mechelen. A century later, it was reinventing itself again as an American style metropolis in the age of speed with highways and downtown districts. Embracing progress and modernity, hosting the atom-themed 1958 world expo, it nearly became the first city on the European mainland with its own nuclear reactor (see chapter 2).

But today's challenges call for new role models. So Brussels is once again trying to reinvent itself, this time taking inspiration from Europe's best-in-class cities such as Vienna, Stockholm and Copenhagen. Recent investments in infrastructure have led to a sharp increase in cycling, and redesigned public spaces now boast water features and biodiverse green spaces.

Above all, there remains the looming threat of climate collapse and increasingly violent weather anomalies, from longer and more intense heat waves to heavier rainfall in shorter periods of time. Cities, including Brussels, not only need to prepare for these extremes, but are also faced with the need to play their part in reducing greenhouse gas emissions, the main cause of rising global temperatures. Based on the concept of Energy Positive Buildings or Passive Houses, which produce more energy than they consume, a growing body of literature discusses the potential of Positive Energy Districts (PEDs), whole neighbourhoods that produce energy surpluses, as a tool to help cities neutralise their carbon footprint. This strategy relies on a combination of high-tech buildings that are extremely energy efficient and a good mix of local renewable energy production. In the first chapter, we will take a closer look at the discourse around Energy Positive Cities and compare three models of PEDs.

Brussels is in the unenviable position of not having the high-quality housing of Vienna or the financial capacity of a Nordic city, which limits the government's ability to act quickly. A large proportion of Brussels residents have below-average incomes, and the fragmented governance structure of 19 municipalities makes for a confusing mix of responsibilities. Nevertheless, there are visible efforts by the city authorities to be at

the forefront of an urban energy transition. The second chapter takes a closer look at these efforts and provides an overview of current progress in energy production and consumption in Brussels.

In the third chapter, we will zoom in on one particular Brussels neighbourhood, Cureghem, which has come under scrutiny due to its economically challenged population and housing problems. At the same time, there is a lot of innovative activity in terms of energy transition, making it a potential testing ground for a climate-neutral Brussels. We will explore the spatial qualities of Cureghem and create a framework for a morphological analysis. Much of the current energy policy relies on a triad of technological innovation, renewable energy and efficiency measures. Chapter 4 discusses the shortcomings of the current approach, including the notion of energy positive districts. While most of the discourse on fossil fuel phase-out focuses on the technical challenges, we will also take a look at the social implications of the energy transition. By reviewing relevant literature, we outline the limitations of the current techno-centric approach to building performance and energy production.

To illustrate the emerging dilemma, Chapter 5 takes a look at a community in Rotterdam that should have made a rapid transition to a renewable district heating network, but ended up destabilising the community's integrity. We spoke to one of the key initiators of a local organisation at the hub of the neighbourhood's attempt to find common ground with a global energy conglomerate and agitated authorities. The final chapter sets out a number of design strategies and presents them in the context of Cureghem. We illustrate the impact of the new infrastructure required by the energy transition and how to make the best use of it, broadening the scope to include climate adaptation measures and opportunities for the formation of new social initiatives.

We believe that the current problem is that the social and spatial aspects of energy transitions are under recognised, especially in the urban context. Because of the difficulties associated with a dense urban environment or an underprivileged population, we often find that these cases are either not discussed in the literature or recommendations are deliberately vague. With this research, we hope to highlight the wide range of challenges associated with the transition away from fossil fuels, which go far beyond the purely technical aspects. We also hope to demonstrate the need for an integrated design approach to the new infrastructure required for this transition.

With this work we want to explore how to reframe the urban energy transition beyond optimising efficiency towards local energy resilience. Using the scenario of an energy positive district, we want to identify the energy potentials of the urban landscape of Cureghem and the potential barriers to a socially and environmentally sustainable energy system.

III Methodology

Before delving into our topic, we will briefly explain the research methods used to investigate the challenges of the energy transition and its impact on the urban and social fabric.

Much of the literature on this topic is written from a general perspective, attempting to develop theories or comparing case studies. We have chosen a research by design approach that integrates the design process as a means of inquiry. The design part of this dissertation combines the findings of the previous chapters and tests them using a scenario approach. By reflecting on our designs, we draw conclusions and generate new insights. The design part is informed by a selection of academic and grey literature, expert interviews and a short case study. In order to keep the bibliography clear, we have chosen to cite academic literature in APA style, embedded in the text, while using annotations for any additional information to enrich the text.

The case study visits to Rotterdam were initiated on the recommendation of one of our interviewees. After our visit to Rotterdam, we arranged for our contact to meet a representative of a similar local organisation to share experiences and discuss local challenges.

We conducted 8 interviews with experts in relevant fields, trying to cover a wide range of backgrounds and views. The interviews were unstructured, although all started with the same set-up of asking participants about their connection to Positive Energy Districts. We chose to transcribe and publish 4 of the interviews that stood out as particularly relevant and insightful. In order to improve the readability of the transcripts, we made minor changes as part of the translation process (the interviews

were conducted in Dutch and French). The order of the questions has remained the same, but we have sometimes shortened answers by removing duplicate information. While maintaining the style and language, we also removed some redundancies such as natural sounds and grammatical errors.

The cartographic analysis was carried out using QGIS, an open source geospatial software, using openly available data provided by the Brussels-Capital Region and OpenStreetMaps. Map data was exported in vector format and edited in Adobe Illustrator for visual consistency.

The choice of a research by design approach was motivated by the aim of avoiding generalisations and unrealistic assumptions, in order to provide a robust framework from which to draw conclusions. The method makes it possible to explore the real spatial implications of our assumptions and strategies. We also want to emphasise that the aim of this work is to produce a result with artistic and aesthetic value. In contrast to design informed by research, the method aims to produce new knowledge from design as a research tool itself. This can generate new kinds of insights that traditional research methods would not produce, thus enriching the overall discourse.

1 The Energy Positive City



The heat-trapping effects of carbon dioxide in the Earth's atmosphere have been known to mankind since the 19th century. Today, the Intergovernmental Panel on Climate Change has reiterated the urgency and benefits of rapid and integrated action to reduce greenhouse gas emissions (IPCC, 2023). As people around the world flock to live in urban areas, attention is shifting to cities to play their part in mitigating the effects of climate change. The IPCC recognises that cities have a crucial role to play in achieving a deep transition away from fossil fuels through long-term resilient urban planning, collective and active transport, or changing and reducing energy consumption. The growing share of urban population could also give cities an increasing lever to help reduce demand-side emissions.

Consequently, creating 100 Climate-Neutral and Smart Cities is one of the EU's missions to deliver concrete solutions within the next few years to support its Green New Deal¹, a comprehensive strategy to achieve climate neutrality by 2050. These cities will be equipped with virtual toll gates for carbon accounting to ensure an annual balance of emissions produced and emissions avoided. One of the tools to achieve climate neutral cities is the deployment of Positive Energy Districts (PEDs). The Commission has tasked a workgroup with supporting the “planning, deployment and replication of 100 ‘Positive Energy Districts’ by 2025”² thereby paving the way for energy performance targets to go beyond individual buildings to the district level (Shnapp et al., 2020). Legislation to improve the energy performance of buildings has long been a central part of the EU's efforts to reduce greenhouse gas emissions from the building sector. Positive Energy Districts fit well with previous EU policies, from building efficiency directives to renewable energy targets to energy market reforms. If ever enshrined in legislation, municipalities or regions could set minimum energy performance targets for clusters of buildings or a specific district.

¹ See EU Mission: Climate-Neutral and Smart Cities on: https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/climate-neutral-and-smart-cities_en

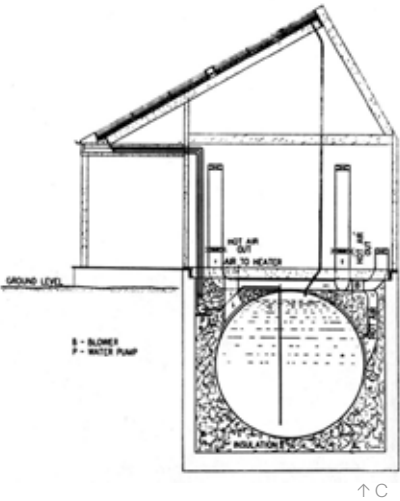
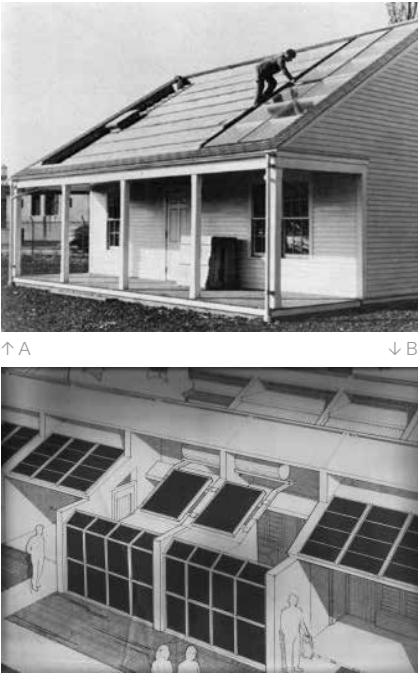
² About: The Implementation Working Group on positive energy districts and neighbourhoods for sustainable urban development https://setis.ec.europa.eu/implementing-actions/positive-energy-districts_en

WHY ENERGY-POSITIVE?

Buildings provide safety, thermal comfort and protection from the elements. Much vernacular housing throughout history has been built to minimise the need for additional heating or cooling, albeit by necessity to adapt to the local climate. The energy efficiency of heating systems has also always been a focus of innovation, for example the Roman hypocaust system, which was used well into the Middle Ages.³ The first solar houses were built by universities in the United States in the mid-20th century, but the focus was still on radiant heat gain and retention rather than energy production.

Public interest was limited at the time because energy was considered cheap and abundant, but following the energy crisis of the 1970s, solar homes and energy-efficient building were back on the agenda. In 1973, a solar house at the University of Delaware was the first of its kind to produce its own electricity using thin-film solar photovoltaic cells - at the time still manufactured in the university laboratory.⁴ In the 1980s, the Passive House standard was developed, combining previous knowledge and research into a clearly defined certification that is still a benchmark for energy-efficient building today. The ‘passivity’ in this concept is usually achieved through technologies such as airtight insulation, mechanical ventilation with heat exchange, high performance PV panels and triple glazed windows.

While the environmental aspect of reducing resource consumption was a major driver for the development of zero energy buildings, the 1973 oil crisis (and subsequent energy crises) also highlighted the critical dependence of energy importing countries on oil and gas producing countries. Ambitions to become ‘energy positive’ or ‘net neutral’ should therefore also be seen as a geopolitical tool to achieve energy indepen-



3 Heat Storage Hypocausts: Air Heating in the Middle Ages, Kris De Decker, Lowtechmagazine, 2017
<https://solar.lowtechmagazine.com/2017/03/heat-storage-hypocausts-air-heating-in-the-middle-ages/>

4 Solar Strong, Beth Miller, University of Delaware, 2015
<https://research.udel.edu/2015/10/12/solar-strong/>

A The Solar 1 house built on the MIT campus in 1939, claimed to be the first house in America to be heated by the sun's energy only and served also for research on air conditioning and power generation.

B Prototype 1 of a bioclimatic and solar row house. South façade of the project.

C Cross-section of the MIT Solar 1 house, showing the large water reservoir.

Images A and C: Department of Mechanical Engineering and the Solar Energy Fund at the Massachusetts Institute of Technology, Building 34 MIT Solar House I, 1939, photograph and drawings, Cambridge, Massachusetts. Image B: Couret, D. G. (2013, January 1). FIGURE 8.18. Elsevier eBooks. <https://doi.org/10.1016/b978-0-12-397269-9.00008-6>

dence. In 1979, in response to the Arab oil embargo of 1973, President Jimmy Carter announced his plans for the US to produce 20 per cent of its energy from solar power and had solar hot water panels installed on the roof of the White House.⁵

BEYOND THE INDIVIDUAL

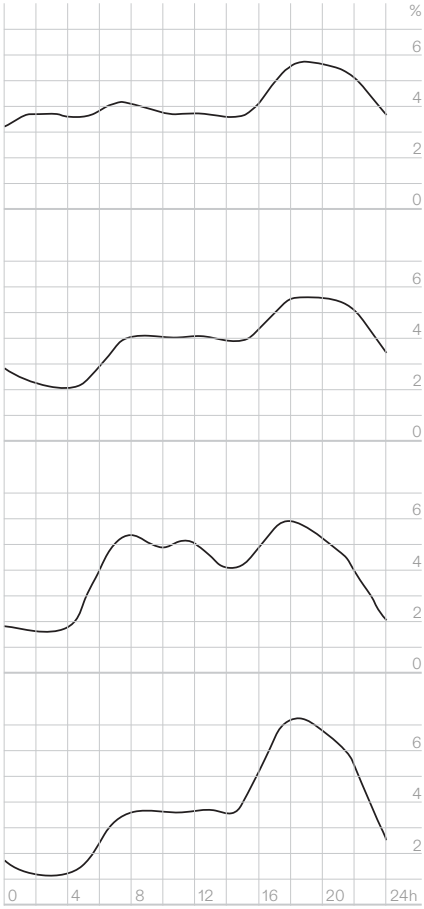
Managing energy expenditure at the level of individual buildings also has its drawbacks. The challenge of zero energy buildings is always to match supply and demand, and smaller buildings in particular have less room for flexibility. This can be partly solved by energy storage, such as batteries, but this comes at a high cost, both economically and environmentally. Larger buildings may have an easier time because they can retain heat for longer due to the greater thermal mass of the structure, providing more flexibility in heating demand, but they can also house a greater variety of functions, meaning that energy demand may be less erratic. For example, commercial use requires more energy during the day when residential activity is lower. This is also true for different socio-economic profiles or people with different types of jobs. A greater diversity of all these factors can smooth the energy demand curve, making it easier to match with a renewable supply.

Extending the definition of ‘energy positive’ to the district level means taking advantage of the greater diversity of people and businesses that the urban environment has to offer. It also opens up the possibility of combining user profiles that complement each other well, but cannot usually co-exist in the same building or block, such as industrial activities and residential neighbourhoods. The district scale also offers new spatial opportunities for energy production through the use of public spaces, whereas zero energy buildings are confined to their site. However, this makes Positive Energy Districts inherently political, as expansion into the public realm requires a spatial diplomacy between stakeholders and residents. Zero Energy Buildings can be assured of their politically uncontroversial status, but this approach has also been unable to deliver the savings needed to reduce emissions quickly enough. According to Architecture Workroom Brussels (2023), one of the research partners in the Cities4Peds programme, the transition in energy use and physical infrastructure must be implemented in an “integrated, collective and inclusive way” (p.4). The district scale is therefore seen as more appropriate to achieve the climate goals that cities, nations and the European Union are aiming for.

DEFINING POSITIVE ENERGY DISTRICTS

The concept of Positive Energy Districts is a logical continuation of the Passive House concept (Koutra et al., 2023), but finding a precise definition of what qualifies as a PED is a murky business. Strictly speaking, one would define them as 'areas where the annual energy demand is lower than the annual energy supply from local renewable energy sources' (Ala-Juusela et al., 2016:1). However, the scale and methodology vary widely in the scientific literature and between case studies. Brozovsky et al. (2021) found 35 different terms used in academic writing, with the two most popular being Zero Energy Neighbourhood and Positive En-

5 Jimmy Carter, Solar Energy Remarks Announcing Administration Proposals. Online by Gerhard Peters and John T. Woolley, The American Presidency Project <https://www.presidency.ucsb.edu/node/250284>

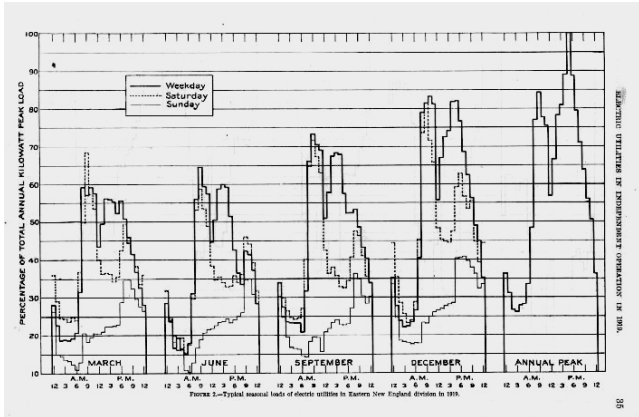


↑ Different user load profiles can be characterised as “Winter Spinners”, “Double Risers”, “Home Lunchers” or “Afternoon Actives”. Adopted from: Kmetty (2016), Figure 31. Load profile segments, daily share UK, 4-cluster solution, hierarchical clustering

ergy District. There is considerable variation in the scale of the different concepts, ranging from zero energy block, campus, community, settlement to district or neighbourhood. While some concepts emphasise the Zero Carbon attribute rather than Positive Energy, others simply call it ‘smart’. There are different ways on how to achieve a positive energy balance within a PED. Wyckman et al. (2019) have defined different sub-types based on where the boundary is drawn within which the energy must be produced. The autonomous type is probably the most intuitive, meaning that a district is able to meet its own energy needs at all times (or to adjust its needs to the available production). Interaction with the grid is still possible (and legally required), but would only be used to feed excess power back into the grid. However, Wyckman et al. question how realistic and useful this would be.

The second type defined is the dynamic PED, where grid interaction is used for both import and export of electricity. Local production capacity does not have to meet demand at all times, and the energy balance is calculated over a longer period, usually a year. This makes the concept much more viable in urban areas, which have higher densities and therefore more limited opportunities for power generation.⁶

The third type defined is a 'virtual' type of PED, where the focus is on matching production and demand through direct contracts with renewable producers in the vicinity. This requires a high degree of flexibility in the energy demand of the Positive Energy District, so that at times when there is an oversupply of electricity (for example, at midday on a windy summer day), the PED can respond by adjusting demand to make use of the available energy. In general, there are two types of demand-side management: Load shifting and peak shaving. With load shifting, the total consumption remains the same, but is spread out over time. This can be achieved, for example, through measures such as thermal activation of building components in combination with heat pumps, so that the building structures can become a kind of thermal battery. During periods of surplus energy, the heat pumps heat or cool building elements that maintain their temperature for several hours when little or no energy is required. Peak shaving, on the other hand, usually refers to simply reducing demand at critical times (for example, when hourly prices are high)



6 These are usually heavily leaning on Solar Photovoltaic production, which means they will produce a greater amount of electricity in summer than in winter.

← The data may be outdated, but the principle still holds up today: Energy demand not only varies throughout the day but also between weekdays and seasons. This beautiful graph shows typical seasonal loads of electric utilities in Eastern New England Division in 1919. United States Geological Survey, 1921. Public Domain

	AUTO PED	DYNAMIC PED	VIRTUAL PED
Energy Production	On site only	On- and off-site	Largely off-site
Energy Storage	+++	+	++
Grid Interaction	Export only	Import/Export	Import/Export
Focus	Energy Autonomy	Local RE and Flexibility	Flexible demand

to help stabilise the grid. This can be achieved through on-site energy storage. Often electric vehicles are part of the equation, with the idea that their internal batteries can be used to provide additional flexibility⁷.

Derkenbaeva et al. (2022) note that autonomous concepts of PEDs may be too idealistic and ultimately not practical or desirable given the spatial constraints of urban areas. As people live more densely together, this results in both higher energy demand and less space for energy production. This is why Lindholm et al. (2021) propose what they call the 'onion model', where Positive Energy Districts should be located in the metropolitan area and help to supply the city with renewable energy. However, this seems counter-intuitive to the ambitions of urban planners to slow down urban sprawl and revitalise city centres. In any case, the definition of a PED cannot serve as a blueprint for its implementation, as each site requires individual considerations: there is no one-size-fits-all solution for PEDs (e.g. Bossi et al., 2020, Lindholm et al., 2021, Sareen et al., 2022 or Koutra et al., 2023). How strict and exclusive should the criteria for PEDs be? Architecture Workroom Brussels (2023) rejects the narrow definitions around energy accounting in their recent publication on PEDs. They believe that any district can be labelled a PED, as long as the overall ambition for energy balance and efficiency is high. They also emphasise the goal of higher quality of life, overall sustainability and the social fabric that goes beyond the district.

While cities have come under close scrutiny to reduce carbon emissions, climate change mitigation is only one of many challenges facing urban areas today. They must accommodate growing populations – a challenge that is particularly acute in emerging economies – and adapt to increasingly extreme weather conditions caused by a changing climate. Europe is under particular pressure to prepare for heat waves as it is warming twice as fast as the global rate.⁸

PEDs are a tool for leveraging the synergies of a neighbourhood's diversity to increase its own consumption of locally produced renewable energy, with the aim of generating more energy than it consumes over the course of a year. So far, PEDs are more common in new developments than in existing ones, and focusing too much on achieving a positive annual energy balance could be counterproductive for a broader adoption.

How can a city like Brussels, with its architectural heritage and diverse population, respond to the challenge of climate change and what role can PEDs play in its strategy?

7 Next Kraftwerke, a Virtual Power Plant operator on Peak Shaving and Load Shifting: <https://www.next-kraftwerke.com/knowledge/what-is-peak-shaving>

8 Europe is not prepared for rapidly growing climate risks. (2024, March 11). European Environment Agency. Retrieved July 28, 2024, from <https://www.eea.europa.eu/en/newsroom/news/europe-is-not-prepared-for>



IV On Energy

Given that energy is the red line that runs through the whole of this work, let us take a step back and reflect on some fundamental concepts. In the context of the energy transition, we are talking about basic energy in the form of heat and electricity. This dualism of heat and electricity has to do with the services provided by energy companies. Households in Belgium usually have two contracts with energy suppliers: one for electricity and one for heating fuel. However, electricity itself is only an energy vector and can also be converted into heat. Conversely, when we talk about heat, we are actually referring to other energy vectors such as natural gas, fuel oil, coal or wood. At the same time, when we talk about energy but mean electricity, we are also talking about different forms of useful energy into which electricity is converted. These include light, motion, heat, chemical energy, sound, magnetic energy or radiation.

Einstein's equation showed how energy and matter are intertwined and how they can be transformed into each other under certain conditions. So while all matter has an energy potential, whether that energy is available and useful varies greatly. For example, although we can quantify energy in terms of calories or joules, there is an inherent difference between a joule of butane gas, sunlight or mayonnaise. It is crucial to consider these fundamental qualities of different fuels when discussing the challenges of the energy transition. Up to now, each new energy source has been adopted because of its superior energy density (wood < coal < natural gas < uranium) or logistics (oil and gas are much easier to move through pipelines, wood and coal not so much). The next transition will break this trend, as solar and wind are more dispersed and therefore require new spatial considerations.

Moreover, fossil fuels have applications beyond electricity generation: coal is used as a reducing agent to make pig iron, natural gas is the key ingredient in the production of synthetic fertilisers feeding the world, and oil derivatives provide the

building blocks for most chemicals used in virtually everything we take for granted in modern life from acrylic paint to paracetamol.

While not all of it may need to be replaced by renewables, it highlights the herculean efforts needed to phase out fossil fuels. It is important to take into account the basic laws of thermodynamics to avoid unnecessary hype and misallocation of public money. Electrification is one of the big bets in the energy transition: rather than using low-carbon electricity to create synthetic fuels and lose most of the energy in the transformation process (second law of thermodynamics), it would be more economical in most cases to use the electricity directly. Shifting from combustion to electric processes has huge potential to drastically reduce energy demand because of the higher efficiency. A trolley bus can travel further on 100 kWh of electricity than a diesel bus can on the equivalent of 100 kWh of fuel. We will discuss this further in the next chapter on the energy needs of Brussels. There is one uncertainty, however, and that is that an increase in efficiency can also lead to an increase in overall consumption. This so-called rebound effect is a hotly debated conundrum, which we will look at in more detail in Section VI.

This is all to remind ourselves to not underestimate the transition ahead and to remain critical of shortcuts and technological quick fixes, because the physical realities cannot be negotiated

Bid on the Grid: Building new Energy Networks

Julien Blondeau is professor for Applied Mechanics at Vrije Universteit Brussels. Apart from teaching students in thermodynamics, he and his team are working on research projects around hydrogen, heat networks and biomass.

JG Jonas Grgeren
JB Prof. Julien Blondeau

JG Where does your interest in Positive Energy Districts (PEDs) stem from?
JB That comes from our projects on heating networks actually. We are now working with interdisciplinary research groups in Europe on the technical possibilities of PEDs. So we are usually working on technical work packages, for example: what is the optimal energy system for a certain district. You have to define what is always a compromise between emissions and costs, for example, but also social acceptability. So those are often the three aspects that play a role.

JG I often see in literature for example, that it is assumed that there is a kind of average environment or hypothetical district. But in reality, it will always be very different. Have you also looked at approaches for different typologies?
JB I often say it in my seminars and workshops: The optimal solution is always local. It will depend on the district, on the demand for heat, on the demand for electricity and also the profiles of the user. And the demand for heat and electricity is not only a theme of a certain quantity, but also *when* do citizens or companies use heat and electricity. In the weekend, evenings or during the day etc. For example, a neighborhood with only residential areas is a more difficult case than one with a mix of offices and homes. On the other hand, a swimming pool or something like that is a large, but also constant user of heat. We are already developing tools to identify the best technical solutions, taking into account the configuration of the area and its energy requirements. It is always also a question of being able to determine the amount of space needed, but that is not always straightforward of course. We often

only have access to total annual usage data, so we need to extrapolate or get additional data to make decisions regarding available energy sources. If you know the energy profiles, you can make better decisions: What are the available energy sources, is there geothermal energy, can I place solar panels? Is there space to build a wind turbine for example? Is there potential access to hydrogen in the future or why not? Is the electricity network strong enough also for the production of heat?

JG Regarding the user profiles, is it desirable to have a mix of different users?
JB Yes, definitely, because there will be lower peaks in consumption. So it would be easier or more interesting to invest in a centralized system. For example, a heating network. A heating network is not always a good idea, but if the density of the population or the buildings is high enough, the investments become reasonable. But the lower the peak, the smaller the unit of energy that the heat plant has to produce, which is also cheaper.

JG You said the transition is also a big challenge on a social level. Is that why it's better to take a more structural approach?
JB One of the advantages of a heating network (although being not always the best solution) is that it is a joint system, so you have to build a structure for everyone anyway, and you can also find private companies that are able to invest in the network and then simply sell the heat to the citizens. Then no investment is needed from the residents themselves and they may get a lower price than natural gas, for example, and a long-term guarantee. The price of heat from the heating network depends on the size of the system and the source of energy. A heat pump in a river or a canal is very advantageous, for instance, because it

can also supply cold. Because the canal is colder than the surrounding air in the summer, but also warmer in the winter. That is very advantageous. There are some legal restrictions however: you cannot simply discharge any amount of heat into the canal, or cold in the winter to not disturb the ecosystem.

JG Is this a big challenge?
JB No, it's simply about the relation between the flow rate and the size of the canal. You should just not discharge the heat of the entire city into the canal.

JG And is there an optimal size of such a heating network?
JB Not really, a micro heating network with two, three, up to ten thousand households is already a good size. But there are also cases where heat networks can cover the entire city and with multiple heat production installations.

JG The housing stock in many districts in Brussels is quite old. The advantage of a high-temperature heat network seems to me that it doesn't require all buildings to be perfectly insulated.
JB Indeed, but it also shouldn't be a reason to *not* insulate. Of course in some buildings it is simply impossible or too expensive. But it is not easy to give a general answer to this. It really depends on the individual case.

JG But the risk is that if you build a heating network with a low temperature, you may actually exclude a lot of households as potential users.
JB That is also a part of the transition. You could opt for a heating network with a high temperature and switch to a lower temperature once a sufficient number of houses are insulated. This way, you foresee an evolution, that's no problem. Starting with a biomass boiler room, for example, whilst planning that it will become a system with heat pumps in the future. Or you build a low temperature heating network and provide extra boilers where necessary.

JG How important is energy storage?
JB Storage is very interesting to adjust the demand profile a little. But you are not going to solve the problem of the difference between the seasons. It is possible to use geotechnics for the storage of heat underground. Using a heatpump, you can actually heat up the geothermal system during the summer and then use this heat again in the winter. You can even store heat through the water temperature of a regular water tank, that's also interesting. These are alternative forms of energy storage with perhaps a lower footprint, which could be beneficial in some neighborhoods for example.

JG Renewables like Photovoltaic take quite a lot of space and heat pumps need specific conditions. What are the spatial challenges for biomass?
JB The problem is simply: how are you going to get the fuel to the heating plant? It is usually a solid fuel, sometimes also liquid in the form of biofuel, or gas. But logistics is the big challenge of biomass and also the particulate matter emission. With a centralised boiler however, you can achieve very low emissions by investing in advanced filtering compared with individual installations.

JG How does biomass fit into the context of positive energy districts when the fuel has to be brought from outside?
JB It also depends a bit on the definition. I don't see exactly how a district of several thousand can be fully energy positive. Of course you always want to produce as much energy as possible on site with the solar panels or geothermal energy. But even with geothermal energy you need a heat pump and you are going to import electricity. A city like Brussels for example will always have to import energy using different energy vectors. Now it is mainly electricity and natural gas, so biomass would be another way to import green energy. The biggest advantage of biomass is that it is *dispatchable*. It produces heat and electricity at the same time, you can store it easily because it is a solid raw material. But you have to be able to certify the sustainability of the source which is not always easy. The total amount of sustainable biomass in Belgium and worldwide

is also too limited to save the world, but it is a nice backup for wind and sun. Usually in any scenario having a small share of biomass between 15 and 30 percent of our total energy consumption is ultimately very useful.

JG In a context such as in Belgium where we actually do not have that many hours of sunshine, is it a good strategy to also focus more on collecting solar heat with evacuated tube collectors for example, which are more efficient in low light conditions compared to photovoltaics?

JB Yes, but there is still a difference. It may be more efficient if you just count the energy, but there is a big difference between the quality of electricity and heat as forms of energy. And heat pumps are also special, because the COP (Coefficient of Performance) is higher than one, so for one kilojoule of electricity you get more heat anyway. Now, I think a mix between photovoltaic solar panels and thermal solar panels can be ideal, but again, it depends. I know of existing installations in Belgium that use concentrated solar power to supply heat at a high temperature to industry. Because in that case the COP of a heat pump will be too low. So the combination of PV plus heat pump is disadvantageous compared to thermal solar panels at a high temperature. But that is why you have concentrated solar power, but that is a lot more expensive than regular thermal solar panels. But for sanitary water, for example, regular solar panels are sufficient for households.

JG Should we try to always build as much Solar PV as possible or can it also become too much?

JB That is a very interesting question. Today it is always more advantageous to install as many solar panels as possible, because they are cheap. Now the next question is: okay, if everyone does that, do you then get a problem with the network? We do already see that in some neighborhoods. So it is both a question of self-consumption and self-sufficiency. If the intention is just to meet your own needs, then there is clearly an optimal amount of PV to be installed. But if you assume that the network will always buy your electricity any-

way, then it is a good business case, so why not. But in the future it will be a problem, certainly with smart meters, because then there will be a difference between trying to sell electricity at noon or in the evening. If one day you get a better price in the evening than at 12 o'clock, it might be wise to also place solar panels in directions that are not so interesting today, to be able to produce electricity in the evening and in the morning.

JG I understand that there are different strategies to make neighbourhoods more energy resilient. But how can we determine the ideal degree of autonomy at the lowest possible price?

JB That's what we do here. We have developed a tool that can provide a so called pareto front. I'm going to draw it for you. Suppose you have two criteria, for example cost in euros and CO2 emissions. Usually, the lower the CO2 emissions, the higher the price for the investment. So you will have something like this [draws two intersecting curves], and here are the optima. You would never choose this system [a point above the curve] for example, because there is always another solution that is cheaper and at the same time greener. So the idea is that you can show a curve like that for different neighborhoods and ask: what are we willing to pay for a good system. Some say: this is the current price we're paying and we want something that's cheaper in any case. Then it usually a trade off with producing more CO2 emissions in return (although it's not always like that). But some people also say: okay, if I have a guarantee in the long term, then it's okay for me to pay a little bit more than for natural gas, because I expect the price of natural gas to go up.

JG But doesn't this neglect the potential of also adjusting demand?

JB Yes, of course, because you calculate this curve based on a certain demand. You would foresee an evolution in the simulations, creating several scenarios. There are still some uncertainties about those parameters and there are also solutions to draw those curves with uncertainties. That is "uncertainty quantification" and then you can build a robust system that also takes the uncertainties into account.

JG I think that is a very important point, and we should not assume that we can always serve any demand indefinitely. But of course there the social aspect comes into play. In how far can you expect from the people there to adapt, especially with vulnerable backgrounds?

JB I always say that the choice to reduce your demand must be conscious and not mandatory. We had a workshop at Sibelga for Brussels a few weeks ago and that was a large part of the discussion: a just transition. Vulnerable families or citizens are often not the owners of their homes, that's a problem because they are also not able to invest in it. A heat network is a kind of centralized system in which all users can still benefit from a lower price without having to invest first in their buildings. That would be advantageous, certainly in Brussels where the renovation of the buildings is not going fast enough. Also due to the fact that many owners simply do not live in their buildings, but would have to pay the bill.

JG Is a heat network always managed by a network operator such as Sibelga or are there other options?

JB That is not entirely clear, it would probably resemble the electrical network in the future. For example, you will have the producers who supply heat to the network, a network operator and suppliers who buy the heat from producers and sell it to the customers. But some parties can have multiple roles, which is often simpler in the beginning for a small network where there is only one producer. But in the future you could afford multiple networks and have multiple producers, and the customer will then have a choice between multiple options.

JG So such a network needs at least one producer and an infrastructure of insulated pipes carrying steam or hot water.

JB Nowadays water; steam was more in the early nineteenth century, but the higher the temperature, the higher the losses, so steam is no longer used. You can even run it at a constant low temperature throughout the year, so that you can supply cold in the summer and heat in the winter using addi-

tional heat pumps in each building.

JG How much space is needed for the pipes?

JB In a large network, there are larger pipes to reach far away and then smaller pipes for distribution. Finding space to bury them underground is a major challenge, especially in urban environments. That is one of the limitations of heat networks.

JG Could they be placed above ground if necessary?

JB Technically possible, but then it becomes more a question of urban design.

JG About heat storage: is it possible to store heat and are there different ways to do it?

JB Hot water mainly. It depends on the heat demand and the available space and then there are tools to determine whether or not it is beneficial to include storage in the system or just cover the demand with dispatchable plants producing heat. I still think it is quite important, because it is a way to link heat and electricity demand, for example with CHP (Combined Heat and Power). That means that this way we follow electricity demand and pay less attention to heat demand if the thermal storage is big enough.

JG I thought CHP is used mainly in combination with fossil power plants?

JB No, you could also use it with biomass, hydrogen or other e-fuels, though.

JG Is heat storage more important than electricity storage?

JB Today it is more important because it is easier and cheaper of course. It would be great to store electricity in the longer term, but unfortunately that doesn't exist. So it's not that it's more important per se, but the technical possibility already exists.

JG Is that already being done in Brussels?

JB I think everyone has a small form of thermal storage at home, so the water heater is not always starting up. At the district level, it exists together with biomass, for example. Because a biomass boiler cannot

just start up in an instant. It is also not ideal in terms of particulate emissions. It is much better for efficiency and emissions that the boiler runs continuously. So if a boiler has to run eight hours a day to provide the intended amount of heat, it is better to do it all at once. Then there is often a biomass boiler plus thermal storage to ensure that the operation of the boiler remains optimal. Now for the gas boiler it's not really necessary, because there are limited emissions anyway, and it is more flexible.

JG Could large-scale storage where water is heated also help to absorb electricity peaks?

JB Yes, for example if you use electricity to produce heat with a heat pump. A heat pump could well run during the day to produce hot water, which could be captured in thermal storage and then later [in the evening and night], provide the hot water. So thermal storage could indeed give flexibility for the electric grid.

JG And is that being done in practice?

JB Not yet, because there is no incentive for flexibility today. The price of electricity is not yet variable enough for residents today to justify such an investment. We are studying it on a neighbourhood level, just to see how good the potential is. Nobody has an answer to that yet. The question is also, should the thermal storage be large enough to heat buildings or is it just about domestic water, for example. It's also a question of the duration of storage. A year seems technically possible to me, but relative to size and area, may not be a good idea.

JG Because we talk about electricity, but about a third of energy is not electric, isn't it?

JB If you are optimistic, you can just say: it is technically possible to divide the heat demand of buildings by three on average in Brussels. That's Renolution's target [the government's renovation strategy], so from 300 kwh per year per square metre to a third of it. Whether that's possible or not, I don't know, but let's suppose it is. Then if everyone uses a heat pump with a COP value of 3, you can divide the energy

demand by nine. That's quite interesting. That would mean that nine kilowatt hours of gas becomes only one kilowatt hour of electricity. So the additional burden on the electricity grid is not that big. But that assumption that everyone can insulate a house in an efficient way and everyone has a heat pump with a COP of 3 or better is a strong assumption, I think. So indeed, heat is the Elephant in the room. That is a very big challenge. That was also apparent during workshops at Sibelga [Brussels' energy network operator] several times. Replacing natural gas to produce heat in Brussels is a huge challenge.

JG What are the differences regarding the typology of the buildings, for example. Comparing a typical historic building within a block with a tall modern tower for instance?

JB The difference is usually less heat demand in winter but still more cold demand in summer from the towers. That can often be solved using heat pumps with a geothermal source. With those large buildings, the private sector often has the means to maintain and renovate them which citizens living in old houses often don't have. In the North Quarter in Brussels, we are now thinking of a low-temperature network for the towers and a high-temperature network at least for the next 15, 20 years with residual heat from waste incineration as source. That is also an incentive for the private sector to invest in a heat network, if they know that a public infrastructure will serve as a backup, for example. And then you can foresee an evolution [in switching to one low-temperature network for all].

JG How can I analyse my study area to see how the profiles balance in each other?

JB You have to look at the curves. If you look at a district with a lot of households next to a district with a lot of offices, then obviously we have to build a big grid, build a system for everyone, thereby combining those two user curves will give a flatter final consumption. That will be an advantageous option.

16.12.2023, Brussels



2 Brussels

There is a strong belief in Belgian planning culture in the *maakbaarheid* of the city: the idea that urban environments can be deliberately designed, shaped and managed to achieve desirable socio-spatial outcomes. Rapid industrialisation and overcrowded cities confronted Belgian society in the early 19th century with fundamental social questions about decent living and maintaining social cohesion. At the centre of the turmoil, Brussels provided fertile ground for ideologues from across the political spectrum to implement utopian schemes.¹ In addition to the recognition of the international architectural community, a tendency towards top-down planning, driven by political vanity and speculation, is part of the legacy of these possibilist interventions. The post-war migration of the middle class to the suburbs left the working class struggling against a paternalistic government.

Brussels' ability to radically alter the urban fabric under the guise of progress has often been a story of power struggles between poorer citizens and visionary authorities. In the case of the Marolles, the people emerged victorious, at least partially saving the iconic district from destruction, while the North Quarter drew the short end of the stick (Maartens, 2009). The Leopold Quarter, once a wealthy district in the 19th century and later a working-class neighbourhood, faced the same fate and gradually had to make way for the new administrative district.² When the EU decided to locate its parliament in the Belgian capital, there was already a large, newly built 'conference centre' with a plenary hall ready for use (Hein, 2000).

While today's context is different, with planning frameworks that would make a Manhattan Plan 2.0 unthinkable, the city has nonetheless demonstrated its ability to take drastic action by transforming its central four-lane road into one of Europe's largest pedestrian zones. As climate change becomes a more pressing issue, it could be used to justify other radical changes. Something that is already being done on a smaller scale by private developers, as we will discuss in Chapter 4.

Brussels is aiming to become one of Europe's innovating cities when it comes to the energy transition. Bruxelles Environnement, the city's environmental agency is focusing on district-specific living labs and community energy projects, especially in social housing to tackle energy

1 Examples: the Cité Hellelmanns, Marolles as 19th century social housing. Garden Cities such as Le Logis Floréal, Het Rad, Tuinwijk Tuinbouw or Bon Air, in line with traditional family values. The Modelwijk Laeken, socialist high rise housing in the spirit of CIAM. The North Quarter as a libertarian utopia inspired by American Business Districts. The Leopold Quarter representing the neo-liberal era.

2 The resulting lack of an architectural identity of the European Quarter is explored Bert de Muynck in his essay 'Whatever Happened to Ground Euro?'. Stedelijk Studies Journal 6 (2018). DOI: 10.54533/StedStud.vol006.art03. CC BY 4.0

→ Map showing former residential districts that had to make way for visionary urban plans and speculative schemes. Only the Marolles have avoided a total demolition.

poverty. Living labs are being used as a main axis of research, involving citizens in the creation and testing of energy solutions. This approach helps to ensure that the solutions are practical and accepted by the community. The agency is also aware of the need for better financial incentives to support the energy transition. There are efforts to create financial incentives and ensure the legal framework supports the development of PEDs (Martine Mvengou, Bruxelles Environnement, personal communication, 2024).

