Project No: IEE/13/650

SUMMARY REPORT on WP3

National plan – local action: supporting local authorities

Insights from drafting local heating and cooling action plans

WP 3: National plan – local action: supporting local authorities
Deliverable 3.d (former Deliverable 3.7)

Co-funded by the Intelligent Energy Europe Programme of the European Union

October 2016

Authors: Erwin Cornelis (VITO, BE), Anne Baastrup Holm, Birger Lauersen (DDHA, DK), Kristina Lygnerud (HH, SE)

With the kind support from (in random order):
Alessandro Provaggi, Aksana Krasatsenka (EuroHeat&Power)
Petra Schöfmann, Ralf-Roman Schmidt, Roman Geyer (AIT, AT)
Virginia Gomez Oñate, Dirk Lauwaet, Erik Laes, Frank Meinke-Hubeny, Nele Renders, Pieter Valkering, Dries Vos (VITO, BE)
Jolana Bugáňová (ADH CR, CZ)
Maria Grajcar, Sarah Vautz (AGFW, DE)
Neven Duić, Damir Dović, Goran Krajačić, Tomislav Pukšec, Tomislav Novosel (FSB, HR)
Alessandro Gnatta, Luca Bertagna, Lorenzo Spadoni (A2A, IT)
Gabriela Crisan-Badea, Bogdan Anton (Tractebel Romania, RO)
Christian Koch (BRE, UK)
Indalecio González Fernández (FAEN, Spain)
Bartosz Dubiński (MAE, Poland)

Contact: erwin.cornelis@vito.be; abh@danskfjernvarme.dk

Deliverable No. 3.d (replacing 3.7): public document.

The STRATEGO project (Multi-level actions for enhanced Heating & Cooling plans) is supported by the Intelligent Energy Europe Programme. The sole responsibility for the content of this document lies with the authors. It does not necessarily reflect the opinion of the funding authorities. The funding authorities are not responsible for any use that may be made of the information contained therein.

Co-funded by the Intelligent Energy Europe Programme of the European Union

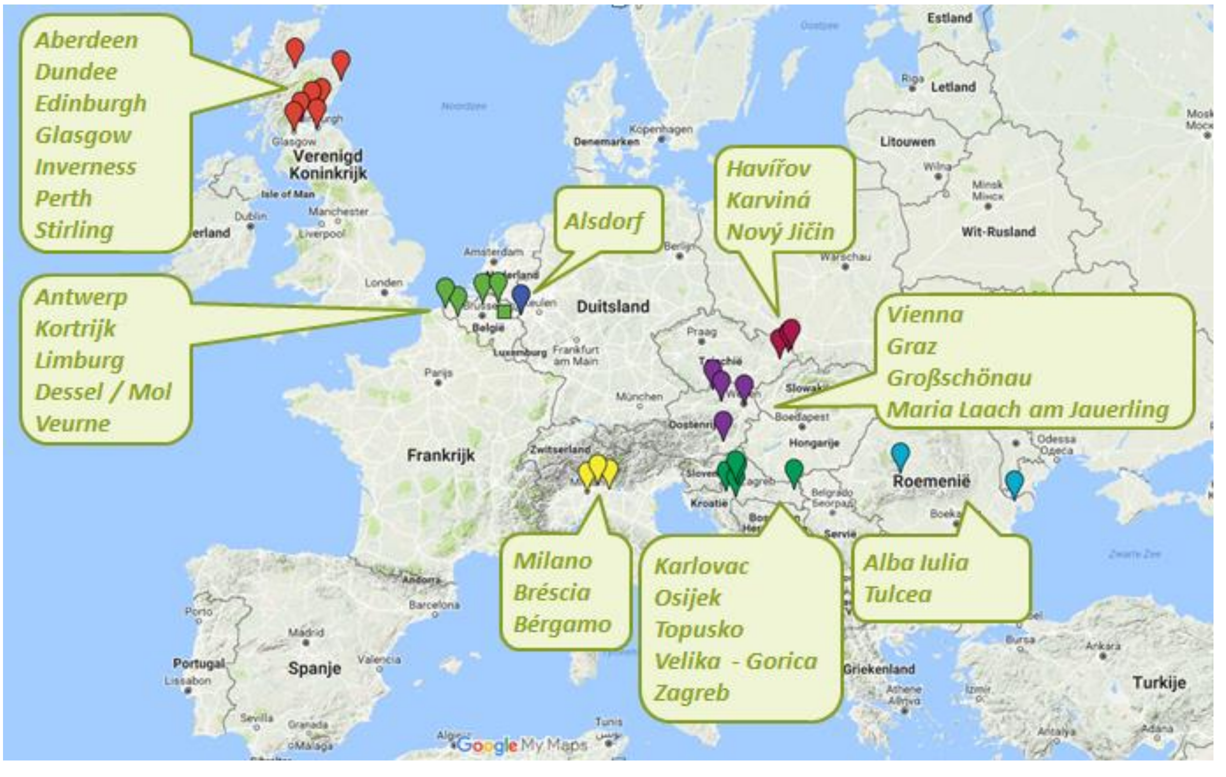
STRATEGO website: http://stratego-project.eu

Executive summary

The STRATEGO project is a European co-funded project developed in the framework of the Intelligent Energy Europe Program. The purpose of the project "Multi level actions for enhanced Heating and Cooling plans – STRATEGO" is to support both national authorities and local authorities in developing Heating and Cooling Plans. The geographical focus of STRATEGO is Austria, Belgium, Croatia, Czech Republic, Germany, Italy, Romania and the United Kingdom, with support from experienced partners from Denmark and Sweden, provide their support.

This report summaries the results of work package 3 of the STRATEGO entitled "National plan – local action: supporting local authorities"; it provides insights on **how to draft tangible heating and cooling action plans at local level**.

Within the framework of this work package, local heating and cooling action plans were drafted for in total 30 target cities. They cover a broad variety of communities, from big cities with over half a million inhabitants to rural communities with less than 1,000 inhabitants, located in eight different countries; covering areas where district heating is relatively new as well as areas where district heating is well establish and is expanding or needs to be refurbished.



The support to the local authorities of these 30 target cities was organised in five tasks:

1. In the first task, demand of heating and cooling was mapped, as well as potential supply points and renewable energy sources. The starting point is the Pan-European Thermal Atlas (PETA)[1], from which data are extracted. This was complemented with locally available data.

[1] Link to PETA: http://maps.heatroadmap.eu/maps/31157/Renewable-Resources-Map-for-EU28?preview=true#

2. Based on the map of local heating and cooling demand and supply, areas of priority for intervention were defined. These are areas where the local conditions are favourable for developing projects first. In total 43 projects were defined in the STRATEGO project.
3. Business models were then developed for each of the identified projects.
4. The results of the previous steps were then discussed with local stakeholders.
5. The results of the previous steps, including the conclusions of the stakeholder meetings, were summarised and presented to the representatives of the target cities, so they can integrate this information in their local heating and cooling action plans.

The results for the individual STRATEGO cases are reported in separate sheets; they can be consulted on the webpage http://stratego-project.eu/projects-description/. The analysis of these cases reveals achievements, challenges, needs and successes for each of the five tasks, which we describe below.

Mapping local heating and cooling demand and supply

Achievements

Heating and cooling maps have been made for 29 STRATEGO cases[2]. The table below indicates which aspect of heating and cooling has been mapped at which level of detail.

Total number of maps = 29		City level	Neighbourhood level	Level of individual installation		
				No details	Additional Info	Metered data
Heating / cooling demand		5	7		6	11
H/C infrastructure			2	13	2	
Sustainable H/C potential	Energy savings	1		1		1
	Excess heat		3	5	1	
	Geothermal		2	2	1	
	Bio-energy		2	1		
	Solar thermal		1	1		

The heat demand has been mapped for all of the STRATEGO cases. Adding the layout of district heating networks to the heat demand map was quite straightforward in most cases. Distinct installations with a significant potential to supply excess heat (such as waste-to-energy installations or power stations) or renewable heat (such as waste water treatment plants) could easily be identified and mapped.

[2] One map combines the heating demand of the two towns Karviná and Havířov,CZ

The STRATEGO five steps' approach to support local authorities in drafting a heating / cooling plan

	Mapping local heating and cooling demand supply	Identification of areas of priority for intervention	Business models for local partners	Involvement of local stakeholders	Input to local heating / cooling action plans
Achievements	Mapping heating demand, district heating networks and distinct excess or renewable heat sources	Definition of projects in all cases Definition of projects of all categories	Business model made according to the proposed canvas for all cases	Involvement of stakeholders, directly involved in the project implemen-tation	Adding the identied projects to the political agenda of the STRATEGO city
Challenges	Mapping of cooling demand, energy saving potential and diffuse renewable heat sources	Assessment of costs and benefits	Developing business models to the level of investment grade plans	Involvement of a wider range of stakeholders	Reaching the level of a strategic heating / cooling action plan for the STRATEGO city
Needs	Appropriate tools for local authorities to map heating and cooling More knowledge on cooling and on how to make it more sustainable	More time to assess the costs / benefits of the projects More focus on sparsely populated areas	More time to develop investment grade business models	A political debate involving a wider range of stakeholders	Guidance to local authorities on how to draft a strategic heating and cooling master plan at city level
Success stories	Simple maps already can provide inspiration for projects	The list of categories gives good guidance to define projects	Business models put the end-consumer at the heart of the projects	An early involvement of a wider range of stakeholders smoothens the path for the implemen-tation of the projects	A strategic master plan at city level puts single projects into a wider context

Challenges

Mapping the cooling demand on the other hand turned out to be much more challenging, as well as the energy savings potential and mapping diffuse sources of renewable heat (such as the potential of heat pumps, solar hot water boilers or biomass sources), because of lack of reliable data sources, quite often even at the national level.

Needs

Mapping heating and cooling demand at local level has demonstrated to be a daunting task. There is a lack of appropriate tools to support local authorities in getting a good overview of heating and cooling demand at a high geographical resolution.

Apart for the need for appropriate tools, there is also a need for easily accessible data to the local authorities, so that they can have estimates of the heating and cooling demands for the different buildings or estimates of the sustainable heat supply potential of various sources.

The STRATEGO cases have demonstrated that cooling is a blind spot overall. There are significant knowledge gaps on the extent that cooling is needed in various sectors, on the already in place installations to provide cooling and on the alternatives and their associated costs and benefits. Research is needed to fill these knowledge gaps.

Success stories

The STRATEGO project partners succeeded, despite the challenges, to present maps showing a huge variety of relevant data layers. It was also observed that simple maps already can provide inspiration for heating and cooling projects.

Maps of	Showcases
Heating and cooling demand	Edinburgh, UK: heating demands maps, based on metered data Antwerp, BE: heating demands maps, based on metered data Zagreb, HR: cooling demand maps based on building characteristics Alsdorf, DE: heating demand maps based on building characteristics Graz, AT: extract from national heating demand maps Tulcea, RO: extract from PETA, the Pan-European Thermal Atlas Limburg, BE: heat demand processes to a statistical map
H/C infrastructure	Vienna, AT: map showing the district heating grid and the heat sources
Energy savings potential	Kortrijk, BE: thermographic scan Limburg, BE: Average fuel consumption per municipality as indicator of energy savings potential
Excess heat potential	Ostrava, CZ : indication of thermal power plants and industrial facilities of some energy-intensive sectors on the PETA-extract Lombardy region, IT: biomass plants, waste incinerators and power plants
Renewable heat potential	Topusko, HR: map of the geothermal boreholes that can be reactivated Antwerp, BE: Map of the municipal biomass waste potential and the heat extraction potential from the sewage system Limburg BE: Statistical map of the potential of some renewable heat sources

Identification of areas of priority for intervention

Achievements

Areas of priority and projects have been identified in all cases; this has resulted in the definition of 43 projects over the 30 STRATEGO cases. The identified projects are showcases of all six categories that will support the enhancement of heating and cooling. It could be observed that some of the STRATEGO cases were a combination of categories. This demonstrates that synergies creates opportunities for projects of other categories.

7 projects on reducing heating and cooling demand at end-consumers
Belgium, Croatia, Romania
Energy savings: 2 – 90 GWh/year
Energy savings: up to 40%

25 projects on district heating networks – refurbishment, expansion and/or new ones
Austria, Belgium, Croatia, Czech Republic, Germany, Romania, UK
8: refurbishment
4: expansion
13: new schemes

1 project on sustainable individual heating and cooling solutions (phasing out heating oil in rural areas)

Belgium
High correlation between share of heating oil and specific heat consumption

13 projects on tapping excess heat potential
Austria, Belgium, Czech Republic, Italy, UK
1: from a data centre 6: from the industry
2: from a power plant 5: from a W-t-E plant
Potential: 70 – 1,400 GWh/year

12 projects on tapping renewable heat sources

Austria, Belgium, Croatia, Germany, UK
Potential: 0.1 – 20 GWh/year

12 projects on improved conversion of fossil fuels
Belgium, Croatia, Czech Republic, Romania, UK
4: CHP instead of HoB
5: better operation of CHP
3: condensing or electric boilers

Challenges

The projects are sometimes quite complex in nature, this made it challenging to assess the costs and benefits for most of the identified projects.

Needs

It turned out that both more time and data are needed to end with a final design of the identified projects. The process between identifying projects and elaborating these to prepare investment decisions is a long process and cannot be fully completed during the timeline of the STRATEGO project.

Most of the cases focussed on city centres and many of these cases investigated the possibilities to refurbish, expand or build new district heating networks. Yet, a sustainable heating and cooling strategy should look to all heating and cooling consumers, also those in sparsely populated areas. More such cases should hence be examined.

Success stories

A guidance for the STRATEGO partners was compiled, explaining a list of six categories of projects to consider, to support the partners in the identification of projects for making their local heating and cooling system more sustainable:

1. Reduce heating and cooling demand at end-consumers
2. Improve and expand existing heating and cooling networks or build new ones in areas with a substantial heating and cooling density
3. Look for more sustainable individual heating and cooling solutions in areas with a limited heating and cooling density
4. Tap excess heat from thermal power stations, waste-to-energy installation, energy-intensive industry, …
5. Tap renewable heating and cooling sources (geothermal, bio-energy, solar thermal)
6. Improve conversion of fossil fuels used for heat or cooling purposes

This list has demonstrated to be very useful to define projects.

The fact that projects of all six categories have been defined demonstrates that the Heat Roadmaps, defined in work package 2 of the STRATEGO project, can be realised in practice.

Business model for local partners

Achievements

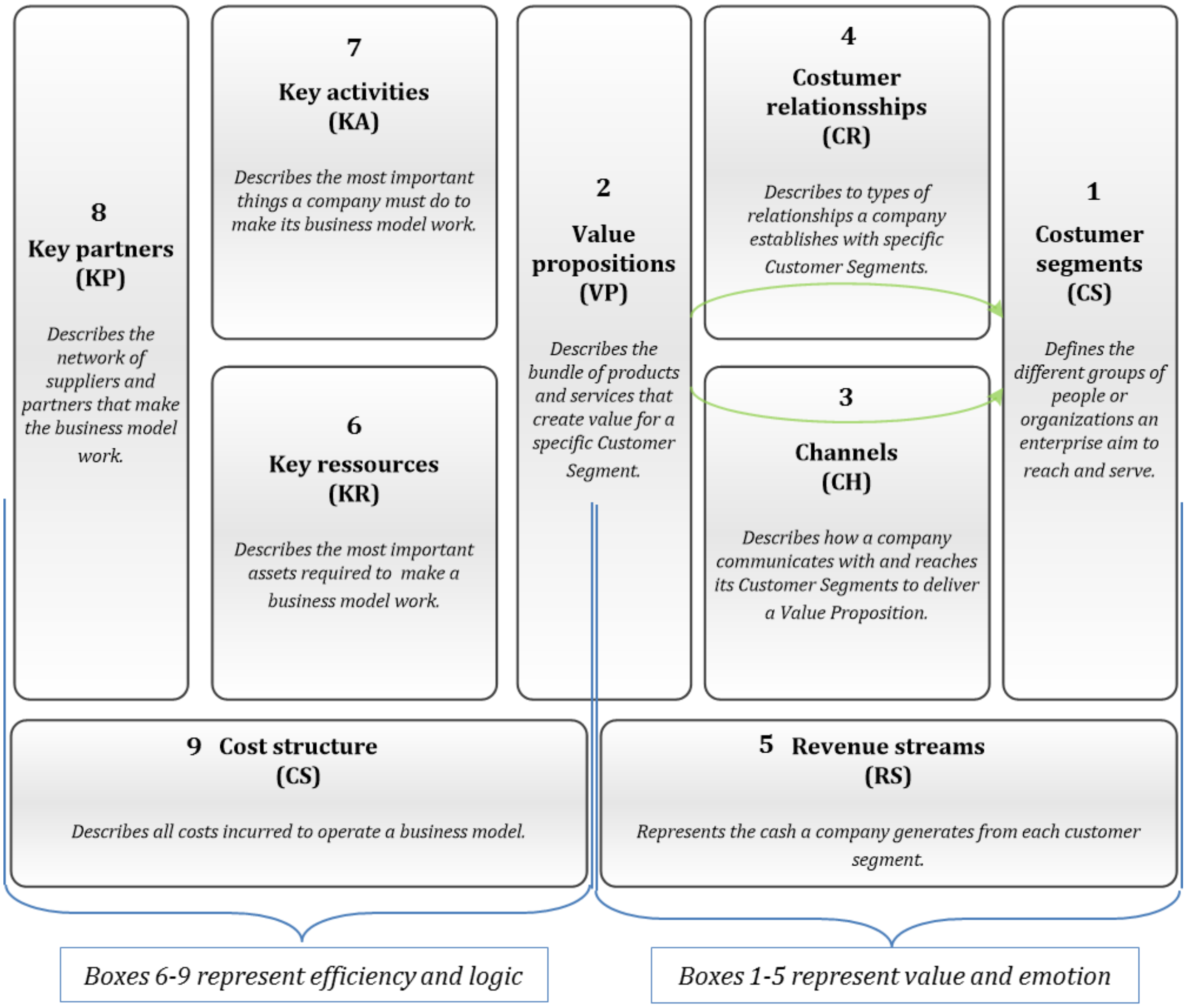
In total 36 business models have been developed for the 43 identified projects. The number of models is smaller than the number of cases since some business models are identical for multiple projects. The development of business models has been based on the Business Model Canvas[3].

Challenges

The business models of the projects are very complex and involve a lot of stakeholders. This makes the development of an "investment ready" business model more time consuming than foreseen at the inception of the STRATEGO project.

[3] Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers / Edition 1, Alexander Osterwalder, Yves Pigneur, 2010

The business models developed during STRATEGO are all in an early stage of development and the majority are characterised by a lot of uncertainty.



Needs

The main lesson from the business model development in STRATEGO is that business models for district heating and cooling need to be flexible to allow changes over time as the focus becomes clearer and uncertainties are sorted out. Furthermore, it has been identified that the different heat markets have different stages of maturity, which also adds to a prolonged phase of the development.

It is concluded that developing district heating and cooling projects, including their business models, is a lot more demanding than foreseen at the inception of the STRATEGO project.

Success stories

The Business Model Canvas has demonstrated to be a useful tool. It allows to look at the projects from different perspectives. They put the end-consumer at the heart of the projects. Some of the STRATEGO cases indeed put the end-consumer upfront by proposing for instance locally generated, low carbon heat and electricity (baseload) at low and stable costs.

Involvement of local stakeholders

Achievements

The projects and their business models have been discussed with stakeholders. In most cases, the stakeholders directly involved in the implementation of the project were involved the most; i.e. the local authorities and the district heating grid operations.

Challenges

A wider range of stakeholders was only involved in a minority of cases. These stakeholders are end-consumers, heat suppliers, regional authorities, energy agencies or suppliers to district heating systems and in some cases STRATEGO coaching partners.

Needs

There is a need for a public debate within the STRATEGO target cities on heating and cooling and its transition towards a more sustainable system. Such a public debate would automatically trigger interested stakeholders to participate, which in turn would broaden the range of involved stakeholders.

Success stories

Some STRATEGO target cities succeeded in organising a public debate involving a wide range of stakeholders. The outcome of these public debates is a common understanding of the city's ambition on heating and cooling and a public approval which smoothens the path for the implementation of the heating & cooling projects, realising the ambition.

Input to local heating and cooling action plans

Achievements

The final step consists of providing input to local action plans on heating and cooling in the STRATEGO target cities. Thanks to this input and to involvement of the local authorities in the stakeholder meetings, the identified projects have been added to the political agenda of the STRATEGO target cities.

Challenges

Although input has been given to all STRATEGO target cities, only a minority of the local heating and cooling plans reached the level of a strategic master plan. The majority tends to focus on the implementation of specific projects. Such a master plan defines strategies for a transition of the heating and cooling system in the major part of the STRATEGO target cities towards a more sustainable system.

Needs

The definition of a strategic master plan requires first of all a political will to start transforming the heating and cooling system, followed by a public debate on the options, their impacts and benefits.

This is a lengthy and time-consuming process. Local authorities might also be in the need for guidance on how to steer this process.

Success stories

The roles of local governments were analysed for one STRATEGO target city (Veurne, BE), using a report of the United Nations Environment Programme as a guideline. This analysis has indicated that the city has a significant role to play as a planner of heating and cooling in the town. At least, the city should integrate energy planning in urban planning. As a next step, the city should consider developing a holistic heating and cooling strategy for the whole jurisdiction. This would provide a frame for local new urban developments and provide inspirations for alternative heating and cooling options.

> *The least what local authorities can do in the new urban development areas / refurbishment areas is considering alternatives for the default heating option (individual gas boilers in many cases); they should pay as much attention to it as to the design and the names of the streets.*

Some of the STRATEGO target cities realised a strategic master plan on heating and cooling. They started this process already years ago. A strategic master plan at city level has the advantage to frame single projects into a wider context, which guarantees a targeted design of the project and an efficient use of public funds.

Conclusions

The discussion of the successes, challenges, needs and success stories of each of the five steps allows to draw some general conclusions.

- The transition towards a more sustainable heating and cooling system at city level begins with the understanding that there is a significant potential in heating and cooling to curb down the city's greenhouse gas emissions. Then there is need for political leadership to start a process of exploring the possibilities and to discuss different options with a wide range of stakeholders.
- The outcome of this process should be a strategic master plan on how to organise this transition towards a more sustainable heating and cooling system in the city. Such a master plan allows to frame single projects into a wider context.
- Individual projects need to be defined to realise the strategic master plan. The five steps' approach, presented in the work package of the STRATEGO project, has demonstrated to provide appropriate guidance to cities for such a process. It was successfully applied to 30 target cities with very different characteristics:
    - → A first step consists of exploring the possibilities. This requires mapping demand areas and supply points of heating and cooling. The experiences of the STRATEGO cases has shown that there is a need for appropriate mapping tools, having access to reliable data and expertise, certainly for cooling. However, it is proven during STRATEGO that simple maps can already give inspiration for project ideas if they combine information on demand and supply.
    - → A second step is the project definition. A list of six categories of heating and cooling projects (reduction of demand; district heating/cooling in densely populated areas; sustainable individual heating in other areas; excess heat; renewable heat; improved conversion of fossil fuels) was used in this STRATEGO project. This list has demonstrated to be a useful tool to give guidance to local authorities in identifying their opportunities/projects.
    - → A third step is drafting business models for the defined projects, based on the business model canvas. This canvas looks at the projects from different perspectives; it especially puts

the end-consumer at the heart of the projects. However, the assessment of all costs and benefits of projects is long process, asking for a lot of time before the required details are gathered to draft an investment ready business model for the projects.

- → A fourth step is the involvement of stakeholders. An involvement of a wide range of stakeholders can provide a social basis of public support to realise the projects. Stakeholders include local public authorities; end-consumers; energy companies; public provincial, regional or national authorities; scientific institutes; …
- → A fifth step is input to the local action plan on heating and cooling. Ideally, this step is no more than an update of the strategic master plan on how to organise this transition towards a more sustainable heating and cooling system in the city. A strategic master plan at city level has the advantage to frame single projects into a wider context, which guarantees a targeted design of the project and an efficient use of public funds.

