A common approach for sustainable heating strategies for partner cities

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Sustainable Heating: Implementation of Fossil-Free Technologies (SHIFFT)

SHIFFT is an Interreg 2 Seas project, running from 2019-2022, promoting cross-border cooperation between 4 European countries: The Netherlands, France, Belgium and The United Kingdom. It has been approved under the priority 'Low Carbon Technologies'.

Space and water heating represent a large fraction of overall energy consumption across the EU Member States, and around one third of carbon emissions. Dependence on fossil fuels has made the heat sector hard to decarbonise in at least three of the four Member States in the 2 Seas region. Further, between 65% and 80% of buildings across these four Member States that will exist in 2050 have already been built, often with fossil fuel heating systems and poor energy efficiency. There is an enormous potential to reduce CO_2 emissions in the sector by shifting to low carbon heating alternatives, but there remain many barriers to doing so.

The main objective of the SHIFFT project is to stimulate the adoption of low-carbon heating technologies in existing buildings. It will take multiple routes to achieving this through its three technical work packages (WP).

WP1 develops city strategies for four small to medium municipalities as well as producing general guidance for cities to make their own strategies for the move to low carbon heating. City strategies will be devised for the Belgian cities of Brugge and Mechelen, the Dutch city of Middelburg and the French city of Fourmies, with planning for each led by the cities as full partners in the project. These will inform a document offering guidance to other cities who want to devise their own strategy.

WP2 focuses on developing strategies for the fullest possible inclusion of communities in developing low carbon heating strategies at the local level. This co-creation process will inform the other WPs so that the views of building users are fully incorporated into decision making. We see it as essential to include communities to the fullest possible extent in decisions about the buildings in which they live, work and play. Partners including community facing energy group De Schakelaar (NL) will be working to incorporate communities in this WP.

WP3 concerns delivery of exemplar community low carbon heating projects; one installation of low carbon heating technology will take place in each of the four INTERREG 2 Seas Member States, with each build led by one of our project partners: Places for People (UK), Fourmies (FR), and Zorgbedrijf Rivierenland (BE). We will aim to capture learning from these developments and pass it on to the widest possible selection of stakeholders in the sector.

Technical support is provided by two universities, the University of Exeter (UK), acting as project coordinator and Delft University of Technology (NL) and by CD2E (FR). These organisations will support city and other partners as regards technology, policy and co-creation of projects with communities.

The specific and measurable objectives of SHIFFT are to assist in the development of city low carbon heating strategies, both within the project and by demonstrating routes to strategy development for other municipalities, to develop exemplar low carbon retrofit heating projects and to work with others to pass on the lesson learned within the project to maximise the value of the lessons learned.

SHIFFT targets local and regional authorities as a primary target group with the purpose of influencing communities, homeowners, districts, cities, energy consultants, energy service companies and SMEs to consider a wider set of heating solutions than is currently the case.

Executive Summary

SHIFFT is an INTERREG 2 Seas project promoting cross-border cooperation between four European countries: the Netherlands, France, Belgium and the UK. The main objective of SHIFFT is to stimulate the adoption of low-carbon heating technologies in existing buildings, through a number of routes:

- helping to develop city strategies in four municipalities;
- producing guidance to help cities develop low carbon heating strategies;
- providing knowledge and best practice to run co-creation processes to ensure communities and stakeholders are involved in the transition to low-carbon heating;
- delivering a number of exemplar low carbon heating projects.

This report sets out some initial work by the SHIFFT team to develop a common framework approach to help cities to create low carbon heating strategies. A common approach can help cities avoid replication of work and overcome some of the complexities in enabling a transition to low carbon heating in homes and community buildings. At a high level, we suggest that a sustainable heating strategy sets out a high-level vision for how this shift will be achieved, with clear goals and a plan or policy on how to achieve these goals, including a roadmap. Drawing on a literature review and practical experience, during two workshops, the SHIFFT partnership has composed a list of key components for sustainable heating strategies. SHIFFT suggests that a sound sustainable heating strategy should:

- offer a clear goal (e.g. carbon- neutrality by 2050) with sub-goals and timeframe (e.g. 2025, 2035);
- develop a roadmap to achieve these goals;
- be co-created by citizens, technical experts, politicians and other stakeholders, so that the strategy developed will be socially legitimate;
- indicate techno-economic feasibility of sustainable heating technologies and solutions and describe under which conditions these technologies are feasible;
- not stand alone but be embedded in other local policies (e.g. climate plan, spatial planning, building regulation);
- build on and feed into heating policy at regional, national and international level (i.e. EU);
- support and steer sustainable heating projects on a district and building level;
- not simply allocate the costs to other domains (e.g. air quality, energy poverty);
- be customised to local conditions;
- be in line with legal and institutional requirements.

In order to help local authorities and municipalities develop a strategy to decarbonise heat, our common framework provides a step-by-step process that considers barriers and opportunities across technologies, people and policy/regulation. The common approach framework will assist in the process of identifying heat supply & demand, whilst identifying opportunities, actors, technologies, resources and barriers for decarbonising heat in a local area. The SHIFFT framework recognises the need for thorough long-term planning and preparation by local authorities, builders, households, communities and wider stakeholders and highlights best practice, tested tools and approaches so that cities can mobilise, inform and facilitate local communities in the transition to low carbon heat.

The step by step guidance within the common framework will help local authorities by providing guidance on technological choices for low carbon heating at different scales. It also sets out how to develop effective approaches with citizens and stakeholders, so that solutions are co-created in a transparent and meaningful way to gain consent for change. It then provides an overview of the key building blocks for creating a local heating policy, including creating a roadmap, zoning and the business case for a low carbon heat transition at city level. We have designed the common framework so that it can be developed and customised to suit local circumstances.

The common approach is currently a working document that will now be used and evaluated with the four SHIFFT partner cities (Middelburg, Bruges, Fourmies and Mechelen). It will then be refined and be used as the basis for developing a much more comprehensive practical guide for local authorities and community groups on how to accelerate the transition to sustainable heating in homes and community buildings.

This report sets out the common approach and is set out as follows. Chapter 1 sets the context for the common approach and Chapter 2 provides a high-level overview of the four partner cities. Chapter 3 provides a step by step overview of the common approach – this is based on seven separate steps that cut across three reoccurring pillars -technology, people and policy. Chapter 4 provides more detailed guidance on each of these pillars, covering: existing high-level strategies; technology overviews; planning tools; citizen and stakeholder co-creation; and building blocks for heat policy.

Two additional Annexes are provided. Annex 1 gives details on heat demand within the EU and for then each of the 2 SEAS countries. It sets out high level data for the way heating and cooling is currently provided and provides a summary of heat decarbonisation targets. Annex 2 provides a policy overview for sustainable heating in each of the 2 SEAS countries looking at: strategy and goals; implementation measures; capacity building and other relevant initiatives.

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Abbreviations

Abbreviation	Meaning	Category
°C	degree Celsius	Unit (temp)
AR-TUR	Centre for Architecture, Urbanity and Landscape in the Kempen region	Organisation
ATES	Aquifer Thermal Energy Storage	Technology
BE	Belgium	Countries
BTES	Borehole Thermal Energy Storage	Technology
BV	Besloten Vennootschap (Limited Liability Company)	Business (NL)
C2C	Cradle to Cradle	Approach
CD2E	Centre de Développement des Eco-entreprises	Project partner
CELSIUS	Combined Efficient Large Scale Integrated Urban Systems	Project (EU)
CEN-EN	Comité Européen de Normalisation – Euronorm (European norm)	Standard
CH_4	Methane	Environment
CHP	Combined Heat and Power	Technology
CO_2	Carbon dioxide	Environment
CoM	Covenant of Mayors	Policy
CoM	Catalogue of Measures (City-zen)	Document
CVBA	coöperatieve vennootschap met beperkte aansprakelijkheid (Limited Liability Company)	Business (BE)
DH	District Heating	Technology
DHC	District Heating and Cooling	Technology
DHW	Domestic Hot Water	Technology
DOEN	Duurzame Ontwikkeling van Energie Neutraliteit (energy broker)	Organisation
DSO	Distribution System Operator	Organisation
ECN	Energieonderzoek Centrum Nederland (Energy Research Centre Netherlands)	Organisation (NL)
EF	Emission factor	Unit (env.)
EFDB	Emission Factor Database	Service
EMP	Energy Masterplanning	Approach
EPBD	Energy Performance of Buildings Directive	Policy instrument
EPC	Energy Performance Coefficient (NL)	Policy instrument
EPISCOPE	Energy performance indicator tracking schemes for the continuous optimization of refurbishment processes in European housing stocks	Project (EU)
EPM	Energy Potential Mapping	Method
EU	European Union	Political entities
EU27	27 European Union member states	Country

Eurostat	Europe Statistical Office	Organisation
FIT	Feed-in tariff	Policy instrument
FJR	Fjernvarmebranchens Registreringsordning for servicemontører	Policy instrument
FP7	Framework Policy 7	Research fund
FR	France	Countries
GHG	Greenhouse gas	Environment
GJ	Gigajoule	Unit (energy)
GWh	Gigawatthour	Unit (energy)
H2020	Horizon 2020	Research fund
HC	Heating and Cooling	Technology
HEP	Hidden Energy Poverty	Socioeconomic
HRE	Heat Roadmap Europe	Project (EU)
HT	High temperature	Technology
ICT	Information and Communication Technology	Technology
IPCC	Intergovernmental Panel on Climate Change	Organisation
IRENA	International Renewable Energy Agency	Organisation
IVBO	Intergemeentelijk samenwerkingsverband voor Vuilverwijdering en –verwerking (waste management service in Brugge, BE)	Organisation
K	Kelvin	Unit (temp)
kg	Kilogram	Unit (mass)
$kgCO_2e$	Kilogram CO_2 equivalent	Unit
km	kilometer	Unit (length)
KPI	Key Performance Indicator	policy
kW	kilowatt	Unit (power)
kWh	kilowatthour	Unit (energy)
LT	Low Temperature	Technology
MT	Medium temperature	Technology
$MtCO_2e$	Megaton CO_2 equivalent	Unit
MW	Megawatt	Unit (power)
MWh	Megawatthour	Unit (energy)
N_2O	Nitrous oxide	Environment
NEA	National Energy Atlas (NL)	Service
NECP	National Energy and Climate Plan	Policy instrument
NL	Netherlands	Countries
NoM	Nul op de Meter (Zero on the Meter)	Measure (NL)
NSS	New Stepped Strategy	Approach
PAW	Pilot Aardgasvrije Wijken (Pilot Natural Gas Free Districts)	Policy instrument
PBL	Planbureau voor de Leefomgeving (Netherlands Environmental Assessment Agency)	Organisation (NL)

PCM	Phase Change Material	Technology
PETA	Pan-European Thermal Atlas	Service
PM	Post Meridiem	Time
PV	Photovoltaic	Technology
PVT	Photovoltaic Thermal	Technology
QGIS	Quantum GIS	Software
REAP	Rotterdam Energy Approach and Planning	Approach
RES	Renewable Energy Source	Technology
RHC	Renewable Heating and Cooling	Technology
SEAP	Sustainable Energy Action Plan	Policy
SEE	Schools as Energy Embassies	Organisation
SHIFFT	Sustainable Heating: Implementation of Fossil-Free Technologies	Project term
SUI	Smart Urban Isles	Project name
TABULA	Typology approach for building stock energy assessment	Project (EU)
TUD	Delft University of Technology	Project partner
TVW	Transitievisie Warmte (Transition Vision Heat)	Policy instrument
TWh	Terawatthour	Unit (energy)
UK	United Kingdom	Countries
vLT	Very Low Temperature	Technology
WP	Work Package	Project term

1. Introduction

1.1. Sustainable heating strategies & guidance for the heating transition

The transition to sustainable heating for homes and community buildings is an immense, complex operation. It calls for thorough long-term planning and preparation by local authorities, distribution system operators, builders, homeowners, etc. It requires robust, practical, tested tools and approaches for cities to mobilise, inform and facilitate local communities to make this change.

WP1 delivers two essential, complementary policy tools for cities to make this possible. The objectives of WP1 are:

- To develop sustainable heating strategies with the SHIFFT partner cities. These identify the scope, opportunities, actors, technology, resources and barriers, and lay out a roadmap for the move to sustainable heating at the city and district level.
- To generate a comprehensive guidance for local authorities and community groups on how to facilitate and accelerate the transition to sustainable heating of homes and community buildings. The guidance presents policy options, solutions and practical tools to tackle key barriers blocking this transition.

SHIFFT will develop a city strategy with Mechelen, Bruges, Middelburg, and Fourmies.

While the strategies will be local in focus, the development process will be a cross-border collaboration. It builds on peer review and interaction between the partners to improve the quality of the strategies throughout the development process. Common, existing tools will be used when possible.

1.2. A common approach for sustainable heating strategies

The first activity of WP1 deals with the development of sustainable heating strategies with the four SHIFFT partner cities. These will identify heat supply & demand, scope, opportunities, actors, technology, resources and barriers for the introduction of sustainable heating for the entire city. They will lay out a roadmap, zoning and timeline and show specific business cases for this transition at city level and identify the specific solutions most suited for individual districts.

Therefore, a common approach for the strategies will be developed that can be customised to local conditions as needed. This ensures all aspects of sustainable heating implementation are covered and facilitates cross-border learning between partners during development of the strategies. This approach will be based on partner city needs, national requirements, state-of-art insights and available good practice.

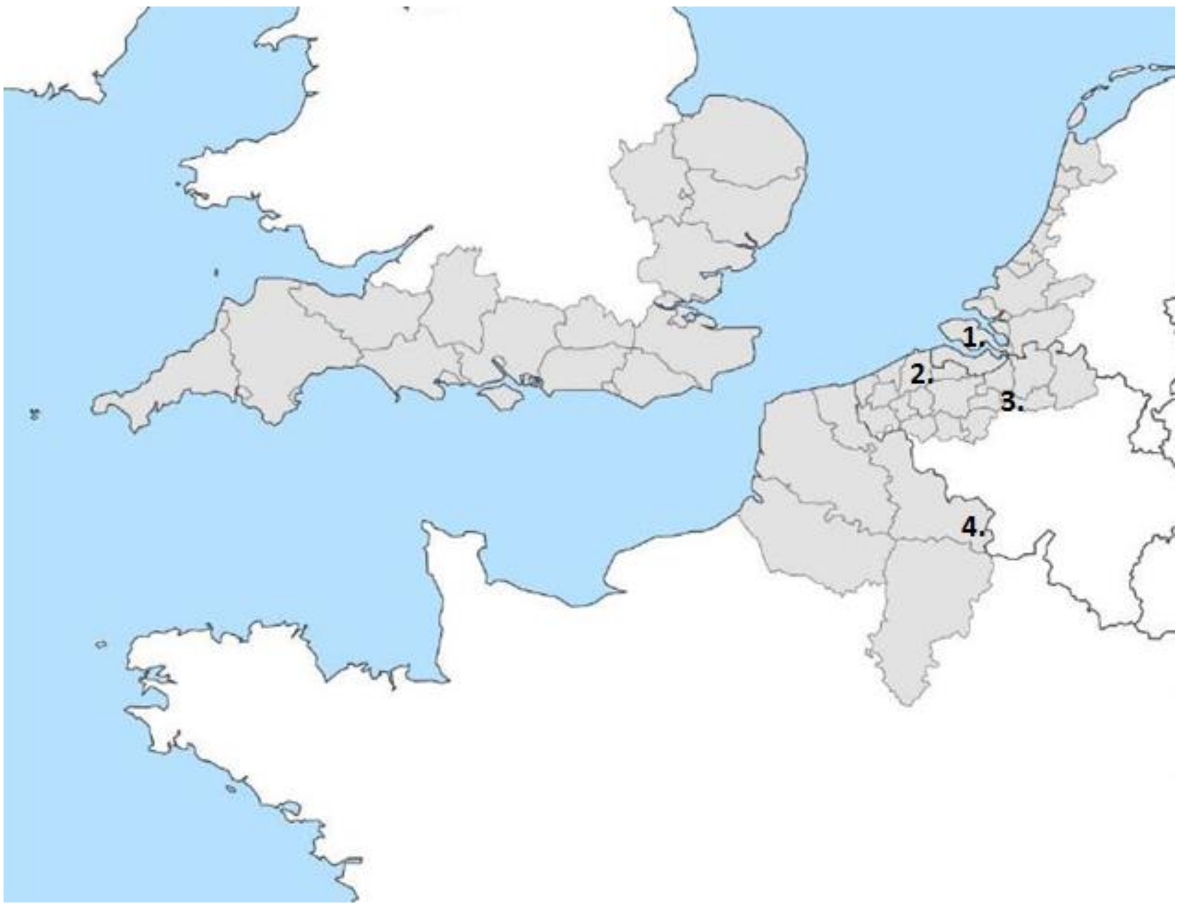
This report presents the results of this work. The common approach will be tested and further refined by the four SHIFFT partner cities during 2020/21.

2. SHIFFT partner cities

WP1 aims to develop city strategies with four small to medium-sized municipalities as well as producing general guidance for cities to make their own strategies to move to low carbon heating.

City strategies will be made for the Belgian cities of Bruges and Mechelen, the Dutch city of Middelburg and the French city of Fourmies, each led by the cities as full partners in the project.

The four municipalities are presented in this chapter.



1. **Middelburg**
2. **Bruges**
3. **Mechelen**
4. **Fourmies**

Figure 1. The four SHIFFT partner cities in the 2 Seas area

2.1. Middelburg

Population: 48,600

Area (km²): 53 km²

Country: Netherlands

Capital of the province of Zeeland

Brief description

Middelburg is a Dutch municipality and the capital city of the province of Zeeland. There are several initiatives that illustrate that the municipality has the ambition to take up an active role in the heat transition.

Firstly, the province of Zeeland is one of the Dutch provinces with A Regional Energy Strategy (RES) in place.

Secondly, the municipality is currently preparing its Transition Vision Heat (TVW). All Dutch municipalities will have to deliver a TVW before the end of 2021. One of the outcomes of the TVW will be an action plan with a roadmap to sustainable heating for selected neighbourhoods of the municipality.

Lastly, there are two ambitious pilot projects in the municipality. The neighbourhood of Dauwendaele in Middelburg is selected as one of the (thirty) pilots in the Netherlands for gas-free neighbourhoods (PAW). The aim of the Dauwendaele pilot is to introduce district heating in an existing neighbourhood, with residual heating supplied from an industrial facility nearby. Furthermore, there is an area with abandoned industrial buildings which now houses the Foodbank (Voedselbank Walcheren) but in the near future will be converted into a new hotspot for circular economy and sustainability.

Main challenges and opportunities

As mentioned, Middelburg will have to compose a sustainable heating city strategy (TVW) by December 2021. One of the key challenges will be to translate the regional energy strategy into a local heating strategy. The Dauwendaele pilot project also poses a very challenging task in introducing district heating in an existing neighbourhood and to convince households to connect to the network.

Key take-aways

- Middelburg is in the process of translating the regional energy strategy into a local heating strategy.
- The municipality has two challenging and large-scale pilot projects in which sustainable heating will be implemented.

2.2. Bruges

BRU
GGE

Population: 118,000

Area (km²): 138.4 km²

Country: Flanders, Belgium

Capital of West-Flanders

Brief description

The proportion of renewable energy of the total energy consumed by households is only 6.5%. For this reason, the City aims for more renewable energy installations like PV installations and wind turbines.

The City of Bruges is now working on a new Sustainable Energy Action Plan (SEAP) to replace the former SEAP. This SEAP demonstrates 35 actions that contribute to become a sustainable city, for households, the mobility sector, industry as for companies.

In 2014, the City of Bruges signed the Covenant of Mayors (CoM) to reduce its CO_2 emissions in 2020 by 30% compared to 2011. Bruges has further signed up to the CoM commitment to reduce CO_2 emissions by 40%, and this is integrated in the new strategy plan as a staging post towards becoming a climate neutral city in 2050.

Main challenges and opportunities

There has been a heat network in Bruges since 1982. The heat source is IVBO, the regional incinerator, located 4km from the city centre. The heat network is quite old, and must be renewed, though there is need to source capital and this also allows time to search for new consumers. The new strategic plan of the City of Bruges commits the city to investigate the possibilities of implementing a heating network in the city centre. The city is thus already looking for other residual heat sources to heat the municipal buildings (70% of buildings are concentrated in the city centre). In this way the city can lead by example by connecting municipal buildings to the heat network.

Whilst working in a co-creation process it's not always easy to find citizen committees which are motivated to bring people together to think about sustainable heating solutions.

There is already one neighbourhood in which residents have showed to be willing to make their area more sustainable.

Key take-aways

- Heating network in the city centre.
- A new SEAP regarding the new CoM commitment for 2030.

2.3. Fourmies

Population: 12,353
Area (km²): 23 km²
Country: France
Region: Nord (59)
Municipality in the North of France

Brief description

The city of Fourmies has defined a strategy to tap its potential 124 GWh of renewable energy from various sources (potentially including geothermal, wind, PV, solar thermal, biogas, biomass and others) by the year 2050. An energy roadmap is in place for the development of these projects according to the available potential and the investment required.

As a pilot project, the municipality of Fourmies will be implementing a heat network powered by locally sourced wood which will be used to heat some of the municipal buildings with high heat consumption. The municipality is considering the buildings (Future Smart Building, City theatre, Mayor's Office and a textile museum) in the perimeter of the feasibility study. The results however indicated a negative business case, mainly due to the low cost of gas and hence the perimeter of the heat network was changed.

Main challenges and opportunities

Integrating sustainable heating technologies in existing buildings is not an easy task, with multiple barriers to be overcome in terms of regulation, finance and community involvement. Finding a successful business case for the district heating network in Fourmies, accounting for the various restrictions that apply is very challenging for the municipality. Another challenge is to create awareness among the citizens regarding the renewable heat opportunity and hence motivate them to participate in the future projects which have been planned.

However, there are several opportunities as well. For example, the incentive for the local population to protect the natural heritage of the region (hedges) by adding value to it (as a source of heat for the heat network) and the creation of local employment due to the development of this new segment of energy infrastructure.

Key take-aways

- The use of renewable technologies to add value to a degrading natural regional heritage (bocages in the Northern France).
- Despite being a relatively small municipality, the municipality of Fourmies is very committed and ambitious in terms of the energy transition (and thus the thermal heating transition).

2.4. Mechelen

Population: 86,000 inhabitants

Area: 65.2 km²

Country: Belgium

Region: Flanders

Province of Antwerp

Brief description

Mechelen has a historical city centre with an old building stock. Mechelen has put much effort into improving the energy performance of its residential building stock in recent years. The city has its own service, “Energiepunt Mechelen”, which citizens can use to get financial-technical advice and support for their home energy renovation. With the support of various EU projects, this is evolving towards a one-stop shop for home energy renovations.

The City of Mechelen is winner of EGLA2020[1] and has a Sustainable Energy Action Plan in place (SEAP) with targets for 2030 (-40% CO_2 compared to baseline in 2011) and 2050 (climate neutral). There is no local heating vision or strategy yet, but several urban renewal projects in the city demonstrate the ambition of the city in terms of sustainable heating. One of the key projects in this regard is the pilot Keerdok, a new residential neighbourhood in which a low temperature district heating network will be implemented, with heat recovered from sewage water and Borehole Thermal Energy Storage (BTES).

Main challenges and opportunities

Mechelen will have to continue its focus on reducing energy demand but needs to investigate its energy potential of renewable energy sources for heating.

Key take-aways

- The residential building stock of Mechelen is old and has a high share of single-family homes / row houses and focus on home energy renovations.
- No heat supply potential identified yet, which seems to indicate that the heat strategy will be demand-driven.

[1] Together with the Irish city of Limerick, city of Mechelen was awarded the European Green Leaf Award 2020 (EGLA2020)

3. A common framework and approaches for developing a sustainable heating city strategy

This chapter puts forward a definition of a "sustainable heating strategy" and proposes the outlines of a common approach to draft sustainable heating strategies for cities and municipalities.

In the 2 Seas region, the Netherlands has made much progress in recent years by developing sustainable heating strategies (see Annex 2). Municipalities must compose a "Transition Vision Heat" (NL: Transitie Visie Warmte, TVW) before the end of 2021. Compared to the other countries and regions in the 2 Seas region, there is a relatively clear national policy framework in place to support municipalities to compose a TVW for their municipality. The Dutch TVWs will serve as a valuable base-reference for the SHIFFT sustainable heating strategies. However, the ambition of the SHIFFT sustainable heating approach is to offer a more holistic and at the same time hands-on methodology.

3.1. Definition of a "sustainable heating strategy"

Sustainable heating (and cooling) involves reducing the energy demand for heating (and cooling), whilst shifting the energy supply for the remaining demand away from fossil fuels to carbon neutral sources, provided through renewable energy sources. In our view, a sustainable heating strategy sets out a high-level vision for how this shift will be achieved, with clear goals and a plan or policy on how to achieve these goals, including a roadmap.

Drawing on a literature review and practical experience, during two workshops, the SHIFFT partnership has composed a list of key components for sustainable heating strategies. SHIFFT suggests that a sound sustainable heating strategy should:

- offer a clear goal (e.g. carbon- neutrality by 2050) with sub-goals and timeframe (e.g. 2025, 2035);
- develop a roadmap to achieve these goals;
- be co-created by citizens, technical experts, politicians and other stakeholders, so that the strategy developed will be socially legitimate;
- indicate techno-economic feasibility of sustainable heating technologies and solutions and describe under which conditions these technologies are feasible;
- not stand alone but be embedded in other local policies (e.g. climate plan, spatial planning, building regulation);
- build on and feed into heating policy at regional, national and international level (i.e. EU);
- support and steer sustainable heating projects on a district and building level;
- not simply allocate the costs to other domains (e.g. air quality, energy poverty);
- be customised to local conditions;
- be in line with legal and institutional requirements.

3.2. A common approach for sustainable heating strategies

The draft common approach to develop a city level sustainable heating strategy is summarised in Figure 2 below. It comprises of seven steps to develop, evaluate and implement a sustainable heating strategy, with three cross-cutting themes that run across each step:

- Technology - e.g. choice of technologies, how to select and apply them and at what scale;
- People - e.g. how to engage stakeholders and communities to co-create acceptable low carbon heating solutions;
- Policy - e.g. how to assess, develop and apply policies to support low carbon heating.

It is proposed that this approach is used to support the development of strategies for the four SHIFFT partner cities of Fourmies, Bruges, Mechelen, and Middelburg. A more detailed version of the common approach is provided at the end of the chapter - Figure 3. The rest of this chapter talks through each step of the common approach.

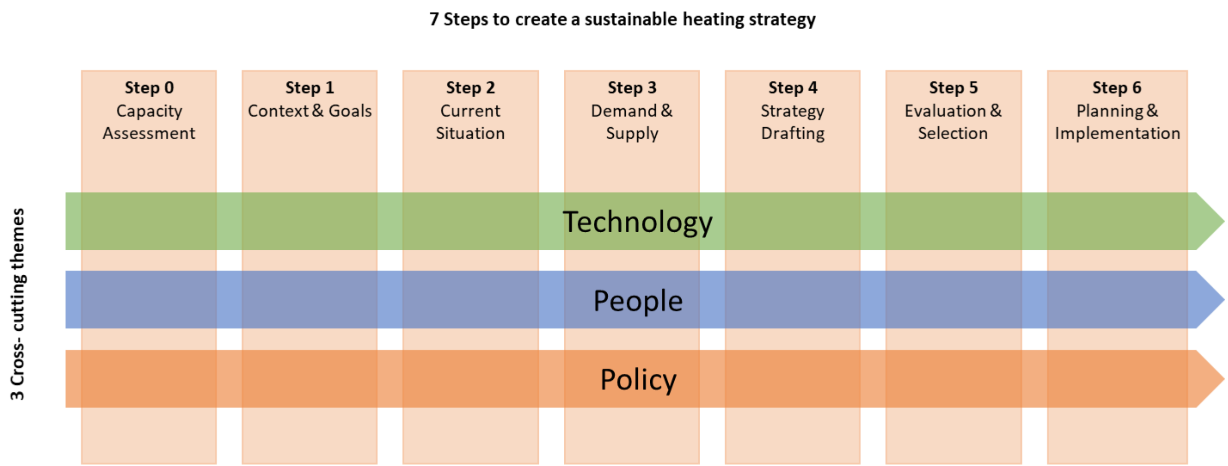


Figure 2. High-level overview of the draft SHIFFT common approach

3.2.1. Step 0: Capacity assessment, getting a team together

The opening step should begin with approval from an elected official, to ensure a democratic mandate for the whole process. The aim of this step is as an internal capacity check – the goals being to:

- establish that the municipal government institutions have the political will (i.e. some enthusiastic politicians in government), the personnel, governing capacity and some financial resources to commit to the process of devising a strategy;
- carry out a review of relevant initiatives that the municipality is already working on (e.g. energy co-operatives);
- identify relevant expertise within the municipal organisation and form a team;
- identify some obvious stakeholders within the local government organisation.

3.2.2. Step 1: Context, boundary conditions, setting goals

In step 1 the goal is to develop a draft vision of what a sustainable heating strategy for your municipality/jurisdiction will look like, ahead of working out the practical steps for achieving this vision. A key enabler of action is setting out from the start what your ambition and goal will be in respect to a local sustainable heating strategy. In simple terms this is about defining what you want to do and the timeframe over which you want to do it. This step should build on the capacity assessment and create some clear milestones, these could be for specific years or you could work to short (e.g. 2025), medium (e.g. 2030) and long-term goals (e.g. 2040). To help with this you might want to consider what ambitions your municipality or jurisdiction has (or would like) in terms of greenhouse gas emissions – do you want to be in line with or ahead of regional, national or EU climate policy goals? Visioning and goal setting should also happen in a deliberative setting with policy makers, stakeholders and politicians involved.

Technology

Low carbon heat technologies (and those to help reduce energy demand) are central to the delivery of a sustainable heat strategy. There are several things to consider as part of this:

- What goals do you want to set? e.g. what percentage or amount of heat would like to be supplied through low carbon sources and by when? (see section 4.2.1)
- What is the market/supply chain for heat in your area/region? Who can you work with/consult e.g. are there local or regional firms; which technologies are available and how are they currently supported? See section 4.2.5 for an overview of possible sustainable heat technologies
- What boundaries will it be most appropriate to work within – i.e. should it be a city-wide approach, or split down into districts, neighbourhoods, etc? See paragraph 4.1 for examples of scales to which you might consider working at.
- Paragraph 4.1 also provides an overview of existing strategies and tools to help inform your thinking on options for your sustainable heating strategy.

People

Heating is a fundamental aspect of the human need for shelter in our climates, and therefore a significant social, cultural, economic, and psychological phenomenon as much as technological. Heating reaches far into people's homes and private lives, not just workplaces or leisure contexts, involving everyday habits and negotiations between building occupants and family members. Heat is a cultural service that cannot only be seen through the lens of economic efficiencies and return on investments. Providing heat is a key aspect of social life (e.g. entertaining guests) and seasonal cultural practices (e.g. wintertime cosiness). In the transition to sustainable heating, homeowners and local communities therefore form essential parts of the system.

Enabling a large-scale shift towards sustainable heating therefore must actively involve the local people. The first stage of this is an external stakeholder assessment and putting in place a citizen and stakeholder engagement strategy. Paragraph 4.4 on engagement has detailed information on co-creating a sustainable heating strategy with local citizens, and there is a more detailed SHIFFT state of the art report on co-creation available from the SHIFFT team on request. This engagement process needs to begin early in the project, before ideas are firmed up, and be maintained as the strategy develops. It is emphasised that it is essential to work with people in your municipality/jurisdiction to develop common and shared:

- Objectives – what are you collectively trying to achieve in terms of the shift to sustainable heating, and why does this need to happen? See Section 4.4.1 for more information.
- Narratives – How are you going to achieve these objectives? What will it look like in practice? What will it cost? What are the next steps? See Section 4.4.14 for more information.
- Refer to the resources in paragraph 4.4 for information on how to find, engage and embed citizen and stakeholder co-creation into the development of your sustainable heating strategy. This section also has some helpful case studies.
- This engagement should be viewed as part of an ongoing process.

Policies and Regulation

An effective sustainable heating strategy should link to other relevant policies. This could include direct links to key policies, policy instruments and policy tools around climate change and energy, but also other policies that could be of relevance in the municipality. It is recommended that a review is carried out to identify relevant links vertically i.e. to EU, national, regional policies and horizontally i.e. locally across other relevant policy areas.

- Vertical analysis – use the information in Annex 1: Context and Background for a high-level overview of EU, national and regional level energy and climate policy with relevance to heat. Speak to energy information centres (see section 4.5.8 on Facilitating as well as Annex 1: Context and Background).
- Horizontal analysis – work with colleagues in other policy areas to identify potential links to other key local policies, such as those relating to climate, energy, housing, health, social care, the environmental, jobs, regeneration, etc. See section 4.4.2 for an overview of possible departments that could already have links to sustainable heat or where links could be developed. Section 4.5 also contains a detailed overview of considerations for developing a heat policy.
- Create visions of a carbon free future. How does your city look like in the future when the sustainable heating transition has succeeded? What are its implications to buildings, infrastructure and local residents?
- Set goals (main goal and sub goals) that should be achieved in order to let your vision become reality.

3.2.3. Step 2: Current Situation

The goal in Step 2 is to create an accessible and transparent energy baseline for your local area. Collating good local data to establish the current situation for energy supply and demand for heating is vital. This step of the strategy development will help you understand the current situation and therefore what will need to be done in order to realise your goals. It will also help identify what might be suitable at different levels, e.g. building, neighbourhood, city level solutions. As well as data on energy, other key sources of information will be important.

Technology

To build the baseline there are some key areas of data that will help understand the current situation and therefore what some of the options for sustainable heating might be. Make use of national, regional and local statistics, as well as your own municipality's data. Also, identify which organisations or experts can provide data to help establish the baseline; this could include information from energy companies, energy regulators, energy information centres, etc.

- Energy Supply Chain (see paragraph 4.2)
  - What is the current demand for energy in your municipality?
  - How does this demand split across end-use, i.e. heating, power, cooking, etc. and sectors i.e. domestic, tertiary, industry?
  - How is energy currently supplied (i.e. what is the current percentage of supply from renewables, gas, oil, coal, biomass, electricity, etc);
  - How is that energy delivered? (i.e. are there local networks for electricity, gas, heat, etc.)
  - Is it possible to estimate the carbon impact from the current supply chain? (see section 4.2.6)

- Local Mapping
  - What is the age of the building stock and what types of households do you have? E.g. percentage of: homes by build year; by tenure e.g. owned, rented, etc; by type e.g. detached, semi-detached, flats, etc; and occupancy e.g. families, single households, etc (see Annex 1: Context and Backgroundfor potential categories to consider).
  - How do different sectors map your local area – i.e. where are homes, industry, tertiary, etc.?
  - Where are the energy sources in the local area? This can include heat, gas networks, etc, as well as any renewable sources or other energy producers e.g. CHP plants, thermal generators, etc.
- Missing Data
  - What data is missing and who could help provide it? See section 4.3.1 for ideas.

People

External stakeholders from across the energy sector, municipality and wider society will play a key role in helping establish the current situation. This could include access to data, knowledge, as well as insights into local preferences. Consider:

- Co-benefits – what are the benefits outside lowering of carbon emissions in enabling this shift for citizens, the municipality, the region, country and global climate? For instance, in terms of increased comfort, air quality, health, social cohesion, wellbeing, or in terms of business and job creation.
- Drivers and barriers – what might encourage people to make changes or reduce heat consumption, and what do they feel is stopping them doing so or dissuading them from acting?
- How can the wider public be engaged to help understand barriers, drivers, preferences, etc.? How to build this into any consultations, co-creation events?
- Paragraph 4.4 provides detailed resources and case studies that can help with this work area, including methods to help create co-ownership.

Policies and Regulations

Building on from the analysis in Step 1, consider in detail which policies could support the development and implementation of a sustainable heat strategy. Consider also how a heat strategy could help other departments or colleagues deliver their priorities. Table 1 in section 4.1.4 lists ideas for possible links and paragraph 4.5 discusses interactions with other policy areas. Some examples are given below:

- Buildings & planning – are there building codes for new build and/or renovations that can encourage the installation of energy efficiency improvements and low carbon heat? Can heat zones be developed for new and existing developments?
- Health & social care – are there goals to reduce fuel poverty or poor housing to improve people's lives? Is advice or financial support available for citizens to keep warm and healthy? Look for relevant issues in local health and social care policy that can be of relevance to your local sustainable heating strategy.
- Energy & carbon – are there polices to reduce carbon emissions, increase the share of renewable energy, improve energy efficiency and how can these policies best support sustainable heat?
- Economy & jobs – can the supply chain or industry for sustainable heat and energy efficiency be developed locally? Does the sustainable heating strategy envision business and job creation

locally? Also look for relevant issues in local economic policy that can be of use to your local sustainable heating strategy.

- Environment – are there clean air or other policies that could link to a sustainable heating strategy? How can local environmental policy contribute to sustainable heating strategy? Perhaps via clean air policy and environmental permit systems regulating buildings and operation of industrial processes (that produce heat).
- Policy gaps – are there opportunities to address policy gaps to enable the development of sustainable heat in your local area, across different policy areas and other policy domains? Who could you work with to address these?

3.2.4. Step 3: Demand Reduction & Supply Potential

Step 3 involves developing a sustainable heat strategy for your municipality or jurisdiction is to consider what the potential is for both reducing heat energy demand and supplying heat sustainably. This will give an early indication of what might be possible at the household, neighbourhood, district and city level. It might also show where there are some quick or easy wins and where more research or consultation might be needed. This step should build on the previous steps and by the end of it you should have a draft outline on the way forward to build upon.

Technology

Working from the baseline data from Step 2 and shaped by your goals in Step 1, calculate the potential to reduce demand and based on that, what an ambitious target for reduction should be (see section 4.2.3) and what also what heat can be supplied from sustainable sources (see section 4.2.4). This could start at the building level and work up or be developed through a district by district approach, etc. To help with this step consider:

- The strategies and tools in section 4.3 which can help focus on the scale of action and the steps to follow to assess the potential – e.g. reduce, reuse, generate sustainably, etc.
- The guidance and tables in section 4.2.5 will also help to identify which technologies might be most appropriate at different scales.
- The technological potential will also depend on the view of stakeholders and citizens – make sure the knowledge gathered from citizens, feeds into the technology analysis.