Brussels also plays a role in some of the international research on Positive Energy Districts. For example, one joint initiative was launched in 2021 with projects in Vienna and Stockholm to explore and share knowledge on the implementation of Positive Energy Districts (Cities4PEDs, 2021). The idea being, their experience should help other cities in the future to create their own PEDs and inform policy makers to improve EU energy legislation. The pilot districts Royal Seaport in Stockholm and Aspern Seestadt in Vienna were already under development at the time. Both are new developments with little or no retrofitting. Aspern Seestadt in Vienna, for example, is a new town built on a former airfield. The Stockholm PED pilot, as the name suggests, is being developed on a former industrial site that will be transformed into a mixed-use residential neighbourhood.

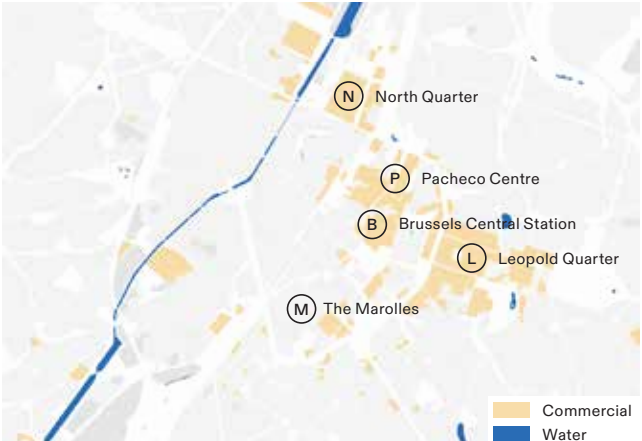
BRUSSELS NORTH

The first PED candidate of Brussels is the North Quarter — an outlier in many regards compared to its European counterparts. Of the three cases, Brussels North is the only one to emerge from an existing neighbourhood and is still in the research phase, far from realisation. This is perhaps not surprising, as new construction allows for a more centralised planning approach with less complex ownership structures. Building from scratch with property developers makes it easier to achieve the high energy performance that Positive Energy Districts require. Nestled between the massive infrastructure of North Station on one side and the Albert Canal on the other, the neighbourhood is an ensemble of high-rise office towers on one side and 19th-century working-class quarters on the other. In the 1960s, most of the existing urban fabric was razed to the ground as part of



↑ Rendered drawing of the Manhattan Plan

↓ Brusselisation, in which, at the urging of property developers and politicians, everything had to give way to what was called modern architecture. Image © C.I.I.I.IV.A. Brussels (2019, June 20). Save | Change the City – Unbuilt Brussels #01. Retrieved July 29, 2024, from <https://civa.brussels/en/exhibitions-events/save-change-city-unbuilt-brussels-01>



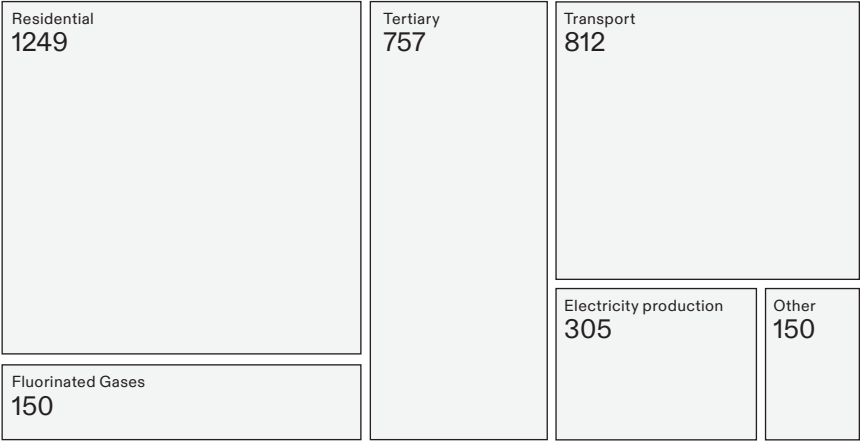
Map data: OpenStreetMap contributors, 2024. Processed by the author

the Manhattan Plan, a masterplan to create an American-style downtown business district adjacent to the city's North Station. Thousands of residents were evicted and some relocated to new high-rise public housing on the outskirts of Brussels, fundamentally disrupting the social fabric.

This disruption is still felt today as the neighbourhood struggles with public safety, livability and quality of public space (Maartens, 2009). Plagued by high vacancy rates, the owners of the office monoliths launched Up4North, a campaign to revitalise the neighbourhood. After the 2019 elections, the regional government wanted to push ahead with its new digital strategy and saw an opportunity in the North Quarter. The Positive Energy District project would combine the digital strategy with urban regeneration under an environmental agenda (Cities4PEDs, 2021). It is not an uncontroversial issue, as the current scheme includes the construction of new high-rise office buildings around the North Station. Neighbourhood organisations are fretting about a Manhattan 2.0.³

BRUSSELS PREPARES FOR CLIMATE NEUTRALITY

Initiatives such as the PED project in the North Quarter are part of an overarching strategy to make the city fit for the future. And as global average temperatures continue to rise, Brussels must step up its efforts to reduce emissions. The latest Air-Climate-Energy Plan ambitiously revises the greenhouse gas reduction target to a 47% reduction compared to 2005 levels, surpassing the previous 40% target. It aims to achieve carbon neutrality by 2050, while also planning to adapt to the inevitable impacts of climate change. This calls for increasing urban resilience through improved soil permeability, comprehensive stormwater management and an increase in green spaces. In 2021, 3518 kilotonnes of CO₂ equivalent were emitted within the borders of the Brussels Region. Residential buildings account for 57% of these emissions, the vast majority of which are related to indoor heating. Brussels' tertiary sector and motorised transport are the next two largest emitters, but fluorinated gases, a refrigerant used in refrigeration and air conditioning, also account for a significant proportion of greenhouse gas emissions (Brussels Environment, 2023). However, per capita emissions

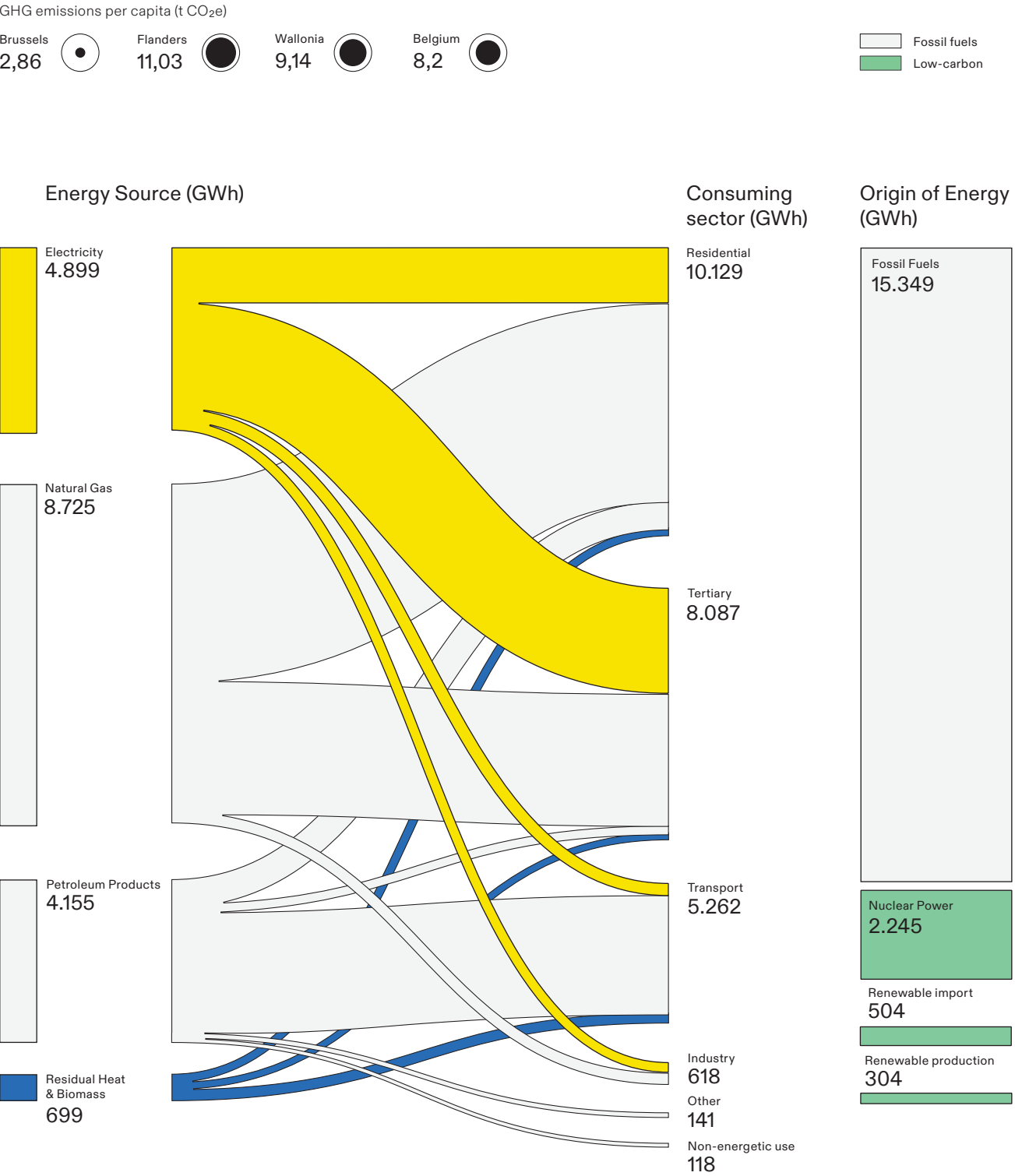


3 Disposable architecture and diversionary maneuvers: fears of gentrification in Noordwijk have not gone away. *Wegwerparchitectuur en afleidingsmanoeuvres: vrees voor gentrificatie Noordwijk niet weg.* (2023, December). BRUZZ. Retrieved July 29, 2024, from <https://www.bruzz.be/stedenbouw/wegwerparchitectuur-en-afleidingsmanoeuvres-vrees-voor-gentrificatie-noordwijk-niet-weg>

Sector GHG emissions
kilotons CO₂ equivalent

Brussels Environment. (2023b). Direct emissions of GHG (without fluorinated gasses) in the Brussels-Capital Region [Dataset]. https://leefmilieu.brussels/sites/default/files/DATA_EE23_climat_EmisGES_evol_nlfr.xlsx

Brussels Energy, 2021

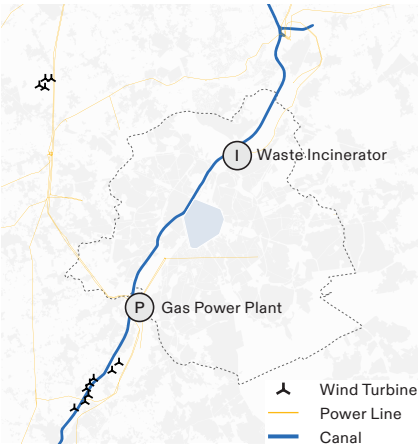


Greenhouse gas emissions. (2023). Federal Planning Bureau. Retrieved July 29, 2024, from https://www.indicators.be/en/i/G13_GHG/Greenhouse_gas_emissions_%28i62%29
Brussels Environment. (2023a). Brussels energy balance between 1990 and 2021 [Dataset].
Energie: stand van zaken. (n.d.). Leefmilieu Brussel. Retrieved July 29, 2024, from <https://leefmilieu.brussels/pro/tools-en-data/het-milieu-stand-van-zaken/energie-stand-van-zaken#prognoses-van-het-energieverbruik-tegen-2040>

in Brussels are relatively low compared to the rest of Belgium, with 2.86 tonnes of CO₂ equivalents versus 11 and 9.1 tonnes of CO₂e in Flanders and Wallonia respectively. However, this only takes into account emissions generated within the regional borders and does not take into account commuting. Brussels is a net importer of energy and Belgium also has a negative trade balance in terms of GHG emissions, which means that the above statistics give an incomplete picture.

Athanassiadis et al. (2017) found a significant increase in the consumption of electricity, natural gas and water in the Brussels-Capital Region between 1970 and 2010, disproportionate to the population growth, indicating a transformative change in urban consumption behaviour and its subsequent environmental impact. Despite a continuously growing population, energy consumption peaked in 2004 and has been declining since then³, suggesting that emissions and growth have been partially decoupled or externalised. The Brussels-Capital Region's annual primary energy consumption in 2021 was 18,405 GWh, similar to that of Vienna⁴ and equivalent to that of the country of Mauritania⁵ or keeping the lights on the Las Vegas Strip on for two days.⁶ Brussels' Environment Agency expects overall energy consumption to continue to fall. In line with efforts to electrify the transport and residential sectors, electricity consumption is expected to increase slightly.

The use of primary energy, the total energy expended before conversion into other forms, as a metric is not without its problems. Critics of the energy transition and fossil fuel lobbyists often use this metric to dissuade policymakers from committing to renewable energy. The amount of primary energy used from fossil fuels may seem impossible to fully replace with renewable electricity. In the case of Brussels, only 1.6% of primary energy demand is currently met by domestic renewable production, and only 4.4% by renewables including imports. Filling the remaining 93.6% within a decade or two seems absolutely impossible - except that it probably won't be necessary. Electric processes have a higher efficiency factor, so the switch from internal combustion has the potential to significantly reduce primary energy demand. Analyst and clean energy advocate Michael Liebreich calls this the "primary energy fallacy" and uses the example of an incandescent light bulb: If you lit your hallway with a



← Map showing the large scale energy infrastructures in and around Brussels. The city is currently relying on energy imports for the majority of its demand. The question remains how high the potential will be of energy produced within the city itself and how much will have to be imported from outside.

3 Energie: stand van zaken. (n.d.). Leefmilieu Brussel. Retrieved July 29, 2024, from <https://leefmilieu.brussels/pro/tools-en-data/het-milieu-stand-van-zaken/energie-stand-van-zaken#prog-noses-van-het-energieverbruik-tegen-2040>

4 Illustrated nicely with a comprehensive Sankey diagram by their energy planning department *Energieflussbild der Stadt Wien*. (n.d.). Stadt Wien Energieplanung. Retrieved July 29, 2024, from <http://ma20.23degrees.io/#/sankey/00%20via%20Stadt%20Wien>

5 Mauretania's primary energy consumption in 2021 was 18 TWh. *Primary energy consumption*. (2023, August 1). Our World in Data. <https://ourworldindata.org/grapher/primary-energy-cons>

6 The Las Vegas Strip consumes approximately 8,000 megawatts of electricity daily, incurring expenses that can reach up to 1.200.000 dollars every day of the year. *This is what it costs to light 7 of the brightest landmarks in the world for a year*. (2017, July 26). Business Insider. Retrieved July 29, 2024, from <https://www.businessinsider.com/the-cost-of-lighting-landmarks-around-the-world-2017-7?r=US&IR=T#las-vegas-strip-3504-million-7>

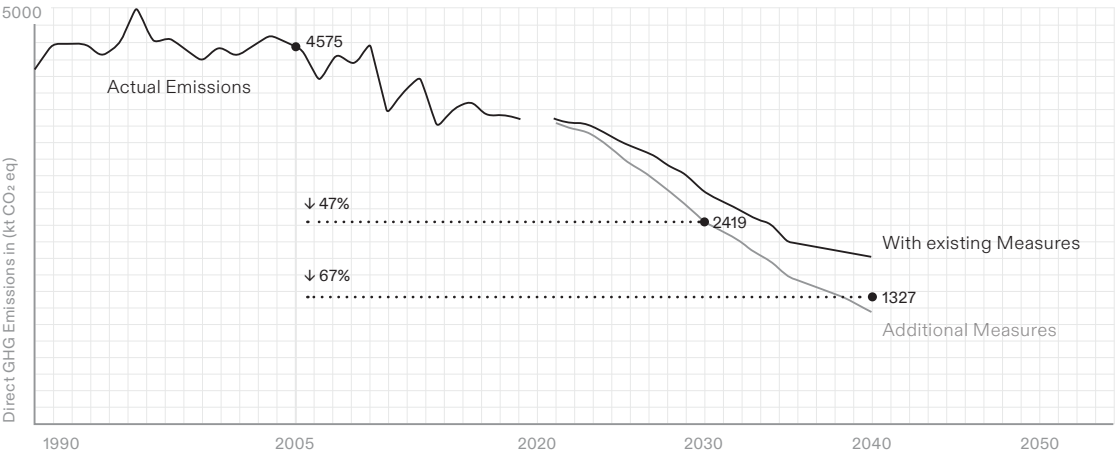


↑ The first nuclear reactor in Mol, Belgium was originally supposed to be built on the Heysel Plateau in Brussels where the atom-themed world Expo '58 was hosted, according to archive material shown at the exhibition POWER at CIVA Brussels (Franceschini et al., 2023). With a capacity of 11,5 MW, it would have produced about 100 GWh annually, 5 times more than Brussels' total energy demand today. Image: Post card Mol, geneanet.org/cartes-postales/view/5462503#0 CC BY-NC-SA 2.0

75-watt incandescent bulb using electricity from a coal-fired power plant with 35% efficiency and 10% grid losses, you would create a primary energy demand of 476 kWh (assuming 2000 hours per year). However, a 10W LED would be able to provide the same amount of light using just 22 kWh, and using hydroelectric power, for example, would result in a 95% reduction in primary energy demand.⁷

In fact, this is one of the main objectives of the Brussels Environment Agency's Renovation renovation programme. At present, the vast majority of energy demand in the residential sector comes from domestic heating. It is hoped that renovating buildings to a higher energy performance level will reduce demand by a factor of three, and that switching to electric heating sources such as heat pumps will reduce demand by a further factor of three (J. Blondeau, 2023, interview). There is no guarantee, however, that this will happen. Behavioural changes and rebound effects (see also Section VI) remain a major source of uncertainty, which could throw a spanner in the works.

Apart from a waste incineration plant, Brussels has no power plants on its own territory. A gas power plant is located in Drogenbos, just outside the city limits. The production capacity of renewable energy in Brussels has increased significantly since 2010, but at 304 GWh it can only cover a fraction of Brussels' energy needs. As the territory of the Brussels Region is limited (and with it the potential for renewable energy), many of the policies of the Air-Climate-Energy Plan 2023 focus on reducing the energy intensity of housing, workplaces and industry. Heating Brussels' century-old housing stock accounts for almost three-quarters of residential energy demand. In the texts of this legislation (Brussels Metropolitan Government, 2023), the term *Energiezeven* appears time and again, a word that is intended to evoke the image of a dilapidated house with single-glazed windows, without any insulation and leaking heat like a sieve. The new plan aims to exploit the enormous potential for savings in the building stock. It foresees the phased introduction of mandatory energy certification, with the worst performers gradually being banned. This policy is controversial because it places most of the financial burden on individual households. And the limited budget for cash bonuses paid to reimburse some energetic overhauls benefit the better-off who



7 BloombergNEF. (2024, February 23). Liebreich: Net zero will be harder than you think – and easier. Part II: easier | BloombergNEF. BloombergNEF. Retrieved July 30, 2024, from <https://about.bnef.com/blog/liebreich-net-zero-will-be-harder-than-you-think-and-easier-part-ii-easier/>

↓ Past and projected GHG emissions of the Brussels Region. Some experts we spoke to questioned the transparency of these numbers.

Adopted from: *Uitstoot van broeikasgassen zal naar verwachting aanzienlijk dalen*. (2023). Brussels Environment. Retrieved July 12, 2024, from <https://leefmilieu.brussels/burgers/tools-en-data/het-milieu-stand-van-zaken/klimaat-stand-van-zaken>

can afford initial downpayments.⁸ One of the main points of criticism is that, although it does not cost the public authorities anything to mandate high energy performance, it asks citizens to make financial investments that even local governments themselves cannot afford for their owned buildings (Interview, M. Chapurlat, 2024).

Architectural heritage and financial hardship have to be met with consideration, because the inhabitants of Brussels are as diverse as its built environment. Despite its large number of underprivileged inhabitants, Brussels has a low proportion of social housing, which means that more and more households have to make concessions in terms of the comfort, size or location of their homes. The housing market in Brussels thus acts as a “social filter” (Dessouroux et al. 2019:27). The resulting spatial income disparity in Brussels is often described as the *croissant pauvre*, referring to the crescent-shaped concentration of disadvantaged households in the north and west of Brussels.

The challenge is already significant in technical terms, as the region currently relies on imported fossil fuels for most of its energy needs. Putting solar panels on rooftops and building more cycle paths are just the lowest-hanging fruit, effective short-term measures but insufficient in the longer term. The deep transition needed to slash emissions will require an unprecedented effort, and the slower the initial response, the more drastic the interventions needed later. At the time of writing, the North District's PED project has lost momentum due to "local indecision" (Interview H. Mangelschots, 2024).

There is general agreement that the transition away from fossil fuels must be just and equitable, as reflected in the Brussels Climate Plan. But with time running out, the energy transition may face the same pitfalls as many - well-intentioned but ultimately destructive - urban renewal schemes in post-war Brussels, discussed earlier in this chapter. It is unlikely that Brussels will ever be energy self-sufficient, so the transition will be a matter of balancing renewable energy production and demand reduction, while ensuring that no one is left behind.

How useful is the PED model for Brussel's underprivileged neighbourhoods? And what infrastructure would be necessary to boost the use of renewable energy while ensuring social inclusiveness?

8 Receiving the bonus payment can also not be relied on, as payments are halted once the annual budget limit is reached. Brussel schort uitbetaling Renolotion-premies op tot 2025: "Budget is opgebruikt." (2024, July 25). BRUZZ. <https://www.bruzz.be/actua/stedenbouw/brussel-schort-uitbetaling-renolotion-premies-op-tot-2025-budget-opgebruikt-2024>



“A city like Brussels will always have to import energy using different energy vectors.”

District Level Dynamics: How to direct the Energy Shift

Hanne Mangelschots is an architect-engineer at Architecture Workroom Brussels (AWB) and co-author of “Powering the Energy Transition at the District Level — A Practical Guide for Local Initiators” published in 2023.

JG Jonas Görden
HM Hanne Mangelschots

JG What exactly is Architecture Workroom Brussels and what's your role regarding the urban energy transition?

HM We call ourselves an independent innovation hub, we initiate and develop project coalitions, working on long-term societal challenges. So, unlike classic consultants who just work on behalf of a municipal council, we proactively engage with them to see who we can work with, including private developers, neighborhood organizations, etc. We also do a lot of projects on the European level. These are part of innovation budgets, subsidies or sometimes we can co-finance them.

JG Why did you decide to focus specifically on Positive Energy Districts (PEDs)?

HM We see that the energy transition is very high on the social agenda. It's a matter of our built environment and will impact the way buildings and even our streets are designed. We also see that we cannot solve this as architects alone, nor can the municipalities or private owners solve it alone, so it requires an integrated approach. That is why we believe in the district as the right scale, not to solve everything, but as a level to interact with the energy transition, especially regarding Positive Energy Districts. According to us, all districts should aspire to be PEDs, not necessarily to produce more energy than they consume – even the most ambitious projects struggle with that – but to engage with renewable energy and sustainability. We had a lot of internal discussions around the "energy positive" definition.

JG There is a whole bunch of different definitions in the literature.

HM You could say in this publication we have created yet another definition, but in

fact one that says: let's stop with talking about definitions and let's talk about what clearly needs to be done. We all have to produce more renewable energy, so let's make a vision so that the budgets that are made up can be used in a better way for the communities that need them most and new housing that's not per se for the upper class, which is today still rather an exception.

JG How do you see Brussels in the European context, can it serve as a pilot city for PEDs?

HM It is very hard to compare, because in Brussels we have immediately chosen one of the most difficult neighborhoods. But in terms of innovative collaborations, we saw that also in places like Vienna it is not a given. Perhaps Brussels is indeed a pilot city because it dares and takes a leap. On the other hand, we have been stuck in the North Quarter because there is very little decisiveness on the ground.

JG Is there a mismatch between the vision of the Brussels region and private developers?

HM Brussels has the ambition to create a Positive Energy District, but at the same time there are no tools at all to create 40 of them. But it's not only Brussels who's failing in this, other municipalities also have no approach to make individual homes more sustainable at an accelerated pace on a neighborhood scale. It simply doesn't exist.

A very concrete discussion that we are having in the neighbourhoods where we work, is to make choices for a collective approach. In the cities and at the regional level, there are energy consultants that provide individual renovation advice to families – there are all kinds of systems for this and they are all financed per advice they provide. So it's all based on individual logic. Our subsidy and premium systems are based on individual households, banks give

individual loans, permits are issued on an individual basis. But we see that we are channelling all our subsidies to the middle class, who, for example, have the starting capital to install solar panels or to insulate, etc. and that we are not actually investing our public money on that group of residents who do not or cannot take action. So what we are exploring and testing is, can we do all of this in a more collective way? Could we install heat pumps on a football field or under a street so that we could, for example, create a collective geothermal energy storage there? Can we offer a renovation package to a whole street? So as a municipality you can participate in various degrees of radical experimentation. Perhaps also the region, because you will have to deviate from certain legal frameworks. Public domain may not simply be used for private investment or even for public investment, even if the municipality were to do the drillings themselves [for a ground source heat pump system], that does not currently exist. That is a first degree of experimentation. But we also notice that strong positions – for example by saying in 2030 there will be no more gas in this neighborhood – can really set things in motion. Because then people know they shouldn't install new gas boilers now, and have time to find a solution on their own within those six years.

JG I see mainly three challenges regarding PEDs: the technical challenge, the spatial limits and the social dimension. The tech issue seems to be solved by now, but social equity and acceptance has barely been touched yet. Do you agree?

HM The social aspect also has different dimensions, right? So on the one hand there's how do you make it inclusive and how do you ensure that not only the well-off can afford it or also understand it or have the time for it, that kind of thing. But for example – and that's also something we saw in Stockholm – even in a middle-class neighborhood, newly built and with all the technology, those buildings often are not used in the right way and therefore score seriously below how they are modelled [in terms of energy performance]. So that's also part of the social issue: we're not going to solve the transition just by making

smarter buildings with the right technologies. It will also require that we use them in a different way, that we adjust certain rhythms or even go back to how we used to do it decades ago. So this aspect of the social is not just that we ensure that we include vulnerable groups, but it is for all of us, it will require a change in our behavior.

I find it interesting how you draw the different domains. The way we sometimes tell it is with five domains and from the premise that we have to innovate on those five at the same time. We group the technical and spatial dimensions together, because that is actually still very typical for architects. We also talk about the social issue, that's certainly a very important one, the financial, the organizational and that of policy. These are also social issues, but at those different levels you see that at the same time, steps are needed that are different there, that each play a different role.

JG What puzzles me is that renovation stands at the base of energy policy. But as you mentioned, renovation generally yields less than expected because of rebound effects.

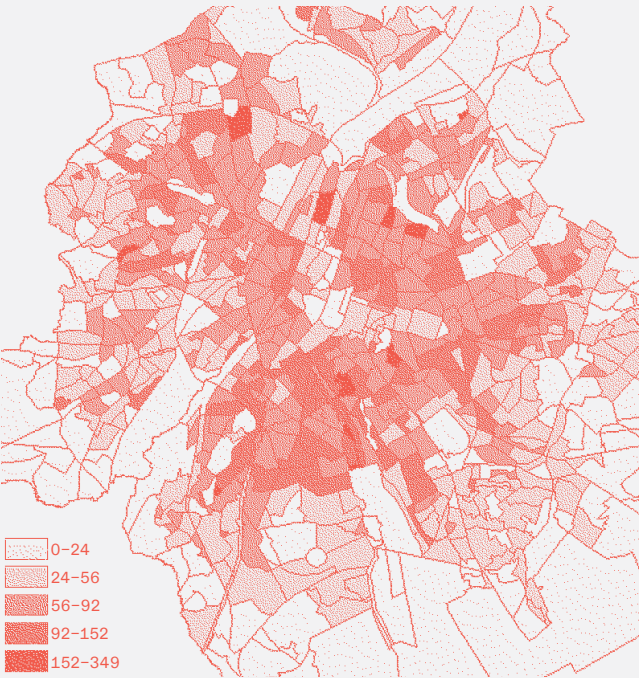
HM That's a really difficult question that also has a very destabilizing effect, because the easiest thing is to say that the energy performance level must go to A. That's already hard enough to get together in the first place. And whilst we're trying to do that, we're also asking that question about the usefulness of efficiency. That in itself is super interesting and there are also a lot of interesting research projects, about what they call 'Slow Heat'. Asking what if we don't have to heat to 19 or 20 degrees, but that we have 14 or 15 degrees. So that our buildings don't succumb to moisture, and we just wear more clothes, or for example, we make a kind of refuge room, one room that we heat and other rooms that we keep around 14 degrees. Those are of course completely different concepts.

JG But this is actually a disquieting realization that on the one hand there is a consensus that renovation is part of the solution and the government's plans are to get all homes to grade A. But this won't be enough to yield the results that we expect?

HM Certainly from the moment that we start including lifecycle analyses, then we are actually now emitting a lot of greenhouse gasses just to renovate those buildings. That is one side of the story. While on the other hand we see, for example, when we talk to financiers there also is the question: how much do we really have to renovate here? Can't we just replace the installation with a high-temperature heat pump, then we don't even need to insulate anymore. But then you need much more electricity to run this heat pump. So again, more technology: where does it come from? where do those raw materials come from? How do we ensure that everyone can participate and not just the people who can afford it? That's a completely different approach and that's because it's actually very difficult to develop a business model or a payback model for that renovation. But that's per-

Residential heat demand in GWh/km²

Adopted from Lempereur et al. (2021), p. 26, Figure 2: Density of residential sector's demand for heating by statistical sector (GWh/km²)



haps the wrong question, because we have to make profit on this energy transition, whilst there are also other advantages associated with renovation. Certainly for those people for whom the fifteen degrees inside is already a reality. Renovation for them is an enormous increase in comfort. How do you make it that the energy is actually seen as a social transition that is about, how do we reduce the gap that is there now, the economic gap that exists in society. So yes, I think that is very destabilizing if your mission is to build and renovate collectively, if it then turns out that the very reason why you are doing it, namely CO2 reduction, this is not a solution. Where do you set the bar then?

JG Looking at this map of residential heat demand in Brussels, what I find interesting is that it does not correspond, at least not exactly, with the [distribution of] income and population density. Because you could assume that, if people lived closer together, the energy consumption will automatically be higher. It is very difficult to draw conclusions from this [map], but I think that the fact that it does not fully correspond with population density does support the fact that many people on small incomes do pay a lot of attention to how much they use.

HM But those also often live in the least insulated homes, which automatically have high heat losses. So it's super difficult to deduce whether it is actually warm [indoors] based on consumption. [It would be interesting] to make a mapping by combining different statistics to measure energy poverty, to be able to say: okay, now it's not just about an average user who wants to be nice and warm in his armchair, but that it's about a building that is poorly insulated, where people are now paying very close attention to their bill, but are losing a lot of heat. Because if we keep telling a story that is about we have to consume less and less and less, that still applies, but that is not necessarily true for everyone. So maybe some people will use more energy, and that may also be fair, because that is also about quality of life.

JG Perhaps we also have to get rid of our generalised view that there is one standard indoor temperature between 19 and 20 degrees, as defined by the World Health Organisation. For me personally, that would be hell. Heat is a very subjective thing. Is there perhaps also a way to look more at individual needs?

HM I am thinking of different aspects here. Certainly with energy labels, there is a very standardised way of looking at heat guaranteed. Impacting policies, obligations, net worth of homes, while that does not take into account Low-tech solutions. What I found interesting from the research around Slow Heat, is that they also observed that heat is pleasant if you look at it dynamically. So if you are cold outside and come from there into a warm space, then 18 degrees is lovely. But this is the way we are used to it now, of always living at the same temperature. But the pleasant thing about heat is the contrast with the cold. You should not hold that against someone who cannot get their house to a certain temperature, but it is about the perception we as a society have about what the minimum requirements are. It is quite remarkable that the WHO makes a statement about that. Not remarkable though if you look at it as protection for people, but remarkable if we find that normal, that we live in houses of a few 100 square meters and that all has to be at 20 degrees.

JG So one conclusion could be that the effect of renovation will be very different depending on the type of population you have. And if there are many people living in poorly insulated buildings on a low income, who are already living on the minimum, then renovation is more of a comfort-enhancing mechanism than necessarily an energy-saving one.

HM There are also very few, certainly larger-scale neighbourhoods that are monitored in terms of consumption. So the neighbourhoods that are well monitored are the new-build neighbourhoods, but you cannot compare them with previous consumption. So in those existing neighbourhoods, there are so few or on such a small scale, that those kinds of conclusions do not actually

exist yet. So that is again, just like the question of how far we should respond, very destabilising.

JG It is of course not meant as an argument against renovation in itself, because renovation is also a broad spectrum. But what I meant is rather about the expectations that we have. If you have a neighbourhood with a low income you may end up with a higher energy consumption in the long term.

HM Yes, that could partly be the case. I would be curious if you put that into a broader perspective, you'd effectively had a higher consumption or if then a number of things neutralise themselves a bit. The difference is of course that now people use [fossil] gas, and afterwards hopefully use renewable energy for heating such as heat pumps. So if you can also increase the quality of living in the neighbourhood with that, then maybe that is still the best way.

3 Cureghem

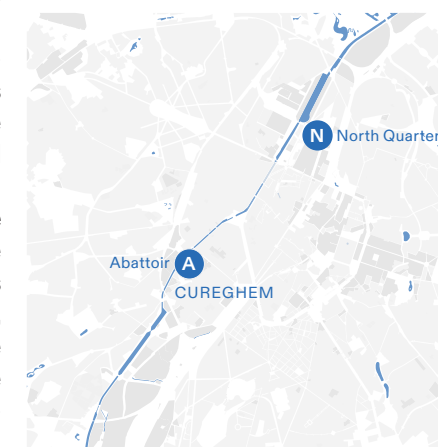


While the North Quarter is the largest and most ambitious PED experiment in Brussels to date, another project has been developing somewhat under the radar, and could be even more promising. A two-year research project, also with Swedish and Austrian partners, investigated the potential of a Positive Energy District on a site in the Cureghem district, south of the pentagonal city centre. Supported by Cosmopolis, the Centre for Urban Research of the Vrije Universiteit Brussel, as a local research partner, the Trans-PED project studied the case of the Abattoir site, a large fresh market and meat-processing plant located in one of the most diverse neighbourhoods of Brussels. This is another unusual site compared to the streamlined PED projects in Vienna or Stockholm. At the heart of the Abattoir site, as the name suggests, is a meat processing facility where animals are today still slaughtered and processed for wholesalers and butchers.¹ At weekends, the site is also home to the largest fresh market in Brussels, which attracts customers from far beyond the city limits thanks to its bargain deals on produce, meat and fish.

In 2011, a master plan for the site was drawn up on the private initiative of the abattoir company, which owns and manages most of the buildings and the site. The plan would densify and reorganise activities on the vast grounds, while opening it up to the neighbourhood on all sides. Wasteful surface car parks would become underground garages to make way for a mix of buildings and new green spaces. Implementation began with the construction of FoodMet, which houses a new permanent indoor market, space for food-related start-ups and an urban farm on its roof. Other planned buildings will increase the mix of functions on the site by housing productive facilities alongside student accommodation and apartments.

Energy is a central element of the Abattoir's site strategy and the subject of the Trans-PED research project. Over the past decade, the company has installed large amounts of photovoltaic solar panels on its buildings and, as of 2020, on the curved roof of the iconic market hall, making the Abattoir one of the largest producers of solar energy in the Brussels Capital Region. Getting the green light from the city's heritage department was not easy, recalls Jo Huygh, director of the urban sustainability agency DUSS-explorers and shareholder of Abattoir SA (personal

¹ The slaughter of animals in Brussels has become increasingly controversial. Especially since both Flanders and Wallonia have banned the slaughter of unanaesthetised animals, a religious practice that is still carried out at the abattoir. The Brussels Times. (2024). Retrieved July 31, 2024, from <https://www.brusselstimes.com/961431/enough-unnecessary-animal-suffering-brussels-sued-for-allowing-unanaesthetised-slaughter>



communication, 2024). Recognising that heritage preservation could not remain at odds with sustainability improvements, the authorities finally agreed to a design with discreetly coloured, flat solar cells².

As an economic no-brainer, PV installations are one of the lowest-hanging fruits of the energy transition. But more effort will be needed to tackle the energy-hungry heating and cooling processes that take place in the "belly of Brussels" (TransPED, 2023). The problem here is also part of the solution: excess heat and cold are ubiquitous in the various functions on the site, but capturing the energy left over and putting it to better use will require a new kind of infrastructure. A network of pipes is planned to distribute heat and cold across the site and eventually to homes. The latest project in the pipeline, called Manufacture, a new production hall for food-related SMEs, will be the first piece of the jigsaw. Further down the line, a public outdoor swimming pool on the roof could complement this strategy, as the large body of water can act to some extent as a thermal battery. This future heat network has the potential to become the foundation of a Positive Energy District in Cureghem.

In addition to its iconic architecture and bustling weekend markets, the abattoir fulfils other important functions for the neighbourhood. As a neighbourhood of arrival, where newcomers look for accessible jobs, many find work in the 'old' industries of meatpacking, the fresh market, the car trade or metalworking (Orban et al., 2021). The economic mastodons such as the Abattoir feed larger ecosystems of business activities that provide employment and cultural identity. Beyond its economic relevance, the site also hosts a wealth of cultural programmes, with the NGO *Cultureghem* playing a leading role. Adapted to the dynamic spatial uses of the Abattoir site, the organisation uses highly mobile equipment for its social interventions when the market halls are empty: public cooking with market leftovers acts as a social glue, and its temporary playgrounds in the shade of the historic hall provide an outlet for children in a neighbourhood where open space is scarce.

According to William Febiri, project manager at *Cultureghem* (personal communication, 20-24), their embeddedness in the social fabric has made them a sought-after partner for public participation and research projects. Febiri emphasises that meaningful citizen participation in urban development requires consistent engagement, something that *Cultureghem* has pursued despite shortcomings in government efforts. To this end, the non-profit organisation focuses on creating and activating spaces for the community. They aim to provide quality spaces for children and residents to engage in various activities, making the neighbourhood more vibrant and inclusive. The organisation relies heavily on volunteers, with over 150 volunteers involved. They also run projects where volunteers can initiate their own projects with support from

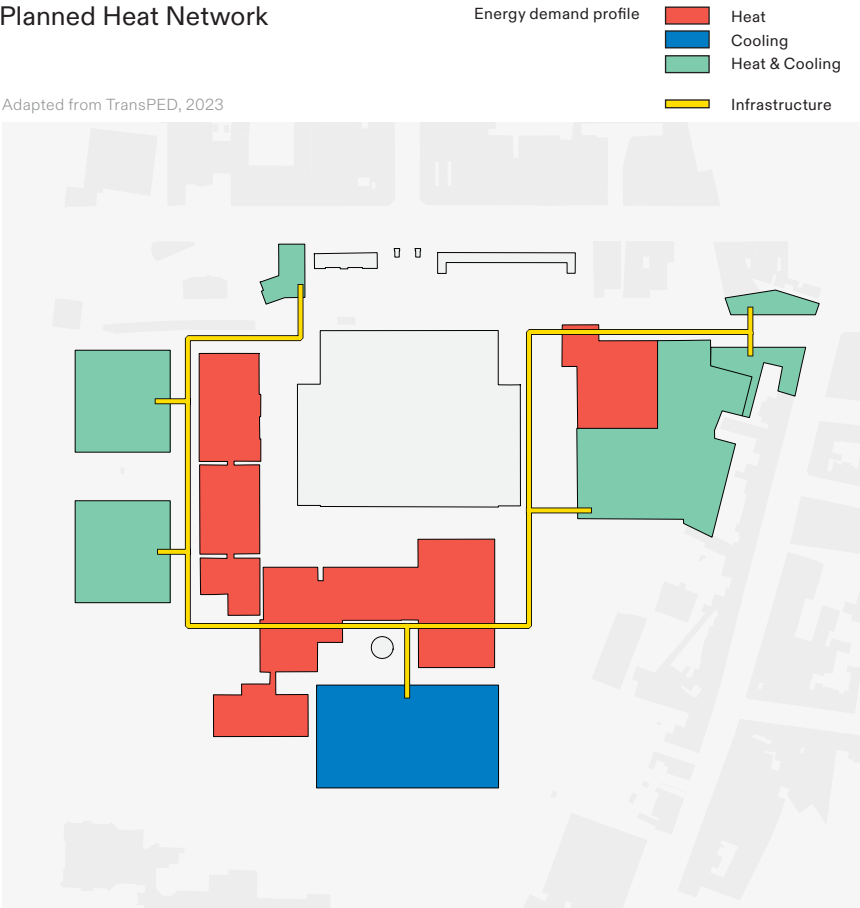


2 The massive solar roof was realised through a shared investment model of third parties and crowdfunders. Anodised aluminium solar panels were used to recreate the aesthetics of zinc, originally used for the roofing. ZincLike : The impossible roof. Accessed March 15, 2024, from <https://www.zincline.be/>

3 About us. Cultureghem. Retrieved March 15, 2024, from <https://cultureghem.be/en/about/>

↓ Solar photovoltaic installations, relative size. Calculation based on manual tracing of PV installations on Orthophoto plans of 2023 provided by Urban Brussels.