It is the hope of the STRATEGO project partners that these conclusions will support European cities in replicating the steps taken by the STRATEGO target cities during this project.

Contents

List of figures

List of tables

0 Introduction

0.1 Introduction to the STRATEGO project – aim of this summary report

The STRATEGO project is a European co-funded project developed in the framework of the Intelligent Energy Europe Program. The purpose of the project "Multi level actions for enhanced Heating and Cooling plans – STRATEGO" is to:

- provide tangible support in developing National Heating and Cooling Plans,
- assist local authorities in evaluating their Heating and Cooling potential,
- find their priority area for intervention, and
- identify concrete projects that should be implemented.

This support to national and local authorities in the implementation of more efficient heating and cooling solutions is organised in different work packages (WPs), see Figure 1.

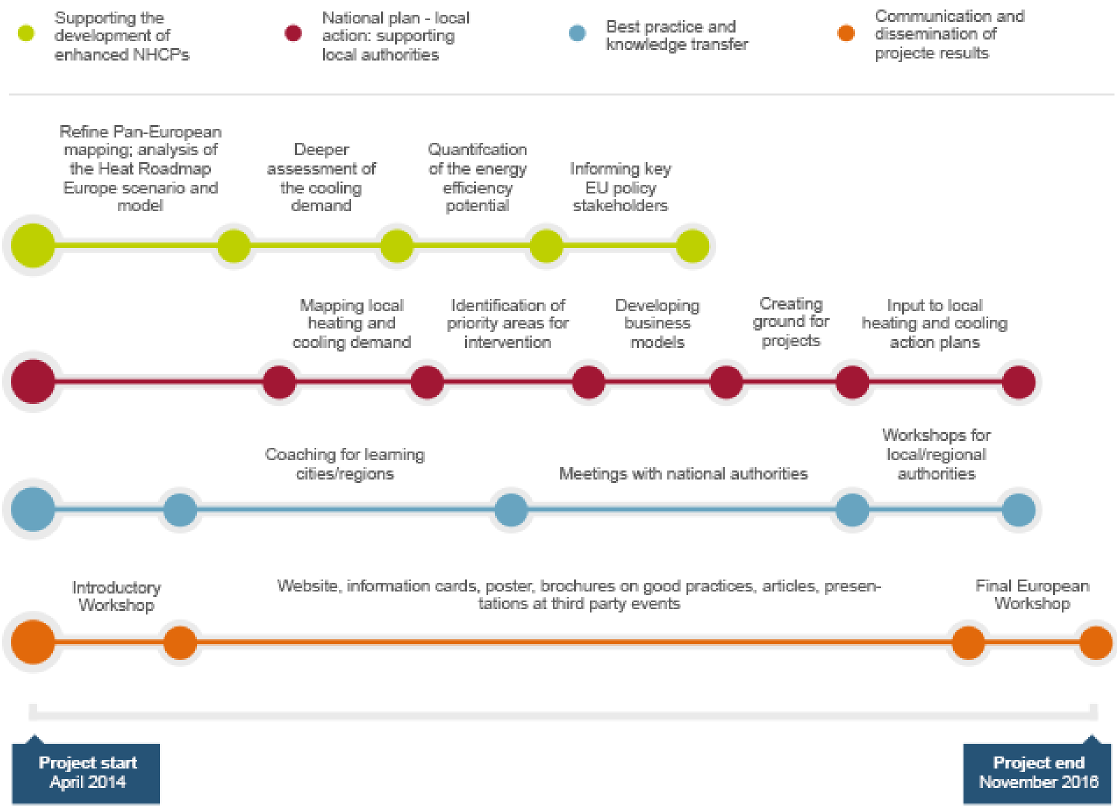


Figure 1: Infographic on the STRATEGO project structure

The geographical focus of STRATEGO is Austria, Belgium, Croatia, Czech Republic, Germany, Italy, Romania and the United Kingdom, with support from experienced partners from Denmark and Sweden, provide their support. The transferability and implementation of the project results outside the targeted countries is ensured by involving partners from Spain and Poland.

This report summaries the results of the WP 3 entitled "National plan – local action: supporting local authorities" see the red line in Figure 1. This report aims at drawing lessons from these results and at providing insights on how to draft tangible heating and cooling action plans at local level.

0.2 National plan – local action: actions taken to supporting local authorities

Within the framework of this WP3, local heating and cooling action plans were drafted for in total 30 target cities. Figure 2 presents an overview of which cities were supported by the STRATEGO project.

They cover a broad variety of communities, see Figure 3:

- 6 of the target cities are big cities with over half a million inhabitants and a population density op to 7,200 inhabitants/km²
- 5 of the target cities are medium cities with 100,000 to 500,000 inhabitants
- 13 of the target cities are towns with 25,000 to 100,000 inhabitants
- 6 of the target cities are rural communities with 1,000 to 16,000 inhabitants[4]

They also cover a broad range of development phases of a local heating and cooling market. Using the categorisation, defined by the Ecoheat4eu project[5], STRATEGO target cities are located in :

- Expansion areas: Austrian and Italian cities
- Refurbishment areas: Croatian, Czech and Romanian cities
- New development areas: Belgian, British (Scottish) and German[6] cities

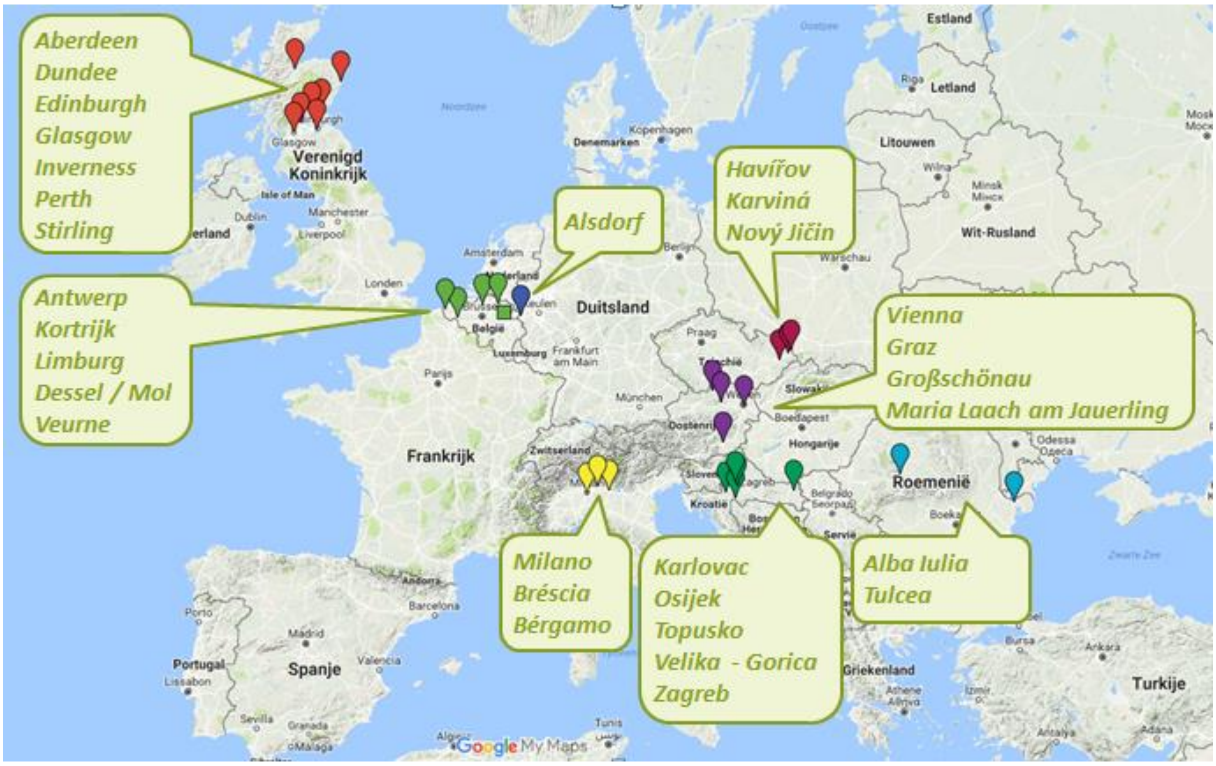


Figure 2: Map of the STRATEGO target cities

[4] This includes the targeted rural cluster of 10 municipalities in the Province of Limburg, Belgium
[5] Heat Roadmap Europe studies, performed by Halmstad and Aalborg Universities for Euroheat and Power (http://www.euroheat.org/Reports/Studies-27.aspx)
[6] Although the Heat Roadmap Europa studies categorise Germany as an expansion area, the German city Alsdorf is added to the list of new development areas in view of the early development of a district heating grid in this city.

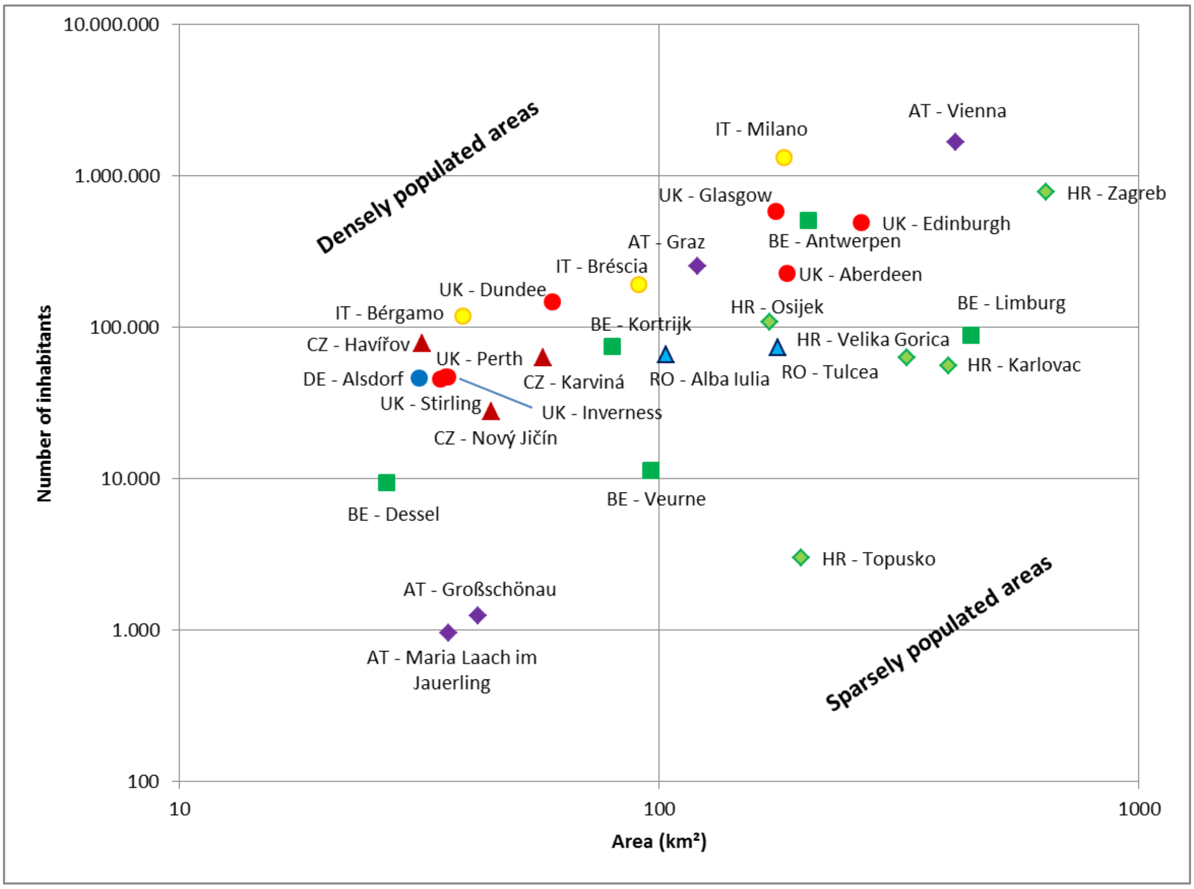


Figure 3: Number of inhabitants versus area of the STRATEGO target cities

WP 3 organised the support to the local authorities of these target cities in five tasks, see Figure 4.

Figure 4: Infographic on the tasks in WP3 supporting local authorities

1. In the first task, demand of heating and cooling was mapped, as well as potential supply points and renewable energy sources. The starting point is the Pan-European Thermal Atlas (PETA)[7], from which data are extracted. This was complemented with locally available data.
2. Based on the map of local heating and cooling demand and supply, areas of priority for intervention were defined. These are areas where the local conditions are favourable for developing projects first. In total 43 projects were defined in the STRATEGO project.
3. Business models were then developed for each of the identified projects.
4. The results of the previous steps were then discussed with local stakeholders.

[7] Link to PETA: http://maps.heatroadmap.eu/maps/31157/Renewable-Resources-Map-for-EU28?preview=true#

5. The results of the previous steps, including the conclusions of the stakeholder meeting, were summarised and are presented to the representatives of the target cities, so they can integrate this information in their local heating and cooling action plan.

0.3 Insights from national H/C plans as a basis for local H/C plans

The basis for WP 3 "National plan – local action: supporting local authorities" were the insights of WP 2 of the STRATEGO project, entitled "Supporting the development of enhanced National Heating and Cooling Plans (NHCP)". The overall aim of this WP 2, represented as the green line in Figure 1, is:

- to develop low-carbon heating and cooling strategies, which are called Heat Roadmaps, and subsequently
- to quantify the impact of implementing them at a national level for five EU Member States, which are the Czech Republic, Croatia, Italy, Romania, and the United Kingdom.

Using an energy model (www.EnergyPLAN.eu), the current and future energy system for each of these five countries is replicated based on the historical year 2010 (Ref 2010), and based on a future 'Business-As-Usual' forecast by the European Commission for the year 2050 (BAU 2050). The effect of an enhanced national heating and cooling plan was then simulated by modifying this BAU-forecasts in six steps:

- Step 1: Adding Heat Savings
- Step 2: Comparing Heat Network Solutions
- Step 3: Comparing Individual Heating Solutions
- Step 4: Integrating More Excess and Renewable Heat
- Step 5: Integrating More Renewable Electricity in the Heating Sector
- Step 6: Heat roadmap

The results of these exercise clearly indicated that the Heat Roadmap scenarios have a positive effect on three key metrics, see Table 1:

- a reduction in primary energy supply of about 20%,
- a reduction in carbon dioxide emissions of about 25%, and
- a reduction in energy system costs (excluding vehicle costs) of about 8%.

Table 1: Heat Roadmap impacts on Energy, Environment and Economy compared to the 2050 BAU scenario for the entire energy systems.

All Sectors	Energy		Environment		Economy	
Heat Roadmap vs. BAU 2050	Change in Primary Energy Supply		Change in Carbon Dioxide		Change in Energy System Costs	
Unit	TWh/year	%	Mt/year	%	Billion €/year	%
Croatia	-18	-15%	-5	-19%	-1	-7%
Czech Republic	-109	-18%	-35	-32%	-3	-8%
Italy	-380	-18%	-101	-22%	-13	-8%
Romania	-118	-23%	-36	-37%	-3	-9%
United Kingdom	-431	-18%	-109	-23%	-15	-8%
All Five Countries	**-1056**	**-18%**	**-286**	**-24%**	**-35**	**-8%**

The overall conclusion in STRATEGO WP2 is that (Connolly et al., 2015):

a combination of energy efficiency measures, in the form of heat savings, district heating in the urban areas, and primarily heat pumps, with smaller shares of biomass boilers and solar thermal in the rural areas, reduces the energy system costs, energy demand, and carbon dioxide emissions in all five STRATEGO countries for the year 2050 compared to a 'Business-As-Usual' projection.

A deeper analysis of the results of WP 2 reveals other key findings from the Heat Roadmaps for these five countries,:

- About half of the potential in energy system costs, energy demand and carbon dioxide emissions reduction results from an optimisation at the demand side (heat savings)
- And the other half results from an optimisation at the supply side (district heating in the urban areas, individual renewable heating devices in the rural areas)

Figure 5 illustrates these findings for the United Kingdom.

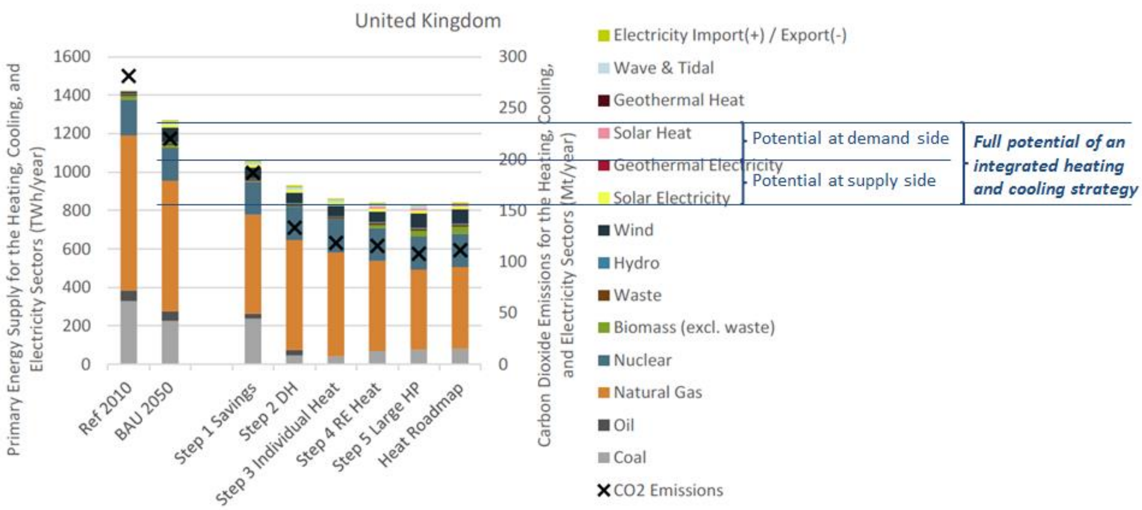


Figure 5: Example of United Kingdom indicating the full potential of an integrated heating and cooling strategy

WP 2 of the STRATEGO project, entitled "National plan – local action: supporting local authorities", hence lead to the insight that:

An integrated heating and cooling action plan both needs to tap the potential at the demand side by reducing the heating and cooling demand **and to tap the potential at the supply side** by fostering the deployment of district heating grid in densely populated areas (tapping the potential of excess heat and other renewable heat sources) and the diffusion of individual renewable heating and cooling devices in less densely populated areas.

WP 2 concluded with a list of 21 key conclusions and recommendations, divided by specific categories relating to the heating and cooling sector.

Heat savings

1. Heat savings reduce the energy demand, carbon emissions, and costs in all countries, but eventually they become more expensive than the cost of sustainable heat supply.
2. The average heat demand in residential and services buildings combined, including space heating and hot water, should be reduced by approximately 30-50% in total. This equates to a heat density of approximately 60-110 kWh/m2, depending on the specific country.
3. Heat savings should be implemented over a long-term time horizon, in combination with other building renovations.
4. There are synergies between the reduction of the heat demand and improvements in the heat supply such as reducing the thermal capacity required and enabling more heat sources to be utilised on the district heating network.

Heating in Urban Areas

5. District heating is more efficient and cost effective in urban areas than natural gas networks.
6. District heating is technically and economically viable in the North and South of Europe.
7. District heating can utilise very large amounts of excess heat and heat from renewable resources, which are wasted today in the energy system.
8. District heating pipes represent a relatively small fraction of the annualised district heating system cost (~5-15%).
9. The sunk costs that could occur during the implementation of district heating do affect the results for the Heat Roadmap scenarios, but the scale of their impact is not significant enough to change the overall conclusion.

Heating in Rural Areas

10. Individual heat pumps are the most preferable individual heat solution based on a balance across energy demand, emissions, and cost. They should be supplemented by smaller shares of individual solar thermal and biomass boilers.
11. The optimal mix of individual heating technologies should be analysed in more detail.
12. Individual heat pumps may be too expensive in suburban areas, where the heat supply transitions from district heating to an individual heating solution.

Cooling

13. The current cooling demand is relatively low compared to the heat demand, but in the future the cooling demand could be relatively larger.
14. District cooling can reduce the cost and energy demand in the cooling sector, but at present the benefits occur at a local level.
15. The optimal level of district cooling is still unclear.
16. The design of the district cooling network should be analysed in more detail.

Sustainable Resources for the Energy System in the Future

17. There is a large amount of excess heat and heat from renewable resources available, but there is likely to be a shortage of renewable electricity and bioenergy in the future.

18. Further energy efficiency improvements are necessary in electricity, industry, and transport to decarbonise the energy system.

Methodologies and Tools for Analysing the Heating and Cooling Sector

19. Alternative technologies in the heating and cooling sector should be analysed from a complete energy systems perspective.
20. A combination of mapping and modelling is essential to analyse the heating and cooling sectors, but it should also be expanded to other parts of the energy system in the future.
21. A variety of different expertise is required to inform, design, and analyse a holistic heating and cooling strategy.

0.4 Structure of this report

The following chapters of this report depict the results achieved for the 30 cities by the STRATEGO WP 3 “National plan – local action: supporting local authorities“. The results of the individual STRATEGO cases are reported in separate case sheets; they can be consulted on the webpage http://stratego-project.eu/projects-description/, see Figure 6.

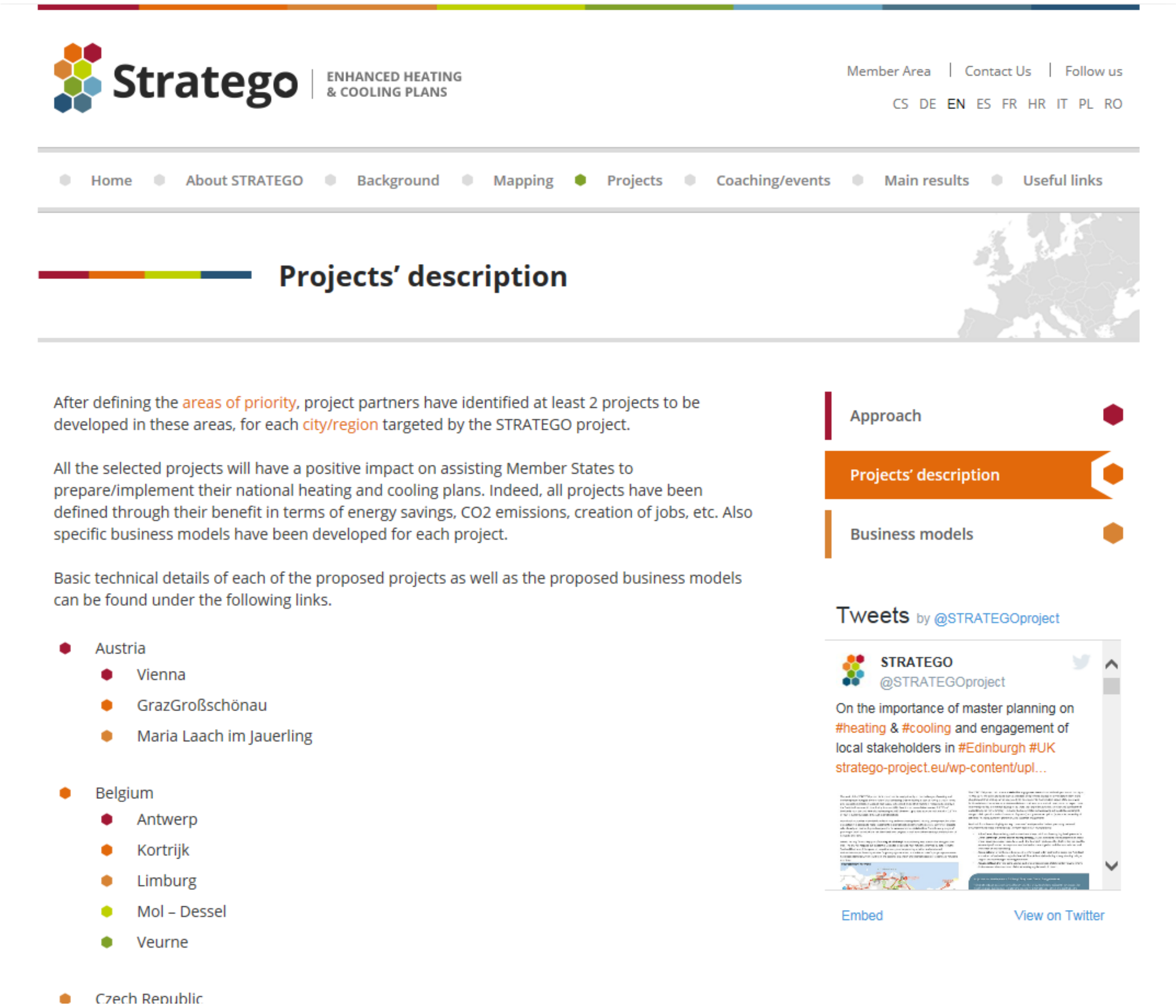


Figure 6: Webpage where the individual STRATEGO case descriptions can be found

The report is structured according to the five steps, in which this WP 3 was organised; chapter 1 depicts the heating and cooling maps that were made for the 30 STRATEGO target cities; chapter 2 describes the 43 projects identified in these target cities; chapter 3 analyses the business models of these projects; chapter 4 combines the conclusion of the stakeholder involvement and of providing input to local heating and cooling plans. The aim of this report is to go beyond depicting the results; it aims also at deriving insights from the case studies. To this end, the last chapter analyses the successes achieved and the challenges encountered with taking these five steps. It also defines needs for new tools, guidance or attitudes and looks at success stories; cases that succeed in taking the steps despite the challenges.