People

The potential to reduce demand and switch to low carbon heat will also directly be influenced by the willingness, preferences and ultimately the consent of local citizens. It will be important to build in information on these aspects into your work with these stakeholders and it may be necessary to carry out ongoing consultation and co-creation events as the possible options become clearer. To help with this:

- Check with people on their preferences for the different options available. Section 0 discuss the potential actors and implications of different technologies for sustainable heating.
- See if a common approach can be found for the most optimal solutions. Where are the opportunities and risks, and where might further consultation and engagement be needed?
- Co-creating a platform where a wider set of people can share their experiences and views of heating, comfort and sustainable alternatives can help broaden participation and input.

Policies and Regulation

Having understood the potential technology and stakeholder options at different scales for reducing demand and supplying heat sustainably, consider what policies and/or regulation might be needed to enable these options to be delivered. The resources in paragraph 4.5 will help with this analysis, also consider:

- Can the potential options be delivered within existing policy frameworks, or will new policies need to be developed?
- If new policies are needed, can you demonstrate that there is stakeholder and citizen support for measures you want to take? If yes, is there the political and departmental support to enable this to happen? If not, how can this developed?
- Use the case studies and tools in chapter 4 to help identify other localities that have taken a similar approach to the one you wish to develop.

3.2.5. Step 4: Formulation of Strategy options, plus indicators (to match the goals)

In step 4 the goal is to formulate a range of specific strategy options that can be compared. These draw on the understanding of the current situation, potential future heat scenarios, and policy best practice and the overall goals, from earlies steps. Formulating a range of options is important to ensure that different possibilities are compared and considered; it also allows preferences to be understood.

Technology

Each option should include detail on several elements:

- Sustainable Heat Technologies
    - The optimal combination of technologies should be identified
    - To an appropriate level of detail these technologies should be mapped onto the locality (e.g. areas with connection to a heat network specified)
    - The costs of the various heating systems should be estimated where possible.
- Key Performance Indicators (KPIs)
    - KPIs are qualitative or quantitative measures used to monitor progress against a specific goal and, collectively, the whole strategy. These measures may pertain to, for example, carbon emissions, energy use, renewably generated energy, autonomy, or impact on material use or space.
    - The selection of KPIs will depend on the goals and sub-goals adopted in each strategy.
    - The precise method for measuring each KPI should be specified.
    - For more detail on these, see sections 4.2.5 and 4.2.6.
- Targets
    - Key milestones should be outlined over the short-, medium- and long-term. These should be measurable in terms of the KPIs you have identified (e.g. 50% of homes connected to district heating by 2030).
    - It should be established whether the strategy will achieve reductions in carbon emissions from heat in line with the goals you have outlined in Step 1. Given the climate benefits of cutting emissions quicker, it may be worth considering options which achieve rapid initial reductions in carbon emissions.

People

Stakeholders play an important role in this step in collectively determining the options to be formulated. The options used will depend on local context and the stakeholders, as such they will vary from case to case, but in scoping out possible strategies you can consider:

- Priorities such as rapid decarbonisation, low cost to consumers, or minimal disruption.
- Technical characteristics such as maximum energy efficiency or electrifying heating.
- Socio-political dynamics such as facilitating community energy, public ownership, or bottom-up implementation.
- It is also possible to formulate scenarios which transition certain areas or demographics earlier or later in the process.

Once the range of strategy options has been decided on, the formulation of the options themselves may well be delegated to expert stakeholders or partners. Linked to policy, a process of stakeholder engagement throughout the strategy's lifetime must also be devised and built into each strategy option.

Given how heating affects the lives of ordinary people, citizens can provide valuable input to developing citizen-based approaches within these strategies. Consider:

- How can the heating strategy best involve citizens? How can citizens be meaningfully involved in choices about their city or region as well as their neighbourhood and home?
- How can local government best organise and support these initiatives?

Policy

For each strategy option, policy initiatives to implement the specified technologies and achieve the milestones need to be specified or devised. Policy tools can be drawn down from best practice or examples in other municipalities (e.g. using grants to subsidise installation of sustainable heating systems) - paragraph 4.5 has more information on this. Where no best practice exists, policy can be devised for a particular purpose. The policy tools specified are likely to include a range of measures such as:

- Policy to stimulate the deployment of sustainable heating technology and energy efficiency measures.
- Regulation to enforce standards of energy efficiency or carbon emissions reduction.
- Pilot projects or zones to test processes for deployment and to demonstrate the benefits of the sustainable heating.
- Partnership initiatives to encourage private, public and community organisations to contribute as well as to facilitate information exchange.

The advantages and disadvantages, as well as incidental co-benefits of each policy tool should be elaborated. These might be related to a policy's likely popularity, cost, inclusivity, ease of implementation, risk of misuse, top-down or bottom-up nature. Additionally, the policy tools may relate to or build on existing programmes and strategies, these should be highlighted. There may also be co-benefits of a policy for the wider community, housing, local health, the local economy, energy security, energy poverty or health. The precise method of evaluation might be a formal process such as cost-benefit analysis.

Crucially, all policy tools should be practically feasible, financially viable, and, insofar as possible, proven to be effective. Be nimble, it is also important to design in a reflexive process for feedback and review of policy tools; this should be established from the outset so that changes can be made, or the policy extended in the future.

In some cases, it may be useful to identify policy which would be necessary or facilitative but is beyond the power of the local government.

3.2.6. Step 5: Evaluation & selection

The aim in step 5 is for the stakeholders and technical experts to evaluate and express their preferences for the range of local sustainable heating strategy options established in the previous step. Helping stakeholders' express their preferences is key to ensuring people have a voice and helps understand which options will be popular and why. This process involves evaluating the strategy options according to how they adhere to the overall goals established in Step 1 as well as how they fare against key performance indicators you have chosen. Other socio-political and economic criteria such as public acceptability and cost-benefit analysis can be used to examine other important dynamics.

The optimal outcome from this stage is the selection of one preferred strategy option, however, it may be more complex, showing a range of preferences which need to be analysed. In this more complex case, the analysis can inform political decision-makers who, in any case, make the ultimate decision. The outcome may be a justified selection of one strategy option, or it could be a modified amalgamation of different strategy options.

Technology

In this step you need to calculate how each strategy option fares against your KPIs and compare each of the options to the current state of affairs. Quantitative KPIs (such as carbon emissions measurements) for each strategy option can be calculated by experts using the methodologies identified in Step 4 (See Sections 4.2.2, 4.2.5 and 4.2.6). Repeating these calculations for each option at specified time intervals (e.g. 2025, 2030, 2040) can provide a picture of how each strategy would likely progress over time. These calculations are then fed into the evaluation of the strategy options and the collective decision-making process. For qualitative KPIs, evaluation may be carried out by experts or by stakeholders themselves, depending on the KPI and the co-creation strategy.

In each case, the current state of affairs (from Step 2) can provide a useful baseline against which to compare the performance of the different strategy options.

People

Stakeholders' views are important in the evaluation and selection of the sustainable heating strategy. All stakeholders who have been involved in the process should be consulted on the strategy options which have been formulated in order to produce a clear understanding of preferences. The pros and cons of the various options can be discussed and shared to allow people to understand how others feel about the available options. See Section 4.4.7 for more detail on gathering preferences. The aim is an agreed an approach/s to deliver.

Whilst the measurements of some of the quantitative evaluation criteria (such as a carbon emissions and other KPIs) are objective and can be carried out by experts, the relative importance given to the different criteria is subjective, and people with different views will therefore prefer different strategy options. Therefore, the evaluation by stakeholders will elicit responses to qualitative criteria as well as priorities among the quantitative criteria.

Policy

Each strategy option will have a different mixture of policy tools and in each case these tools and their outcomes should be evaluated, and preferences elicited and recorded.

Appropriate criteria need to be applied to each policy or set of policies. The criteria used to evaluate policy tools will depend on the type of policy tool and the local priorities. Some example criteria to consider are:

- Stimulating policy (e.g. grants, loans)
    - Value for money
    - Risks of use
    - Appropriate target demographic or sector
    - Public acceptability
    - Practical feasibility
- Direction Setting
- Regulation
    - The ease with which it can be enforced
    - Effectiveness at achieving desired outcomes
    - Public acceptability
    - Practical feasibility
- Demonstrating
    - Value for money
    - Appropriateness (i.e. is this the right demonstration project for the right technology?)
- Facilitating

3.2.7. Step 6: Commitment, planning, and implementation

Step 6 involves the local government adopting a sustainable heating strategy, and the subsequent planning need to implement it. The adoption of a strategy is primarily a political decision-making process. The planning involves the local government administration establishing a delivery team who will then set out how the various elements of the strategy will be implemented, including the various policies, public engagement processes, and monitoring.

Technology

Proposed initial plans should be developed in order to be discussed with stakeholders. These plans will be based on the technology pathway/s chosen and they may involve, for example, pilot or demonstration projects or changes to public procurement of heating technology. Many of the policies (such as those involving mapping or technical feasibility assessments) may require technical support, at least at the beginning.

Data collection processes need to be in place going forward to allow for the KPIs to be monitored. Establishing whose responsibility this is and that there is capacity and monitoring in place is important.

People

The strategy should be co-implemented with citizens – their views and input to decisions are still important. Citizens' involvement in decision-making throughout the implementation phase empowers them to be part of the heating transition and minimise any disillusionment. By monitoring the adoption of new technologies as well as how the transition is affecting different groups, the municipality can keep track of progress and, where necessary, adjust its communication approach or incentives. There could be a role for 'heat champions' and 'energy ambassadors' here. See Section 4.4 for more information on the possible roles of citizens and stakeholders.

Co-creating the sustainable heat strategy with a relatively small, but representative, group of stakeholders is just the beginning; for the implementation to be inclusive these engagement and co-creation strategies need to be embedded in policy development and deployment. This will require a broader public engagement strategy.

Policy

Once the municipality or local government has adopted a strategy; the details of the policy needs to be put into action. Initial planning involves identifying the resource, personnel, and partners that the policy will require. Some areas to consider are:

- For areas of policy building on existing strategies
  - Which existing strategies are these?
  - What sort of collaboration with other policy teams is needed?
  - Who will be responsible for developing and implementing this policy?
- For new policy areas
  - Replicating best practice
    - What is the most appropriate policy example to replicate? Why?
    - How does the best practice relate locally? Does it need altering?
    - Are there other municipalities who could assist with expertise or experience?
- Devising new policy
  - What similar policy (in the local government or elsewhere) can be drawn down on?
  - Should the policy be piloted initially?

Processes for ongoing monitoring and revision of all policies should be established from the outset.

	0 **Capacity assessment, getting team together**	1 **Context, boundary conditions, setting goals**	2 **Current Situation**	3 **Demand reduction & supply potential**	4 **Formulation of Strategy options, plus indicators (to match the goals)**	5 **Evaluation & selection**	6 **Commitment, planning, and implementation**
	Focus on local government	Focus on municipality or jurisdiction	Focus on the local energy state of affairs now	Focus on the future			
	Milestone: You have a team!	**Milestone:** Visioning document and imagery created	**Milestone:** Baseline established	**Milestone:** Report on state of affairs and future vision.	**Milestone:** Co-creation event/s held	**Milestone:** Draft approach developed and sense checked	**Milestone:** Your SHIFFT strategy is adopted by the local government!
Technology	• Are there existing initiatives or projects (for example energy cooperatives)?	• Establish technical and environmental ambitions and goals • Consider local / regional / national market conditions • Consider the boundaries to work within	• Examine the energy supply chain and its carbon emissions • Local mapping of existing buildings, households, developments, energy resources • Missing data	• Calculate potential for reducing energy demand and increasing sustainable heat • Use the data from consultation and events to assess the potential	• Match (present and future) demand and supply • Evaluate different sources, networks and carriers • Establish key performance indicators to be used	• Calculate KPI(s) impact per alternative • Compare to the current situation (baseline) and goals	• Identify initial plans for execution with stakeholders • Ensure data collection for KPIs
People	• Who are the internal stakeholders? Let them help you with assessing external stakeholders	• External stakeholder/citizen assessment • Collectively explore & agree objectives • Co-write personal narratives that fit to goals	• Collectively explore co-benefits, drivers & barriers of participants • Collective data collection, leveraging local information and preferences • Create co-ownership	• Continue co-research and dialogue for reduction and supply opportunities • Co-create a local platform on existing experiences	• Collectively identify a range of strategy options to pursue • Include citizen-based approaches and alternatives. What is needed to adopt or support these initiatives by the local government?	• Collectively evaluate different scenarios discussing the pros and cons of the available options for sustainable heating transition • Select the most appropriate scenario to implement	• Co-implement and monitor how citizens adopt or are affected by the strategy & adjust communication & incentives if needed • Apply & embed co-creation approach in projects or policy-making.
Policy & Regulation	• Elected official starts • Assessment of political will, personnel, governing, and financial capacities.	• Build on and look for links with existing policies and departments across climate, energy, housing, environment, jobs, etc	• What local policies can (or could) impact a sustainable heat strategy • Are there policy gaps or barriers?	• Evaluate efficacy, cost and politics of policies for demand reduction & supply. Draw on case studies.	• Identify and develop optimal policy tools for each option. • Elaborate wider & co-benefits of policy tool in each option.	• Evaluation and selection of policies in each option using specified criteria	• Local government adopts strategy and commits to implementing policy. • Ongoing review of efficacy & cost-effectiveness of policy

Figure 3. The draft SHIFFT common approach framework

4. Inventory of current challenges and approaches to sustainable heating

This chapter considers implementation challenges from three different viewpoints (technical-financial, governance and societal point of view) and more importantly, ways to overcome these.

4.1. Existing high-level strategies and approaches to achieve sustainable heating

After the oil crises of the 1970s and the emergence of societal environmental awareness, many strategies and approaches have been developed to achieve increased sustainability in the built environment. This section describes a few of them, in terms of their relevance to the SHIFFT perspective of sustainable heating and cooling in the built environment.

4.1.1. NSS: New Stepped Strategy

The New Stepped Strategy (NSS) (Van Den Dobbelsteen, 2008) is a simple step-by-step approach to achieving full sustainability efficiently, and has its roots in the Trias Energetica (Duijvestein 1989[2] and (Lysen, 1996). It is usually summarised as **reduce, reuse and generate sustainably**, although for practical purposes the analysis phase is also included, as an important preparatory step:

0. Analyse the present
1. Reduce energy demand
2. Reuse existing waste flows
3. Generate the remaining demand sustainably

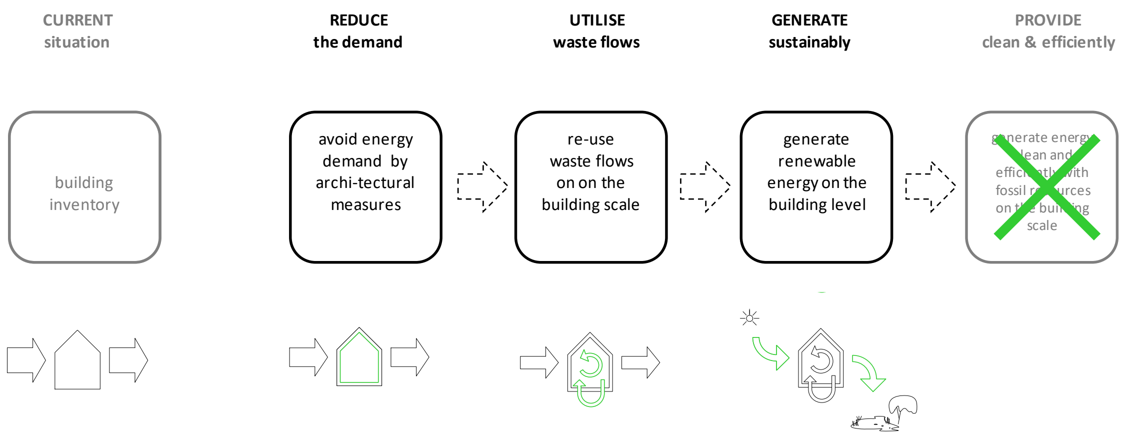


Figure 4. NSS: New Stepped Strategy

In terms of heating and cooling, **step 0**, analysing the present, can involve not just assessing the existing building stock (for example thermal efficiency of the shell, type of delivery systems and user behaviour), but also considering the networks that feed these systems. Energy Potential Mapping (or

[2] Duijvestein, K - An ecological approach to building (1989)

EPM, described in 4.3.1) maps demand, reduction potential and residual and renewable supply opportunities and results in an energy atlas, can also be included here.

Step 1 identifies measures to reduce the required heating and cooling flow, for example improving insulation, but also applying external sun shading to reduce summer cooling demand. The more efficient the demand side is, the smaller and therefore more cost efficient the energy system that supplies it can be.

Step 2 considers the energy losses from a building after step 1 improvements and recovering as much of them as possible in order to further reduce the flow. For a dwelling, these can be the exhaust from heating and ventilation systems, and sewage coming from showers. This step mainly involves transferring some of the lost energy from the outgoing flow to the incoming one, by using a heat exchanger.

Step 3 finally fills the remaining heating and/or cooling demand from renewable (and nearby/suitable residual) sources. The analyses done in step 0 (for example EPM) will show the opportunities available in the project area or near the building under consideration.

The final step in the illustration is the use of fossil fuels, which, in the final state of a fully renewables-based energy system, is eliminated, and therefore not elaborated upon.

4.1.2. REAP: Rotterdam Energy Approach and Planning

Developed from the NSS, Rotterdam Energy Approach and Planning (REAP), introduces a spatial component to the steps in the NSS. The reason behind this is that different measures work on different levels (for example insulating an individual home vs. capturing waste heat from a sewage treatment facility that can provide thousands of them), but they can all influence on the shape of the future energy system. REAP helps identify the different measures and their effects at these different scales. This helps transcend boundaries between stakeholders and find the best solutions for each area in a city that complement each other.

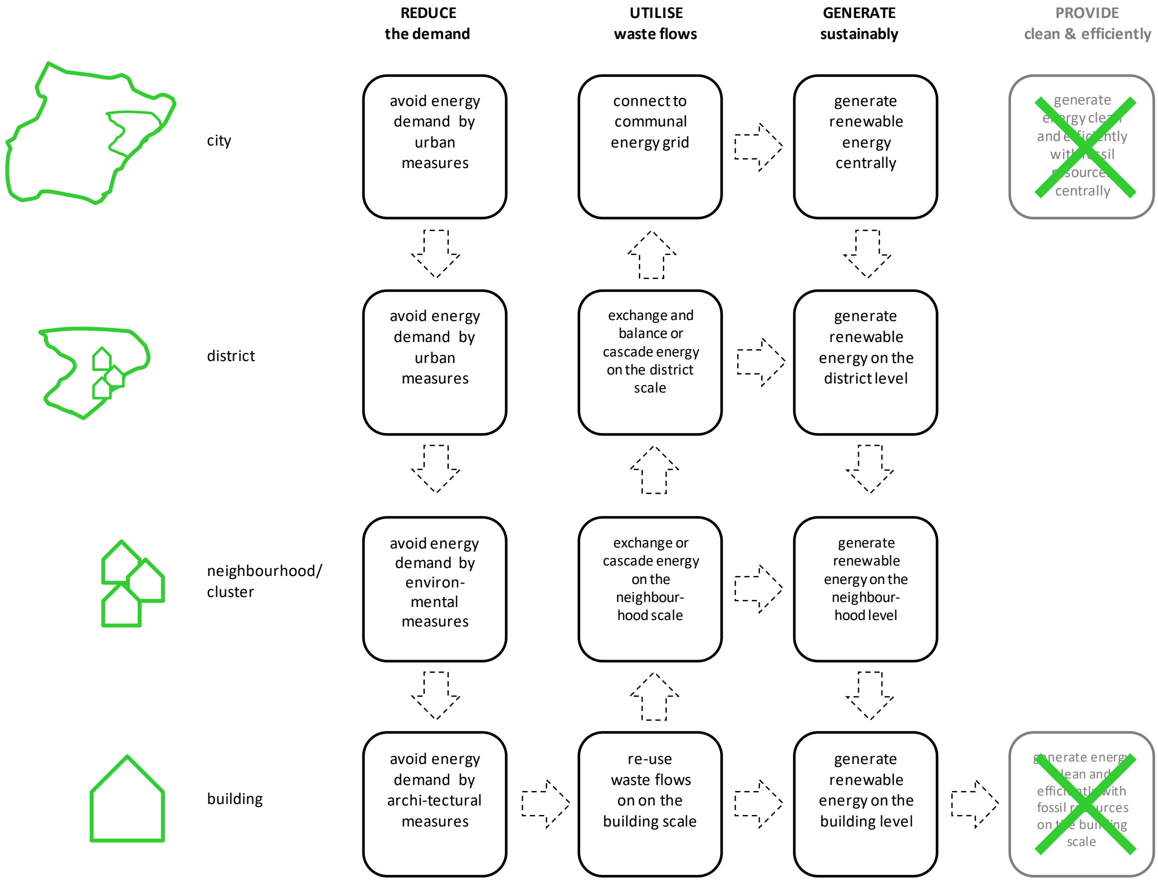


Figure 5. REAP: Rotterdam Energy Approach & Planning

Scale levels are of particular importance to heating and cooling, because, contrary to electricity and gas, thermal energy is generally low intensity/quality and therefore difficult to transport economically over greater distances. However, low temperature residual and renewable sources of heat and cold are abundant in and around most built environments, so if they can be used locally, they can reduce the cost of the system while achieving full sustainability.

As with the NSS, REAP can be used for urban energy systems in general, however within SHIFFT, the methodology is applied to heating and cooling. These are a few practical examples of REAP measures and their effects:

- *REDUCE, <u>building</u> level*: insulation (reducing heat demand in winter)
- *REDUCE, <u>neighbourhood</u> level*: increasing green/blue (water and parks) coverage (reducing cooling demand in summer)
- *REUSE, <u>building</u> level*: shower heat exchanger (reducing heat demand all year)
- *REUSE, <u>neighbourhood</u> level*: sewage treatment plant heat recovery (providing district heating, usually combined with centralised or building heat pumps)
- *GENERATE SUSTAINABLY, <u>building</u> level*: rooftop solar thermal collector (heat production, summer, or all year in combination with sufficient storage)
- *GENERATE SUSTAINABLY, <u>city</u> level*: geothermal well (heat production, all year)

Storage facilities and thermal networks also have various properties and sizes (for example diurnal and seasonal, and temperature levels), and are within REAP considered part of the sustainable generation step.

4.1.3. The City-zen Energy Transition Methodology

In the City-zen project (FP7, 2013-2019, cityzen-smartcity.eu), the transition to renewable energy was considered, with a focus on refurbishment and the role of citizens. The project revolved around partner cities (Amsterdam and Grenoble), their demonstrators and various knowledge partners (including TU Delft). Products included demonstrators, games for stakeholder involvement and awareness and the City-zen Roadshow, which applied the City-zen results in ten European cities.

One central element to the City-zen project was the **City-zen Urban Energy Transition Methodology**[3]. The core of this approach is similar to the NSS in the sense that the present is considered, and measures are then defined. However, with City-zen the focus is on taking into account the time (years or decades) that a complete transition takes, and identifying early no regret measures as well as high impact but long term ones, and monitoring progress, staying on track towards the set goal.

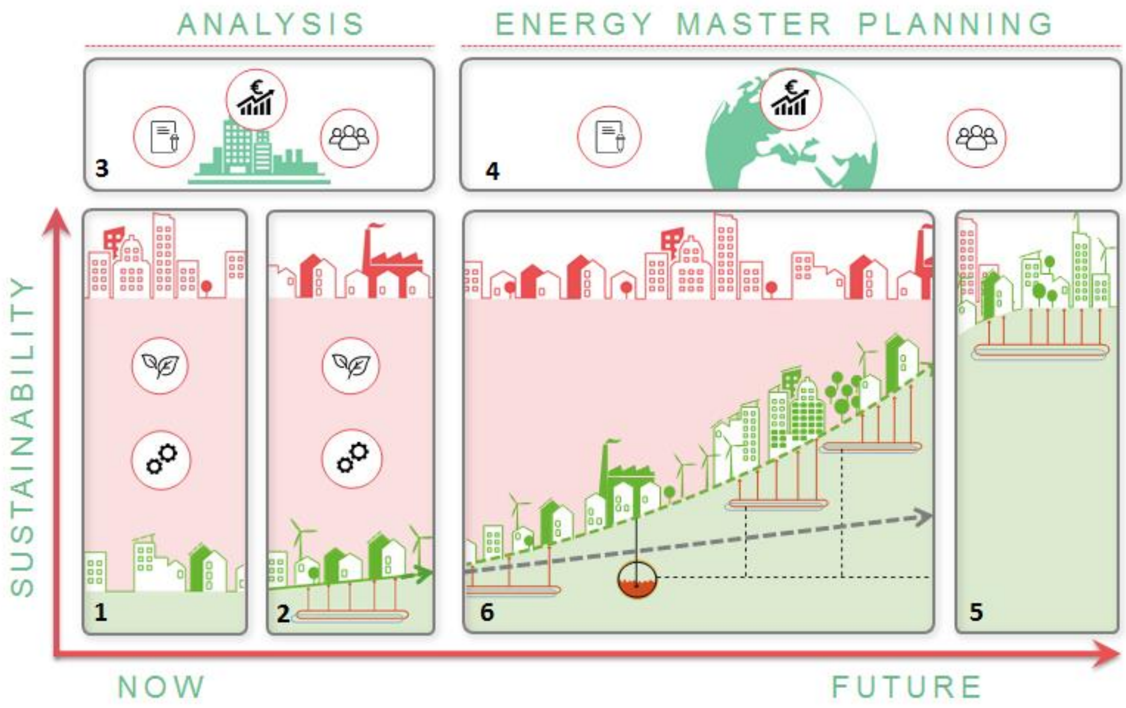


Figure 6.The City-zen Urban Energy Transition Methodology

The City-zen approach consists of six steps. The first three are the analysis stage:

1. Basic energy analysis
2. Current planning and trends
3. Societal and stakeholder analysis

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[3] City-zen deliverable d4.5: Urban Energy Transition Methodology (2019)

The final three steps form Energy Master Planning:

4. Scenarios for the future
5. Sustainable city vision with goals and principles
6. The roadmap

In the analysis stage, step 1 involves EPM in order to map and quantify demand, reduction and supply opportunities. Because plans and local trends towards sustainability tend to be elaborated and monitored anyway, step 2 involves making an inventory of these and assessing their impact. Step 3 considers the political, legal and economic environment of the city.

The information collected in the first stage can be used during the Energy Master Planning stage. Step 4 defines scenarios for the future (external variables that will influence the future of cities), which helps to identify resilient (and no-regret) measures. In step 5 both the end goals and key principles are defined (for example *“CO_2 neutral”*, *“100% renewables based”* or *“reducing energy poverty”*). Step 6 finally builds the Roadmap, which combines all these measures over time and ends with the goals set in the vision.

As part of the City-zen methodology, the Catalogue of Measures[4] was developed. This contains two-page overviews of a very large number of sustainable heating, cooling and electricity related technologies, and is intended as a primer to help define the measures in the roadmap.

4.1.4. SUI: Smart Urban Isles

The ‘smart Urban Isle’ (SUI) project is a JPI Urban Europe project, with partners from Spain, Austria, Cyprus, Romania, Switzerland, Turkey and the Netherlands. A ‘smart Urban Isle’ is defined as ‘an area around a (public) building that locally balances the energy as much as possible, resulting in minimized import and export of energy from outside this area’.

Hence, the aim of the SUI project was to develop energy systems for urban areas that locally balance the energy as much as possible, thereby considering both building measures and neighbourhood energy solutions. Within the SUI project, a systematic step-by-step approach was developed that supports the design or development phase, i.e. the generation of various energy system configurations for neighbourhoods. Following this approach can lead to various innovative neighbourhood energy configurations. After this concept development approach, further optimization of the promising concepts can be carried out.

The SUI approach consists of 5 steps, as shown in Table 1.

[4] City-zen deliverable d4.5: City-zen catalogue of measures (2018)

Table 1: SUI Guidelines for developing locally balanced neighbourhood energy concepts

Steps	Goal	Results
1. SUI description & KPI's a. Site description b. Buildings c. Context d. KPI's	to define the project area, site characteristics, describe buildings and infrastructure and select Key Performance Indicators (KPI's).	1.1 Site characteristics 1.2 Overview of existing and 1.3 planned buildings & infrastructure 1.4 Context and boundaries 1.5 Selected KPI's
2. Energy status quo: a. Existing energy infrastructure b. Energy demand c. Current energy supply	to provide an overview of the status quo of the current energy system. For new buildings a reference situation based on requirements can be defined.	1.1 Existing energy infrastructure 1.2 Current energy demand 1.3 Current local renewable energy supply
3. SUI concept potentials a. SUI Bioclimatic improvement potential b. SUI energy exchange c. SUI renewables potential	to determine all energy potentials: potential reduction of the demand, exchange between different functions and renewable supply using different technologies.	3.1 Quantified demand for various building solutions 3.2 Potential energy exchange 3.3 Energy potential of local resources
4. SUI concept development a. Connecting demand and supply potentials b. Heating and cooling options c. Electricity supply options	to develop energy configurations that meet the demand with maximised use of local energy potential, in order to evaluate the preferred option in step 5.	4.1 Schemes of the different energy configurations that can meet the demand 4.2 Energy balances of the configurations
5. Evaluation & selection	to quantify the performance and evaluate the KPI's for the different solutions developed in step 4	5.1 KPI's of each concept 5.2 Selection of 1 or 2 promising SUI solutions for further development

4.1.5. The Smart Energy Cities strategy

The Smart Energy Cities strategy was developed to accelerate the energy transition of Dutch districts and neighbourhoods. The strategy consists of two routes: a social approach (green) and a technical/financial innovations (blue). Both routes are equally important and dealt with simultaneously.

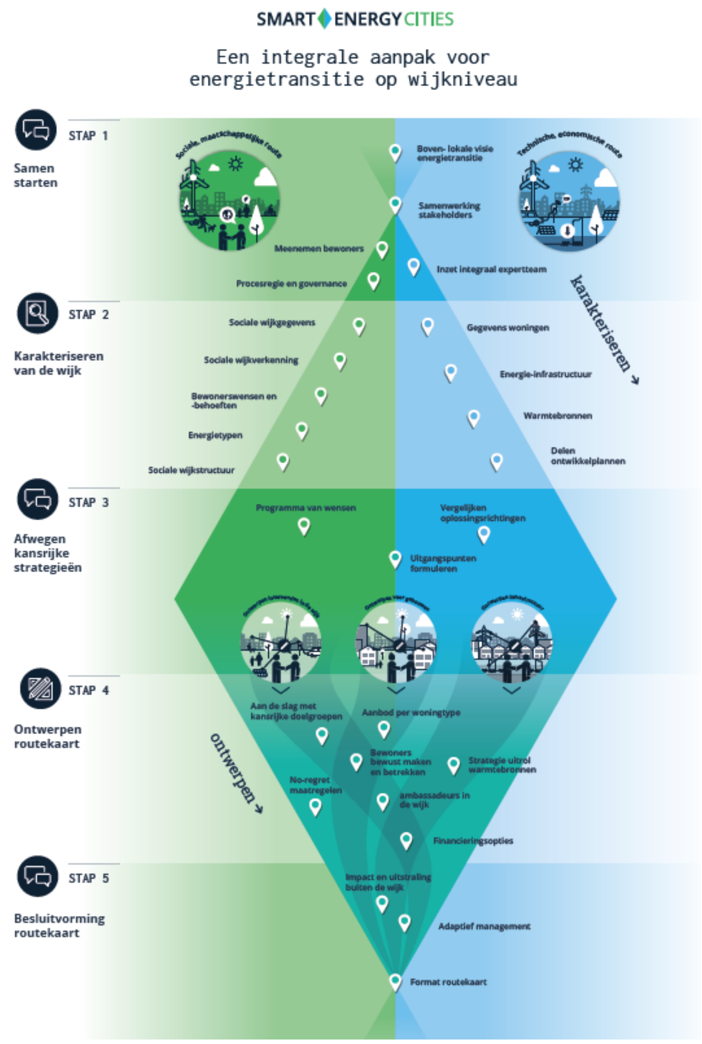


Figure 7. The Smart Energy Cities model (smartenergycities.nl)

The strategy consists of 5 steps, each including both routes and results in an integrated and adaptable roadmap [smartenergycities.nl]:

- Step 1: Start together – map the stakeholders, map the local ambitions and actively involve the citizens.
- Step 2: Characteristics of the district/neighbourhood: social characteristics of the neighbourhood and its citizens (2.1) and the technical characteristics (2.2) of the project area. The technical analysis includes building stock, energy demands, possible savings, existing infrastructure, available heat sources and the existing initiatives and plans.
- Step 3: Weigh promising strategies – use the insights of the social and technical analysis to define guidelines and possible heat strategies (alternatives).
- Step 4: Design the roadmap – determine the steps and actions required to:
    - Stimulate involvement and active participation of inhabitants and building owners: develop a (communication) strategy to achieve certain adaptations and investments;
    - Develop a building renovation approach that fits within the heating strategy;
    - Gain investments required for the (new) energy infrastructure.

- Step 5: Decision making roadmap: implementation program with short-term interventions (no-regret measures) and therefore required investments. Set moments at which decisions should be made about the investments and interventions required on long term.

The Smart Energy Cities approach is comparable to the City-zen Urban Energy Transition Methodology, including similar steps in a slightly different order. However, the Smart Energy Cities approach elaborates more on the social aspects of the energy transition and provides guidelines on how to deal with citizen participation. Within City-zen strategy, on the other hand, more attention is paid to goal setting (step 5: Sustainable city vision with goals and principles).

4.2. Heating and cooling: technology overview

This paragraph describes technical principles, concepts and terms relevant to the transition to renewable heating and cooling. The paragraph is structured according to the SHIFFT common approach for sustainable heat strategies and provides more information on the technology pillar of the approach.

4.2.1. CONTEXT: The energy supply chain, from demand to (renewable) production

For understanding and evaluating energy systems the energy flows can be determined on three different levels of the energy supply chain: Energy demand, final energy, and primary energy. The energy chain for heating starts with the net heat demand, which eventually needs to be supplied with renewable resources. In-between we need technical components to convert, store and distribute the energy into the right form, at the right time, and at the right place. The energy chain is shown in figure 8.

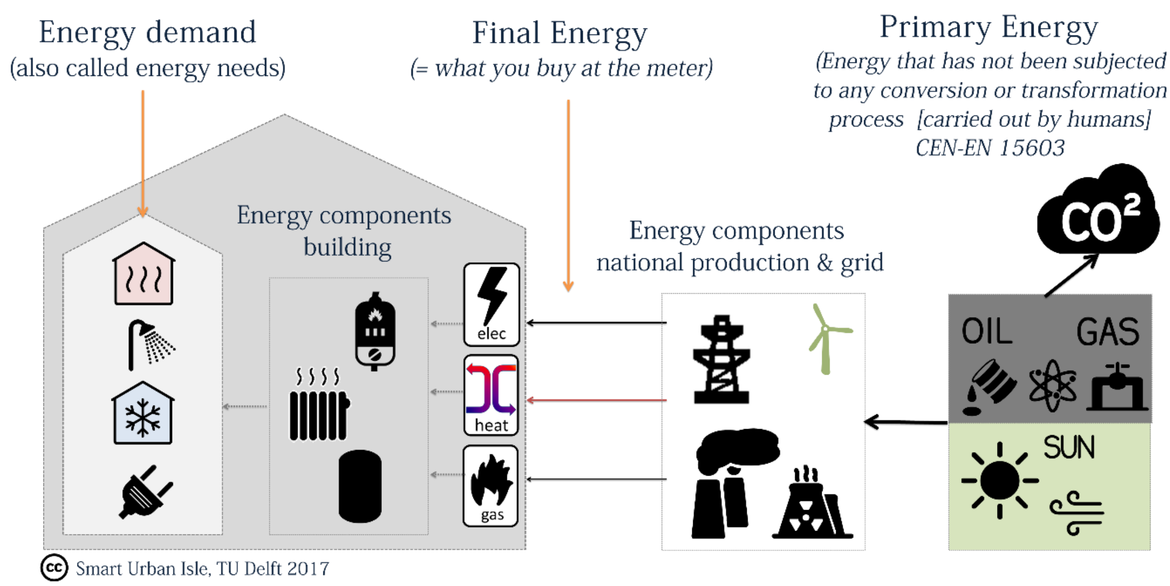


Figure 8. The Energy Chain

The different levels are defined as follows:

- The energy demand for heating and cooling has been defined for energy performance of buildings as ‘the heat to be delivered to, or extracted from, a conditioned space to maintain the intended temperature conditions during a given period of time’. At building level, the energy demand is produced by the building energy system which requires an input of energy. The energy demand is thus an indicator of the building properties (insulation, air tightness etc.) in combination with the use of the building; it is independent of the applied technical systems.

- Final energy is the energy in the form of an energy carrier (gas, electricity or heat) used on consumer side of the meter; it is defined by Eurostat as 'the energy consumed by end users', such as households.
- Final energy represents the fraction of primary energy that reaches the consumer. The European Committee for Standardisation defines primary energy as 'energy that has not been subjected to any conversion or transformation process'. In principle, the primary energy includes both fossil and renewable sources. However, in the determination of the national primary energy factors (PEF) it is not always clear how renewables are assessed, as explained by Molenbroek et al.

Temperature levels

The quality of the energy supplied (referred to as exergy) is important. For thermal energy this directly refers to the temperature level, where high temperature sources have many uses, and low temperature heat sometimes needs upgrading to get to the required level. Source temperature levels can also fluctuate over time, and surface water can for example in summer be used to charge a seasonal store with heat, and in winter with cold.

Fluctuations in time (storage)

In a conventional fossil fuel based energy system, supply can always be adjusted to match the required demand at any given time (if everyone wants to cook dinner, do the laundry and charge their electric vehicle between 6 and 8 PM, the network would be able to supply this). For many renewable and some residual sources, this is however not always the case. Sometimes storage, or demand side management are required.

It is therefore important not just to consider the annual yield, but also how much of this can be used directly, both diurnally and seasonally, and how much of the remainder would need to be stored, for it to be usable.

Presence and availability

Both residual and renewable sources vary in local availability. It is therefore important to find out where they are located. Section 4.3.1 describes Energy Potential Mapping or EPM, the underlying method to spatially quantify these.

4.2.2. CURRENT SITATION: how to calculate current energy demand

When identifying the current energy 'use' it must be clear which level of the energy chain is presented (demand, final energy or primary energy), as explained in section 4.2.1. Often, some conversion between these is necessary.

For existing neighbourhoods the final energy consumption can often be obtained from the grid operators. If no measured final energy data are available, national reference numbers can be used, preferably based on building characteristics such as year of construction, energy performance certificate or energy label, in line with the European Energy Performance of Buildings Directive . Also, energy performance calculation methods can be used to estimate energy consumption, but it has to be noted that significant differences can occur between calculated and actual energy performance .

After determining the (final) energy consumption, the division between the different energy types - heating, hot water, cooking, cooling, lighting and other electricity use – should be determined.