Planned Heat Network

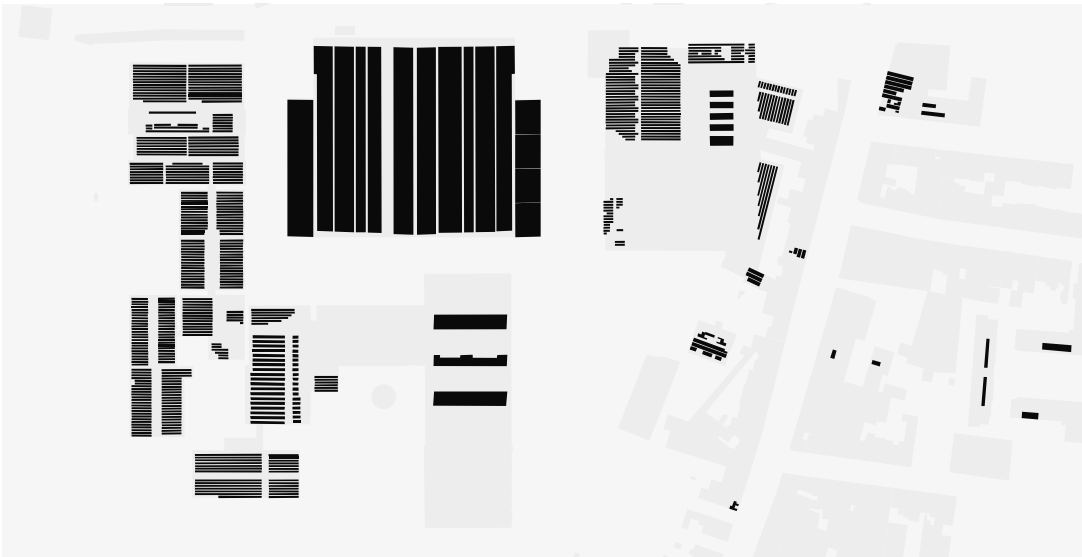


Adapted from TransPED, 2023

Surface of installed photovoltaics

PV surface, 2023

PV surface areas are based on Orthophoto plans of 2023 by Urban.brussels.



↑ 3.1

↓ 3.2



3.1 Architectural rendering of the new Manufacture building, which will eventually host the public pool. Image © Abattoir SA

3.2 Anodised aluminium solar panels covering the roof of the historic market hall. Image © SkySun

Cultureghem, including help in securing funding. All this culminates in the annual *Cultureghem* Festival, organised by residents and volunteers, with daily themes showcasing different talents and cultures. *Cultureghem* relies on the support of the Abattoir company, which provides space for their activities, allowing them to use temporarily unused areas for events ranging from open-air cinema to skateboarding. The management of the Abattoir recognises the importance of *Cultureghem*'s role and the need for a social programme alongside its commercial activities.

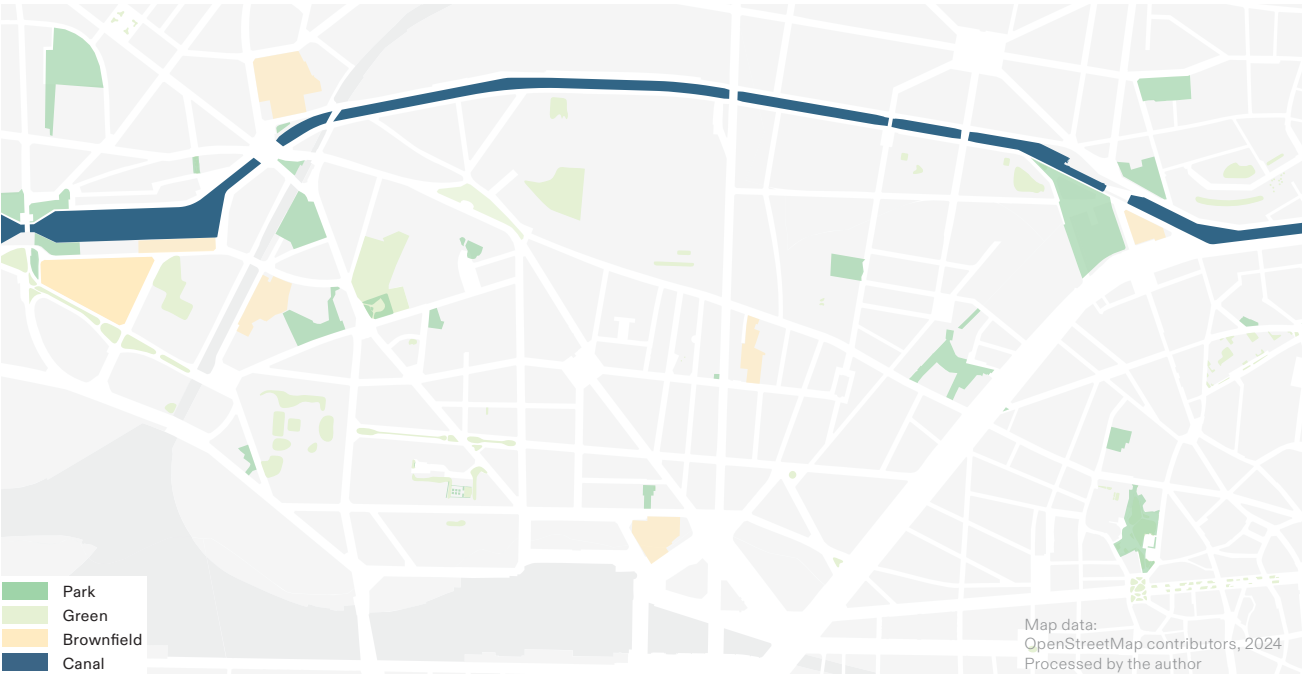
NEGLECTED AND REDISCOVERED

Until the mid-1990s, the neighbourhood was of little political interest, due to its geographical isolation, a high proportion of non-Belgian nationals (who cannot vote) and institutional racism (Sacco, 2010). The indifference and lack of strategy on the part of policymakers fuelled speculation to the point where it seemed that Cureghem was largely destined for demolition. In a plan eerily similar to the fate of the North Station area, several blocks of dense working-class housing had to make way for a new high-speed train terminal and office buildings. Even the existence of the abattoir in its current form should not be taken for granted. In the 1950s, as part of the mayor's drive to remove "unhealthy" industries from Cureghem, it was only due to its economic success that it was saved from demolition.⁴

The turning point for Cureghem came with a series of Neighbourhood Contracts, a policy tool for integrated urban renewal and community engagement which reversed the trend from planned destruction to rebuilding (Sacco, 2010). Despite mixed results, much of the positive impact of these interventions can be felt and seen today as one walks through the neighbourhood past new pocket parks and apartment blocks. The majority of housing is still concentrated around the historic centre of

4 Our history. 2019. Abattoir sa/nv. Retrieved March 15, 2024, from <https://www.abattoir.be/en/our-history>

↓ Open green space is extremely scarce in Cureghem, due to its industrial roots and decades of political disinterest.



Cureghem with its 19th century town hall. The few high-rise buildings are located in the south-west, on former industrial sites. Although the cotton mills and dyers are long gone, there is still a unique profile of economic activity in the district. Orban et al. (2021) make a clear distinction between old and new activities, the old being the meat cutters and wholesalers around the abattoir, some metalworking and printing businesses, and second-hand car dealers specialising in exports to the African continent. These businesses take advantage of the highly skilled workforce that is well established in Cureghem as well as of the cheap unskilled labour of the newcomers.

Among the new types of enterprise that have emerged as part of the renewal strategy are food start-ups and recycling companies. They also benefit from the ready supply of newcomers looking for work, but have less need for the specialised skills of the 'old generation' (Orban et al., 2021). These industrial agglomerations are largely concentrated around the Abattoir and in the Heyvaert district along the canal towards the Porte de Ninove. Some of these activities, such as meat packing and the car trade, face an uncertain future for a number of reasons. One is the lack of space, since there simply isn't enough left in Cureghem for businesses to expand, and car dealerships are not particularly space-saving. The other is urban policy, as such large-scale industrial activity is hard to justify in a dense residential area in the 21st century. The Tetris-like clusters of warehouses may well be emptying in the near future, raising new questions about the neighbourhood's future.

In addition to its unique industrial profile, a significant part of the territory of Cureghem is home to a number of educational institutions. The Erasmus campus next to the Abattoir, built in the 1980s, and a cluster of secondary schools built in the 60s and 70s a little further south. For a long time, Cureghem was home to the State Veterinary School, in a neo-Flemish Renaissance complex⁵ that has recently been converted into a trendy co-working space. The Faculty, as the new site is now called, advertises its proximity to the Midi train station and its lush parkland surroundings. And the dusty office buildings along the railway have recently been given a makeover, adding to the tertiary character of the south of Cureghem. The Brussels Midi railway station forms the south-eastern border separating Cureghem from the lower Saint-Gilles. As an international railway hub with connections extending as far as Vienna and London, it is the busiest station in Belgium, with more than 50,000 passengers per day.⁶ Over the decades, it has been demolished, rebuilt and modified several times, most recently with the high-speed train terminal and shopping gallery built in the 1990s.

Cureghem is geographically defined by major infrastructures such as the Albert Canal, the Brussels inner ring road and the railways. Despite its geographical detachment, this makes it extremely accessible by road, rail and water. It is crossed by strategic arterial roads that carry large volumes of traffic. The district is also served by tram line 81, the busy circular metro lines 2 and 6, and bus routes operated by MIVB and DeLijn. Mobility remains a sensitive topic, as recent efforts to curtail excessive through traffic have failed to get public support, also due to inadequate citizen participation.



↑ A typical cluster of warehouses with car garages surrounded by terraced housing. Many of these clusters were demolished after the Second World War to make way for schools and apartment blocks. They are still in decline today, as the former warehouses give way to pocket parks and new blocks of flats.

5 Inventaire du Patrimoine Naturel. (n.d.). Ecole vétérinaire de Cureghem. Heritage.Brussels. Retrieved August 1, 2024, from <https://sites.heritage.brussels/fr/sites/69>

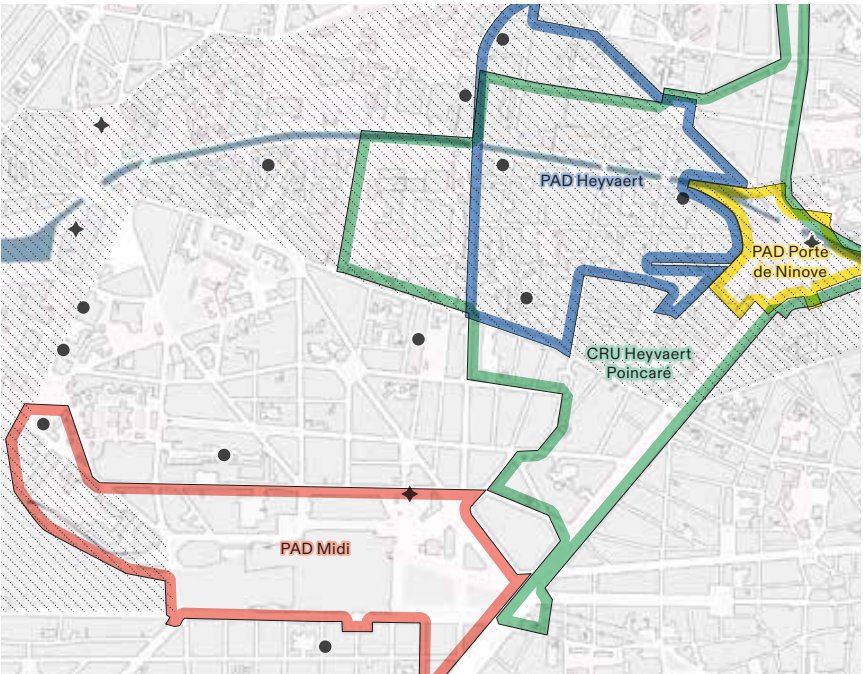
6 Whilst Brussels North is slightly more frequented during weekdays (60.449 p) than Midi (58.344 p), based on the most recent counts, Brussels Midi has a third more travellers on weekends (~32k) than North (~19k). SNCB. (2023). Number of boarding passengers per station in 2023. Retrieved January 8, 2024, from <https://www.belgiantrain.be/nl/about-sncb/enterprise/publications/travellers-counts>

Despite the fact that rents in Cureghem are affordable by comparison with other areas of Brussels, many of the buildings are poorly insulated or in a state of disrepair. Almost 80% of Cureghem's population is renting, and rely on the private housing market, of which only 4% consists of social housing according to Scohier & Rosenfeld of Inter-Environnement Bruxelles (2022). Over the last 20 years, Citydev, a public operator, has built over 1,100 'acquisition' housing units in Cureghem to facilitate home ownership. But even though these units are cheaper than market rates, they remain often beyond the budgets to those on social housing waiting lists, instead catering to a higher income bracket. While urban renewal policies have improved the quality of public spaces, Scohier and Rosenfeld argue that they haven't adequately addressed the housing market or speculation, and have attracted too many private investors. These large-scale private developments, even in nearby areas, add to the pressure on Cureghem, potentially displacing low-income populations.

Cureghem has seen a number of neighbourhood contracts and land use plans (Plans d'Amenagement Directive). Many of them focusing on improving the quality of the public space, introducing new green spaces and play grounds for children. Scohier and Rosenfeld argue that it is essential to preserve Cureghem as an accessible urban area for economically underprivileged populations. To this end, public authorities should increase social housing, tax and confiscate empty apartments, preserve public land and introduce a rent control system based on residents' incomes. They argue that this situation in Cureghem is not inevitable and that timely intervention could prevent the displacement of the current population. The energy transition will be another major factor in this challenge, as we will discuss in Chapter 4.



↑ One of the latest developments along the canal: the industrial hall of a former car export company has been transformed into a playground with some social housing and a space for a circular economy initiative.



Local development plans and housing projects

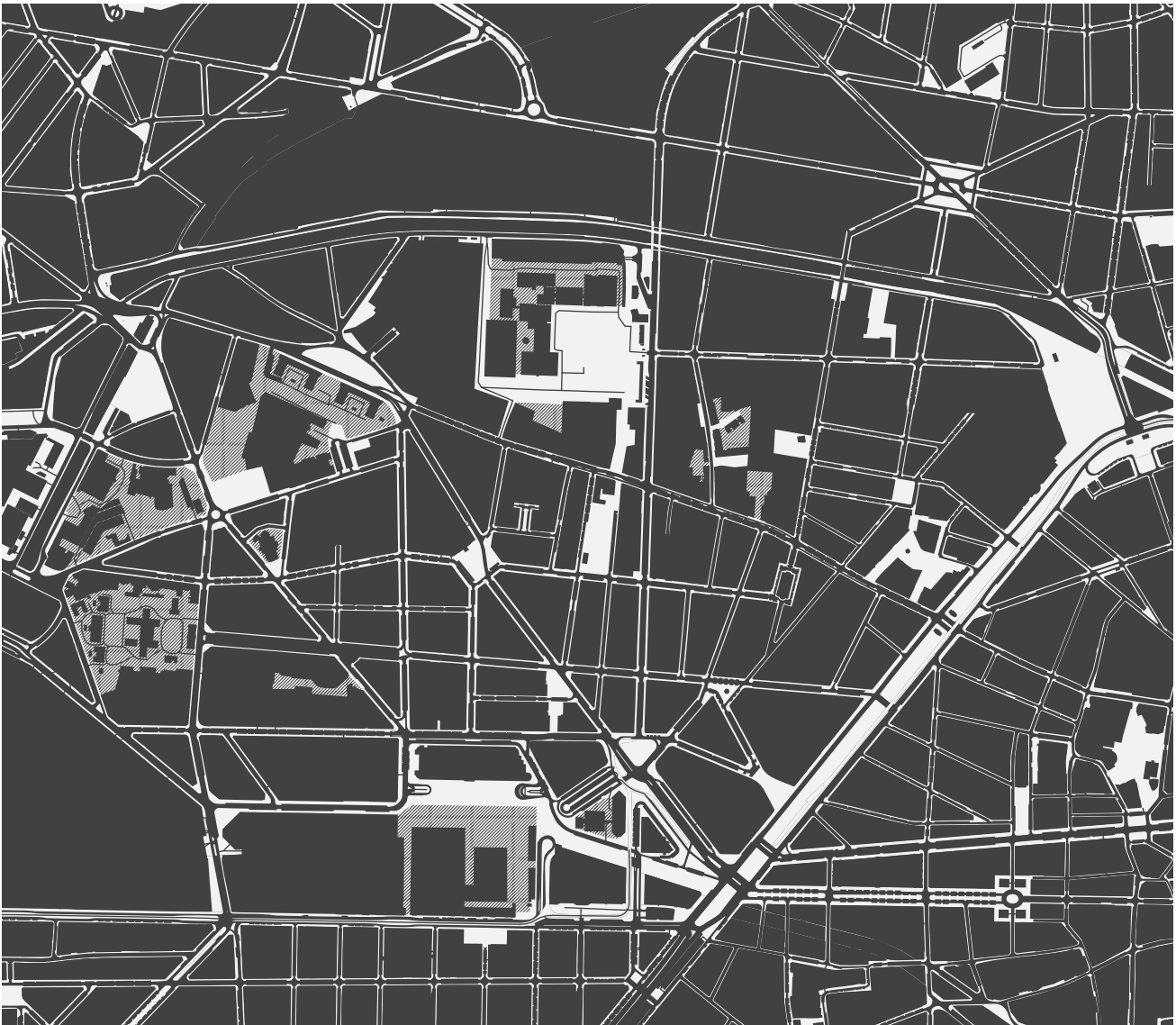
CRU - Contrat de Rénovation Urbaine
Targeted urban renewal project for specific neighborhoods.

PAD – Plan d’Aménagement Directeur
Strategic plan guiding long-term development in larger areas.

Landscape and urban quality plan
Design guidelines ensuring landscape and urban quality in development.

- Landscape and urban quality plan
- Large private real estate project
- Large social/subsidised housing project
- Urban fabric
- Canal

Map data © Mathieu Van Crielingen - 2021
Taken and adapted from Scohier and Rosenfeld (2022)
Added "Landscape and urban quality plan" by perspective.brussels (2024), published by Brugis, urban.brussels



Nolli Map of Accessible Spaces

This map based on the principle of the famous 1748 map of Rome by architect and surveyor Giambattista Nolli, which mapped not only the public space but also included accessible indoor spaces such as churches or courtyards.

For this Nolli-inspired map of Cureghem, we took the perspective of a pedestrian, asking ourselves, which spaces are truly accessible to roam, not only public in the technical sense. This is because, unlike in 18th century Rome, much of the public space today is dedicated to motorised traffic, effectively illegal and dangerous to use for a person on foot. By excluding these spaces that are reserved for traffic and car parking, we gain a

more accurate picture of the availability of public space in Cureghem. Without blackening these surfaces reserved for traffic, one could have the impression that the neighbourhood has rather ample public space and wide, inviting streets. For example Chaussée de Mons, the main road traversing Cureghem, has a wide profile of almost 20m, however only about 4m are pavements for pedestrians, the rest is dedicated to on street parking, car traffic and a separate bus lane (see street profiles chapter 6).

- Public and accessible
- Restricted access
- Inaccessible

V Cureghem at a Glance

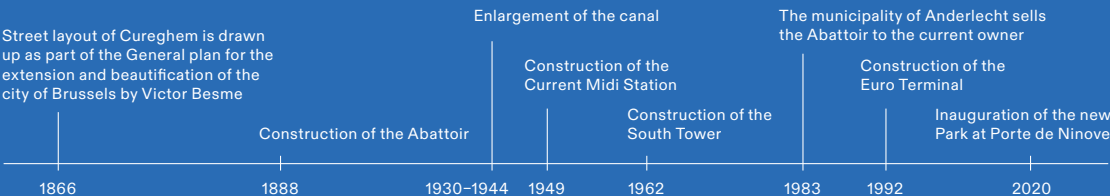


Site area	ha	197,86
Building footprint	ha	92,02
Population density	inh/ha	443,15
Office floor space	m²/ha	1.632,92

Street surface	12,5%
Buildings	45,2%
Public Green space	5,1%

Median taxable income	EUR	17.524,43
Social housing units	per 100 inh	8,4

TIMELINE

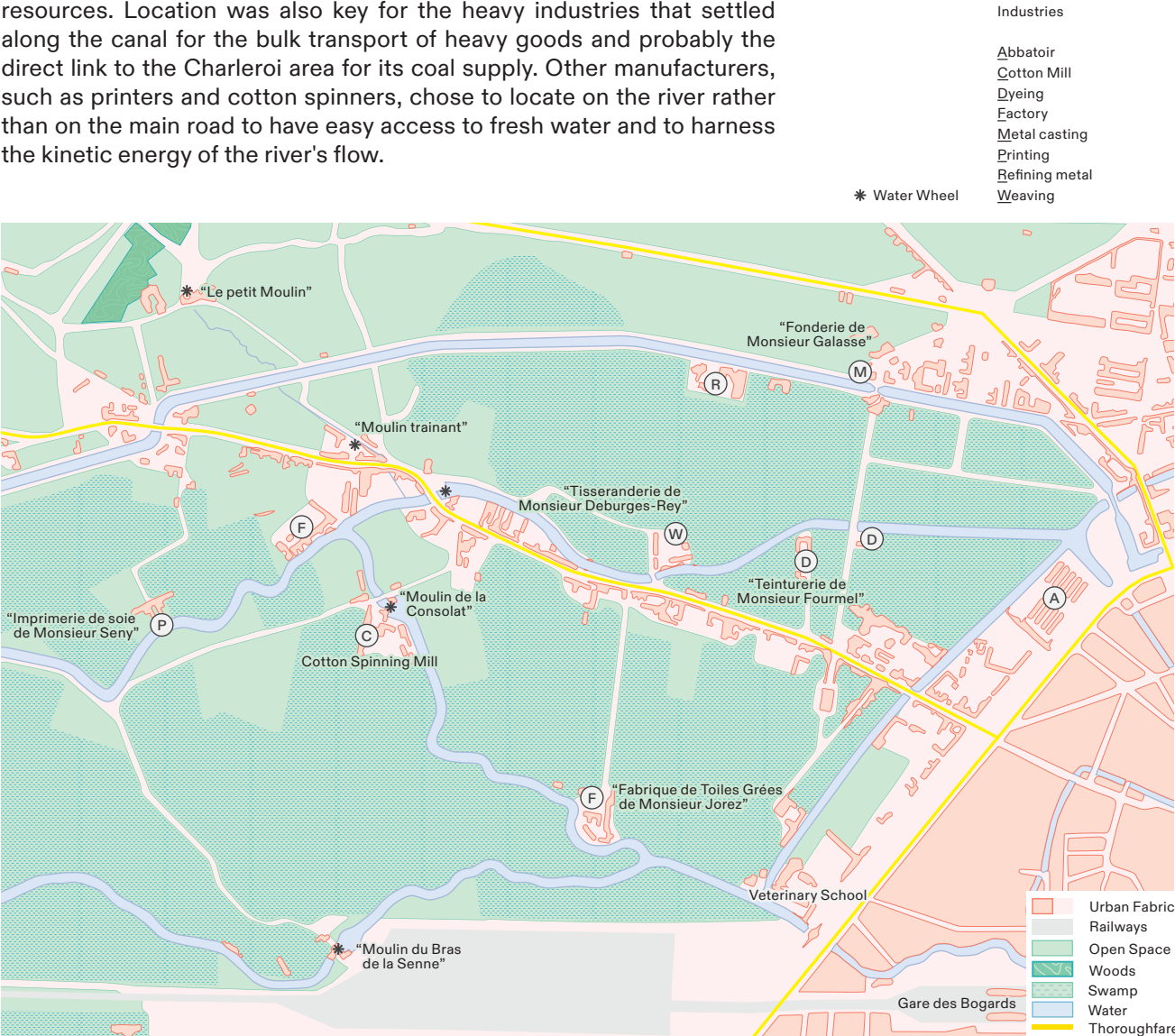


Spatial data
Site area
Public green space
Statistics

own processing based on following datasets
building footprints, street surfaces: Urban Brussels. (n.d.). BruGIS [Dataset]. <https://gis.urban.brussels/geoserver/web/?0>
OpenStreetMap contributors. (2024). Selection of leisure and landuse categories using QuickOSM plugin for QGIS
Monitoring des Quartiers. (n.d.). IBSA - L'Institut Bruxellois de Statistique et d'Analyse. Retrieved August 1, 2024, from <https://monitoringdesquartiers.brussels/>

At the dawn of the Industrial Revolution, Brussels was already a manufacturing powerhouse. Before Victor Besme's plan for the expansion of Brussels, Cureghem was largely a marshland with the arms of the Senne meandering through it. One of the only remaining features is the Chaussée de Mons, which has linked Brussels to the Pajot region for centuries. Before the formal development of Cureghem as a district, the 1856 map of Huyvenne shows the emergence of industries along the river, the canal and the paved main road. Four water mills are marked on the map, which would have provided mechanical energy for processes such as cotton spinning, weaving or hammers for metalworking. The River Senne also provided fresh water for a number of dyers who secured a prime site in this area before the river entered the city and became polluted with sewage and waste.

This shows how location was key to access to useful energy and resources. Location was also key for the heavy industries that settled along the canal for the bulk transport of heavy goods and probably the direct link to the Charleroi area for its coal supply. Other manufacturers, such as printers and cotton spinners, chose to locate on the river rather than on the main road to have easy access to fresh water and to harness the kinetic energy of the river's flow.



Based on Huvenne. (1858). Topographic and hypsometric map of Brussels and its surroundings. Via Brugis. <https://gis.urban.brussels/brugis/>. Own processing by the author

↓ Ferraris. (1777). Kabinetskaart der Oostenrijkse Nederlanden en het Prinsbisdom Luik. Via Brugis. <https://gis.urban.brussels/brugis>



↑ Belfius postcards. (1920). Vieux Moulin – Chaussée de Mons. Via Bruciel. <https://bruciel.brussels/#>

↑ Huvenne. (1858). Topographic and hypsometric map of Brussels and its surroundings. Via Brugis. <https://gis.urban.brussels/brugis/>

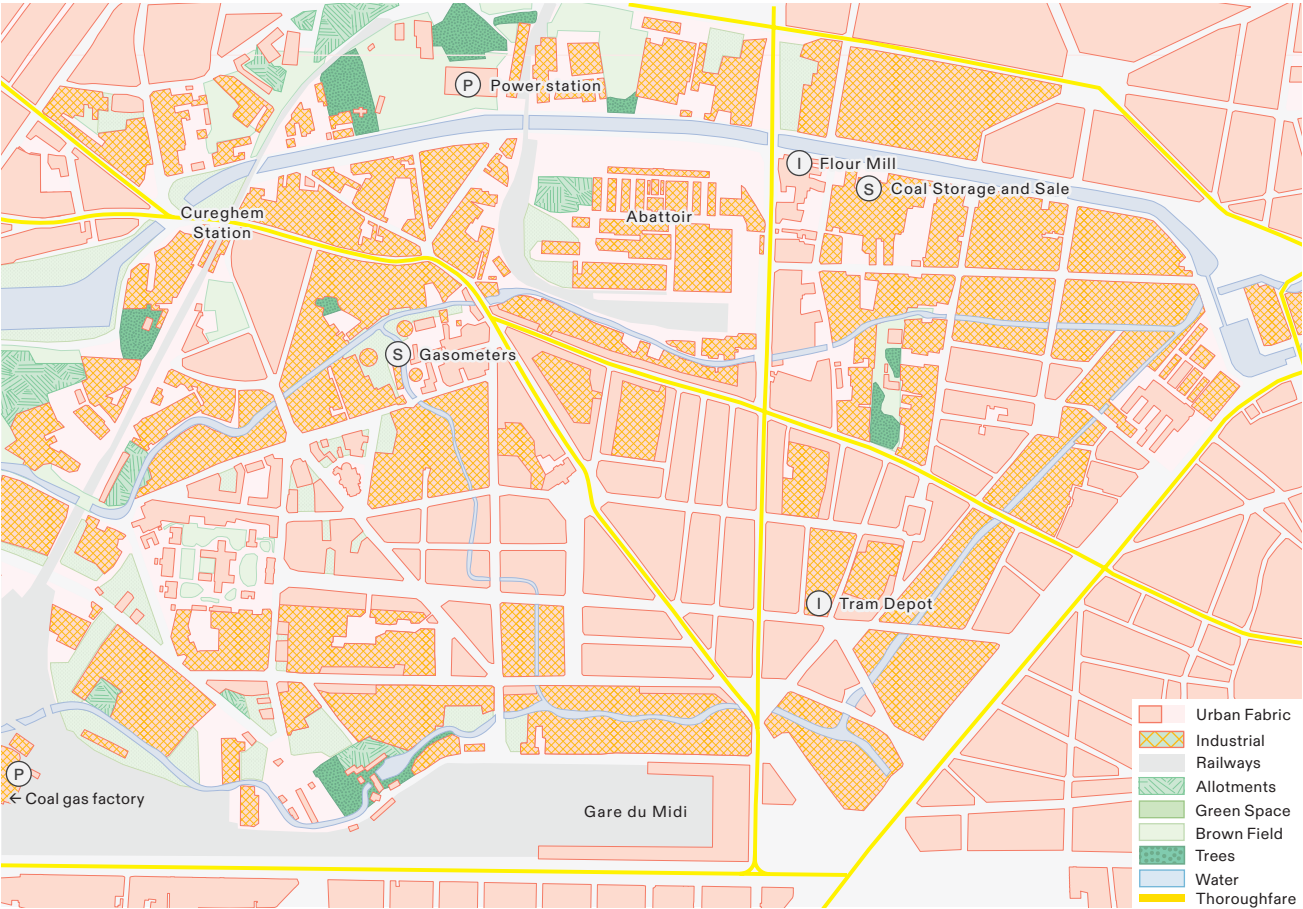
↓ Edmond De Schamphelaar. (1881). Moeras. Via Heritage Brussels. <https://collections.heritage.brussels/nl/objects/42766>



The Industrial Revolution transformed Brussels during the 19th century and the area along the canal was sometimes referred to as ‘little Manchester’ or ‘Belgian Manchester’ in reference to the origin of Industrialisation⁷. Industry in the area of Cureghem was booming and home to countless enterprises small and large.

The spatial logic of the urban morphology has also changed. Compared to the artisanal city of the early 19th century, companies were less restricted in terms of energy availability. The invention of the steam machine meant that it was no longer necessary to be close to a water current to power mechanical processes. The energy network is organised in local grids and the first power stations were usually for a specific purpose, such as delivering power to the tram network or producing gas from coal for the street lighting (De Raedt, 2020), such as the ones visible on the map below.

In Cureghem, the river Senne was still running above ground until the second half of the 20th century, but was not fulfilling much purpose anymore for industries. The canal remained important for logistics, carrying goods and fuel, but the railways were now just as vital, delivering the coal to the two power plants near Cureghem. We also see energy storage for the first time, which is visually very present, with several gas storage units as part of a factory in Cureghem and a storage and sale of coal.



↑ Belfius postcards. (<1920). Usine d'électricité – Quai Fernand Demets. Via Bruciel. <https://bruciel.brussels/#>



↑ Belfius postcards. (<1920). Meunerie au Canal de Charleroi – Quai de l'Industrie. Via Bruciel. <https://bruciel.brussels/#>



↑ Belfius postcards. (<1920). Compagnie Continentale du Gaz Usine de Forest, Cour centrale – Rue du Charroi. Via Bruciel. <https://bruciel.brussels/#>

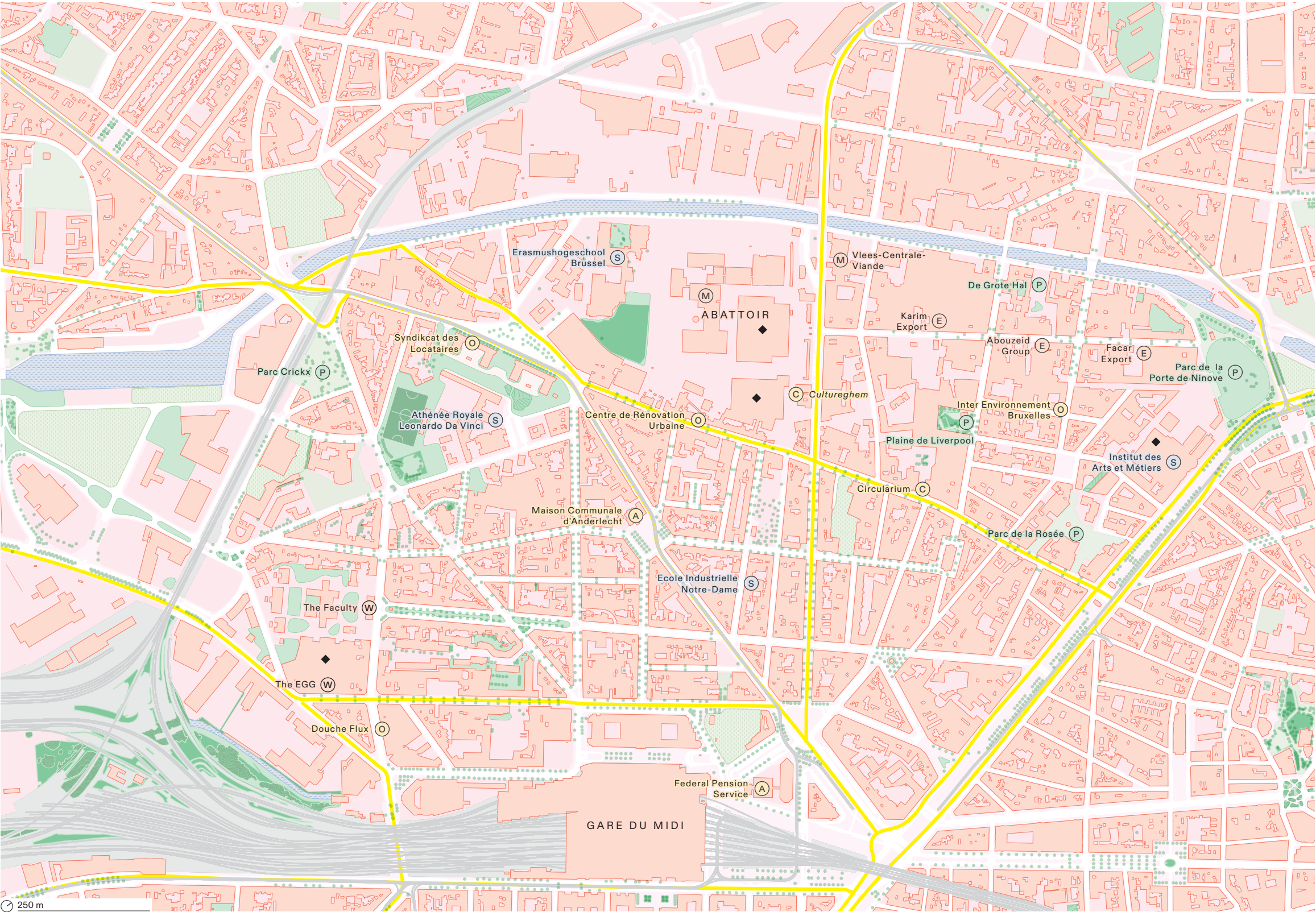


↑ Orthophotoplans 1930 - 1935 Via Brugis. <https://gis.urban.brussels/brugis/>

Small allotments nestled between industry and urban fabric



↑ Orthophotoplans 1930 - 1935 Via Brugis. <https://gis.urban.brussels/brugis/>



Cureghem today is characterised by its diverse population and the layers of urban change that have occurred over time. Its industrial character is still present in much of the area along the canal and woven into the urban fabric. While we see major real estate initiatives around the Gare du Midi, recent urban developments have also focused on smaller interventions to create pockets of Green and playgrounds. Centralised energy production has disappeared as a distinct function in the urban ensemble, but could reappear as local heat and power production continues to grow. Car exporters could not only provide entry-level jobs, but also the space and means to install new energy equipment. Schools and offices can also install a lot of energy-generating kit that will provide a surplus in the after hours. This diversity can be a boon to a local energy network, where dozens of different user profiles can help keep demand steady and predictable.

Points of Interest

Parks

Schools

Cultural organisations

Car Export

Meat processing

Co-Working

Administration

Organisation

Map Legend

Urban Fabric

Railways

Green Space

Sports Field

Brown Field

Water

Thoroughfare

Large PV producer

Spatial data: OpenStreetMap contributors, 2024

Processed by the author

ENERGY LOGICS

Looking at the relationship between energy and the built environment, we observed three distinct logics in Cureghem. Using historical cartography from the early 19th century, the earliest aerial photographs from the 1930s, recent satellite imagery and OpenStreetMap data, we created three maps to facilitate comparison of the different spatial patterns resulting from a specific energy logic.

The map of today's Cureghem, titled 'The Fluid City', shows the distribution of built space, the remaining open and green spaces, as well as a selection of interesting locations that show the diversity of Cureghem's socio-economic profile. Today, the infrastructure and energy production are largely invisible. In the second half of the twentieth century, power grids were put underground, the network nationalised and internationally connected, as supply shifted to a few large power stations. According to Juwet and Ryckewaert (2018), the ongoing transition away from fossil energy is challenging this pattern making it explicitly a "spatial project". The term 'power' takes on a double meaning here, as renewable energy also offers a democratisation of energy production.

With the relentless expansion of renewables in the city, energy infrastructure is making a comeback in the urban landscape in the form of solar PV systems or district heating plants. The centralisation of the power grid has made the spatial relationship between producers and end users diffuse and almost irrelevant. But in the Fluid City, the location of consumers and the local potential of renewable energy production reintroduce a logic of proximity. As in the industrial and artisanal era of the city, proximity to a body of water, such as the canal or the river Senne, has again become an asset. Today, however, it is not so much its logistical capacity or the kinetic energy of the water flow. Instead, the energy inherent in the water's temperature offers great potential for energy production using heat pumps. As well as location, architectural morphology has also become key, with flat or south-facing roofs – the bigger the better – being covered in solar panels.

Does this mean a return to the energy logic of the pre-industrial era, when business and manufacturing was determined above all by location? Not as long as we want to achieve near 100% reliability of energy supply, since the pre-industrial economy was more attuned to the weath-

	FLUID CITY	INDUSTRIAL CITY	ARTISANAL CITY
Spatial Logic	Dispersed, largely invisible, supply both hyper-local and internationally connected, distance to user irrelevant	Local power grid, production is built where needed (lighting, transport, etc.), near railways or canal for fuel	Location specific production, energy users settle themselves at suitable supply (water wheel, road connect.)
Energy Intensity	+++	++	+
Energy Sources	Natural Gas, Oil, Uranium, Solar PV, Wind power, CHP	Coal, gas (from coal), petroleum	Water, biomass, coal, animals
Focus	Decentralising production, supralocal connection	Reliable power, conversion into usable energy (gas, elec.)	Mechanical processes
Period	~2020	~1930	~1860



er and the seasons. Instead, there will be a mix of the energy logic of the artisanal city and the industrial city, where we will see both local facilities and infrastructure, but also rely on an international connection with other energy-producing regions to supply the city when local capacity is unable to meet demand.

The organisation of this supra-local exchange will also call into question its sustainability and resilience. Guaranteeing a stable energy supply in a renewable energy system requires additional infrastructure beyond the local level. The Belgian government is planning to build new gas-fired power plants to stabilise the grid and guarantee supply, but obtaining the necessary permits is proving more difficult than expected.⁷ Critics point to the hypocrisy of green-minded politicians who see building new fossil-fuel infrastructure as the lesser evil compared to extending the life of the country's nuclear fleet. Energy Minister Van der Straeten (Greens) rejects the criticism, instead pointing to nuclear power's lack of flexibility to react quickly to intermittent renewables.⁸ At the same time, Europe has also recognised the issue of balancing the regional availability of renewable energy. Earlier this year, the Council adopted conclusions proposing a massive expansion of infrastructure to create an “EU Super-grid” (Council of the EU, 2024). All this additional infrastructure will require huge amounts of raw materials, threatening the overall sustainability of a renewable energy system.