1 STEP 1: Mapping local heating and cooling demand and supply

1.1 The challenge of making local H/C maps

The aim of the local heating and cooling (H/C) maps is to create a more detailed picture of the heating and cooling supply and demand and the identification of project opportunities in STRATEGO's partner cities and regions. Capitalising on local data, knowledge and expertise, the goal is to use the local maps to visualise and assess who needs heat, where heat comes from and what opportunities exist to connect them under current conditions or in future development projects.

In contrast to the results of WP2 which is based on maps and data sources of existing heating and cooling demands and supply, in WP3 the local knowledge and stakeholder engagement is being used not only to create a more detailed picture, but also to document valuable information in regard to the conditions of existing heating and cooling infrastructure and future/planned heating and cooling demands and supply. Examples for valuable information regarding the conditions of installations would be the remaining lifespan of installations, maintenance and/or repair backlogs, changes in the end user customer base (e.g. declining number of DH consumer contracts) and known disconnections of existing installations (e.g. pipe sections). Valuable information regarding planned heating and cooling demands are for example land areas earmarked for residential, commercial or industrial development, planned construction or major renovation of public buildings and the expansion or renovation of heat supply installations.

While each local partner is different and brings unique circumstances to the STRATEGO project a common systematic approach to the local mapping is essential. At a minimum the resulting maps contain the following three dimensions:

- Heating and cooling demand
- Heating / cooling infrastructure and supply, including existing district heating installations
- Sustainable heating / cooling potential

While on the one hand the local knowledge is a very valuable and essential for the identification of potential projects, it also a challenging task to gather, document and map the information. The challenge is to gather information from stakeholders, spatial data sets and other maps and convert them into a useful format which can be integrated into the local heat maps. Since most of the information was not initially documented for the creation of a heat map, the quality will vary to a high degree. It is important to stress that the quality and value of the final map will depend on the quality of the data sources used to generate it.

When making H/C maps within the STRATEGO project, distinction is being made among five levels of detail on which data can be found. The more specific the information, the higher the quality of the information and the more useful the map.

1. Data only available at city level
2. Data available for different neighbourhoods within the city
3. Location of distinct customers / installations known, but no data on these customers or installations is available
4. Location and characteristics of distinct customers / installations known
5. Energy data related to distinct customers / installations metered

The level of information introduced here is closely related to levels of confidence as it is used in the Scotland Heat Map (Carbon Trust Resources and Ramboll Energy, 2014). When different levels of data are available, the higher level of quality should be selected. After data is chosen as being relevant for the local map, it is encouraged to categorise the quality of data and to document the categories and sources of each data set in the map. This can be accomplished by creating separate layers containing data source information in digitized maps (e.g. GIS) or by creating accompanying documentation which can be consulted by the map user. The user of the final map has therefore the possibility to understand what quality of information is given to him and make an informed judgement if the level of detail is sufficient for the specific planning purpose or if additional investigations are required.

Table 2 presents a matrix overview of the information to be included in each of the three map dimensions and five quality categories. This matrix is presented as a guideline to the STRATEGO partners to point towards sources for data collection, categorising and mapping. In addition, a list of useful data sources and tools has been provided to the STRATEGO partners, see (Cornelis E., 2015).

Table 2: Matrix to structure the data collection for building heating and cooling maps

		City level	Neighbourhood level	Level of individual installation		
				No details	Additional Info	Metered data
H/C demand						
H/C infrastructure						
Sustain-able H/C potential	Energy savings					
	Excess heat					
	Geothermal					
	Bio-energy					
	Solar thermal					

Geothermal: heat pumps, (deep) geothermal wells, … includes also air source heat pumps and heat extract from the sewage system and water bodies; Bio-energy: includes biogas from various sources, solid biomass, liquid biomass

The subparagraphs below now presents best practices maps for each of the three dimensions and discuss the related challenges.

1.2 Mapping local heating and cooling demand

Heating and cooling maps have been made for 29 STRATEGO cases[8]. All of these H/C maps include data on the heating demand. Mapping the cooling demand has turned out to be much more challenging, only the Department of Energy, Power Engineering and Environment at the University of Zagreb, HR has developed cooling maps for the five cities they have examined.

Table 3: Number of STRATEGO cases that collected data on heating and cooling demand

Total number of STRATEGO cases = 29	City level	Neighbourhood level	Level of individual installation		
			No details	Additional Info	Metered data
H/C demand	5	7		6	11

[8] One map combines the heating demand of the two towns Karviná and Havířov,CZ

The level in which the heating demand was mapped varies considerably between the different cases, as Table 3 indicates. More than half (17 out of the 29) are based on the actual or estimated heat demand of individual consumers, less than half (12 out of the 29) only indicate the heating demand on city or neighbourhood level.

1.2.1 Heating demand maps based on actual or estimated heat demand of individual consumers

About one in three STRATEGO case studies (11 of the 29 cases to be more precise) succeeded in mapping the heating demand based on monitoring data. Figure 7 presents a couple of examples of such maps.

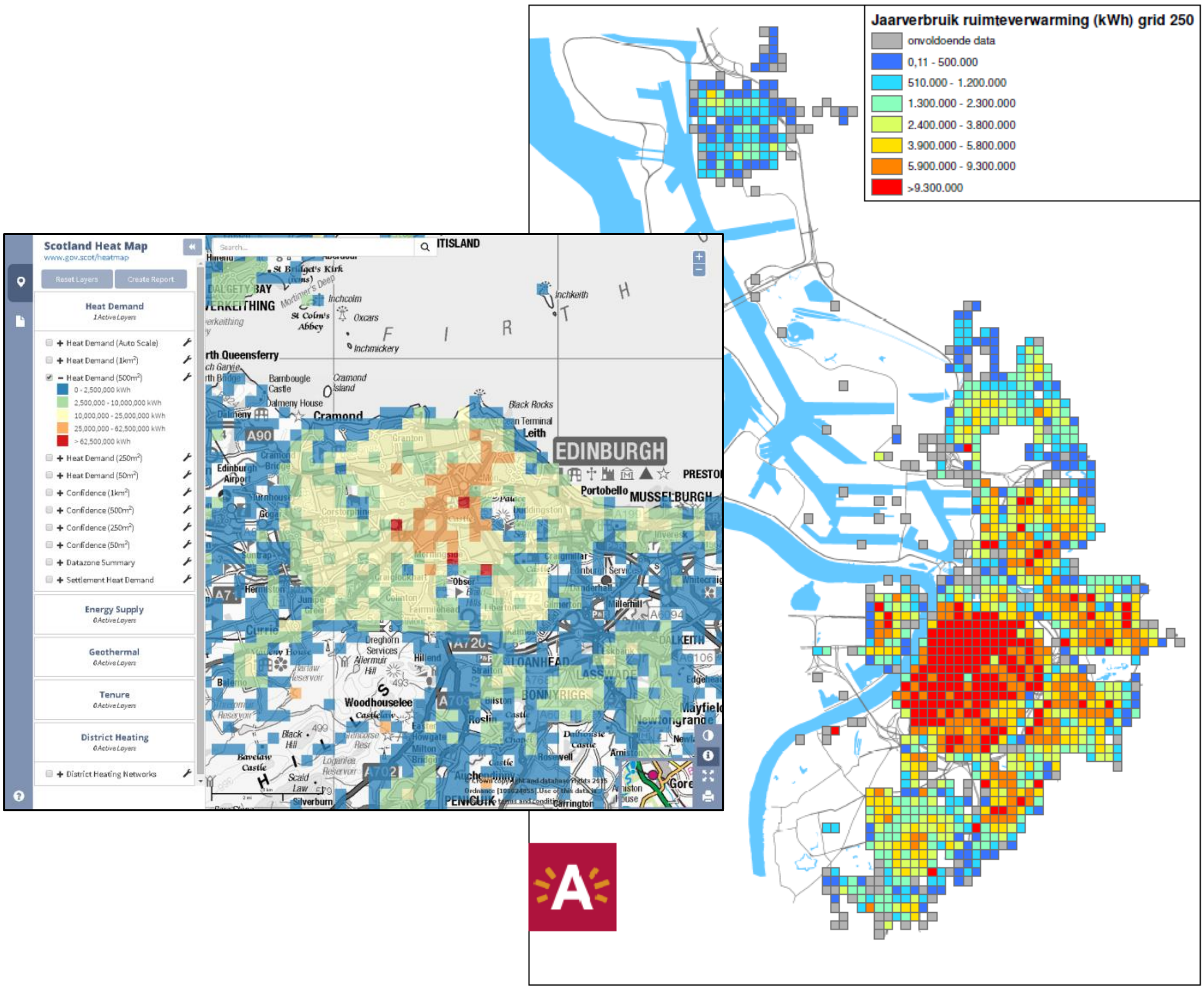


Figure 7: Examples of heating demands maps, based on metered data (Left: Edinburgh, UK - Right: Antwerp, BE)

These maps are based on metering data of gas, district heating and electricity. This requires a collaboration with distribution grid operators who collect such data as part of their operation. They only can provide data on the energy carriers they distribute. They cannot provide data on heating oil consumption or coal consumption. The buildings relying on these fuels hence need to be identified and their heating demand needs to be estimated.

A second issue concerns the confidentiality of these energy data. The heating maps should not allow the determination of the heating demand of an individual heat consumer. There are basically two ways of preserving this data confidentially. It can either be preserved geographically by clustering the heat demand of a number of heat consumer in an area (typically a grid cell of 50m by 50 m at least as in the Scottish Heat Map) and by only presenting the average heat consumption of these areas. Areas with an insufficient number of heat consumers can be left blank. Or the confidentiality can be preserved by representing the heat demand according to categories with wide enough ranges. The latter method is especially relevant for large heat consumers that are indicated as distinct heat demand points on the map; energy-intensive industrial facilities for instance.

In case metered energy data cannot be used, building characteristics can then be used as a basis for heating and cooling maps. Figure 9 presents heating map for Alsdorf, DE and the cooling demand map of Zagreb, HR as examples. The basis for the former is the age and the size of the buildings which is used to categorise and colour-code the buildings in different classes of specific heat demand. The basis for the latter is the size (rooftop view multiplied with the number of floors) and the age of the buildings, allowing to classify the buildings into six categories. A multiplication with a specific heating / cooling demand ultimately has led to the heating and cooling maps for the five Croatian cities.

1.2.2 Heating demand maps on neighbourhood or city level

The heating demand in twelve STRATEGO cases is mapped either on neighbourhood level or on city level. It is in most cases an extract taken from the local heating and cooling map, or when not available, from PETA, the Pan-European Thermal Atlas, see Figure 8.

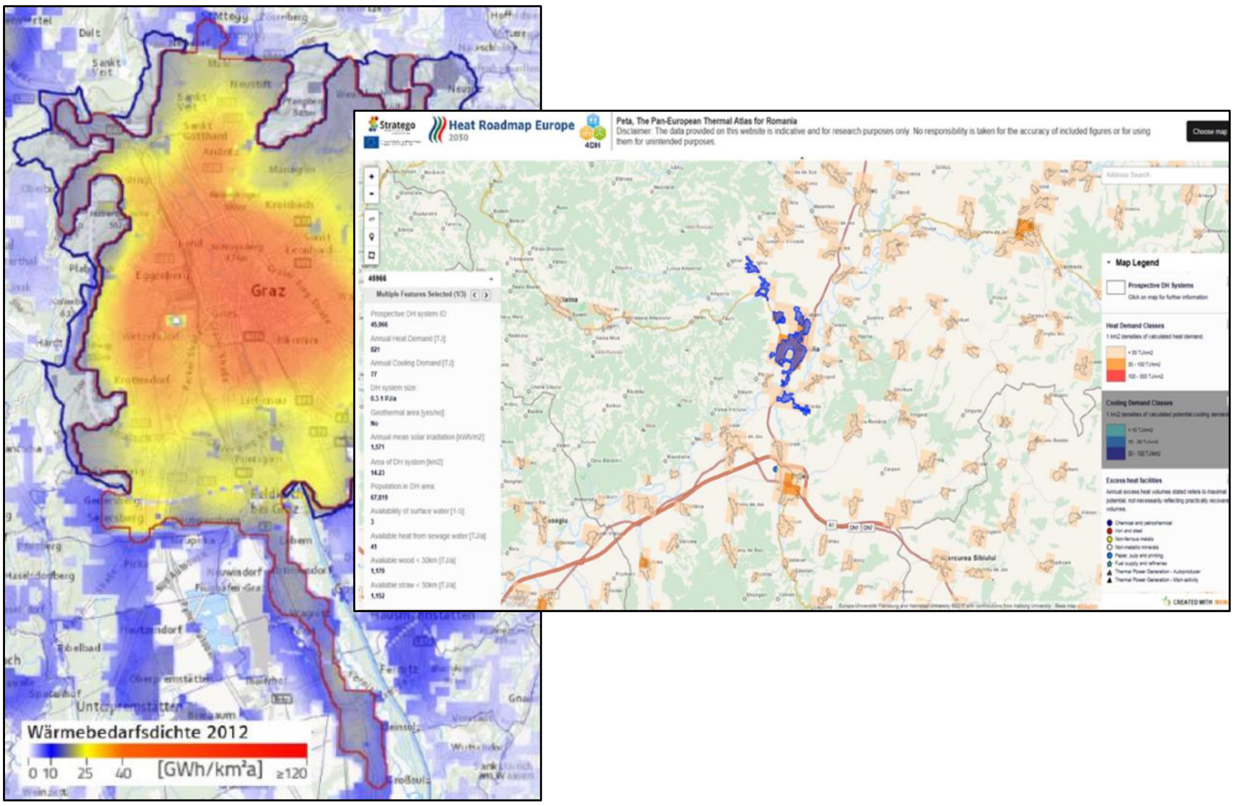


Figure 8: Examples of heating demand map, taken from national heat maps or from PETA (Left: Graz, AT – Right: Tulcea, RO)

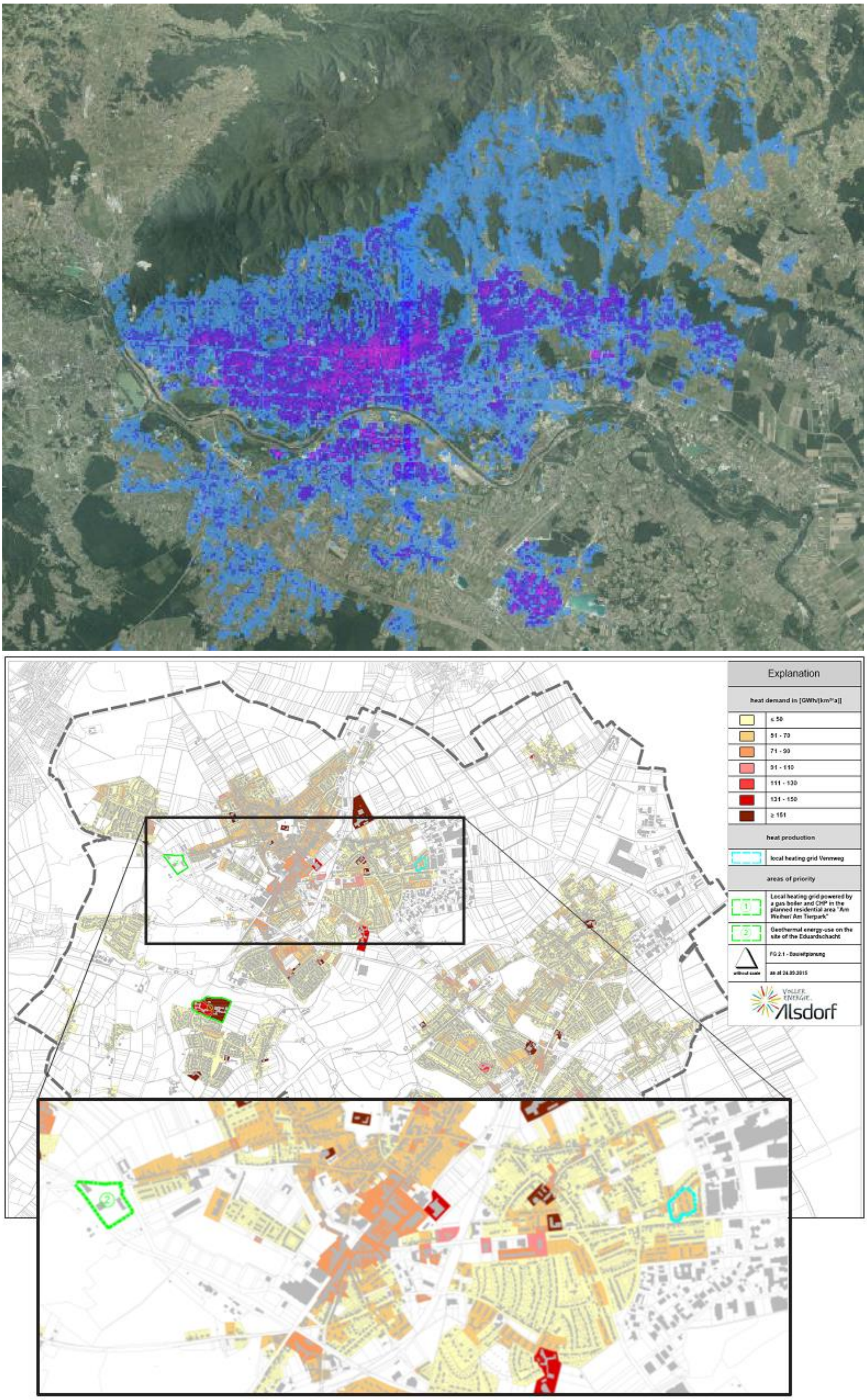


Figure 9: Examples of a H/C demand map, based on building characteristics (top: Zagreb, HR – bottom: Alsdorf, DE)

One case takes a step beyond purely mapping the heat demand. The (residential) heat demand data of the Province of Limburg, BE is converted into a statistical map indicating the quantity of fuel use for heating and its split in three different fuels for each of the municipalities, see Figure 10. In addition, some municipalities with a high share of natural gas or heating oil are highlighted. Such a statistical map is a powerful way of representing the heating and cooling demand and a strong enabler to start the debate on how to make heating and cooling more sustainable in the area.

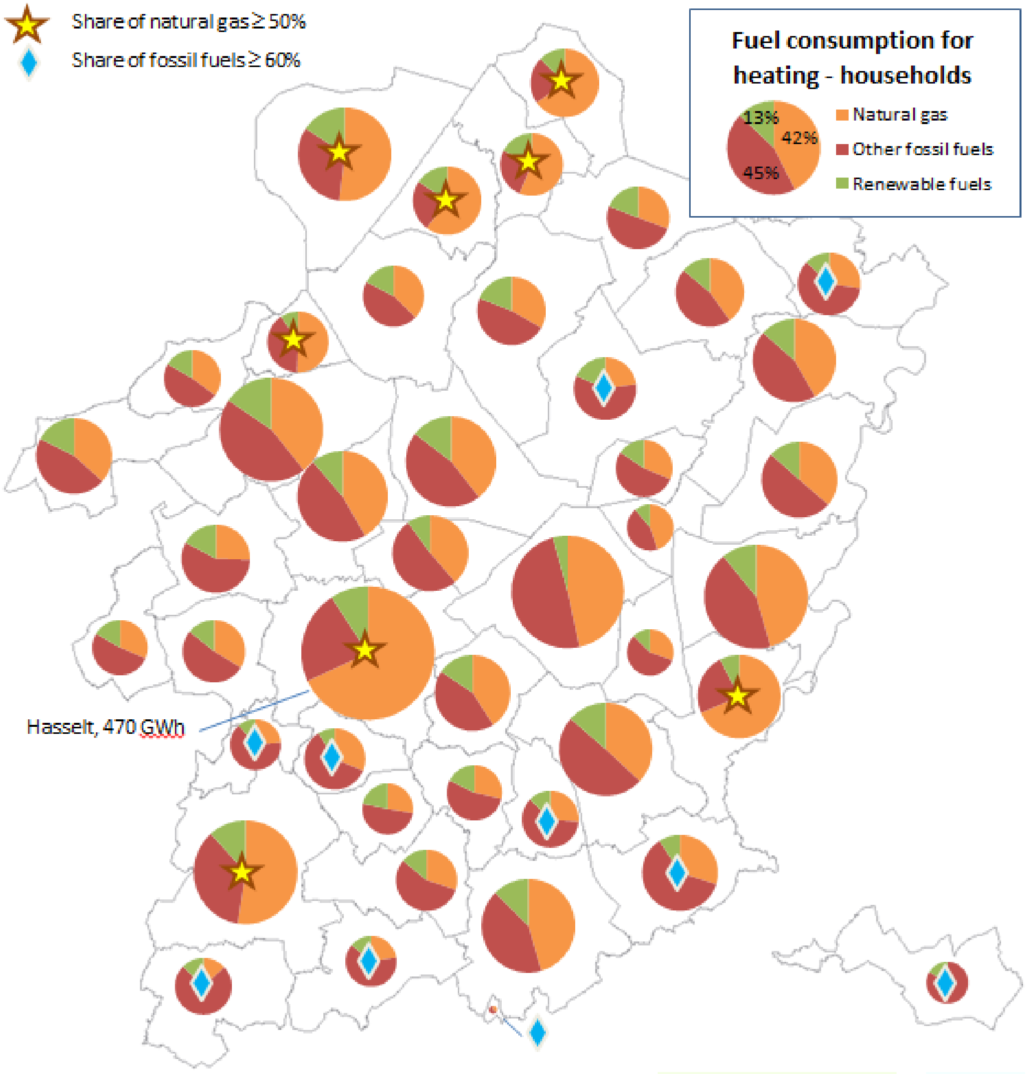


Figure 10: Heating demand processed to a statistical map (Limburg, BE)

1.3 Mapping the heating and cooling infrastructure

About half of the heating and cooling maps (17 out of the 29) include items of the heating and cooling infrastructure, see Table 4.

The mapping goes down to the level of individual installations in most of these cases; it mainly concerns the location of the district heating grid and the connected heat sources. The map showing the topology of the DH grid of Vienna and the various sources feeding in to it is an example of such a map, see Figure 11.