Finally, as most real data is provided based on ‘final energy’ consumption, this number must be converted to energy demand or needs (see section 4.2.1). The energy needs are the basis for the energy saving potentials as well as the new to be developed (building) energy system. In the next section this is shown for the case study.

4.2.3. DEMAND REDUCTION: Energy demand reduction potential

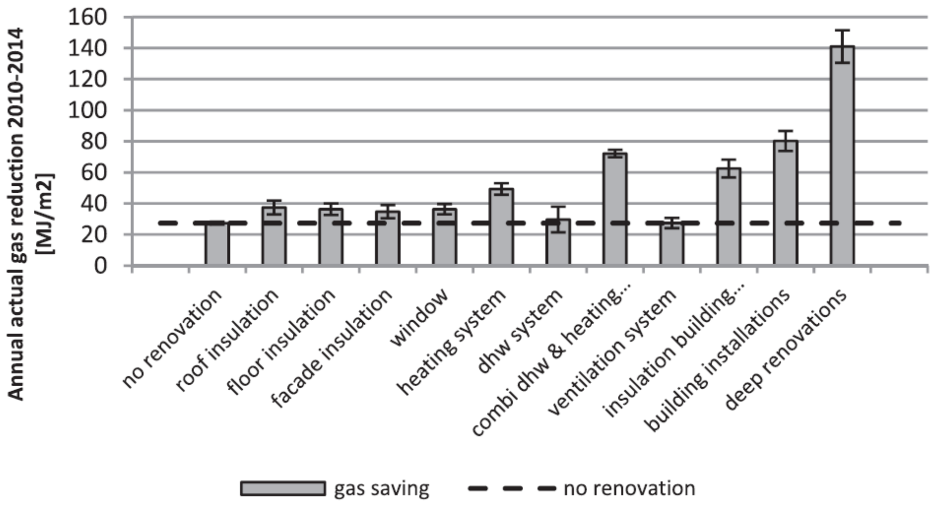
To enable 100% renewable energy supply, the reduction of the energy demand is an essential component. Is stated in the. As mentioned in a special IPCC report (J. Rogelj, et al., 2018), we will not sufficiently reduce CO_2 emissions on time, when we do not reduce our (final) energy consumption.

Energy efficient design

Abundant research can be found on energy efficient building design. (Pacheco, Ordóñez and Martínez, 2012), present a review on the different aspects and design measures that can be used to minimize energy demand for heating and cooling, being: building shape; orientation; properties of the building envelope including glazing types; shading systems and passive measures such as nocturnal ventilation. For energy renovation or retrofitting there is obviously less freedom of design, but many of these aspects can be considered.

Actual energy demand reduction versus calculated energy demand reduction

As is the case with the estimation of the actual demand, is has to be noted that the real demand after renovation is not equal to the calculated energy demand. This is often due to the fact that after renovation also the thermal comfort increases, while the energy reduction is less than according to the calculated reduction which assumes a standardised thermal comfort level. A recent study by (van den Brom, Meijer and Visscher, 2019), analysed the effect of various renovation measures on the reduction of gas used for heating in the Dutch Climate, see the Figure 9.



Average energy saving (corrected for degree days) per thermal renovation measure (including confidence interview 0.05) dashed line is actual difference in gas reduction between 2010-2014 for non-renovated houses.

Figure 9. Average energy saving from different measures (van den Brom, Meijer and Visscher, 2019)

Required temperature level for heating

Another important aspect is the temperature at which the building needs to be heated. A lower temperature can often be with more, low temperature, renewable sources and in the case of heat pump technology, with a higher efficiency or COP. The required temperature of a heating system depends on the heating power needed, which is in term a function of the insulation value, air tightness and ventilation system, and on the available power of the heating system (radiator or floor heating system) at a given temperature level. Often, the temperature of the heating system can already be lowered after renovation, as the original system is dimensioned for e higher power.

Many studies are currently being done on lowering the supply temperature of heating systems, in relation to more sustainable supply of district heating systems and application of heat pump technologies. Nagy et al. (2014) study how much the supply temperature can be lowered in relation to the renovation state of a building's envelope. Findings are that supply temperature can be lowered, within comfort limits, from the original 55°C to 45°C in the baseline and first retrofit stage. When insulation is improved in the second retrofit stage, supply can further decrease to 40°C.

4.2.4. SUPPLY POTENTIAL: (renewable) energy resources

When both the present and expected future demand are known, both in quantity and temperature level, these can be matched to the locally and regionally available residual and renewable resources.

In this section we provide a list of (renewable) energy resources and primary conversion technologies to convert these to useable energy carriers in the form of electricity, heat (i.e. hot water or any other heated medium) and fuels.

Renewable sources

Fully renewable resources can be used indefinitely, provided the technology that harvests them (for example solar thermal panels or geothermal wells) can be maintained over time. Common examples are solar thermal, geothermal and biomass, however others such as surface waters might have significant local potential. Renewable thermal sources can be divided into a few main categories, as shown in Table 2 below.

Table 2. Renewable thermal sources comparison

Primary resource	Primary conversion technology	Resulting energy carrier	notes
Sun	PV, solar thermal	Heat	Fluctuating supply
Air	Heat pump / direct	Heat / cold	Fluctuating supply
Water	Heat pump / direct	Heat / cold	Fluctuating supply
Geothermal	Heat pump / direct	Heat	Constant supply, underground must be suitable
Biomass	Combustion (CHP)	Heat (/electricity -> cold)	Can be stored, requires storage, availability varies

Residual sources

Most human activities result in waste heat, and in a few cases in waste cold. These can be used for space heating, domestic hot water or other functions by exchanging and cascading. The latter is the most common and uses waste heat from one process to supply another that requires a lower temperature. The table below shows a few examples of residual sources commonly found in and near the urban environment.

Table 3. Examples of residual thermal energy sources

Residual thermal source	Primary conversion technology	Resulting energy carrier	notes
Subways	Heat pump	Heat	Uses heat exchangers in ventilation shafts
Data centres	Heat pump	Heat	Relatively constant supply
Parking garages	Heat pump	Heat	Uses forced ventilation exhaust in closed facilities
Supermarkets, ice rinks, refrigerated storage facilities	Heat pump	Heat	Residual heat from (product) cooling/freezing
WWTPs	Heat pump	Heat	Residual heat from purification process
Sewage networks	Heat pump	Heat	Residual as well as environmental heat
Heavy industry	Direct	Heat	Steel plants, aluminium smelters etc
Light industry	Heat pump / direct	Heat	Paper mills, large bakeries etc
LNG terminals	Direct	Cold	Residual heat from the existing fossil fuel infrastructure

With residual resources, long term planning is important. Industrial facilities for example may be able to provide large amounts of high temperature heat and singlehandedly supply entire districts, however if global economic circumstances change, they may decide to move their business elsewhere, as a result depriving the connected DH network from its source. Even though the industrial facility might either provide its heat at cost or even less, it is safer to consider large sources like these as transitional, allowing network investments to be spread out over time. Changes in smaller sources in networks are easier to coped with due to their limited impact, but it is important to anticipate both kinds of changes and the effects of supply interruptions at the source.

Examples of electricity based residual resources are datacentres and refrigerated storage facilities. These can only be considered renewable if the source of the electricity is renewable as well.

4.2.5. STRATEGY OPTIONS: Energy System Technologies

Sustainable energy system technologies can be used to match the future demand (section 4.2.3) with the local energy potentials (section 4.2.4) and includes technologies related to distribution, conversion and storage of energy. In step 4 of the SHIFFT common approach an optimal combination of these technologies should be identified. The databases for the SUI Technology Matrix, SUI Technology Inventory and the City-zen Catalogue of Measures (CoM) provide an extensive overview of these technologies.

Figure 10 is a product of the SUI project (SUI approach, see section 4.1.4) and gives an overview of alternative heat solutions for the built environment: heating without the use of fossil fuels. In the bottom of the diagram, the primary energy sources: sun, wind, waste heat, ground/geothermal energy, biomass and water. These primary energy sources can be converted into a certain energy carrier (secondary energy source), the technologies used for this conversion are described in the previous paragraph.

The diagram makes a distinction between individual systems and collective heat systems (district heat networks). The energy carrier electricity can for example be used for individual heat systems: heat pumps, infrared and electrical heaters.

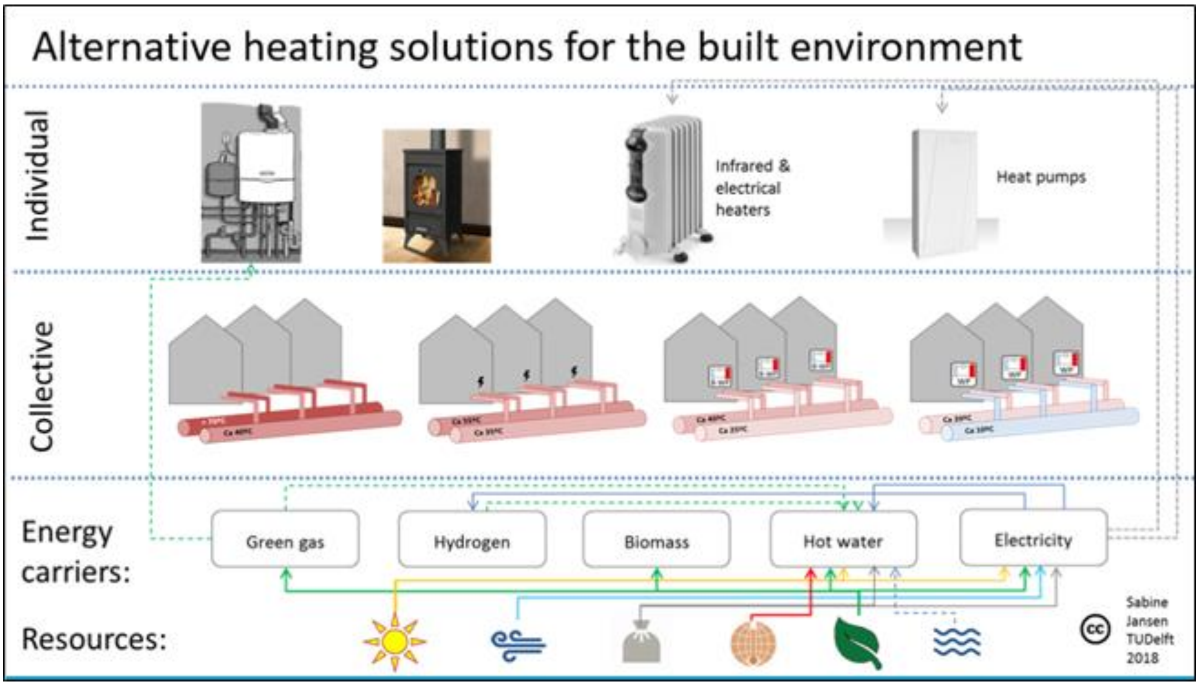


Figure 10. Alternative heating solutions for the built environment, SUI Project (Jansen, S.C., et al, 2018)

The technology matrix of the SUI project is a tool that visualizes which technologies and sources should be further considered and which should not, given the local conditions. More details about these technologies can be found in the SUI Technology Inventory: an overview of different technologies, products, manufacturers and services. The main categories of heat technologies discussed within SUI are: PVT (Photo Voltaic Thermal, PVT combined with seasonal energy storage, PVT combined with a boiler, solar collectors, wastewater, waste and biomass (Jansen, S.C., et al., 2018).

Both SUI and City-zen make the distinction between four sustainable heat systems green gas (biogas), biomass, hot water (district heating) and electricity. The catalogue of Measures provides relevant information about a wide range of possible energy measures at both technical and strategic level, for this paragraph only the technologies related to heating are included. As part of the Catalogue of Measures the ‘sustainable heat systems diagram’ is created: an overview of the technologies that are included in the catalogue (Figure 11).

The diagram shows the four main sustainable heat systems divided into individual and collective systems. On the left the individual systems biomass (I), biogas (I) and all-electric heating (II) and on the right, collective heat networks. Horizontally, the diagram is divided into four temperature levels: from high temperature till very low temperature heating. The scheme visualizes which heat systems are effective at which temperature level and the therefore required energy labels and building installations (for heating, cooling and domestic hot water). The black icons represent the different energy technologies that can be used to supply the energy required in the selected heat system (Broersma S., 2018).

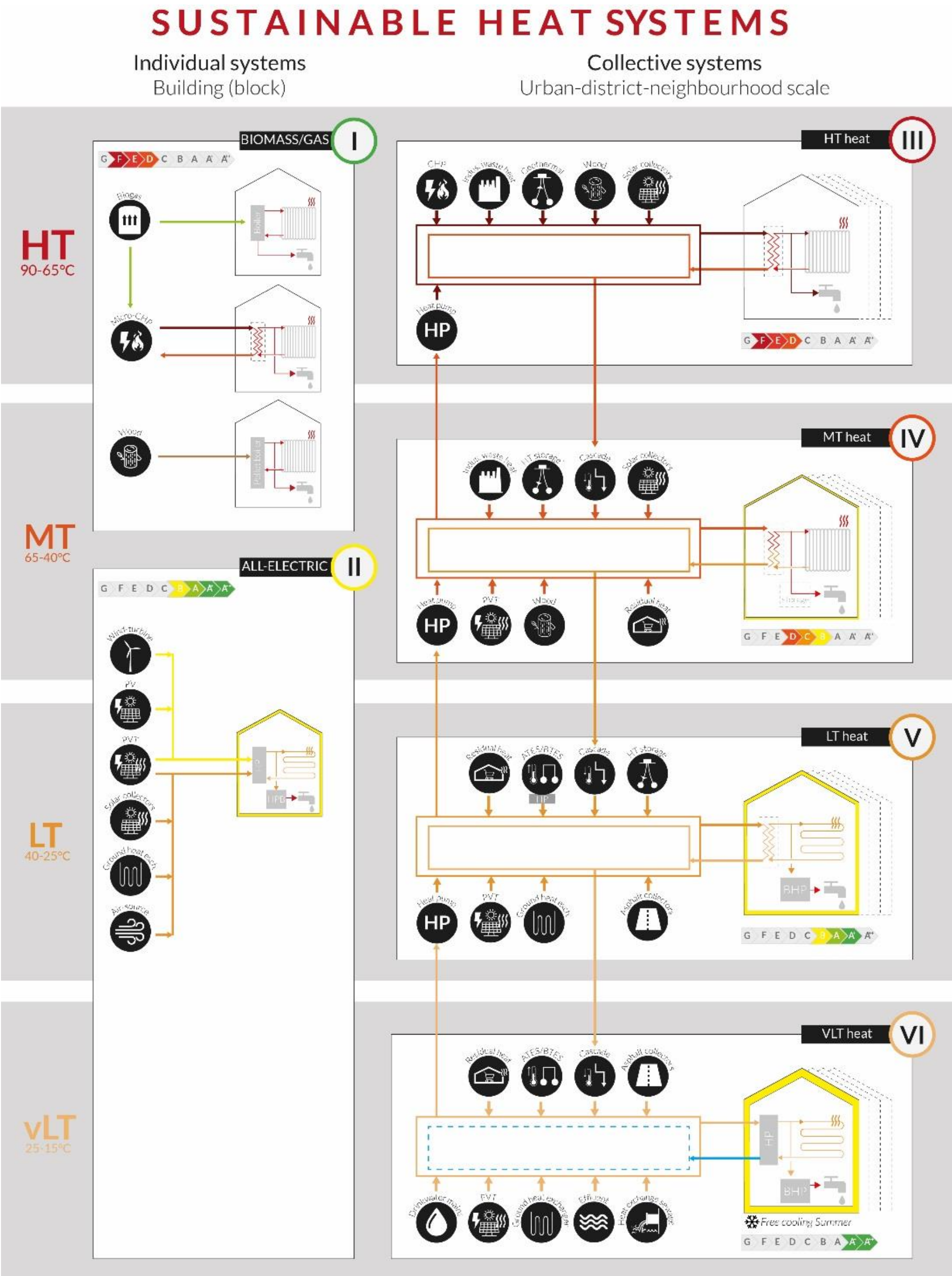


Figure 11. Sustainable heat systems diagram city-zen [Broersma et al. 2018a]

The CoM provides the most complete overview of sustainable heat systems technologies, the tables below give an overview of the technologies that can be found within this catalogue, where necessary additional information can be found within the SUI technology matrix. A division is made between technologies related to distribution, generation, conversion, storage and systems. Systems are combinations of the different technologies discussed in the catalogue.

Within the SHIFFT project the Catalogue of Measures is recommended as a source of inspiration and as background information for the participating authorities.

Table 4. Catalogue of measures

Chapter CoM	Title/system	Technology	Dimension
Distribution			
42	Heat network	District heat/cold network	Community & Grid scale
22	District cooling	District heat/cold network	Community & Grid scale
Generation and conversion			
23	Heat pump	Heat pump	Building & community scale (collective HP)
24	Air-source heat pump	Heat pump	Building scale
25	Ground-source heat pump	Heat pump	Building & community scale (collective HP)
26	Hybrid heat pump	Heat pump	Building scale
27	Biogas	Biomass	Grid scale
28	Biomass	Biomass	All scales
29	Geothermal energy	Geothermal	Community & grid scale
30	Solar collectors	Solar thermal	Building & community scale
31	Asphalt/road solar collectors	Solar thermal	Community scale
41	Booster heat pump	Heat pump	Building scale
44	Fuel cell micro CHP	CHP/cogeneration	Building & community scale
50	PVT	Solar thermal, PV	Building & community scale
64	Power-to-Gas	Power-to-gas	Grid scale
65	Power-to-Heat	Power-to-heat	Grid scale
Storage			
34	Heat hub	Thermal storage	Community scale
35	Borehole thermal energy storage (BTES)	Thermal storage	Building & Community scale (larger building blocks)
36	Aquifer thermal energy storage (ATES)	Thermal storage	Building & community scale (larger building blocks)
37	High temperature seasonal thermal energy storage in underground closed systems	Thermal storage	Building & community scale
38	High temperature ATES	Thermal storage	Building & community scale
39	Seasonal storage for zero-energy building	Thermal storage	Building scale
40	Smart district heat network with PCM	Thermal storage	Community scale

Systems			
8	District heating networks with cascading temperature levels	District heat/cold network	Community & grid scale
9	District heating network with PVT and seasonal storage	District heat/cold network, solar thermal, thermal storage	Community scale
10	Sewage water exchanger	Heat exchange water	Community scale
11	Mini district heat network on effluent with individual heat pump	District heat/cold network, heat pump, water	Community scale
12	High temperature district heat network with solar collectors and storage	District heat/cold network, solar thermal, thermal storage	Community scale
13	Biomass in district heat network	District heat/cold network, biomass	Community & Grid scale
14	District heat network on industrial waste heat	District heat/cold network, residual heat	Grid scale
15	Mid temperature district heat network on residual waste heat	District heat/cold network, residual heat	Community & Grid scale
16	Power-to-Heat combined with district heating	District heat/cold network, power-to-heat	Grid scale
17	Heat pump on surface or sea water	Heat pump water	Community scale
18	Low temperature district heat network with heat pumps on mine water	District heat/cold network, heat pump, heat exchange water	Community scale
19	Biogas and heat from wastewater treatment (bio refinery)	Biorefinery	Community & grid scale
20	Waste incineration with combined heat power	CHP	Grid scale
21	Usage of cooling and heat from drink water infrastructures	Heat exchange water	Community scale

4.2.6. INDICATORS: Evaluating impact

Within step 4 of the SHIFFT common approach for sustainable heat strategies the user will select Key Performance Indicators based on the goals and sub-goals adopted in each of the strategies defined within the first part of this step.

Energy Key Performance Indicators

The SHIFFT project uses energy key performance indicators (KPIs) to assess sustainable heat strategies. Within the first step of the common approach framework (Figure 2) 'Context, boundary conditions, setting goals' the sustainability ambition of the municipality is established.

The interpretation of these sustainability ambitions/targets by local authorities differs, even where the same term is used. There is a lot of confusion about the different definitions of sustainability goals. Below the definitions of these sustainability goals and the related KPIs are defined [Broersma et al. 2018a]:

(Net) zero carbon, carbon neutral, climate neutral

Over a year the (net) GHG-emissions are zero (KPI). Carbon emissions may be compensated, for example by carbon trading (CO_2 certificates), CO_2 storage and CO_2 uptake by forests. Since the goal of becoming (net) zero carbon or carbon neutral is related to climate change mitigation it can also be called climate neutral.

In total the released CO_2 equivalents should be equal to the amount of CO_2compensation.

(Net) zero energy, energy neutral

The amount of energy used within the system is equal to the amount of renewable energy produced over a year (KPI). The use of fossil fuels is still allowed but should be compensated by on-site renewable energy production. Therefore, energy neutral doesn't mean the system is fossil free. Where more energy is produced then used within the same system over a year, the system can be called energy positive.

The performance of the system is measured in terms of the on-site energy production compared to the energy usage/demand (both expressed in kWh or GJ).

Fossil free

Being completely fossil free means operating with zero fossil fuels; fossil resources aren't allowed anywhere within the system. Compensation of carbon emissions is not allowed. The system can be called circular on its energy performance, but not for other flows as water, material and food. KPI: the amount of fossil fuels (expressed in kWh, GJ or m^3) used within the system is zero.

Circular

Circularity is often only connected to the use of products: focusing on reusing, recycling and reprocessing materials. However, circularity can also include energy, water and nutrient cycles. A circular system reuses all waste flows and resource with only the input of renewable energy. A circular system functions by itself; it is self-sufficient. It is difficult to measure to what extent a system is circular, there are no numeric KPIs.

Other KPIs

While each of the sustainability goals comes with a different KPI there are also other relevant KPIs and sub-targets to assess the by the (partner) cities defined sustainable heat strategies. Figure 12 below, was developed within the SUI project and can be used to select the energy KPIs for the in step 4 defined heat strategies (Jansen, Bokel and Müller, 2017; Jansen, S.C., et al., 2018).

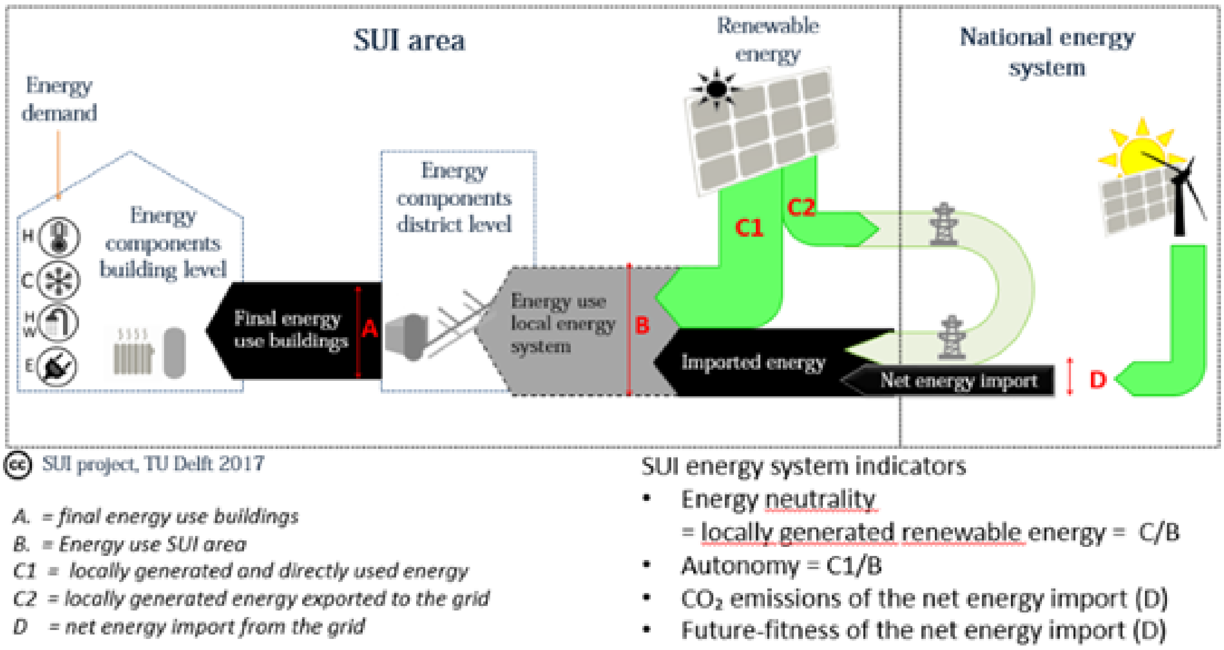


Figure 12. Energy Chain and Key Performance Indicators (source: Jansen et al. 2018)

A = Final energy use of buildings - The final energy use of all buildings in the project area (what you buy at the meter). Measured in GJ of gas, heat (and electricity) per year.
B = Energy use of the local energy system - Total energy input in the area, including the energy losses within the project area, for example heat losses in the local district heat network. Measured in GJ gas, heat and electricity per year.
C = Locally generated renewable energy - The total amount of renewable energy produced within the boundaries of the project site. Expressed in GJ per year.
D = Net energy import from the grid - The amount of energy that (still) needs to be imported from the regional energy system to supply the energy demands of the project area. The consumption of energy which is not produced within the boundaries of the project area. Expressed in GJ gas, heat or electricity imported from the grid over one year.
C/B - Percentage of locally generated renewable energy - The amount of locally generated renewable energy in GJ per year (c) divided by the total amount of energy used within the system (b). Expressed in percentage.
D - CO_2-emission of the net energy import - Total CO_2-emissions coming from the amount of imported energy (d). The emissions in CO_2-equivalents (kgCO_2-eq/year) can be calculated with the use of the specific emission factor (EF) of a certain activity. For example, the EF of electricity depends on the local electricity grid mix, typically a mix of both fossil fuels and renewable sources [Pulselli 2019]. The emission factor (EF) is expressed in kgCO_2-eq/unit of the activity or energy source, in the case of electricity the EF is expressed in kgCO_2-eq/kWh. For information on how to calculate CO_2-emissions.
C1/B = Autonomy - The fraction of energy consumer on site that is produced from local renewable energy sources over a year. To calculate, divide auto-generated renewable energy consumed on site (c1) in GJ per year by the total energy use of the local energy system (b) in GJ.
D = Future fitness of the net energy import - Future availability and the sustainability of the used energy sources. Long term availability of heat sources is central to forward energy planning. A few examples: when using residual heat sources, it should be considered if the source/function will still be there in the future or might changing economics reduce availability? Might geothermal sources be exhausted? Could sourcing of biomass conflict with local nature or food production.
Impact on material use and space - Not included within the SUI diagram is the impact of the proposed heat strategy on both material usage (CO_2-emissions released during the lifespan of the product) and space (m^2). Spatial impact: a sustainable heat system requires space for generation, transportation, storage and conversion of energy. This can be both underground as above the ground. Above that space is required for noise, safety zones and so on. Therefor the integration of the heat system within the built environment is an important KPI to reduce the spatial impact.

How to calculate CO2 emissions?

A common KPI is the reduction of the CO_2 emissions. The Greenhouse Gas Protocol aims to set a global standard on how cities calculate their CO_2 emissions (Fong, W.K., et al., 2014) and is therefore used as the calculation method in SHIFFT.

The Greenhouse Gas Protocol divides the different emissions into three scopes. The project is focussing only on Scope 1 and Scope 2 emissions. Therefore Scope 3 emissions (e.g. "well to tank" emissions from energy consumption, or embodied emissions associated with building works) are excluded.

- Scope 1 - direct GHG-emissions from the combustion of fossils within the city boundary.
- Scope 2 – GHG-emissions from sources occurring as consequence of the use of grid-supplied energy, heat, steam and/or cooling.
- Scope 3 – all other GHG-emissions that occur outside the city boundary as a result of the activities taking place within the city boundary.

The GHG protocol distinguishes six main sectors that cause CO_2-emissions from city activities. Within the SHIFFT project only the stationary energy sector (related to the built environment) is considered. The stationary emissions that should be included within the SHIFFT project are coming from the combustion of fuels in residential, commercial and institutional buildings and facilities.

Calculating the stationary emissions

The emissions are calculated by multiplying the activity data by the emissions factor related to this activity.

Activity data

A quantitative activity that results in the release of GHG-emissions (Fong, W.K., et al. , 2014). In this case the annual final consumption data per energy carrier of each building in the project area: final natural gas consumption in m^3, final electricity consumption in kWh, final heat consumption in GJ, etc.

To have a fair comparison between the space heating energy consumption data before and after the implementation of the heat strategy, the effect of the weather conditions should be eliminated. This can be done with the heating degree days method. To do this, the weather dependant consumption is multiplied by the typical annual degree days and divided by the actual annual degree days that occurred during the measurement period. This is then added to the non-weather dependent consumption.

If insufficient data is available to accurately establish the base temperature, then the standard value of 15.5°C should be used. Degree day data is usually published regionally by countries or can be established from other sources (e.g. www.degreedays.net) or can be measured if sufficient data exists from on-site temperature measurements. The "typical" annual degree days that is usually taken is the 20-year average for the site or region.

Emission factor

The corresponding emission factor (EF) should be used to calculate the emissions; expressed in kg CO_2-eq per unit of the activity or energy source. This emission factor varies per region and therefore it is preferred to use local, regional or national data. When the national emission factor isn't available the cities should use the emission factors as defined by IPPC (Intergovernmental Panel on Climate Change) or in the EFBD (emission factor database) (Fong, W.K., et al., 2014).

For district heating, the emission factor will depend on specific local factors. The operator of the DH scheme should be able to provide a factor for use in the calculations.

Emission factors for most of the fuels are likely to remain similar over time, the exception to this is grid electricity, which is projected to significantly decrease as a greater fraction of electricity is generated from renewable sources[5]. This means that, for example, for an electrically heated building the "post" emissions might be lower than the "pre" emissions even if nothing is done, due to the decarbonisation of the grid. To combat this, it is suggested that a single fixed year is used to make the annual comparison. Alternatively, a different approach might be to annualise emissions over the lifetime of the heating system e.g. 20 years and include projections for grid decarbonisation in the calculation. In all cases, as well as reporting GHG emissions, the energy consumption (kWh) should also be reported as this will be unaffected by changing emission factors.

For the production of on-site energy, a distinction should be made between locally generated energy that is consumed directly and the locally generated energy that is exported to the grid. This refers to c1 (directly consumed) and c2 (exported) in the SUI diagram (Figure 12). The saved emissions due to the exportation of on-site produced energy can be extracted from the total emissions. In the current regulations the emission factors for the on-site produced energy that is directly consumed and exported are still the same.

Carbon equivalents

The CO_2-emissions will be expressed in CO_2-equivalents (CO_2-eq). Since not only CO_2- emissions, but also other greenhouse gasses (GHG) should be considered. Therefore, it requires calculating the CO_2-equivalents (CO_2-eq) of the observed system. These carbon equivalents correspond to the three main greenhouse gasses released in the atmosphere: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (Pulselli *et al.*, 2019). The emissions are multiplied by their Global Warming Potential over a period of 100 year: CO_2 GWP = 1, CH_4 GWP = 28 and N_2O GWP = 265 (Fong, W.K., et al, 2014).

4.3. Technical planning tools, methodologies and toolboxes

Translating the high-level strategies developed into concrete plans can be challenging. In this paragraph, several tools, methodologies and toolboxes are described that can support this process by providing a technical basis.

4.3.1. EPM: Energy Potential Mapping

The transition to a sustainable built environment requires making better use of local and regional potentials. This is especially the case when considering heating and cooling, because as mentioned before, these are difficult to transport economically over greater distances.

[5] It worth mentioning that where nuclear is a major contributor to electricity, such as in France, then there is less potential for reducing carbon emissions where electricity is already used for heating.

The method of Energy Potential Mapping (Broersma, Fremouw and Dobbelsteen, 2013), developed at TU Delft, is the process of spatially quantifying demand, demand reduction potential and residual and renewable supply potentials (further described in sections 384.2.2, 4.2.3 and 4.2.4), and produces an energy atlas. At the core, EPM applies the New Stepped Strategy (section 4.1.1) by connecting geospatial indicators with conversion factors in order to arrive at a functional demand, demand reduction and a technical supply potential, using the same units for all layers (for example *"GJ/ha"* or *"GJ at 80 °C"*). The end goal is to connect these and facilitate the creation of heat zoning plans (see also section 4.5.5 on Steering and envisioning). The EPM method is at the basis of any energy atlas and sustainable spatial planning tool.

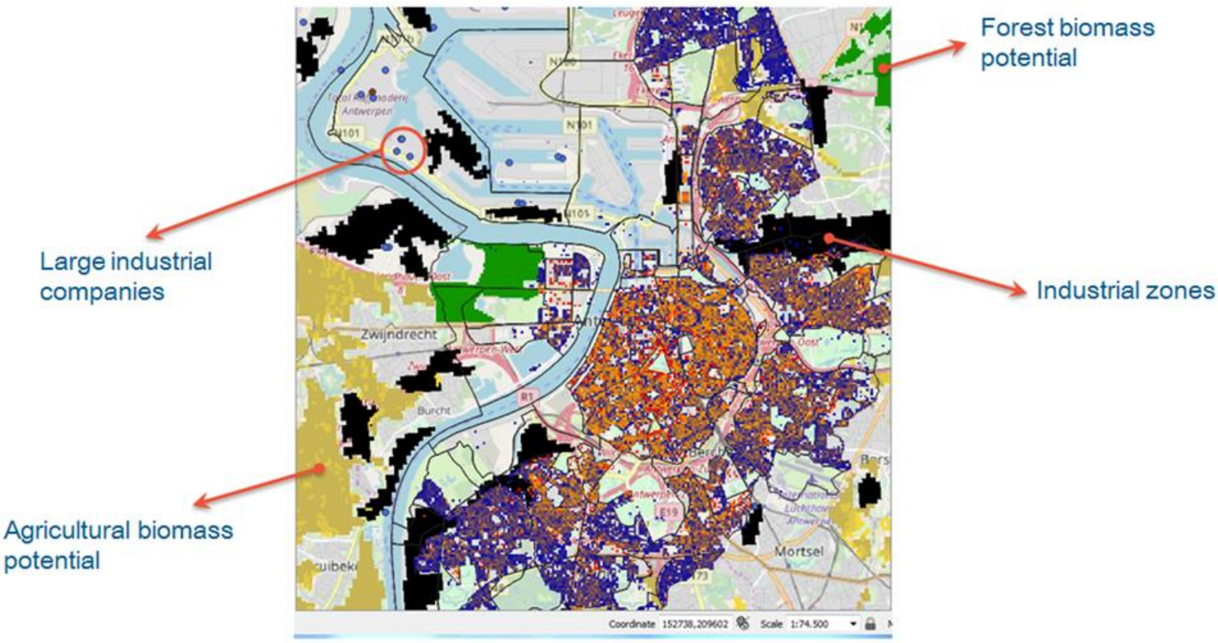


Figure 13. Energy potential mapping, illustrated for the city of Antwerp, using the PLANHEAT toolkit. (source: PLANHEAT)

An example is shown in the map highlights the energy potential for forest and agricultural biomass on one hand, and residual heat from large industrial companies and industrial zones on the other hand, in this case projected over residential space heating demand.

Mapping heat demand

Mapping the heat demand in most cases is a first step towards a sustainable heating strategy. The main challenge is collecting the data:

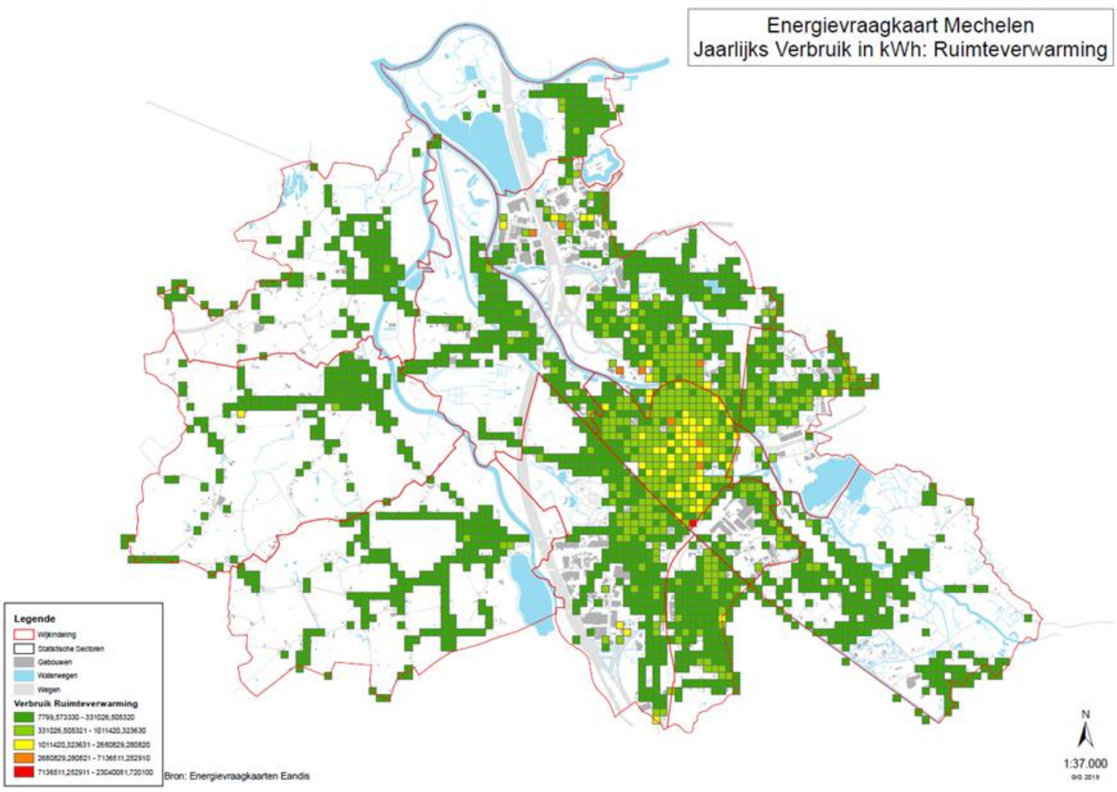
- individual consumption figures are not accessible due to privacy legislation, and in any case not all the data is collected centrally;
- in theory, consumption figures for natural gas and electrical heating can (relatively easily) be acquired from the distribution system operator (DSO). Consumption figures for other heat sources such as fuel oil or biomass can be more challenging.

Data collection can also be an opportunity as a local authority can have exclusive access to data sources, for instance energy consumption of its own building stock.