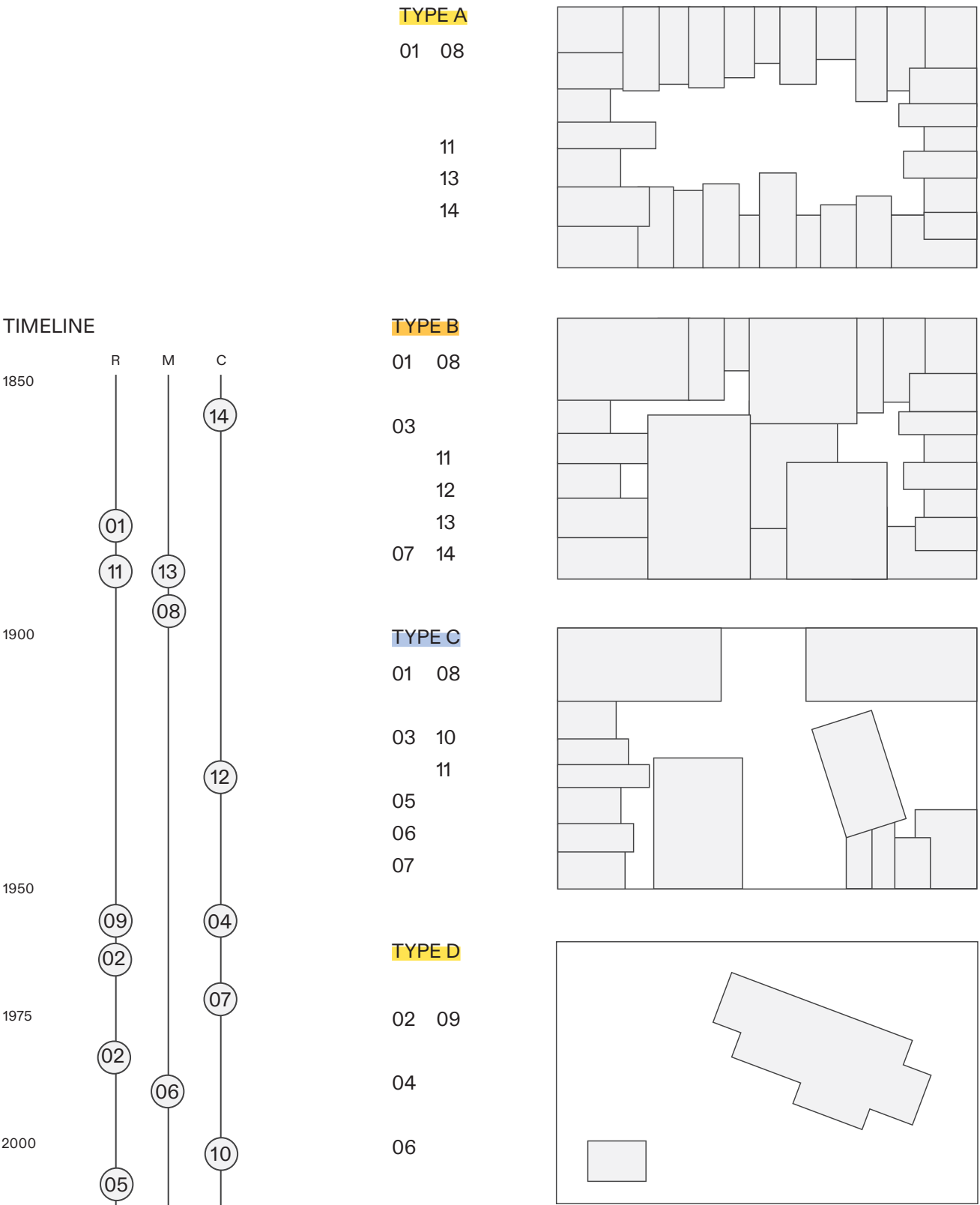
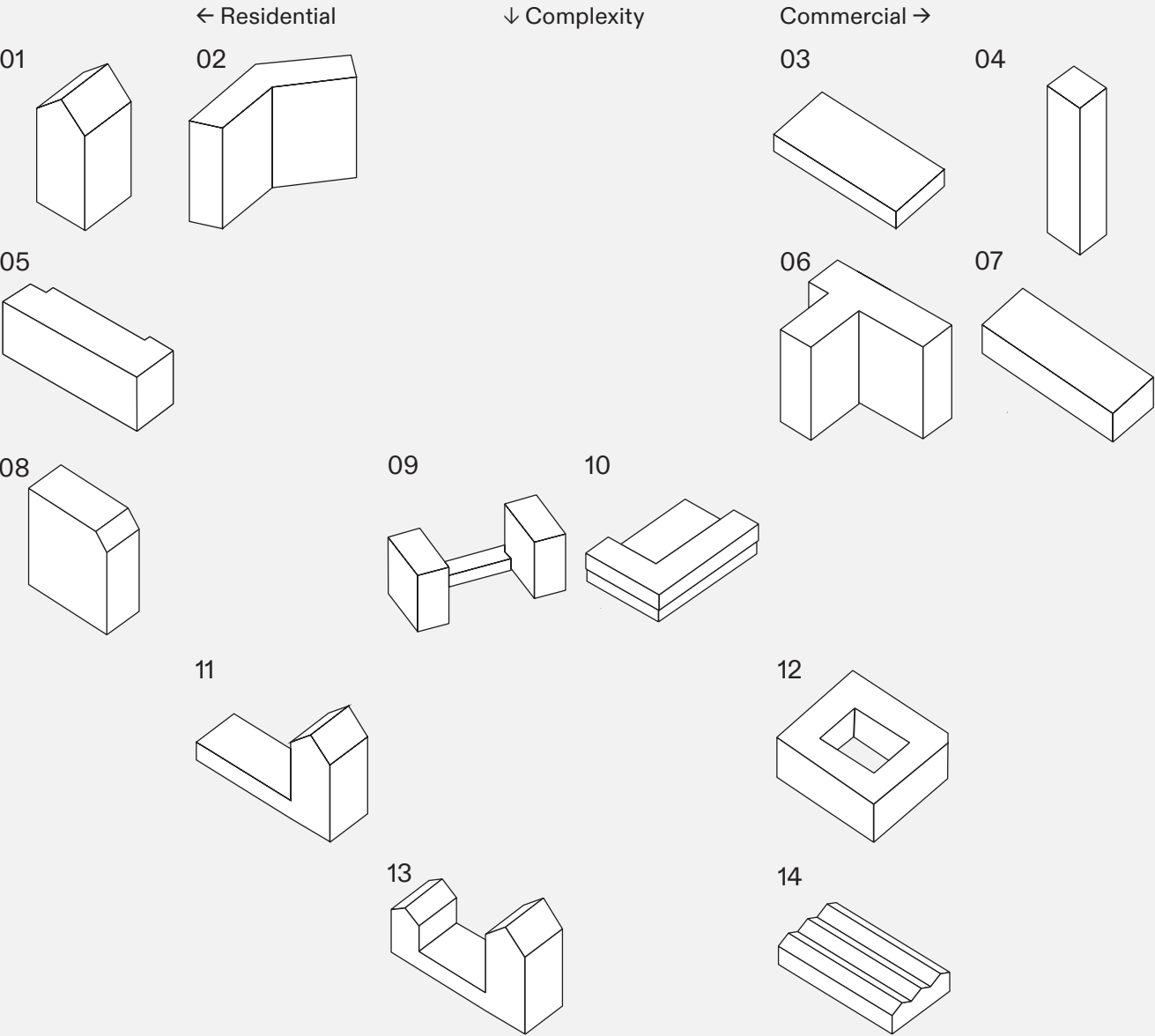
The diversity of building typologies, economic activities and user profiles in Cureghem calls for a multi-level strategy to build a resilient and renewable energy system. In order to determine the best strategies, we will study the composition of the urban fabric in Cureghem. The spatial analysis can provide us with a basis for developing an integrated energy strategy.

7 Schillewaert, N. (2022, March 15). Engie/ Electrabel krijgt niet tijdig vergunning voor gas-centrale in Vilvoorde. VRT News. <https://www.vrt.be/vrtnws/nl/2022/03/15/vergunning-gas-centrale-vilvoorde/>

8 Cabinet Tinne Van der Straeten. (n.d.). Vervangen jullie de kerncentrales door gascentrales? [tinnevanderstraeten.be](https://www.tinnevanderstraeten.be/vervangen_jullie_kerncentrales_door_gascentrales). Retrieved August 4, 2024, from https://www.tinnevanderstraeten.be/vervangen_jullie_kerncentrales_door_gascentrales



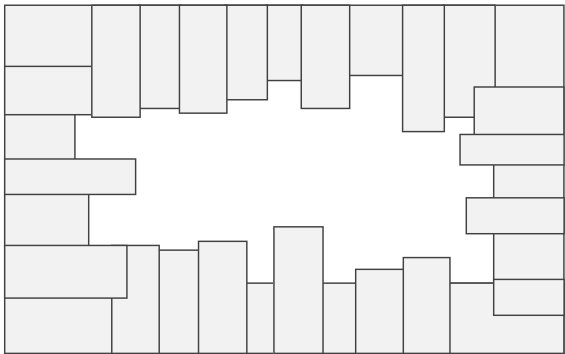
00	Building Type		00	Residential Mixed Commercial	
01	R	Single family, terraced	08	R	Multi family, terraced
02	R	High rise social housing	09	M	Apartment block, ground floor retail
03	C	Single Warehouse	10	M	Retail with apartments
04	C	Office tower	11	M	Multi family, ground floor retail
05	R	Apartment block	12	C	Multi-enterprise building
06	C	Office building	13	M	Multi family, terraced with attachment
07	C	Multi-storey car storage	14	C	Warehouse cluster



TYPE A

01 08

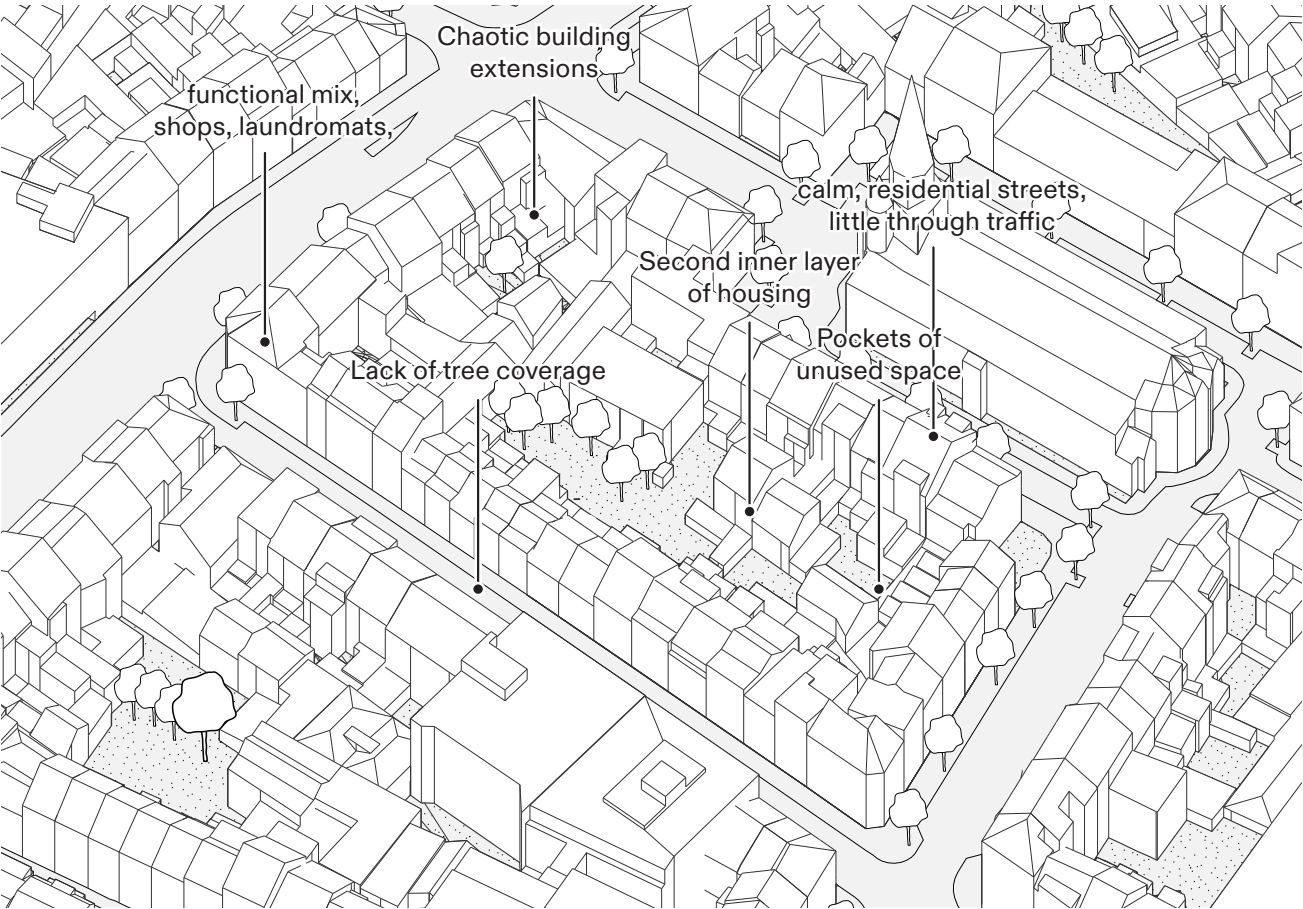
11
13
14



Building density	●●●●●
RE potential	●○○○○
Functional mix	●●●○○
Key challenges	Building quality Renovation Accountability Lack of green space



Example: Residential block in historic centre of Cureghem
Chaussée de Mons, Rue Docteur De Meersman, Rue de la Clinique,
Rue Gheude

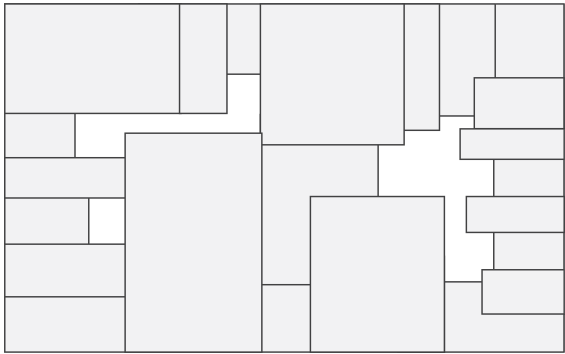


This type of urban block is common in the centre of Cureghem and has some of the oldest housing stock. It consists mainly of dense terraced housing, usually with more than one household. They are usually surrounded by smaller streets. Most of the surface of these blocks is fully built up, with only some un-built space remaining in the form of private gardens. Many of the courtyards also seem to have no purpose, as they are usually too small to be used and surrounded by other extensions. Appearances can sometimes be deceptive, as buildings can be linked together, especially on the inside of blocks, to form a larger space. These are often organisations such as mosques or social initiatives that need more space than a single building.

The energy potential here is very limited. The roofs are often suitable for solar PV, but won't be enough to meet more than a third of the demand, as the houses are usually occupied by more than one household. In some cases it may be possible to install conventional heat pumps, but the low level of home ownership means that there are few incentives for such investment. Ground source heat pumps seem even less suitable for the same reasons, the lack of open space and the risk of groundwater contamination with so many individual installations.

TYPE B

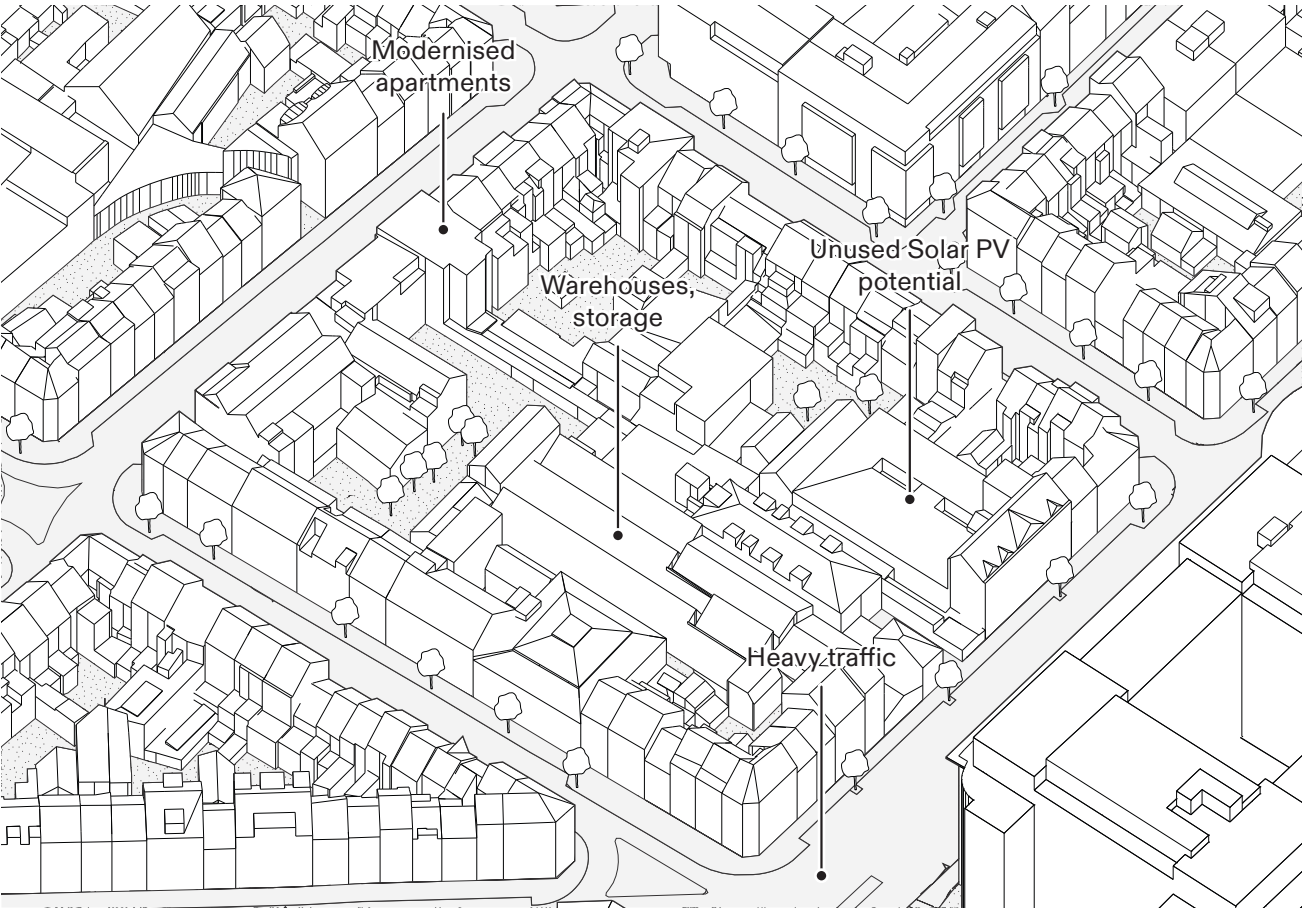
- 01 08
- 02 09
- 03 10
- 04
- 05



Building density	●●●●●
RE potential	●●●○○
Functional mix	●●●●○
Key challenges	Unused RE potential
	Lack of green space
	Through traffic
	Overall Liveability



Example: Mixed block near Gare du Midi
Rue Brogniez, Rue Rossini, Rue Bara, Rue de l'Instruction

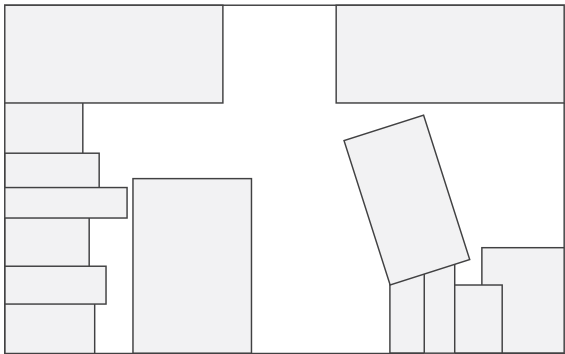


Type B is a dense block consisting of both residential and commercial units, often with larger warehouses or storage facilities in the centre of the block. This type is associated with the historic character of Cureghem, but often includes some modernised residential units. Most of the surface of these blocks is built up, with only some unbuilt space in the form of gardens or car parks. It is often located on one of the busier streets and may also attract some heavier traffic as part of economic activities such as the car trade, which makes it difficult to combine with a liveable urban environment.

This type of urban fabric has a more favourable energy potential. Economic activities such as trade and retail are not extremely energy intensive and have large flat roof areas with great potential for solar PV installation. Many of these warehouses are not yet equipped with solar energy and could provide a significant surplus for neighbouring buildings and households. The larger buildings are well suited to the installation of heat pumps, especially for businesses that also have a need for larger cold storage. The remaining unbuilt space could also be used to drill for some larger ground source heat pumps, for example under a car park. Many of these possibilities may not be common knowledge among business owners and could be interesting business cases.

TYPE C

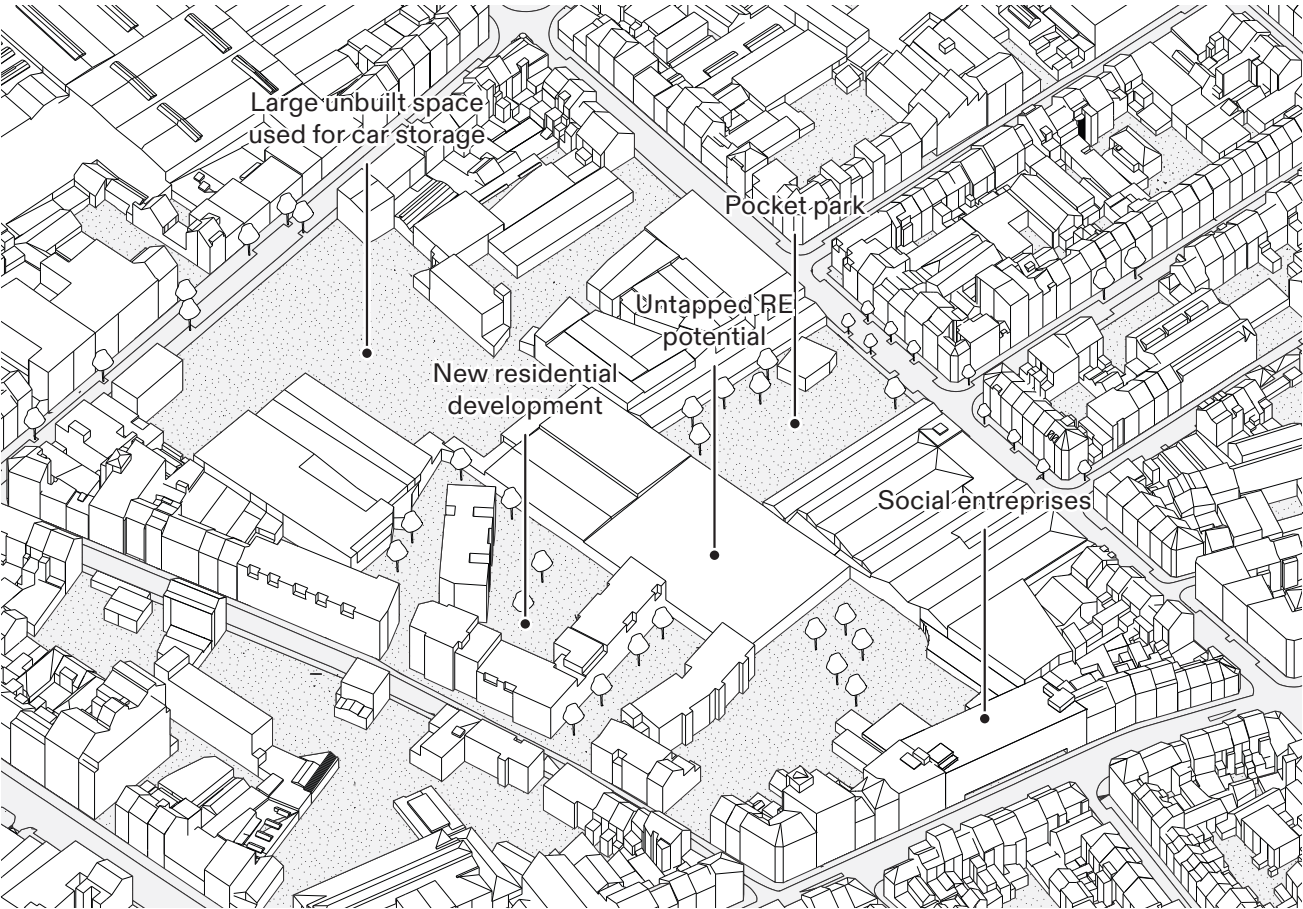
08
02
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07



Building density	●●●○○
RE potential	●●●●○
Functional mix	●●●●●
Key challenges	Unused RE potential Impermeable ground Inefficient space use Heat island effect



Example: Large mixed block in the Heyvaert quarter
Rue Heyvaert, Rue de Liverpool, Chaussée de Mons, Rue du Compas

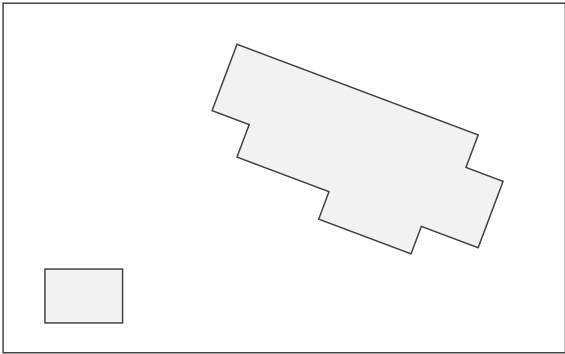


Type C is similar to B in terms of functions and building types, but is less densely built, often with larger unbuilt areas for car parking or even a small park. This type is characterised by larger buildings in general and office buildings. In almost all cases, however, there are still a few old dwellings tucked away somewhere in between. It is almost always located on one of the arterial roads and will also attract heavier traffic as part of economic activities such as the car trade and office commuters, which poses a challenge to the nearby residential blocks.

This type of urban fabric has a fairly good energy potential. Economic activities such as trade and retail are not extremely energy intensive and have large flat roof areas with great potential for solar PV installation. The higher proportion of offices adds another interesting layer of functionality and a very predictable energy use profile. Many of the large roofs and car parks are not yet solar and could provide a significant surplus to neighbouring buildings and households. The larger buildings and offices are well suited to the installation of heat pumps. The higher proportion of unbuilt space can be used to drill boreholes for large ground source heat pumps, especially under the car parks. The high proportion of larger businesses is favourable in terms of investment capacity and simpler ownership arrangements than the two denser types. The production of surplus heat for a district network could provide interesting business cases for these companies.

TYPE D

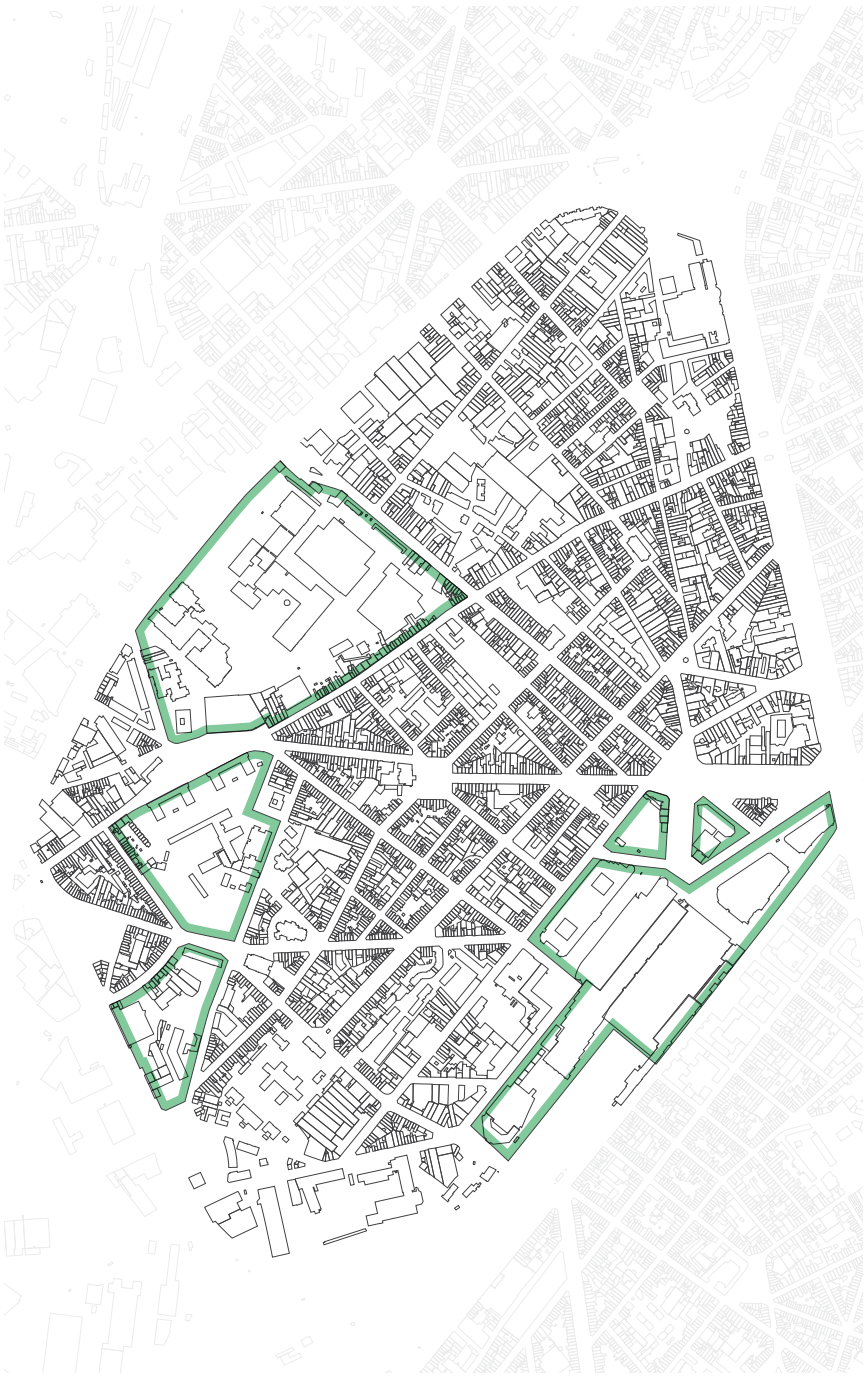
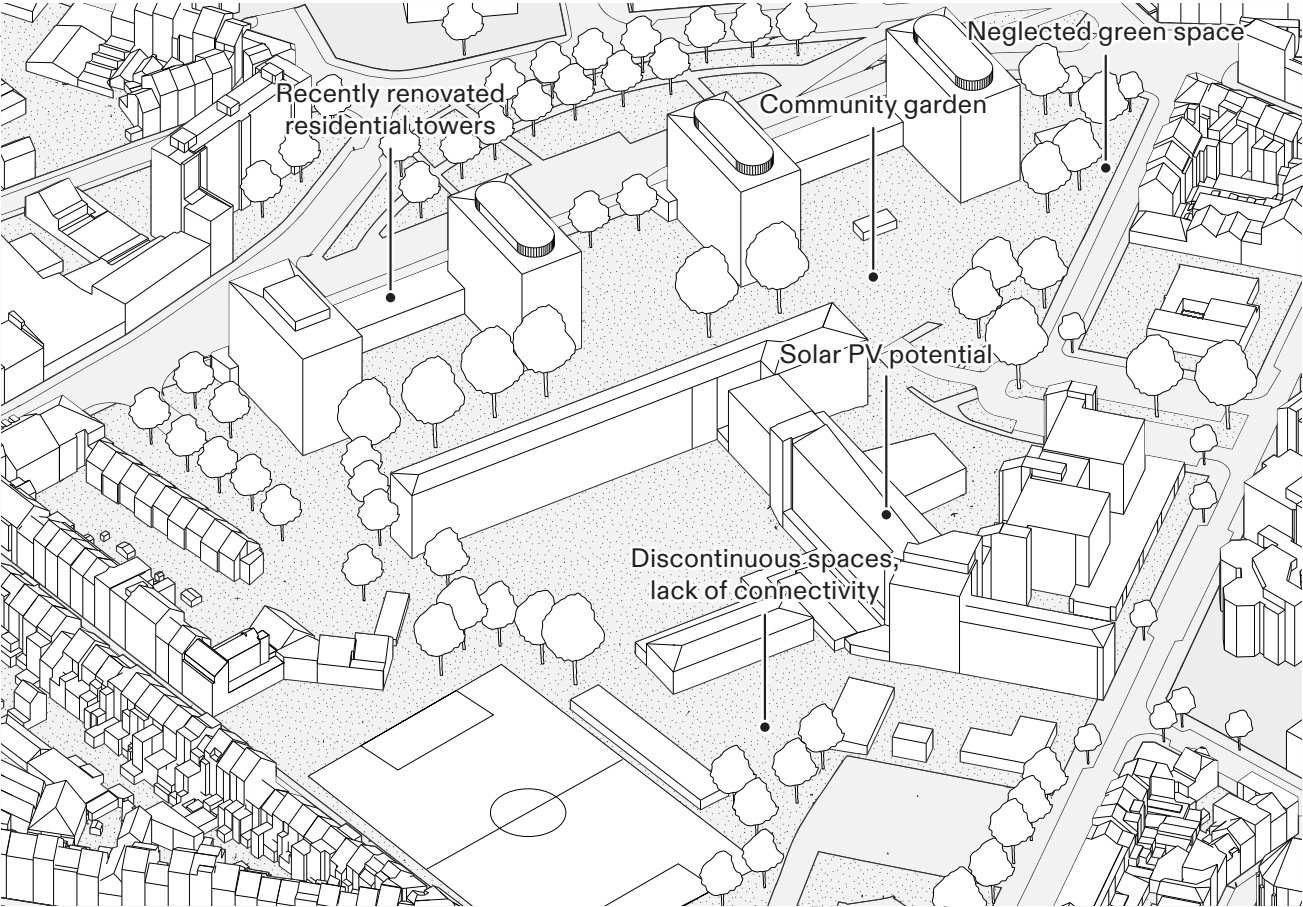
11
12
13



Building density	●○○○○
RE potential	●●●●●
Functional mix	●●○○○
Key challenges	Unused RE potential Lack of green space Through traffic Overall Liveability



Example: Large mixed block in the Heyvaert quarter
Rue Brogniez, Rue Rossini, Rue Bara, Rue de l'Instruction

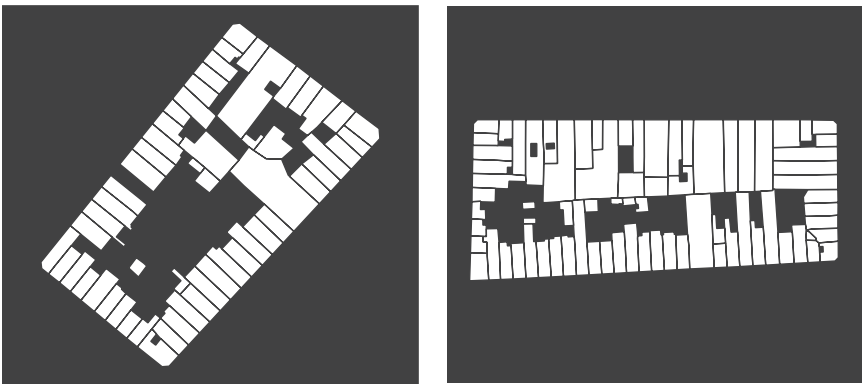


Type D is the least common because it consists of a few large buildings on an otherwise undeveloped site. Examples are the abattoir site or the block around the secondary schools. The buildings in these blocks are relatively new and some have been recently renovated. All the examples are very different from each other in terms of function and layout. What they all have in common is that the buildings are quite tall with a lot of unbuilt space around them in the form of car parks, green spaces or even a football pitch.

This type of urban fabric has the highest energy potential. Although there is a very high energy demand due to energy-intensive activities or the high residential buildings, there are large areas on the roofs to install solar PV systems. Together with the large unbuilt areas, this offers a powerful combination as an integrated system of solar plus ground source heat pumps that could supply excess heat to the neighbourhood. The abattoir is already leading by example and the other cases could follow suit. One obstacle is that some of the sites are publicly owned and may not have much financial leverage. However, the area around the Midi station could become another powerhouse if energy were to become a major element of the current development plan under the PAD Midi.

TYPE A
01 08

04
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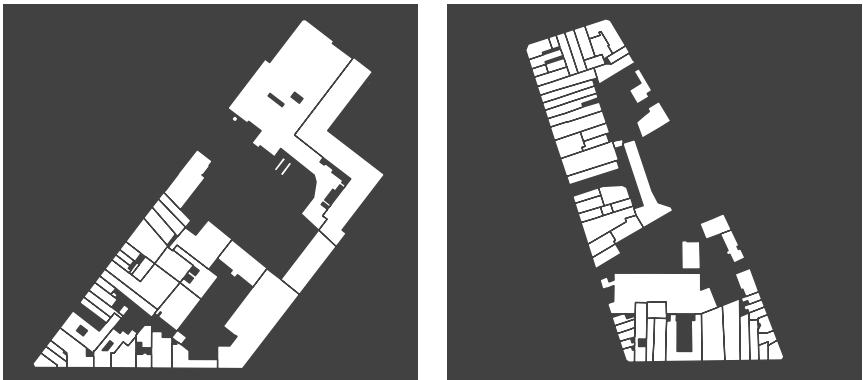


TYPE B
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02 09
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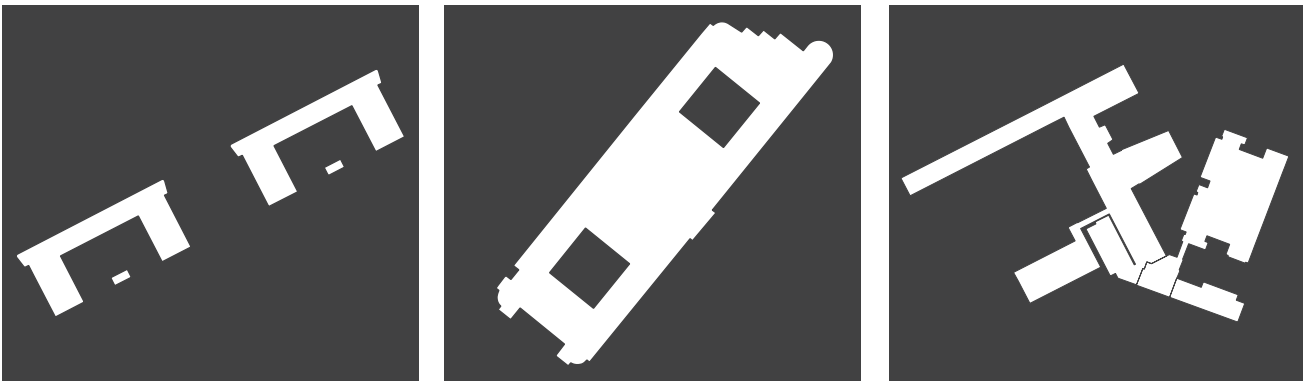
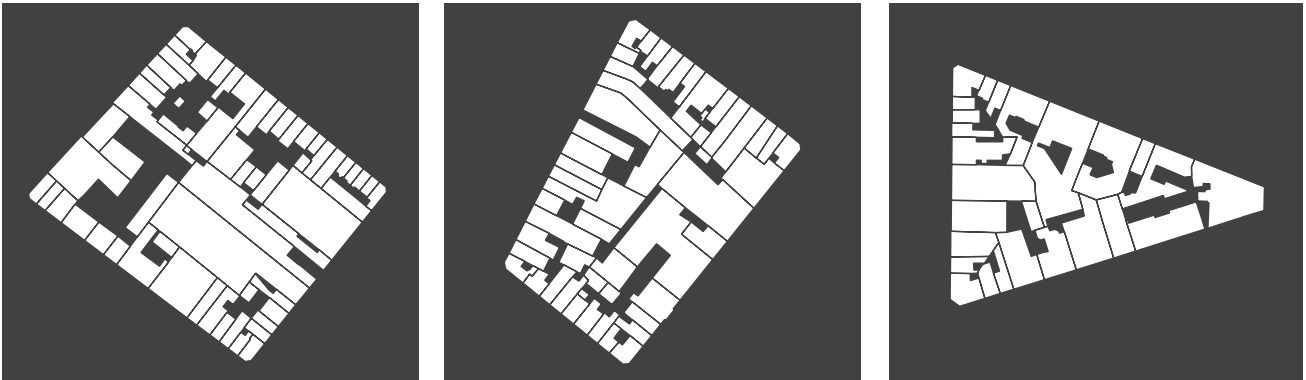
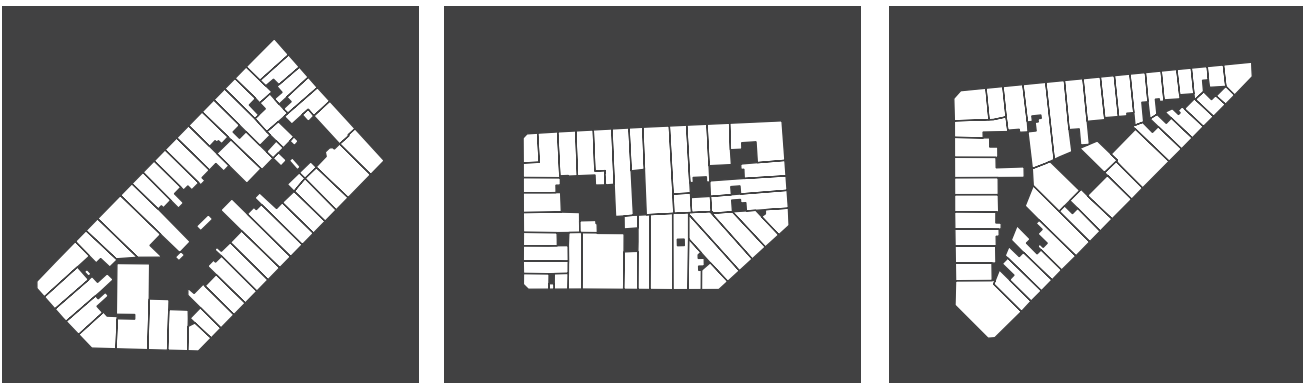
TYPE C
08
02

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06
07



TYPE D

11
12
13







Doubts on progress and technology

Kris DeDecker is a science journalist and the founder of *Low-tech Magazine*, an online publication dedicated to exploring how past technologies and simpler solutions can address contemporary sustainability challenges, advocating for a critical reassessment of technological progress and its environmental impact.