Table 4: Number of STRATEGO cases that collected data on heating and cooling infrastructure

Total number of STRATEGO cases = 29	City level	Neighbourhood level	Level of individual installation		
			No details	Additional Info	Metered data
H/C infrastructure		2	13	2	

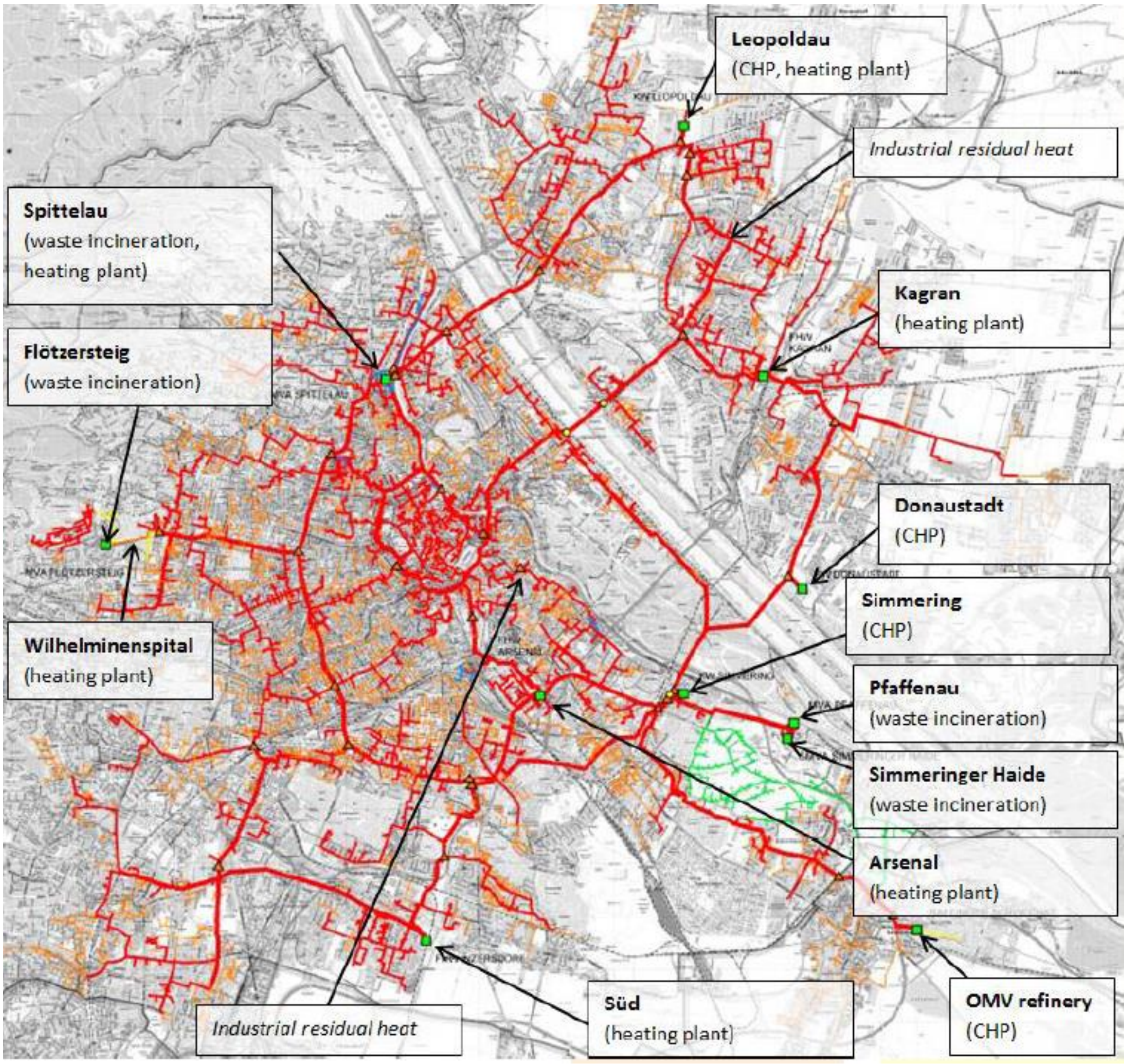


Figure 11: Example of a map showing the district heating grid and the heat sources (Vienna, AT – source: Wien Energie GmbH)

1.4 Mapping the sustainable heating and cooling potential

Half of the maps (14 out of the 29) include the potential of at least one sustainable heating and cooling source, see Table 5.

The level of detail is on the level of individual installations or on neighbourhood level in most cases. Excess heat sources are mapped the most, followed by geothermal wells. Just a few maps include information on the energy saving, bio-energy or solar thermal potential

Table 5: Number of STRATEGO cases that collected data on sustainable heating and cooling potential

Total number of STRATEGO cases = 29		City level	Neighbour hood level	Level of individual installation		
				No details	Additional Info	Metered data
Sustain-able H/C potential	Energy savings	1		1		2
	Excess heat		3	5	1	
	Geothermal		2	2	1	
	Bio-energy		2	1		
	Solar thermal		1	1		

1.4.1 Mapping the energy saving potential

Only four STRATEGO cities have a map indicating the potential of reducing the heating demand. Antwerp and Kortrijk have the most detailed map; it consists of a thermographic scan indicating the heat loss of the roofs, see Figure 12. This scan was taken on January 19th, 2016. These images are processed and mapped on a one-line platform with the aim to inform the citizens on the heat loss of their dwelling and to stimulate them to take action to improve its insulation. The need for such actions is high in the city centre especially, as the thermographic scan indicates.

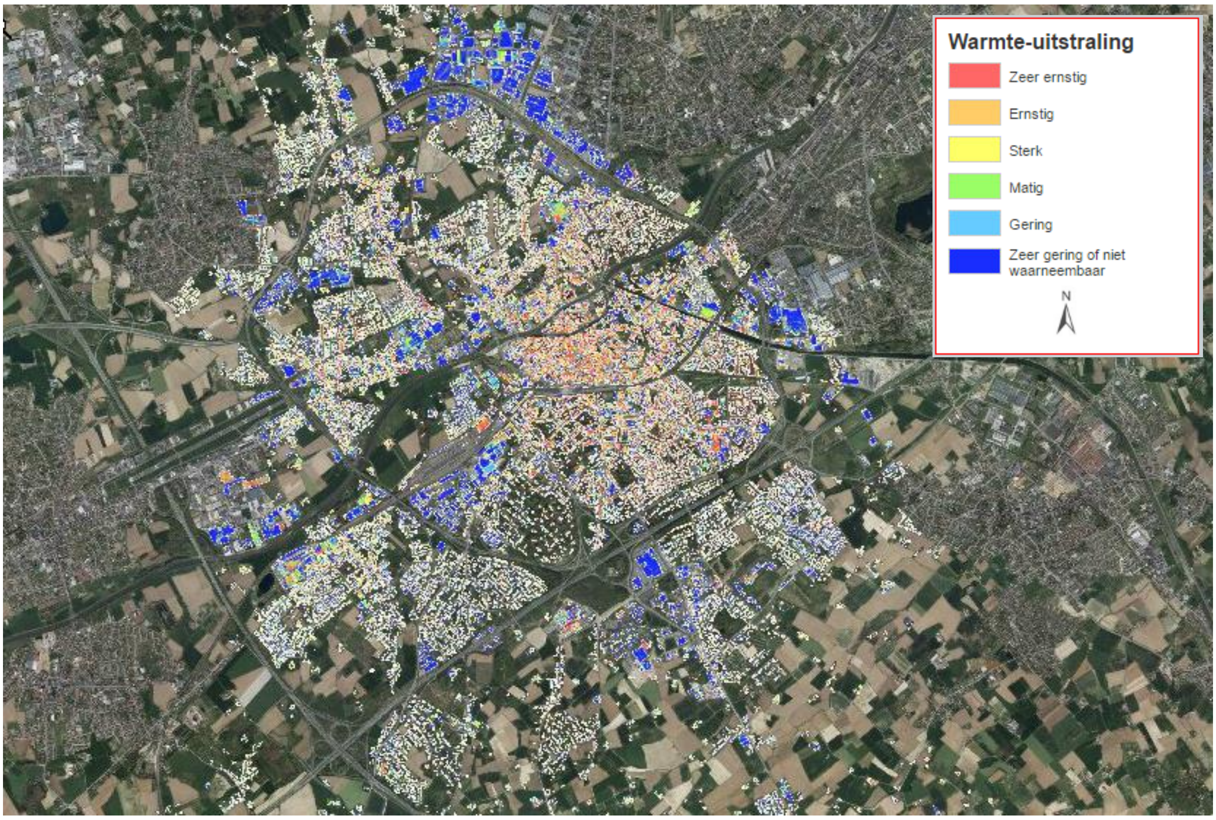


Figure 12: Thermographic scan of Kortrijk, BE indicating high thermal losses in the city centre (source: http://www.kortrijk.be/dakenscan)

Figure 13 is an example of a map showing the energy saving potential at the level of city. It shows the average fuel consumption per household for each of the municipalities of the Belgian Province of

Limburg. This consumption is higher than average in some villages in the south and the north-east of the province. These municipalities also have a high share of heating oil in the fuel mix for heating.

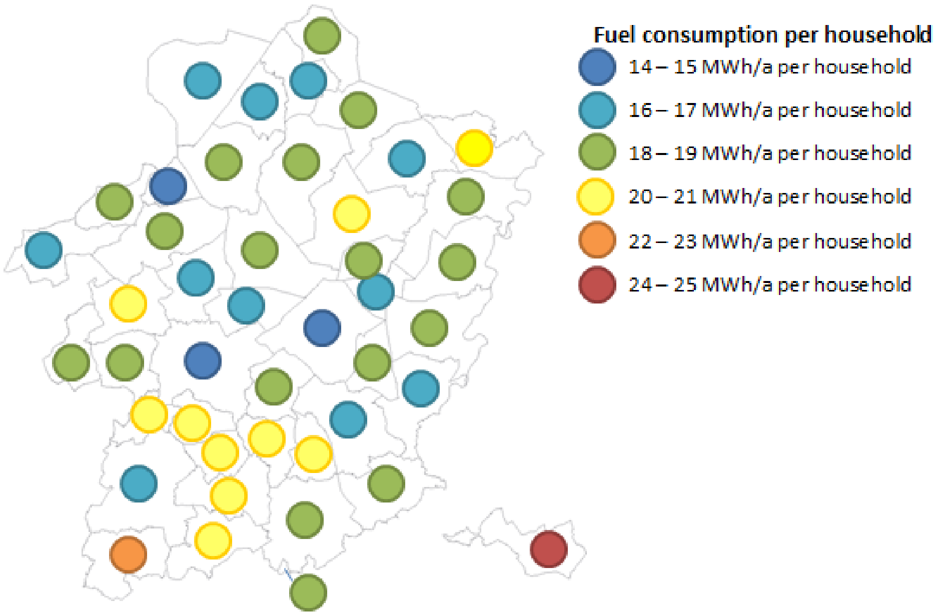


Figure 13: Average fuel consumption per household in the Province of Limburg, BE as proxy of energy savings potential

1.4.2 Mapping the excess heat potential

Obvious potential sources of excess heat are (large) industrial facilities, power plants and waste-to-energy plants. They are usually large in size and small in number, which makes it easy to map these potential sources.

Figure 14 and Figure 15 are two examples of such maps; the former is an extract of PETA, the latter is made by regional authorities.

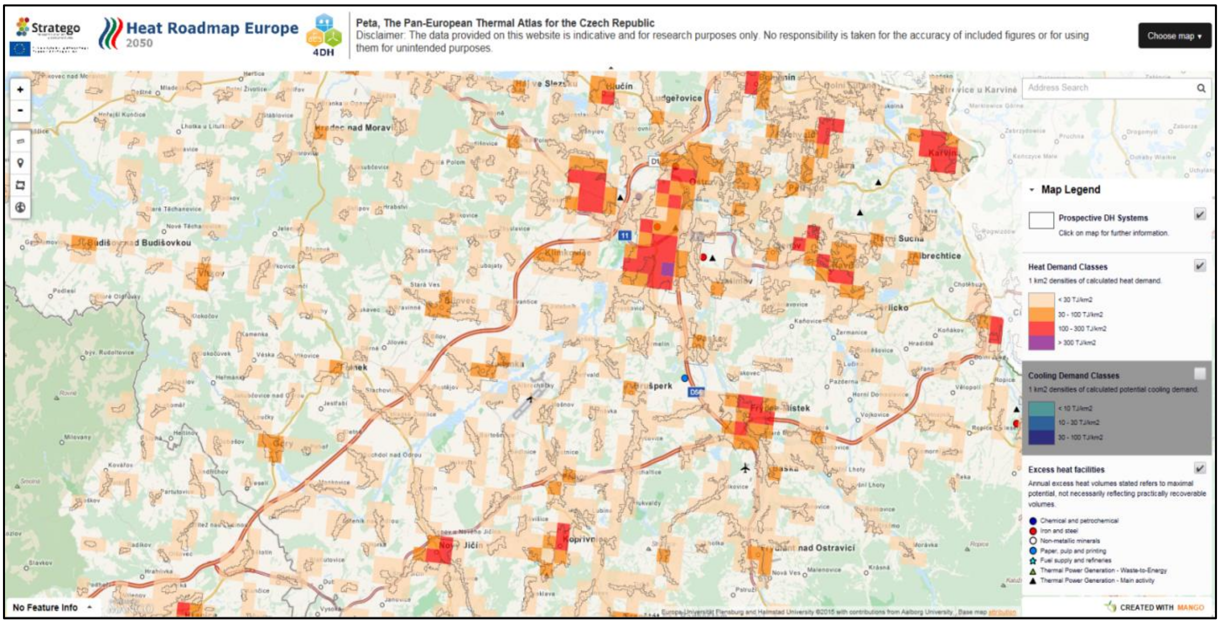
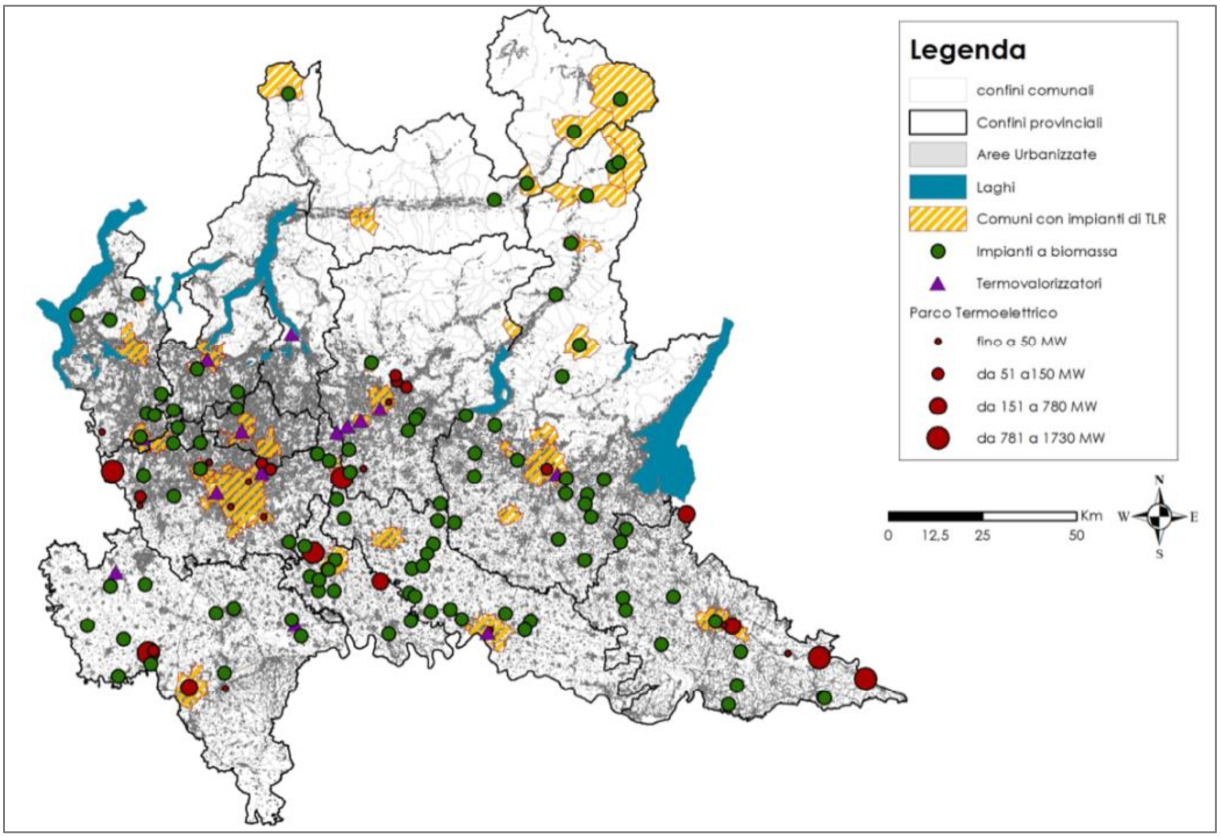


Figure 14: Indication of thermal power plants and industrial facilities of some energy-intensive sectors on the PETA-extract for Ostrava, CZ



Source: PEAR 2015 REGIONE LOMBARDIA – District heating systems, biomass plants, waste-to-energy plants, thermoelectric plants - census in Lombardia, 2012 (Regione Lombardi, Divisione Energia Infrastrutture Lombarde – SIRENA20)

Figure 15: Biomass plants, waste incinerators and thermal power plants in the Lombardy region, IT

1.4.3 Mapping the renewable heat potential

Renewable sources of heat include geothermal wells, heat pumps, (solid) biomass, biogas and solar thermal boilers.

Some of these sources are large in capacity and small in number, just like the potential excess heat sources. Examples are deep geothermal wells or waste water treatment plants annex biogas production. These sources can be added to the heating and cooling map as a distinct data point. This is for instance the approach taken for indicating the locations of the geothermal well in Topusko, HR, the areas that already are served by these sources and those that could be served in future, see Figure 16.

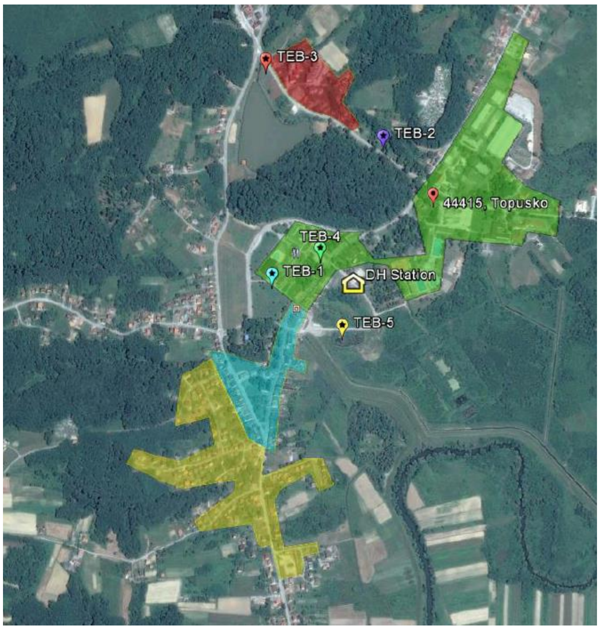


Figure 16: Map of the geothermal boreholes that can be reactivated to feed the district heating grid in the potential expansion area (yellow) (Topusko, HR)

Some other source are more diffuse. Figure 17 presents some examples; it shows the biomass waste potential and the potential of heat extraction from the sewage system. The former is derived from a combination of a population map, quantities of waste generated per person and the share of biomass in the waste. The latter is based on a map of the biggest sewers; the estimation of the sewage water flow in these pipes has then been converted into a heat extraction potential. This map, in combination with a map of public buildings with a considerable heat demand, such as swimming pools, helps to identify feasible projects.

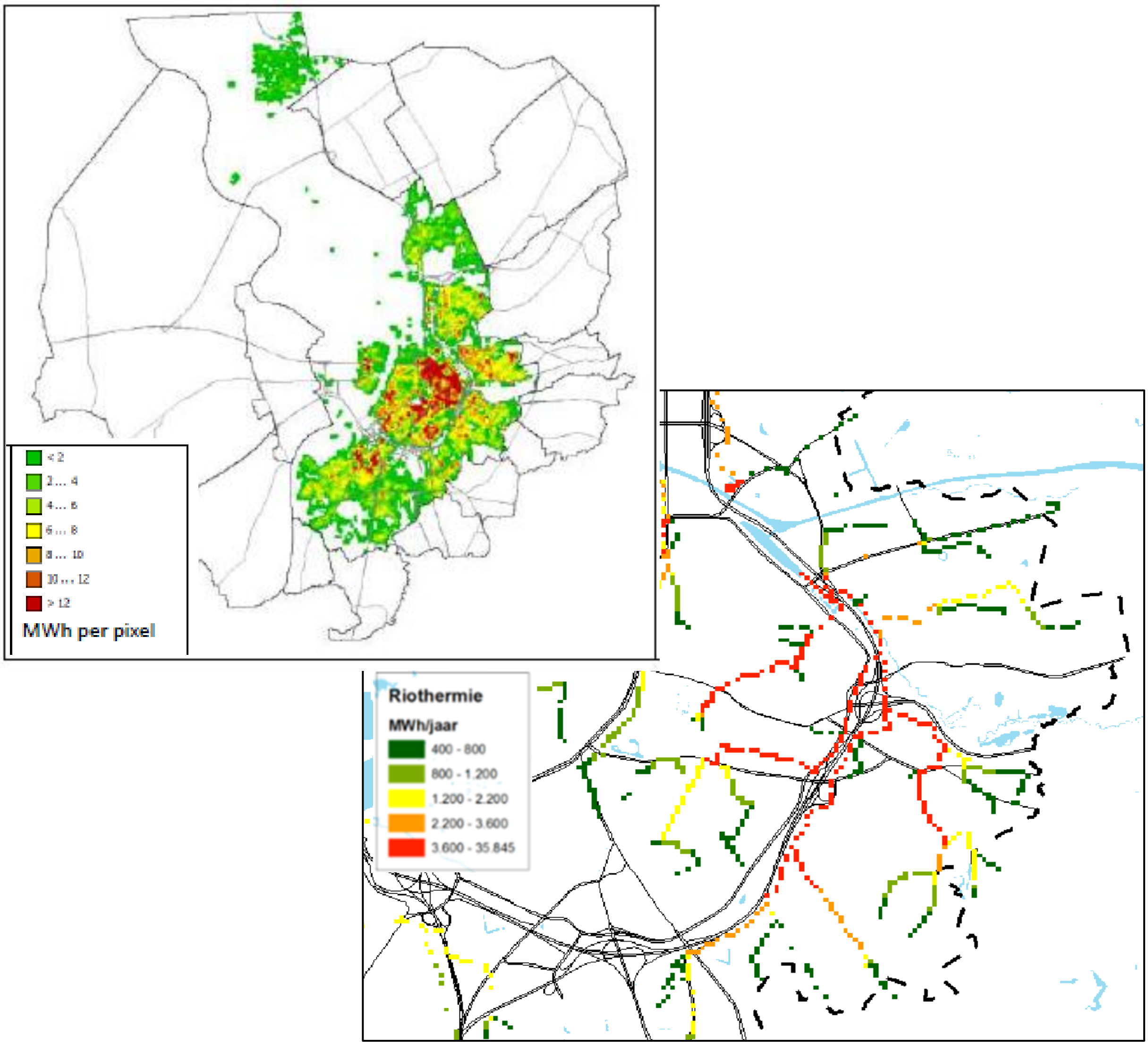


Figure 17: Map of the municipal biomass waste potential (left) and the heat extraction potential from the sewage system (right) (Antwerp, BE)

Similar maps have been made for the Province of Limburg, BE. The potential map of biogas is based on a map on cattle breeding in the province, the potential map of wood is based on the forest segment of a land use map, the potential map is based on a combination of a soil property map and a land use map, the solar hot boiler map is based on a map of the roof tops of buildings.

These potential maps have been further processed into a statistical map, indicating potential of these four renewable heat sources for each of the municipalities of Limburg, see Figure 18.