Depending on data availability and data quality, following building stock data can provide insight about the heat demand and might be considered (non-exhaustive list):

- Location of public buildings, non-residential buildings, which are typically large consumers;
- Energy performance data: EPCs or energy labels;
- Heat density maps, based on energy consumption data – raster map;
- Heat density maps, based on energy consumption data – linear per street length;
- Heat density maps, based on energy consumption data – linear per connection point;
- Urban renewal projects (on-going and upcoming);
- Building age classes and building typologies (single family housing, multi-family housing, social housing);
- Other building stock characteristics such as thermal insulation level, potential for energy renovation, the presence of a central boiler room, protection as a monument, etc;
- Renovation activity: building permits for renovation or grants for energy performance improvement measures.

Figure 14. heat density map of the city of Mechelen (raster 100x100m) (source: Fluvius, 2017)



For reasons of data privacy, it might be the case that data has to be aggregated e.g. building block or statistical sector level.

Heat density maps (e.g. Figure 14 and Figure 15) in particular might be a valuable tool to provide information about the potential for district heating (from a demand-side perspective). As a rule of thumb, heat networks are theoretically feasible as of 2.5 – 3.0 MWh/lm.

Valuable resources in this regard are the national and regional databases developed under the framework of the European research projects TABULA and EPISCOPE[6] , which categorised residential typologies of residences (both individual and collective), depending on the year of construction, the type (e.g. detached house, terraced house, apartment building) and the thermal insulation level.

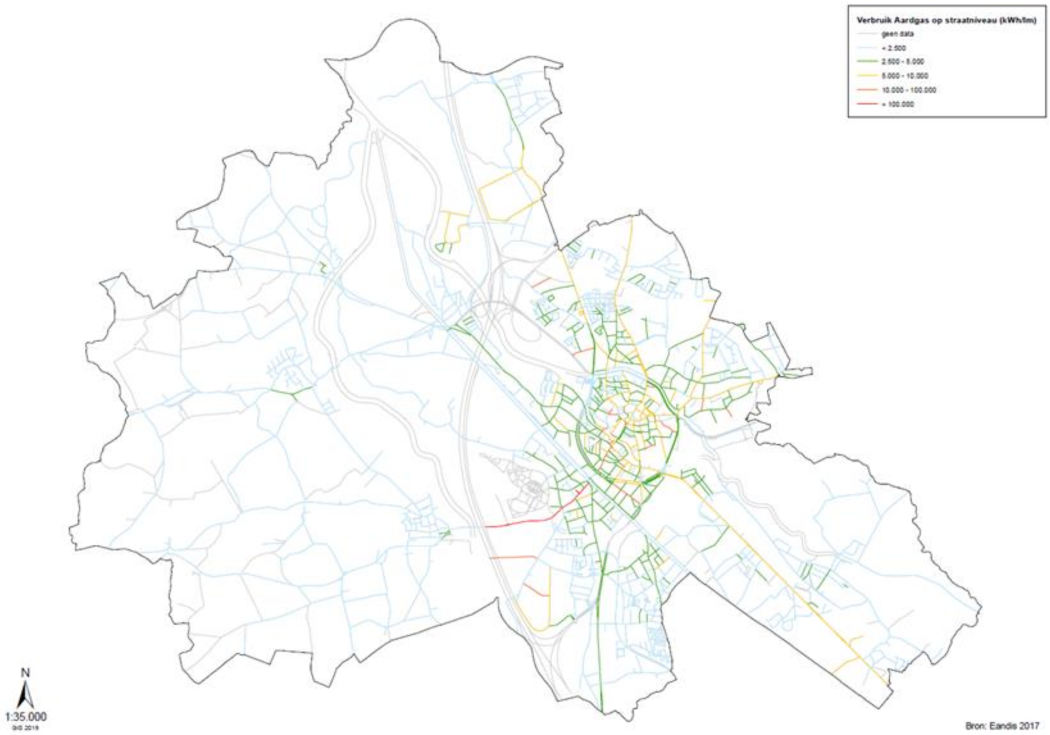


Figure 15. Linear heat density per street map of the city of Mechelen (source: Fluvius, 2017)

Figure 15 shows an example of a linear heat density assessment per street of the city of Mechelen. Heat networks are theoretically feasible (from a demand-side perspective) when streets are coloured green, yellow or red.

Mapping heating supply

The transition to a sustainable built environment requires making better use of local and regional potentials. This is especially the case when considering heating and cooling, because as mentioned before, these are difficult to transport economically over greater distances.

Because of the highly varying nature of the energy categories involved, input data can come from many sources, and is increasingly publicly available. The projects mentioned further down this chapter streamline the process of converting this data into useful maps for making heat zoning plans.

The concept of the energy atlas has taken great flight over the years. A global example is IRENA[7], the International Renewable Energy Agency, which provides global atlas on a few common renewable resources like sun, wind and surface waters. At the national level, the Dutch government is building

[6] https://episcope.eu/
[7] https://www.irena.org/globalatlas

the Nationale Energie Atlas[8] together with many partners, which combines a large number of formerly separate data sources relevant to the energy transition. At the local level, the City of Amsterdam provides a number of energy related maps[9] (one example being Figure 15) for viewing and downloading (under the 'sustainability' category). Similar initiatives can be found in other regions and countries of the 2 Seas area. In the case of Flanders (Belgium) the Environmental Department of the Flemish government has developed the "Hernieuwbare Energie Atlas"[10][11], which is available for all Flemish cities and municipalities. In the UK, there is a web-based heat map for London that can help developers, local councils, energy companies and others assess the heat demand and the potential for heat networks[12]. There is also a heat map available covering the whole of Scotland[13].

Energy atlases can also include heat zoning plans (see also section 4.5.5 on Steering and envisioning) which have processed this technical information further by including economic, societal and political factors.

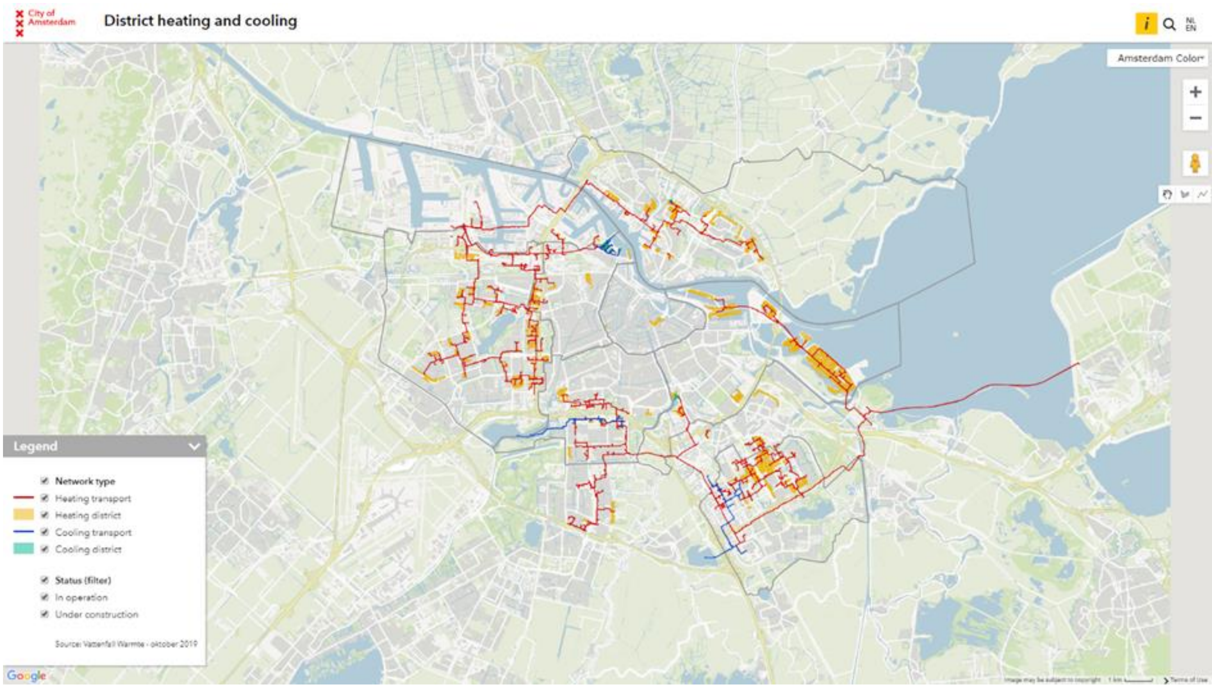


Figure 16. DHC network map (source: maps.amsterdam.nl)

Transparency of the underlying calculation methods is highly important for energy potential maps. If assumptions are made that could change within a few years (particularly due to changes in financing, and to a lesser extent technological developments), maps that are generated in a black box environment will lose their value completely, whereas for maps with documented calculation steps, these could simply be tweaked and run again.

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8 https://www.nationaleenergieatlas.nl/
9 https://maps.amsterdam.nl/?LANG=en
10 http://www.burgemeestersconvenant.be/hernieuwbare-energieatlas
11 http://www.geopunt.be
12 https://maps.london.gov.uk/heatmap
13 http://heatmap.scotland.gov.uk/

An example of this are solar atlases, which are sometimes sold commercially and provide a suitability rating and preliminary financial overview. Without maintenance, these reach obsolescence fast however, and may not be entirely correct in the first place if they do not take into account local financial incentives and other circumstances.

Generating the technical and financial maps separately would help in this case, for example *'solar thermal technical potential'*, *'PV and thermal financial suitability for home owners'*, and *'solar thermal network financial suitability'*, however, even when structured like this, black boxes should be avoided.

4.3.2. CELSIUS toolbox

The FP7 funded CELSIUS project (celsiuscity.eu, 2012-2017) aimed to cover the transition to residual and renewable heating and cooling in the built environment as broadly as possible, and revolved around five partner cities (Gothenburg, London, Rotterdam, Cologne and Genoa), their demonstrators (near market Heating Cooling technologies) and knowledge partners (like TU Delft), with the intent to comprehensively increase the impact of these technologies within the European Union.

Around twenty large scale demonstrators were built, monitored and used in experiments. Examples of these are the Heat Hub in Rotterdam (an 8.000 m^3, 185 MWh heat store located in the demand area rather than next to the production facility), demand side management in Gothenburg (reducing peak demand by using buildings as heat batteries) and subway ventilation heat recovery in the London Borough of Islington.

CELSIUS has produced an extensive online knowledgebase called the 'toolbox', which combines the collective results of the research project, from a technical and economic perspective, and includes a vast array of useful information that helps implement these technologies. The toolbox can be found at http://www.celsiuscity.eu/toolbox/ and is kept up to date by the CELSIUS 2.0 initiative.

4.3.3. PLANHEAT toolkit

Another very practical research result is that of the Horizon 2020 funded PLANHEAT project (PLANHEAT.eu, 2016-2020). In PLANHEAT, a QGIS-based software toolkit was developed that guides the user through all stages of developing heating and cooling plans for an urban area. The toolkit consists of three elements:

- Mapping module.
- Planning module.
- Simulation module.

At the basis is the mapping module, which effectively applies EPM to an area of choice, mapping demand, reduction potential and residual and renewable supply opportunities.

In the planning module, scenarios can be defined based on this information, and includes defining refurbishment levels for buildings and areas, selecting sources and temperature levels and if networks are required, route optimisation.

When the user clicks 'run', the simulation module then runs the defined scenario through a reference year to determine the impact (for example CO_2 exhaust, number of working hours per source, storage charge and discharge etc) compared to the baseline. Because the modules build upon one another, many different scenarios can be run and compared without having to repeat the initial mapping process.

4.3.4. HoTMAPS toolbox

The Horizon 2020 funded open source toolbox HoTMAPS (HoTMAPS-project.eu, 2017-2020) helps local authorities and city planners to develop H&C strategies. The toolbox provides models and default data that enables the user to identify, analyse, model and map H&C resources and solutions.

The toolbox allows the users to:

- Map the current heating and cooling demands and supplies;
- Mapping the potential of local heat sources for large scale heat pumps for H&C;
- Mapping local renewable energy sources (biomass, solar thermal etc.);
- Mapping industrial waste heat potentials;
- Define the potential for district heating options;
- Compare the costs of individual heating systems vs district heating options;
- Develop decarbonisation pathways for heating and cooling; CO2-reduction potentials, share of local energy sources.

4.3.5. THERMOS tool

The Horizon 2020 funded THERMOS (Thermal Energy Resource Modelling and Optimisation System) software (THERMOS-project.eu, 2017-2020) is developed to accelerate the planning process of a district heat network and to make it more efficient and cost effective. Allowing the user to identify the options for DHC-networks in their project area by developing thermal energy system models and optimisations.

This tool is useful for local authorities and energy planners and can be applied to city and district scale. The three main functionalities are:

- Mapping the current heat demand;
- Feasibility assessments of district heat networks;
- Optimization of heat supply.

The THERMOS software works with high-resolution spatial information. The user can override this data with site-specific data related to financial, energy and climate change circumstances. With this tool THERMOS aims to speed-up the energy transition by the development of low-carbon heating and cooling systems within Europe.

4.4. Citizen and stakeholder engagement in the heat transition

Energy, climate, or environmental officials easily slip into the roles of stressing advantages and ‘selling’ environmental change (Horsbøl, 2018). Many citizens react critically to this or become suspicious due to the resemblance of advertising practices or unwelcome paternalistic behaviour. Public officials can quickly find themselves defining what is important for the citizen (for instance, a job, housing comfort, etc.) instead of taking a step back and letting citizens define what is important to them (Horsbøl, 2018).

A thorough stakeholder analysis and engagement belongs to the basics of any public involvement in the energy transition. The social side of the transition to sustainable heating and gas-free living is however complex and not linear. This results in a new tension between project management and an orientation towards clear objectives, milestones, and follow-ups on the one hand with the iterative and reflexive behaviour of stakeholders and citizens on the other. A second inevitable tension exists between the principle that a broad range of affected and interested parties should be included and the reality that intensive deliberations on complex issues require thorough preparation, time, commitment, and inclusion, which not everyone is capable or willing to provide. There is evidence that, even when sustainable heating technologies are voluntarily installed in homes by the occupants, they do not necessarily replace previous fossil fuel heating, but complement them, leading to systems installed that are far from optimal. These would not be predicted or expected by technical experts but show how crucial engagement is for effective heat transitions, even when dealing with willing volunteers, before, during, and after installation phases. In order to avoid that citizens and stakeholder engagement is followed by intuition rather than using a sound methodical approach, we offer a few essential guidelines. And yet, these guidelines are written as recommendations. They are certain to need adaptation to local cultures and contexts.

4.4.1. Discovering objectives and co-benefits

Public engagement means addressing matters that are already emerging within a community. A community is unlikely to be motivated to engage in a project which doesn't come from the community itself. Citizens become involved in working together with the municipality for different reasons. For example, someone who is about to buy an apartment and is concerned that in a few years' time the expensive heating system will need replacing may be seeking clarity on sustainable heating. Another person, who loves cooking with gas, might be reluctant to give up on this known technology.

Before conducting a citizens´ and stakeholder engagement at neighbourhood level or in the built environment, it is crucial to ask whether the transition to sustainable heating can:

- create recreational open space?
- upgrade neglected neighbourhoods?
- increase housing comfort?
- reduce energy bills?
- stimulate business development or job creation?

It can even go so far as the case of Bruges where a well-known local brewery is considering participating in setting up a district heating system and contributing the excess heat created in the brewing process. The brewery needs to channel the excess heat outside the residential area as it would overheat the groundwater in the immediate area. Imagine if you knew that drinking beer from your local brewery will heat your home?

4.4.2. Stakeholder identification

Deciding which groups, or which representatives, need to be engaged is a sensitive matter and conveys a decision that should be made collectively. There are different strategies for this but, ultimately, it should serve the objective of inclusiveness. This, in principle, simply means that everyone who is affected by the issues and the outcome of a decision should have the right to participate or to be represented in that process. No one should be prevented from exercising these rights (Susskind and Cruikshank, 2006).

One of the best ways of identifying all relevant stakeholders is to start by identifying key internal colleagues within your organisation (Carbon Trust, 2018). Internal stakeholders represent those within the organisation that might have important knowledge or authority over certain domains or policies that touch upon sustainable heating, fossil-free living, urban design, and co-creation. Examples of this could be colleagues from departments such as:

- Energy and environment;
- Sustainability and circularity;
- Building;
- Social affairs;
- Finance;
- Housing;
- Health;
- ICT and digital city;
- Planning;
- Economic development;
- Democratisation.

These colleagues might be helpful in drawing a first map of who needs to be invited. It is also crucial to keep them in the loop about the process as, without their consent, you might run into blockages, mostly at a later stage, within your organisation.

Outside your organisation there are many stakeholder groups that can be included, especially considering the heating transition at the city district and neighbourhood level. Table 5 lists some stakeholders that can be considered.

Stakeholders are groups who have made it clear that they are affected by the issue, and/or have a stake in the outcome either by being affected or having a serious interest. They may have the power to block or delay a decision, they may have a certain expertise, they may own infrastructure or land, or they may be simply too important to be left out. Certain stakeholders may be highly affected by a project or a policy even though they don’t show a high level of interest. Thus, it is important to differentiate between pure interest and the extent to which stakeholders are affected by certain outcomes.

Table 5. A summary of some of the stakeholders who may be involved in the transition to sustainable heat

<table>
<tr><th>Demand side</th><th>Supply-side</th><th>Regulatory institutions</th></tr>
<tr><td rowspan="3">• Landlords
• Tenants of privately owned properties
• Project developers
• Housing associations or cooperatives
• Tenants of social housing or cooperatives
• Social housing agencies
• Private homeowners
• Local businesses
• Public sector buildings
• Industry buildings
• Condominium associations (associations of homeowners in multi-storey buildings)</td><td rowspan="3">• Energy providers
• Heat sources (including businesses who produce excess heat)
• Energy utilities
• Local community energy collectives generating energy of their own
• Contractors
• Prosumers
• Construction companies (contractors, subcontractors)
• Technology solution providers
• Architects
• Installers
• Electricians
• Plumbers</td><td>• Distribution system operator
• Public agencies (planning, procurement, environmental protection, etc.)
• European regulations</td></tr>
<tr><th>Investment, trading sector</th></tr>
<tr><td>• Property / real estate owners
• Investors (like pension funds, banks)
• Energy data-base or platforms
• Energy brokers</td></tr>
<tr><th colspan="3">Intermediary organisations</th></tr>
<tr><td>• Cultural institutions
• Energy poverty groups
• Tenant ambassadors
• Consultancy agencies and engineering companies
• Knowledge institutes
• Process managers</td><td>• Local politicians
• Local NGOs
• Local media
• Local influencers
• Neighbourhood cooperatives
• Neighbourhood managers</td><td>• Governmental organisation delivering intermediary services
• Citizen initiatives (including community energy collectives)
• Energy balancing managers</td></tr>
</table>

4.4.3. Sustainable heating technologies and stakeholder selection

Selecting stakeholders to work with relates to the type of sustainable heating technology chosen**.** Table 6 provide an overview of alternative heating solutions for the built environment and suggest how citizens and stakeholder engagement might take shape depending on the technology, respectively depending individual and collective heat systems (district heat networks) – see also Figure 10. Table 6 also gives an overview of different sustainable heating solutions and how citizens and stakeholder engagement differs in terms of the scope and site, the actors involved, and potential implications.

Table 6. Overview of sustainable heating solutions and citizens and stakeholder engagement

Technology	Scope and site	Actors	Implications
Individual solutions (Home and building owners)			
• Heat pumps • Solar thermal • (Geothermal) • Biogas, biomass • Insulation	• Co-initiating thematic workshops on how co-benefits can be realised through individual solutions • Co-researching homeowner preferences • Co-creating a local platform on opportunities and learning experiences • Co-designing customer journeys • Co-creating the communication on the difference between a heat price and a gas price • Co-creating demand side management for electric solutions • Collective procurement	• Private homeowners • Local businesses • Local media • Local influencers • Neighbourhood cooperatives • Energy communities • Prosumers • Construction companies (contractors, subcontractors) • Architects • Installers • Electricians • Plumbers	• Increasing trust in novel technical solution • Voluntarily installed sustainable heating technologies, do not necessarily replace previous fossil fuel systems, but complement them, leading to systems that are far from optimal • Raising comfort level, health, and well-being, reducing prices are important considerations but there is no clear knowledge over each individual households' preferences • Unclear knowledge over which households are in the process of buying or renovating a home
• Individual storage • Electric or pump solutions	• Co-research for storage opportunities • Co-testing individual storage applications	• Similar actors to above	• It is not yet clear which storage technologies will prevail and become affordable
Shared solutions (Owners and tenants)			
• Heat pumps • Solar thermal • (Geothermal) • Biogas, biomass • Insulation	• Co-writing feasibility studies • Co-designing combination of solutions • Co-implementing user guidelines and	• Investors • Developers • Housing associations • Housing contractors • Tenants	• Complex models of actors and aligning their interests • Trust in novel technical solution • Voluntarily installed

Technology	Scope and site	Actors	Implications
	maintenance strategies • Co-creating a local platform on opportunities and experiences • Collective data collection • Collective procurement	• Management firms • Energy communities	sustainable heating technologies, do not necessarily replace previous fossil fuel systems, but complement them, leading to systems that are far from optimal • Creating diverse and inclusive engagement of homeowners and tenants
• Shared storage • Electric or pump solutions	• Co-research for storage opportunities • Co-testing shared storage solutions	• Similar actors to above	• It is not yet clear which storage technologies will prevail and become affordable
Collective solutions (Urban, district, or neighbourhood)			
• District heating networks • District heating network with PVT and seasonal storage • Sewage water exchanger • Mini district heat network with individual heat pump • High temperature district heat network with solar collectors and storage • Biomass in district heat network • District heat network on industrial waste heat • Mid-temperature district heat network on residual waste heat	• Co-writing feasibility studies and action plans • Co-initiating thematic workshops on how co-benefits can be realised through collective solutions • Co-initiation Living Labs • Collective deliberation on preferred scope, scale, and sources of district heating network • Co-designing customer journeys for switching to a DH system • Co-designing communication campaign towards large and small customers	• Distribution system operator • Public agencies • European regulations • Energy providers • Businesses who produce excess heat • Energy utilities • Local community energy collectives - Construction companies (contractors, subcontractors) • Local politicians • Local media • Local influencers • Neighbourhood managers	• Network route is passing properties • Experience of disruption and nuisance • Ensuring connectivity to households • Willingness to pay for connection is unclear • Freedom of choice is reduced if there is mandatory connection requirement • Energy source or facility might be popular or unpopular locally

Technology	Scope and site	Actors	Implications
• Power-to-Heat in a district heat network		• Energy balancing managers	
• Collective storage • Heat hub • Borehole thermal energy storage • Aquifer thermal energy storage • High temperature seasonal thermal energy storage in underground closed systems • High temperature storage in the ground	• Co-research for storage opportunities • Co-design of storage facilities • Deciding on preferences	• Similar actors than above	• It is not yet clear which collective storage technologies will prevail and become affordable • Dense areas, technological and geological constraints will reduce available alternatives

4.4.4. Stakeholder drivers and barriers

One of the pivotal steps is to understand, from every stakeholder, whether they are from within your organisation or external, what their main drivers and barriers are that might lead to engagement, resistance, or ignorance of the policy, the project, or issue at stake.

Exploring and aligning interests and motivations

The interests and motivations of the stakeholders might not align in the first place. The following questions will help to gaining insights into the distinct drivers and barriers of the various stakeholders.

- What are the stakeholders' interests in the project and in collaboration? E.g. do they have interests in claims, positions, public resources, and technology or do they have financial–economic motives?
- What private or public values do they adhere to? And are these short-term or long-term interests with a public or private sector character?
- What would be a good co-creation result in one-, three-, or five-years' time? An improved quality of knowledge, a higher amount of CO_2 reduced, more and more diverse citizens reached, better incorporation of citizen's needs into policy, higher satisfaction among citizens, a higher acceptance and adoption of renewable heating technology, managing resources more efficiently, integrating isolated and fragmented low carbon heating systems into a larger network, etc.?

Spokesperson authority

It is crucial that stakeholder representatives involved in participatory processes have sufficient authority to make commitments on behalf of their organisation. Without this authority there is the risk that a solution or compromise obtained through co-creation may not reflect the interests of the represented group and could easily be rejected by its members. Moreover, every party, whether private, public, non-governmental or citizen-based comes with a set of constraints born out of its own identity, organisational structure, or internal politics. Stakeholder representatives need to be in constant communication with their members to ensure they are working within the constraints of their organisation, are reporting ongoing developments and can adjust preferences during the process.

Extent of stakeholder influence

Some actors have decision-making power while others have the power to block decisions. Yet others may make use of formal objections and exert informal power through social media campaigns, online petitions, or protest movements. An often-neglected point is that effective sustainable heating initiatives require on-the-ground knowledge and sustained community support for implementation and long-term operations and maintenance. Hence, it is important to determine the amount of influence citizens and actors exert over certain parts of the project.

Intermediary organisations and networks

Many stakeholders will not only be engaged more effectively through a third party whom they already know and trust, but a third party might also be able to better translate or connect to their needs and interests. If the adoption, maintenance and trust in new heating technology is to be encouraged, intermediary organisations will play an important role in reaching out, encouraging and involving citizens since decisions that are made in heat consumption are largely a matter of personal and private interests.

4.4.5. Managing co-creation: Investing time, energy, and resources

A thorough assessment of the necessary time, energy, and resources that citizens and stakeholder engagement requires can support the municipality as well as stakeholders in making informed decisions about whether they are realistically prepared. An assessment like this includes aspects such as:

- What kind of feasible procedures within the organisation need to be set up?
- What kind of infrastructure is needed to communicate with citizens?

In the early stages of citizens and stakeholder engagement, it is key to balance flexibility and practicality of the process against the increase in complexity and sensitive issues. Therefore, it is very important to support these processes with experienced process and communication management, which can be a collaborative task. A lack of prior preparation causes missteps, which not only affects the motivation and intention of relevant parties and stakeholders to participate but also contributes to failure. Experience has shown that the preparation and the broad involvement of stakeholders in the groundwork are crucial for its success. If all the interests of the stakeholders are recorded it is easier to integrate those interests into co-beneficial solutions and it frees stakeholders from competing for attention. It also opens the possibility of engaging in active listening and solution finding.

Supporting citizens

Getting the communication departments on board is a must. Not only are they familiar with which language to use with citizens, they may also have internal expertise, tools, and contacts that will come in handy during the process. For example:

- they could help in setting up an operative engagement plan together;
- advise on when to use mailing lists;
- when to use social media or when to use a good old letter.

They might also be knowledgeable in:

- avoiding stakeholder fatigue or;
- preventing over- or under-frequent communication.

Some municipalities and organisations have dedicated stakeholder or citizen engagement departments, which could probably take over some of the responsibilities in initiating and managing a citizens and stakeholder engagement process in sustainable heating.

If not, it is advised to set up a periodical task force that combines different skills, makes use of existing contacts, resources, and established communication channels within your organisation. This is to make sure there are the necessary capacities to manage and process communication, which will naturally be a two-way process, not just information from the municipality to another stakeholder. Communication needs to be responsive and have a clear purpose. Engagement must be thought through and well organised, and the relevant data stored and properly analysed. Long gaps in communication should be avoided or explained.

Using external support

If you conclude that you might need external support, make sure facilitators or consultants meet the following criteria:

- they should be impartial;
- possess process management skills;
- have excellent listening skills;
- must understand and be able to explain complex issues;
- display patience and creativity;
- be persuasive;
- have experience and legal expertise with the issue.

However, bear in mind that if an external party is leading the stakeholder engagement you might lose authenticity, knowledge, direct stakeholder relationships, or raise suspicion. This can lead to a disconnect between the stakeholder and the ongoing process.

4.4.6. Embedding citizen and stakeholder involvement in ongoing planning or formal decision-making processes

Along with this question comes the paradox that participation and dialogue processes can still be detached from current decision-making even though that might not be initially intended. In the beginning, the intention is that involving citizens and stakeholders takes place in close proximity to decision-making processes and has a significant influence on decision-making. In reality, however, many citizen involvement processes set off a participation biotope with scope for creative ideas but very limited intersect with political decision-making. Beware that, despite good intentions and competences, citizen and stakeholder engagement may be completely disconnected from political activity, as if it is happening in a parallel world.

Embedding collaborative heating systems adaptation in an ongoing planning or formal decision-making process can reduce disruption and cost. For example, new infrastructure might be better installed as part of a broader neighbourhood development or reconstruction project rather than as a standalone project, thus minimising nuisance to citizens living close to construction sites.

Furthermore, it may contribute to achieving multiple goals (e.g. installing district heating infrastructure to support lowering the carbon footprint in a given neighbourhood while at the same time contributing to becoming more resilient to extreme weather events). This will also contribute substantially to the cost-effectiveness of construction activities by reducing the risk of unexpected consequences, foot-dragging, or resistance.

4.4.7. Inviting stakeholders and citizens

Having identified the most obvious stakeholders, a small group of these stakeholders should be contacted and informed early on that the municipality (or other organisation) seeks to initiate a process toward to sustainable heating. These pre-identified stakeholders should be asked if they would be interested in engaging in such a process and to specify who, in their eyes, seems to be a further relevant or affected party that should be represented in the systems or the decision-making level of the heat transition. To reduce the risk of excluding non-visible groups, the municipality or an external facilitator can also actively decide to include groups that are typically underrepresented, or hard to mobilise.

When you try to involve citizens and stakeholders, this can be a small or large group. It should however be an inclusive group and a reasonably representative sample. The sample is based on the critical mass needed for transition, i.e. not the 10% most advanced in sustainability or the 10% most reluctant, or the 10% who may not care about anything but the 60–65% of remaining middle group.

To activate those middle groups, make use first of existing contacts, resources, and established communication channels within your organisation. Are there citizen panels, ambassadors, neighbourhood committees? Are there other project partners or intermediary organisations already involved that can co-invite? Make use of established contact points such as direct mailing, social media, apps, or office branches. The earlier stakeholder identification process should yield clear information on:

- where the different subgroups of stakeholders can be found;
- through which channels, platforms, intermediaries or previous contacts they might be best approached;
- which type and complexity of language they use and;
- which incentives or triggers they need to engage.

The last point cannot be overstated.

To increase participation, use a catchy entry questions and communicate clearly about the transparency of the process and provide answers to what happens with the results.

It is not only pertinent to identify and activate less powerful and marginalised groups but also to organise the citizens and stakeholder processes in such a way that allows these groups to participate in a meaningful way. Thus, provide low entry barriers:

- Design and use language as close to the private sphere as possible;
- Combining on- and offline co-creation spaces;

- Foster trust in individual competence/expertise to participate;
- Demonstrate the potential impact of participation;
- Enable the possibility of passing the invitation on to someone else;
- Offer incentives, e.g. compensate participants or provide them with a special experience.

4.4.8. Timing

As a baseline, the earlier the involvement with citizens and stakeholders starts, the more everyone will have the feeling of an equal partnership. A good indicator is to look into previous experiences with stakeholders and citizens and understand their opinion on the timing of their involvement. Another option is to find out if there is already an ongoing community initiative around sustainable heating or a third-party project that the municipality might get involved with. Timing also depends heavily on clarifying the stage at which stakeholders, citizens, and the municipality get engaged; determine if is this in co-initiating, co-designing, or co-implementing sustainable heating initiatives.

4.4.9. Best practices of citizens and stakeholder involvement in the sustainable heating transition

In the following section, we provide a state-of-the-art and good practices in sustainable heating with citizen and community energy involvement that involve case studies from different European (2 SEAs) countries, and countries outside the European Union. Denmark is the leading country on sustainable heat, which is why we start with three key inspirations from there.

4.4.10. Denmark as a guiding country

In Denmark, 65% of all homes are supplied with heat from a heat network. Consumer-owned district heating facilities (heat source, network, and supply) produce 36% of this heat. Of the 430 Danish heat networks, 360 are owned by residents through a cooperative. Specialised service companies are responsible for the development and operation of these heat networks.

Denmark has a long tradition of ‘doing things’ using cooperative formulas making use of three key approaches to stimulate households in existing gas-fired neighbourhoods to connect their homes to district heating (DH):

- A district heating package;
- An instrument to help customers save energy;
- The customer journey to persuade and unburden householders who switch their connection from the conventional gas grid to the DH system.

A district heating package

In order to begin and realise a project, 30% of homeowners (i.e. 30% of the heat demand) in each project have to accept a conversion to DH from natural gas, electricity, or oil. Therefore, each project starts with a marketing period. A measure that is used to achieve the 30% is the Pakkeløsning – a conversion package for the home-owner. The Pakkeløsning is:

- A home visit and an agreement of where the DH unit is going to be;
- Establishing a heat service line to the consumer’s house and a restoration of the garden;
- Removing the consumer’s existing heating source;
- Delivering and installing a new DH unit.

Helping consumers with energy saving

In 2015, the energy saving committee in Hvidovre Fjernvarme decided to give DH consumers the opportunity to improve their energy efficiency and save money on their heating bill by offering them the FJR-ordning for free. The FJR-ordning is a survey of the consumer's heating installations every second year.

The first survey checks the DH unit and provides a thorough energy analysis of the house, that is, guidance of how the consumer can save energy in their house. At the end of the survey, the consumer receives an energy report for their house. In the report, the consumer can gain an impression of whether their heating consumption is below or above the average consumption and the report gives guidelines for what the consumer can do to optimise their energy efficiency. This type of check is repeated occasionally. Two years after the first check a maintenance check of the DH unit is performed.

The customer journey

The customer journey is a method used to evaluate DH projects. The main goal is to understand the process of getting DH from the customer's point of view in order to optimise the customer experience. The process of getting DH can be divided into four phases:

- Deciding (the customer decides whether to get DH or not);
- Going (the customer has decided to get DH);
- Doing (installation of DH in the customer's house);
- Using (the customer uses DH to heat the house).

Community energy action in sustainable heating transition

Working with community energy collectives[14] in sustainable heating projects offers certain benefits over working with conventional parties only. There are several reasons that these specific groups are better positioned to accelerate sustainable transitions than other energy service providers:

- Community energy members live in the neighbourhood itself, are familiar with local circumstances, and are recognised and familiar to the local community;
- Community groups have capacity and critical mass;
- They are embedded in the local, social network;
- They are involved in awareness raising and education activities;
- Particular social norms apply in energy communities that support pro-environmental behaviours;
- Trust;
- Tailoring energy production and services to local needs;
- They engage in collective action seeking to avoid commons tragedies from happening;
- They are keen to balance interests on social acceptance concerning the siting of renewable energy projects;
- They invest financial gains (from energy production) into actions and projects that benefit the local community;
- The scale level of collective district heating facilities is, in principle, within the reach and sphere of influence of a neighbourhood community energy cooperative;

[14] Energy cooperatives have several internationally agreed principles governing their operations. For more informaition visit REScoop.eu

- Managing and supporting planning and implementation processes (towards cooperation with municipalities, DSOs, etc).

4.4.11. The case of Meer Energie (Amsterdam, NL)

One of the first new heat cooperatives was created in Amsterdam in 2015: Meer Energie (More Energy). In 2015 the idea arose to use residual heat from the Equinix data centre for heating homes in Watergraafsmeer (around 5,000 households, the largest cooperative heat network project in existing buildings). The technical idea is that water goes to the neighbourhood via a (pipe) where a district heat pump raises the water to 70 degrees centigrade. It goes further into the neighbourhood via the heat network. The residents are keen to start their own energy company. A lot of work still needs to be done to reach the project goals, but a number of important steps have already been taken. In 2018, Meer Energie, Alliander DGO (manager of the heating network) and the Equinox data centre stated that they wanted to develop the network together in a declaration of intent. In July 2019, the Amsterdam city council approved the construction of the pipelines for the heating network in (city district) Middenmeer Noord. A big advantage in the project pertains the fact that the streets are already open for major maintenance (HIER Opgewekt. Lokale Energiemonitor 2019).

4.4.12. The case of Thermo Bello (Culemborg, NL)

Thermo Bello is a small-scale power-to-heat district heating (DH) system operator located in the district of Culemborg, drawing heat from a drinking water basin situated there. The heat is supplied to 210 households and around seven commercial buildings. EVA-Lanxmeer, the heating cooperative, is described as a very strong and well-knit community, with its people having been involved in several collaborative efforts to improve their local environment, for example, the citizens manage the greenery of the district on their own. The plans, when presented to the wider community, gained popular support leading to the formal opening of Thermo Bello in 2008. A distinct role was played by the Municipality of Culemborg who were receptive towards incorporating sustainable technologies and thereby facilitated the process. The overall process was however strongly community driven, with its members taking extra efforts to be inclusive, for example, the initiators drew up a ‘programme of requirements’ that made the business plan understandable to everyone in the community without getting bogged down by technical details. Surveys were frequently taken to gauge opinion of the local residents which improved transparency.

4.4.13. Lessons from local energy communities

Key conditions for promoting local energy community models and practices:

- There should be a clear political commitment either through binding policies or voluntary commitments in the framework of initiatives, for example, a Covenant of Mayors. Without motivation or direction from a political authority it is difficult for individual members of the community to step up to a leadership role.
- Energy communities are vulnerable to policy changes as seen in Germany where a key driving force behind the emergence of energy communities in Germany has been access to the country’s feed-in tariff (FIT). However, the reform of the renewable energy law in 2015 introduced bidding schemes which heavily disadvantaged small and local energy communities.
- Community project developers may also run into barriers related to permits and environmental impact assessments that they are not equipped to overcome.

- Communities can also face challenges in entering the energy market, gaining access to grids, and competing on a fair basis with energy utilities, where distribution system operators may not recognise a community energy structure as a supplier, or may prioritise energy from other resources.
- Cultural issues relating to common ownership of resources will also affect how quickly a community adapts to these set-ups. While Denmark, Germany, and the Netherlands have had a long history in cooperative ownership traditions many other countries are still in the process of uptake. Hence, collective energy solutions must be tailored, adapted, and communicated to the local culture.

Natural gas free neighbourhoods (Delft, NL)[15]

In the transition to natural gas free, municipalities and cities are expected by the national government to develop neighbourhood-level strategies for alternative sources of heat, such as an all-electric system, district heating, or hybrid systems.

The municipality of Delft has chosen to open up this discussion to its inhabitants by organising several information and discussion events on natural gas free neighbourhoods, in which citizen involvement in policy and project development was encouraged. In 2018, three information and discussion meetings were held with the goal to develop a document for the city council with starting points ('uitgangspunten' in Dutch) for the heat plan, which the city council has to establish in 2021. It specifically asked which actions should be taken when to make sure the municipality of Delft will have a heat plan adopted by the city council in 2021.