JG Jonas Görgen
KDD Kris De Decker

JG You experiment a lot with producing energy yourself with solar panels on your balcony or a self-built bike generator. Can you imagine an energy positive city?

KDD If everyone lived in a villa, each family could easily install enough solar panels on their roof to meet their needs. The problem is once you start piling people into apartment buildings, your roof area remains the same but demand of course increases with each floor. So in that respect it seems to me that it is actually a concept that simply cannot work. Unless you spread the population and build a kind of Los Angeles. That is possible, but then you of course have other problems, when you are too far apart for public transport and the like.

JG But there seems to be a consensus that we can produce enough heat locally, even in the city, using heatpumps and geothermal probes for example.

KDD So yes, the heat pump can indeed extract heat from the ground but it needs electricity and where does that electricity come from? You immediately see the same problem. The difference between winter and summer in Belgium for a solar panel is enormous, that is a factor of ten or twelve. This cannot come from the solar panels on the roof, so when you need the energy for your heating, it is simply not there.

JG Another potential that's often discussed is combining heatpumps with biomass in a district heat network.

KDD [laughs] Ah interesting, I thought you were no longer allowed to light a fire in Belgium. But jokes aside, you still have to build a double infrastructure that will

cost resources and energy. There are of course very good examples, especially in the former Eastern Bloc countries or Berlin, that district heating is a great idea. But you still need a heat source. In the Netherlands, they want to build heat networks using the excess heat from a petrol refinery – surely it can't be our intention that we are going to heat homes with petrol.

[pause]

What is problematic for me is the idea that a city can exist by itself. A city is always dependent on the countryside and the larger the city, the larger the hinterland it depends on, whether it is food or energy. It has always been this way. As long as we don't question our energy intensive lifestyle, this idea of energy positive cities just seems like a total fantasy to me, especially in a city like Brussels.

JG You mentioned the relationship between city and its hinterland. How is that still relevant today?

KDD When a city was under siege, the attackers usually did not shoot it to pieces, they simply surrounded the city and waited until it surrendered. Because as soon as you surrounded a city, there was no more food available, no firewood or peat. Nothing more can get in and so the city just dies. I wrote an article in 2011 about the history of peat cutting in the Netherlands where I describe how the entire country was actually raised and a whole network of canals and peat areas were created to run those industrial centers in Amsterdam and the like. You might think that Amsterdam back then was a gigantic Powerhouse, but actually the whole country was involved. And that is still the case today in the Netherlands: In order to provide the Randstad with energy, people's houses are falling apart in the north of the country. [editors note: from natural gas extraction] It's a bit like this whole idea of urban

agriculture with vertical farming in a residential tower in order to become independent of the countryside. Firstly, you would need a lot of those vertical farms to feed a larger population. And secondly, you also need energy to make that vertical farm work and where are you going to get that energy from? So then you need extra solar panels and where are they going to be located? Not in the city, so you'd build them in the countryside. But then why are you moving agriculture from the countryside to the city?

JG One argument is, that you only need to build the infrastructure once and then it's there. Once you install the solar panels and wind turbines, they keep producing energy.

KDD Yes, but that is not entirely true either, because those things do not have eternal lives. You'll have to replace those systems within 20 or 30 years. So you will first invest a lot of CO₂ etc, inject it into the air and then count on it giving a net result in the long term? That is for me the problem with the whole approach to sustainability. All solutions are: let's build a gigantic amount of metal and concrete infrastructure that will perhaps provide an advantage in 40 years. I do think that there is a certain urgency here to act and this way we are actually making things worse.

JG So we are forgetting to look at the full lifecycle costs of our current approach?

KDD It is quite typical not to talk about that at all, just like with the electric car. Fortunately, there is now a little more nuance, but in the first years it was just assumed emissions: zero. That is of course not true because on the one hand you have the emissions of electricity and on the other hand the emissions to produce the 500 kilogram battery that you need to replace every ten years. So you're just basically playing around with statistics. For the bureaucracy it is then solved. But in reality, of course, nothing has changed. What happens is just the emissions shift from one category to another and it also shifts to another country. Which of course is great for the carbon accounting of Belgium, because electric cars, batteries and solar panels are not produced in Belgium,

the lithium is not extracted in Belgium. They are not solutions in the sense that they really make a contribution to reducing greenhouse gas emissions, they are solutions in the sense that on paper it seems as if you are doing something about it. Whether a car runs on electricity or fuel, the fundamentally unsustainable thing about a car is that you use 2000 kilograms of steel to get a 75 kilo person from one place to another.

JG How do you translate this example of moving people to heating a home?

KDD We have to look critically at the entire way of heating and start warming people instead of spaces. That is with thermal underwear, with hot water bottles, building smaller rooms in your room in which you retreat in the winter. These are all ways in which you can immediately reduce heating consumption by a factor of ten to 100. And then you can of course still say, oh, now we can try make it energy positive. But first you have to drastically reduce energy consumption and therefore question all those modern habits.

JG Where does frugality end for you and energy poverty begin?

KDD One is voluntary and the other is not. What happens in rich countries is that even the poor live beyond their means in terms of energy consumption and emissions, but often because they need a car, for example. Especially in Belgium in places where public transport does not work on your side, you need a car to earn money in order to be able to pay for fuel and so on. And if you don't have a car, then you don't have a job either. There was a recent article in the Guardian that many Americans can no longer afford a car. And in America that really is a fundamental problem, because then you don't go anywhere. So people are forced to use a lot of fuel and then you can say: that is unsustainable, but they actually have no other choice.

JG What would you tell a family living in an old, uninsulated building with mould that makes them sick – to buy a hot water bottle?

KDD Of course not. But *You* want to make Brussels energy positive. My point is not that you shouldn't heat your house, but you won't necessarily find that energy in the city. In the Belgian climate where there is also a lot of humidity you need heating, otherwise you will have mold in your house, which is unhealthy. So my proposal, what I also wrote in a book about heating, is that in countries like Belgium you use central heating to maintain a kind of minimum background temperature of roughly between twelve and sixteen degrees, depending on the person. And then you create micro climates in the house with different places where it is warmer, where you can sit still. That can be done, for example, with a heated carpet or woollen blanket and so on – there are many possibilities.

So in any case, you will need a minimum of heating in Belgium, but you won't get the energy from within the city. You could take it from biomass instead of fossil fuel, but the biomass doesn't grow in the city, there is not enough space. So again, you are starting to ruin the whole idea because the forests where the biomass comes from are probably on the other side of the world. My article about coppiced woods illustrates this very well, where you see how cities were historically dependant on the countryside and that there was a maximal distance from where you could get fire wood, due to lack of good transportation, which was about 25 kilometres. Further than that it was pointless because the energy needed for transport became too big. So in fact, the city was surrounded by forests and coppiced woods within 20-25 kilometres. This way, the energy demand and supply was always in balance, because as a community you knew: if we chop more wood this year than we actually can, then next year we won't have enough.

You always have to import energy from the countryside. And certainly when it comes to heating, because ultimately that is the largest chunk of energy consumption.

JG According to La Pile, a local organisation, if we would put solar panels on every roof, we could provide for 60% of our electricity needs.

KDD Yes, as we've already discussed, when the sun shines, you do indeed have energy. But what do you do when the sun doesn't shine? When it's cloudy, the solar panel doesn't work. Well, a little still comes out, but it's certainly not enough to heat a home. And secondly, when does the sun shine: in the summer. Because the days are longer, the sun is higher, there is less clouds, so then you have ten to twelve times more solar energy in Belgium than in the winter. But in the winter you need the heating. In Spain it works, because you still have a lot of sun in the winter. But the whole idea in Belgium, to run heating on solar energy is just totally absurd. It just doesn't work. What works much better in a country like Belgium is to heat with wind power because the wind blows mainly in the winter so there is more energy in the winter than in the summer. But where are you going to put those wind turbines? You cannot put them in the city by definition, because that is not possible. You cannot live between wind turbines, so again, it is perfectly possible to put a few large windmills to produce energy to heat the city, but you have to put them outside the city.

JG Another argument is, that it only make sense to heat with renewables if the energy does not disappear through windows and doors. What do you think about this?

KDD That is the idea that you have to insulate your house. I have a different opinion there, I think that it is much more efficient to insulate people instead of the house. In the case of Belgium, where you also have to deal with more humidity, it is of course a compromise between the two. You do have to heat your house to some extent and I am not against insulation. It is just very easy to say, we are going to insulate, but for a lot of buildings, insulating afterwards is particularly complex and expensive whilst the benefits are rather small. For example, with triple glazing you first have to invest not just a lot of money, but also energy and materials, and therefore a lot of greenhouse gas emissions before you can in theory begin

to reduce emissions in the long term. But there is research from the Netherlands that shows that this is only the case for some households. So from a list of all different interventions that you can do, none of those measures are financially and energetically viable for any type of household, and some only for less than a third of all households. Why? Because it costs too much investment in energy and money and the energy savings are limited in comparison. There simply is a lot of old architecture, and – I hope – you cannot just demolish the whole of Brussels and then build very well insulated buildings. And you cannot just re-insulate those old buildings to bring them to the level of efficiency that we now want all buildings to be. You make it so expensive for people to buy a building, that ultimately a house becomes something for the very rich and if it continues like this, no one can afford a house anymore.

JG You're addressing another issue that interests me, which is eco-gentrification.

KDD I have not heard the term yet, but it sums it up pretty well. We come up with solutions that only the rich can afford. That is also a discussion we had in Rotterdam with the government and the social housing company and their vision is just a classic high-tech story. But it is also the poorest district of the Netherlands, Bospolder Tussendijken, so how are they going to pay for that? The social housing companies themselves do not want to pay. So you have a population that has no money at all, and then you come with heat pumps, electric cars and solar panels, that cost an arm and a leg. I mean, you don't even have to be very poor. Even an ordinary dual-income couple, they won't be able to afford it either. That's the High-tech vision, and you see that happening with cars too, for example. By switching to electric cars we're making the car an exclusivity for the rich and that doesn't seem very fair to me. It's a way to solve the problem in the sense that you're reducing car use, but at the same time you're kind of back in feudal times.

JG How much does this social aspect of the energy transition matter according to you?

KDD I think that it is essential. If you

already see how in a country like Belgium – one of the richest countries in the world – that most people cannot afford an electric car or an energy-neutral home, how are you going to do it on a global level? This high-tech approach simply doesn't work, A, because you have to invest too much energy in infrastructure to really achieve meaningful savings in a reasonable period of time. And B, because it is a completely anti-social measure.

JG But at the same time, the social aspect is also an argument *for* building renovation, that despite the performance gap, people have a right to a heated and healthy home.

KDD Yes, of course. But, I mean, the reality is not necessarily very attractive. So coming back to the question of: what is the difference between energy poverty and frugal living? Well, they are close together, only one is voluntary, the other is not. I once went to Finland for a report on the wooden buildings there. In the 70s they started to insulate them all and a few years later they had a huge problem with mould and an unhealthy indoor climate. How are you going to solve that? So I interviewed an architect there and they said: yes, you should just leave them open, the wind has to blow through them, and then you don't have mold. But how can you expect people to sit in a draughty house? You know, the fundamental problem is that we used to be physically active all day and also in Finland – where of course it's mostly cold – people were working outside all the time, in the woods or in the fields, and then you come inside and the fact that you're just sitting in a house, even though it's draughty and cold there, is just because you've been physically active all day you don't get cold. And the reason that we as modern people are so dependent on artificial heating is of course that we don't move at all anymore. We just sit all day, and that also applies to poor people nowadays. We sit in front of the TV or in front of our smartphone or computers. Yes, then you need heat, of course, because you're not doing anything. So, the whole context has changed.

This is something we considered in our scenario for Rotterdam: if everything would be human powered, the whole population is

active during the day and wouldn't need heating when no one is home. The whole office culture is also just a side-effect of a global scale industrial complex. If you organise it more locally, you won't need all that office work anymore – why would anyone want to sit around typing on a laptop? We are now trying to make our lives more sustainable whilst the whole lifestyle is in its essence unsustainable and cannot be continued like that. As long as you stay within this system, it's impossible to find a solution. And that is of course the biggest challenge and the reason why our efforts won't work after all.

JG You also wrote an article about energy security with the title: 'Keeping some of the lights on'. Do you think energy resilience is perhaps a better framing than energy positive?

KDD Yes, it's much more interesting because to make the society more energy-resilient means you're looking at energy production but even more so at the energy demand. If there was a black-out right now in Brussels, that would be a gigantic disaster, everyone may be dead within a week probably. [laughs]

JG It's true, I couldn't believe that the door to my apartment building wouldn't work anymore the other day when there was a power cut.

KDD Yes, and this is something where we have to say, we want to build a society that isn't completely dependent on uninterrupted electricity. It seems silly, but the automatic door is actually a great example, because you will only see that in a country where electricity is always 100% available. No one in a country where this isn't normal would be stupid enough to place an automatic door. But most people here, except some elderly, have no clue anymore how life could be without electricity. So in this sense it's a lost cause already, because who even still knows how to wash clothes without a washing machine.

That's why there is so much inspiration in the past, because back then there was no abundance of energy, so per definition, everything before about 1850 was extremely efficient. Even with computers, in the beginnings of the internet, everyone built very efficient websites because the connec-

tions and processors were slow. But since we have unlimited internet connections that work 24/7, we got a whole lot of applications and websites that simply won't work if energy isn't available in this amount anymore. And it's not like the internet would have to vanish with less energy, we would just have to built it differently, and the same goes for everything from heating to transport.

01.02.2024, online





VI On Efficiency

Energy systems are evaluated using a variety of metrics, and overall system efficiency is a common test point. An incandescent light bulb powered by a coal-fired power station a hundred miles away will have a lower system efficiency than solar panels powering an LED light. Improving efficiency is one of the main tropes of electrification that accompanies the energy transition. Critics of the energy transition often point to the huge gap between renewable energy produced and primary energy consumed. But, as discussed in chapter 2, this can be misleading as electrical processes often require far less energy, effectively reducing primary energy demand. Electric engines, electric arc furnaces or heat pumps are all superior to their fossil fueled counterparts in terms of efficiency.

While energy efficiency is one of the main pillars of energy policy, there are some pitfalls associated with increasing it. Economist and logician William Stanley Jevons observed in the 19th century that technological improvements in the efficiency of resource use can lead to increased overall consumption of that resource. The extent of this so called rebound effect is still very much debated, with some seeing energy efficiency as a fundamentally flawed concept (Shove, 2017) whilst others argue its effects are overstated (Gillingham et al., 2016) and may be used as an excuse for inaction.

The answer may lie somewhere in the middle, with rebound effects varying from case to case. In the context of buildings and space heating, rebound effects from improved insulation are well documented. This is sometimes referred to as the performance gap, where the predicted savings from efficiency improvements don't materialise in real conditions. This is discussed in Chapter 4 below.

Similar phenomena can be observed in other sectors. Efficiency gains in internal combustion engines have not been matched by savings, as the US Environmental Protection Agency (EPA) noted in a 2023 report: while CO₂ emissions per vehicle type

are at record lows, “long-term market shifts away from cars and toward sport utility vehicles (SUVs) have offset some of the fleet-wide benefits”.

In other words, as heavier vehicles become more efficient and therefore more affordable to own, more people seem to opt for them. The list of examples is long: bigger televisions thanks to LED technology, bigger or multiple refrigerators as their individual energy consumption has become negligible, exponential growth in aviation emissions despite huge efficiency gains in jet engine design. Searching for the precise reasons beyond rebound effects can involve a lot of speculation about motives, but the bottom line is that increasing efficiency does not guarantee a corresponding reduction in energy demand. Yet this is what current energy policies, such as the Brussels renovation programme Renovation, are based on. More caution is needed when considering efficiency gains, as the long-term results are counter-intuitive and have proven to be unpredictable.

4 The PED Predicament

Producing renewable energy in cities to reduce dependence on fossil fuels poses something of a paradox, as wind and solar energy are much more diluted than concentrated fossil fuels. Nor does a hydroelectric dam work well in an urban setting. Biomass has been used to produce heat (and later some electricity) since the dawn of cities, but the fuel always has to come from outside, because there is obviously not enough space to grow so many plants and trees in the city. Nuclear power is a different kind of low-carbon energy source, and according to the IPCC (2023) will play a significant role in reducing CO2 emissions, but nuclear power plants are usually built far from densely populated areas to minimise the risks in the event of an accident. Atomic power has the advantage of unrivalled energy density, which means that no other energy source has a smaller footprint in terms of space and raw materials needed to produce a kilowatt hour. While fuel elements can last for years before they need to be replaced, they also require the use of finite resources from distant countries. So-called Small Medium Reactors (SMRs) could enable nuclear power in more densely populated areas thanks to their inherently lower risks, but despite their advantages, Mignacca et al. (2020) conclude that the technology has received very limited investment to date and will therefore not be relevant for the immediate decarbonisation needed today.

Besides reducing carbon emissions, producing energy locally can have other benefits, such as shrinking grid infrastructure, improving grid resilience¹ and promoting social cohesion (Kammen & Sunter, 2016). Which type of energy system configuration is ultimately most effective is one of the key questions for creating Positive Energy Districts (Sareen et al., 2022) and is best determined according to the individual characteristics of the area (J. Blondeau. Personal communication, 16 November 2023). As space remains the ultimate limit to energy production in the city, we will take a closer look at each renewable energy source and discuss its potential in the context of an energy transition in Cureghem. In analysing the energy potential, we have to look beyond the technical challenges to other limiting factors. We also take a critical look at the social implications of implementing a PED in a context like Cureghem, an aspect that is increasingly present in today's discourse.

1 Although this is true in theory, while solar power can contribute to a more resilient energy system, standard inverters (which convert DC power from the panels into grid-compatible AC power) are not designed to keep homes powered in the event of a blackout. Special back-up inverters are needed to keep the power flowing to the home when the grid connection is lost. SWECO. (2023). Solar energy resilience. Retrieved March 8, 2024, from https://www.sweco.co.uk/wp-content/uploads/sites/19/2023/06/Report_Solar-energy-resilience_Urban-In-sight-by-Sweco-1.pdf

WIND

Electricity from wind is generated by blades spinning either horizontally or vertically around a generator axle. Like solar power, the output is variable depending on the weather and season. A cloudy and windy country like Belgium lends itself well to wind power² and the seasonally strong output in winter makes it a good companion for solar power within a system. Whilst wind turbines themselves take up little space on the ground, they still have a significant spatial footprint, as the surrounding needs to be free of obstacles and minimum distances are required between individual turbines. Their visual impact and noise make them a disliked neighbour.³

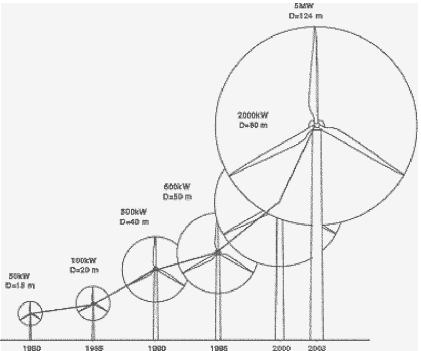
Urban environments are particularly challenging for generating energy from wind, as buildings create turbulences and suitable space is scarce (Kammen & Sunter, 2016). Vertical Axis Wind Turbines (VAWTs) are considered more suitable for cities as they can better handle erratic winds than their horizontal axis cousins. However, the power output of wind turbines increases exponentially with the blade diameter.⁴ This means smaller turbines have a significantly lower power output and will take longer to offset production emissions.⁵ As a result, commercially available micro wind turbines barely deliver enough energy to power a light bulb. In urban areas, they actually produce less energy than it takes to make them, and their economic return on investment is much longer than they're expected to last (De Decker, 2008). There are commercially available installations of VAWTs combined with Solar Panels designed to be installed on rooftops of tall buildings, but their lifecycle emissions have yet to be put under closer scrutiny. With its dense population, building morphology and geographic location, "wind energy does not seem to be an interesting option for Cureghem" (Prof. Marc Runacres, VUB, personal communication, Nov 5, 2023).

SUN

While almost all energy sources on Earth are essentially converted sunlight, solar panels use the radiation from our nearest star directly to generate heat or electricity. Solar water heaters come in flat versions or as an array of evacuated glass tubes, where a liquid in a vacuum absorbs the sun's thermal energy. These so-called evacuated tube collectors have several advantages over their flat counterparts. They are more effective in bad weather conditions and are less affected by ambient temperature, thanks to the built-in vacuum. Ayompe and Duffy (2013) found an overall system efficiency of 52% in a field trial in Dublin, Ireland. Modern photovoltaic panels are capable of converting around 20% of sunlight into electricity (this doesn't take into account power conversion and transmission losses, so the overall system efficiency will be lower than this). But thanks to the versatility of electricity and the higher returns on investment, solar PV has become the standard choice over solar thermal collectors. Another disadvantage of solar thermal systems is that they don't usually come as a stand-alone system and require a hot water storage tank and an additional hot water boiler to achieve the desired final temperature. In the Belgian climate, most hot water is produced in the summer months, when it is least needed, without seasonal storage. These factors make solar thermal collectors rather unattractive for households in Cureghem's

2 Windmills were a main source of kinetic energy throughout centuries in Flanders alongside other types of mills. Centrum Agrarische Geschiedenis (CAG). (2011). *Een slag van de molen. Erfgoedbakens in ons landschap*. Retrieved March 8, 2024, from <https://cagnet.be/page/slag-van-de-molen>

3 Environmental organisations recommend engaging with residents early in the planning process, ensuring fair distribution of benefits and burdens, and encouraging financial participation in the projects to (re-)gain community support for wind turbine projects in Flanders. Grietens, E. (2023, February 6). *Windmolens met draagvlak: Het kan*. Bond Beter Leefmilieu. Retrieved March 8, 2024, from <https://www.bondbeterleefmilieu.be/artikel/windmolens-met-draagvlak-het-kan>



4 The power yield of a windturbine built in 2003 with a diameter of 124 metres is 100 times higher than a 15 m rotor diameter turbine from 1980. This physical principle puts smaller turbines at great economic disadvantages. Figure retrieved from: Tarfaoui, M., Nachtane, M., Khadimallah, H., & Saïfaoui, D. (2017). Simulation of Mechanical Behavior and Damage of a Large Composite Wind Turbine Blade under Critical Loads. *Applied Composite Materials*, 25(2), 237–254. <https://doi.org/10.1007/s10443-017-9612-x>

dense urban morphology and climate. High system efficiency and a smaller material footprint could, however, be a good argument for application on specific sites in Cureghem that have a constant demand for heated water, such as the future public swimming pool on the abattoir site or the high-rise blocks in the Vétérinaire district.

Looking at the current installed capacity (see chapter 3), photovoltaic panels are clearly the preferred technology in Cureghem. They are easier to install than their solar thermal counterparts and don't require any additional equipment apart from the inverter, which converts the direct current from the panels into grid-compatible alternating current. According to the *Carte Solaire*, a web tool of Bruxelles Environnement⁵, almost every building has an economic incentive to be equipped with solar PV panels. By selecting a plot on the digital map, the tool provides an estimate of the potential costs and savings that could be achieved with the available roof area. As discussed in chapter 3, solar PV is already installed on many roofs in Cureghem, most notably on the abattoir site, which has now covered almost all of its suitable roof area with solar panels. However, the vast majority of roofs in Cureghem are still bare, leaving a chunk of the neighbourhood's energy potential untapped. We will discuss the socio-economic factors influencing the deployment rate further in this chapter.

Both wind and solar represent a trade-off, avoiding direct emissions but requiring more material inputs per kilowatt-hour than conventional power plants. There are also emissions associated with the production of the solar panels, wind turbines, electrical converters, batteries, transformers and power lines needed for a 100% renewable grid. The carbon intensity of PV power will therefore vary depending on the grid emissions where it is produced and where it is installed. A solar panel produced in China, with its high share of coal in the electricity mix, and installed in cloudy Belgium will have higher emissions per kilowatt-hour of electricity produced than a solar panel produced in Sweden, using hydropower, and installed in Spain. The energy transition will require vast quantities of materials such as copper and steel, but also rarer elements such as lithium, manganese, nickel, graphite, cobalt and the group of so-called 'rare earths' such as neodymium (which, despite their name, aren't necessarily rarer than other elements).⁶ The big bet is that these minerals, once mined, can be reused virtually forever,⁷ while critics fret about the uncertainty of this gamble in the face of the need for urgent action (see interview with Kris De Decker, 2024).

While renewables promise energy independence, the material infrastructure they require introduces another layer of dependency. In recent years, China has become the dominant player in the production of solar PV modules. In 2022, it produced 2.5 times more PV modules than the rest of the world combined, according to a special report by the International Energy Agency (2022a). They also found an increasing concentration in the processing of raw minerals used in solar PV manufacturing, stating that "China significantly dominates every single segment of the solar PV supply chain" (p. 17). More than three-quarters of the modules installed in Europe come from China, a quarter from the Asia-Pacific region, with insignificant amounts produced in Europe itself (p31). Efforts

5 Bruxelles Environnement. (2024). Carte Solaire. Retrieved March 8, 2024, from <https://geodata.environnement.brussels/client/solar/>

6 Clean tech such from wind turbines to electric vehicles rely on a range of critical minerals for their components. "Demand for these minerals is growing quickly as clean energy transitions gather pace." Critical Minerals. (2024). International Energy Agency – IEA. Retrieved August 2, 2024, from <https://www.iea.org/topics/critical-minerals>

7 "As long as battery energy density improves by 10% every 15 years – and remember it doubled in the past decade – your initial battery minerals will continue providing the same storage services forever." BloombergNEF. (2024, February 23). Liebreich: Net zero will be harder than you think – and easier. Part II: easier | BloombergNEF. BloombergNEF. Retrieved July 30, 2024, from <https://about.bnef.com/blog/liebreich-net-zero-will-be-harder-than-you-think-and-easier-part-ii-easier/>

to reverse this trend will be difficult as projects to increase production of critical minerals in Europe face stiff resistance.⁸ Nevertheless, the importance of solar PV should not be diminished as expanding PV capacity still has a very positive effect according to a review of production factors by Bošnjaković et al. (2023).

AIR AND SOIL

Solar PV can be particularly effective when combined with a heat pump. Similar to a refrigerator, electricity powers a compressor that moves refrigerant, a mixture of chemicals that can quickly change between liquid and solid form, through a closed circuit. Rather than converting the electricity directly into heat or cold, some of the energy is transferred from the ambient temperature⁹ from one side of the circuit to the other. Because the heat (or cold) is merely 'transported' rather than generated, heat pumps are able to deliver more watt-hours of heat than the watt-hours of electricity expended (IEA, 2022). The ratio of useful energy produced to energy input is measured as the Coefficient of Performance (COP) – the higher the COP, the more efficient the overall heat pump system. Depending on the ambient temperature, heat pumps typically achieve COPs of 4 or higher, meaning that for every kilowatt hour of electricity used, 4 or more kilowatt hours of heat are delivered. Similar to other low-carbon-technology, Naumann et al (2022) found that heat pumps performed worse in terms of emissions than a gas condensing boiler on 7 out of 11 points, but their overall carbon intensity was still 70% lower.

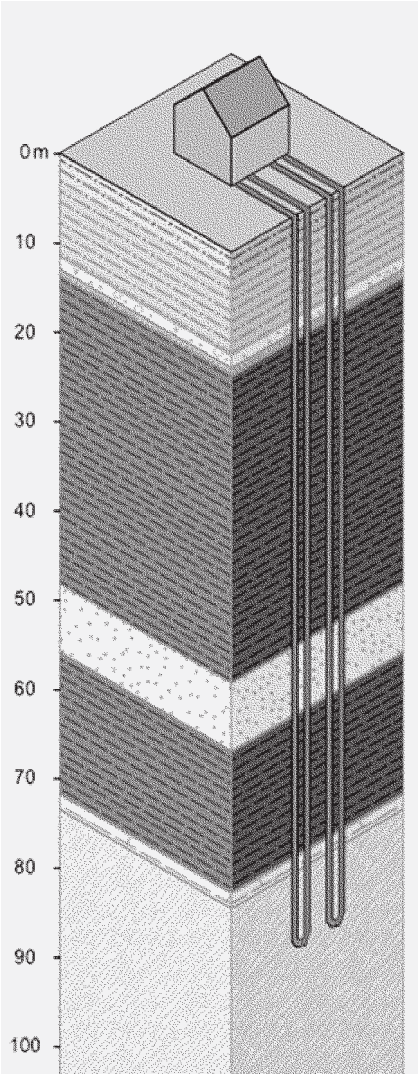
In their simplest form, heat pumps extract energy from the ambient air in a similar way to an air conditioner, but can also be set up to use the less volatile groundwater or soil temperature.¹⁰ Ground source heat pumps have the great advantage of being able to provide a certain amount of seasonal storage. The heat pump mechanism works in both directions and can provide both heating and cooling. In the warmer months, the ground can absorb heat from cooling the interior, making heating more efficient in winter. However, this requires a deep borehole or a large network of buried pipes, which makes the method more expensive and space-consuming. This means that ground-source heat pumps will not be an option for most households in Cureghem, where the urban fabric is dense and most residential blocks are fully developed. A novel but promising option could be to use public spaces for drilling boreholes, such as football pitches, car parks and even under streets (Architecture Workroom Brussels, 2023). While this can be a catalyst for a bottom-up energy transition, there are major legal vacuums regarding this kind of use of public space (H. Mangelschots, personal communication, 26.01.2024). Cureghem has many such promising locations on public land and would hugely benefit from new legal arrangements that would make it possible to exploit them. Some of the most interesting options are using the canal's water, the river Senne or the large football pitch surrounded by a residential neighbourhood.

→ A geological analysis to determine the feasibility of creating a ground-source heat pump system with a closed circuit for an address in the Rosée quarter in Cureghem. In this analysis, the borehole would have a depth of 80m. Bruxelles Environnement. (2022, May). BrugeoTool. Retrieved April 12, 2024, from <https://environnement.brussels/brugeotool>

8 "An agreement to supply the EU with critical raw materials has triggered a wave of protest across Serbia." Hodgson, R. (2024, July 31). Serbia: Fresh protests threaten EU-backed lithium mining plan. Euronews. <https://www.euronews.com/my-europe/2024/07/31/serbia-fresh-protests-threaten-eu-backed-lithium-mining-plan>

9 "Physically, heat energy is present whenever the temperature is above absolute zero (at 0 Kelvin or -273 °C)." (IEA, 2022b, p. 18)

10 Sometimes the term 'geothermal' is used to describe ground or water source heat pumps, which can be misleading as geothermal also refers to the use of heat from the earth's crust. OECD/IEA. (2010). Renewable Energy Essentials: Geothermal. In IEA. Retrieved August 2, 2024, from <https://www.iea.org/reports/renewable-energy-essentials-geothermal>



DEMAND AND STORAGE

The biggest remaining challenge for solar (and wind) energy is its inherent intermittency and seasonal variability. This is well illustrated by this simulation of a PV system installed on an average house in Cureghem. Although the expected annual production of this building would be almost twice the average consumption of a single household, it would not be enough to meet the energy demand due to the mismatch between the times when solar energy is available and the energy demand (see also Energy Demand Profiles, Chapter 1). As a result, only 36% of the energy produced is actually consumed by the household (about two-thirds of the estimated total consumption). It could be argued that this isn't generally a problem, as the remaining energy is not lost but simply fed into the grid, and if the remaining over-consumption is eliminated through efficiency measures or demand reduction, decarbonisation is complete. However, the rate of self-consumption is an average and will vary greatly depending on the season¹¹. In practice, the greatly reduced output of solar panels during the winter months would need to be compensated by other sources, which could significantly increase the embedded emissions of the energy system due to the additional infrastructure required. This somewhat undermines the very idea of decentralising and democratising power supply, if in the end the system relies on international grid connections and off-shore wind parks at critical moments despite an overall positive energy balance.

There are two possibilities to increase the rate of self consumption. One is to reduce demand at times when no power is available, which we will discuss further in this chapter. This is in fact how humanity has operated until the industrial revolution, where the economy functioned in sync with the available energy, such as windmills, sail boats, preserving food, salt production, etc. The other option is to increase the amount of power storage to increase flexibility. This can be in the form of batteries, however those are at least for now too expensive and their ecological footprint is far higher than solar panels, dragging down the carbon-intensity of the whole system. There are simpler solutions, some of which are already commonly used, such as hot water reservoirs (interview J. Blondeau, 2024). They can store hot water produced when local energy is available to provide it at a later point in time. There are also other low-tech options, such as compressed air storage, but those haven't enjoyed much attention yet and have a bigger spatial footprint, making them more suitable for industrial applications.¹²

BIOMASS

In an energy grid with a high proportion of variable energy from wind and solar power, a flexible and reliable energy supply is very valuable. Biomass is a collective term for organic matter that can be burned to produce heat and electricity. It usually comes in the form of wood chips or biogas from food or agricultural waste. There are also biofuels made from oleaginous plants or leftover cooking oil, but these are generally intended for



↑ Calculation of the solar potential of a common building type according to the *Carte Solaire* tool of Bruxelles Environnement

Total roof area	90 m ²
Suitable surface area	35 m ²
Expected annual production	3.678 kWh
Average household consumption	2.036 kWh
Rate of self-consumption	36 %

11 Brussels gets on average 2 hours of sun in winter compared to 6,6 hours in summer. KMI. *Klimaatatlas*. Retrieved April 12, 2024, from <https://www.meteo.be/nl/klimaat/klimaat-van-belgie/klimaatatlas/klimaatkaarten/zonnestraling/zonneschijnduur/winter>

12 When using the physical effects where air heats up when compressed and cools down when de-compressed, these systems can achieve extraordinary efficiencies using simple components and materials. De Decker, K. (2018, May 16). Ditch the batteries: Off-Grid compressed air energy storage. *LOW<TECH MAGAZINE*. Retrieved August 2, 2024, from <https://solar.lowtechmagazine.com/2018/05/ditch-the-batteries-off-grid-compressed-air-energy-storage/>

vehicles, not for power generation. Burning biomass does emit CO₂, but it can be considered carbon neutral if the wood or raw material comes from a sustainably managed source. This is a complex issue and in fact the whole definition of whether biomass should be considered sustainable depends on how the source of the organic material is managed. The distance from where the organic material comes from is another important factor in the overall sustainability of biomass energy.

There remain several problems with biomass as an energy source. It has a low energy density compared to fossil fuels, so larger volumes need to be transported. This can make logistics more challenging, especially for larger installations, which require suitable infrastructure such as a canal, railway or major road.¹³

Another issue is that biomass combustion produces other types of emissions in addition to CO₂ that need to be managed, the most critical being particulate matter. This is important, especially in residential areas, to minimise health risks to residents and children. Fortunately, there have been advances in filtration technology that can eliminate most of the harmful effects (interview J. Blondeau, 2024). This is also an advantage of centralised district heating infrastructure, where these factors can be effectively managed and filters easily maintained.

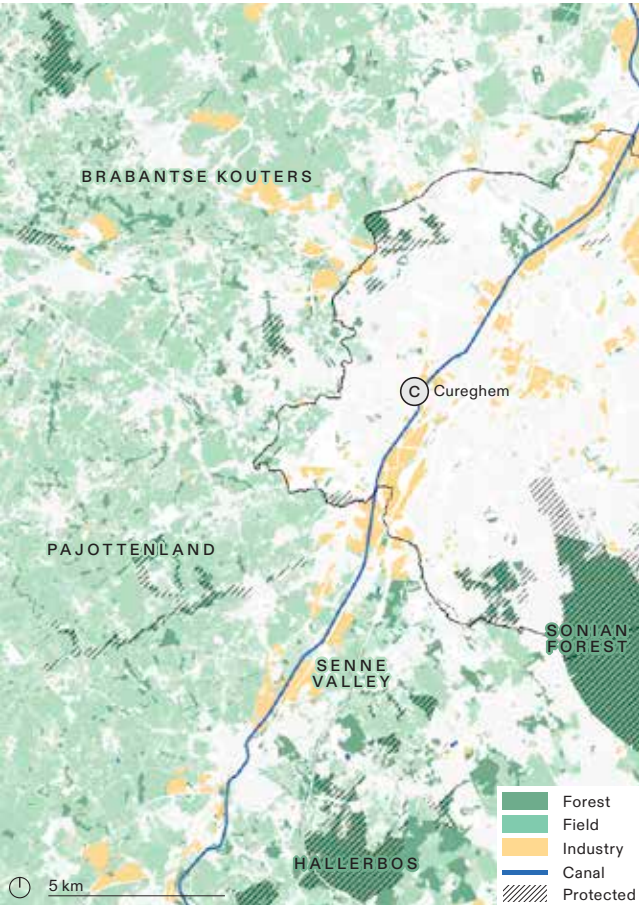
Biomass, as a form of dispatchable energy that delivers regardless of weather conditions, is useful for filling supply gaps and stabilising the grid. However, the availability of sustainable biomass is very limited and therefore, according to Blondeau, it cannot make up a large part of the energy mix, with around 10% being a useful addition. This is also a problem for its use in Cureghem, as the area around Brussels is very urbanised and consists mainly of agricultural land or protected nature areas. If this supply problem could be solved, for example by identifying and contracting with producers close to Brussels who can produce biomass from hedges and coppices in agricultural areas, this could be a very interesting option for Cureghem, as the canal and road infrastructure provides good access to the nearest countryside of the Senne valley or the Pajottenland.

Biomass – but where?

There is little available biomass around Brussels as the area within a 25 km radius has practically no forests that aren't protected nature. The dominating land use is agriculture, which does offer some potential to produce biomass if coppiced hedgerows, a technique common until the 20th century, were to be reintroduced widely.

Spatial data: OpenStreetMap contributors, 2024
Processed by the author

13 M. Mietz' master thesis is a fascinating read about the challenges of biomass logistics. It investigates the fuel economy of roman bathhouses, which, despite being symbols of wastefulness, were probably fuelled by sustainably grown local wood, agricultural waste and other leftovers. It was unlikely they would have used imported wood or coal following a "rationale" that the pre-modern economy was an organic economy, trying to capture as much energy as possible instead of solely relying on raw wood" (Mietz, 2016, p. 86)

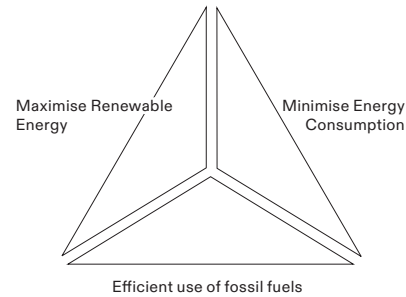


THE ELEPHANT IN THE ROOM

Strategies and policies for an energy transition away from fossil fuels such as Positive Energy Districts are based largely on the so called Trias Energetica, a three-way principle to reduce emissions by maximising renewable production, reduce energy demand through efficiency improvements and, if unavoidable, use fossil fuels as efficiently as possible. This approach however, is increasingly questioned, as its approach is very techno-centric: relying heavily on improvements of efficiency to achieve the necessary reduction in energy use and emissions.

A growing body of literature points to the inadequacy of energy efficiency measures to meaningfully address overall energy use. This counterintuitive and worrying phenomenon is well documented and is also known as the building performance gap, which refers to the discrepancy between the energy consumption expected from building models and the measured conditions in the real world (Van Den Broeck, 2020). Majcen (2016) found that actual gas consumption in Dutch homes was much lower than what was calculated as theoretical consumption, and that this difference was highest in the worst performing homes, while consumption in the most efficient homes was 20% higher than estimated. Sunikka-Blank and Galvin (2012), using data from 3400 German households, found that energy consumption for heating was 30% lower than the energy rating would predict. They coined this phenomenon the ‘prebound effect’ because people reduced their consumption in less efficient homes - in contrast to the rebound effect, where consumption increases with higher efficiency. These results have been replicated in other countries.