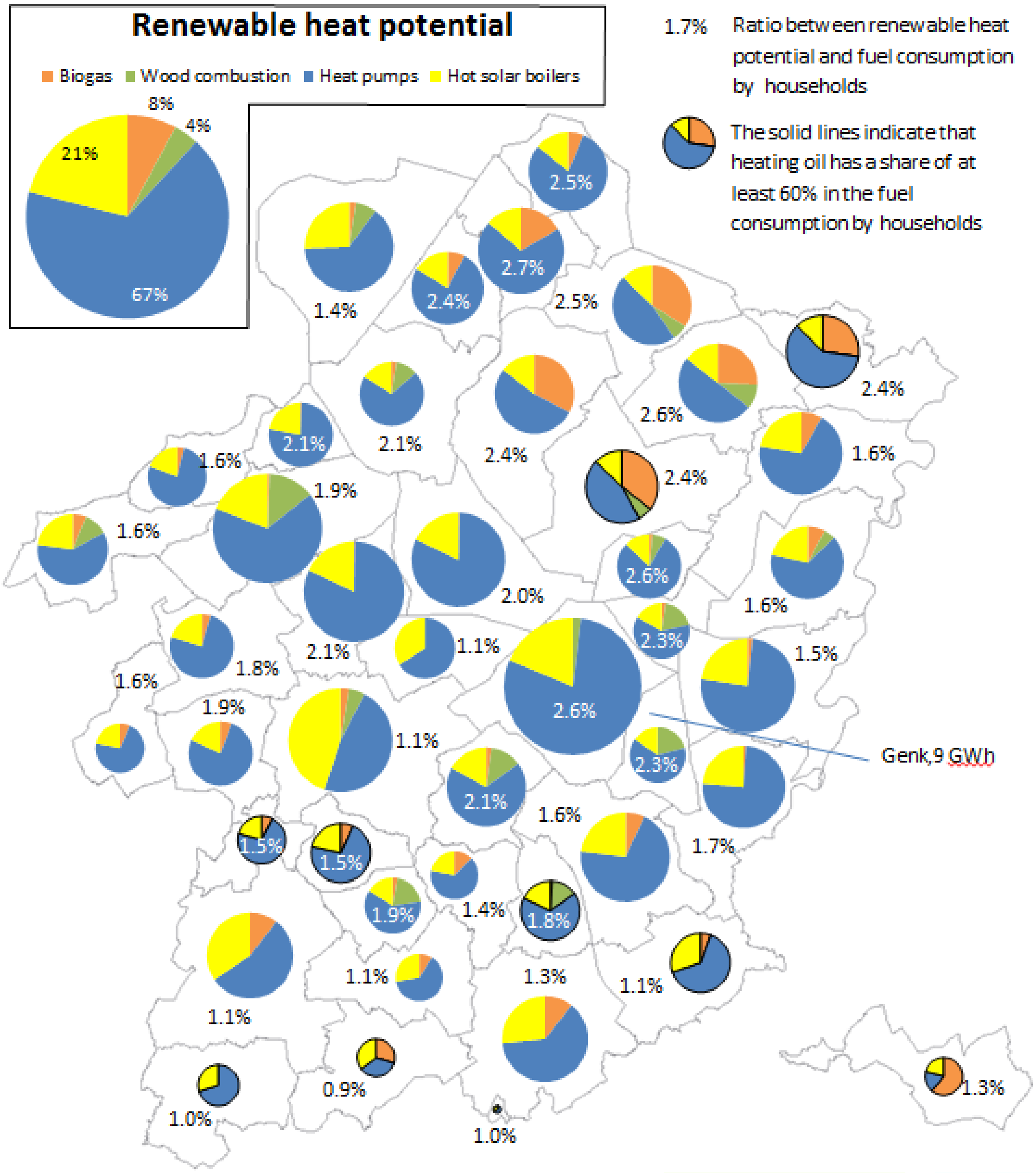


Figure 18: Statistical map of the potential of some renewable heat sources in the Province of Limburg, BE

1.5 Feedback loop from the local heating and cooling maps to PETA

The use of extracts from the PETA for some of the STRATEGO cases allows to draw some conclusions on the applicability of PETA for assessing the local demand and supply for heating and cooling.

The STRATEGO cases have demonstrated that local heating and cooling maps should have a high enough resolution. The 1 km x 1 km grid cell of the PETA has shown to be too coarse to visualise the local variation in heating and cooling demand. In line with this conclusion, PETA extract of the STRATEGO cases on a 100 m x 100 m grid cell were offered to the STRATEGO partners.

For one particular STRATEGO case – the Province of Limburg, BE more in particular – a more in-depth comparison between the refined PETA and a local heating and cooling map was carried (Grundahl L., 2016), see Figure 19. This local H/C map is the Flemish Heat Map, commissioned by the Flemish Energy Agency to comply with the EED Art 14, see https://ec.europa.eu/energy/en/topics/energy-efficiency/cogeneration-heat-and-power - Belgium. The PETA and the Flemish Heat Map were compared both in terms of the amount of heat demand found and in how well they reveal the exact location of the heat demand. This comparison was made both on a provincial and municipal scale.

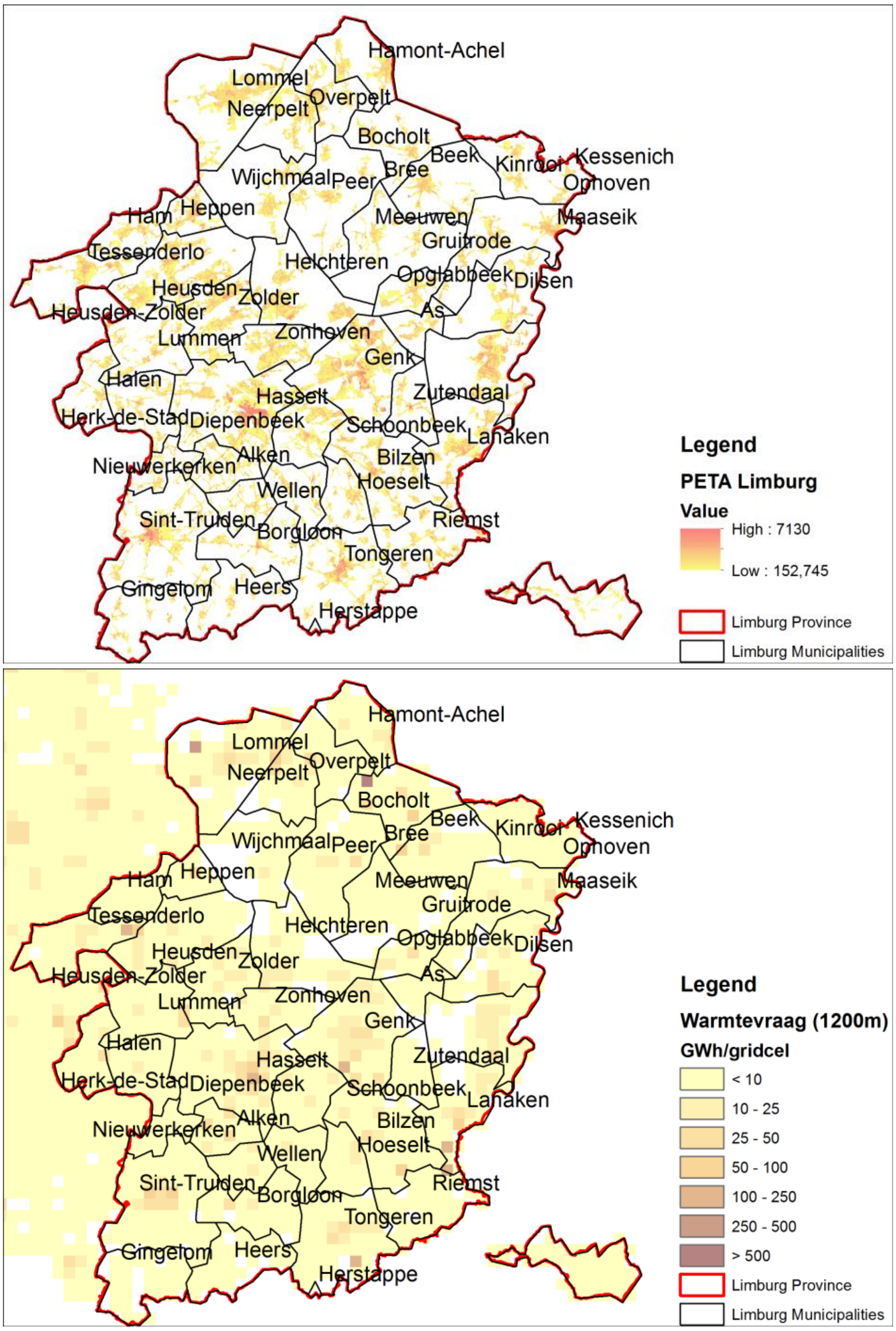


Figure 19: Comparison between the Pan-European Thermal Atlas (above) and the local heating and cooling map (below) for the Province of Limburg, BE

Overall, a high agreement has been found between the PETA and the Flemish Heat Map. Yet, both maps show differences.

A first determining parameter is the use of different underlying data sources; PETA relies on a population maps, whereas the Flemish Heat Maps relies on energy data on municipal level. The PETA, as a pan-European tool, does not allow to represent this local variations in the heat demand.

The second determining parameter is the ability of the methods to give a reasonable spatial distribution of the heat demand. Overall, the Flemish Heat Map is hindered by its methodology used for the protection of privacy. A substantial part of the heat demand is distributed evenly in the 1200x1200m resolution, resulting in vast areas with almost similar heat demands. The PETA succeeds better in representing the patterns of urban settlements in the distribution of the heat demand.

It was concluded from this comparison that a heat map developed with actual metered data will better represent the actual heat demand, but the methodology in PETA can be used to more accurately map the heat demand while still respecting the privacy of energy data.

Insights of this comparison have been used to improve the heat demand map for the province in the Energy Atlas for Limburg. Local datasets on the energy consumption were used as a basis of the Energy Atlas Limburg. This allows to represent the local variation in heat demand well. Yet, as the Energy Atlas Limburg distributes the energy consumption for heating purposes according to a best suited variable, the spatial distribution of the heat demand is a proxy rather than an exact determination. This safeguards the confidentiality of energy data, especially of the energy-intensive industry, and allows at the same time to represent the heating demand in a high spatial resolution.

This method allows to combine the benefits of the Pan-European Heat map (high spatial resolution), the benefits of the Flemish Heat Map (accurate energy data) and responds to the confidentiality concerns of the energy consumers.

A last aspect in the comparison between the local heating and cooling maps and PETA concern the data on potential sustainable heating and cooling sources (excess heat, renewable heat). It was concluded that these data layers in the local heating and cooling maps are often very specific to the case. Similar data all over Europe should be looked for in order to add these data to the PETA, which is not feasible. On the other hand was the data layer on potential excess heat sources very appreciated by the local STRATEGO partners, as they often have no access to data of these facilities, which makes it hard for them to map these.

2 STEP 2: Identification of areas of priority for intervention

2.1 Types of sustainable heating and cooling projects to consider

The next step in the support to the local authorities of the STRATEGO target cities, after mapping heating and cooling, is the definition of areas of priority for first intervention. These are areas where the local conditions are favourable for developing projects first.

The types of sustainable heating and cooling projects looked for in the STRATEGO target cities, is inspired by the results of WP 2 of the STRATEGO project, entitled “Supporting the development of enhanced National Heating and Cooling Plans (NHCP)”. The effect of an enhanced national heating and cooling plan was simulated in this WP 2 by modifying this BAU-forecasts in six steps:

- Step 1: Adding Heat Savings
- Step 2: Comparing Heat Network Solutions
- Step 3: Comparing Individual Heating Solutions
- Step 4: Integrating More Excess and Renewable Heat
- Step 5: Integrating More Renewable Electricity in the Heating Sector
- Step 6: Heat roadmap

These six steps are redefined slightly in six categories of projects to consider in the aim of making the local heating and cooling system more sustainable in the STRATEGO target cities, see Table 6.

Table 6: Areas of priority to look for in function of the projects to consider

Projects to consider	Areas of priority to look for
1. Reduce heating and cooling demand at end-consumers	• Areas with a higher specific heat or cooling demand than average • Areas with buildings with a poor energy label • Areas suffering from energy poverty
2. Improve and expand existing heating and cooling networks or build new ones in areas with a substantial heating and cooling density	• Areas where there is currently a district heating or cooling grid (DHC grid) • Areas currently without a heating or cooling grid but close to an existing DHC grid and with a high enough heat or cooling density or with a cluster of large heat or cooling customers • Areas with a high enough heat density [3]: ○ DH grid high feasible: > 300 TJ/km² ○ Current DH grid feasible: 100-300 TJ/km² ○ 4^{th} gen. DH grid feasible: 30 – 100 TJ/km² • Clusters of large heat consumers • Clusters of large cooling consumers
3. Look for more sustainable individual heating and cooling solutions in areas with a limited heating and cooling density	• Areas where roofs are suited to install solar water boilers • Areas where there is enough free land around the building to install heat pumps • Areas with a supply of biomass sources
4. Tap excess heat from thermal power stations, waste-to-energy installation, energy-intensive industry, …	• Installations that can supply excess heat and that are nearby potential heating (eventually cooling) consumers

5. Tap renewable heating and cooling sources (geothermal, bio-energy, solar thermal)	• Areas where large solar hot water boilers can be installed • Areas where large heat pumps can be installed • Areas with favourable geologic conditions to install (deep) geothermal wells • Related to the previous point: water purification stations or large sewers nearby potential heating (eventually cooling) consumers from which heat can be extracted • Areas with a supply of biomass resources
6. Improving conversion of fossil fuels to heat or cooling	• Areas with a gas grid or where a gas grid can be expanded and where existing, currently less efficient, boilers can be replaced by o Cogeneration units o Condensing boilers

Projects of each of these categories have been defined in the course of WP 3 "National plan – local action: supporting local authorities". This chapter will now illustrate these projects.

2.2 Project category 1: reduction of heating and cooling demand at end-consumers

2.2.1 Number of projects identified in this category

The first category of projects to look for are those aiming at reducing the heating and cooling demand of end-consumers. Such kind of projects were identified in 6 of the 30 STRATEGO target cities, see Figure 20. The total number of identified projects in this category is 7; their energy savings vary from about 2 to 90 GWh/year, see Table 7. Some of the cases are now highlighted.

Figure 20: STRATEGO target cities with projects on reduction of heating and cooling demand at end-consumers

Table 7: Overview of the identified projects on reduction of heating and cooling demand at end-consumers

Country	STRATEGO target city	Project	Energy savings (MWh/year)
BE	Kortrijk	Refurbishment of single family dwellings Renovation of multi-family dwellings	3,000
	Province of Limburg	Refurbishment of single family dwellings in rural areas	90,000
HR	Osijek	Refurbishment of historic buildings	15,000
	Velika – Gorica	Refurbishment of apartments	2,400
	Zagreb	Refurbishment of apartments	4,200
RO	Alba Iullia	Refurbishment of apartments – project 1	4,200
	Alba Iulia	Refurbishment of apartments – project 2	10,200

2.2.2 Case 1: Alba Iulia – reduction of heating demand by 40%

Alba Iulia is a medium-sized Romanian city, with around 63,000 inhabitants, situated in the heart of the historical region Transylvania, in Alba County. Many of the buildings in the city were designed and constructed on the basis of standards applicable before 1990 are of poor energy performance and present high potential for energy savings in space heating consumption. As a result, these buildings are the most energy inefficient buildings. Their energy consumption is high as a consequence of the poor thermal insulation as of the design (even lower now as deteriorated in time), inefficient interior installations (old and not properly maintained).

Hence, the main current challenges of Alba Iulia Municipality are:

- Improving thermal insulation of the envelope for residential buildings from Alba Iulia City (external walls, windows, doors, upper floor, floor above the basement), roofs and covers and, if the case, including measures on structural strengthen of buildings;
- Improving indoor comfort of thermal rehabilitated flats;
- Reducing the maintenance costs for heating and hot tap water;
- Reducing pollutants emissions generated by the production, transport and consumption of thermal energy.

Two areas with residential buildings were identified in Alba Iulia for first intervention after various meetings with the local stakeholders and the Municipality's representatives:

- The refurbishment of 30 residential buildings in Zone 1. They were built between 1978 and 1988, have 6 to 10 floors and host 659 apartments.
- The refurbishment of 44 residential buildings in Zone 2, built between 1967 and 1988 and hosting 1,410 apartments.

All apartments are equipped with individual natural gas boilers; their efficiency is around 80%. The heat losses of these buildings are substantial, as the constructive structure of the envelope is degraded, resulting high air infiltrations (single glass, wood/metallic frames, glass broken, etc.). Following thermal rehabilitation solutions are proposed:

- External walls insulation;
- Replacing the existing external old windows and doors with insulated double glazed/PVC joinery;

- Roof insulation;
- Floor above the basement insulation.

After the implementation of these measures, the energy consumption for heating will decrease with 4,200 MWh/year or to about 43% of the actual consumption for the buildings in Zone 1 and with 10,000 MWh/year or to about 40% of the actual consumption for the buildings in Zone 2.

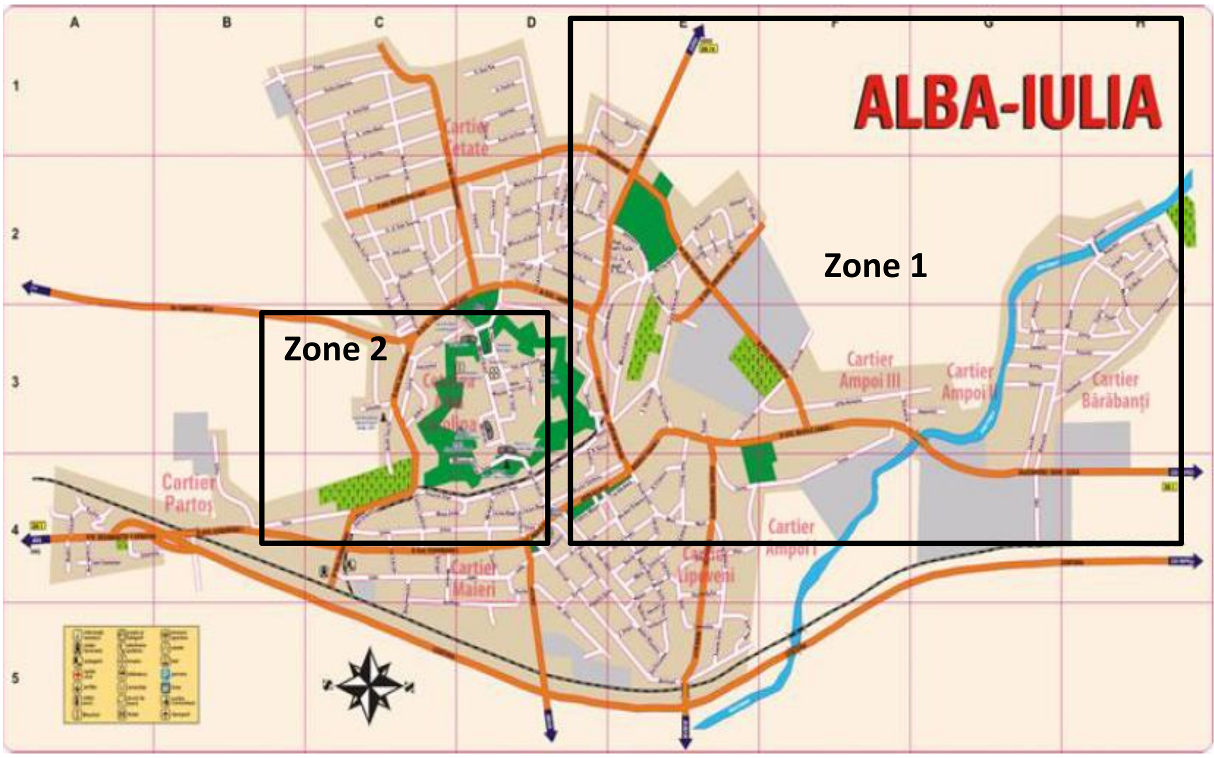


Figure 21: Areas for first intervention in Alba-Iulia, RO

2.2.3 Case 2: Osijek – refurbishment of historic buildings

Tvrđa is the Old Town of the city of Osijek, HR. It is the best-preserved and largest ensemble of Baroque buildings in Croatia and consists of a Habsburg star fort built in early 18th century on the right bank of the river Drava.

According to Croatian consensus in 2011 it has about 10.000 inhabitants living in about 3300 households, while rest of the buildings are mostly occupied by public and commercial sectors mainly through restaurants, hotels, couple of schools, few churches, one huge museum and local government buildings. Since all of those buildings were built according to 18th century standards, when masonry walls were much thicker than today and made out of solid bricks and stone, the average yearly specific heat consumption is around 160 kWh/m^2.

Most of those buildings, except few local government buildings and schools, have never been refurbished and have poor insulation, if they have any at all. The main challenge is the reduction of yearly specific heat consumption to about 60 kWh/m^2 trough refurbishment of buildings and implementation of water heat pumps which could also reduce primary energy consumption by up to 90%.

Two scenarios are considered to achieve this reduction of heat demand:

- Internal solid wall insulation
- External solid wall insulation

The annual gas consumption can decrease in both scenarios from 24.9 GWh/a to 9.3 GWh/a which could lead to the reduction of CO_2 emissions by almost 3.532 tonnes/a.

Table 8 shows the cost-benefit of both scenarios. Investment costs are about 13 million € for internal solid wall insulation; about 19 million € for external solid wall insulation. Subsidy levels should be about 60% to 70% in order to attain a net present value of 0 € for these investments. The potential program is the ELENA facility from the European Commission's Intelligent Energy Europe II (IEE) that covers up to 90% of eligible costs. There are also several national Croatian programs that also can cover part of the eligible costs.

The annual gas consumption can decrease in both scenarios from 24.9 GWh/a to 9.3 GWh/a which could lead to the reduction of CO_2 emissions by almost 3.532 tonnes/a.

Table 8: Cost-benefit analysis of insulation measures in Osijek, HR

Kind of solid wall insulation	Internal	External
Energy savings (MWh/a)	15,559	15,559
Investment costs (million €)	13.1 ± 1.5	19.0 ± 5.1
Required subsidy level to attain NPV = 0 €	$60\% \pm 4\%$	$69\% \pm 7\%$

2.2.4 Case 3: Kortrijk – renovation to passive house standard

The neighbourhood 'De Venning' in Kortrijk, BE has been built by the city's social housing company 'Goedkope Woning' (means 'Cheap dwelling') in the sixties. It is located at about 1.5 km east from the city centre. The social neighbourhood was at the time built as a so-called 'garden-quarter' and counts 163 separate entities, each with a small garden. The well-meant 'social character' (affordable renting houses for the low-income people) has - in people's perceptions - evolved towards bearing the hallmark of 'social ghettos'. The renovation and the creation of inhabitable houses must at the same time go hand in hand with the restructuring of the neighbourhood and its public space and with a better integration into its wider district area. A master plan for reconversion was made in 2010. The city has chosen to aim for a carbon neutral social housing estate after conversion. Kortrijk wanted to present the Venning neighbourhood as a best practice that is exemplary for reconversion of other (social housing) estates in Belgium.

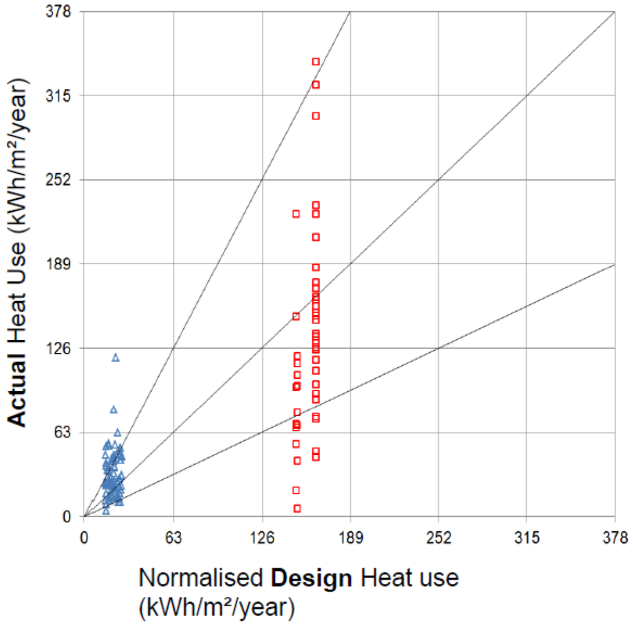
There are two options to achieve this:

1. By reducing the heat demand by insulating the dwellings well
2. By generation and distributing heat in the most efficient way while respecting the climate ambitions of the city

Kortrijk has looked for an optimum between these two options and the final strategy chosen was:

- The 49 smallest dwellings were demolished and replaced by 82 new apartments with a passive house standard (high insulation standard, air tightness, orientation that allows PV, collective ventilation system type D with heat recovery)
- 64 dwellings, with 2 or 3 bedrooms, are demolished as well and replaced by new ones with a passive house standard
- The remaining 50 dwellings, with 2 or 3 bedrooms, were renovated to a low-energy standard

The fuel consumption after renovation has dropped to about one eighth of the consumption before renovation, see Figure 22. The heat density remained nonetheless high enough to have a viable district heating project. This case hence demonstrated that building refurbishment and deployment of district heating networks can go hand in hand.