By providing these starting points residents could shape the document and indicate 'what they find important' in the formation of energy policy. The meetings took a stepwise approach:

1. In the first meeting, a general brainstorm session was held in which inhabitants could voice concerns and values they deemed important for the topic. Over a hundred ideas were collected.
2. The second meeting set to prioritise these concerns and reformulate them into several key topics.[16]
3. The last meeting presented a summary of common rules, focused on recognition (did participants recognise themselves in the summary?) and identifying relevant actions for establishing a heat plan.
4. Besides voicing values, concerns, and critiques these meetings had an additional effect. They created a sense of community around energy policy. In the third meeting it was suggested that a platform was created to share knowledge about the energy transition and the technological

[15] https://www.delft.nl/milieu/energie/aardgasvrije-wijken/denkt-u-mee

[16] Discussions were held around following key topics (amongst others): "The central government must only provide financial assistance to homeowners and entrepreneurs who are unable to make investments in gas-free living." "Natural gas-free, that's a step-by-step approach. The municipality must provide clarity and incentives in the short term." "Natural gas-free is not automatically sustainable, reliable and safe: it requires much more". "Knowledge is crucial and Delft has it like no other". "Transition to natural gas-free: own initiative or centrally managed? (bottom up or top down) - tension between regulation and rule-free". "Private initiatives must be stimulated and facilitated by the municipality and can take place at different levels of scale: district, neighbourhood or street level. The most important thing is that this is done jointly, in cooperation where possible."

options available to residents. This would be a new platform that distinguished itself in its open-ended character. Everybody was welcomed because they were living in the city of Delft, not because they already had a specific interest (e.g. in setting up an energy cooperative or making their household more sustainable). It was proposed to run a pilot test of the district approach. The participants agreed that it is all about when and how which district will become natural gas free.

Schools as neighbourhood energy embassies (Utrecht and Amsterdam, the Netherlands)[17]

Schools can play an important role in spurring energy transition at the neighbourhood level. There are several reasons for this:

1. School buildings can be used to install solar panels, heat pumps and so forth or adopt energy saving equipment and serve as (visible) landmarks in neighbourhoods: showcasing or even branding their ecological intentions.
2. Pupils can be educated about sustainability, 'environmental literacy', '21st-century skills', and conservation behaviour like energy saving. Pupils also indirectly influence their social environments and may enthuse their parents to engage in environmentally friendly behaviours.
3. Schools can be seen as social hubs in neighbourhoods as many neighbourhood residents have children at school and meet each other in walk in-events at school.

The Dutch project: "Schools as energy embassies in neighbourhoods (SEE)" was implemented over a two-year period (2017–2019) with eight Living Labs in Utrecht and Amsterdam. Each of these Living Labs consisted of one school and a network of stakeholders connected to the school or neighbourhood. This included representatives from local government, housing association, distribution system operator, neighbourhood corporation, community energy collective, energy service company, and local entrepreneurs. Stakeholder interviews followed by a set of co-creation workshops were carried out. Ultimately, Seventeen new initiatives were generated, including energy renovation of school buildings, generation of innovative new smart and renewable energy projects, new energy services and awareness campaigns, and initiatives that addressed other pressing needs in neighbourhoods like a litter reduction campaign and the installation of smart waste bins. Other positive effects of the programme pertained to schools adopting sustainable education curricula and teaching methods, increased environmental awareness in pupils, and intention vis-à-vis sustainable heating and other sustainable development topics. The SEE used a participative inquiry action research method.

Figure 17 illustrates how it works in practice and breaks it down in two parts: addressing school pupil action and addressing local stakeholder action. The figure also reveals that multiple action research methods were used, including stakeholder interviews, photo voicing, village mapping, visualisation, focus groups, and follow-up supportive actions.

[17] https://projecten.topsectorenergie.nl/projecten/scholen-als-energieambassade-in-de-wijk-actieonderzoek-naar-de-rol-van-scholen-in-de-energietransit-00029194 and https://www.energie-u.nl/wp-content/uploads/2019/12/STT-Actieonderzoek_slotbrochure_nov19.pdf

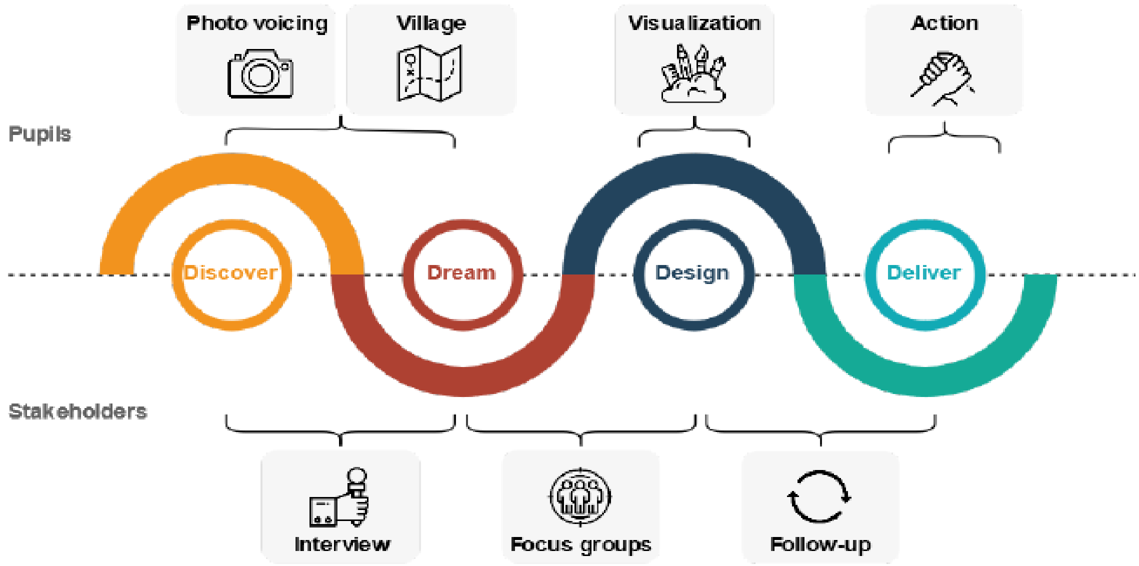

Figure 17. The Participatory Action Research (Eelderink, 2020)

Neighbourhood engines ('Wijkmotor' Kempen region, BE)

In two neighbourhoods with high (cultural) heritage value, the Centre for Architecture, Urbanity and Landscape in the Kempen region (AR-TUR) set up a Living Lab to generate knowledge on how to sustainably renovate homes: Egelsvennen in Mol en de Parkwijk Turnhout.

The neighbourhood engine is a model that can be used to convert neighbourhood capital in the form of people, tools, and resources into added value for the neighbourhood. This added value can manifest economically and socially, and it also results in better environmental quality and greater comfort for the homes in the neighbourhood. The neighbourhood engine involves five steps:

1. Co-initiate: A neighbourhood collective is formed, a neighbourhood director is appointed, and expertise is involved;
2. Co-sensing: Challenges and opportunities are identified, and ambitions are set;
3. Co-creation: A joint vision and process are co-designed;
4. Prototyping: Sub-projects are carried out;
5. Co-evolve: Quality monitoring, evaluating, and adjusting governance incentives are used.

In September 2018, the project started with a neighbourhood exploration involving stakeholders and experts. This was followed with a workshop in which neighbourhood qualities and challenges were identified. This resulted in developing several studies, including resident narratives, neighbourhood photography, and neighbourhood design research. This was performed in the winter of 2018–2019. Based on the results several neighbourhood scenarios, that were discussed during a scenario workshop in April 2019, were developed. To inspire residents, informative talks were given on how to renovate neighbourhoods. Multiple good practice examples were presented and discussed with residents and stakeholders in May 2019. Because the two neighbourhoods included social housing and tenants as occupants an approach had to be developed for engaging with private homeowners. To accommodate this group a workshop was organised in July 2019 to address how homeowners could get involved collectively in neighbourhood renovation processes. A major output of the project was a renovation project toolbox, including neighbourhood renovation concepts[18].

Figure 18. The neighbourhood engine. From neighbourhood capital (people, resources, instruments) to neighbourhood profit (social, economic, technological, and comfort)[19]

The process resulted in a working model with recommendations that offer starting points for a future-oriented approach. Figure 18 illustrates a model for a neighbourhood engine.

4.4.14. Co-writing a narrative for a sustainable heating transition

People often see the stories of heroes and villains, even where there are tables, codes and graphs. Successful narratives in sustainable transitions, are not easy to co-create. Instead of everyday stories, we revert to old narratives, and polarizing the phasing out of gas and oil based systems.

The Leuven roadmap for climate neutrality, which is a great but everyday example of storytelling, started its first chapters in 2011, when the then mayor officially declared to make the city climate-neutral. A scientific report that was completed in 2013 included a list of possible and necessary measures: an overview of possible scenarios for achieving a climate-neutral city by 2050. This scientific basis led to the birth of a wider co-creation and narrative writing process, when 60 founding members, including residents, companies, knowledge institutions and (semi-)public authorities, jointly founded the urban non-profit association Leuven 2030. The non-profit organisation has grown considerably in the meantime to more than 500 members. The Roadmap 2025 - 2035 - 2050, drawn up by Leuven 2030 in 2019 and numerous experts, serves not only as a guideline for achieving the goal of a climate-

[18] Wijkmotor is een concept van AR-TUR, ontwikkeld in Kempenlab Wijkrenovatie 2019.
[19] *Source: https://arturarchitectuurcentrum.files.wordpress.com/2019/11/ar-tur-cahier-9-web-spread.pdf*

neutral city by 2050, but also a narrative from 'doing what you can' to 'doing what you have to do' to co-create a systemic change in the city, the build environment and in local communities[20]. In September 2019 a professional team of program managers started to translate this roadmap into further concrete action and impact.

In writing a common narrative, balanced messages communicate both advantages and disadvantages of the sustainable heating transition are likely to be taken most seriously. In the spirit of: "The bus might not get you there as fast, but it is good for the environment", balanced messages acknowledge a disadvantage of taking the bus, as well as an advantage, with a slight humorous tone. Balancing is relevant because it enhances the credibility of the source and the message. This holds particularly true for communications from sources that should be objective, such as public agencies (de Vries, 2020)).

4.4.15. New roles and responsibilities

From being passive participants to active initiators, designers, and implementers, the sustainable heating transition implies changing roles for citizens through the increase in citizen agency and professionalisation. For example, running local heat and energy grids smoothly through communities, such as the local cooperative heat network of Thermo Bello in Culemborg, the Netherlands, needs a responsible operator that takes decisions on behalf of the whole community and in consent with municipal oversight. To take such decisions, the operator needs a certain degree of unilateral authority to control production and storage within the microgrid. This may require participants to give up some of their freedom to do things differently. Market and regulatory arrangements on the other hand need to be able to make provisions for local energy communities to receive remunerations for their provision of grid services.

At the same time, the sustainable heating transition implies new roles for public officials too, as brokers, area managers or advisers, using their competencies and their network in leveraging citizen initiatives, respectively offering public spaces and infrastructure to be used by citizens, social entrepreneurs, artists, and other actors of urban change. Recent attempts to explore these changing roles like the EU Interreg project "Co-creating Green Transitions" (2016–2018) involved municipalities from Sweden and Denmark dealing with different but similar problems related to energy transition. While the public officials prioritised "achieving environmental goals" over "citizen participation in the process" at the very beginning of the project, a reversal was observed at the end of the project where citizen participation was prioritised far more, as a means of gaining environmental.

The sustainable heating transition is a process that develops on a shared platform that is driven less by rules and more by initiatives taken by both parties (citizens and public authorities) to involve each other in ensuring better governance. Climate and energy considerations may be subordinate to comfort and a sense of home. People rather dislike it when a change in their daily routines and habits

[20] The roadmap states the following recommendations regarding the sustainable heat transition: "The biggest challenge is to renovate (or replace) existing buildings much more quickly. The reduction in the demand for heat must be as high as possible. However, the imbalance in passing on the costs of gas versus electricity, which makes heating on gas too cheap and hinders investments in insulation or more sustainable forms of heating." This points to a clear policy change. Other possible measures to accelerate the sustainable heating transition during renovations that are agreed upon in the roadmap: "Obligations to connect to collective heating systems such as heating network as well as an accelerated mandatory replacement of oil-fired boilers".

is dictated from the outside. 'Why should I change my daily routine? Just because Big Brother wants me to?' are frequent objections top-down demand side management. Consumers also fear that handing over control of climate issues in their home will lead to a loss of control over their entire home. This is strongly related to distrust against governmental intervention.

The process of co-creation will be rendered more efficient when the authorities themselves realise the importance of looking outside the bounds of legal role and professional expertise and leveraging citizen perspectives in order to create a joint understanding of problems and solutions.

In Delft (the Netherlands), the heat transition process brought about a new citizens' platform, which turned into an advocacy body that was very enthusiastic and offered to help in writing energy policy. This unforeseen role caused unease amongst public administrators. While they did not want to slow down the newly gained engagement of the platform, the public officials involved wanted to keep the co-creative and the political trajectories separate (Spruit, 2019).

To sum up, in dealing with changing roles and responsibilities, the key is to adopt a learning attitude where citizens, stakeholders, and government officials learn from each other. Therefore, perspective-taking during the heat transition helps to find the necessary balance between competition and cooperation, between self-interest and other-interest.

4.5. Building blocks for a local heating policy

4.5.1. Importance of a local heating policy and the role of a local authority

Considering that 72% of the European population lives in urban areas - defined as cities, towns and suburbs, cities play a key role in driving the sustainable heat transition, for a number of reasons:

- Renewable heating technologies typically have a local character or range, for instance ground-source heat pumps or district heating supplied by residual heat.
- The policy objectives of central governments (Europe, national, regional) have to be translated locally into concrete projects and achievements.
- Citizens have the most confidence in their local government. In this sense, local authorities are better suited to create local support and to strengthen the involvement of citizens and companies in the heat transition.

In other words, cities and municipalities have an important role to play and can influence whether or not the heat transition that we have to realize will succeed. This emphasizes the need for a local heat policy.

4.5.2. Role of local authorities in the heat transition

There is pressure from citizens in certain cities and municipalities to even go beyond the regional or (inter)national energy objectives. In recent years, the commitment and willingness to take action against climate change of many European local authorities has already become visible, as evidenced by the signing of the Covenant of Mayors and its translation into local climate plans[21].

[21] http://www.covenantofmayors.eu/

Position	Passive passenger	Traffic director	Active pilot
			
Role	Tolerating/permitting heat network project	Facilitating heat network and drawing the outlines	Setting up municipal heat network to realise heat network
Impact	Minimal impact on staffing and budget	Provide with staffing and financial resources	Major impact on extra staffing and extra resources
Risk	Blootstelling aan verdoken risico's	Risks made visible and primarily assigned to external parties	Almost all risks borne by local government
Focus	Granting access to public domain	Facilitating a feasible and broadly-supported project; anchoring agreements in law	Making its own heat company operational with own accents
Policy impact	Risk of fragmented and suboptimal local spatial and energy policy	Option to expand a coherent local spatial and energy policy	Need to expand a coherent local spatial and energy policy

Figure 19. Possible roles of local authorities for district heating projects (Source Kelvin Solutions 2017)

The local wish for an ambitious heat policy requires that these municipalities take up an active role (facilitator or director). They have a crucial role in raising awareness, mobilizing, unburdening and guiding the target groups with a view to investing in energy efficiency and environmentally friendly energy production. This creates initiatives that can serve as an example for other local authorities.

4.5.3. Challenges and opportunities for local authorities

Cities and municipalities have to take up a pioneering role in order to unlock the heat transition. However, they often lack support to implement it. Moreover, the extent to which a local government can implement a local heat policy depends on its governmental capacity, as there is a need for sufficient time and manpower to be able to play this supporting role in the implementation of the heat transition. In that sense, the policy options of local authorities can differ greatly. This demand for support or unburdening is widely supported by many local authorities.

Lack of data

To develop a strong local energy policy, local governments need detailed data on energy consumption and renewable energy production on the territory and within their own organization. Central governments and market actors need to provide cities with information on available renewable heating and cooling technologies and systems for all heating, cooling, and hot water needs (new and refurbished buildings, districts, industries), which will help to decarbonise cities. Most of the data openly available is on the supply side and the infrastructure for heat distribution and storage. However, on the demand side, including dwelling characteristics, end-user characteristics, and behaviour, little data is available and released as open data. Data with great potential, but not yet captured adequately, relate to (1) citizen preferences and attitudes towards the alternatives for natural gas and retrofit measures, and (2) the dwelling's structural state and the retrofit and thermal installation measures implemented (Diran *et al.*, 2020).

Lack of specific expertise and skills

There is a need for knowledge and specific expertise at the local government, requiring training of technicians, civil servants, and decision-makers from regional and local authorities, in order to provide the technical background necessary to approve and support renewable heating and cooling projects.

Interaction with other policy levels

Cities' efforts will only have the desired impact if they are complemented by compatible regulatory frameworks and favourable investment mechanisms established at the European and national levels. Therefore, regional, national, and European governments should define targets and provide clear direction to the local actors. Long-term climate and energy targets must then be translated into adequately ambitious mid- and short-term actions through policies that facilitate the energy transition.

However, innovation and new organizational structures also require regulations that can follow these evolutions and facilitate them and not slow them down. A lack of alignment between different policy domains can influence actions at the local level. For instance, spatial policy regulation that prevents the installation of solar PV panels on rooftops (in historic city centres). The policy framework must provide incentives for society to contribute to the heat transition through clear and coherent regulations, together with clear and transparent subsidies. Furthermore, the supporting and regulatory function of the regional level must be better connected with on-field practices. This makes it possible to maintain an efficient and adaptive policy that fully supports the energy transition. This requires multi-level governance, i.e. new cooperation and coordination between the national or regional level that coordinates and facilitates strategic transformations with knowledge and instruments and strengthened capacity at the local level.

Learning network

An increasing number of local heat transition projects are initiated in cities and municipalities. However, there is still no exchange of knowledge and experience between the actors here, and there is no coordination to ensure that the various pilot projects can learn from each other. Herein lies an important key to scaling up the ambitions from the existing progressive projects.

4.5.4. Policy instruments related to the heat transition

A successful local heating policy will require a carefully selected mix of policy instruments. Only providing financial incentives in the form of local grants or imposing obligations will not necessarily lead to the desired result.

In the following chapter, we have selected a number of policy measures in the field of sustainable heating that can support a local heating policy. It is a mix of conventional, existing instruments and policy tools, that are already commonly applied, and more innovative ones, that have showed promising results in particular cases. This selection of instruments and tools is composed based on literature review, best-practices and experience from the SHIFFT partnership. It is a non-exhaustive list, meant as an inspiration for cities and municipalities when composing their sustainable heating strategy.

Different kinds of policy instruments and tools are distinguished, depending on:

- the level of involvement and the relation between policy and society (Y-axis), and;
- the type of governance (X-axis).

This results in four classes of policy tools: (1) facilitating; (2) steering / direction setting; (3) regulating; and (4) stimulating. Furthermore, a local government can also (5) take action on its own, which can also be treated as a fifth class of policy tool or action: demonstrating.

See Figure 20. Overview of policy tools for local authorities related to sustainable heating (based on (Verheul et al, 2017)) for the overview of the selected policy instruments and tools. In the following chapter, they are discussed more in-depth.

Figure 20. Overview of policy tools for local authorities related to sustainable heating (based on (Verheul et al, 2017))

4.5.5. Steering and envisioning

Mapping the heating demand and supply potential of its territory (see section 4.3.1) can strongly contribute to developing support, interest, capacity and insight into its own heat situation within the city or municipality. The resulting heat maps or heat zoning plans are at least as informative and potentially mobilising – it is also an aid for heat users to plan investments in energy renovation.

Heat zoning plans

While energy potential maps give insight about the heating demand of the built environment and information on potential renewable or residual energy sources to supply heating, heat zoning plans match demand and supply and link the potential of sustainable heating technologies to certain neighbourhoods or district, taking into account the building stock characteristics of that specific neighbourhood or district.

Local heat zoning plans based on heat maps can be a key component for a local heat strategy. Local heat plans show in detail which sustainable heating technologies or solutions are techno-economically preferred in a certain district/part of a city or municipality. For instance, a heat zoning plan can indicate where heat networks (or equivalent alternatives) are to be placed in the future – 'mandatory zones', where heat networks are desirable if feasible (e.g. connection in later phase) – 'potential zones', and also where heat networks may not be installed – i.e. 'restriction zones'. In the latter individual heat solutions will need to be installed or all-electric heating systems must be encouraged.

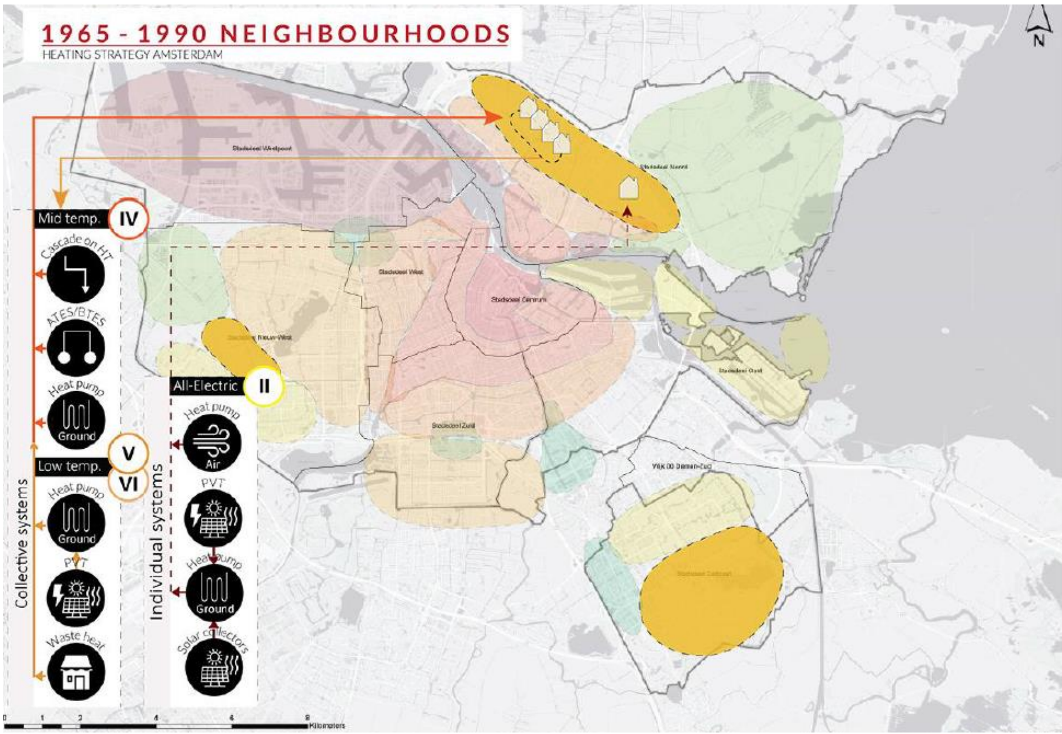

Figure 21. Heat zoning plan, illustrated for the city of Amsterdam (Source (Broersma S., et al, 2018))

The practice of composing heat zoning plans is rather new in the 2 Seas area. An exception is the Netherlands, which can be considered frontrunner in the field of heat zoning plans: All Dutch cities and municipalities have to submit a Transition Vision Heat by the end of 2021. The Dutch government have developed various instruments to support the cities and municipalities. This includes the "Start Analysis" (NL: Startanalyse). The Start Analysis could be interpreted as the Dutch version of heat zoning plans and is developed by the Netherlands Environmental Assessment Agency (PBL, Planbureau voor de Leefomgeving).

The Start Analysis is a technical-economic analysis based on national data, using the Vesta MAIS model[22]. This analysis provides a first idea of the technical-economic and environmental impact (such as national costs, energy demand, CO_2 emissions) at neighbourhood level for five sustainable heating alternatives (see Figure 22). Basic assumptions are made with regards to the energy performance of the buildings. More specifically, an energy performance improvement is assumed that corresponds with energy label B.

[22] The Vesta MAIS (Multi Actor Impact Simulation) model is a spatial energy simulation model which calculates energy consumption and CO_2 emissions of the built environment. https://www.pbl.nl/modellen/vesta

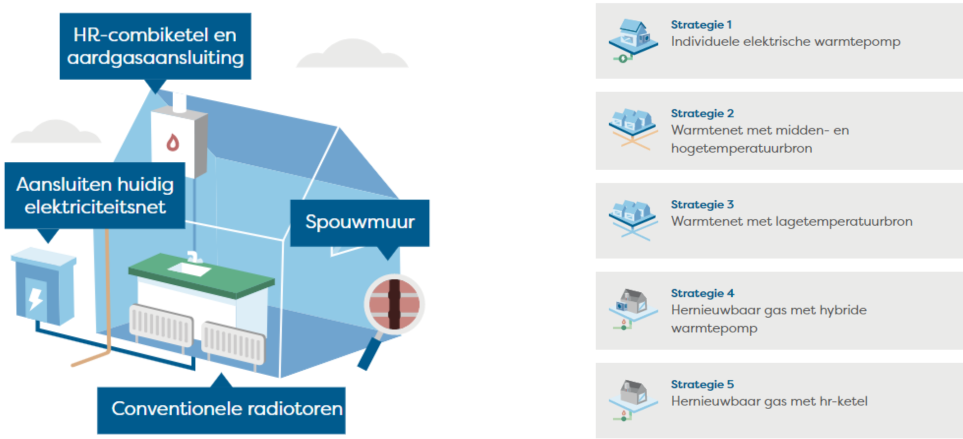

Figure 22. Start Analysis with default configuration for residential buildings (left) and the five sustainable heating alternatives (right) (Source: ECW, 2019)

4.5.6. Regulating

Legislation related to heating will most of the time be the result of regional and national policy. Nevertheless, local authorities do have the opportunity to complement it with additional legislation adapted to the local context. In this section, we discuss a couple of examples[23].

Building permit regulation: Quick scan or pre-feasibility check for sustainable heating

New construction projects or urban developments are in fact a window of opportunity to integrate sustainable heating in building or infrastructure projects. Project developers could be obliged to perform a quick scan (in Flanders, the term “Warmtetoets” or “Heat Test” is put forward in this regard). The aim of this quick scan is to gain insight in the feasibility of sustainable heating alternatives for the project, both on technology (e.g. heat pumps, solar thermal collectors…) and on the system level (e.g. CHP, district heating). The regional and national implementation of the Energy Performance of Buildings Directive (EBPD) – Article 6 provides the legal framework. A local authority can improve the applicability of this quick scan by linking it with local heat demand and/or supply maps or heat zoning plans (see section 4.5.5).

Building permit regulation: Urban planning ordnance on central boiler rooms

Collective buildings with multiple residential units and mixed functions may be attractive users for a heat network, due to their relatively high energy consumption for heating.

To avoid lock-ins, preventing future connections to district heating networks (due to the choice of individual gas boilers per apartment), the local authority can impose the obligation to provide a central boiler room for new constructions of medium to large-sized condominiums. As a legal instrument, the municipality can approve an urban planning ordinance for the whole territory. The obligation to provide collective boiler rooms usually applies for a minimum number of apartments, e.g. from ten or twenty.

[23] source: WNVL, 2018, guideline district heating for local authorities

Spatial planning requirements: Conditions in the Spatial Implementation Plan

When drawing up a Municipal Spatial Implementation Plan (GRUP), guidelines about a conditional connection obligation, a boiler room at ground level and/or reserved lanes for heat pipes can be useful:

- An obligation to connect to the heat network can be applied for buildings requiring a permit in certain zones. This is of course only possible on the condition that the installation of a heat network is planned and the developer/operator of this heat network can provide clear figures of expected costs and conditions.
- For individual residences, the spatial implementation plan can include the requirement that the boiler room is located on or close to ground level and is easily accessible from the public space e.g. on the street side).
- Reserved lanes in the public space facilitate the later installation of a heat network. The spatial implementation plan can require these lanes to be provided, including lanes for them to be connected to the buildings.
- If space is still needed in the technical design of the heat network for heat production and/or transfer stations, the spatial implementation plan can also require the developer to provide space for this.

4.5.7. Stimulating

Grant for energy efficiency or renewable energy measures

As is the case with regulatory policy instruments related to sustainable heating, financial incentives are more likely to be imposed from regional or national government. The ability to complement these with local grants or financial stimuli will very much depend on the government capacity of the local authority (and thus the corresponding financial resources).

Financial stimuli can be rather straightforward, such as additional financial support for sustainable heating technologies[24]. A particular case of additional support for an energy efficiency measure is a grant to connect to a district heating network in an existing single-family house or existing apartment building. Other possibilities can concern grants for technical expertise. The City of Antwerp offers residents of apartment buildings of at least twenty years old with at least twenty residential units a premium to conduct an “energy renovation masterplan”[25]. A similar service is offered to groups of single-family home-owners[26].

4.5.8. Facilitating

Energy cooperatives

For local authorities, citizen energy cooperatives have already proven to be a valuable partner in mobilizing financing and public support for local energy projects. The recent anchoring of energy communities in European legislation (I.e. the Revised Renewable Energy Directive; EU/2018/2001

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[24] For example: support for solar thermal systems for domestic hot water in the city of Antwerp https://www.antwerpen.be/nl/info/576d06b6dbae0175522b3c68/premie-voor-zonneboiler

[25] https://www.antwerpen.be/nl/info/577221477d610898327ed781/verbouwadvies-voor-appartementsgebouwen

[26] https://www.antwerpen.be/nl/info/5a7306792d2a3c74eb653ca9/premie-voor-renovatiebegeleiding

which entered into force in December 2018) offers opportunities to further promote these local dynamics, under the condition that it is implemented in national legislation.

Nevertheless, there is still potential to engage citizens in cooperative sustainable heating initiatives, as the majority of renewable energy cooperatives focus on solar or wind projects. For instance, in the Netherlands, out of 582 local energy cooperatives, a minority (but increasing number) of 54 initiatives is engaged in local heating projects in 2019[27], including only one actual heating network exploited by an energy cooperative: Thermo Bello in Culemborg. Another case of a cooperatively exploited district heating network, is the district heating network by Beauvent cvba in the Flemish City of Ostend[28].

Figure 23. official opening of "Heatnet Ostend" by energy cooperative Beauvent cvba, with residual heating from the waste incinerator plant IVOO (Source: Beauvent cvba)

Energy information centres

An energy information centre is a means to connect demand (homeowner) and supply (construction and installation sector). Energy information centres have been established in almost all municipalities in recent years. Sometimes that is a "local" energy information centre, sometimes it is an energy information centre that works for several municipalities.

An energy desk is a place (website, mail, telephone number, and / or physical location) where residents are further assisted in their “customer journey”. An energy counter offers its own services to residents or points owner-residents to other service providers, such as an energy cooperative, an energy coach or a financial adviser. Many energy desks also have their own database of trustworthy providers Some examples:

- Netherlands - https://www.verbeterjehuis.nl/vind-jouw-energieloket/
- Flanders (Belgium) - https://do.vlaanderen.be/provinciale-en-stedelijke-steunpunten and https://www.mijnenergiehuis.be/homepage

[27] Lokale Energiemonitor 2019, https://www.hieropgewekt.nl/lokale-energie-monitor
[28] https://www.warmtenetoostende.be/

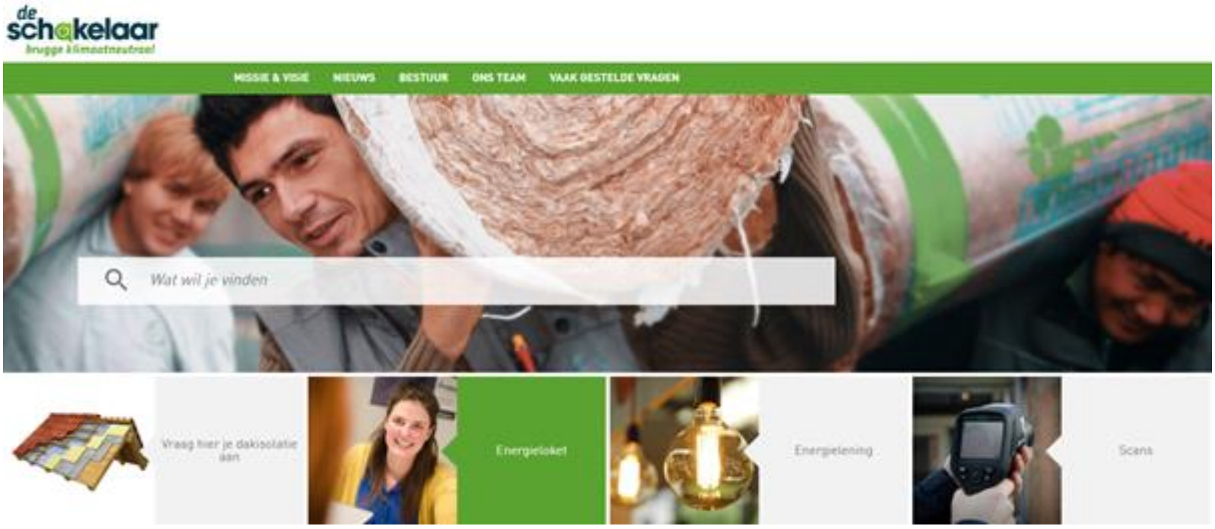


Figure 24. SHIFFT partner De Schakelaar is responsible for the home energy information centre of the city of Bruges and offers a range of services for citizens, such as energy loans, home visits with renovation advice

Energy broker

The project DOEN[29] develops the methodology of the "energy broker" in Flanders and The Netherlands, a public service that links (residual) energy from companies to potential energy customers. The challenge is to bring suppliers and consumers of heat into contact with each other. And in addition, there is often still a step- in advance: raising awareness among companies about ware of the potential of available heat that they can link to consumers.

The energy broker, as (part of) an organization, can be located at a municipality, province, regional inter-municipal company, foundation, development companies. Smaller municipalities will be forced to fall back on their regional inter-municipal companies, provinces or DSOs (Distribution System Operators). This is primarily a fact of limited governmental capacity in smaller municipalities.

4.5.9. Demonstrating

Defining pilot zones or projects

Urban renewal projects can serve as leverage projects to accelerate the heat transition. Figure 25 for example shows the urban renewal project Keerdok in Mechelen, which will feature a low temperature heat network, supplied by heat pumps with sewage water recovery and borehole thermal energy storage (BTES) fields.

[29] https://www.energie-makelaar.net/

Figure 25. Urban renewal project Keerdok in Mechelen (Source: Fluvius, 2019)

Public buildings as example buildings

Public buildings are an important meeting place between government policy and citizens. It concerns an interface where sustainability approaches become tangible. In this regard, there is much to gain for local authorities in developing, financing and implementing a sustainable real estate strategy.

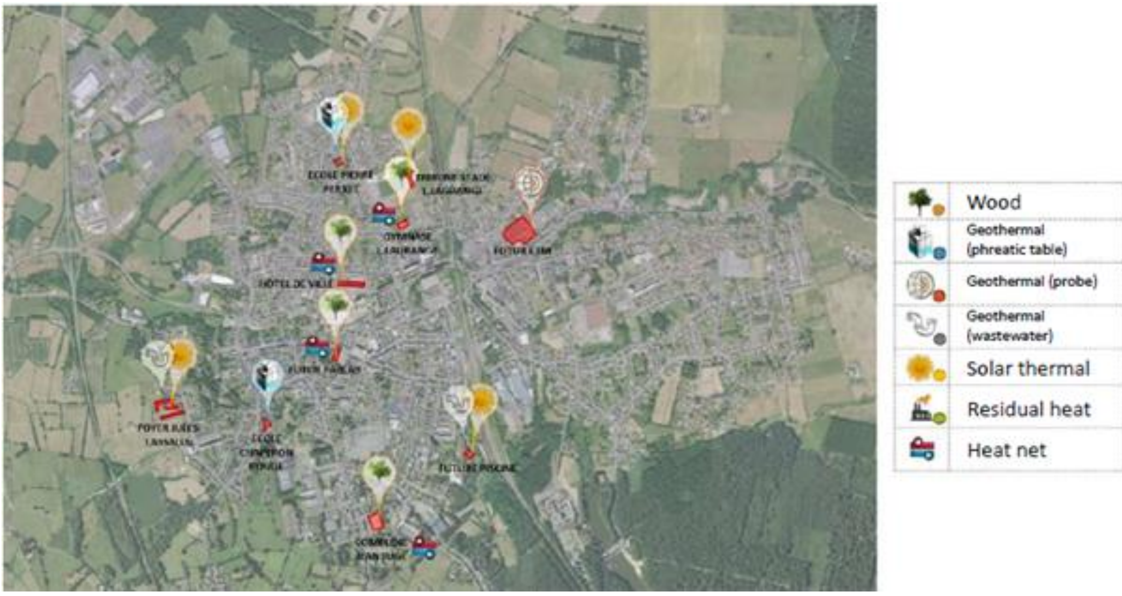


Figure 26. Visualisation of (future) sustainable heating systems for the public building stock in the municipality of Fourmies

A local authority is often also a (public) building owner. Public buildings are therefore typically the first candidates to connect to a district heating network.

5. Conclusions and next steps

This report puts forward a common understanding of sustainable heating strategies and a common approach to developing sustainable heating strategies. This approach is based on the needs of cities, national requirements, state-of-art insights and available best practice. The four SHIFFT partner cities of Middelburg, Bruges, Fourmies and Mechelen will each develop a draft sustainable heating strategy based on this general approach. These partner cities will identify and analyse heating needs, heat supply opportunities (e.g. residual heat, geothermal), actors, technologies and barriers for sustainable heating for their city. This will be done in an interactive process involving different city departments, community groups and stakeholders.

The practical experience of this development will be used to enhance this guidance. Development of the draft strategies will include two cross-border peer review sessions to feed into improving both the city strategies and the SHIFFT Guidance.

Partner cities will also update their draft strategies based on findings from the SHIFFT co-creation and investment pilots in Mechelen, Middelburg, Fourmies and Norwich. The consolidated strategies will be discussed with local stakeholders and brought to the city boards for political approval, to ensure these strategies are part of the long-term sustainability agenda of these cities and will be used to ascertain roll-out sustainable heating solutions to other parts of the city after the project.

The final output of SHIFFT WP1 is a comprehensive practical guidance for local authorities and community groups on how to accelerate the transition to sustainable heating of homes and community buildings, with the partnership and consent of their residents. The guidance will consist of different modules, covering co-creation, financial tools & incentives, strategy and regulation, and technical solutions.

Annex 1: Context and Background

A1.1. Introduction

Global average temperatures have increased by over 1 degree Celsius since the industrial revolution and global greenhouse gas emissions continue to rise (IPCC, 2018). The latest UN Emissions Gap Report suggests that we need global reductions at a rate of 7.6% per year to stay below 1.5°C. In the EU greenhouse gas emissions have fallen to around 80% of 1990 levels (at an annual rate of around 1%) but since 2014 total emissions have roughly stayed level (Eurostat, 2019). The EU has progressively increasing targets to reduce GHG emissions, in line with the Paris Agreement, set out in the 2020 climate and energy package and the 2030 climate and energy framework. In 2019 the European Council endorsed an objective for the EU to become climate-neutral by 2050 (European Council, 2019). Meeting these goals will require a complete transformation of the energy system, across heat, power and transport.