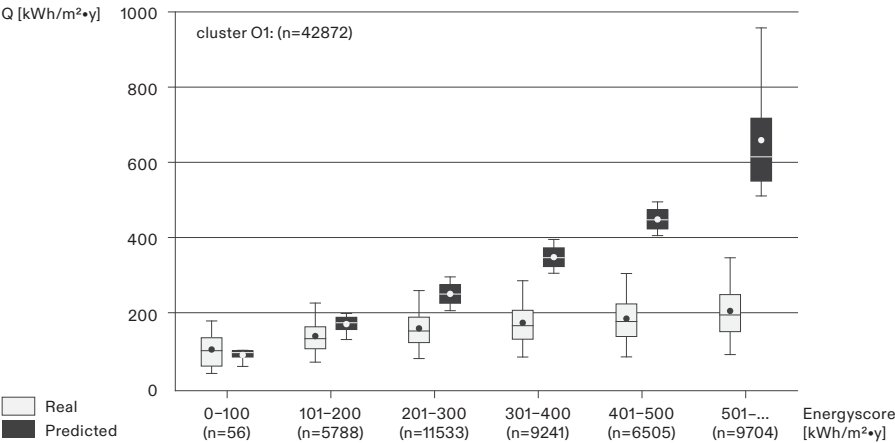
A team from the University of Ghent studied the accuracy of models for predicting residential energy use based on building parameters using a large dataset of several hundred thousand housing units (Van Hove et al. 2021). They also found that there is a significant gap between predicted and actual measured performance. This discrepancy was largest for the worst performing buildings, where the estimated average



↑ The Trias Energetica, a three-step strategy to minimise dependence on fossil fuels. Its techno-centric approach is increasingly being called into question.

Real energy use of dwellings versus ‘Energyscore’

Adopted and translated from Van Hove et al. (2021), Fig. II “primaire energiegebruik per m² versus ‘Energiescore’”, p.XII



was more than twice the actual consumption, the lowest estimate and the lowest actual value for the worst category was off by a factor of 4. Conversely, more than half of all buildings in the best category actually performed worse than predicted. The average energy saving between the best and worst performing buildings was only 50% in real conditions, instead of a predicted reduction of 85%.

This astonishing discrepancy is largely attributed to changes in occupant behaviour. Research in England and Wales showed that energy savings from loft and wall insulation disappeared between two and four years after renovation (Peñasco & Anadón, 2023). In deprived areas, there was even no association between efficiency measures and energy savings. Hens et al. (2010) and Barthelmes et al. (2017) found that occupants' lifestyles were the biggest uncertainty factor for the final energy consumption of a building, regardless of its performance level. Conniff (2017) also points to the shortcomings of digital building models in accurately accounting for all external factors during the design phase of a building. One consequence is that mandatory energy labelling will force frugal occupants to make useless investments that will never pay themselves back. In fact, research by Tigchelaar et al (2011) found that for one in three Dutch households, no renovation measures would ultimately be cost-effective. Only cavity wall insulation, window insulation and the installation of a condensing boiler were cost-effective for two out of three households.

A look at the heat demand of Cureghem reveals a very nuanced picture. Despite its old housing stock and dense population, the heat demand per square kilometre in the residential areas is average or below average. Of course, it is not possible to deduce from this data whether this is due to choice or necessity. Renovation of the buildings

Residential heat demand in GWh/km²
Adopted from Lempereur et al. (2021), p. 26, Figure 2: Density of residential sector's demand for heating by statistical sector (GWh/km²)



would certainly improve the living conditions of most of the inhabitants of Cureghem. However, the literature on rebound effects suggests that it would not significantly reduce the energy demand of Cureghem, in particular the study by Peñasco & Anadón (2013), which found no effect of building renovation on energy demand.

SOCIAL IMPLICATIONS

Income and energy consumption are closely correlated, with richer people emitting disproportionately more greenhouse gases than households with lower incomes (Büchs & Schnepf, 2013; Druckman and Jackson 2016; Duarte et al., 2021; Piao & Managi, 2023). The impact of current energy policies on economically disadvantaged groups should not be overlooked. Or as Dilman et al. observed already in 1983 when energy prices were soaring: “The poor accept lifestyle cut-backs while the wealthy invest in conservation”. Similar observations with French households were made by Cayla et al. (2011). This also explains why retrofits don't seem to have an impact on energy demand in deprived areas, as residents already keep their consumption to a minimum and are happy to increase their comfort for the same budget. This doesn't have to mean it's inevitable that improving lower incomes position must result in higher emissions. Duarte et al. (2021) demonstrate that a fair transition is possible whilst reducing emissions through income redistribution and changes in consumption.

Gentrification has been another phenomenon under closer scrutiny. Like many neighbourhoods in Brussels, Cureghem has also come under greater pressure of rising property prices. Eco-gentrification, a term originally introduced by Dooling (2009), may describe a real risk associated also with the energy transition and the creation of PEDs. Harper (2019) describes in his paper how the apocalyptic portrayal of climate change has an impact on public perception and urban planning. He uses the term 'immunopolitics', where sustainable urban development is designed to make city dwellers feel protected from the effects of climate change, while at the same time giving the impression that its users are relieved of responsibility for it. “Capitalising” on common eco-anxieties, urban projects are justified using the term ‘sustainability’, which has become an empty signifier without a clear definition or consistent application. Harper highlights the need for a critical examination of sustainable urban development projects, warning that they could reinforce capitalist dynamics and lead to further social and environmental injustices.

«most of them live a life that is extremely economical compared to other, more well-off households and are generally very aware of their energy consumption. But for them it's usually an economic motivation, not so much an ecological one.»



↑ The real estate developer Atenor promotes the controversial Move'Hub project at Brussels Midi as “a zero fossil fuel energy building, Move'Hub also promotes the re-use of materials, prefabrication and modularity to reduce carbon footprint and waste. The outdoor spaces and terraces on all floors and the creation of a communal garden for residents contribute to well-being and climate protection (cool island and biodiversity). Move'Hub contributes to the sustainable transition of the neighbourhood”. Move'Hub. (2024, June 11). ATENOR. Retrieved August 2, 2024, from <https://www.atenor.eu/en/projects/move-hub-real-estate-project-brussels/>



Preaching Performance but Missing the Mark

Manon Chapurlat is an architect and works at the *Centre de Rénovation Urbaine* in Cureghem. Providing technical and administrative support for renovations, CRU also lobbies for neighborhood renewal with a mission to retain the existing population.

JG Jonas Görden
MC Manon Chapurlat

JG What's the role of CRU in the urban energy transition?

MC We offer free advice to tenants and owners in order to find the most sensible building renovation measures. We will also start to systematically guide residents who just moved into a new building with high energy efficiency.

JG Why do people need guidance in buildings which already have a very high energy performance? I thought the problem was with unrenovated dwellings.

MC These highly technological buildings are quite problematic on many levels. They are designed to be used in a certain way to achieve this high level of efficiency, but that leads usually to a "wrong" use of these buildings because people don't know better. We see this among people who are in a very precarious environment, but really also among the richer households. It's just that the way these buildings function is very complicated. So on the one hand, we try to provide support to ensure a proper use of these buildings and on the other hand we try to make these buildings a bit less high-tech and more accessible and hands-on.

JG But this sounds very contrary to the current energy paradigm. The Brussels government is planning on mandating higher building energy performance (PEB) scores during the coming years.

MC We are starting to think with other experts involved on the subject about alternatives to this PEB system because it poses a huge problem for us. We are talking about policies aiming for an ecological energy transition, but in the end it is not very ecological as we are pushing a green consumerism which is more focusing on efficiency rather than in saving energy per se.

JG But the idea is that with those initial investments and emissions, we achieve greater savings later on.

MC Well, yes and no. There is a study from Cambridge that looked into energy renovation of many houses, which found a real saving over four years on average, but beyond four years, it was back again to overconsumption. We are also looking for studies to what extent the advantage of energy savings of your PEB certificate, are compensated by the embodied energy from production and the renovation process, considering that you are going to have to maintain and repair it. What bothers us a lot is the fact that we have a policy that is very generalised and that we are not considering it on a case-by-case basis. They are going to push a big campaign on heat pumps and on thermal insulation, whatever the type of materials, whilst we are getting more and more testimonies of people who come to us saying: I insulated because I was told to do so, and now I found myself with mould in my home. Much of Brussels is built on a swamp, so there are many buildings which already have humidity and infiltration issues but now we are going to give priority to energy renovation, without first trying to solve the root cause.

JG An image often evoked in the discourse around renovation is that of the poor *Brusseleir*, getting ill from living in a cold, damp apartment. Is it just a cliché?

MC Yes those exist, but I'm not fully convinced that renovation policies are an adequate solution. While I see the importance of actions like insulating the roof or basement, it feels like we're putting the cart before the horse. We're asking Brussels' residents to make financial efforts they simply can't afford. The idea is to protect them [from unhealthy living circum-

stances], but imposing a €30,000 fine for not making energy renovations? If people had that kind of money, they might want to prioritize other needs, like a decent central heating. Often, the poor tenants I talk to barely heat their homes due to faulty or inefficient heating systems. There was a time when initiatives helped households switch to gas boilers, providing them and fixing installations with a payment system based on monthly bills, tailored to residents' financial hardships. Now, it feels like the region's priorities are completely out of touch. Even public services, which should set an example, can't afford the energy renovations for social housing or offices. The government and region don't have the resources to implement the policies they require from the public. One problem is people wanting to sell because they can't afford renovations, but who will buy? There's a skewed power dynamic that could disrupt the entire real estate market.

JG What about the plan of the Brussels region to mandate higher PEB scores in the coming decades?

MC If PEB certificates accurately reflected actual consumption, it would be relevant. But that's not the case. Take, for example, a small house of 50 square meters compared to a large one of 500 square meters with the same wall composition. The energy performance will be far better in the larger one than in the small. So those who have the smallest housing will have the crappiest scores, which also won't promote housing density. It is a great injustice.

JG You're also very much rooted in the Cureghem neighbourhood. What is CRU's mission here?

MC It's mainly about integrated local development, focusing on citizen mobilization and generating public interest. We architects at CRU have several roles: we help residents on questions around renovation, we discuss the impacts of a new zoning plan or neighbourhood contract and visit the construction sites. We also work for example with the union of tenants of Cureghem (ULAC), who are trying to recover abandoned buildings. The goal is to recreate as much housing as possible, especially lots of large housing for families. We want

to help keeping the current residents of the neighborhood in place to avoid the population replacement which is looming.

JG You mean gentrification?

MC It's extremely harsh. Even neighborhood contracts, not just building renovation, but any urban revitalization project, dramatically accelerates gentrification within a few years. Our goal is to keep the community intact. However, it feels like we are just tinkering [with solutions]; we alone are not strong enough to face this challenge.

JG What kind of advice to you usually give to people coming to you?

MC They often come to us being very excited: I'm going to insulate my house, it's great! And then show us pictures and we see the electricity isn't up to standard, the gas isn't up to standard and there are leaks in the roof. So it usually means reviewing plans a little bit and putting things into perspective. That means managing the underlying problems before starting with the energy renovation. Sometimes that means doing it little by little, because there are people who don't have the budget to do everything at once. Giving specific advice involves considering where someone lives, their current life, and future plans, ensuring the advice doesn't lead to financial strain.

JG Do you sometimes try to give people advice on changing certain habits?

MC We try sometimes, but I don't want to fall into paternalism – we are not gurus. What we sometimes do when we make home visits, is that we have a look at the thermostat for instance. On my last visit, it was set to 32. The lady said her son changed it because she was cold but her house was cluttered with stuff piled all around the radiators and the boiler. I'm afraid one day they'll be poisoned, it's a horrible thought! So you have to see to what extent it is your place to tell people to tidy up their home and remind them of their energy bills, it's complicated. You should give advice, but you can't tell people how to live their lives.

JG I guess those cases are the exception rather than the rule?

MC There are plenty of people who welcome you in winter wearing t-shirts at home. But most of them have a life that is extremely economical compared to other, more well-off households and are generally very aware of their energy consumption. But for them it's usually an economic motivation, not so much an ecological one. I would like us to launch workshops on overheating, for example, so people learn to help themselves. The classic thing in Brussels is heating the whole house including the stairwells. If you can make them understand that you have to compartmentalize your home, to heat just the spaces you actually occupy, it would already be a great victory. Because the only advice they get right now is to stick newspaper on their windows which is not adequate and, I think, also a little bit insulting to the people.

JG Why do you think there is such a divide between politics and the reality?

MC We recently followed a training by Brussels Environment because we want to give better advice to people how to renovate step-by-step. It was given by an external consultation office whose engineers kept telling us the best strategy is renovating everything at once, because it's much more efficient. Their budget estimates to renovate an old house top to bottom was around 230.000 euros if done all at once. We don't know anyone in our network of households who would have such a budget. They kept telling us to go for an all-inclusive approach. But we are not going to tell people to get a heat pump if the state of their building doesn't allow it. They would have to get a hybrid system with an additional boiler, and then have two installations to acquire and maintain. That would be completely insane! This disconnection [between well-intended advice and reality] is very problematic.

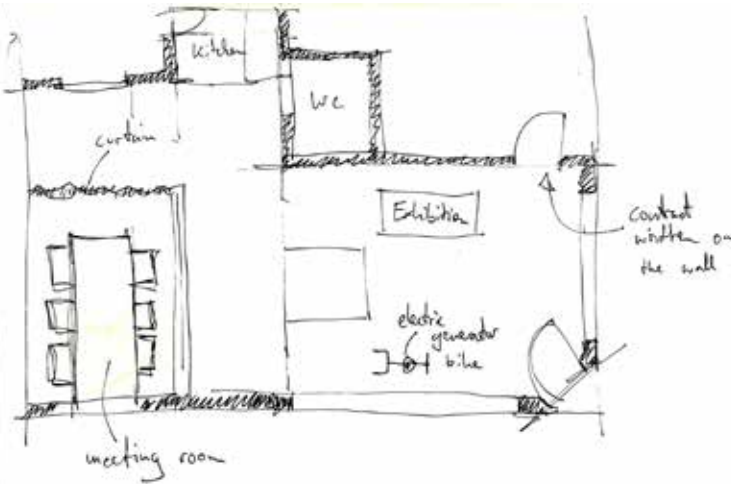


5 The Human Power Plant

It is a cloudy Wednesday as we approach Rotterdam Central Station on our train from Brussels. Our destination, a 30-minute walk from the station, is a district of particular importance for the energy transition in the Netherlands: Bospolder-Tussendijken (BoTu in short). It will be one of the first neighbourhoods to become gas-free in the coming years¹. The energy supply of the Netherlands has been heavily dependent on gas for heating, cooking and electricity² thanks to the plentiful resources in the area around Groningen. This year, however, the production of gas was shut down for good, because the damage caused by the resulting earthquakes had become too much for the local population to bear.

Walking around BoTu, with its large market at the centre, it's hard not to notice the diverse population and lively street atmosphere. Similar to Cureghem, the average income is low by national standards, and the population is generally perceived as underprivileged. The main difference is in the urban morphology, as BoTu was conceived in 1910 as a working-class neighbourhood by modernist architect J.J.P. Oud, to meet housing demand due to the fast-growing harbour of Rotterdam.

We are meeting Melle Smets, artist, researcher and one of the main initiators of a local organisation called *Huis van de Toekomst*, the House of the Future, who welcomes us inside their space set up in a former corner shop. The appearance of the shop space they are occupying looks all but futuristic – which is precisely the point as we are about to find out. Inside we find a self-built bike generator next to a stash of woollen blankets and a wall display of vintage bed-warmers. On the opposite side of the room stands a large wooden model of the housing block that this space is part of. We notice a text written on the wall above one of the doors: “Residents of BoTu receive space and means from Eneco, Havensteder and Municipality to practice the social energy transition” it reads in thick black permanent marker, signed by each of the mentioned parties.



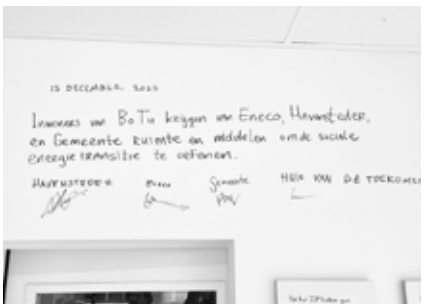
1 BoTu aardgasvrij. (2024, May 14). Bospoldertussendijken.nl. Retrieved July 26, 2024, from <https://bospoldertussendijken.nl/energietransitie/>

2 Klimaatweb. (2024, February 12). Gasverbruik Nederland opnieuw lager. PONT Klimaat. Retrieved July 26, 2024, from <https://klimaatweb.nl/nieuws/gasverbruik-nederland-opnieuw-lager/>

“We are in a test-phase right now”, Smets tells me, “this residential block is in bad condition and needs renovation, so people have to leave in order for it to be renovated”. But it may take years until the building permits are granted and the construction work can begin. The buildings are protected heritage which calls for accurate restauration in parallel with the renovation works, a big effort and beyond the mission of the social housing company, he explains. While municipality and social housing provider are squabbling over responsibilities and financing, it will serve as a community hub and a testing ground for an alternative energy transition.

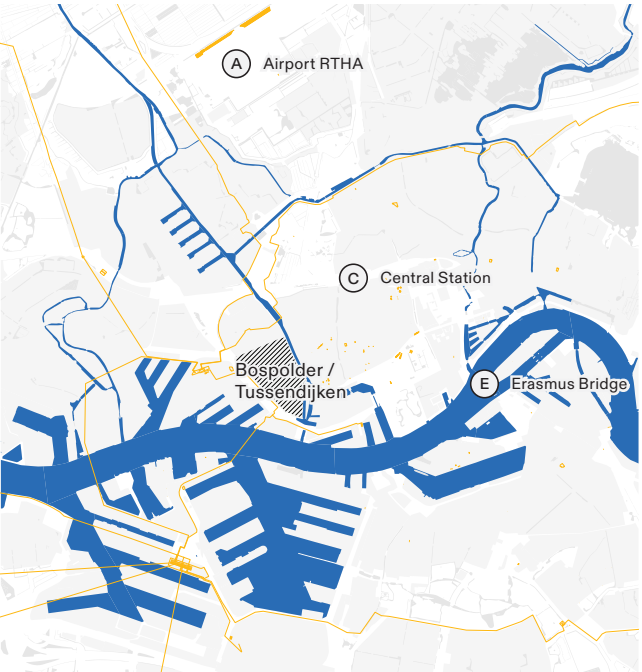
But why has this community hub emerged around the rather technical theme of energy and the transition away from fossil fuels? Having worked on artistic projects in the public space, Smets tells me the initial assignment, to do a social design project around the topic of poverty, came from Museum Boijmans van Beuningen, with a grant from the Ministry of Education and Culture (OCMW). “That was already suspicious to me because, poverty can mean a lot of things”, he remarks “eventually I found out, it's really about the energy transition. Which is when I decided we're going to start our own energy society, our own energy community.” This was at a moment in time when the project to get BoTu ‘off the gas’ was threatening to come to a halt. The municipality had signed a contract to build the heat network in the neighbourhood with Eneco, an energy utility. “It was a classical example of top down decision-making” Smets told us on a later occasion, “First make the deal and then face the community. The problems became gradually social, instead of technical. Some people refused to open the door, elsewhere it turned out that there were people living in houses who weren't mentioned on the lease. Slowly the problem got bigger and bigger until they had to stop the works, which is when it gets expensive and then everyone panics. Except the system does not panic, it starts forcing to get to it's goal.”

Smets was already familiar with the topic of energy. A few years ago he started an art project called ‘The Human Power Plant’, together with the journalist Kris De Decker, author of the online publication Lowtechmagazine. Together they've developed scenarios on how to run a civilisation on human power, the only source of energy which becomes more abundant as population increases, they argue.³ It's a fundamental critique on the short-sightedness of industrial capitalism and a praise of human ingenuity at the same time. *Huis van de Toekomst* emerged from the Human Power Plant by making a site specific scenario, and then testing it with tangible prototypes. Created together with residents and volunteers, it was also simply a space where locals could come and have a coffee or tea and have someone to talk to (also about the ongoing energy dilemma). “We heard that a lot of bread is baked in the neighbourhood, but all illegally, in sheds or in the attic”, Smets recalls. “We invited Stoker, a community of breadbakers who have ovens all over the Netherlands and we built a big oven that everyone can



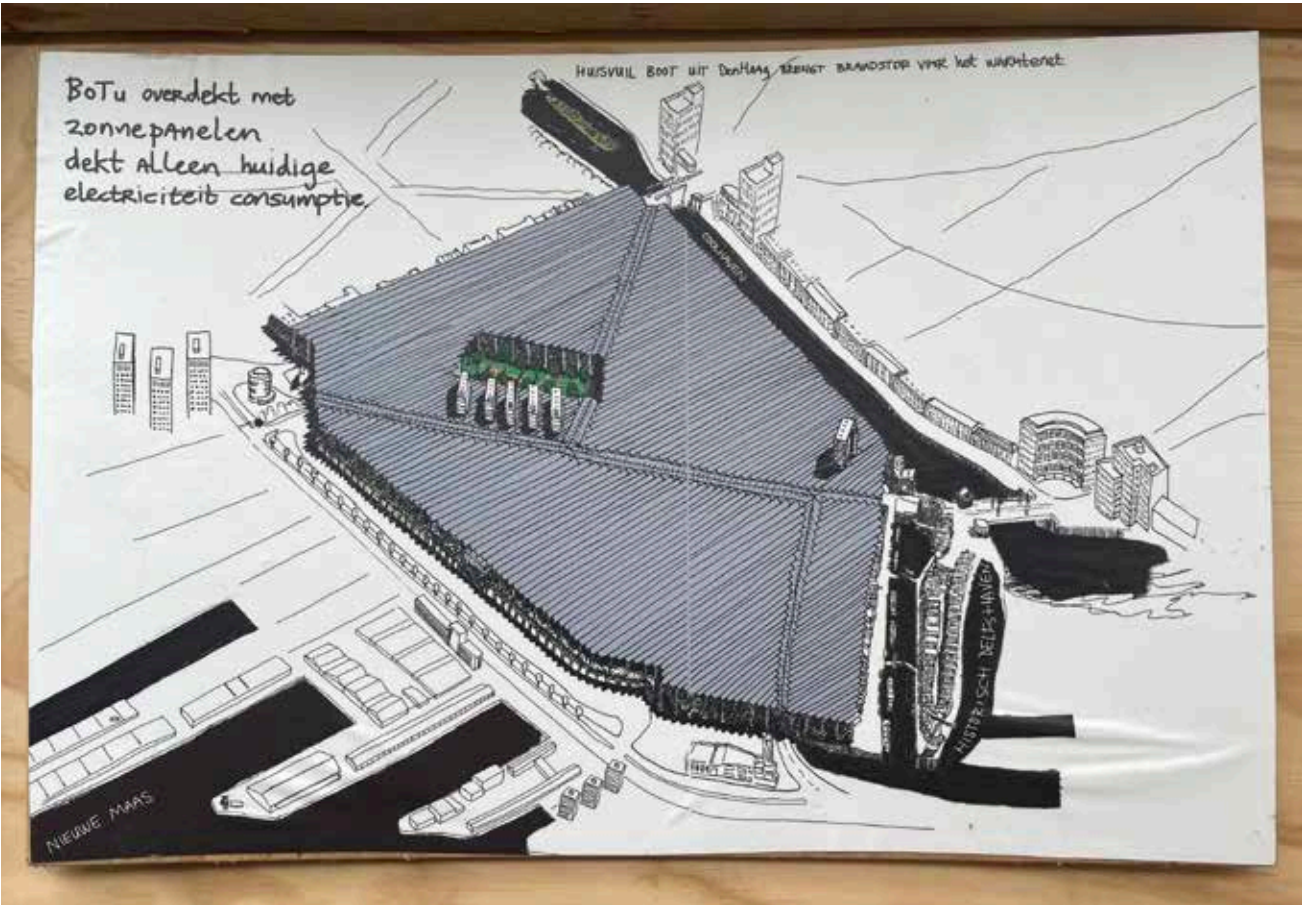
↑ Agreement written on the wall of the Huis van de Toekomst, saying: “Residents of BoTu receive space and means from Eneco, Havensteder and Municipality to practice the social energy transition”

3 “Human power is always available, no matter the season or time of day. Unlike solar panels, wind turbines, and batteries, humans don't need to be manufactured in a factory. Unlike all other power sources, human power increases as the human population grows. With a combination of low-tech solutions, lifestyle changes, and some exercise, the Human Power Plant demonstrates that a fossil fuel free life is possible.” The Human Power Plant. (2024). Retrieved August 13, 2024, from <https://www.humanpowerplant.be/>



“BoTu covered in Solar Panels only meets today's electricity consumption”

“Garbage boat from The Hague delivers fuel for the heating network.”



use.” Weekly courses ensure everyone gets an opportunity to learn how to fire the oven and bake bread. Whilst they harness the appeal of food as a connecting element in a fragmented neighbourhood, there is also the simple idea behind this that if we fire just one big oven instead of a dozen smaller ones, we also save some energy and cause less pollution. They also realised that people from different cultural backgrounds would bring useful knowledge and practices on how to do other things more sustainably, from heating strategies to processing raw wool into warm blankets.

The indoor space of the *Huis van de Toekomst* is not heated, an irritation to some visitors who come for the first time, Smets admits. It was indeed a bit chilly on a March afternoon inside, but we noticed how their meeting table was put in a smaller compartment, separated from the rest with a window and a blanket curtain. This means just by being in there with a few people, the heat coming off the bodies will be enough to raise the temperature and with the help of a blanket ensure thermal comfort even during prolonged meetings. The next planned step is to overhaul the inner courtyard of the building block, as Smets demonstrates during our visit, “we are going to tear down all the walls between private gardens and it becomes a big kind of park.” The empty flats on the ground floors will become available to be used by local initiatives, such as *Team Toekomst*, who help over 500 children in the neighbourhood supporting parents and teachers with their education.³

Spending time listening and engaging with residents was bearing fruit and it emerged that there is a deep distrust between residents and the authorities. Even though the intention of the municipality has been good, the execution has become downright evil at some point, Smets criticises. The infrastructure is financed and managed by Eneco, an energy utility owned by Mitsubishi, who need a guaranteed profit margin to operate. “It is a pure extraction model”, says Smets, “they effectively said, we are the boss for 50 years. And everyone who comes to live in this neighborhood must get a contract with them.” There were other unexpected frictions when *Delfshaven Energiecoöperatie*, a local energy sharing community, proposed to set up solar panels across several blocks, like a bottom-up electric utility and got a warning from Eneco’s lawyers on the grounds of allegedly illegal competition.

Huis van de Toekomst’s engagement with the concerns of citizens has resulted in some unorthodox actions, making them slowly evolve into a protest-organisation against their will. “I haven’t made many friends” Smets laughs, referring to the grant-giving authorities. That is partly due to a difference in expectations: the municipality expecting a mediating role, calming the already tense relations with local residents.

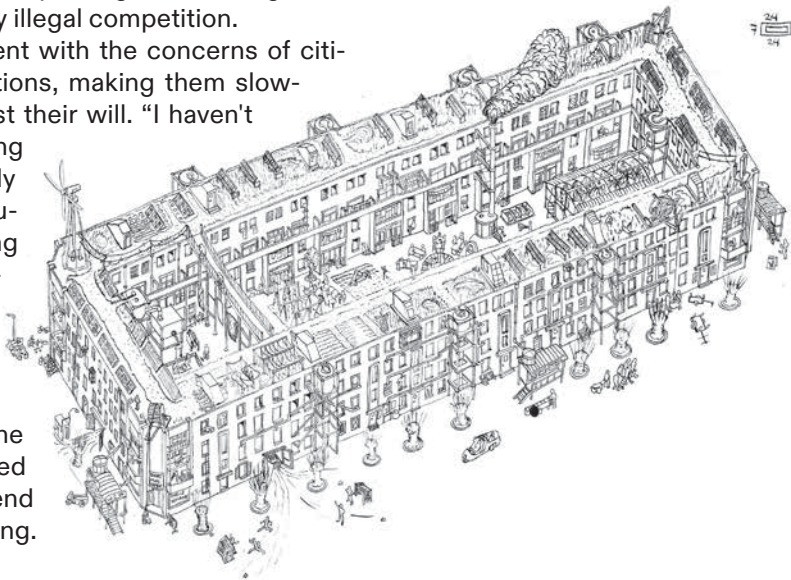
While they have been clearly advocating their low-tech vision from the very beginning, says Smets, it seems like it was not being taken very seriously and once it was the project hit a wall. As they are not considered to be providing a service, they have to depend on pilot budgets rather than structural funding.



↑ The collective bread oven in action in the backyard of the Huis van de Toekomst. Photo: Huis Van De Toekomst. Retrieved July 26, 2024, from <https://www.huisvandetoekomst.org/nieuws>

3 Team Toekomst. (2024, April 5). *Over ons*. Retrieved July 26, 2024, from <https://teamtoekomst.nl/over-ons>

↓ The Huis van de Toekomst occupied building block transformed into a fossil-fuel-free experiment powered by humans, sun and wind. Image: Melle Smets, Retrieved July 26, 2024, from <https://www.huisvandetoekomst.org/nieuws>



A few weeks later we meet Melle Smets again at Brussels Midi station for a walk around Cureghem, our study area, and to visit *Cultureghem* vzw, a community-focused cultural hub. We are welcomed by William Febiri, project coordinator at *Cultureghem*, who introduces their work and their efforts to activate places for the community in this particular area with limited public space. In contrast to *Huis van de Toekomst*, the organisation based on the Abattoir site can rely on many years of experience and a network of over 150 volunteers. What emerges throughout the discussion is that part of the success of the NGO lies in its clearly defined role. Whilst they do work with researchers and authorities for street activations, they also make sure to distance themselves. “We have deliberately stopped certain activations until the elections in June”, explains Febiri, “because we believe that during this period politicians will try to profit from them.”

This cautiousness comes also after having had some uncomfortable experiences in the context of the disastrous implementation of a local circulation plan, where *Cultureghem* had been involved in the participation. The spectacular failure and partly violent confrontation between residents and authorities had also put at risk the trust the organisation had been building and nurturing over the years. “We were in a vulnerable position, because we’ve been working a lot together with the aldermen and politicians”, says Febiri, “so we are now changing our approach, but we are still committed to activation.” The importance of external perception is one of the main takeaways for Smets, as he and the team at *Huis van de Toekomst* are faced with the decision of how to position themselves in the future. Being asked how he sees their role in the years to come, he admits it has become more difficult to stick to their narrative. “We have created a very complicated role” Smets explains, “Reasoning everything from an artistic idea, clashes with reality on all sides.” However, it would be inevitable that things become more difficult as they get more concrete, according to Smets. It is a fragile balance between groups, power positions, money, trust and culture, and this constant shift of perspective is what intrigues him after all.

The story of *Huis van de Toekomst* and the experiences of *Cultureghem* show the fragility of even the most well intended implementations. Having the technology and funding without a shared vision with residents about where the journey is heading may leave locals disenfranchised and with a feeling of powerlessness. These sentiments may ultimately hurt the overall goal we are all meant to be heading towards: a just and sustainable transition away from fossil fuels. Given the similar context and challenges, the experience of BoTu is all the more relevant for a successful transition in Cureghem and the rest of Brussels.

Even small neighbourhood organisations can become part of a complex web of interests and power plays, as Smets recalls. “Yesterday we had someone from Shell visiting us who said they’d want to pay us, because they are the competitor [of Eneco]. But they are the ones who got us in this mess in the first place and we would lose our own credibility if we would be working with them.”



↓ Construction of the new district heat network in Bospolder-Tussendijken was well underway during our visit in March 2024.

huisvande toekomst



↑ The corner shop set up by *Huis van de Toekomst* with another sign reading “BoTu on Human Power” referring to the low-tech practices of the initiative.

«You can never go faster than the consensus of the group doing it.»



← Location and surroundings of the *Huis van de Toekomst* initiative in what is perceived as one of the more underprivileged areas of Rotterdam and the Netherlands



6 Threads of Transformation

Cities are living organisms, complex and ever-evolving. Streets, buildings, and public spaces intertwine like threads in a tapestry. Each thread represents a unique aspect of urban life, and it is through the careful interlacing of these threads that the fabric of a city gains its strength, resilience, and beauty. The properties of the yarn determine the overall quality and appearance. The denser and stronger the threads, the richer and more detailed the resulting image. Similarly, a robust and well-built infrastructure is essential to support an intricate and high-quality urban fabric. In the same way that a weaver needs clever tools and a well-constructed loom to weave a beautiful tapestry, cities need to have enabling elements that provide the foundation for sustainable development. As energy is the lifeblood of any economy, a robust energy network acts as the backbone that supports and enhances the urban environment.

The previous chapters explored the current state of Brussels' climate strategies and took a closer look at one of its more complex districts, shining a spotlight on the many obstacles that stand in the way of a climate-neutral city. While progress has been made, much remains to be done. Brussels is not on track to meet its climate targets, and as we get closer to zero emissions, the pace of progress is likely to slow once the low-hanging fruits have been picked. Cureghem can be a pioneer of a socially just energy transition by demonstrating an integrated approach that combines technological solutions with social strategies that ensure inclusivity. It has the potential to set a precedent for the use of new legal frameworks for the use of public land and shared energy infrastructure. We already see commitment of local actors such as the Abattoir Company that could initiate a novel, district-wide energy planning.

We also established that current strategies based on the trias energetica are technocentric and insufficient to achieve net-zero emissions. Rebound effects and life-cycle emissions reduce the overall impact of high-tech approaches. Relying solely on technological innovation risks leaving behind those who lack the means to participate. Social and economic innovation is equally necessary. Communities in Cureghem are particularly vulnerable to the effects of 'green gentrification' and are unlikely to benefit from the current energy paradigm, which mainly supports the middle class through subsidies for individual systems such as solar

panels, heat pumps and electric cars. The current energy policy trajectory has significant conflict potential, as demonstrated by the failed implementation of a traffic-reduction scheme in Cureghem based on the regional mobility strategy GoodMove, which showed how sustainability measures without broad support can lead to social unrest.¹ The struggling implementation of a heat network in Bospolder-Tussendijken, Rotterdam, illustrates the conflict potential of the energy transition. In the previous chapter we discussed a neighbourhood organisation in BoTu, who have shown how the meaning and perception of energy varies between social groups and statuses, offering insights and practices that can be activated and shared.

In this final chapter, we will discuss our design approach to address the conundrums of the energy transition in Cureghem. Cureghem is emblematic of the challenges facing Brussels: it has a diverse and relatively old heritage, a diverse population with limited economic means and little open green space. The aim is to show how even the most complex urban situations can evolve to empower their citizens to navigate the ongoing transition in the most appropriate way. Amid confusion and uncertainty about the current individualistic approach to the energy transition, which focuses solely on renovation and energy generation at the household level, collective solutions appear to be a more viable alternative that shifts responsibility away from individual households.

DESIGN STRATEGY

Following the framework of Architecture Workroom Brussels (2023), we will develop a strategy that aims to achieve a best-effort scenario in terms of energy autonomy, but not an energy-positive scenario for its own sake, as this would require huge investments in infrastructure and renovation, with many uncertainties about the social impact. Because the area is so diverse, the most suitable approaches will vary depending on the context. We will therefore create a layered strategy of different approaches based on our previous spatial analysis of urban typologies. In the process of developing these scenarios, the author presented his findings and different approaches to a group of experts from two neighbourhood organisations at the Centre de Rénovation Urbaine (CRU) in Cureghem, a local

¹ "The GoodMove plan divides Cureghem: an action by the VéloFiets Collective gives rise to quarrels." and similar headlines dominate the discourse. BX1.be. (2022, October 11). *Le plan GoodMove divise Cureghem : une action du Collectif VéloFiets donne lieu à des querelles*. Retrieved July 18, 2024, from <https://bx1.be/communes/anderlecht/le-plan-goodmove-divise-cureghem-une-action-du-collectif-velofiets-donne-lieu-a-des-querelles/>

↓ Presentation and workshop with Members of Centre de Rénovation Urbaine (CRU) and Inter Environnement Bruxelles (IEB), two neighbourhood organisations working on equitable urbanism and energy strategies, both based in Cureghem.



non-profit organisation focused on renovation consultancy and combating gentrification. Three experts from CRU were joined by two experts from Inter Environnement Bruxelles (IEB), a non-profit organisation working on urban environmental issues and sustainable development through research, advocacy and public campaigns. Their critical input helped to sharpen our design principles, particularly with regard to the social aspects of this transformation, as they warned against social-washing when designing social spaces without consulting the needs of local residents.

In addition to considering social impacts and mitigation measures, we aim to incorporate elements of climate adaptation. As Europe and Brussels are currently lagging behind in preparing for increasing climate risks (European Environment Agency, 2024), adaptation to extreme weather events must become part of a broader design strategy. Cureghem is particularly vulnerable to extreme weather events. Most of the area is considered to be at high risk of flooding from heavy rainfall. We can see a concentration of the highest flood risk around the Chaussée de Mons, an area with a high degree of impervious surfaces. Like much of Brussels, Cureghem is built on a swamp and residents experience regular inconvenience from flooded cellars after heavy rain and mouldy cellars (interview M. Chapurlat, 2024). Most of Cureghem is also extremely exposed to heat stress due to the lack of open green spaces. Conversely, in areas with tree cover and open green spaces, the risks are drastically reduced.

Measures to support climate resilience also have a positive impact on the overall liveability of the neighbourhood. Currently, many streets lack tree cover and green space, and street designs are wide and straight, encouraging speeding and leaving little space for pedestrians. Where there are trees, they are often in poor condition due to pollution and lack of permeable soil. Depaving parts of the road would also help to create a healthier and larger tree cover, which in turn offers countless benefits, the bigger the better.

There are clear constraints on financing such adjustments. As Brussels administrations run on deficits, creative solutions have to be found to avoid inertia. At the same time, the redesign of public space must be carried out with a view to its socio-economic impact, as the neighbourhood is already under pressure from gentrification processes. Turning Cureghem into a large park is not the answer. We will therefore focus on tactical interventions and quick wins, as opposed to a master plan or urban renewal scheme. These measures should make use of construction works that are already planned or are part of the ongoing energy transition.

While we are aware of the risks of social washing, there are some relevant examples of social innovation in the context of the energy transition. This is important as we have established in chapter 4, the individual behaviour is the biggest factor of uncertainty for final energy consumption. It became clear during the workshop at CRU, that many residents in Cureghem should not be expected to change their behaviour, if it's not beneficial for their economic situation. Instead we aim for enabling locals to find the best strategies for themselves without paternalism, after the model of *Huis van de Toekomst* in Rotterdam.



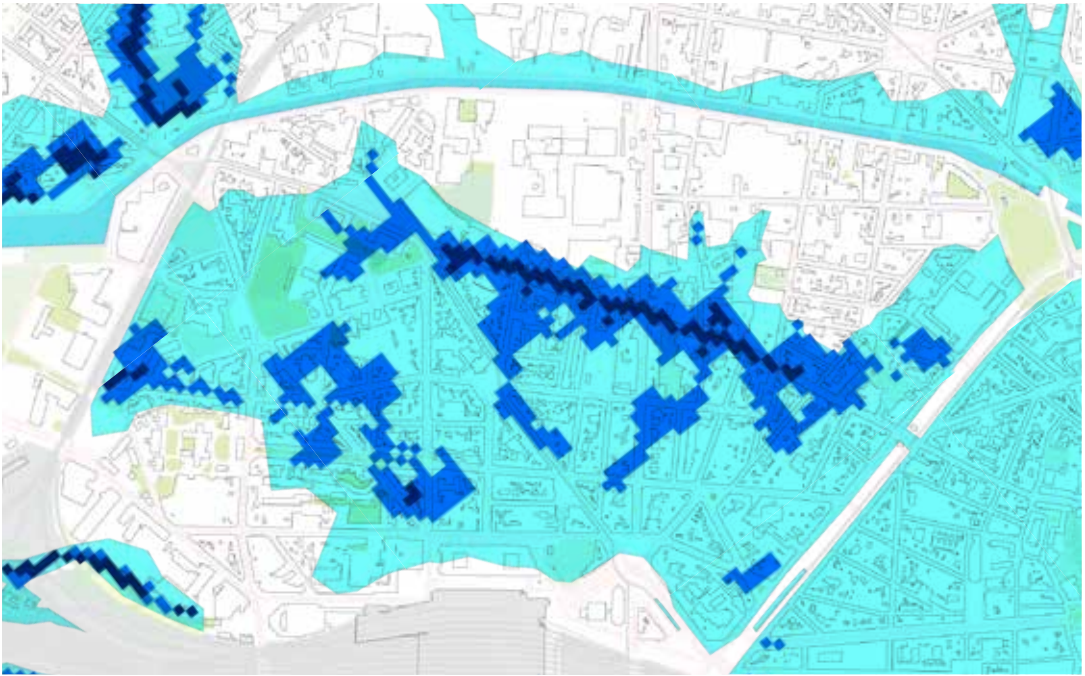
↑ Many of the residential streets in Cureghem lack tree cover and greenery. The road layout is very wide and straight which encourages speeding and limits space for children and pedestrians.

↓ Many trees we observed were in poor condition. Compacted and impermeable soil inhibits root growth and limits supply of oxygen and nutrients. Pollution from traffic can also have an impact on tree health.