Source: Himpe E. (2015) ECO-Life in Belgium. Kick starting Green Transition in European Cities Conference, Høje-Taastrup (DK), 29-30 October 2015

Figure 22: Comparison between the heat use before (red) and after (blue) renovation in the Venning neighbourhood of Kortrijk, BE

2.3 Project category 2: district heating networks – refurbishment, expansion and/or new ones

2.3.1 Number of projects identified in this category

The second category of projects are related to district heating networks. It either aims at refurbishing existing networks, expanding these or deploying new schemes. In total 21 projects of this kind were identified in as many of the 30 STRATEGO target cities, see Figure 23 and Table 7.

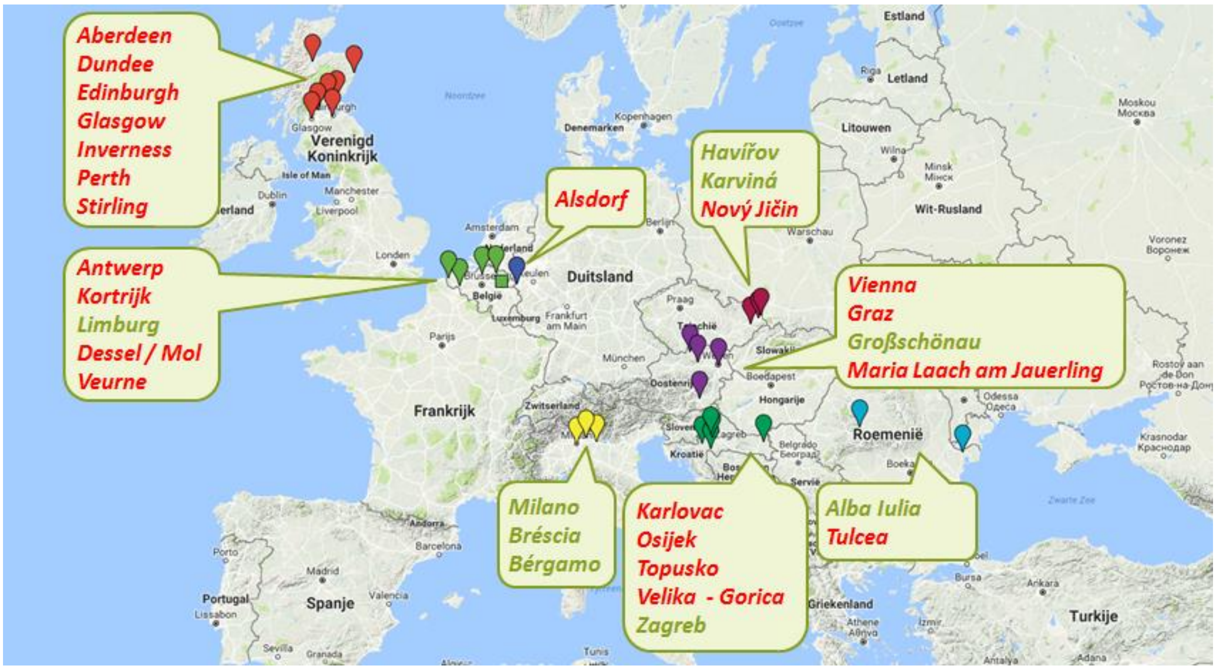


Figure 23: STRATEGO target cities with projects on district heating networks – refurbishment, expansion and/or new ones

Table 9: Overview of the identified projects on district heating networks

Country	STRATEGO target city	Project
AT	Vienna	Reduction of the return temperature in the DH network
	Graz	Reduction of the return temperature in the DH network
	Maria Laach am Jauerling	Reduction of the return temperature and heat losses in the DH network
HR	Karlovac	Construction of a heat storage
	Osijek	Construction of a heat storage
RO	Tulcea	Rehabilitation of the distribution network
CZ	Nový Jičin	Expansion of the DH network form an underutilized boiler to a nearby urban area and a hospital
HR	Topusko	Improved thermal insulation of the pipes and expansion of the DH network
	Velika Gorica	Interconnection of individual grids and expansion of the DH network Construction of a heat storage
UK	Aberdeen	Expansion of the DH network in the city
	Glasgow	Expansion of the DH network at the university of Glasgow into the city
BE	Antwerp	Development of an transport heat line from the port to the city
	Dessel	Development of small schemes in existing industrial estates and a new urban development
	Kortrijk	Development of a small DH network in the city centre
	Veurne	Development of a small DH network in the city centre
DE	Alsdorf	Development of a small DH network in a new urban development
UK	Dundee	Development of a DH network covering major parts of the city
	Edinburgh	Development of a DH network covering major parts of the city
	Inverness	Development of a DH network in the city centre starting from an energy centre
	Perth	Development of a DH network in the city centre
	Stirling	Development of a DH network in the city starting from an energy centre

2.3.2 Case 1: Reduction of the return temperature and heat losses of the DH network in Maria Laach am Jauerling, AT

Maria Laach am Jauerling is a small village in Lower Austria with about 950 inhabitants. A district heating network in the centre of the village, with an overall length of 1.5 km, supplies heat to over 30 heat consumers. The main heat consumers are restaurants and hotels, a primary school, a municipality office, multifamily apartments, business enterprises, a parish office annex church and some single family houses.

The age and energy consumption situation is very heterogeneous and reaches from old heritage buildings, hotels, public buildings to low energy single family houses and apartment buildings. The total heat demand of the consumers are 1,650 MWh/a and 1,200 MW heating output is connected. The heat losses of the distribution are approx. 18 %. The only energy suppliers are 2 biomass boilers with a heating output of 440 kW and 280 kW.

Analysis of the metering data from the substations of each heat consumer and from the two biomass boilers revealed a relatively high return temperature of 65 °C often occurs, see Figure 24. This opens a potential for improvement. A reduction of the return temperature would also lead to a reduction of the heat losses and electricity demand for grid pumps; it will in addition open the possibility to feed in low temperature sources.

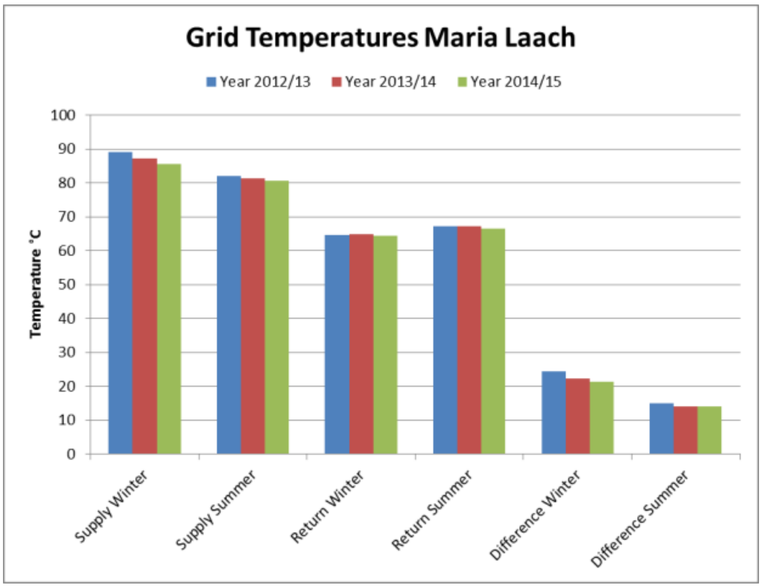


Figure 24: Return temperatures in the district heating network of Maria Laach am Jauerling, AT

It was identified that the source of these problems are planners and installers which are not aware of the special needs of DH networks in connection with the installation of the secondary side respectively the consequences if they are not fulfilled. The aim is to develop an agenda for an education module or workshop which addresses the planners and installers.

The relevant stakeholder for this project and mainly addressed in the STRATEGO project is AGRAR PLUS. This organisation was founded in the year of 1985, by an initiative of Lower Austrian Councillor responsible for agricultural affairs. His aim was to create a contact point for all persons who are interested in establishing communal biomass district heating plants and also to create an independent advice centre providing support in the examination and development of ideas and concepts. AGRAR PLUS is one of the leading companies in Lower Austria for realizing bioenergy projects and developed more than 30 district heating systems fired by wood chips in the last 5 years.

2.3.3 Case 2: Inclusion of a heat storage in an existing DH network of Karlovac, HR

Karlovac is situated near the southeast edge of central Croatia, some 56 km south-west of the capital city of Zagreb. It has 55.705 inhabitants. The heat, supplied by a 42 km long district heating network, covers about 11% of the total heat demand of Karlovac. About 4/5 of this heat consumption is residential, the remainder part is commercial and public services.

There is currently one heat only boiler (HoB) which delivers between 66 and 87 GWh/a, for space heating only. There is an ongoing private investment project for a new biomass CHP plant with 5 MW_E/20 MW_H capacities, some 2 km north-west from the current DH plant as shown in Figure 25. This new biomass CHP is intended to operate over 8000 h per year and should be able to cover all hourly heat demands that are lower than 20 MWh. This will lead to a reduction of the operation hours of the existing boiler and as a result of that, it will operate at a lower sub optimal capacity. This issue is especially relevant during spring and autumn when the demand from the DH network is just above the maximum production capacity of the CHP plant and when the relative small surplus demand has to be covered by the old HoB.

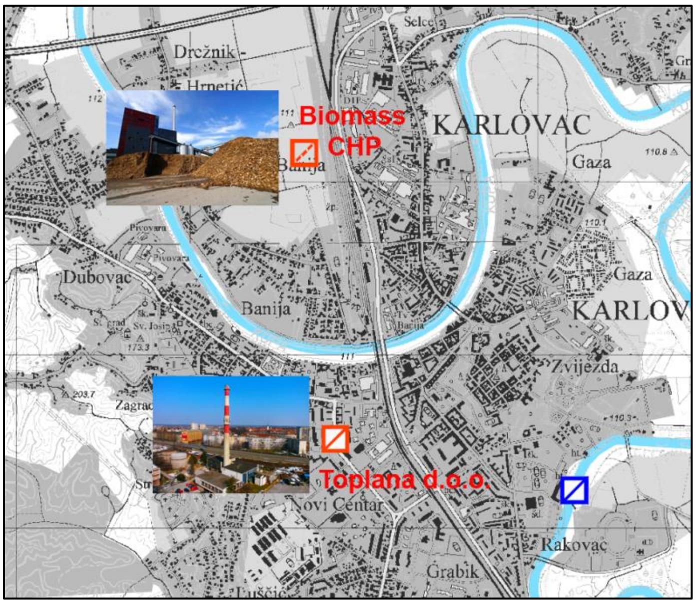


Figure 25: Locations of the existing boiler (South) and the new biomass CHP plant (North) in Karlovac, HR

An inclusion of a heat storage system within the district heating network has been proposed as a solution to this challenge. It will provide a bigger operational flexibility of the existing HoB which, consequently, leads to an improved conversion efficiency, in turn reducing the fuel consumption, the excess heat production, the operational costs, and the greenhouse gas emissions.

A techno-economic assessment of two designs of a heat storage (with a capacity of resp. 1,700 and 8,300 m³) reveals that the simple pay-back time is resp. 1.7 and 5 years, which is very short in view of the expected operational lifetime of 20 years. (Internal rates of return of resp. 58% and 20%). The consequent greenhouse gas reductions of the integration of either design of the heat storage is about 18%.

2.3.4 Case 3: expansion of the district heating network in Topusko, HR

Topusko is small Croatian municipality at about 55 km south of Zagreb. It has 2985 inhabitants on 198,3 km. It is well known in the area for its geothermal water sources that emerge from the depth of 1500 m and are of volcanic origin. In 1980's four boreholes TEB-1 (20 l/s), TEB-2 (15 l/s), TEB-3 (16 l/s) and TEB-4 (100 l/s), were drilled and put into usage for medical purposes, such as rehabilitation and tourism, and as heat source for municipality's small DH (district heating) network in the mid 1980's.

Currently, the northern district Novo naselje and some houses are connected to the borehole TEB-3 (the red area on Figure 26) , while a thermal rehabilitation centre, two schools, a kindergarten, an industrial complex and some houses are connected to municipality's main DH network which is connected to the two boreholes TEB-1 and TEB-4 (resp. the blue and green area on Figure 26). The yellow area represents a small residential district that could potentially be covered by a new geothermal borehole TEB-5 or trough new pipeline connection that connects it to the existing DH network. The heat capacity of the existing DH network could be higher if the pipes that connect borehole TEB-1 to the DH station were properly insulated. The main priority for improving the current situation in the municipality is the reduction of heat loses trough installation of proper pipe insulation. The connection of the new potential consumers from the yellow region would require an expansion of the existing DH network with approx. 450 m of which 150 m are main distribution pipelines while the rest are ancillary pipelines that are connected directly to the consumers.

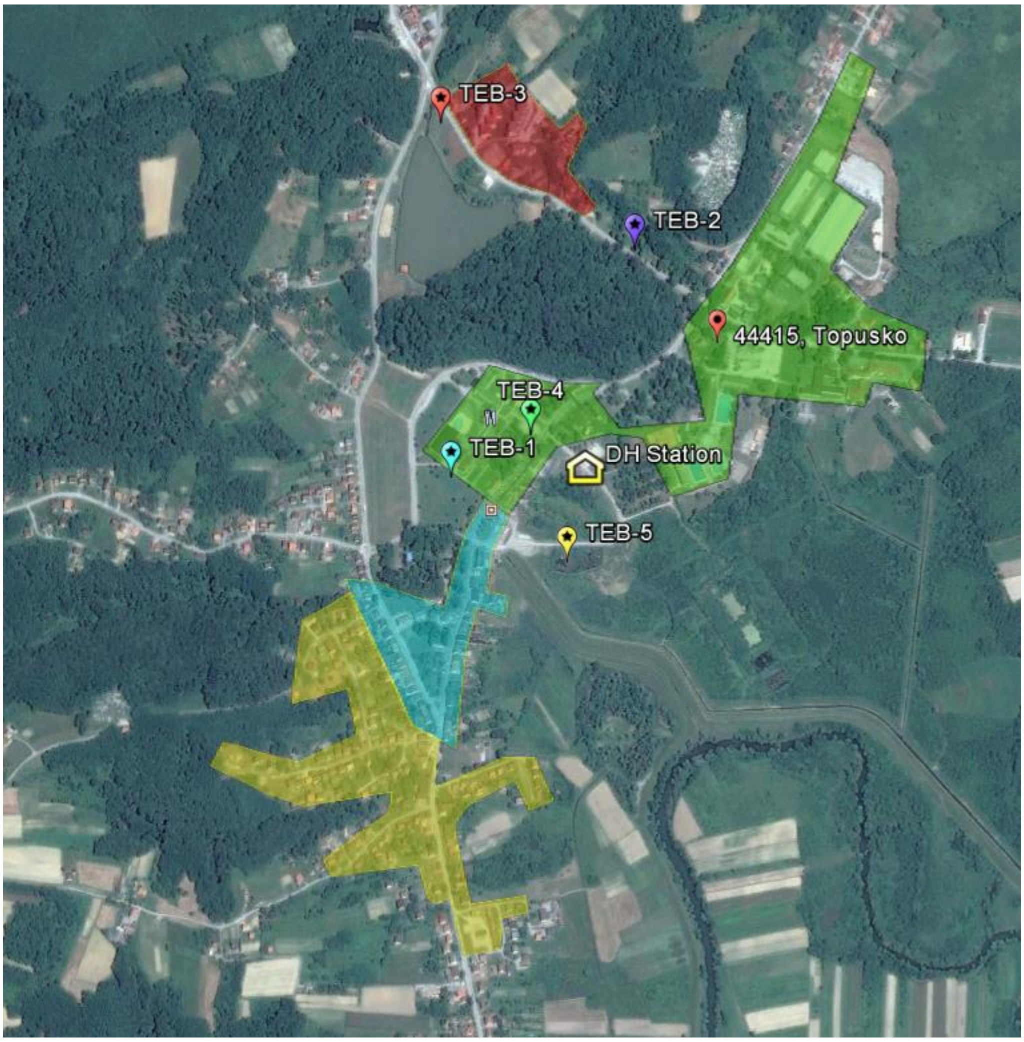


Figure 26: Grid expansion areas in Topusko, HR

2.3.5 Case 4: Building stepping stones in Dessel / Mol, BE

The two municipalities Dessel and Mol are located in the north-east of Belgium, close to the Dutch border. A deep geothermal well is currently under development. It taps water from 3.6 km deep. Its capacity will amount to 15-17 MW_{th} and 1.5 MW_{e} on the short term. Once fully developed, its capacity will amount to about 50 MW_{th} and 5 MW_{e} and it would be the fourth biggest deep geothermal well in Europe.

It was decided from the start to connect the blue shaped area on Figure 27 (VITO, SCK, BP), in which research institutes are located, to the deep geothermal well. The question is under what conditions a development of a district heating network in three areas with high heat density is feasible, prior to the development of the deep geothermal well. In other words, can micro-DH-networks be developed in these areas in a feasible way, with the perspective to interconnect this stepping stone at a later stage to a more integrated scheme. The areas are:

1. North from the well: a new residential development, called Elsakker
2. East from the well: an existing industrial area, called Goormansdijk
3. East from the well: an existing industrial area, called Kastelse Dijk

Figure 27: Areas to create stepping stones in Dessel/Mol, BE in view to connect these to a deep geothermal well

The conclusion of this analysis is: the conversion from the existing individual boilers to a district heating grid in the two industrial estates is not feasible on its own. However, once the deep geothermal well has proven to be a success, the boundary conditions change. The deployment of a district heating network and its connection to the well then turned out to be a feasible option.

The situation for new district developments is different as there are no sunk costs of an already existing gas infrastructure. The development of a district heating network has demonstrated to be a viable option for the examined case even in absence of the carbon-neutral heat source.

These conclusions are important guidelines for setting up a local heating policy. The option of a district heating grid should be investigated for every new residential development. This allows to create a heat market that on its turn can stimulate the development of the deep geothermal well. In the meanwhile, the discussions should start with other industrial estates and other major heat consumers in the area to prepare their shift once a deep geothermal well or any other major sustainable heat source is ready to be exploited.

2.3.6 Case 5: Development of a district heating network from a redeveloped energy centre in Inverness, UK

Inverness, in the Scottish Highlands, is a city with about 47,000 inhabitants. A potential for a DH scheme in the centre of Inverness was identified, mainly focused around commercial heat and electric loads. The initial centre DH scheme could be established from an energy centre at the defunct UHI Inverness College Campus at Longman Road. The university had a generously sized energy centre in place with large stack. Main heat loads identified nearby are the Longman Campus redevelopment, police station, retail centre, public library, hotels, supermarkets and a large shopping centre, see Figure 28.

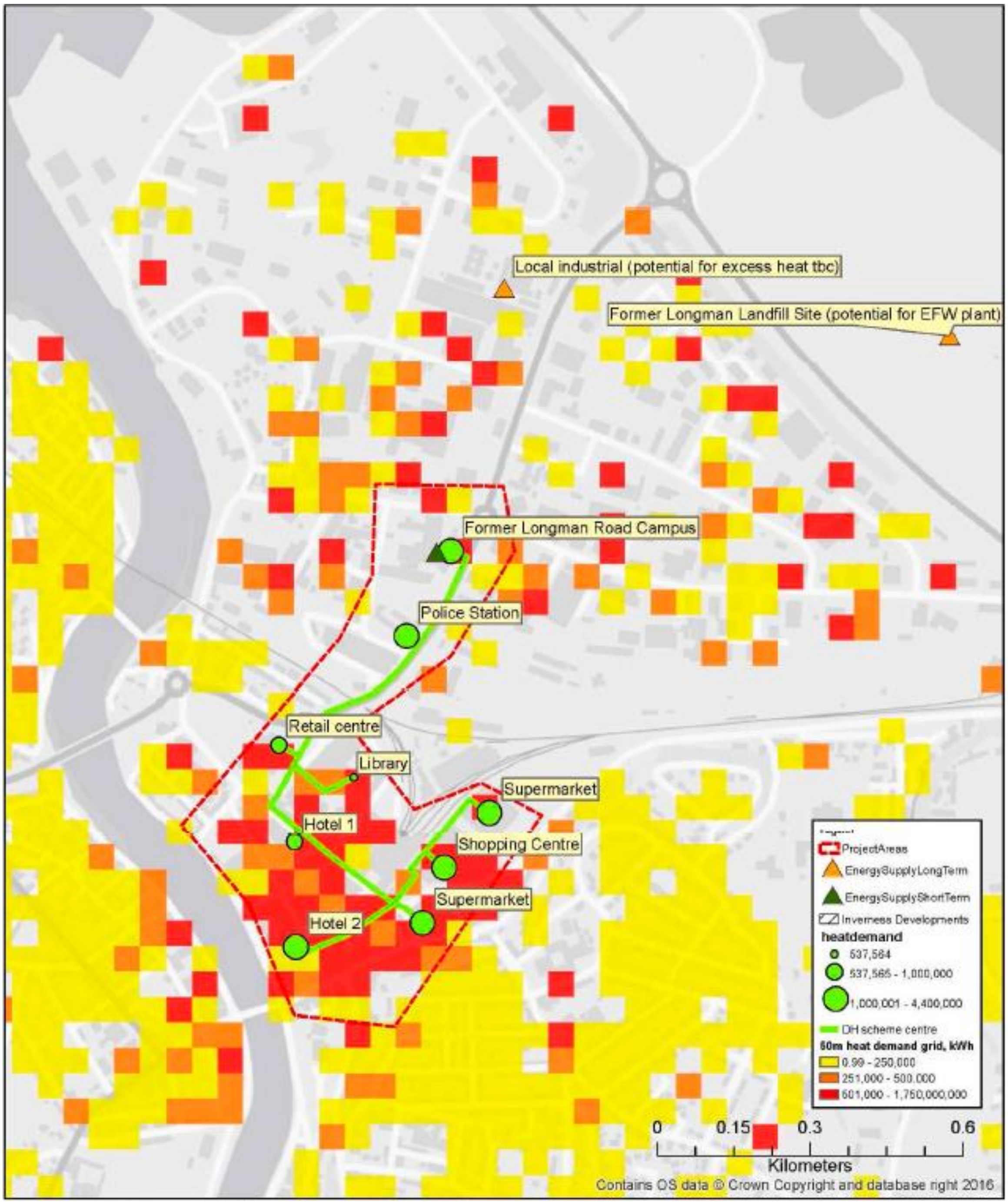


Figure 28: Potential design of a new district heating network starting from a redeveloped energy centre in the centre of Inverness, UK

The total approximated heat demand for the system is 16.3GWh. The linear heat density of the proposed network (1.9km length) equates to about 8.6 MWh/m which is high compared to other UK networks. Despite a moderate number of connection points which could lower initial network costs, the high number of different and commercial consumers could become challenging.

The annual electricity consumption of the supermarkets (freezing and chilling food) and the large shopping centre (electrically heated store units and air handling/cooling units) is estimated at about 10GWh. Hence, a CHP plant together with private wire connection could displace parts of the grid electricity currently used, resulting in lower energy costs for consumers and payback for DH developers.

In a later phase of development of the DH network, a connection of the potential energy centre to local industry nearby and an envisaged Landfill Energy from Waste plant would provide heat to the DH systems with reduced carbon emissions at stable prices

The city centre's key quality is the diverse stock of more than 130 historically listed buildings. A low carbon DH network could reduce carbon emissions from this large number of historically listed buildings that might otherwise be hard to treat with external wall insulation. However, as big parts of the centre are within a conservation area, it creates network routing constraints. Any DH trenching would need to fit in with visual criteria as any other utility trenching. The crossing of a railway bridge might require additional considerations.