Across the EU heating and cooling represents around half of all energy use, more than half of which is generated by burning gas and oil (Heat Roadmap Europe, 2017). Efforts to reduce carbon emissions within the energy system so far have reduced emissions from electricity, particularly cutting the use of coal-fired power stations, but have largely neglected heating and renewable sources of heat are a small minority – heat pumps provide less than 1% of EU heating, electricity 12% and heat networks 9% (though these are currently gas-fired for the most part). Heat is generated locally and not distributed nationally; it is very often generated within each building, and sustainable solutions tend to generate heat local to a building or neighbourhood. Heat represents a significant challenge to decarbonising our energy system, and one which is effectively tackled at a local level. As well as replacing fossil fuels with more sustainable energy sources, a shift towards low carbon heating will also require investments in energy efficiency to reduce overall energy demand (Mathiesen, B. V., et al., 2019).

The established heating system is similar across the four countries involved in this project, this includes the state of the sector and a reliance on gas, as well as the possible solutions and the barriers to their implementation. There is a potential for accelerating learning from sharing good practice between the four countries, as well as benefits to scaling up the markets and delivery infrastructure across a scale wider than the country.

A1.2. EU-28 Heat Demand and Policy

A1.2.1. Heat demand and carrier

In 2015, across the EU 28, heating and cooling accounted for around 52% of all energy consumption (6,352 TWh; (Heat Roadmap Europe, 2017; Eurostat, 2019) and it is estimated that this contributes around 27% of EU carbon emissions (Decarb Heat). Cooling is actually a relatively small part of this consumption, estimated at around 4% in 2015. The spilt between different types of heating and cooling are broken down in the pie chart below.

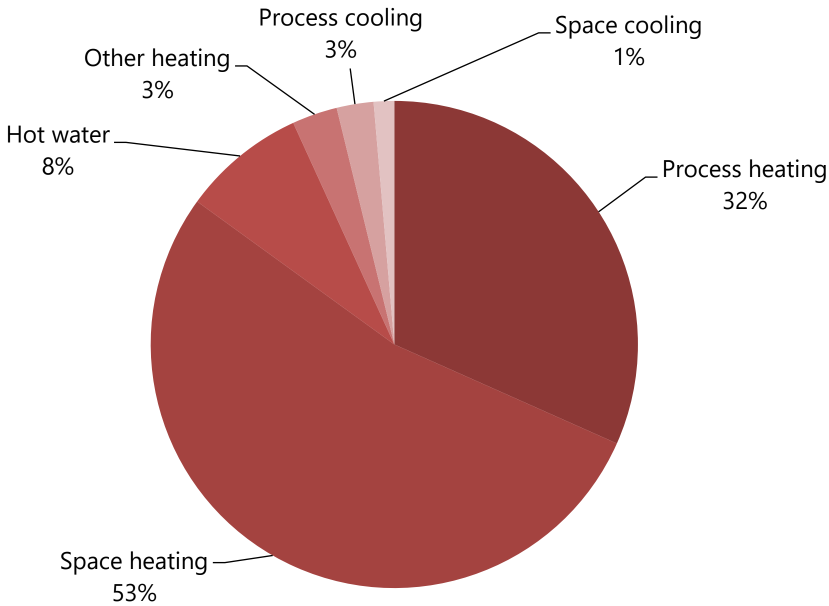


Figure A1-1: Heat use across the EU 28 countries across all sectors in 2015 (Heat Roadmap Europe, 2017)

This total demand for heating and cooling is provided by a range of different energy carriers, as shown in the figure below. It can be seen that a large proportion of heating and cooling is currently met through the use of fossil fuels, it is estimated that 19.5% of heat demand comes from renewable sources (European Council, 2019).

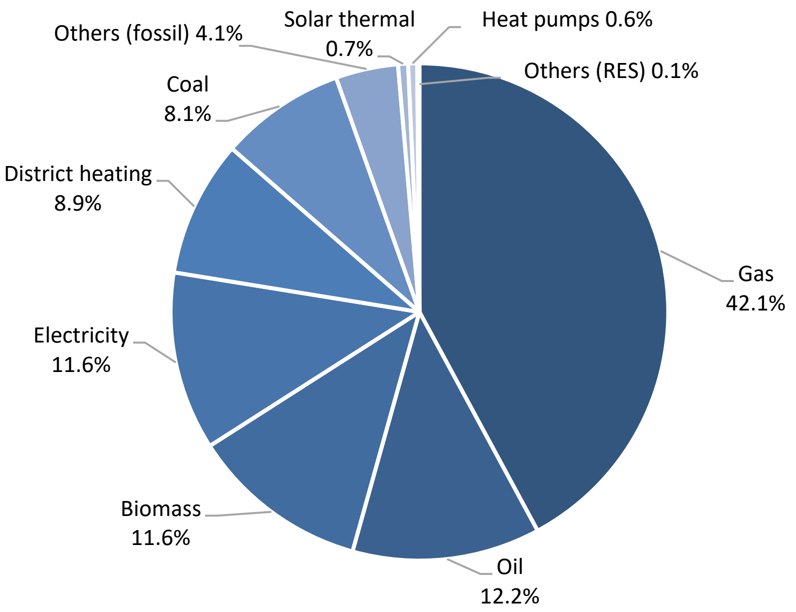


Figure A1-2: Energy carriers in EU 28 for total heating and cooling demand 2015 (Heat Roadmap Europe, 2017)

Looking at total demand for heat and cooling in 2015, 45% is from the domestic sector, 37% is from industry and 18% is from the tertiary sector. The figure below breaks this demand down by end use, it can be seen that space heating makes up most of the demand in the residential and tertiary sectors, whilst within industry most of the demand is from process heating.

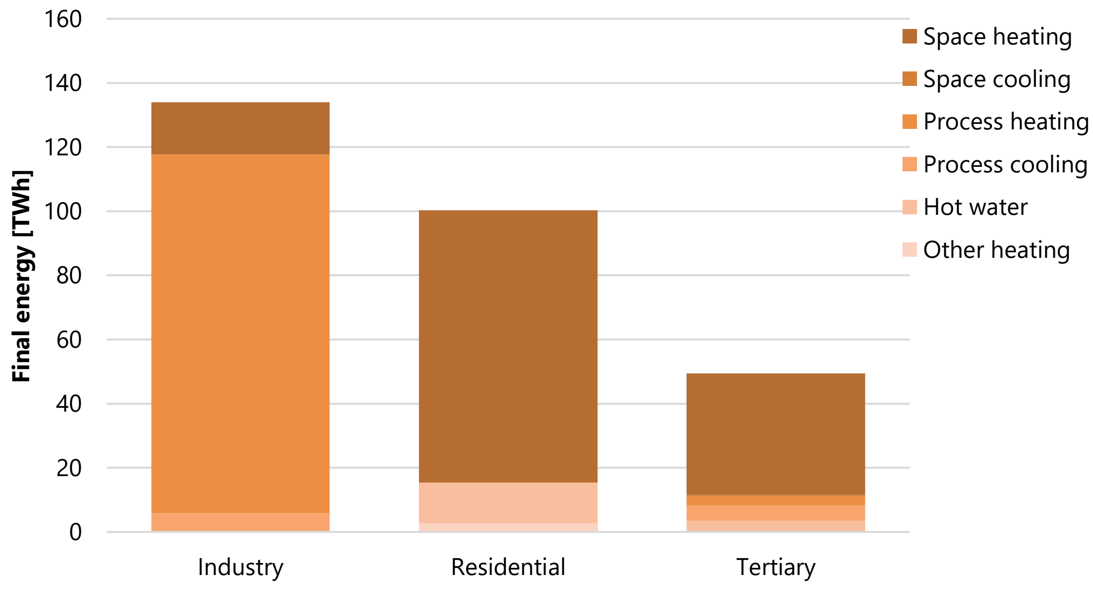


Figure A1-3: Heating and cooling demand by sector and end use in the EU 28, 2015 (Heat Roadmap Europe, 2017)

Looking at the residential sector in more detail, the figure below looks at the different ways in which the total demand of 2,845 TWh in 2015 for heating and cooling needs were met. It can be seen that fossils fuels, largely gas, are currently the dominate energy carrier.

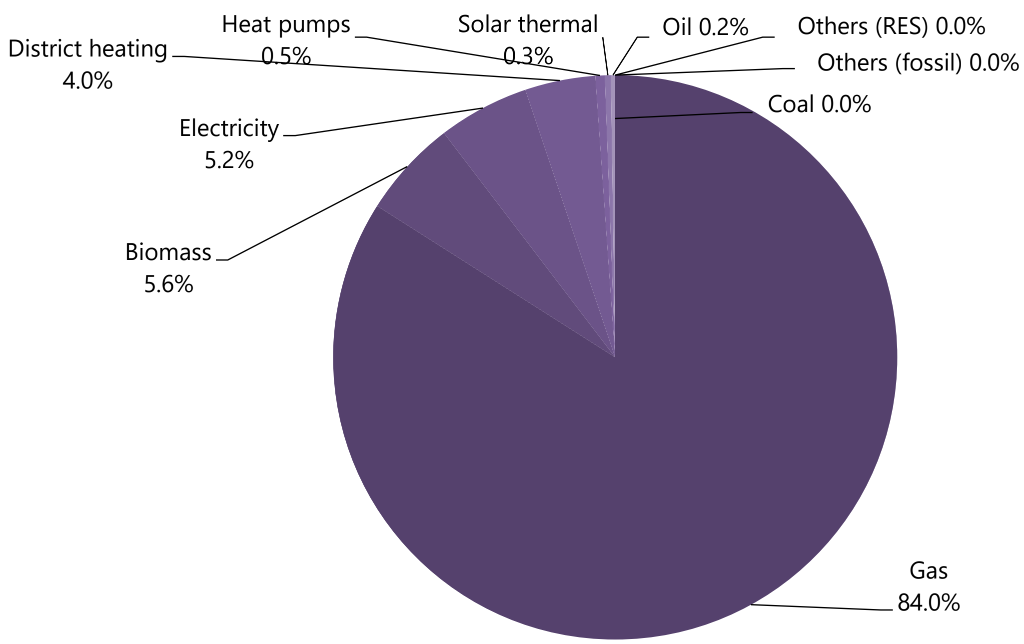


Figure A1-4: Total residential energy carriers in the EU 28, 2015 (Heat Roadmap Europe, 2017)

A1.2.2. Targets for Heat Decarbonisation

Under the 2030 Climate and Energy Framework the EU has collectively committed to a reduction in carbon emissions to 40% below 1990 levels by 2030 (European Council, 2014) and it is recognised that

that to do this the way in which heat is provided has to be addressed (EU Commission, 2018b). There is also a target for 32.5% increase in energy efficiency by 2030 (European Parliament, 2018). In the 2016 Clean Energy for all Europeans package the Commission proposed a framework for the deployment of renewable, efficient and sustainable heating in buildings and industry (EU Commission, 2018b). As part of this the Renewable Energy Directive was revised in 2018, setting a target for renewables to make up at least 32% if the EU final energy consumption by 2030 (EU Parliament and Council, 2018). This includes an indicative sub-target for heating and cooling, requiring an average 1.3% annual increase in renewables from 2021-2030 (EU Commission, 2018b).

The longer term goal for the EU to be net zero by 2050 will very likely require further efforts to decarbonise the heating and cooling sectors in the years to come.

A1.3. Belgium Heat Demand and Policy

A1.3.1. Heat demand and carrier

In Belgium, heat and cooling represents around 56% of all energy consumption (214 TWh (Heat Roadmap Europe, 2017; Eurostat, 2019)). This heat demand is broken down in the pie chart below, space heating is the large end use demand across sectors, followed by process heating.

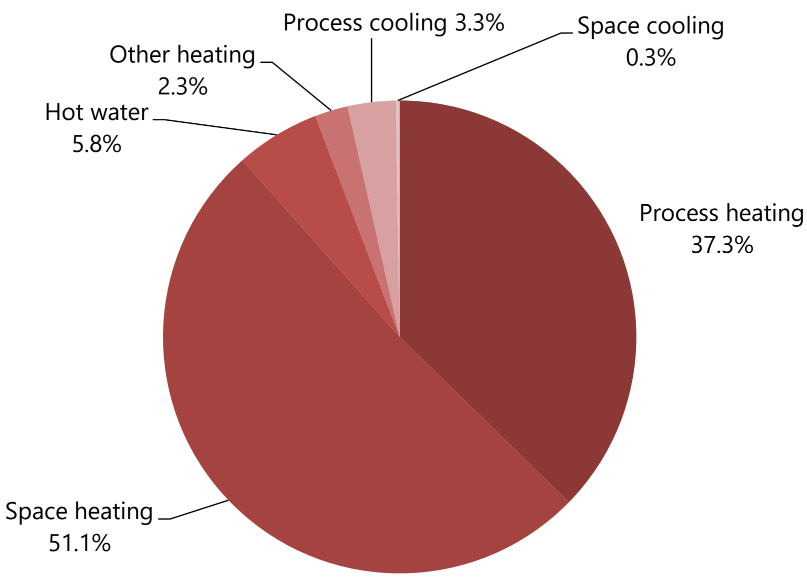


Figure A1-5: Heat demand by end use across all sectors in Belgium in 2015. (Heat Roadmap Europe, 2017)

Across the domestic, services and industry sectors heating is mainly provided by gas (47%) and oil (20%), as shown in the figure below.

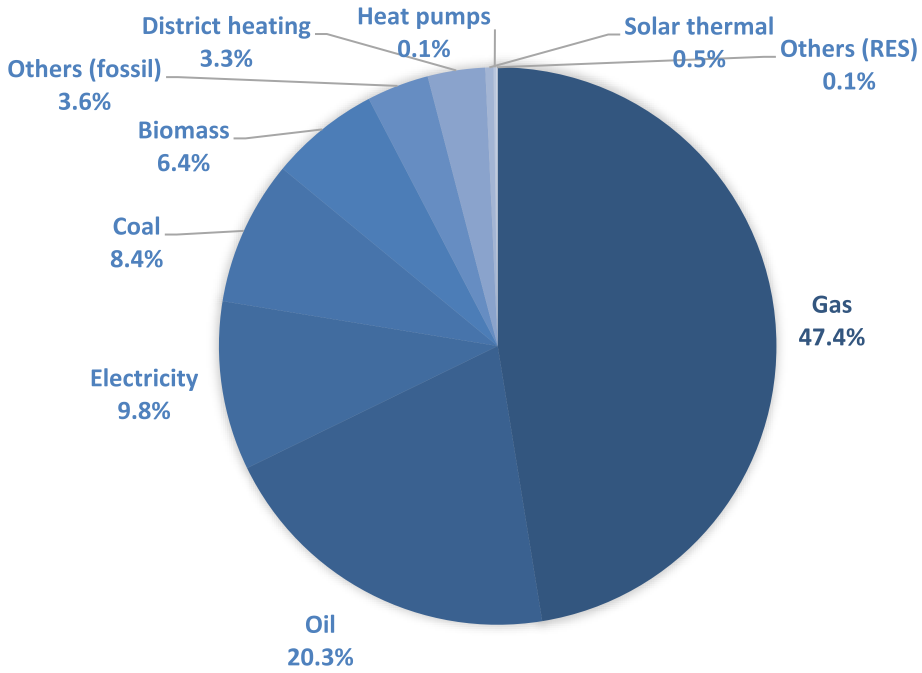


Figure A1-6: Energy carriers in Belgium for total heating and cooling demand 2015 (Heat Roadmap Europe, 2017)

Looking at total demand for heating and cooling within Belgium in 2015, industry is the main sector, accounting for 44% of final demand, followed by the residential sector at 44% and the tertiary sector 17%. The figure below breaks this demand down by end use across these sectors.

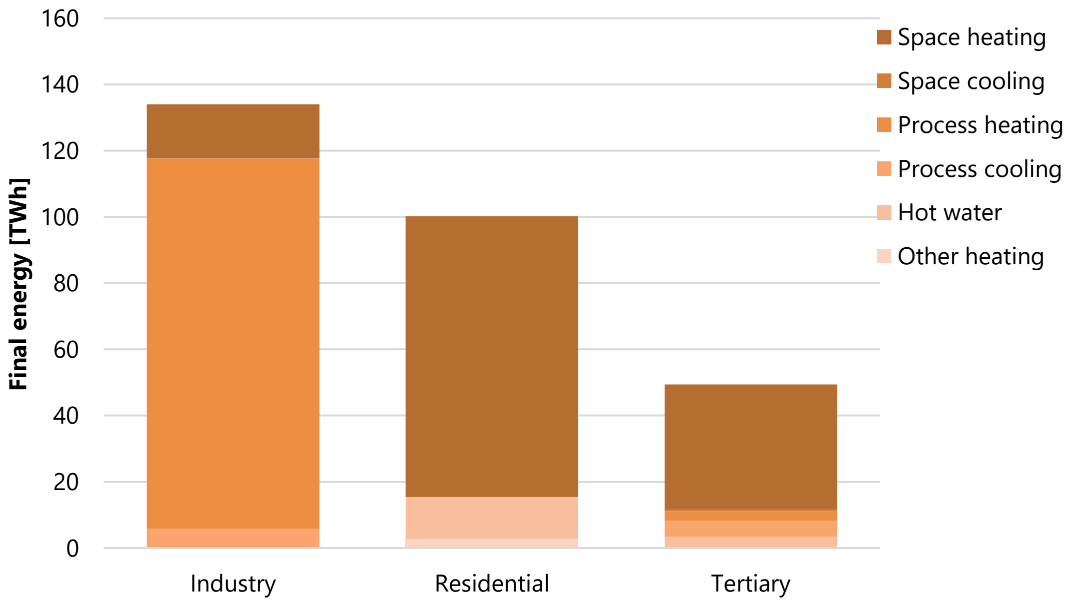


Figure A1-7: Heating and cooling demand by sector and end use in Belgium, 2015 (Heat Roadmap Europe, 2017)

Looking at the Belgium residential sector in more detail, there are around 4.7 million households (Statista, 2019), space heating accounts for 82% of final heat demand and hot water makes up 12% of final demand. The breakdown of total demand for heat in Belgium in 2015 of 84 TWh across different energy carriers is shown below. It can be seen that gas is the dominate fuel providing around 47% of demand for heat, followed by oil at 20%, the balance is met from a number of different sources.

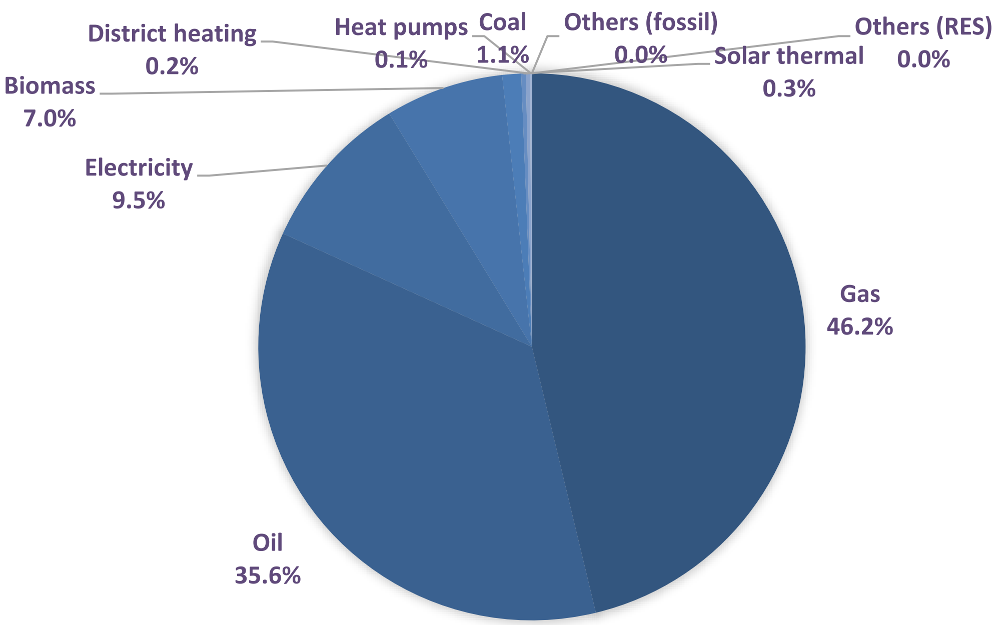


Figure A1-8: Heat and cooling energy carriers in the residential sector within Belgium, 2015 (Heat Roadmap Europe, 2017)

A1.3.2. Heat Decarbonisation Targets

Belgium has an Integrated National Energy and Climate Plan which sets out the objective of a 100% reduction in fossil fuel consumption by 2050. It also establishes earlier goals of a 40% cut in CO_2 emissions and a 27% reduction in primary energy consumed by 2030 (NECP, 2018).

Adding together the forecasts of all three regions, there is an ambition to generate 24,087 GWh of renewable heat by 2030. This equals about 8% of the current heat demand in Belgium (NECP, 2018). The draft National Energy and Climate Plan of Belgium estimates the possible share for renewable heat by 2030 could increase to 12.7%, through the promotion of heat pumps and heat networks that use renewable or waste heat (EC Commission, 2019). The draft NECP also details a number of ambitions for built sector, such as: not allowing new residential buildings to be connected to the gas network or use oil heating from 2021; new EPC certificates; building passports; and renovation roadmaps.

A1.4. France Heat Demand and Policy

A1.4.1. Heat demand and carrier

In France, heat and cooling represents around 46% of all energy consumption (758 TWh (Heat Roadmap Europe, 2017; Eurostat, 2019)). This demand is broken down in the pie chart below, space heating is the dominate demand across all sectors.

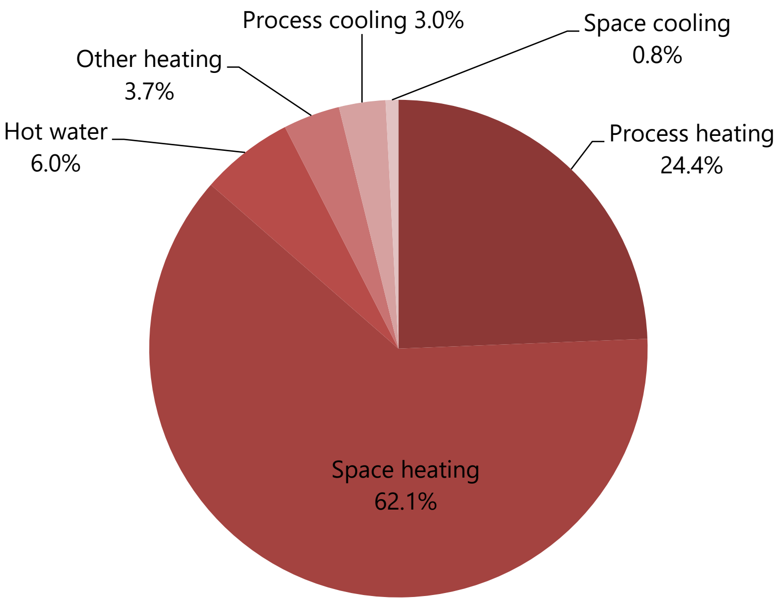


Figure A1-9: Heating and cooling demand by end use across all sectors in France in 2015. (Heat Roadmap Europe, 2017)

Across the domestic, tertiary and industry sectors the heat and cooling demand is mainly met by fossil fuels, mainly gas (42%), with electricity, oil and biomass the next largest contributors.

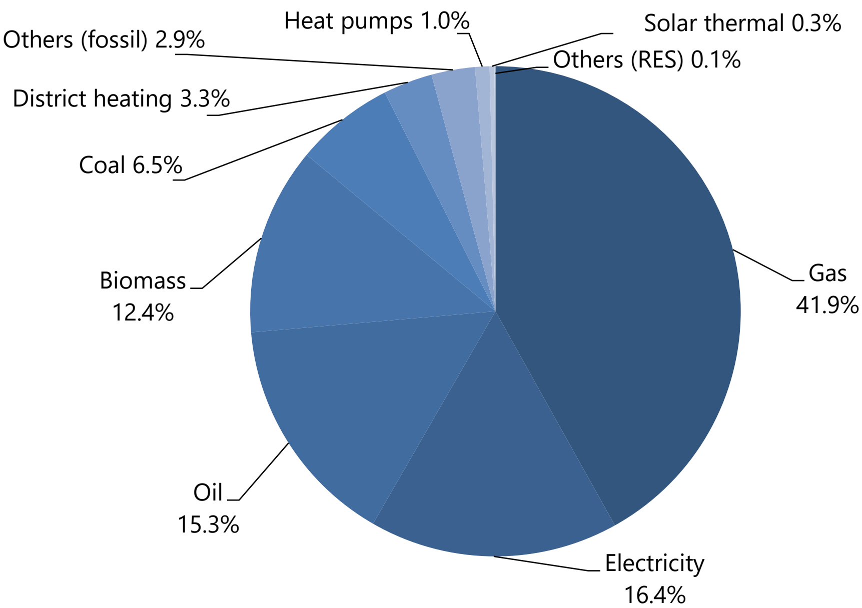


Figure A1-10: Energy carriers in France for total heating and cooling demand 2015 (Heat Roadmap Europe, 2017.

Looking at total demand for heating and cooling within France for 2015, around 51% is from the residential sector, 29% is from industry and 20% is from the tertiary sector. The figure below breaks this demand down by end use across these sectors.

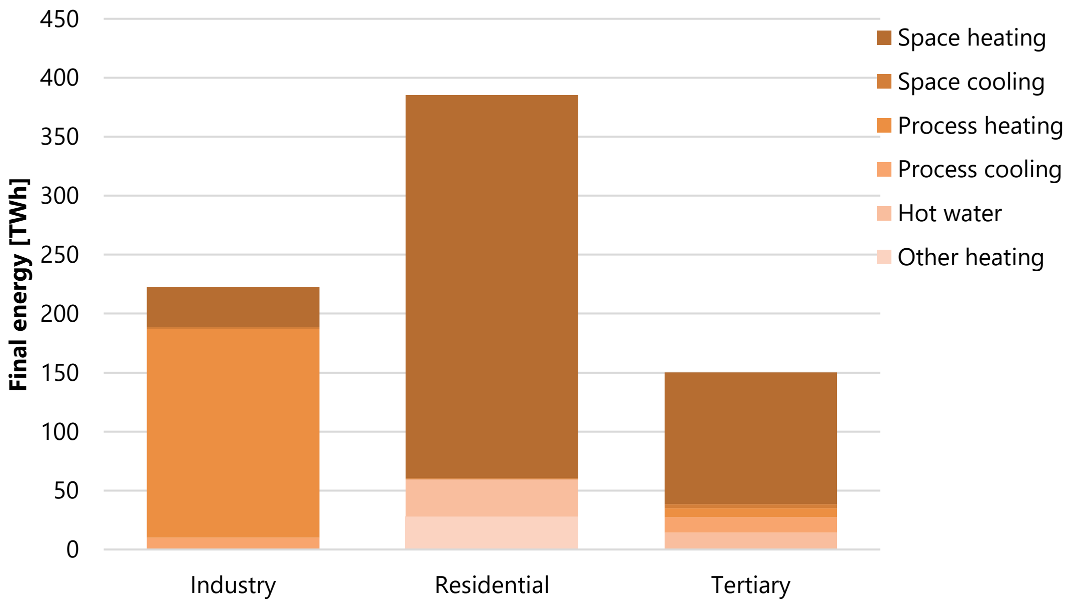


Figure A1-11: Heating and cooling demand by sector and end use in France, 2015 (Heat Roadmap Europe, 2017)

Looking at the French residential sector in more detail, there are about 29.1 million households (Vivid Economics & Imperial College London, 2017) and space heating accounts for 84% of final heat demand and hot water accounts for 8%. The breakdown of total demand for heat in France within the residential sector in 2015 was 385 TWh. This total demand is provided by a number of energy carriers, shown below, it can be seen that a variety of carriers are used, gas dominates providing around 37% of the demand for heat, but electricity, biomass and oil also play significant roles.

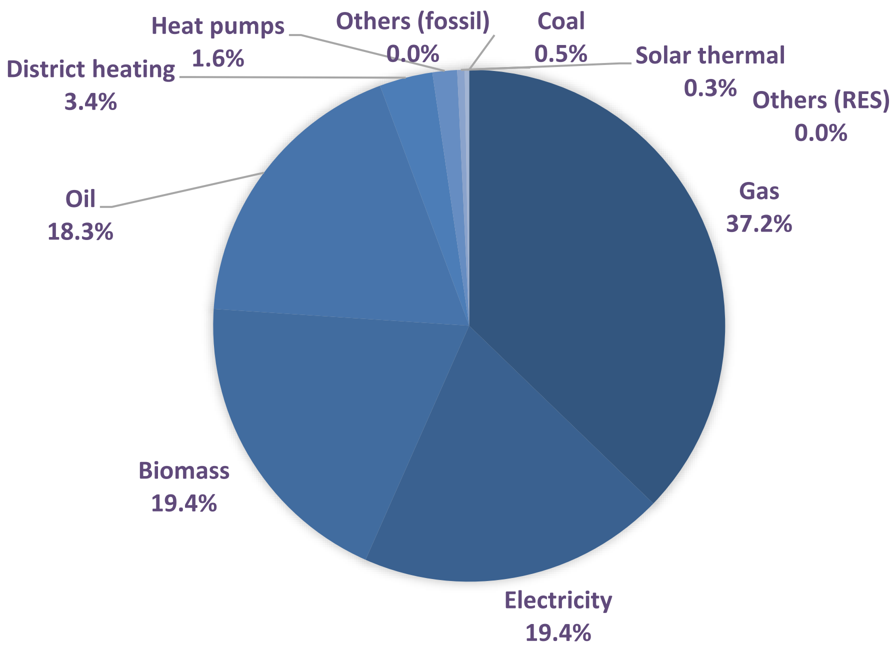


Figure A1-12: Heat and cooling energy carriers in the residential sector within France, 2015 (Heat Roadmap Europe, 2017)

A1.4.2. Heat Decarbonisation Targets

In 2019 the French Government legislated for net zero carbon emissions by 2050 (Reuters, 2019). The legislation includes a target for reducing fossil fuel use by 40% by 2030, with targets for increasing low carbon energies, renewable hydrogen and cut emissions and reduce energy consumption in 7.2 million poorly insulated homes by 2028 (Reuters, 2019). The Government has also stated an intention to end domestic coal heating by 2028, the replacement of 10 000 coal heating system (half of the total in 2019) and 1 million of fuel heating system (on 3.5 million in 2019) by sustainable heating system or high efficiency natural gas boiler by 2023; as well as connect 3.4 million homes to heat networks and have 9.5 million homes heated by wood by 2023 (Ministère de la Transition Écologique et Solidaire, 2018).

The draft National Energy and Climate Plan of France has an aim to increase the share of renewable energy in the heating to 38% by 2030 (EU Commission, 2019) and increase the share of renewable and waste energy supply district heating five-fold by 2030 (Vivid Economics & Imperial College London, 2017). Every new building must have a minimum share of sustainable heat by 2020.

A1.3. The Netherlands Heat Demand and Policy

A1.3.1. Heat demand and carrier

In the Netherlands, heat and cooling represents around 67% of all energy consumption (284 TWh (Heat Roadmap Europe, 2017; Eurostat, 2019)). This heat demand is broken down in the pie chart below, space and process heating dominate final demand.

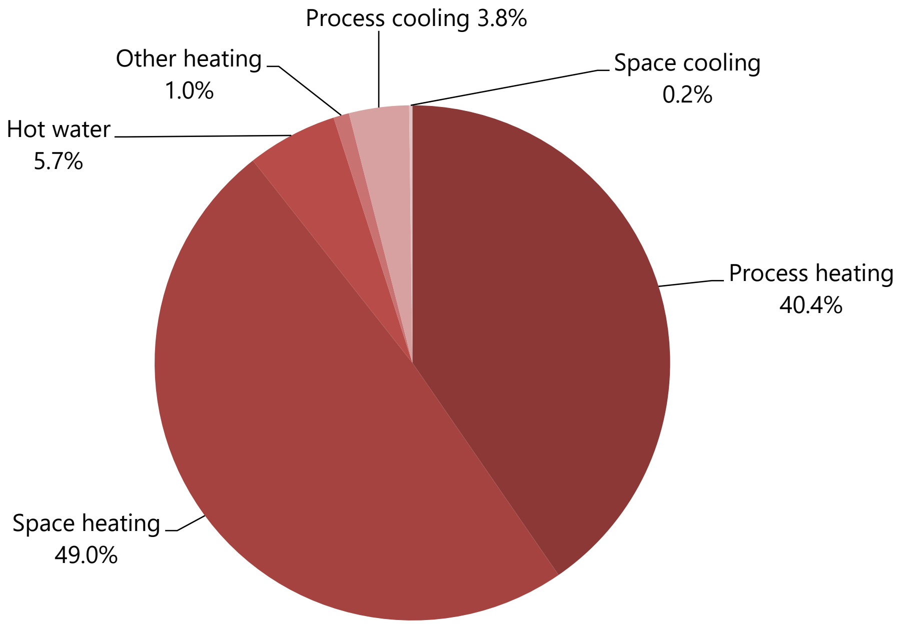


Figure A1-13: Heat demand by end use across all sectors in the Netherlands in 2015. (Heat Roadmap Europe, 2017)

Across the domestic, services and industry sectors heating is mainly provided by gas (62%), followed by other fossil fuels, electricity, district heating and coal, as shown in the figure below.

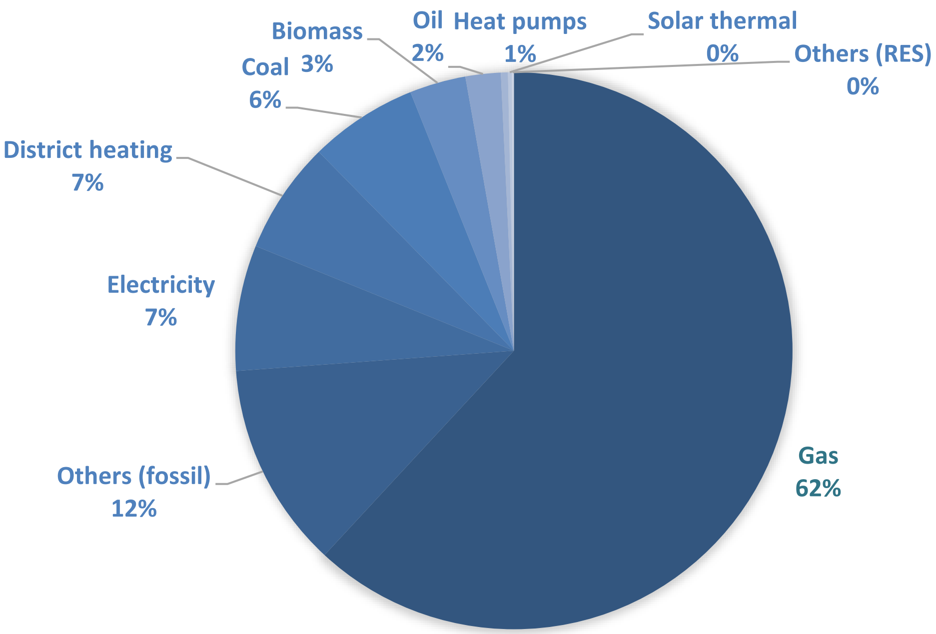


Figure A1-14: Energy carriers in the Netherlands for total heating and cooling demand 2015 (Heat Roadmap Europe, 2017)

Looking at total demand for heating and cooling within the Netherlands in 2015, industry is the main sector, accounting for 47% of final demand, followed by the residential sector at 35% and the tertiary sector 18%. The figure below breaks this demand down by end use across these sectors.

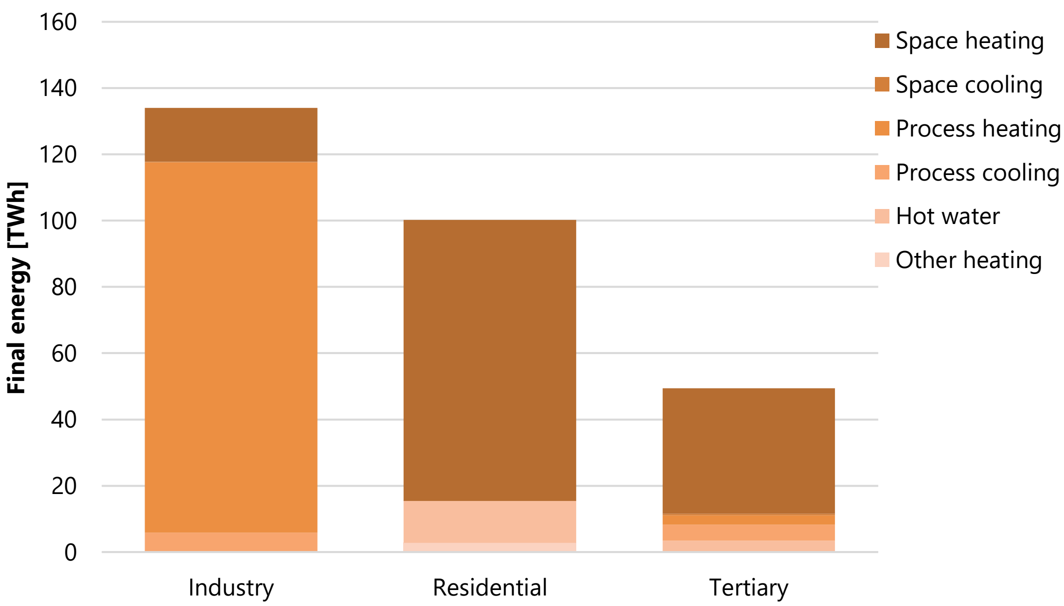


Figure A1-15: Heating and cooling demand by sector and end use in the Netherlands, 2015 (Heat Roadmap Europe, 2017)

Looking at the Netherlands residential sector in more detail, there are around 7 million homes (Vivid Economics & Imperial College London, 2017), space heating accounts for 84% of final heat demand and hot water makes up 13% of final heat demand. The breakdown of total demand for heat in 2015 of 100 TWh across different energy carriers is shown below. It can be seen that gas is the dominate fuel providing around 84% of demand for heat, followed by a mix of different carriers. Domestically, 93% of properties are connected to the gas network in the Netherlands, and 4.5% are connected to a heat network (ECN *et al.*, 2016, quoted in (Lowes, 2019)).