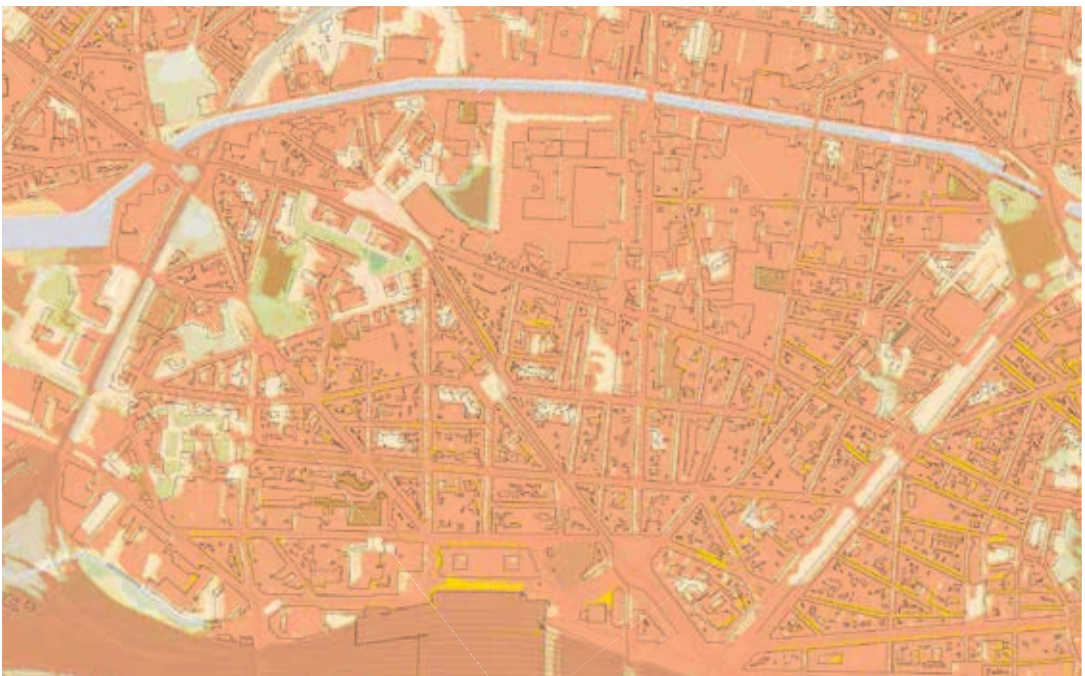
Indicated Inundations: Cureghem's risk of pluvial flooding

Brussels Environment. (2019). Flood Hazard Map [Dataset]. <https://geodata.leefmilieu.brussels/client/view/1a3cae6b-dd04-4b28-a3e2-c432dc83e24f>



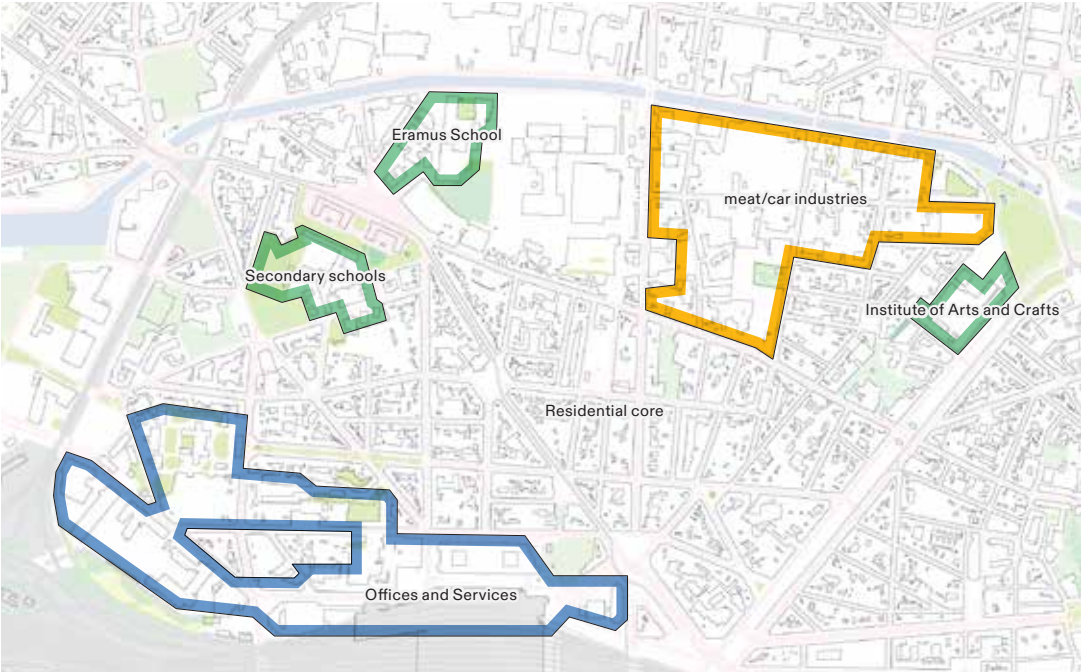
Code Orange: Cureghem in the grip of the heat island effect

Brussels Environment. (2020). Health Effect Screening - Heat stress (CC Attribution (CC BY)) [Dataset]. <http://datastore.brussels/web/data/dataset/3d28d442-7097-4618-9600-a9618e9b424d>



An important factor for *Huis van de Toekomst* was the availability of a semi-public space they could occupy and experiment with. This type of back-set space exists in Cureghem, but is often used for parking or for storage by companies. These spaces could be activated and made available to community initiatives, for instance as part of *Cultureghems* programmations, in the right constellation, for example when a space becomes vacant or a company no longer needs all of it.

PIPE DREAM
Lastly, we also want to focus on local heat generation. We propose a scenario for the longer term, where the heat network on the Abattoir site is expanded in stages across Cureghem based on a logic of decentralised locations, similar to the energy logic of the artisanal city discussed in chapter 3. The density of households and variety of user profiles make Cureghem an ideal candidate for a heat network. This would also mean a shift of responsibility away from the individual household towards a more collective approach for mitigating GHG emissions. Instead of mandatory renovations, we suggest a tailored strategy based on a new legal framework that allows collective renovation packages with the aim to offer cheaper, quicker and more accessible home renovations. Renovation in this context should aim to strike a sensible balance between investment, providing comfort and lowering emissions. We reject the use of energy labels as a general reference of measure. The heat network has to be implemented in a socially responsible way, learning from the case in Rotterdam, to avoid creating a monopoly. The financing and ownership of the heat network infrastructure can be mix of the different producers, the Brussels energy network provider Sibelga.



← Cureghem has a highly diverse economic profile. The various user profiles of the different sectors can complement each other well in terms of energy consumption, which contributes to flattening the energy demand curve and reducing investments relative to the size of the network (interview J. Blondeau, 2023).

Functional clusters
Education
Industry
Tertiary

Perspectives on energy planning and policy

Energy Researcher J. Blondeau, VUB	Architectural Innovator H. Mangelschots, AWB	High-tech critic K. De Decker, LTM	Social renovation advisor M. Chapurlat, CRU
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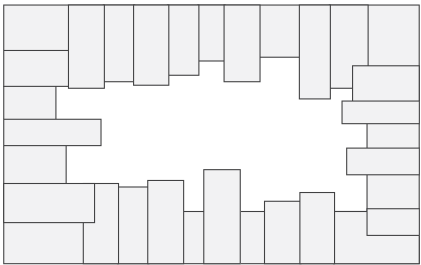
“A heating network is not always a good idea, but if the density of the population or the buildings is high enough, the investments become reasonable.” “The advantage of a heating network is that it is a joint system, so you have to build a structure for everyone” “No investment is needed from the residents themselves and they may get a lower price than natural gas and a long-term guarantee.” “A heat pump in a river or a canal is very advantageous because it can also supply cold. The canal is colder than the surrounding air in the summer, but also warmer in the winter.” “It could resemble the electrical network in the future. You will have the producers who supply heat to the network, a network operator and suppliers who buy the heat from producers and sell it to the customers.”	“The energy transition is very high on the social agenda. We cannot solve this as architects alone, nor can the municipalities or private owners solve it alone, so it requires an integrated approach. That is why we believe in the district as the right scale.” “Brussels has the ambition to create a Positive Energy District, but at the same time there are no tools at all to create 40 of them.” “All is based on individual logic. Our subsidy and premium systems are based on individual households, banks give individual loans, permits are issued on an individual basis.” “We keep telling a story that is about we have to consume less and less and less, that still applies, but that is not necessarily true for everyone. So maybe some people will use more energy, and that may also be fair, because that is also about quality of life.”	“What is problematic for me is the idea that a city can exist by itself. A city is always dependent on the countryside and the larger the city, the larger the hinterland it depends on, whether it is food or energy. It has always been this way.” “There are very good examples, especially in the former Eastern Bloc countries or Berlin, that district heating is a great idea. But you still need a heat source and you still have to build a double infrastructure that will cost resources and energy.” “All proposed solutions are: let's build a gigantic amount of metal and concrete infrastructure that will perhaps provide an advantage in 40 years. I do think that there is a certain urgency here to act and this way we are actually making things worse.”	“I'm not fully convinced that renovation policies are an adequate solution. While I see the importance of actions like insulating the roof or basement, it feels like we're putting the cart before the horse. We're asking Brussels' residents to make financial efforts they simply can't afford.” “I am not going to tell people to get a heat pump if the state of their building doesn't allow it. They would have to get a hybrid system with an additional boiler, and then have two installations to acquire and maintain.” “What bothers me a lot is the fact that we have a policy that is very generalised and that we are not considering it on a case-by-case basis.” “We should not fall into paternalism. You should give advice, but you can't tell people how to live their lives. [...] I would like us to launch workshops on overheating, for example, so people learn to help themselves.”
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Transformation Type A + B

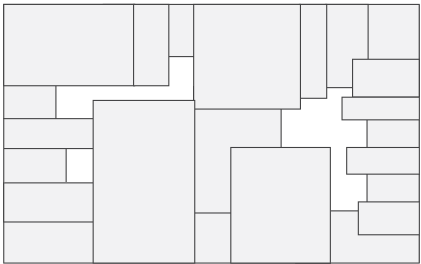
Our analysis showed, that the options for renewable energy generation is limited within these two typologies. In this context, strategies to increase public participation are crucial to empower residents to make independent choices. Interventions in public space should focus on improving the quality of urban space while accommodating the necessary energy infrastructure. Strategies such as the creation of energy communities are a useful tool in the context of Cureghem's complex ownership structures, allowing tenants to benefit from nearby solar PV installations.

It is therefore important to focus on activating larger commercial and industrial rooftops for solar PV, which could form the basis of an energy community. The close integration of residential and industrial buildings will be an asset for Cureghem's energy transition.

More efforts should be put into activating currently unused spaces, as there is still a lot of potential, especially on private property. New spaces for organisations and residents will be a welcome addition to the neighbourhood. Given the lack of public funding, public space improvements should focus on quick wins and tactical interventions that make use of scheduled road works and the resources of the many social organisations in the area. Incremental strategies should succeed in building the necessary trust and public support for much needed traffic calming and greening measures.



TYPE A



TYPE B



← While blocks of these typologies are almost fully built, there are many garage entrances and backyards that could be activated and extended to offer space for social initiatives and energy communities.

Opportunities



↑ The first energy community in Brussels sharing the electricity from the roof PV installation of a local school.
© Bambini. (2021). via BRUZZ.
<https://www.bruzz.be/milieu/hoer-de-eerste-energiegemeenschap-brussel-zonnestroom-deelt-2021-02-04>

Energy sharing

A recent trend in Brussels is the creation of 'energy communities', where several households enter into an agreement to share the energy from a common PV system. On the one hand, this is simply a better reflection of the physical reality of electricity. In a regular energy contract, a user always pays a flat rate to the grid operator for the use of the energy infrastructure, which makes up a large part of the energy bill. An energy community involves the creation of a separate billing system where the use of locally generated electricity is accounted for and charged at a lower price, with a deduction for network charges. This can also encourage people to be more aware of their consumption and shift demand to times when solar power is more plentiful.

On the other hand, it can lower the threshold for investing in a solar PV system by sharing the initial costs and benefits. In this way, residents without their own roof can benefit from local PV power.

One remaining obstacle is the counter-intuitive billing, as energy communities receive two energy bills. While the regular supplier's charges will be lower, resulting in a net gain, the perception is different at first, requiring a robust information campaign to get residents on board.



↑ Collective renovation in Mechelen
© Stad Mechelen - Ighor Van de Vyver
via bondbeterleefmilieu.be

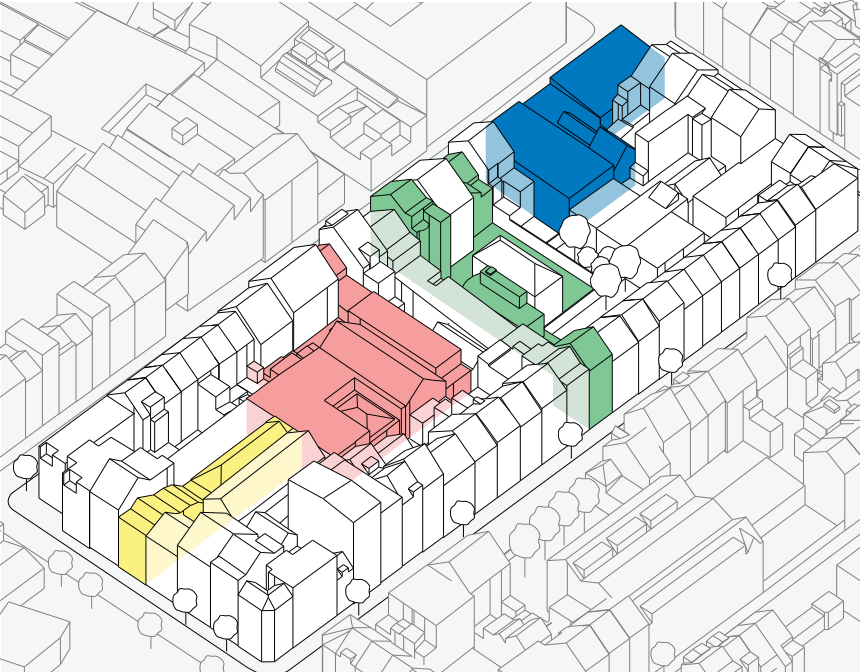
Collective Renovation

As renovation is probably one of the most controversial aspects of the energy transition, there are ways to make it more socially acceptable while increasing the speed of the transition. Currently, financing, planning and implementation have to be organised on an individual basis (interview H. Mangelschots, 2024). A new legal framework is needed to offer renovation packages for an entire street, to which residents can subscribe. This would provide a coordinated approach, reducing costs for all parties involved, but also providing an incentive for homeowners who are reluctant to renovate or who are overwhelmed or unable to organise it themselves. According to Reynaerts, K. (2020) of BondBeterLeefmilieu, an environmental non-profit organisation, a pilot project in neighbouring Mechelen has achieved positive results in terms of emission reduction and social acceptance. Cureghem's complex ownership structure could benefit from a tool to collectively organise meaningful renovation quick wins.

Backyard activation

Much of Cureghem's urban fabric is fully built up, but our analysis suggests that much of the private space behind buildings is inefficiently used and unnecessarily compartmentalised. As homeowners have gradually extended their buildings over the last century, the interior of certain urban blocks has become a complex or rather chaotic ensemble. Our case study of Bos-polder-Tussendijken has shown the importance of semi-public spaces at the back of buildings to enable energy-conscious activities. We have observed that, contrary to appearances, many buildings and rear extensions are already interconnected by organisations or companies. Using this principle could activate currently unused, dead backyards and consolidate them into larger shared units that benefit everyone. This could also become a funding mechanism for home renovation, as owners would sell a small piece of their land to create the backyard.

→ Analysis of interconnections within a block in Cureghem. There is potential to use this principle to create larger common backyards.



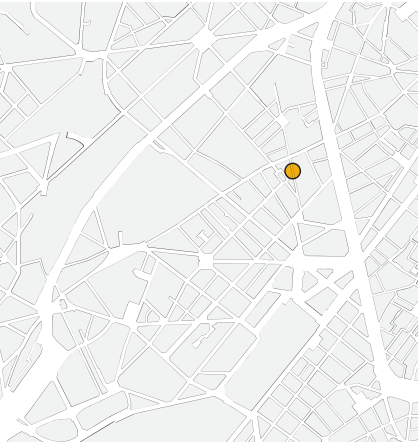
Backyard activation



While most of Cureghem is densely built with little to no publicly accessible space, there are countless backyards and hidden interconnections between buildings. Many of these are currently unused or used for parking cars, offering an opportunity to activate these spaces to be used by local organisations such as *cultureghem* for example.

While the programming of such space does not have to be energy focused, even activities such as communal cooking are energetically favourable compared to individual actions. On the other hand, these places could host workshops and contact points for people with questions about home renovation, seeking to reduce their energy bills or looking to find repair for a household device.

As we have seen with the case of *Huis van de Toekomst* these kind of semi-public spaces can offer great potentials for emerging initiatives. The occupation can also be temporary in preparation of renovation works. Or, in the case of a consolidation of several unused backyards into a new common space, the funds from the sale of private property can be used for investments in energy production or certain building renovation measures.



Transformation Type B + C

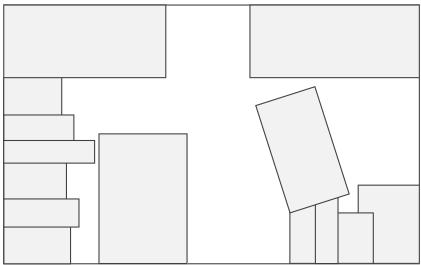
This context offers some interesting opportunities to promote renewable electricity and heat production. Our analysis suggests focusing on integrating larger energy infrastructures into the urban fabric. Car parks, brownfield sites and sports grounds can offer huge potential for efficient ground-source heat extraction using industrial-scale heat pumps. It is therefore important to give companies financial incentives to invest in these production methods by providing a clear path for the development of a heat network in Cureghem. This will provide planning certainty and a horizon as to when and where the infrastructure will be rolled out. This approach can benefit from the larger capital of these companies and their ability to invest in infrastructure on their own premises.

Another aspect that should not be overlooked is the activation of open green spaces. As these are scarce throughout Cureghem, the existing ones should be assessed to improve their quality, as many of these spaces are still limited to simple grass fields or car parks.

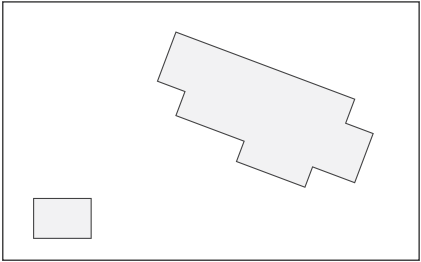
A novel approach could be to use new energy infrastructure such as above-ground district heating pipes or solar PV structures to provide social functions such as a climbing wall, swings or even a hot water tap. It can also offer opportunities for depaving and adding greenery.



← The few open spaces in Cureghem are an opportunity for the installation of ground source heat pumps.



TYPE C



TYPE D

Opportunities

Geothermal heat exchange

As the capacity for renewable electricity generation is limited in Cureghem due to the lack of available space and the high population density, a solid PED strategy should focus also on local heat generation (Architecture Workroom Brussels, 2023).

The risks and benefits of heat pumps are discussed in chapter 4. Cureghem could benefit a lot from the capacity of large ground source heat pumps to provide flexibility to the energy grid by storing heat underground. To minimise the risk of groundwater pollution, these installations should be done collectively to ensure high professional standards and public oversight. New legal frameworks are needed to use the public domain for this purpose (interview H. Mangelschots, 2024). These semi-public heat pump installations could form the backbone of a district heat network for Cureghem. Architecture Workroom Brussels showed how the city of Ghent is already successfully exploring this principle (p.167).



↑ Voetbalveld Standaard Muide wordt warmtebron voor buurt. (2022, December 21). Stad Gent. <https://stad.gent/nl/energiecentrale/nieuws-evenementen/voetbalveld-standaard-muide-wordt-warmtebron-voor-buurt>



↑ CopenHill by Bjarke Ingels Group. Image: Rasmus Hjortshøj/Courtesy of WAF. Retrieved from <https://bustler.net/news/8548/copenhill-amager-bakke-wins-2021-world-building-of-the-year-award>

Infrastructure as lever

The energy transition will require a lot of new infrastructure, from solar PV installations to electricity and heat networks. As this is one of the major cost drivers, we should aim to use this as much as possible for other means of improving quality of life, biodiversity and climate resilience. Putting some of the new infrastructure above ground in appropriate places could save costs and create opportunities for new creative uses. Landscape designer Piet Oudolf, known for his use of wild grasses, has demonstrated the potential of heat network infrastructure to support greenery.

A district heat network requires a whole new layer of infrastructure. This intervention can be used as an opportunity to improve the quality of the public space without much additional planning. When burying the new pipes, instead of simply paving over the surface with asphalt, it could be left open as a bed for plants or paved using permeable stones. A simple interventions by CollectifDallas at the Justice Palace in the Marolles shows the effectiveness of simple depaving.

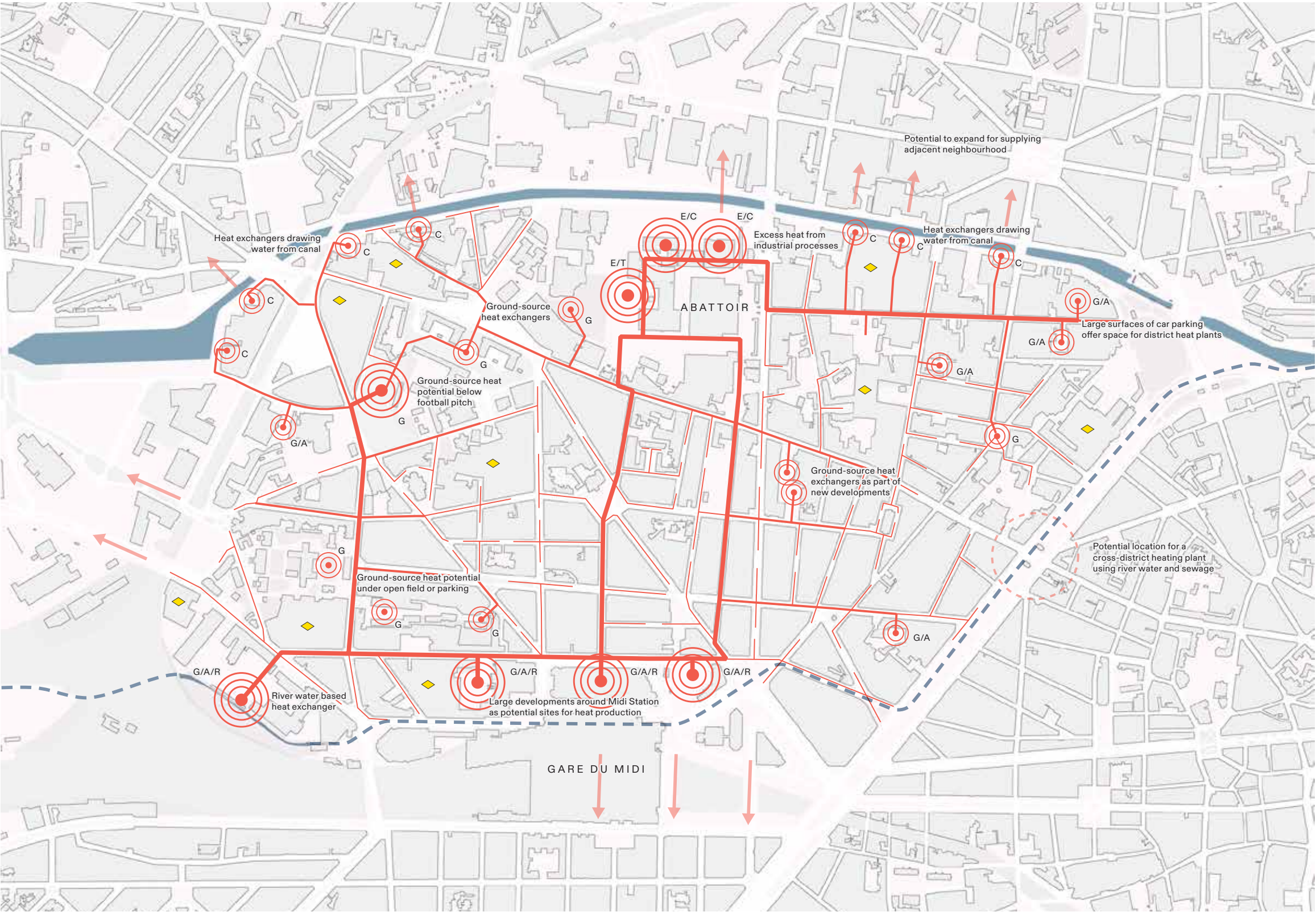
Another example of using infrastructure as a lever is Copenhagen's new waste incineration plant, which has been designed as a landscape element from the beginning. A similar approach could be applied for smaller neighbourhood stations. Instead of usually passive designs, it can be used as an active element in the streetscape through playful elements and an inviting design.

← Plantings by landscape designer Piet Oudolf on infrastructure of a former factory in Strijp S, Eindhoven. Photo © Marleen Beek retrieved from <https://landezine.com/strijp-s-by-carve-and-piet-oudolf/>

↓ Intervention by CollectifDallas at the Justice Palace, Marolles. Photo © Cinzia Romanin from <https://collectifdallas.eu/jardins-suspendus>



Heat Network Potentials



The density of households and the diversity of user profiles make a Cureghem a very suitable candidate for a heat network. This map shows a proposed structure derived from the identification of suitable locations for larger heat generators. It shows a maximum scenario of installing heating capacity throughout the district with the aim of connecting all households.

The largest sources around the Abattoir are associated with excess heat from industrial processes. The scenario also assumes the integration of the planned swimming pool as a thermal reservoir to smooth out peaks in demand. Another element of this heat plan is the use of the canal's thermal potential. The many industrial sites along the canal are well suited for medium-sized heat exchangers that draw water from the adjacent canal.

The forthcoming developments around the Midi station also offer a window of opportunity to maximise heat production. The large size of the plots makes it possible to drill boreholes for efficient ground-source heat pumps. Another opportunity lies in the Zenne river, which runs underground alongside the station.

Smaller ground-source heat pump stations, integrated into the urban fabric on previously undeveloped land, can form a second layer of this heat network and provide a boost to the district heating system.

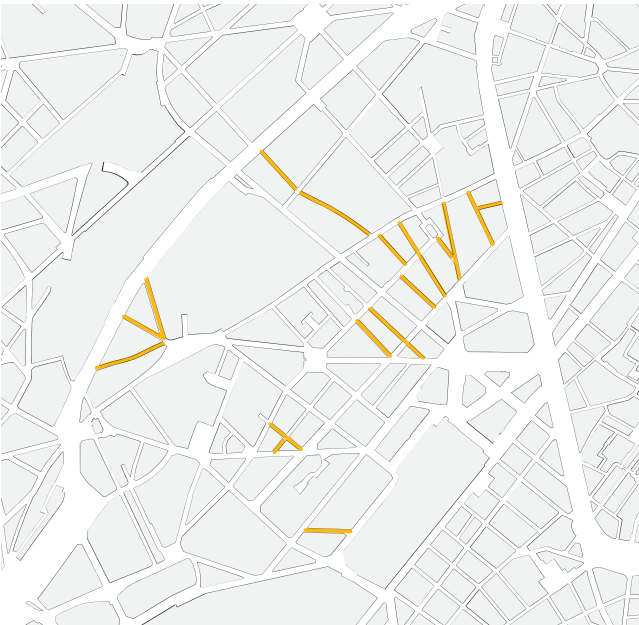
As most of the surface area of Cureghem is already built up, alternative approaches are needed to find suitable locations for the installation of ground source heat pump systems. It could become a testing ground for installing these systems under parking lots or public sites such as sport fields and parks.

Street type 1

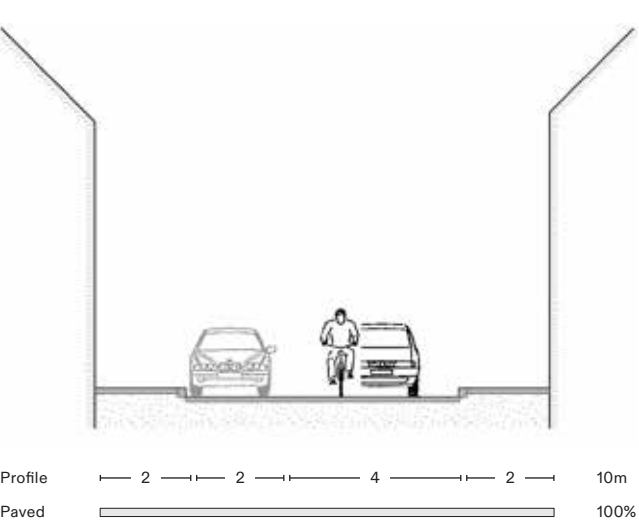
A common type of road in the residential areas of Cureghem, with no tree cover, making it vulnerable during heat waves. The current design has pavements two metres wide, which is the minimum for comfortable passage for wheelchair users or people with pushchairs. The carriageway is quite wide in this residential context and the straight, unstructured design encourages speeding, which we observed during our site visits.

Assuming the scenario of a heat network being installed on this type of street, we propose two strategies. The first focuses on quick wins that would not require additional design. In this case, we suggest laying the pipes at the side of the road and paving it with permeable stones. In this way, the functional division of the road is clear, while at the same time improving rainwater retention and flood resistance in the event of heavy rainfall. We also propose to leave the ground open for planting at the building junctions.

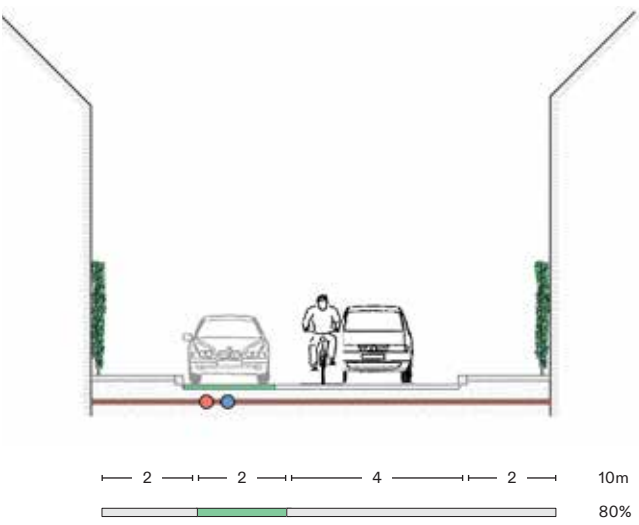
The alternative scenario proposes a different approach, using the excavation work for the heat network to create alternating parking bays on either side of the road. Trees could be planted on the side opposite the main pipes, as their roots won't interfere with the main heating network. In this way, most of the parking capacity is retained, while the road is made visually narrower with obstacles to discourage speeding.



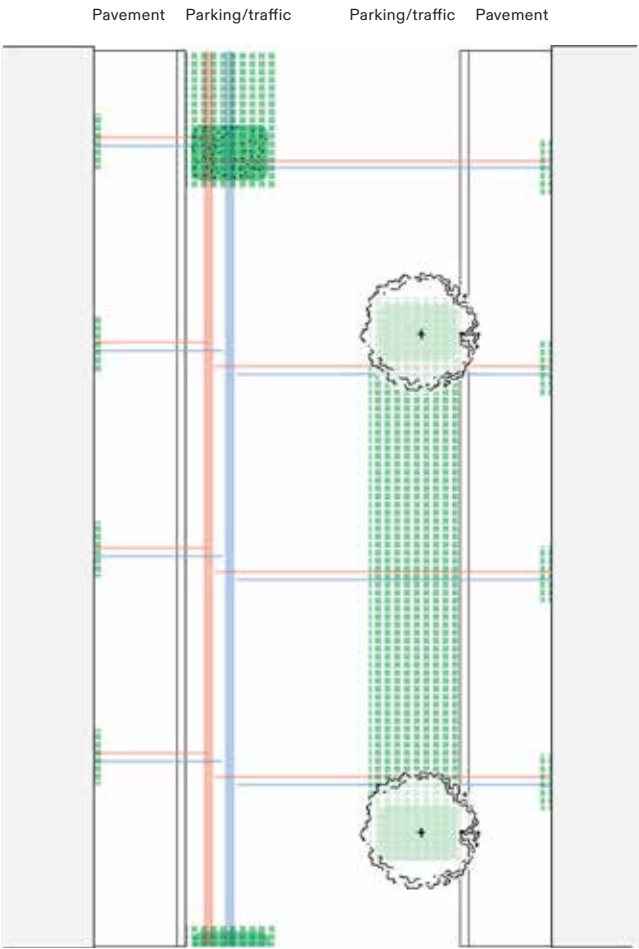
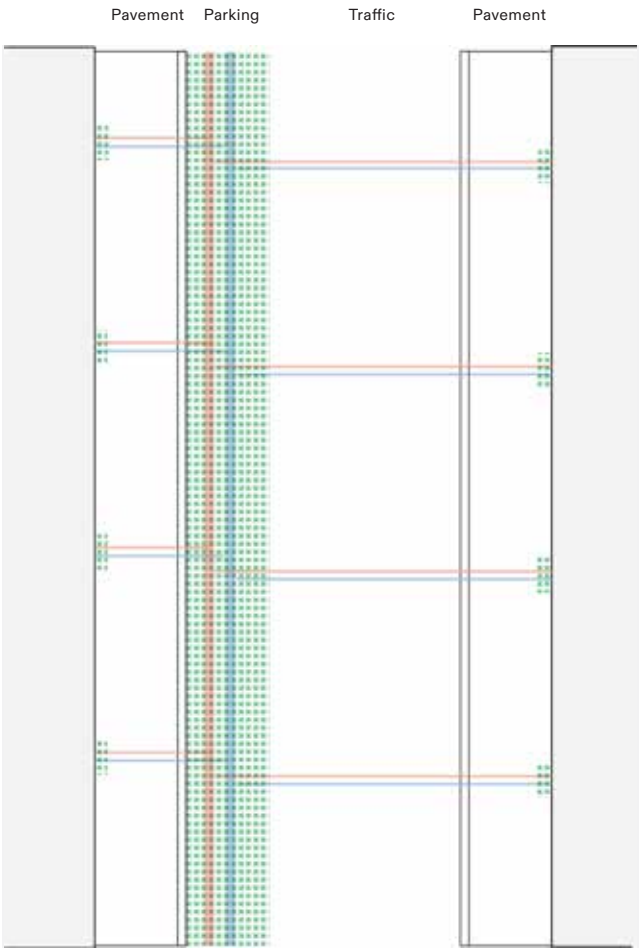
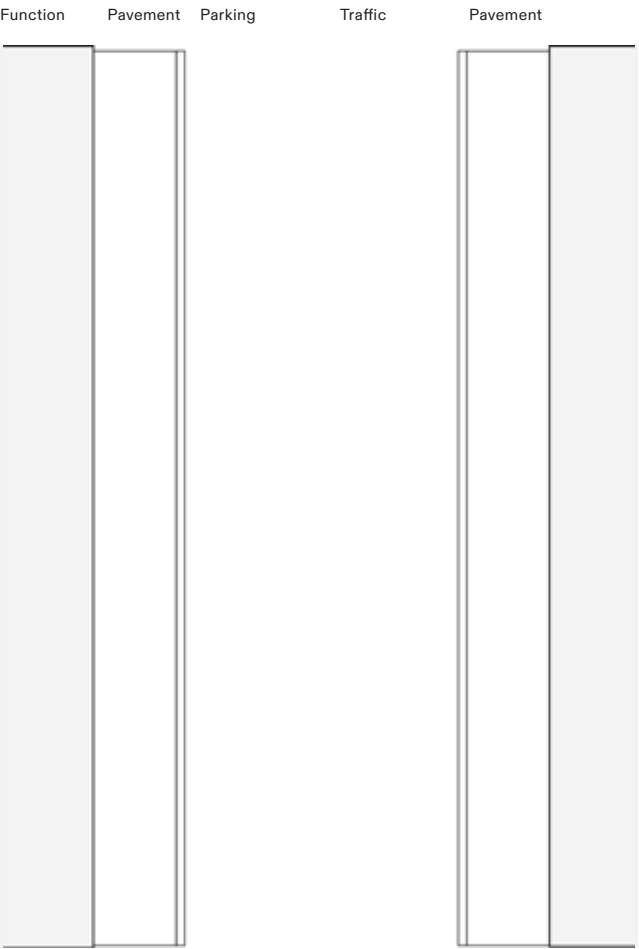
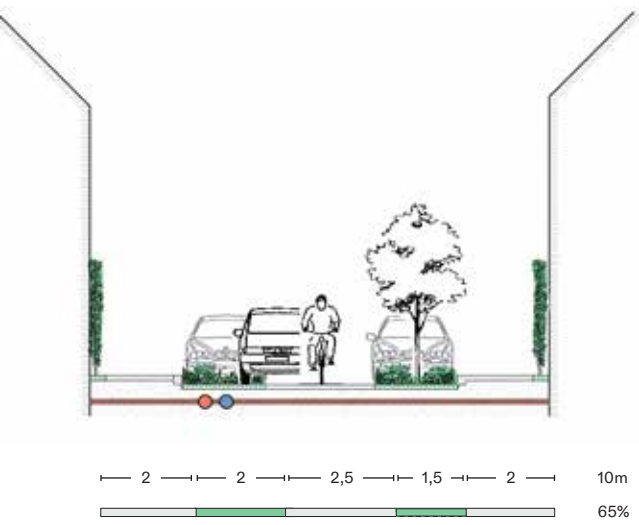
Current



Quick Wins



Traffic Calming

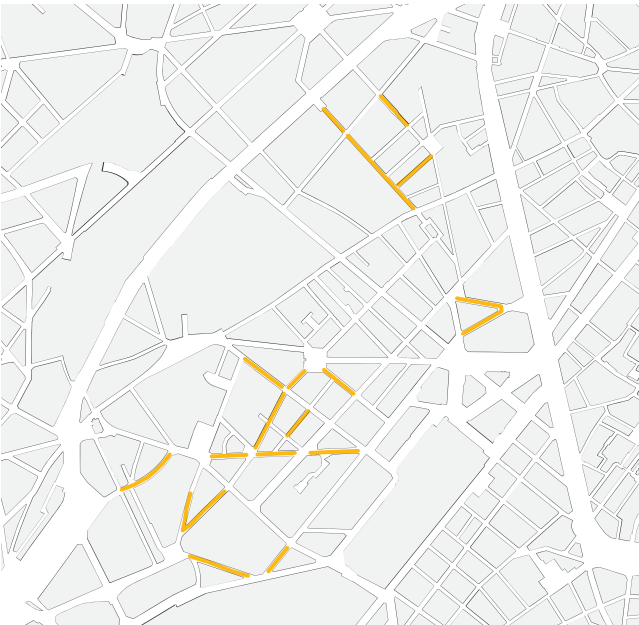


Street type 2

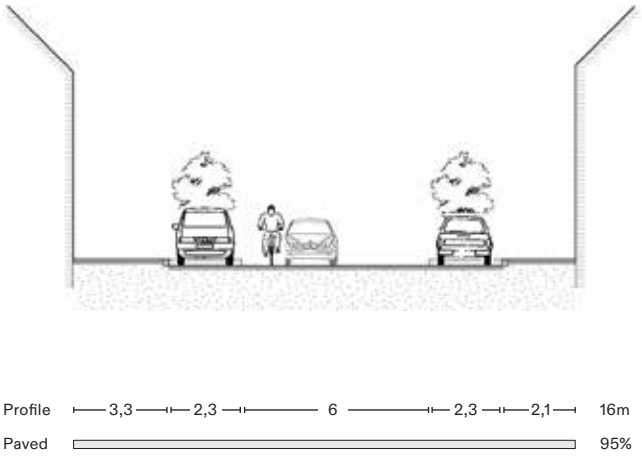
A regular type of street that appears with variations throughout Cureghem. The trees are either on the hard shoulder or on the verge. Again, the carriageway is often quite wide and unstructured, which encourages speeding.

Here, too, we propose a quick-win strategy that would make direct use of the groundwork for laying the pipes for a heat network. The trees are a constraint for the underground pipes, so we would not suggest using fully permeable stones with holes where the main pipes are, as this part of the road is used by cyclists. Instead, we suggest paving with regular stones, as is often done in the Netherlands, which still makes the road look a little narrower and allows more water to seep through than asphalt. The sections that cross the parking lanes can still be paved, as can the connections to the houses.