2.4 Project category 3: sustainable individual heating and cooling solutions

2.4.1 Number of projects identified in this category

One STRATEGO case focuses specifically on individual sustainable heating solutions, see Figure 29.

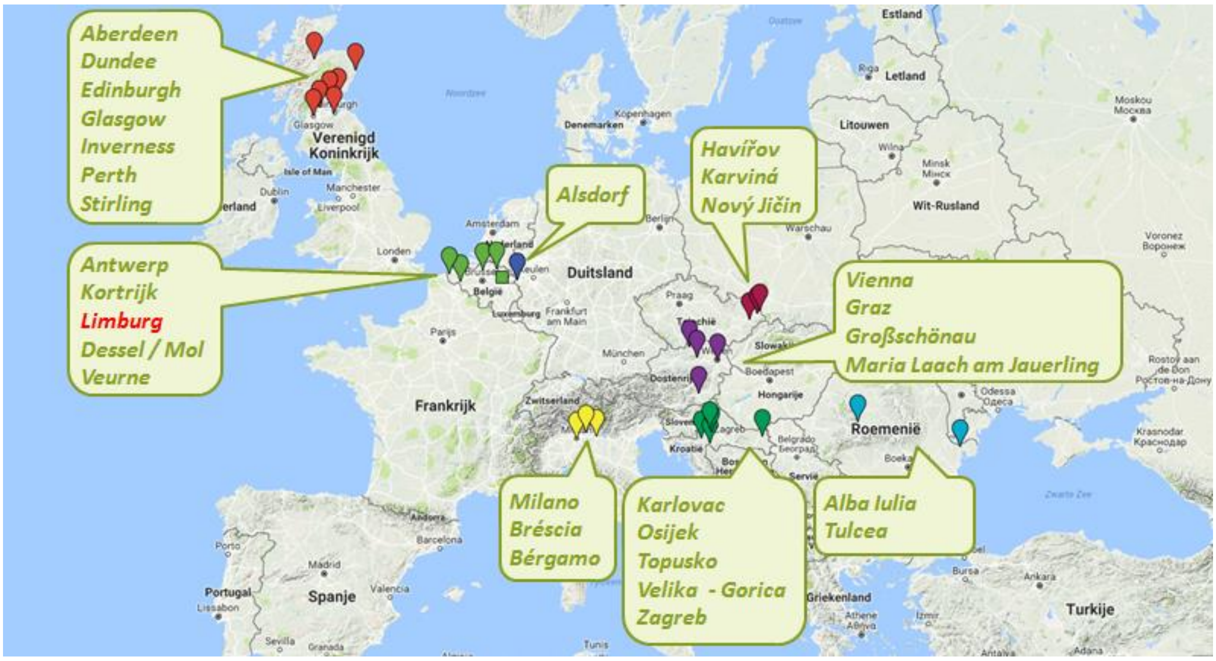


Figure 29: STRATEGO target cities with projects on sustainable individual heating and cooling solutions

2.4.2 Case 1: Phasing out heating oil in rural areas in the Province of Limburg, BE

The fuel used for heating by households in the Province of Limburg, in the east of Belgium, was analysed. It indicated two areas with a high share (>60%) in the south and the north-east of the province, see Figure 10. An additional analysis on the average fuel consumption per household per municipalities highlighted the same areas, indicating a high correlation between both, see Figure 30.

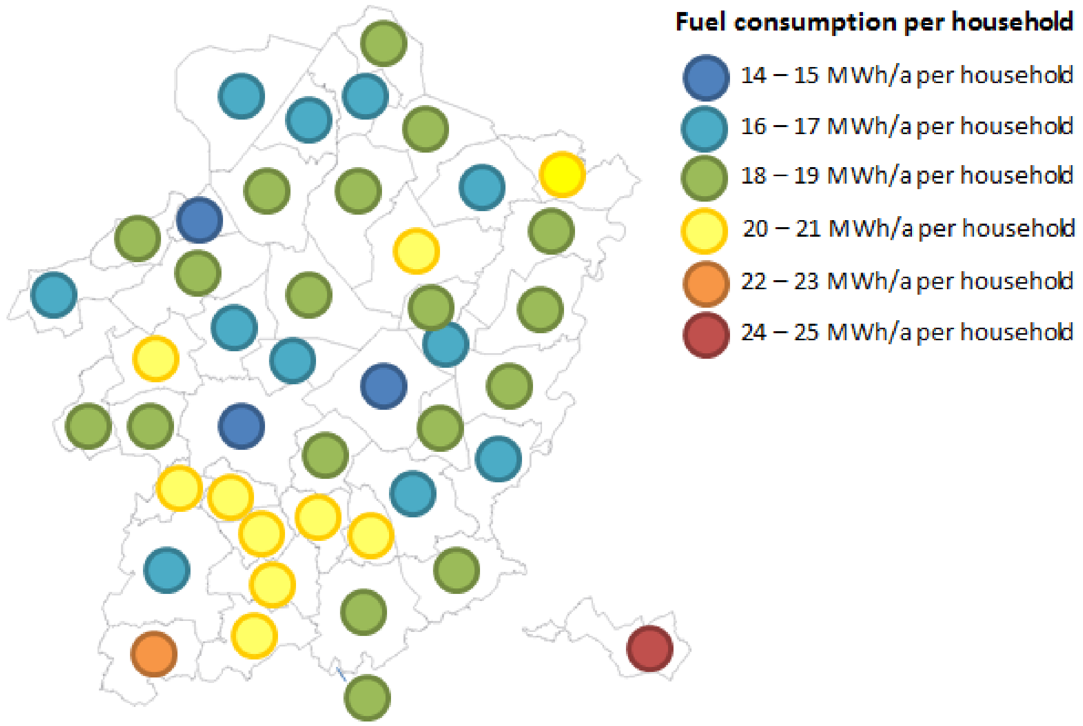


Figure 30: The average consumption per household and per municipality of fuel for heating in the Province of Limburg, BE

The type of the buildings can partly explain the higher share of fuel oil: the buildings in the south are in average older than in the rest of the province; the buildings in the north-east are more detached than in the rest of the province. Fuel oil is more common in houses built before the ‘80s and in more in favour in rural areas because of the slower penetration of natural gas pipes in during the past decades. In Flanders, as well is in Limburg, these rural buildings have on average a higher living area compared to more urban areas. As a consequence, the average heat consumption is higher compared to other fuel types. As a conclusion, these areas reveal an energy demand reduction potential in the first instance. This seems to be the prime lever for phasing out heating oil and other fuels. Reducing the specific fuel for heating demand in these areas to the province’s average would save about 90,000 MWh of energy annually.[9]

The assessment of the renewable heat potential indicates that by 2020 the share of heat pumps and hot solar boilers can be doubled compared to current installed capacity (Van Esch, 2016). However, it only would replace 1% to 2% of the total fuels consumed by the household in the province; estimated at about 9,500 MWh/year. Deploying renewable heat sources is hence a secondary lever for phasing out fossil fuels (other than natural gas) in the focus areas.

[9] See: http://www.limburgklimaatneutraal.be/ (in Dutch only)

2.5 Project category 4: exploiting the excess heat potential

2.5.1 Number of projects identified in this category

The fourth category of projects aims at exploiting the excess heat potential. The main potential sources of excess heat are waste-to-energy plants, power plants and the (energy-intensive) industry. Thirteen projects aiming at exploiting the excess heat potential were identified by the STRATEGO project, demonstrating a potential from various sources, see Figure 31. The potential excess heat supply varies from 1,500 to 1,500,000 MWh per year, see Table 10.

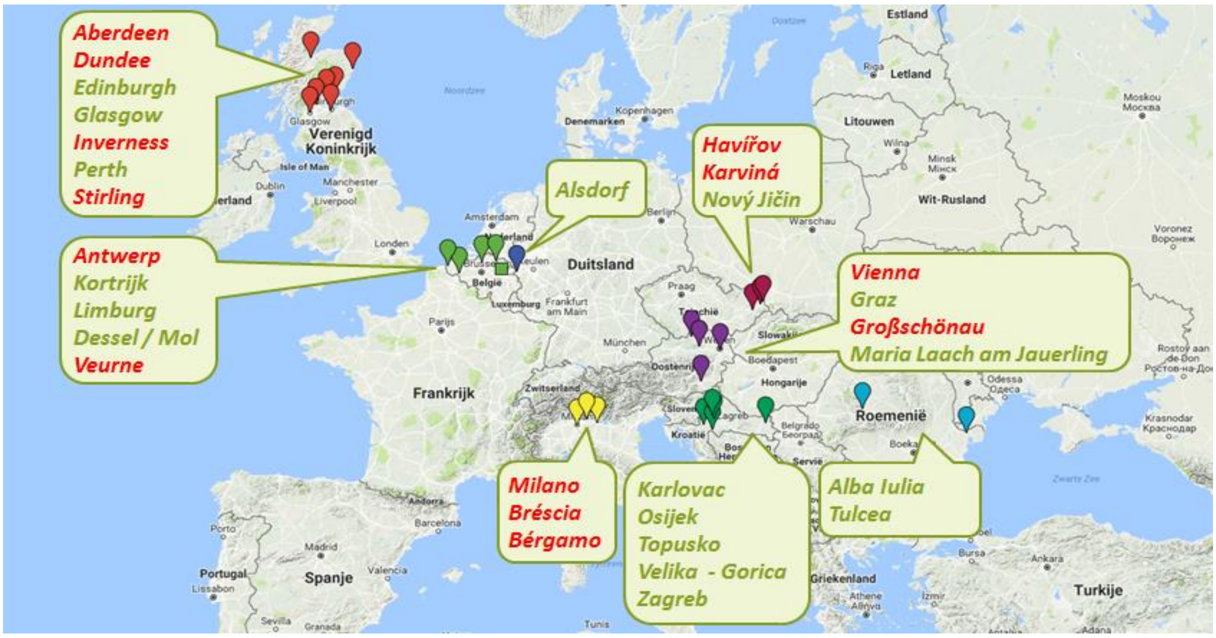


Figure 31: STRATEGO target cities with projects on exploiting the excess heat potential

Table 10: Overview of the identified projects on exploiting the excess heat potential

Country	STRATEGO target city	Excess heat sources	Energy deliveries (MWh/year)
AT	Vienna	Three energy-intensive industrial companies	~1,000,000
	Großschönau	Small & medium-sized enterprises	n.a.
BE	Antwerp	Waste-to-Energy plant Oil refineries and petrochemical factories	~90,000
	Veurne	Small & medium-sized enterprises	1,500
CZ	Karviná - Havířov	Waste-to-Energy plant Power plant	n.a. 320,000
IT	Milan	Power plant	1,000,000
	Brescia	Three industrial sites	77,000
	Bergamo	An industrial pole	90,000
UK	Aberdeen	Waste-to-Energy plant	n.a.
	Dundee	Waste-to-Energy plant	n.a.
	Inverness	Waste-to-Energy plant One energy-intensive industrial companies	n.a.
	Stirling	Two energy-intensive industrial companies	n.a.

n.a.: not assessed

2.5.2 Case 1: excess heat from the industry

Antwerp signed in 2009 the Covenant of Mayors. It was concluded from its SEAP that there are vast amounts of excess heat available in the Port of Antwerp. The Port Authorities of Antwerp commissioned in 2012 a study to assess this excess heat potential. Sources of excess heat between 80 and 120°C and a minimum thermal capacity of 1 MW were listed. Altogether, they represent a thermal capacity of 433 MW, divided in 6 clusters, see Figure 32[10]. An additional 48 MW thermal was detected in industrial sites outside these clusters. Excess heat sources providing excess heat warmer than 120°C were not listed, there are indications though that this excess heat potential is as high as the excess heat potential between 80-120°C.

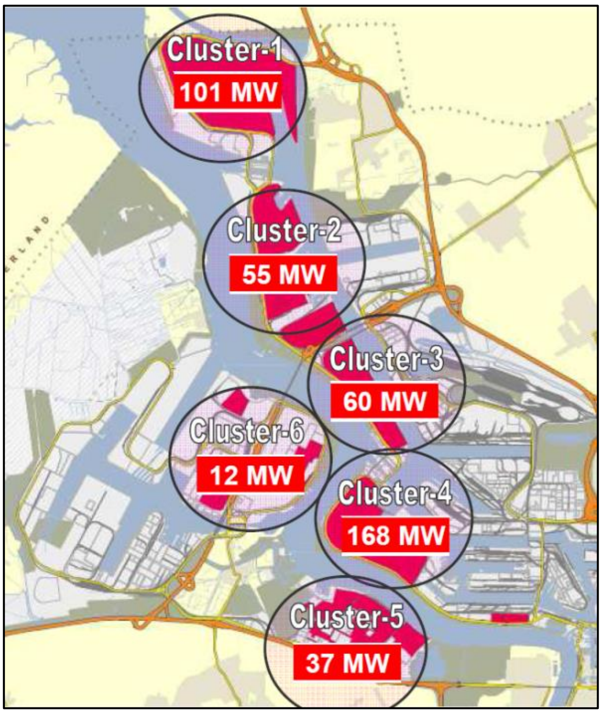


Figure 32: Excess heat potential in the Port of Antwerp, BE

Bringing that excess heat to the city would result in a significant improvement of the sustainability of the city. Since then, it is Antwerp's ambition to bring that excess heat to the city. The City of Antwerp has a real challenge though realising this ambition as there are not any district heating grids in the city (apart from some small schemes at high school and hospital campuses).

A feasibility study on the potential for district heating grids, finished in 2014, showed that a substantial part of the Antwerp has a techno-economical potential to be connected to a district heating grid, which is about 150,000 dwellings. The city's ambition is to connect 4,000 dwellings each year.

A first major development of district heating in Antwerp is Nieuw-Zuid (New South) in the south of the city along the Scheldt river. About 2000 buildings will be built during 2015-2030 with a total floor area of 270.000m². On April 28, 2015, the first district heating pipe was laid in the ground, the first of a 5km network. When completed, it will be the largest DH system in Belgium.

A next strategic project in Antwerp concerns the construction of a transportation line of about 12 km and a distribution network of about 30 km to connect to Port of Antwerp to residential areas and potential industrial and commercial demand zones in the north of Antwerp. The main source to these developments in the north of Antwerp will be excess heat from an plant incinerating industrial waste; oil refineries and petrochemical installations can feed in excess heat at a later stage. This entire district heating network would be fully operational by 2022.

[10] Source: Gemeentelijk Havenbedrijf Antwerpen - 2012

2.5.3 Case 2: A power plant and a W-t-E plant as alternative heat sources in Karviná, CZ

The northern part of the Moravian-Silesian region, CZ is characterized by its original focus on heavy industry, particularly metallurgy and coal mining. Next to the region's major city of Ostrava there are large residential complexes - towns Karviná and Havířov. These towns are supplied with heat primarily through the extensive district heating system with two CHP installations and a gas heating plant. The two CHP installations are older sources with emission levels exceeding the permit thresholds. A significant upgrade or replacement of these sources is required in the future.

An alternative potential heat source is a power plant at a distance of about 9 km from the centre of Karviná. This Dětmarovice power plant has a capacity of 4 x 200 MW_e. This plant could be gradually modernized and adapted to allow heat supply to the district heating network.

A Waste-to-Energy incineration is considered in addition. It could be either located at the power plant of Dětmarovice or within one of the existing CHP installations, see Figure 33. The optimum configuration of the Waste-to-Energy incineration consists of 2 lines with overall capacity 192 t tons of waste per year. The installed thermal capacity would amount to 40 MW, which would be able to provide 320,000 MWh/year. This incinerator could replace one of the old CHP installations.

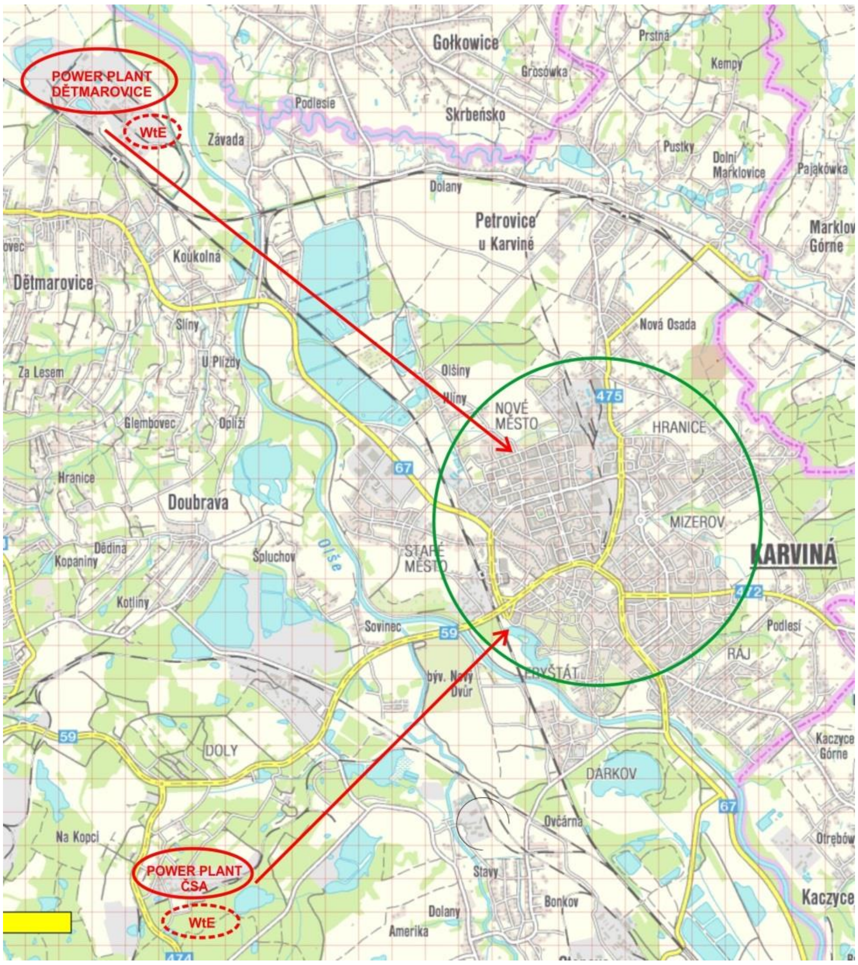


Figure 33: Location of the alternative excess heat sources in Karviná, CZ.

This project has significant non-energy benefits. The WtE incinerator will reduce landfill by about half, which in turn would allow the Czech Republic to fulfil its obligations under from EU Directive

31/99/EC on the landfill of waste. The progressive retrofit of the Dětmarovice power plant will reduce pollutant emissions so that emission limits according to EU and Czech legislation after 2020 are met. This will be an important achievement as Ostrava and whole Moravian-Silesian region is one of the most contaminated regions of the Czech Republic in terms of emissions.

2.5.4 Case 3: excess heat from a power plant

District heating meets currently in Regione Lombardia (Italy) only 2% of final energy demand. The waste heat from existing power plants and industrial activities could be important resources to reduce primary energy consumption in the region. The district heating networks could allow to recover for heating purposes a large amount of excess heat that nowadays is lost. This would allow a significant overall increase of efficiency at the local level.

Milan is the biggest city in Regione Lombardia and it represents the most densely populated area. Milan has therefore been identified as one of the area with priority of intervention because improving measures taken here can have important effects on the whole regional scenario.

One of the main solutions to improve the heating system of Milan could be to improve its district heating system by feeding it with thermal energy recovered from the existing CCGT power plant in Cassano d'Adda. This project could supply till about 400 MW of thermal power to the Milan district heating system. This will result in an improving of total energy efficiency, and it will save roughly 126,000 toe annually, avoiding emissions of about 340,000 tons of CO_2 for each year.

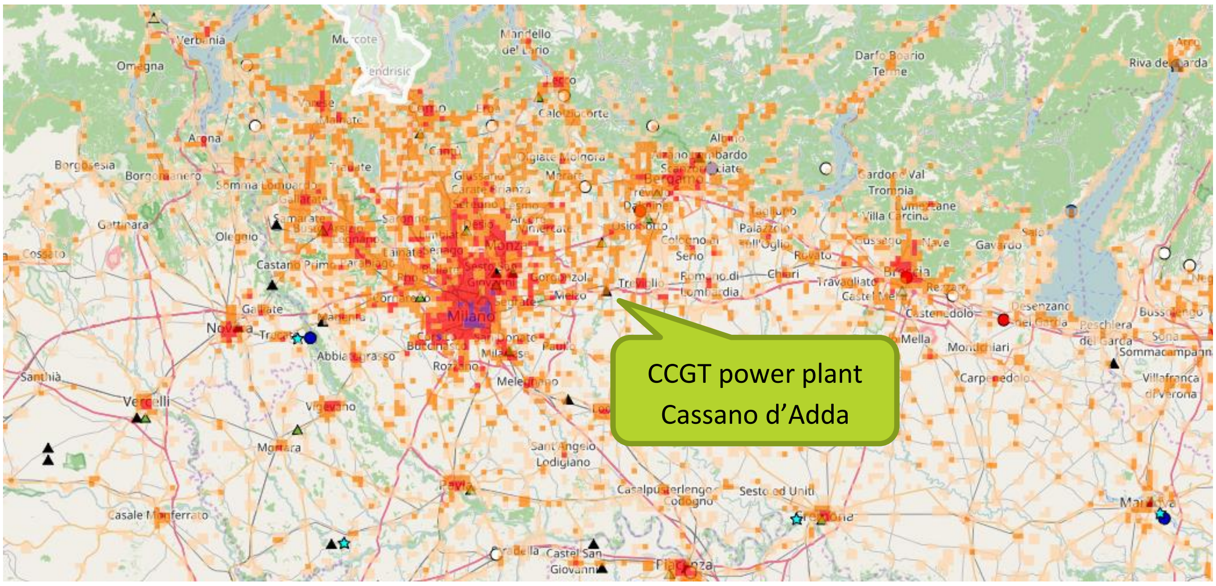


Figure 34: Location of the power plant that can supply heat to the DH network of Milan, IT

2.6 Project category 5: exploiting the renewable heat potential

2.6.1 Number of projects identified in this category

The fifth category of projects aims at exploiting renewable heat sources. Ten such projects were identified by the STRATEGO project, demonstrating a potential from various sources including geothermal sources, heat pumps, solar thermal (collective or individual), biogas and biomass, see Figure 35 and Table 11. The potential excess heat supply varies from 1,500 to 1,500,000 MWh per year.