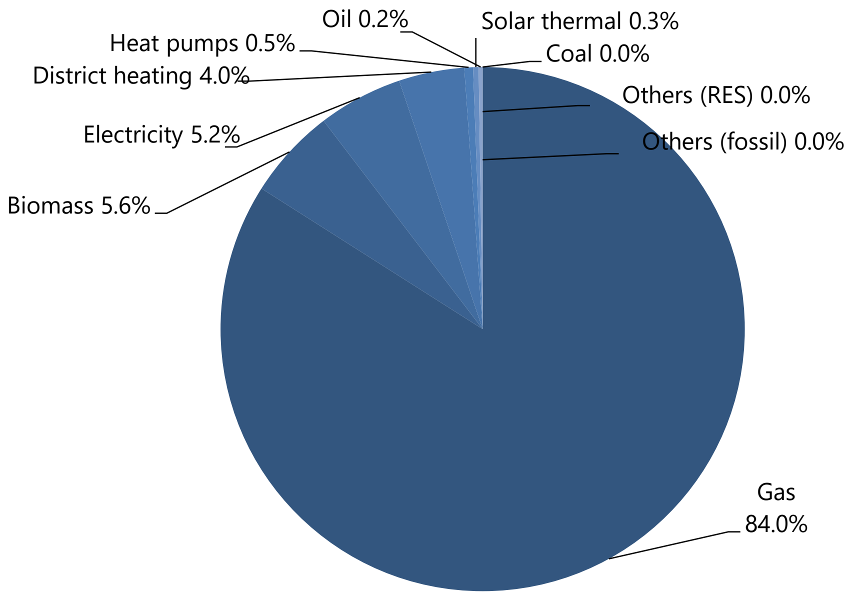


Figure A1-16: Heat and cooling energy carriers in the residential sector within the Netherlands, 2015 (Heat Roadmap Europe, 2017)

A1.3.2. Heat Decarbonisation Targets

In its 'Energy Report – Transition to Sustainability' the Dutch Government committed to an 80-95% cut in greenhouse gas emissions by 2050 (Ministry of Economic Affiars, 2015). For heat, they plan to phase out case for low temperate heat processes, requiring 6-7 million houses to become gas free between 2030 and 2050 (Vivid Economics & Imperial College London, 2017). For heat it is stated that this means very close to zero carbon emissions and decommissioning of the gas network (Lowes, 2019).

The Netherlands has a target to provide 14% of energy demand with renewable sources by 2020 (European Union, 2019). To hit the more ambitious targets for 2050 will require a reduction of emission from a mix of different technologies, including green gas, geothermal, district heating and electrification, with modelling suggesting a range or possible scenarios for mixes between these options (Vivid Economics & Imperial College London, 2017).

A1.4. UK Heat Demand and Policy

A1.4.1. Heat demand and carrier

In the UK heat represents around 48% of all energy consumption (673 TWh (Heat Roadmap Europe, 2017; Eurostat, 2019)). This heat demand is broken down in the pie chart below. Heat is responsible for 28% of all carbon emissions from energy in the UK (88 MtCO2e - (BEIS, 2019c)).

In respect of energy end use the biggest demand for heat is for space heating, which accounts for 60% of final demand.

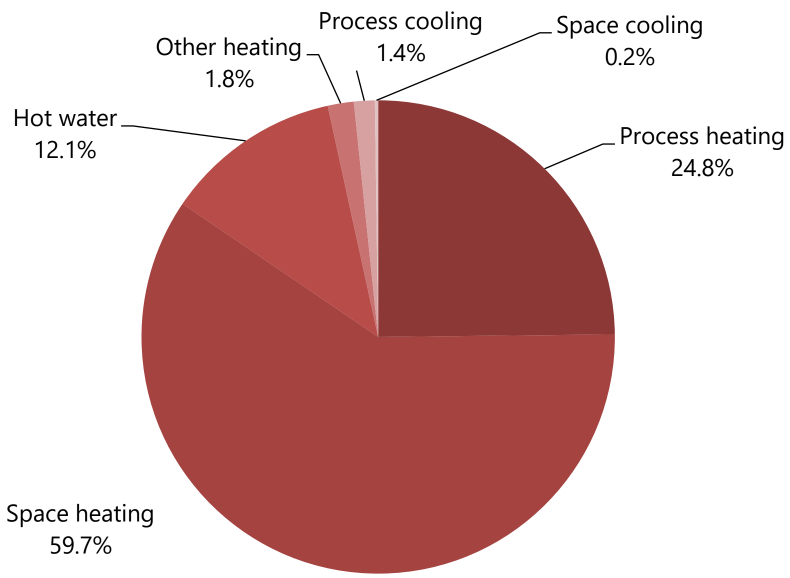


Figure A1-17: UK Heat and cooling demand by end use across all sectors in the UK 2015 (Heat Roadmap Europe, 2017)

Across the domestic, tertiary and industry sectors most of the demand for heating in the UK is provided by gas, with oil and electricity the next largest contributors.

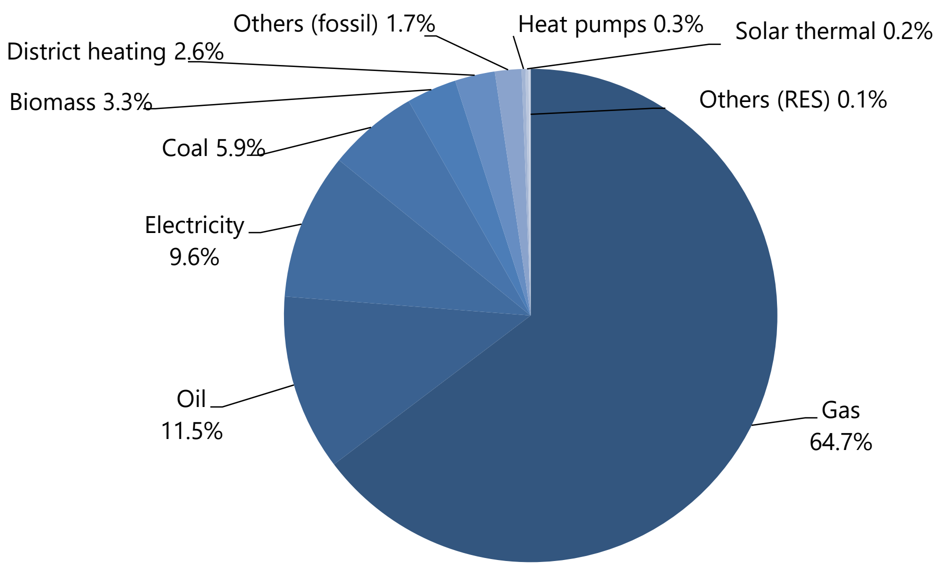


Figure A1-18: Energy carriers in the UK for total heating and cooling demand 2015 (Heat Roadmap Europe, 2017)

Looking at total demand for heating and cooling within the UK in 2015, around 53% is from the residential sector, 30% is from industry and 17% is from the tertiary sector. The figure below breaks this demand down by end use across these sectors.

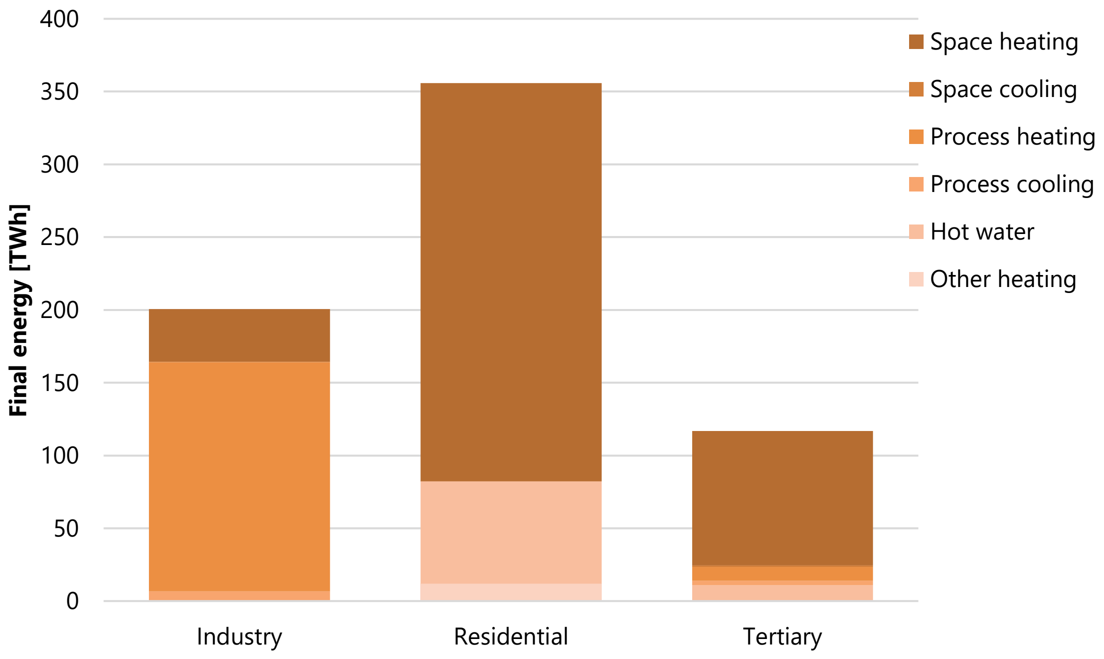


Figure A1-19: Heating and cooling demand by sector and end use in the UK, 2015 (Heat Roadmap Europe, 2017)

Looking at the heat demand in the UK residential sector in more detail, there are around 27.8 million homes (ONS, 2019), space heating accounts for over three quarters of final demand at 77%, with hot water accounting for a further 20% of final demand. The breakdown of total demand for heat in the UK in 2015 of 356 TWh across different energy carriers is shown below. It can be seen that gas is the dominate fuel providing around 75% of demand for heat, reflecting the fact that 84% of homes are connected to the gas grid (Lowes, 2019).

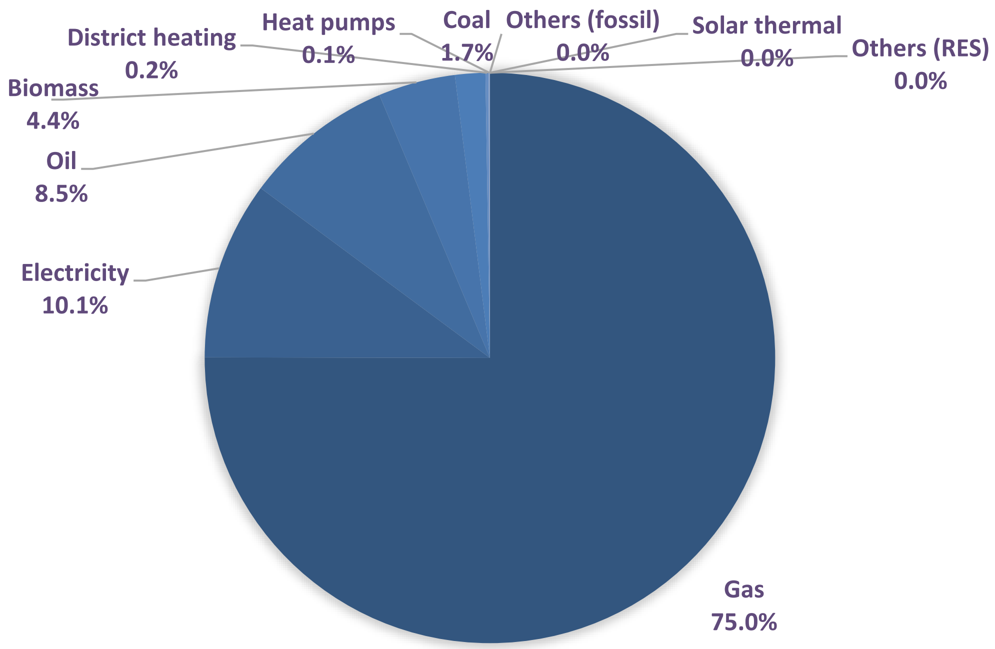


Figure A1-20: Heat and cooling energy carriers in the residential sector within the UK, 2015 (Heat Roadmap Europe, 2017)

A1.4.2. Heat Decarbonisation Targets

The UK has a legal commitment to reduce GHG emissions by 100% of 1990 levels (net zero) by 2050 and a series of carbon budgets to achieve this (HMG, 2008, 2019). The carbon budgets are stepping stones towards the 2050 target and they are set at least 12 years in advance to allow policy-makers, businesses and individuals enough time to prepare. The first five carbon budgets have been put into legislation and run up to 2032, requiring a reduction in emissions of 57% over 1990 levels (CCC, 2019b).

The UK has a target to provide 12% of heat demand with renewable sources by 2020 (DECC, 2009). The UK Committee on Climate Change has recommended that all new homes built after 2025 should not be connected to the gas grid (CCC, 2019a), a position endorsed by the government (Taylor, M., 2019), and it is developing a new roadmap for policy on heat decarbonisation, expected in 2020 (BEIS, 2018a).

A1.5. Additional information

A1.5.1. Energy Poverty in the 2 SEAS regions

Table A1-1: Comparing energy poverty in across 2-SEAS regions

	BE	FR	NL	UK
2M	14.7	18.1	-	17.8
HEP	10.5	23.7	-	9.8
Keep Warm	4.8	5.0	2.6	6.1

The 2M indicator is those whose expenditure on energy as a proportion of income is twice the national median.

Hidden Energy Poverty (HEP) is the proportion of households whose expenditure on energy is less than half the national median – inferred as evidence that they cannot afford energy.

‘Keep warm’ is the proportion of households unable to keep their home adequately warm based on self-reported thermal discomfort.

A1.5.2. Energy Prices across the EU and SEAS countries

Table A1-2: Comparing energy prices across 2-SEAS regions and the EU ((EU Commission, 2018a); (BEIS, 2019e)**1 nb: £1:€1.16)**

	EU	BE	FR	NL	UK
Domestic Cost of Electricity (€/kWh)	0.20	0.29	0.16	0.16	0.16
Domestic Cost of Mains Gas (€/kWh)	0.07	0.06	0.07	0.08	0.05 [1]

A1.5.3. Residential sector information in SEAS countries

Table A1-3: Residential sector comparisons within 2 SEAS regions

	BE	FR	NL	UK
Number of homes (1)	4.7 million	29.1 million	7 million	27.8 million
% on homes on gas network (2)	55%	41%	94%	85%
% owner-occupying households (3)	65.0	57.7	55.6	64.3
% private rented households (3)	34.1	39.7	42.4	34.3
% single occupants 2011 (4)	32	34	32	30

Notes:
(1) (Vivid Economics & Imperial College London, 2017; ONS, 2019; Statista, 2019);
(2) (ECI, no date; Vivid Economics & Imperial College London, 2017)
(3) (Eurostat, 2017a)
(4) (Eurostat, 2017b)

A1.5.4. Age of buildings and stock type in SEAS countries

The average age of buildings and the share of new buildings in the overall stock can be a useful proxy for energy efficiency. Generally, the higher the share of new buildings, the higher the levels of energy performance because of increasingly efficient standards within building regulations.

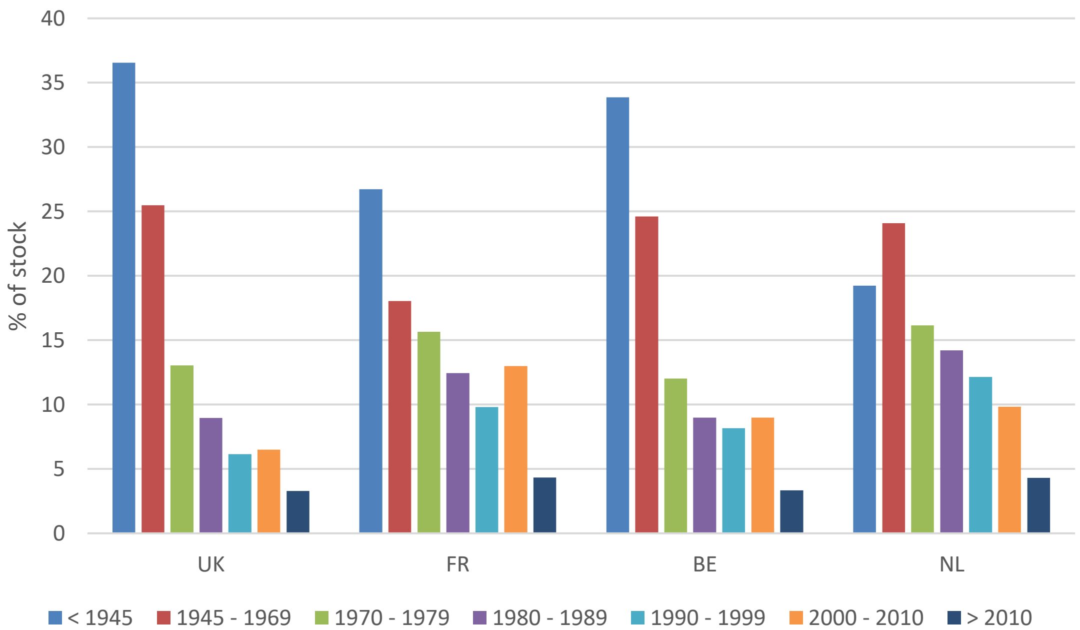


Figure A1-21: Residential building construction dates 2014 in four SEAs countries (EU Building Stock Observatory, 2016b, 2016d, 2016a, 2016c)

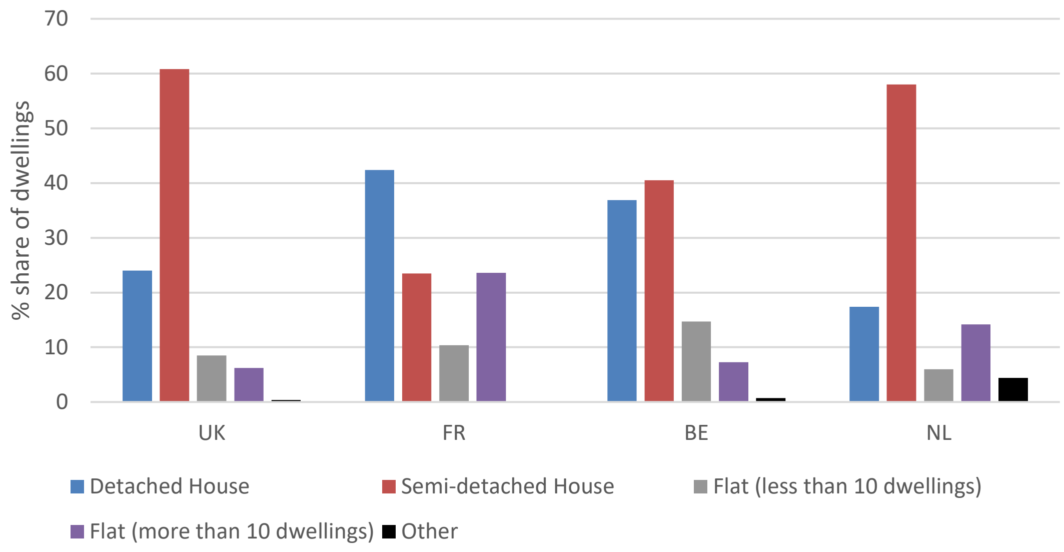


Figure A1-22: Comparison of domestic built stock by type 2016 in four SEAs countries (Eurostat, 2019)

A1.5.5. Building regulations

Most EU countries have a building act that provides the legal framework for legislation concerning the content and implementation of building regulations. How these are established set and managed vary between countries, with the Belgian system of building regulations and controls, in particular, standing out as being different from other EU countries (Meijer, F.M., H.J. Visscher, H.J., and Sheridan, 2002). In general, central authorities are involved in setting technical building regulations and this include subjects like safety, health, practicability and energy saving in many Member States, but regional and local authorities has can play a role in the organization and formulation of technical building regulations. Building regulations cover new buildings and to some extend existing buildings, although how the latter is treated varies between countries. Some areas apply general building regulations to all construction works, but for existing buildings relaxations of the provisions are possible; whilst others apply general building regulations apply to new buildings and reconstruction, extension, extensive renovation or change in use of existing buildings (Pedro, J.B., Meijer, F., and Visscher, 2010). The table below summaries what subjects are included in technical building regulations for new buildings and at what level they are set.

Table A1-4: Comparing technical building regulations in the 2 SEAS regions (adapted from Pedro et al, 2010)

	BE	FR	NE	UK
New Buildings				
Building & plot	L	L	L	L
Safety	C	C	C	C
Health	C	C	C	C
Practicability	R	C	C	C
Energy saving	R	C	C	C
Envir. protect	L	C	-	C
Existing Buildings				
Regulations in place?	No	No	No	No

C – central; R – regional; L- local; - not included

In terms of wider comparison in the SEA countries, the table below compares approaches for new-build and renovations for building codes, performance requirements and prescriptive/element based criteria for a number of energy efficiency measures.

Table A1-6: Comparing prescriptive and element based criteria in building codes within 2 SEAS regions (Atanasiu et al., 2014)

	Building code requirments		Performance Based Requirements		Presciptive/element-based criteria in building codes					
	New Build	Renovations	New Build	Renovations	Thermal Insulation	Air permeability	Ventilation requirements	Boiler/AC system efficiency	Lighting efficiency	Other requirements
BE - WI	Y	Y	Y	N	Y	N	Y	N	N	Overheating indicator should not exceed 17500kh. T_{in} must be under 26°C for 90% of year in RE. K-values on global thermal insulation of entire building. Thermal bridges
BE – BR	Y	Y	Y	N	Y	N	Y	N	N	
BE – FI	Y	Y	Y	N	Y	N	Y	N	N	
FR	Y	Y	Y	Y	Y	Y	Y	Y	NRE	Max T_{in} applies based on a number of factors
NL	Y	Y	Y	N	Y	Y	Y		NRE	Daylight
UK	Y	Y	Y	Y	Y	Y	Y	Y	Y	

A key driver for the energy components of building regulations within individual countries has come via EU legislation. Initially through the 2010 Energy Performance of Buildings Directive and then the 2012 Energy Efficiency Directive, both of which were amended in the Clean energy for all Europeans Package in 2018 & 2019. These directives promote policies to help: achieve a highly energy efficient and decarbonised building stock by 2050; create a stable environment for investment decisions; and enable consumers and businesses to make more informed choices to save energy and money (EU Commission, 2020). These directives require Member States to put provisions into national law so that energy performance and other energy measures are set for new and existing buildings – which come through in building codes/regulations. To assist with elements of this policies and supportive measures were developed, including benchmarking to allow comparisons and identify cost-optimal energy performance measures for new and existing buildings and their building elements like walls, roofs, windows, etc. (EU Commission, 2016).

Heat demand of a building/dwelling will largely be shaped by the envelope thermal properties for buildings and this is expressed in terms of U-values which are indicators for the heat lost through building elements. U-values at the building and/or component level for new build and renovations are set out within building codes. The figures below show how the average U-values per building element for different counties between 2008 and 2014 compare to the EU average values. Changes between years are due to the combined effect of new construction and refurbishment of the existing stock and related national requirements. For all elements in all four countries the U-values are higher (i.e. less energy efficient) than the EU average.

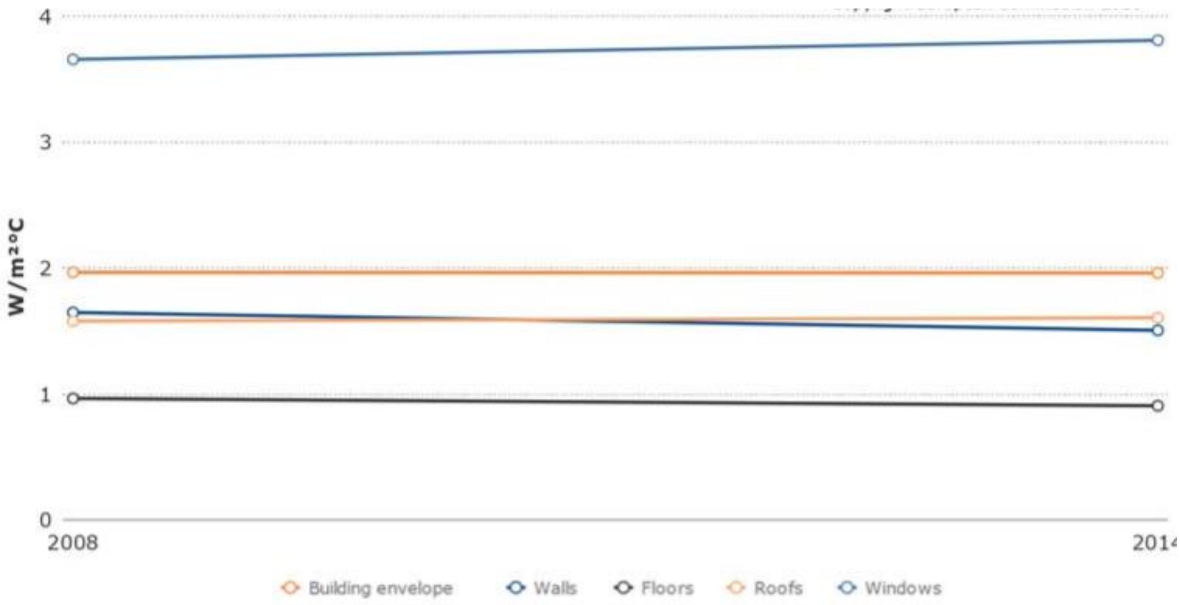


Figure A1-23: U- Values of building elements in Belgium compared to the EU average (EU Building Stock Observatory, 2016b)

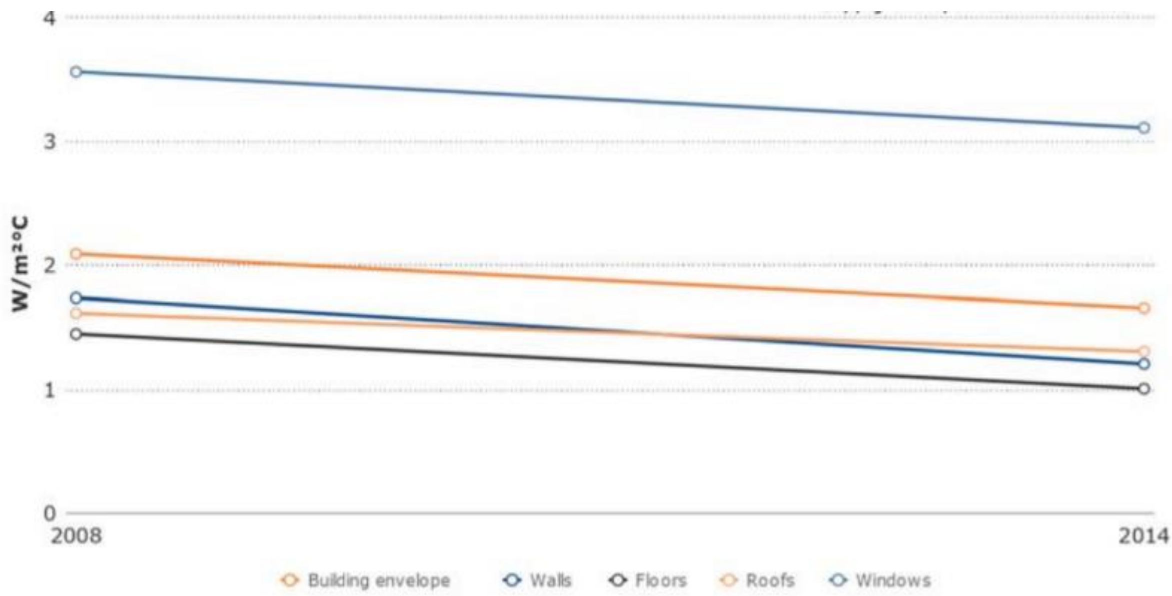


Figure A1-25: U- Values of building elements in the Netherlands compared to the EU average (EU Building Stock Observatory, 2016a)

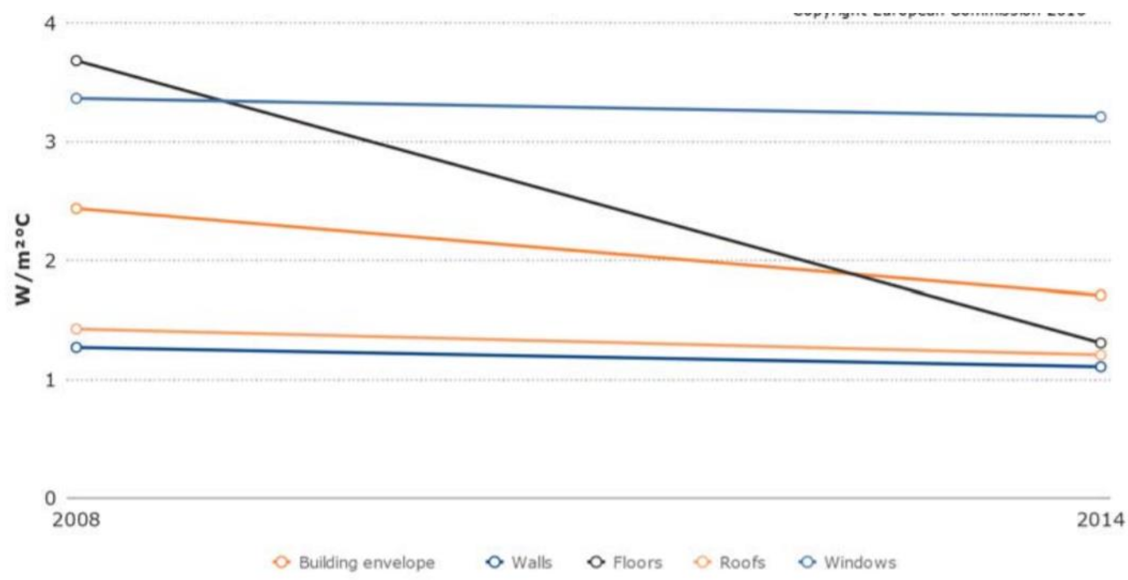


Figure A1-26: U- Values of building elements in the France compared to the EU average (EU Building Stock Observatory, 2016c)

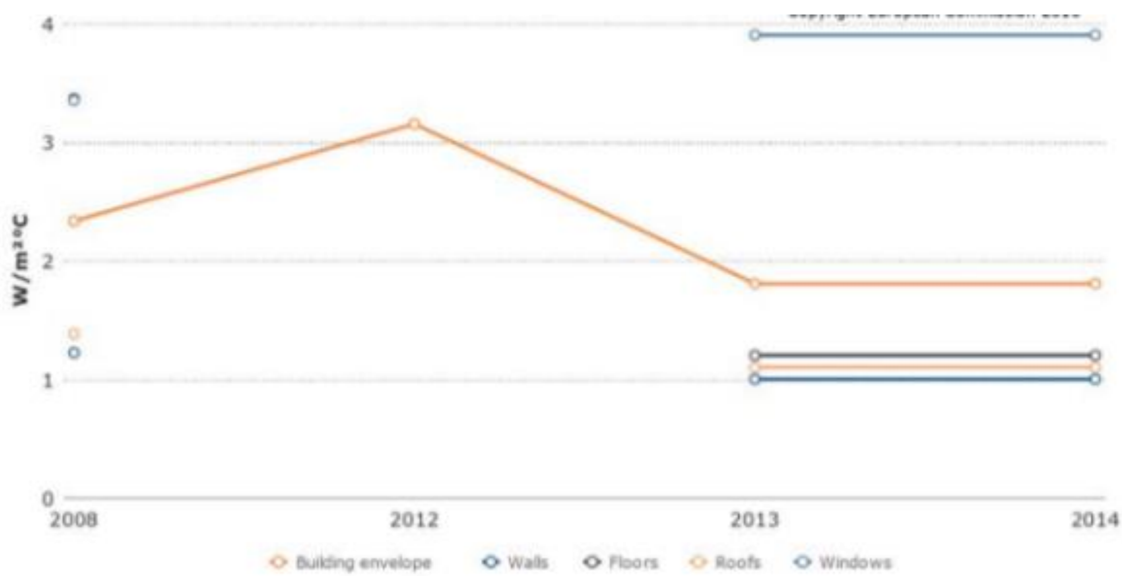


Figure A1-27: U- Values of building elements in the UK compared to the EU average (EU Building Stock Observatory, 2016d)

Annex 2: Policy overview

This annex provides an overview of the national and regional policy framework concerning sustainable heating in the 2 Seas Region.

A2.1. United Kingdom

A2.1.1. Strategy and goals

The UK's Climate Change Act 2008 commits the country to net zero greenhouse gas emissions by 2050. In 2009 the UK set a national target for 12% of heat demand to be provided by renewables by 2020 (DECC, 2009). In 2017, the latest year for which data is available, 7.3% of heat was renewable (BEIS, 2019c).

The Government established a target to upgrade the energy efficiency of 1 million homes between May 2015 and April 2020. As of the end of September 2019, about 911,000 homes had been upgraded (BEIS, 2019c).

The UK Government is currently developing its approach to cutting carbon emissions from heat for the 2020s, to support the delivery of the 2050 net zero target. This includes work to reduce the barriers to low carbon heating and cooling, reducing the reliance on subsidies and building sustainable supply chains. The Government believes that a range of technologies will be needed to meet the 2050 targets, particularly including heat networks and heat pumps, as well as possibly a role for hydrogen and biogas; and they recognise that the combination which will best work at scale, at a reasonable cost and with acceptability for consumers, is not yet know. There is a recognition that most heat within buildings and industry currently comes from fossil fuels, predominately gas, reflecting the prevalence of a national gas grid, which creates a particular challenge for shifting to low carbon heat (BEIS, 2018b).

In 2018 a review of evidence for transforming heating was produced and the Government is currently developing a developing a new roadmap for policy on heat decarbonisation that is expected to be released in 2020 (BEIS, 2018b). They have also announced a ban on gas boilers installed in new homes from 2025, but this is yet to be formalised (Taylor, M., 2019) and there is an ambition to phase out the installation of high carbon fossil fuel heating in new and existing off gas grid residential buildings during the 2020s (HMG, 2017).

Within the 2018 evidence review, the UK Government sets out what its approach to heat decarbonisation will likely be based on. This includes:

- Reducing heat demand by building an energy efficiency markets for homeowners, reducing energy use in businesses by 20% by 2030; improving energy efficiency in new and existing buildings; working with industry to reduce demand through two support programmes.
- Supporting in the short term a sustainable growth in 'no or low regrets' low carbon heating, by supporting the deployment of heat networks with grant and loans and continuing with the Renewable Heat Incentive.
- Developing a new long-term policy framework for heat to support the national transition. This framework will seek to: give appropriate support to consumers; enable a cost-effective transition across energy industries and industry; and deal with the uncertainties that will arise of a multi-decadal heat decarbonisation timetable (BEIS, 2018a).

A2.1.2. Financial Support Measures

The UK has a range of subsidies, grants and innovation programmes to support the implementation for low carbon heating and improvements in energy efficiency. This includes a Renewable Heat Incentive to encourage the installation of renewable heat generation technology, an investment programme for heat networks, and demonstration programmes for heat pumps. There is also legislation and support for energy efficiency improvements and range of emerging policies for new buildings and existing buildings.

The Renewable Heat Incentive (RHI)

The Renewable Heat Incentive has been introduced since 2011 and now comprises both a domestic and a non-domestic scheme. Both schemes rely on the owner of the system paying for the installation, before qualifying for payments based on heat generated over a number of years following installation. The payments are designed to provide a return on investment. Technologies eligible under the RHI are air-source or ground-source heat pumps, solar thermal, biomass boilers, and some commercial biogas.

The domestic RHI has accredited over 72,000 systems, the proportions of different technologies are shown in the pie chart below.

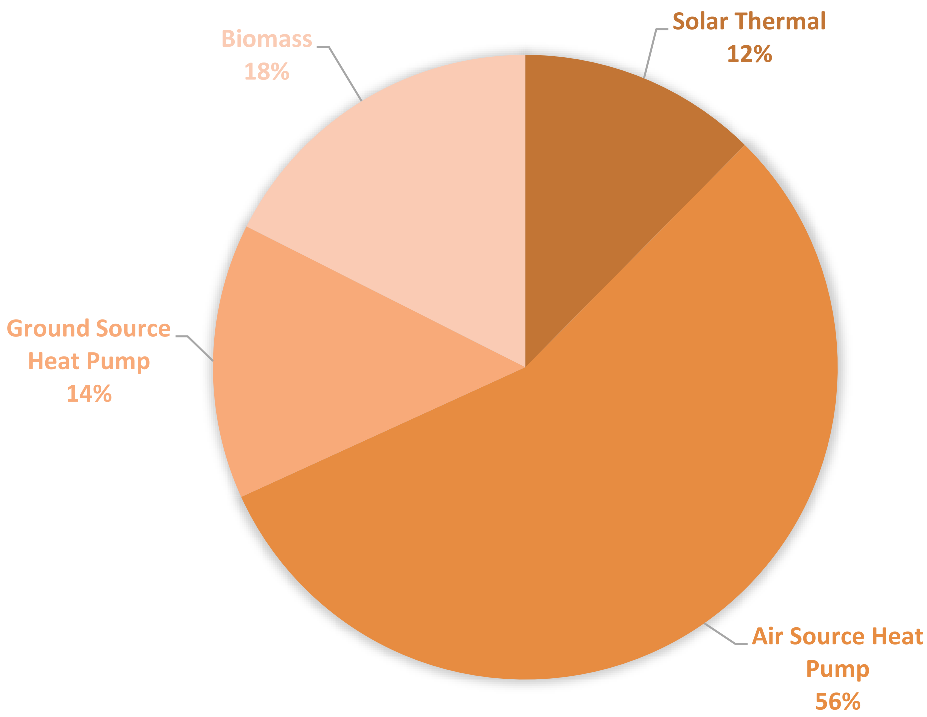


Figure A2-1: Domestic RHI installations by technology type up to Sept 2019 (BEIS, 2019c)

The non-domestic scheme has supported mostly biomass boiler installations (86%) and around 4,500 MW of heating in total.