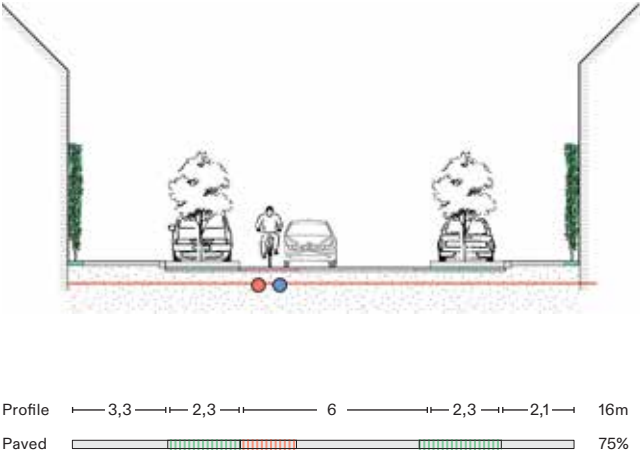
We also propose a scenario to maximise additional green space: as this road is quite wide, it would be possible in a residential context to move the left parking lane inwards and replace it with a wadi to maximise water retention and biodiversity. The parking does not have to be completely replaced, we propose a system of pockets alternating with parking where cars can pass each other. This narrows the road significantly, discourages speeding and allows more space for trees and greenery, making the design more climate resilient.



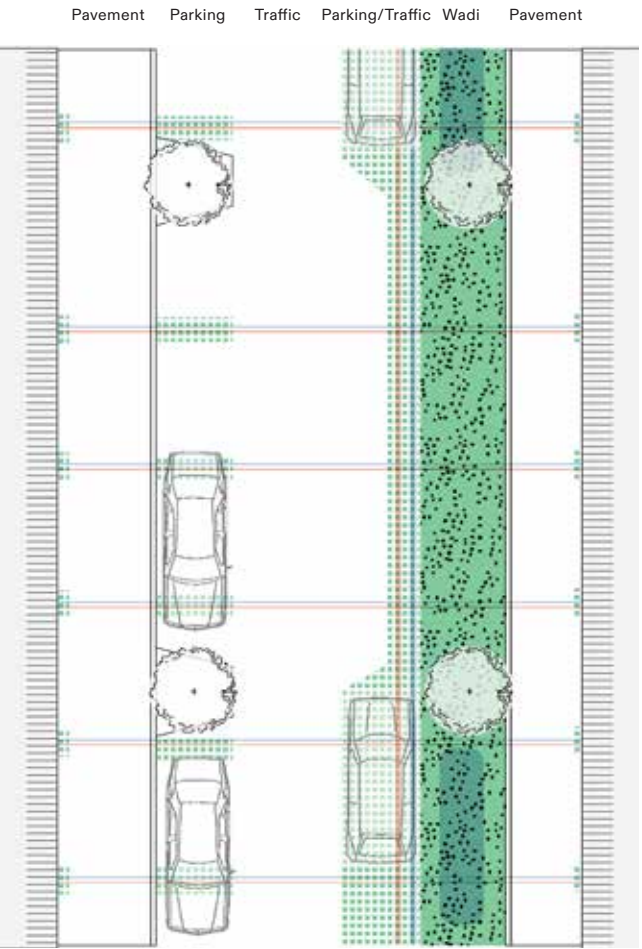
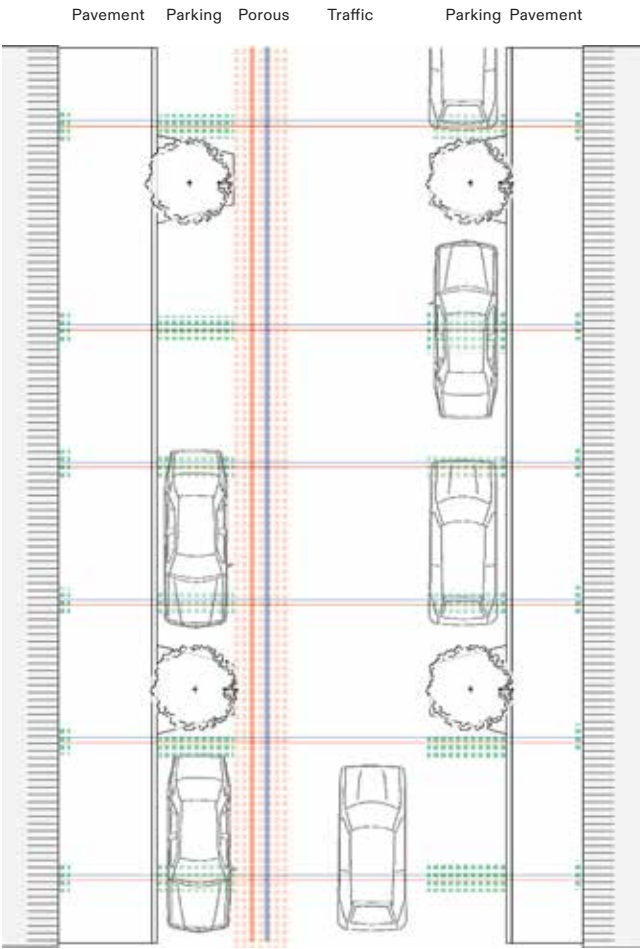
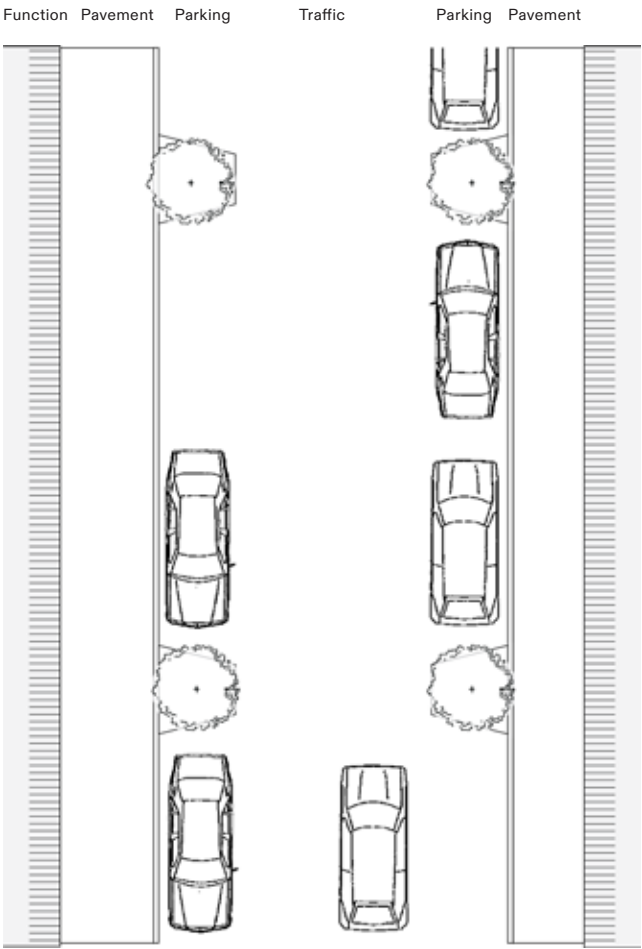
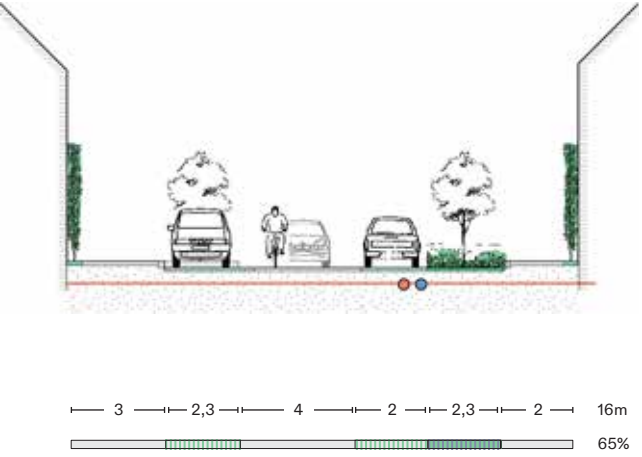
Current



Quick Wins



Biodiversity Boost

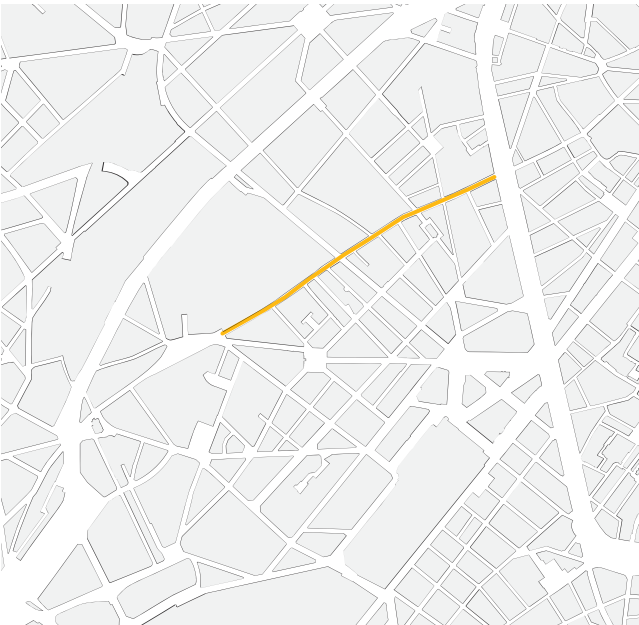


Street type 3

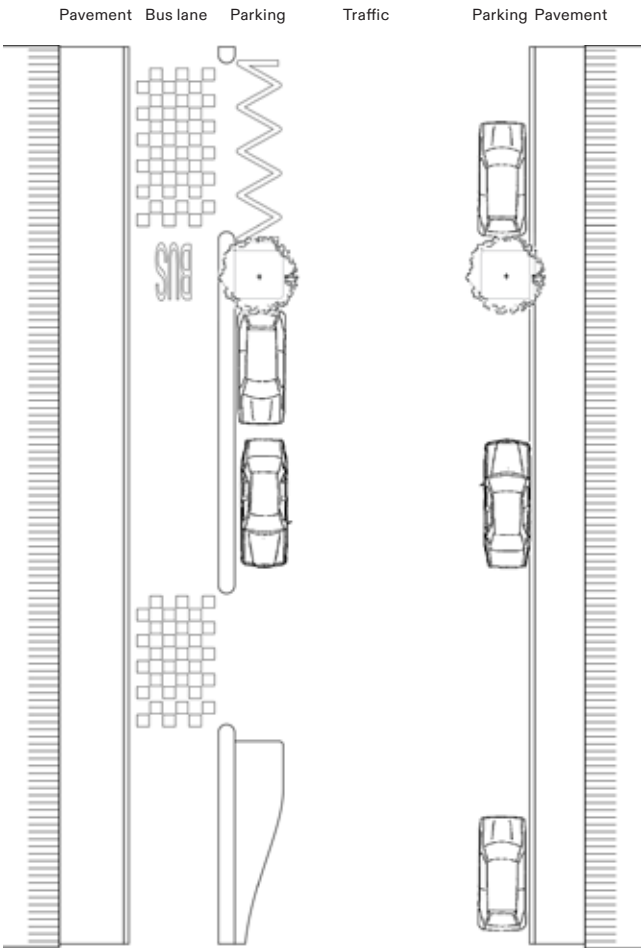
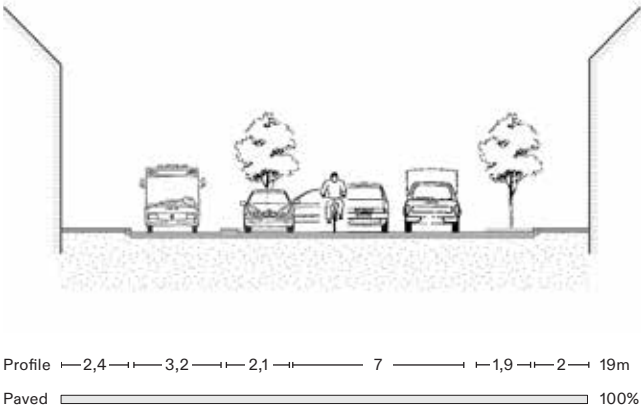
This type is specific to the main road, Chaussée de Mons, which runs through Cureghem. The current design has a separate bus lane with a parallel parking lane and few trees. It is one of the busiest roads, with many shops that require deliveries.

Using the heat network as a starting point, we propose a quick-win strategy that would use the bus lane for laying the heat network, which can also be partially paved where the bus does not need to turn and access from the road is not required. Where the bus lane has to be crossed for access, we propose permeable paving. Along the distribution lines, we propose depaving the parking lanes to maximise the permeability of the road surface and minimise the risk of flooding from rain.

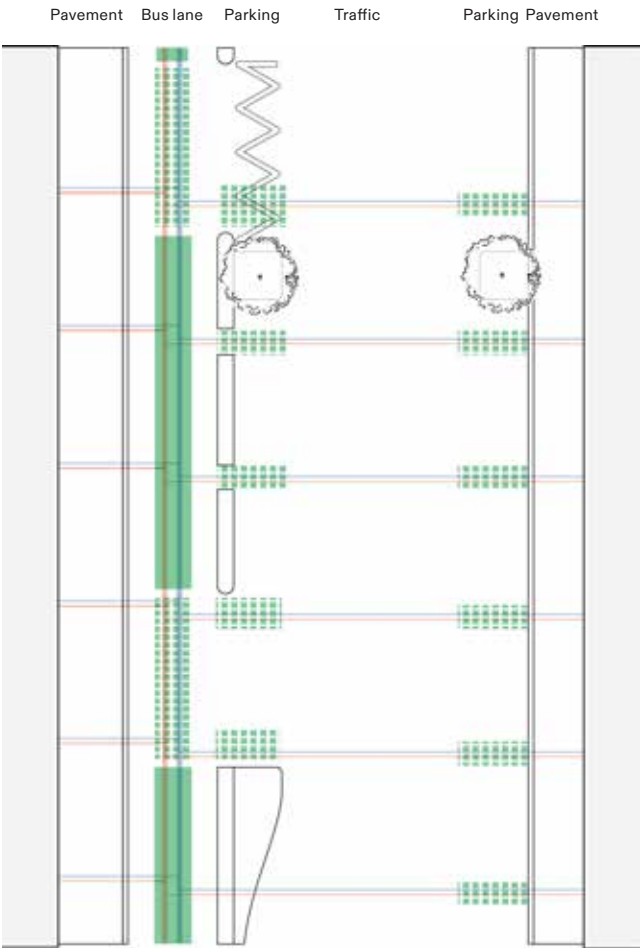
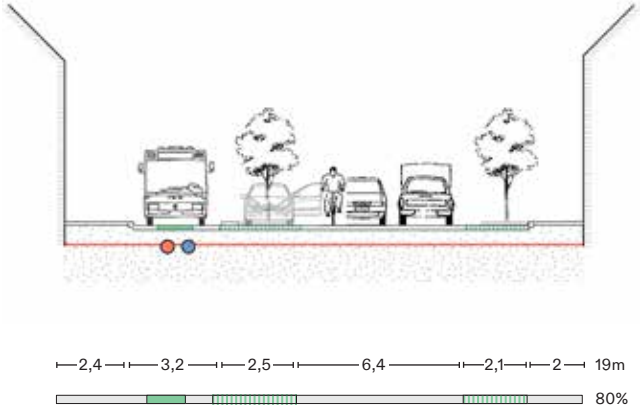
The second scenario focuses on creating a larger and taller tree canopy to better protect the road from summer heat. The current street trees are in poor condition, with little space for roots and surrounded by paved surfaces and heavy pollution. To improve this, we propose to sacrifice additional space in the central reservation for permeable stones and additional trees. The species will need to be chosen to withstand the pollution from the road, the large paved area and the high water table. We would not propose to remove the entire parking lane as the street is a hotspot for deliveries and social life and any open green space would be expensive to maintain.



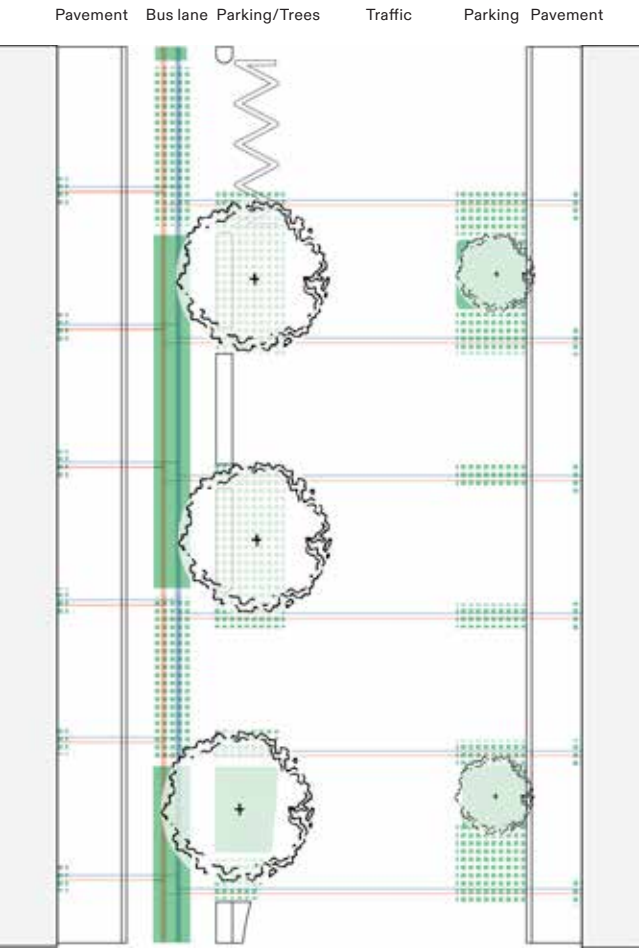
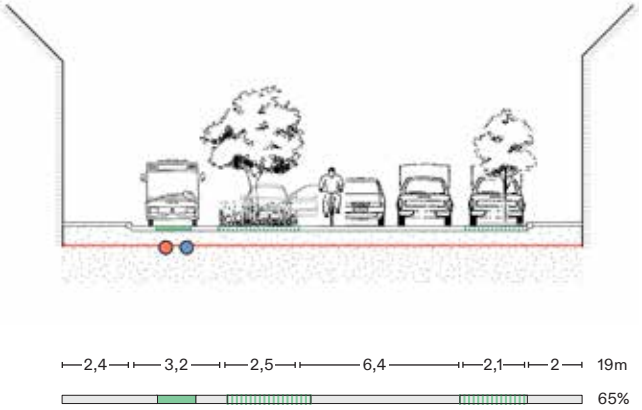
Current



Quick Wins

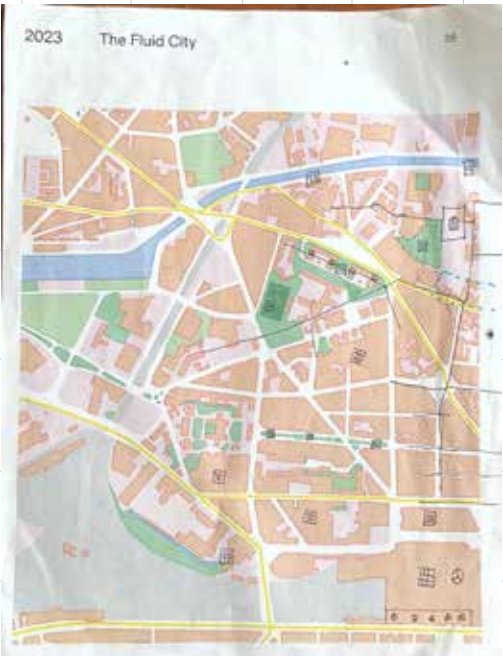
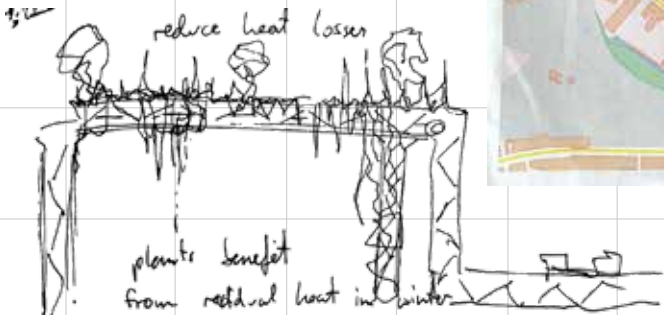
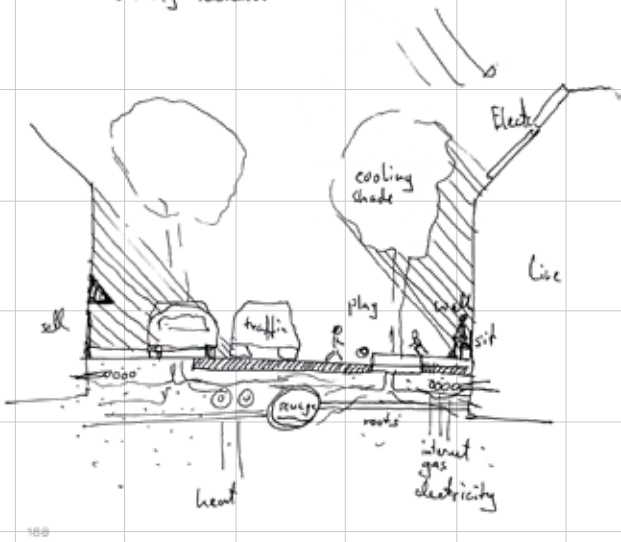


Canopy Building

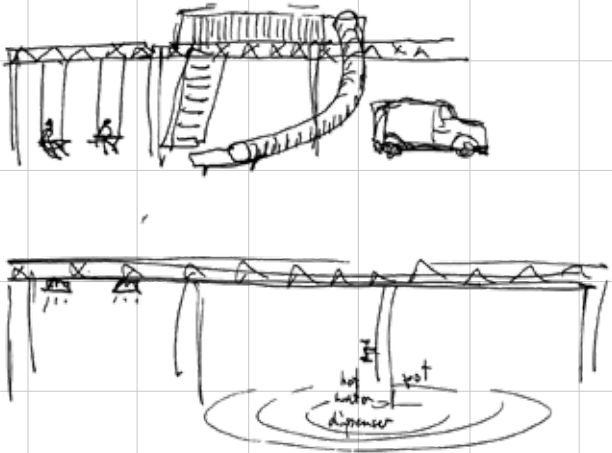


FUNCTIONAL LAYERS
evolving with time
can be in competition with each other
↳ semi-public space as energy catalyst
behaviours
novel space uses
sharing facilities

Research
by Design



urban
energy
landscape



① HEAT NETWORK

Undiscussed
potential of using
excess heat and
cold from
Pressurised Air
Storage Systems

Quick wins Residential street

The construction of a heat network inevitably involves significant intervention in the road to lay the pipes. Often this is done with a thorough renovation of the entire street layout. While this is efficient, it also contributes to the high upfront investment required to build such a district heating system. On the previous pages, we discussed an approach to improving the quality of life and climate resilience of the streets in Cureghe that would use the construction of a heat network. Completely renovating every street in Cureghe where the heat network would be extended does not seem financially viable. We therefore take a more minimalist approach to the intervention, opening only the road where the pipes need to be laid, avoiding trees and other obstacles.

Using this intervention, we propose quick wins that would not significantly increase construction costs, but would improve permeability and climate resilience. The quick win strategy would be to choose not to fully pave the surfaces after the heat network has been laid. Wherever possible, the pipes should be laid under parking lanes or at the side of the road. In this way it would be possible to use permeable stones instead of asphalt to finish the surface.

As discussed on the previous pages, there are many ways to do this, but the result will always be the removal of a previously sealed surface. If the budget allows, further measures can be planned, such as using the infrastructure works to create green pockets and wadis to increase infiltration and biodiversity, or as traffic calming measures by rearranging parking lanes. Removing some of the pavement over the heat network can also help nearby trees to grow larger and provide more ecosystem services, such as active cooling during heat waves.

All of these measures could benefit from the construction of a heat network, making Cureghe more resilient to the effects of extreme weather.



→ Image of the campaign 'Bruxelles plante!' where Brussels' mobility department invited residents to propose interventions to add greenery to their street.
Image: © Brussel Mobiliteit

Decentral production Canal zone



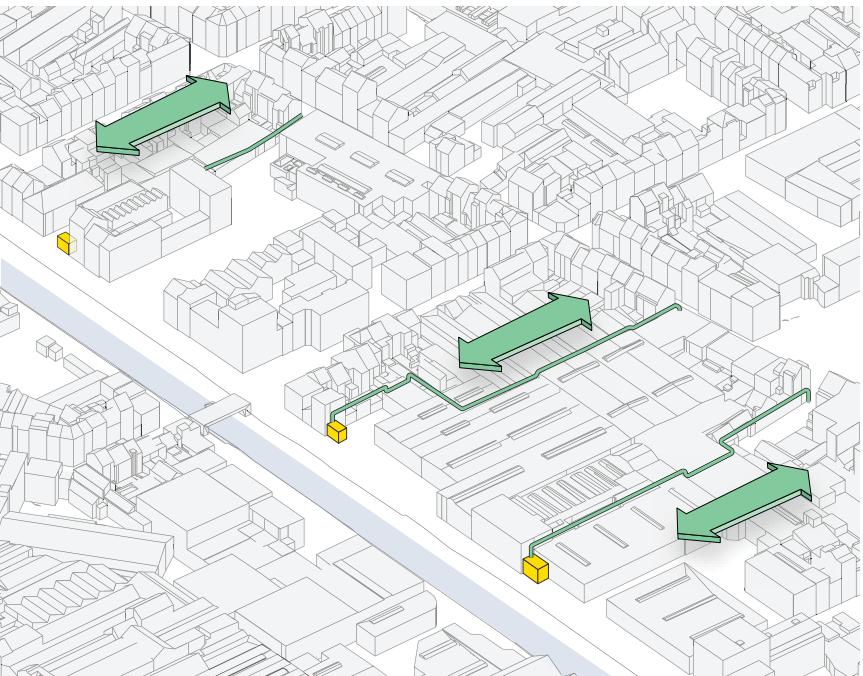
Based on these quick win principles, we also propose an additional strategy for the industrial areas of Cureghe along the canal. The proximity of the canal offers a unique opportunity to install large heat pumps alongside the industrial estates, taking advantage of the stable water temperatures and the resulting high yields from heat exchangers. Instead of a network running parallel to the road, it is also necessary to transport this heat laterally towards the residential areas of Cureghe. The large industrial complexes, with their flat roofs, offer a cheaper alternative to tearing up the road by going above ground, over the buildings, creating a more direct energy supply between the canal and the inner Cureghe.

This scenario also proposes to use this pipe infrastructure to provide greenery in places that are otherwise desert of any plant life. The metal structures can support plants that create green corridors for animals or provide shade for climbing plants.



↑ A bus corridor in Eindhoven, Netherlands using existing industrial infrastructure to create a green canopy.
© Photo: Nanda Sluijsmans under cc-by-sa-2.0.

This scenario assumes that businesses along the canal would take an active role in supplying heat to the network as a sound business model. Not only would this create a more resilient heat network, but it could also foster a sense of pride and ownership in Cureghe's district heating among residents and business owners.



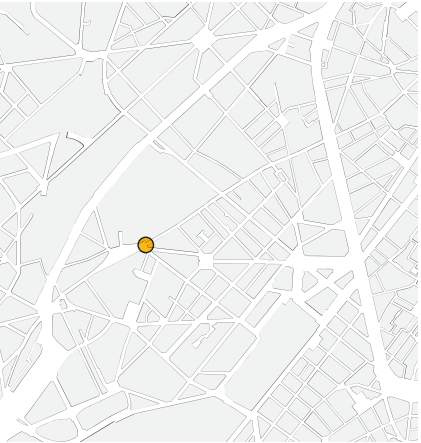
Activation of Infrastructures



Making a district like Cureghem climate neutral or even energy positive requires new infrastructure for the production of renewable heat and electricity, as well as a robust network for distribution. Given the spatial requirements of these structures, new spatial conflicts may arise if the implementation does not provide for integration.

Rather than problematising the additional use of space, we propose a strategy of using these new infrastructures as tipping points for local activation. In partnership with organisations such as *Cultureghem*, which already have experience in tactical interventions. Many urban spaces in Cureghem are inadequately designed to meet the needs of young adults and children, have a high proportion of impermeable surfaces and prioritise the majority of space for motorised traffic. Changing these shortcomings has so far proved difficult, either because of local resentment of government intervention, or because of lack of funding. As there is a clear limit to funding, this proposal does not rely on a complete redesign of a site, but uses technical infrastructure as a means of enabling improvements through tactical interventions. The removal of a few car parking spaces may meet with less resistance if it is for the construction of a heat network, and once the work is complete, it could simply be replaced by interactive elements and child-friendly street design, without the initial conflict of space.

The technical installations themselves, such as district heating plants, could also be designed to include elements that allow for play and interaction. While open spaces are rare in Cureghem, many of the existing ones lack a minimum level of quality and are not inviting to stay. Piggy-backing on new infrastructure works could be a quick win to improve these spaces with high social potential.



Timeline

2025	2026	2030	2040	2050		
Following a national initiative, subsidies for electric vehicles are partly redirected to organisations such as <i>Centre de Rénovation Urbaine</i> to improve the dialog between residents and authorities. A research project started to collect data and knowledge about individual needs of residents, create user groups to understand the different profiles and their relationship with energy. Initiate legal frameworks for collective renovation and energy production on public land using geothermal heat exchange. The public network utility Sibelga prepares the creation of a legal framework for local heat networks that can combine several individual producers into the same grid. The first energy-commission is created for Cureghem as part of a trial for future PEDs. It consists of stakeholders from different expertise: local NGO's, municipal administration, regional administration, regional utilities and network managers. A new tool is tested to identify the best technical solutions for districts in Brussels which takes into account the configuration of the area and its energy requirements. Among other things, it determines the amount of space needed to make better informed decisions regarding available energy sources. First initiative is launched of a new programme to facilitate direct contracts between rural biomass producers nearby Brussels and Cureghems future energy suppliers.	First installation of a large ground-source heat pumps under a football field or a park. Creating the first producer contributing to the heat network. The first 500m of heat network are laid, testing different spatial configurations and designs. A group of stakeholders is identified which will develop a programme for placemaking and space activation in conjunction with the coming infrastructural works. Quick wins around the new infrastructure are identified for creating additional green space, depaving or traffic calming. The first renovation packages are developed for a number of streets with support to find the necessary funding also through national and european funds. First results of quantifying the effects of social activities of social organisations on energy consumption are evaluated. Connection of a local company to the first parts of the heat network. The metal part supplier has installed a large heat pump with a borehole under their backyard material storage and will start sharing excess heat with the network.	Following the example of Cureghem, the 15th energy positive district commission has been founded and implementation is underway. The first round of collective renovations have been finished. Six new semi-public spaces have been created throughout the neighbourhood.  The heat network is rapidly growing, boosted by new developments around the Gare du Midi, a lot of additional energy production capacity is added. The network coverage is still patchy due to lack of funding and slow coordination. But connected residents report stable energy bills at lower prices creating a growing enthusiasm about the coming network. Residents that live on streets that have been depaved after the heat network installation report fewer issues with rain water flooding their basements. A pilot project is launched to install a hot water tap on a former intersection in a residential street following the connection with the heat network.	Several programmes for temporary interventions in streets have been made permanent after the success, traffic through the residential streets connected to the heat network has dropped by half. The Abattoir finishes construction of its new housing units and buys a plot of land of a nearby car dealer, planning to expand economic activities and invest in additional heat infrastructure. The swimming pool on the Abattoir site is finished and includes a heat exchange system to help cover peaks in heat demand during the evenings. New developments near the canal have put additional pressure on Cureghem's housing market, but also caused an increase in energy demand due to the wealthier inhabitants, delaying the connection to the heat network due to lack of production capacity. For the first time more than 10 new energy communities have been created within a single year. 	As the heat network is expanding rapidly, some parts have to be constructed quickly to better interconnect production capacities. Due to a lack of funds, the local energy commission decides to construct some of these interconnections above ground, calling for ideas for the best dual use of the infrastructure.  Thanks to individualised energy advice and support programs for residents by local NGO's, energy demand has been slowly declining over the past 10 years and the peak demand is three times lower than before due to individual behaviour shifts and the growing number of energy communities. The first large scale heat pump drawing water from the canal is connected to the grid. A car dealer specialising in the conversion of oldtimer cars to electric vehicles has invested in the system to increase profits from his enormous roof solar system covering his garage.	Collective renovation programmes are also gaining popularity, with one bold initiative starting to reorganise the complete inner structure of the housing block. Using some innovative architectural techniques and a clever system of volunteers, most of the structures are dismantled by hand for the bricks to be reused for a new building on the inside of the plot. The freed up space becomes a shared courtyard. The funding raised from the sale of the individual backyard is used to finance a part of the renovation works. Cureghem experiences a small job boom, as many local companies are using their expertise on installing renewable infrastructure to sell elsewhere. By 2043 Cureghem has managed to connect 78% of all households to the shared energy network. The remaining amount will be harder to connect sometimes due to the stubbornness of residents, or lack of available capacity. As global temperatures reach new record highs, Cureghem's canopy initiative is showing fruit, thanks to better infiltration and less paved surfaces, the new trees have grown quickly to create a taller and wider coverage. This has successfully reduced average street temperatures during heat waves by around 3 degrees. While the sales of air conditioning units have soared, electricity peak demand in Cureghem has not been growing as fast as elsewhere.	Cureghem has been officially declared as climate neutral after connecting 99% of households to the local energy grid. As 2049 marked the first time where the last remaining backup gas boiler was not needed during the entire year. Most of the heat now comes from a network of ground source heat-pumps, many of them located at the canal. The flexibility of Cureghem's energy system has enabled them to secure a few very favourable contracts for excess electricity from six wind turbines further down the canal. The grid being able to absorb a lot of electricity in a short amount of time, heating up temporary hot water storages.  Belgium experiences one of its worst power outages in years, after a heatwave made electricity demand soar throughout Europe and unfavourable weather conditions in the previous months had depleted any long term storage. Cureghem however, was able to maintain functionality of its heating system thanks to a coordinated response from residents to adjust demand and the local micro grids who could continue operation without external grid power.

VII Conclusion

Technological paradigm shifts always create friction between different points of view. As with the energy transition away from fossil fuels, the adoption of new technologies has historically triggered debates about equity and justice. One example is the Luddite movement, which sabotaged textile machinery in the early 19th century in protest against the forces of industrialisation. Today, the term Luddite has become synonymous with a general rejection of progress. Similar accusations are levelled at those who remain sceptical about the promises of green tech to solve our current environmental dilemmas. It would be wise, however, to take a broader perspective. According to the historian E.P. Thompson (1968), contrary to the popular portrayal, the Luddites did in fact have a very nuanced view of technology and industrialisation. Concerned about the inferior quality of certain mechanised processes and the obsolescence of human skills, they targeted specific machines rather than entire factories. Thompson argues that the Luddites were not blindly opposed to new technology, but criticised the way it was being used to undermine their rights and livelihoods.

In the same spirit, this dissertation aimed to critically examine the spatial and social implications of the ongoing energy transition in the city, through the example of a neighbourhood in Brussels. The first part started with a broad perspective on the why's and how's of the energy transition and the Energy Positive City. We discussed the general need for coordinated action, zooming down to the city level and then to the neighbourhood level. The concept of the Energy Positive City has gained traction as cities are expected to step up their efforts to reduce their emissions. While Positive Energy Districts are a tool for achieving this, the definitions of what qualifies as such vary. As some practitioners question the rigidity of the concept and its ability to transform existing urban neighbourhoods, we have highlighted the need for flexibility and process-oriented solutions.

While Brussels has stepped up its efforts, our analysis suggests that the city is unlikely to be on track for climate neutrality by 2040. As additional efforts will be needed, it remains unclear what these will look like. We chose Cureghem as a neighbourhood to study because it is emblematic of many of the challenges Brussels faces in this transition.



↑ Unknown. (1812). The Leader of the Luddites [Illustration]. Working Class Movement Library. Wikimedia Commons. https://commons.wikimedia.org/wiki/File:The_Leader_of_the_Luddites.jpg [Public domain].

Using spatial design techniques such as mapping, photographic survey and morphological analysis as tools, we explored the energy potential within the urban fabric of Cureghem. We found a high diversity of building types from various periods and a wide range of local activities. But the lack of open green spaces and high proportions of impermeable surfaces leave the district exposed to climate risks such as extreme weather events. As the neighbourhood evolved through different periods, each of them can still be seen in today's urban pattern, creating the complex and diverse character of Cureghem. Four morphological typologies were defined on the basis of building types and spatial configuration. A historical analysis, based on maps and aerial photographs, revealed distinct patterns of energy use. From an artisanal economy based on access to running water, to coal-fired micro-grids, to decentralised rooftop solar energy, each period has its own spatial logic.

A review of the literature on renovation and the counter-intuitive effects of energy efficiency measures showed that there is a gap between calculated energy use and the actual performance of a building due to occupant behaviour. This knowledge of the performance gap is not yet part of the public discourse, which may be due to the time lag between scientific findings and policy implementation. Climate mitigation strategies in Brussels are still largely based on the expected benefits of increased energy efficiency, aiming for at least a threefold reduction in energy consumption. However, this seems unlikely in the light of the recent studies we have discussed, which document much smaller savings in real-world conditions. During our research, we often encountered duplicitous arguments, proposing building renovation on the grounds of reducing emissions and defending it against criticism with the higher living comfort. It's a complex and highly relevant topic that deserves more attention in future research.

Documenting the case of an organisation in a Rotterdam neighbourhood showed the importance of considering the social implications of the urban energy transition. We presented a local initiative that aims to give residents agency in the energy transition. Their confrontation with the conventional thinking of the authorities and their challenge to the monopoly position of the multi-national energy supplier put them in a difficult position. We discussed parallels between *Cultureghem* and *Huis van de Toekomst* and facilitated an exchange between actors from both communities. For both organisations, having access to the right type of spaces is of crucial importance to enable their activities and programmes. Authorities and researchers alike seek their valuable role within the neighbourhood. Enabling these kinds of mediating organisations is key for effective participation of residents in the energy transition.

The research by design part of this dissertation aims to explore the scenario of an energy-positive Cureghem by focusing on local heat generation and space optimisation for local initiatives. We proposed and explored several strategies incorporating direct feedback from local organisations who work on renovation, energy policy and urban renewal. Our infrastructure centred design approach highlighted the potential of using the new infrastructure required for the energy transition. We proposed sev-

eral street designs making use of the necessary construction works for building a heating network to also improve the quality of public space and increase climate resilience. A second approach was aimed at restructuring some of the denser urban blocks by activating and interconnecting existing but unused back spaces. These could be made available to the kinds of local organisations whose importance we've highlighted before. The spatial designs showed the transformative power of tactical interventions and space activation in contrast to a masterplan. We proposed a timeline for a gradual transformation that allows for citizen participation in the neighbourhood design.

There remains a significant knowledge gap regarding the effects of activities from energy-centred organisations and social initiatives. Communal cooking with leftover market vegetables, as the organisation *Cultureghem* does regularly, clearly has energetic advantages compared to individual cooking at home. The impact of such structural activities on a district level has yet to be quantified. Similarly, the renovation advice and home visits to optimise heating strategies for residents by the *Centre de Rénovation Urbaine* may have an impact on final energy consumption on a neighbourhood level. However, the impact of such actors still seems abstract if not trivial compared with the attention and efforts that go into energy efficiency measures. Yet, human behaviour is identified as a key factor for final energy consumption in scientific literature.

Transforming a neighbourhood into an Energy Positive District comes with an enormous impact and investment required for the additional infrastructure. But little is done today to try and combine technical interventions with improvements in quality of public space, biodiversity and climate resilience. We tried to show the potential of joining forces to maximise the positive impact of the necessary investments. Every single intervention should strive to leave a positive impact on the environment. Integrating climate adaptation with mitigation measures will also help reduce future energy demand if the effects of heat waves can be tempered.

Lastly, there is still only fragmented evidence on the lifecycle costs and emissions of the energy transition as a whole. What is certain is that the proposed solutions require enormous amounts of materials and emissions with uncertainties about the eventual savings. While we would not go as far as the Luddites and propose smashing electric car chargers, we believe a more honest debate is necessary.

Is it a truly sustainable transition or rather a pipe dream about building an infrastructure that no one can afford and that won't bring the emission savings it promises? Achieving a true transition is a fragile balance between groups, positions of power, money, trust and culture. Can we create a new trias energetica based on maximising social consensus, integrated spatial design and a responsible use of technology?

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Thesis submitted to obtain the academic degree of
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This thesis explores the ongoing efforts of cities to reduce their greenhouse gas emissions through the example of Cureghem, a district in Brussels. The concept of Positive Energy Districts is examined as a tool for the energy transition in cities. Looking at the spatial and social dimensions of this transition, the research highlights the limitations of current techno-centric approaches and underlines the need for integrated design strategies that combine collective action with climate adaptation. Some adverse effects of current approaches are discussed, in particular the 'performance gap' regarding energy-efficient buildings. The social implications of large-scale energy infrastructure projects are discussed and illustrated by a concrete case in Rotterdam. Through a research by design methodology, including historical and morphological analysis, spatial design and photographic survey, different approaches are explored through street designs, collages, mapping and scenarios. Concluding the design research, this thesis argues for an integrated approach to urban energy transitions that prioritises local resilience and community engagement. Gaps in understanding how social factors affect district energy demand are identified.