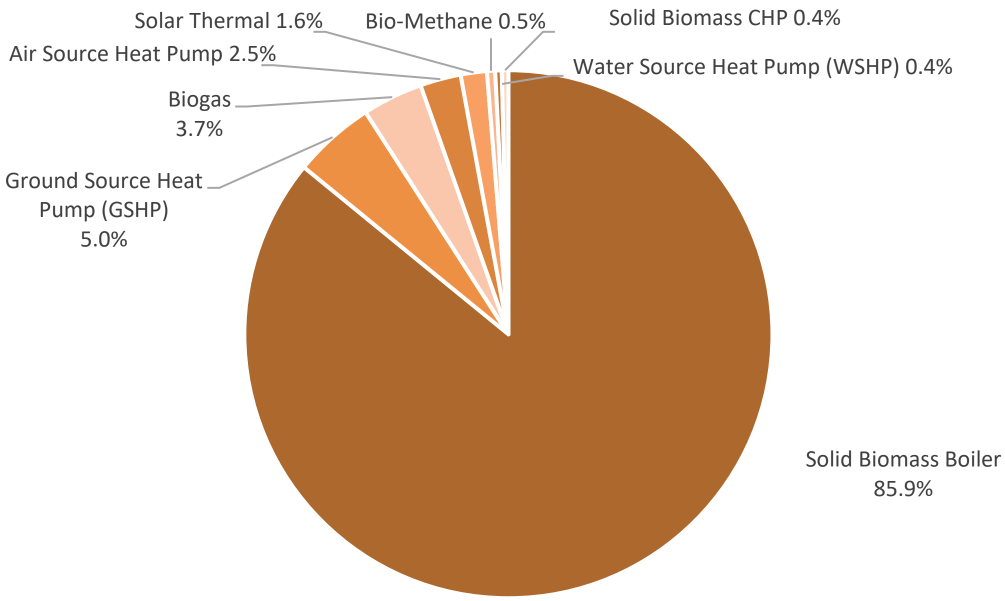


Figure A2-2: Non-Domestic RHI Installations by technology type up to June 2019 (BEIS, 2019c)

As set out in the 2017 Clean Growth Strategy, the RHI was reformed after its implementation to focus more on long-term decarbonisation through greater uptake of technologies such as heat pumps and biomethane injection to the gas grid (BEIS, 2018b).

Heat Networks Investment project

The Government established a Heat Delivery Unit in 2013 which supports local authorities in England and Wales with heat project development, including mapping, planning, feasibility studies and project development. Around £19m (€21.7m[30]) of funds have been awarded through the delivery unit. In 2018 a new £320m (€365m) Heat Networks Investment project to provide capital funding to promote heat networks in areas of denser heat demand. The funding will be open for applications for up to three years (BEIS & Triple Point, 2019).

Electrification of Heat Demonstration Project

The Electrification of Heat Demonstration Project aims to demonstrate the feasibility of a large-scale roll-out of heat pumps in Great Britain by installing them in a representative range of 750 homes. Approximately £16.5m (€18.8m) is available under this programme. The scheme will open to applications in 2020 (BEIS, 2019b).

Energy Efficiency Subsidies

The UK's major national policy for facilitating energy efficiency (EE) improvements is the Energy Company Obligation (ECO) which makes suppliers responsible for providing EE measures to poorer households. Between 2013 and 2019 the ECO (and the short-lived Green Deal) has seen measures installed in around 2 million properties. Overall, most (55%) measures installed were insulation – of

[30] Comparisons at average 2019 exchange of £1:€1.14 (https://www.ofx.com/en-us/forex-news/historical-exchange-rates/yearly-average-rates/)

which 22% was cavity wall insulation, 15% was loft insulation, and 7% was solid wall insulation. 28% were improvements to boilers and 18% categorised as 'other heating' measures (BEIS, 2019c), 2019a). However, uptake of all these measures has stalled recently, even those most cost-effective such as loft insulation (CCC, 2019b).

The Government is also seeking to reduce energy demand within industry, through the £18m (€20.5m) Industrial Heat Recovery Support Programme. This grant funding is design to encourage and support investment in heat recovery technologies, helping businesses of any size to identify and invest in opportunities for recovering and reusing heat that would otherwise be wasted. The programme runs until March 2022, covering feasibility studies; preliminary engineering; and detailed design and delivery (BEIS, 2019d).

There will also be a £315m Industrial Energy Transformation Fund (IETF) to support businesses with high energy use to cut energy bills and carbon emissions through investing in energy efficiency and low-carbon technologies. The Government expects the fund to be open to applications in summer 2020. For energy efficiency they intend to support technologies that improve industrial process energy efficiency and those that reduce energy demand across a system. For deep decarbonisation they will allow projects such as industrial carbon capture, fuel-switching options (low carbon hydrogen, biomass, and electrification), and material efficiency (BEIS, 2019g).

There is also a competition with around £6m of funding to support the development of new business models that encourage take up of energy efficiency projects by small and medium businesses (SMEs). This links to a Government ambition to improve energy efficiency in businesses by at least 20% by 2030. The competition closed in May 2019 and 14 projects were funded to develop feasibility studies. From those further funding will be provided in January 2020 for projects that will run until March 2021 (BEIS, 2019a).

A2.1.3. Regulation

UK Building Regulations outline the minimum standards for energy efficiency and carbon emissions with which all new buildings must comply. These include standards for different elements of building fabric and heating systems; for example, the 2018 Boiler Plus standards for domestic boilers, set out in building regulations, set minimum standards for boiler efficiency, the need for time and temperature controls to be installed, or be working if already installed (BEIS, 2017). As a result of these regulations new houses now mostly have an Energy Performance Certificate level B (MHCLG, 2019), but only 1% of new homes built in 2018 were Energy Performance Certificate band A (CCC, 2019a). The Committee on Climate Change have emphasised that the 'performance gap' between regulated standards and how houses actually perform must be closed in order to meet climate targets.

The Minimum Energy Efficiency Standards (MEES) have recently been introduced to improve the efficiency of private domestic rental properties (BEIS, 2017). The aim is to raise all properties to at least a level E on their Energy Performance Certificate in order to be rented out. The landlord is obliged to comply by a certain date (April 2020 is the final cut-off) unless reaching that level would cost in excess of £3,500 (€3,990) (including VAT), in which case an exemption can be registered (BEIS, 2017).

As part of the UK Industrial Strategy, under the Clean Growth theme, there is the Buildings Mission which seeks to at least halve the energy use in new buildings by 2030 (BEIS, 2019f). One of the mechanisms to support this will be the Future Homes Standard (currently under consultation (MHCLG, 2019)). This sets out the Governments plans to increase the energy efficiency requirements for new homes in 2020 and require all new homes to be future-proofed with low carbon heating and high levels of energy efficiency from 2025 (within England). This includes improvements to current building regulations. The aim is to build homes that have 75% to 80% fewer CO_2 emissions than those built to current building regulations. There is also a stated objective of halving the cost of renovating existing buildings, but little detail on how this will be achieved.

Linking to the Buildings Mission, a Future Framework for Heat in Buildings is looking at how to phase out the installation of high carbon fossil fuels from rural homes and businesses off the gas grid during the 2020s, starting with new buildings (BEIS, 2018a). The Government recognises that it has an important role in enabling this to happen, their view is that that the most effective approach will be through making properties more efficient and then electrifying heating in the majority of buildings. The Government is currently developing a policy framework to enable this to help build a market and standards to help drive an industry response. To help develop this policy framework the government is proposing to: consult on new regulations; consult on skills and training, installation standards, compliance and enforcement options; and consult on changing part L of Building Regulations (BEIS, 2018a).

A2.1.4. Capacity building

Skills & Training

The UK Government provided Renewable Heat Training vouchers for heating engineers. The scheme provided vouchers for training which could be booked through an online platform as well as an apprenticeship initiative to skill up people coming into the industry. £650,000 (€741,000) was invested in the programme up to 2014. £400,000 (€456m) was available for training courses (up to £500 or 75% of the cost of the training). 100 green apprenticeships were funded at a cost of £250,000. The programme was reported as popular, but is no longer funded. Both the Committee on Climate Change and the Government recognize that new training and skills will be needed (BEIS, 2018a; CCC, 2019a). As part of the development of its new heat policy framework the UK Government is looking at what their role should be in low-carbon heat (re)training for installers (BEIS, 2018a).

Transforming Construction

As part of the wider work the UK Government is carrying out within its Industrial Strategy and ongoing work on improving buildings and shifting towards low carbon heat, there are a range of initiatives to support the transformation of the construction sector.

This includes a £170m (€194m) for a Transforming Construction Industrial Strategy Challenge Fund, which is matched by £250m (€285m) of private sector investment, for new construction products, technologies and techniques. Wider initiatives include: a Construction Sector Deal setting out partnership plans between the industry and the government that aims to transform the sector's productivity through innovation and skills development; an Active Buildings Centre with £36m (€41m) investment from government and industry to develop new building materials which generate electricity from light and heat; an investment of £72m (€82m) to establish a Construction Innovation Hub, to support research into developing and commercialising digital design and offsite manufacturing technologies; and supply chain pilots to funded with £3m (€3.4m) to test different approaches to increase the rate of energy efficiency improvement by supporting local supply chain integration and project coordination. The work on Transforming Construction also links to wider policy developments discussed above, including the Future Home Standard, consultations on improving building regulations, and includes a design competition for the Home of 2030 to encourage innovation in the design and delivery of higher quality, more energy efficient housing (BEIS, 2019g).

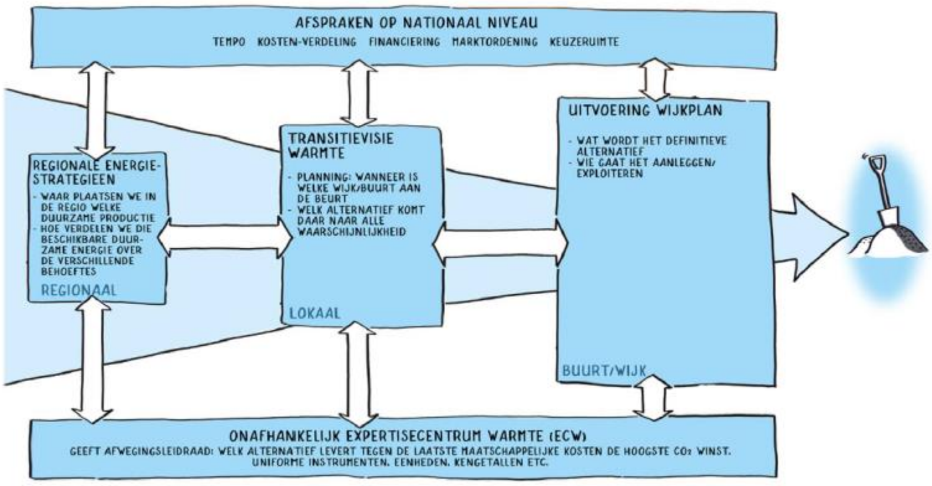
Whole House Retrofit (WHR) Competition

Also linking to the initiatives on construction, this competition seeks to reduce the cost of domestic retrofits. It is supporting Government ambitions to: halve the cost of retrofitting existing buildings to the same standard as new builds by 2030; the Fuel Poverty target to bring as many fuel poor homes as reasonably practicable to EPC band C by 2030; and the aspiration for as many homes as cost effective, practical and affordable to reach the same standard by 2035. Around £9.4m (€10.7m) of funding was made available for a number demonstration projects, these are due to be completed by 2021 (BEIS, 2019h).

A2.2. The Netherlands

Klimaatakkoord - Energieagenda
https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/duurzame-energie-opwekken/verduurzaming-warmtevoorziening/beleid-warmte-en-koude
https://publicaties.energieakkoordser.nl/2018/domein_12

Figure A2-3: (bron: KaapZ (2018) Van het aargas af - Lokale warmtetransitie voor gemeentes)



Regionale Energiestrategieën (RES)
https://regionale-energiestrategie.nl
Handreiking Regionale Energiestrategieën https://regionale-energiestrategie.nl/handreiking/default.aspx
https://www.rvo.nl/initiatieven/overzicht/28175

Transitievisie warmte
Inspiratiegids:
OverMorgen (2017) Samen aan de slag met aardgasvrij Inspiratie voor gemeenten. Publicatie iov. Rijksdienst voor Ondernemend Nederland

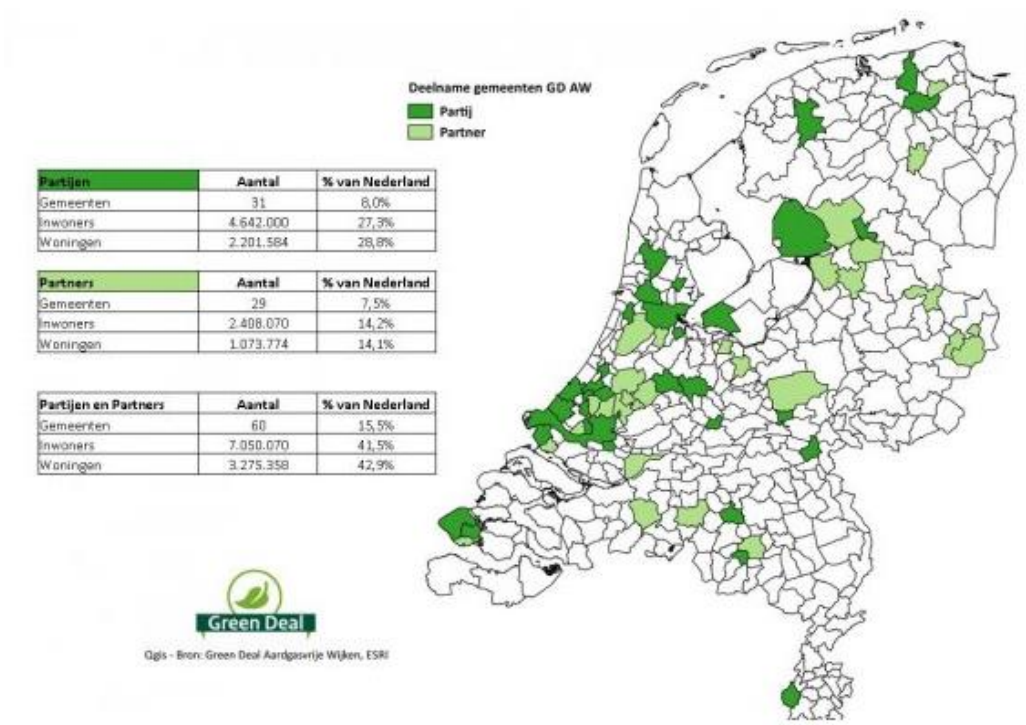
https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/duurzame-energie-opwekken/aardgasvrij/aan-de-slag-met-aardgasvrij/transitievisie-warmte-en-wijkuitvoeringsplan

Leidraad (handreiking) Transitievisie Warmte
https://www.expertisecentrumwarmte.nl/leidraad/default.aspx

Wijkuitvoeringsplan

- Green deal aardgasloze wijken
  - https://www.greendeals.nl/green-deals/aardgasvrije-wijken
  - https://www.rvo.nl/onderwerpen/duurzaam-ondernemen/duurzame-energie-opwekken/aardgasvrij/ervaringen-green-deal-aardgasvrije-wijken

Figure A2-4 source: Green Deal



Partijen	Aantal	% van Nederland
Gemeenten	31	8,0%
Inwoners	4.642.000	27,3%
Woningen	2.201.584	28,8%

Partners	Aantal	% van Nederland
Gemeenten	29	7,5%
Inwoners	2.408.070	14,2%
Woningen	1.073.774	14,1%

Partijen en Partners	Aantal	% van Nederland
Gemeenten	60	15,5%
Inwoners	7.050.070	41,5%
Woningen	3.275.358	42,9%

- Handreiking (~handleiding) gebiedsgerichte warmteuitwisseling

Expertisecentrum warmte (ECW)
https://www.expertisecentrumwarmte.nl

Varia

- https://www.hierverwarmt.nl/
- Green deal Warmtepompen (officieel "Green Deal Ontwikkeling Decentrale Duurzame Warmte- en Koudetechnieken") https://www.greendeals.nl/green-deals/ontwikkeling-decentrale-duurzame-warmte-en-koudetechnieken

A2.3. Belgium, Flanders

A2.3.1. Strategy and goals

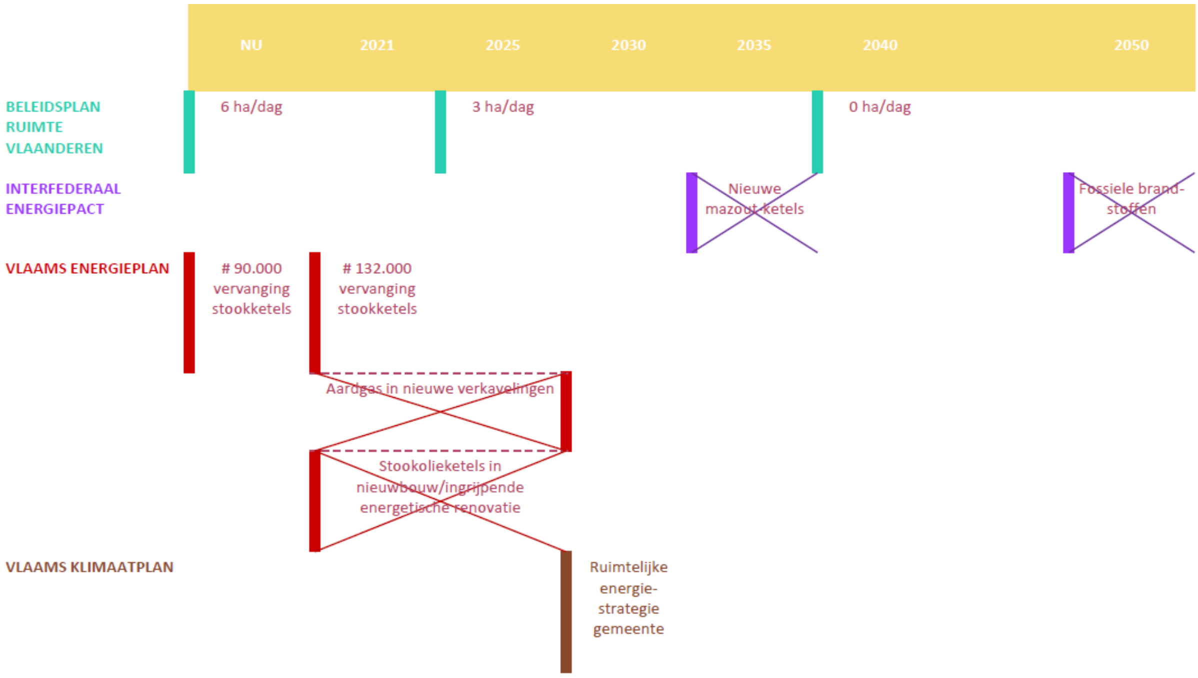
A comprehensive overview of energy policy in Flanders is available on the website of the Flemish Energy Agency (VEA)[31]. This chapter discusses a selection of relevant policy initiatives, both on national and regional level. This concerns existing policy frameworks as well as policy initiatives under progress.

Flemish Energyplan 2021 - 2030

The Flemish Energyplan 2021 – 2030 is currently in design phase. It serves as input from the region of Flanders for the National Energy and Climate Plan (NECP)[32]. A public consultation has been held in summer 2019 and five working groups have been concluded in September 2019.

Key measures related to sustainable heating concern a phase-out of fossil-fuelled heating systems by 2030 and the requirement for local heat zoning plans by 2030.

Figure A2-5:



The draft reports are currently under revision as the final Energy and Climate Plans will have to be submitted in the end of 2019.

[31] https://www.energiesparen.be/vlaamsenergiebeleid

[32] Draft reports and the European Commission's evaluation: https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union/national-energy-climate-plans

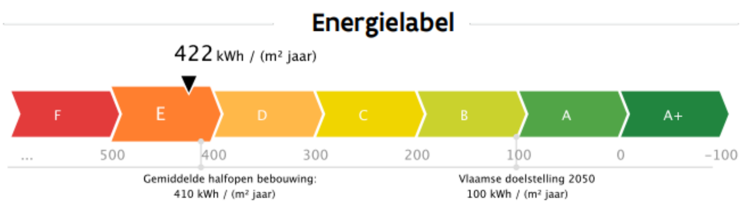
Flemish Heat plan 2020

Flemish renovation pact and energy performance certificate regulation

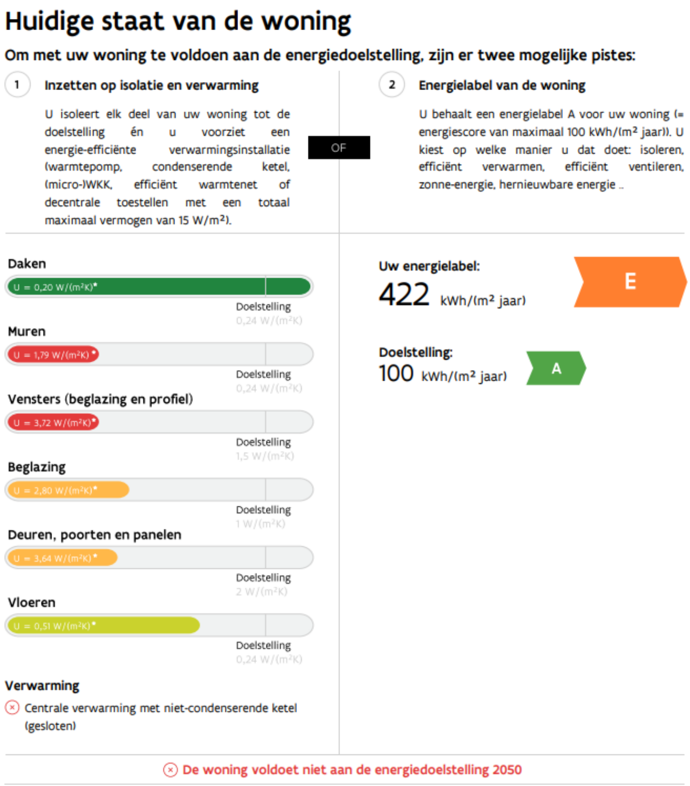
The Renovation Pact[33] is initiated by the Flemish government in December 2014. It is coordinated by the Flemish Energy Agency (VEA) and is a collaboration of the Flemish government and 22 stakeholder organizations. Policy instruments such as a building renovation passport (NL: Woningpas) and an improved energy performance certificate (EPC+) were developed as part of the Renovation Pact.

The goal of the Renovation Pact is to have all existing homes in Flanders in 2050 as energy efficient as new-build homes, compared to current energy efficiency standards. More specifically, this corresponds with an energy performance level for the building (label A (100 kWh/m².year or better) or E-level E60, depending on the energy performance calculation method). Another option is to meet the insulation standards for the different building components and to have an energy efficient heating system (heat pump, condensing boiler, microCHP, connection to district heating of a decentralised heating system with a maximum capacity of 15 W/m²)[see figure X].

Figure A2-6: 2050 energy performance targets as visualised on current EPCs [www.energiebesparen.be]



[33] https://www.energiesparen.be/renovatiepact



Currently there are no obligations associated with the 2050 energy target put forward by the Renovation Pact. However, it is expected that homes that do not meet these targets might decrease in real-estate value as a result of their negative energy performance level.

A2.3.2. Implementation measures

Grants and subsidies

At the time of writing, the following grants and subsidies for sustainable heating are applicable:

- Call 'green heating, residual heating, district heating networks and green gas' [34]
- Ecology grant for businesses for selected energy technologies[35]
- Combined Heat and Power (CHP) certificates[36] [37]
- Grants for selected energy efficiency measures for individual homeowners (including heat pumps and solar collectors in existing homes)[38]

Every year, the Flemish Energy Agency launches a call for green heating projects. Financial support can be requested for projects related to green heating, residual heating, district heating networks and green gas (i.e. bio-methane).

In 2019, 28 projects were submitted, which is a significant increase compared to previous years (12 submitted projects in 2017; 13 submitted projects in 2018).

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[34] https://www.energiesparen.be/call-groene-warmte
[35] https://www.energiesparen.be/ecologiepremie-ep-plus
[36] https://www.energiesparen.be/groene-energie-en-wkk/prof/WKC
[37] https://www.vlaio.be/nl/subsidies-financiering/subsidiedatabank/ecologiepremie
[38] https://www.fluvius.be/nl/thema/premies

Table A2-1: Overview of granted projects in 2019 (https://www.vlaio.be/nl/subsidies-financiering/subsidiedatabank/investeringssteun-groene-warmte-restwarmte-en-biomethaan & https://www.ode.be/nl/artikel/390/jongste-call-groene-warmte-steunt-26-projecten)

Technology	Projects granted	Energy production	Subsidy
Green heating: heat pump technology, solar collectors, biomass	15#	72 GWh/year	6,5 M€
Residual heating and district heating	10#	12 GWh/year	5,8 M€
Bio-gas	1#	-	

Flemish Energy performance regulation - feasibility study for renewable energy technologies

In particular the requirement to conduct a feasibility study for renewable energy technologies[39] for new built with a net surface area greater than 1.000 m² is worth mentioning. This relates to EPBD article 6[40]. For new buildings, before construction starts, the technical, environmental and economic feasibility of high-efficiency alternative systems such as those listed below, if available, has to be considered and taken into account. A distinction is made between *technology level* (e.g. heat pumps) and *system level* (e.g. district heating).

Figure A2-7:

te onderzoeken alternatieve systemen		stads/blokverwarming of -koeling indien beschikbaar	warmtekracht-koppeling	warmtepomp onder bepaalde voorwaarden	gedecentraliseerde systemen voor energievoorziening op basis van hernieuwbare energiebronnen		
te onderzoeken technologie			warmtekracht-koppeling	warmtepomp voor verwarming	biomassaketel	zonneboiler of warmtepompboiler	fotovoltaïsche zonnepanelen
gebouwbestemming (hoofdbestemming)	bruikbare vloeroppervlakte in m² (steeds > 1000 m²)						
wonen	< 5000	x	x			x	x
	≥ 5000	x	x	x	x	x	x
kantoor	< 5000	x	x				x
	≥ 5000	x	x	x	x		x
onderwijs	< 5000	x	x				x
	≥ 5000	x	x	x	x		x
industrie	< 5000	x	x				x
	≥ 5000	x	x	x	x		x
gezondheidszorg		x	x	x	x	x	x
sport		x	x	x	x	x	x
handel	< 3000	x	x				x
	≥ 3000	x	x	x	x		x
bijeenkomstgebouw	< 3000	x	x				x
	≥ 3000	x	x	x	x		x
horeca	met verblijf	x	x	x	x	x	x
	zonder verblijf en < 3000	x	x			x	x
	zonder verblijf en ≥ 3000	x	x	x	x	x	x

[39] https://www.energiesparen.be/EPB-pedia/haalbaarheidsstudie

[40] DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings (recast), article 6

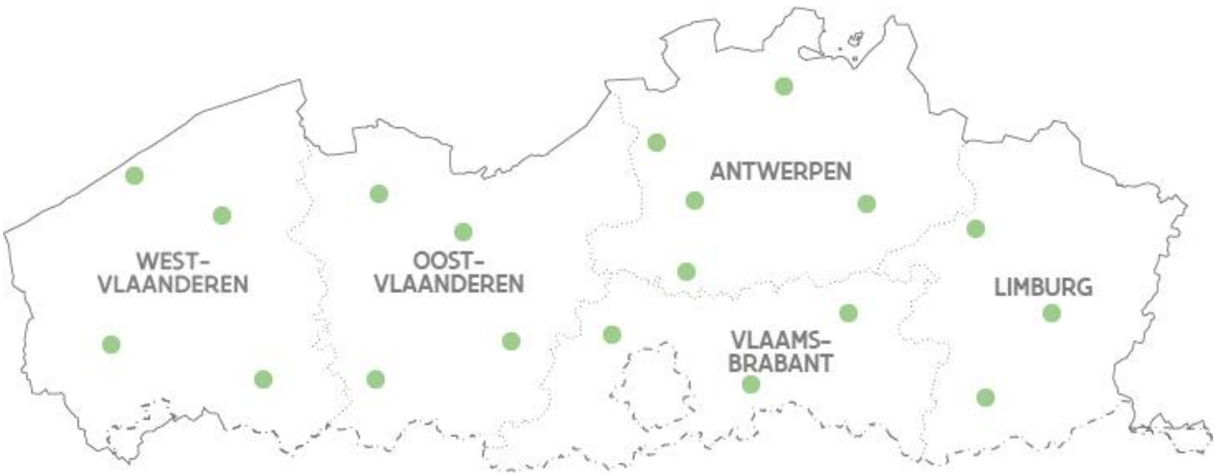
There are no specific requirements in terms of the skills and required technical competences put forward for the one who conducts the study. Furthermore, specifications for the feasibility study leave much flexibility with regards to the tools and calculation method to use. This is expected to vary greatly in complexity, depending on the project and building context.

The feasibility study has to be submitted to the Flemish Energy agency via an online form within one month after applying for a building permit.

A2.3.3. Capacity building

Provinciale steunpunten[41] en Energiehuizen[42]: An Energy House is a municipal entity or a collaboration between different municipalities. From 2019 onwards, citizens can contact Energy Houses for all questions about energy savings, grants and loans for energy efficiency measures, home energy renovation advice, energy scans, etc. Flanders currently has 19 Energy Houses. There is an Energy House for almost every municipality.

Figure A2-8: Overview of Flemish Energy Houses [www.mijnenergiehuis.be]



Furthermore, each province has a contact point for sustainable living and building.

A2.3.4 Other relevant initiatives

Safety and heating[43]

Mandatory and voluntary measures to avoid safety and health issues. This involves inspection and maintenance requirements for heating systems.

Green Deal

huishoudelijke houtverwarming[44]: A public private partnership focusing on residential biomass heating systems. This concerns the phase-out of old, malfunctioning biomass heating systems, requirements

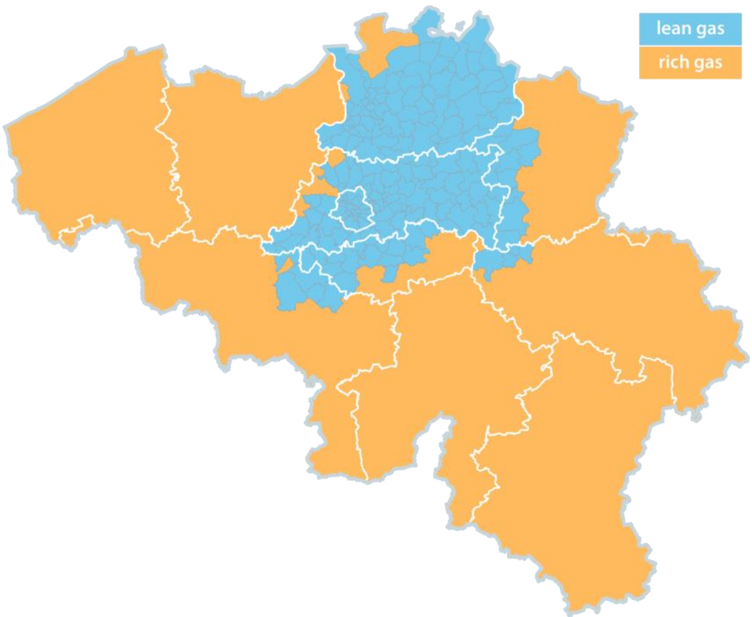
[41] https://do.vlaanderen.be/provinciale-en-stedelijke-steunpunten
[42] https://www.mijnenergiehuis.be/home
[43] https://www.lne.be/veilig-verwarmen
[44] https://www.lne.be/green-deal-huishoudelijke-houtverwarming

and recommendations related to the installation, maintenance and use of heating systems, development of high-performance heating systems, etc..

Conversion from lean to rich gas[45]

In Belgium, over 3 million households and companies use natural gas from the distribution network, mainly to heat their home or place of residence, for water heating and for cooking. Half of these users consume lean gas, imported from the northern Netherlands (Groningen - Slochteren). However, the Dutch authorities have announced that they intend to reduce their gas exports and to halt them completely from 2030. Lean gas will be replaced by rich gas, which will be imported from other countries such as Norway, the United Kingdom, Qatar and Russia. This means that Belgian households and companies currently consuming lean gas will instead receive rich gas. Today, one in two Belgian gas consumers are already using rich gas. Rich gas has a different composition than lean gas. This is why the infrastructure used to transport gas from the Netherlands and around our country must be adapted.

Figure A2-9: (www.gasverandert.be)



A2.4. France

A2.4.1. Strategy and goals

In France the PPE (Programmation pluriannuelle de l'énergie) defines the national policy strategy and goals for energy. After a year of debate and preparation, a draft policy document was published in January 2019. The Multiannual Energy Programme (PPE) is not legislation but presents the trajectory to be followed over the next ten years in terms of energy policy. The PPE's ambition is to lead France

[45] https://www.gaschanges.be/en

to a new energy mix that should be more efficient and more diverse while reducing consumption. The PPE fixes targets to reach in 2023 and 2028 in harmony with Stratégie nationale bas carbone (SNBC). Two scenarios are studied, one ambitious (B) one realistic (A).

The PPE gives priorities of action to public authorities. For sustainable heating, below are the sum-up of the goals per energy.

Figure A2.10: Overall objective trajectory for sustainable heating in France (Syndicat des énergies renouvables (SER))

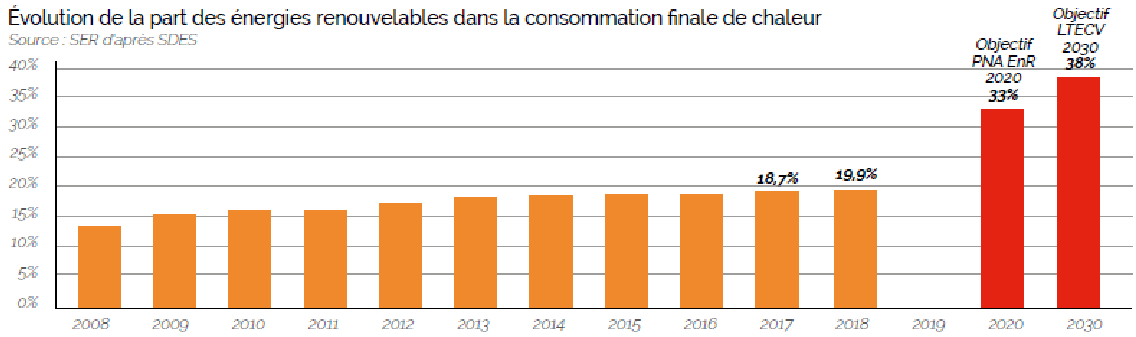


Table A2-2: Goals of sustainable heating production per energy in France

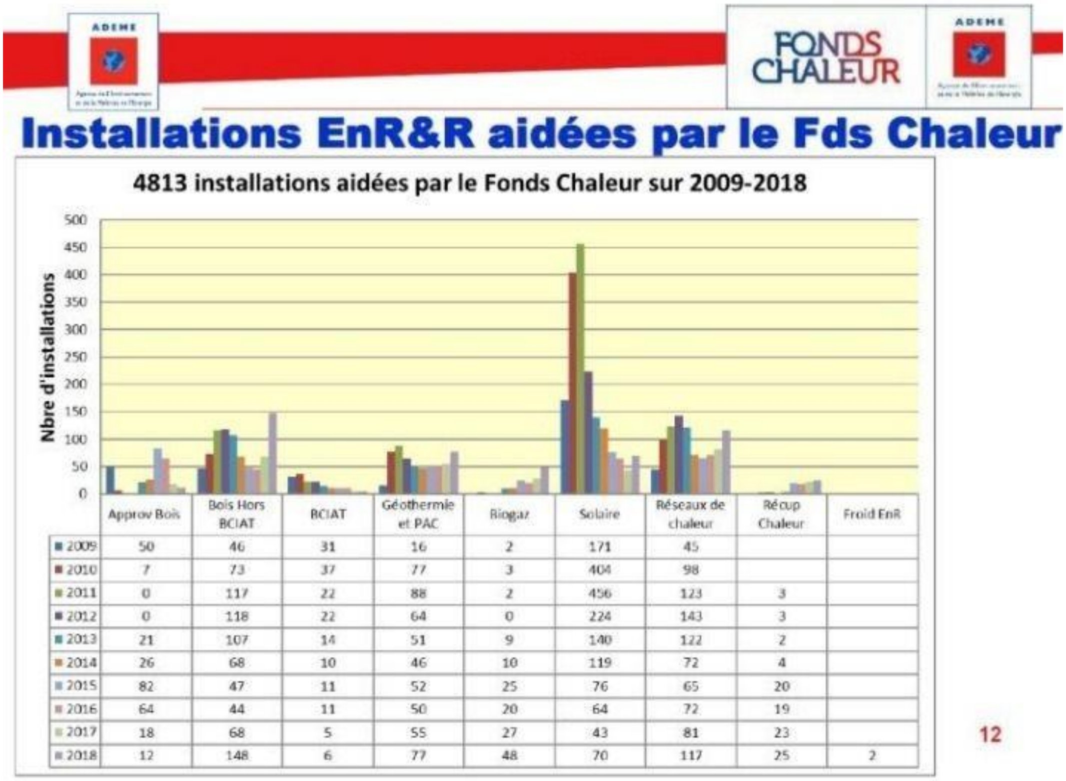
PPE objectives (TWh)P	2023	2028 Scenario A	2028 Scenario B
Share of renewable heat in final heat consumption	169	218	247
Solid Biomass	145	157	169
Of which households	*80*	*80*	*80*
Air thermal heat pumps	35	39	45
Geothermal heat pumps	4,6	5	7
Deep geothermal energy	2,9	4	5,2
Solar thermal	1,75	1,85	2,5
Residual Heat	4,47	12	18

A2.4.2. Implementation measures

The French government created in 2008 the Fond Chaleur in order to support the production of sustainable heat. The budget is estimated at €350 million in 2019. For small and middle sustainable heating projects the support is administered by the regional agencies of ADEME. The district heating network shall use at least 50% of heat from renewable energy to be eligible. The amount of financial support depends on the technical and economical characteristics of the project, the goal is to be competitive compare to a conventional energy project. For solar thermal plant between 25m² and 500 m² the support in Hauts de France is €55/MWh over 20 years.

ADEME finance local organisation to promote sustainable heating and give technical and administrative support to the stakeholders of a project.

Figure 2-11: Results of projects subsidised by the Fonds chaleur (Source….).



	Approv Bois	Bois Hors BCIAT	BCIAT	Géothermie et PAC	Biogaz	Solaire	Réseaux de chaleur	Récup Chaleur	Froid EnR
2009	50	46	31	16	2	171	45		
2010	7	73	37	77	3	404	98		
2011	0	117	22	88	2	456	123	3	
2012	0	118	22	64	0	224	143	3	
2013	21	107	14	51	9	140	122	2	
2014	26	68	10	46	10	119	72	4	
2015	82	47	11	52	25	76	65	20	
2016	64	44	11	50	20	64	72	19	
2017	18	68	5	55	27	43	81	23	
2018	12	148	6	77	48	70	117	25	2

For households the French government has created a national programme in thermal in order to lower the energy losses.

There are also some tax incentives; inhabitants investing in sustainable heating are eligible for an income tax credit (Crédit d'Impôt) and for a zero percent-interest loan.

A2.4.3. Capacity building

In France citizens can contact the "Espace info Energie" for all questions about energy savings, grants and loans for energy efficiency measures, home energy renovation advice, energy scans and renewable energy production. There are at least 60 "Espace info Energie" in the Hauts de France region. Those energy houses help only the residential sector. For mid and large-scale installation, regional organization like CD2E can provide technical support.

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