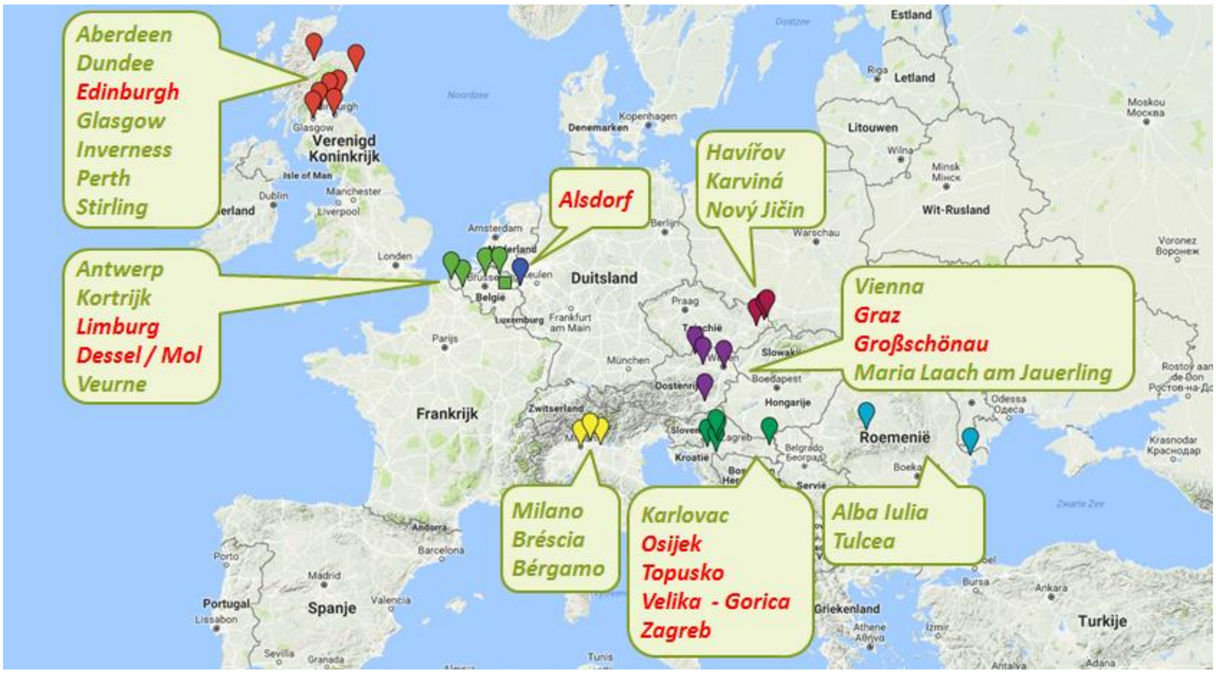


Figure 35: STRATEGO target cities with projects on exploiting the renewable heat potential

Table 11: Overview of the identified projects on exploiting the renewable heat potential

Country	STRATEGO target city	Renewable heat sources	Energy deliveries (MWh/year)
AT	Graz	Upgrading waste heat via heat pumps, biomass plant, solar thermal plant	n.a.
	Großschönau	Solar thermal, booster heat pump	n.a.
BE	Dessel	Deep geothermal	24,000
	Limburg	Ground source heat pumps, individual solar thermal, biogas from mono manure digestion	9,500
DE	Alsdorf	Geothermal	
HR	Osijek	Heat pump, extracting heat from a river or waste water treatment plant	22,00
	Topusko	Geothermal, heat pumps connected to a geothermal well	7,600
	Velika Gorica	Solar thermal	125
	Zagreb	Solar thermal	250
UK	Edinburgh	Biogas from sludge digestion	n.a.

n.a.: not assessed

2.6.2 Case 1: Integrating solar thermal and a heat pump in the rural district heating network of Großschönau, AT

Großschönau is a village with about 1,200 inhabitants in Lower Austria. A district heating network supplies the centre, providing heat to some municipal facilities, businesses and households, see Figure 36[11]. A wood chip heating plant with a thermal capacity of 500 kW was built in 1994 and has been since continuously in use. For supplying the DH network with a wood chip heating plant 30 % more biomass is burned as locally grows.

[11] Source: Sonnenplatz Großschönau GmbH

The aim of the village of Großschönau is to develop concepts and strategies for sustainable energy supply for rural communities having a high degree of transferability to other regions. However, the village struggles with some challenges. First, there is no capacity to connect new customers nor to expand the grid. Second, efficiency problems arise, especially in summer-period in which the system supplies hot sanitary water.

On the other hand, some alternative heat sources are detected. Some buildings have solar thermal systems on their roof top that are not yet connected to the DH network. A nearby water treatment plant can serve as heat source for a heat pump for decentralized integration and some SMEs next to the village can provide excess heat.

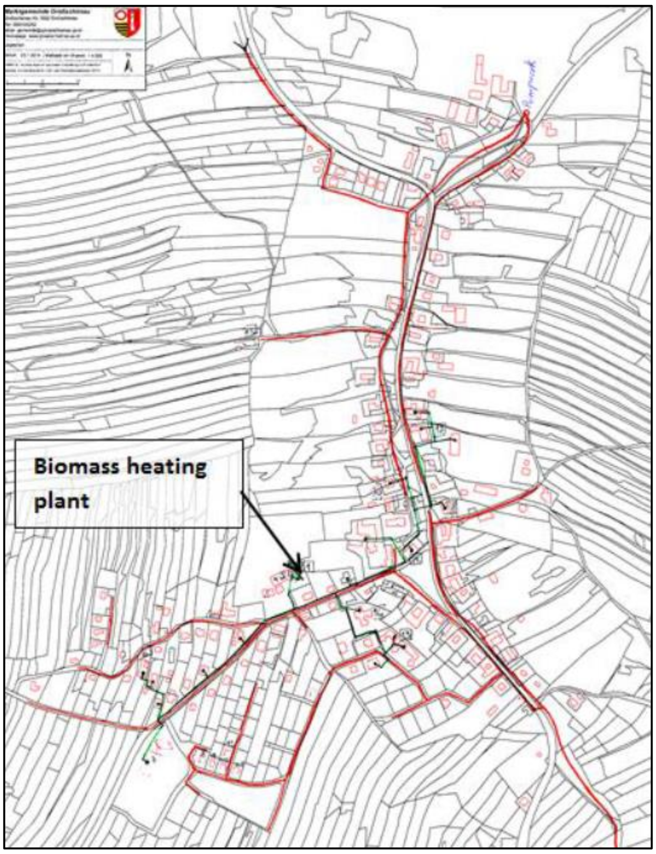


Figure 36: Location of the district heating network in Großschönau, AT

The integration of these alternative and renewable heat sources into the district heating network of Großschönau was discussed in the framework of the STRATEGO project. This case can act as a stepping stone towards real implementation of a demonstration project with a high replicability potential in the wider area.

2.6.3 Case 2: Distributed renewable heat sources as an alternative to fossil fuel heating in Limburg, BE

The analysis of residential fuel use data for the Province of Limburg, in the east of Belgium, has revealed some areas with a high share of heating oil in the fuel mix, see Figure 10. A deeper analysis showed that these areas have a higher average fuel use per household than in other municipalities in the province, in turn revealing a potential to save energy, see Figure 13.

A next step is the deployment of renewable heat sources. As the focus of this case is on rural areas, where natural gas grids deemed not to be economic feasible, as well as district heating grids, only distributed renewable heat sources are looked at: heat pumps, hot solar boilers, biomass boilers (burning residual wood resources from forestry) and biogas installations (with manure as basic input). Only the potential, that can be realised by 2020 taking into account the current socio-economic context, the planned investments and the known policy measures is considered (Van Esch, 2016). A statistical map indicates the potential for each municipality in the province, see Figure 37.

The map of the renewable heat potential shows that heat pumps contribute the most to this potential (two thirds of the total potential), followed by hot solar boilers (one fifth of the potential) and next by biogas and solid biomass (resp. 8% and 4% of the total potential). The map shows some regional differences. The biogas potential is prevalent in the north-east of the province mainly, where there is a substantial cattle breeding activity, also in the south, but to a lesser extent. The biomass potential is mainly located in the middle of the province, where there is a lot of forestry.

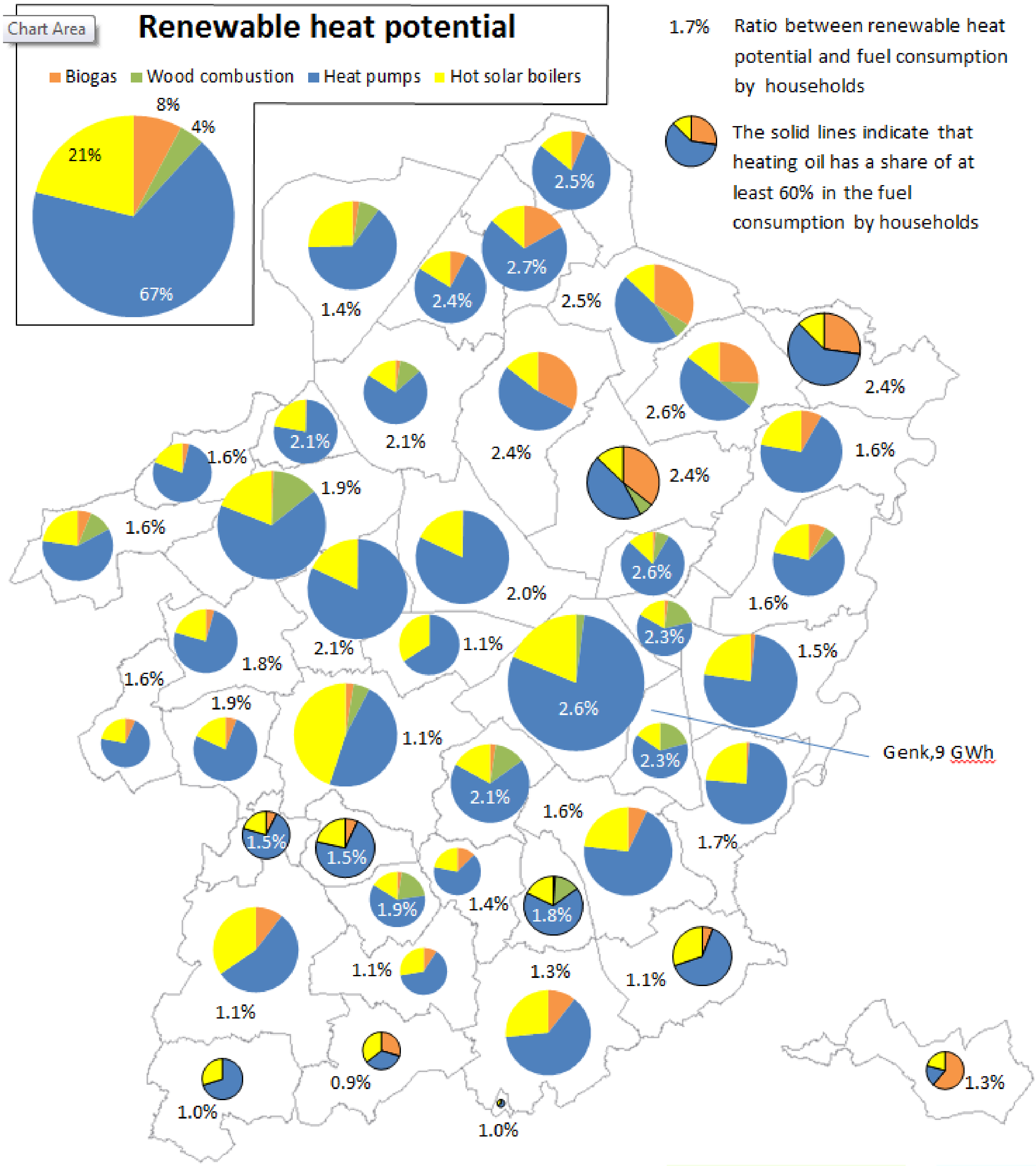


Figure 37: Distributed renewable heat potential by 2020 in the Province of Limburg, BE

The depicted potential of heat pumps and hot solar boilers by 2020 is about the double of what is currently installed in the province, whereas additional solid biomass potential is a small fraction of the current use and the use of biogas in the residential sector is questionable.

The potential of these four renewable heat sources is compared to the residential fuel use; it is found that this potential only adds about 2% to the current renewable share in the fuel mix. The renewable heat potential for municipalities with a high share of heating oil varies between 0.9% and 1.8% in the south of the province and amounts to about 2.5% in the north-east, where there is a higher biogas potential.

This analysis indicates that reducing the energy demand for heating should be the prime lever for phasing out heating oil and other fuels, whereas the deploying of distributed renewable heat sources a secondary lever. A targeted policy and approach might be necessary to speed up the conversion from fossil fuels to renewable heating in these focus areas.

2.6.4 Case 3: Revitalisation of a mine water well in Alsdorf, DE

Alsdorf is a medium-sized city near Aachen, BE. It has about 46.500 inhabitants on 31,67 km². The city was strongly shaped by the coal mining industry since the 1850´s.Over many years Alsdorf was the most important coal mining site in the region of Aachen. The last operating coal mine, the “Grube Anna”, was closed in 1983. Alsdorf current focus is on local climate protection and renewable energy use, which is represented by the city’s new claim “Alsdorf – full of energy”.

Figure 38: The Eduardschaft in Alsdorf, DE: a closed coal mine - a potential source of renewable heat

In Alsdorf, only one small-sized district heating grid is in operation now. Most heating systems in private households and municipal buildings are running on natural gas, a few systems are using oil. Alsdorf’s city centre used to be supplied by a district heating grid until 2009. Due to extreme high costs for refurbishment of the network, the operator decided to take it out of operation and instead of heat the utility supplies the city centre with natural gas.

The energy policy of the city/region prioritises the construction of low-energy and passive houses. The renewable energy potential is very limited (few potentials for wind/solar) in this region. Nonetheless, there are project ideas to supply future new urban developments with small DH grids.

A potential source is mine water. A possible location for this geothermal energy in Alsdorf is the closed coal mining shaft “Eduardschacht”. It is located on the “Energeticon” site and 900 m deep. It holds mine water with a temperature of 26°C. The revitalisation of the mine water well to heat the “Energeticon”, a science museum on mining and renewable energy, was evaluated in a former feasibility study, but ended inconclusive. The development of new housing areas, close to the mining shaft “Eduardschacht” in the near future, offers however new perspectives for using the mine water for heating purposes.

2.6.5 Case 4: Integration of solar thermal via a seasonal heat storage in Velica Gorica, HR

The city of Velika Gorica is located some 16 km southeast from the capital city of Zagreb, HR. According to Croatian census from 2011 it has a population of about 63.517 people making it the 6th largest city in Croatia.

A district heating grid is 9,4 km long and serves 5.650 customers. It consists of 13 local boiler plants, 3 of which are connected in one large district heating grid. The connected load is 46,2 MW and the installed power 69,6 MW. All of the plants were originally operated by fuel oil but a switch to natural gas is slowly but systematically being implemented. Still, the city of Velika Gorica has a lot of potential for the upgrade of its district heating system through several key steps: the individual district heating grids can be interconnected and the switch away from fuel oil can be completed. The city also has a high renewable heat potential, such renewable biomass, and the cheap electricity allows an economic feasible integration of heat pumps and electric boilers.

Another area of priority is implementation of solar district heating. The old neighbourhood Trnsko in the Novi Zagreb –zapad district is selected as a test case. The case focuses on two buildings in a residential apartment block that was built in the 1970’s when there were no restrictions and policies that would encourage construction of energy efficient buildings. Almost 60% of the apartments are owned by the city as well as a nearby field area, see Figure 39.

Refurbishment could reduce the annual specific heat consumption from the present 165-185 kWh/m².a to about 45 kWh/m².a which could potentially reduce the heating bills by 73%. If part of the available roof area is covered with solar collectors, the fuel consumption can additionally be reduced by another 3%. The latter would require the installation of a seasonal storage tank for an optimal integration of the solar thermal heat in the heating system. The optimal size for such a storage in this case is 580 m^3 of water equivalent or heat capacity of 34 MWh. This small apartment block was chosen because of the nearby public 4000 m^2 park area that could potentially be a good location for the seasonal heat storage.

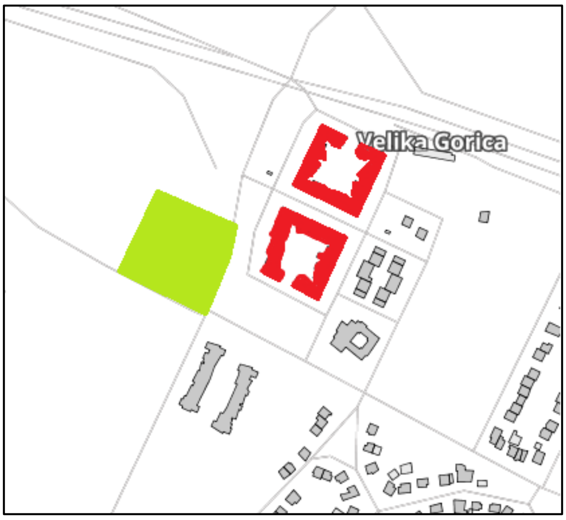


Figure 39: Buildings in Velika Gorica, HR that are chosen for the refurbishment (red) and potential location for seasonal heat storage (green)

2.6.6 Case 5: Biogas from a wastewater treatment plant as a cornerstone for a city-wide heat network in Edinburgh, UK

District heating forms a key part of the Edinburgh’s Sustainable Energy Action Plan. In 2006 it was estimated that up to 35% of the council area-wide heat demand could be provided by district heating. The city has already mapped out a potential vision for a city-wide heat network as depicted in Figure 40.

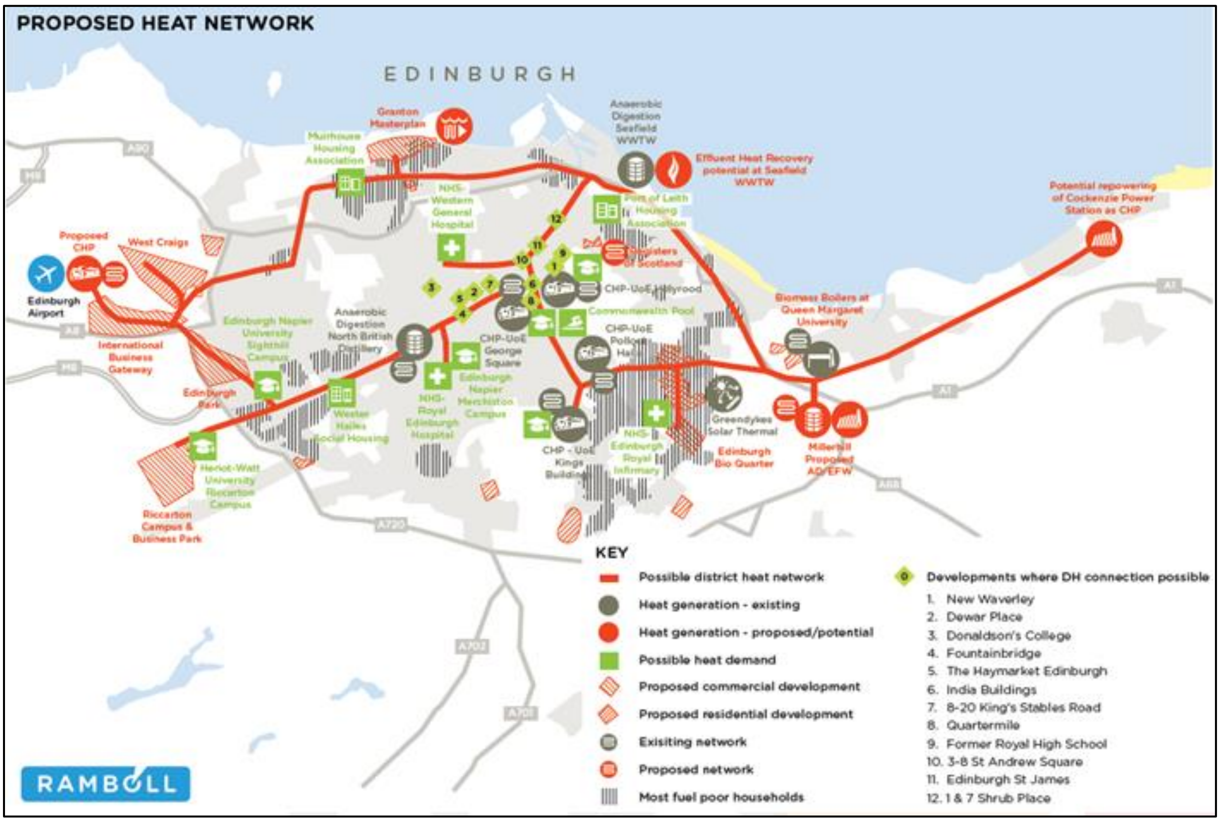


Figure 40: Vision for a city-wide heat network in Edinburgh, UK

The long term vision for Edinburgh is to build the Millerhill Energy-From-Waste plant (EFWP) with adjacent anaerobic digester towards the East of the city. The plant is estimated to output 20 MW heat and 11 MW electric energy from 2018 onwards and would connect with a heat network transmission pipe to central parts of the city. The plant would provide the benefits of diverting waste from landfills and recovery of by-products while incorporating efficient flue gas treatment technologies to minimise emissions.

In the West of the city, a wastewater treatment plant (WWTP) makes already produces a certain amount of biogas from sludge through anaerobic digestion. The company currently operates a CHP which could be increased in its capacity to displace more grid electricity used on site. This in turn would result in higher revenues and spare heat becomes available which might not be needed for digester heating or the thermal hydrolysis process on site. Thus, heat could be injected into a heat network which could also offer an additional revenue stream to the WWTP.

The advantage of the site is that a CHP unit could potentially run much longer than usually assumed under best practice (7,500 h/a instead of 5,000 h/a) leading to increased revenues and carbon savings. It is also anticipated that the industrial site could offer enough space for a heat store to decouple heat generation from demand retaining increased flexibility over plant control at site.

The recovery of heat and power from the plant will be decisive for future-proofing the envisaged city-wide heat network in terms of carbon savings but also to improve energy security based on a local material stream and affordable heat prices. It is anticipated that conventional gas-fired Combined Heat and Power (CHP) engines in heat networks will only deliver carbon savings until the late 2020s when the UK grid electricity emission factor will have significantly fallen (Committee on

Climate Change, 2015). However, in order to make use of the Millerhill EFWP, existing heat networks would need to expand considerably and new networks implemented within only a few years.

2.7 Project category 6: improved conversion of fossil fuels

2.7.1 Number of projects identified in this category

The last category of projects to consider aim at improving the conversion efficiency of fossil fuels into heat. Twelve such projects were identified in the STRATEGO cases, see Figure 41. Either a less efficient heating device is replaced by a more efficient one in these cases or the connection with new heat consumers allow a better operation of the already existing heating devices, see Table 12

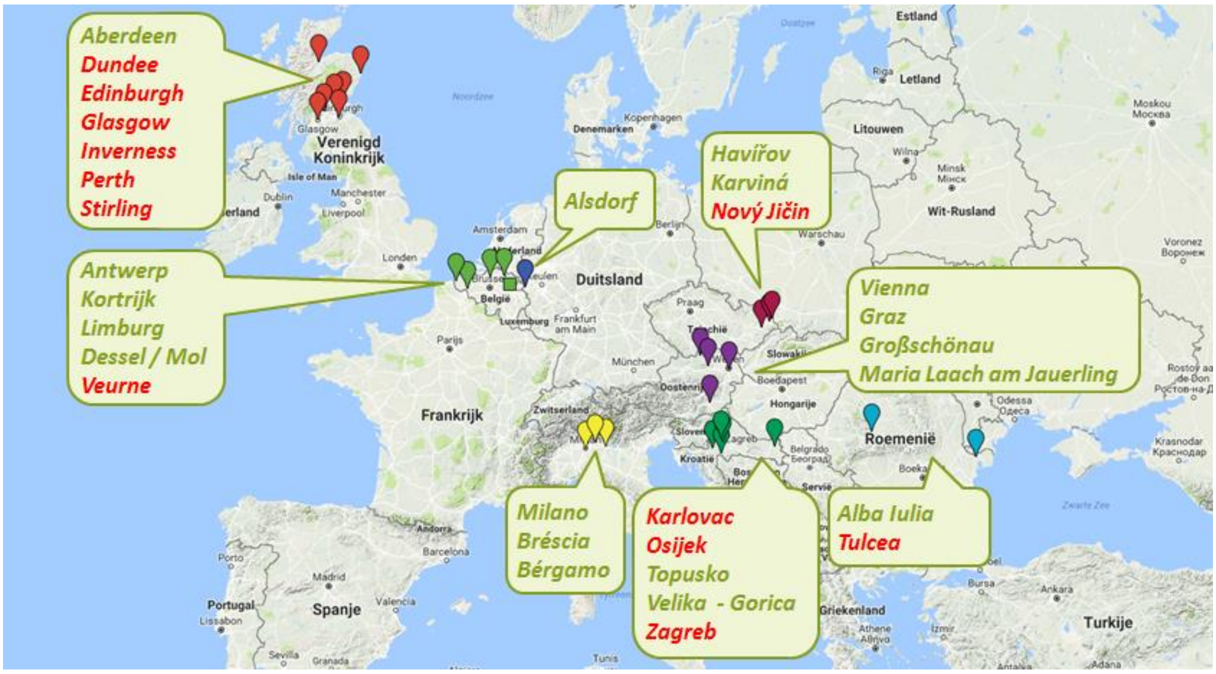


Figure 41: STRATEGO target cities with projects on improved conversion of fossil fuels

Table 12: Overview of the identified projects on improving the conversion of fossil fuels

Country	STRATEGO target city	Project
BE	Veurne	Improved operation of an existing CHP installation
CZ	Nový Jičin	Replacement of a Heat only Boiler (HoB) by a CHP
HR	Karlovac	Partly replacing fuel boilers by electric boiler
	Osijek	Improved operation of an existing CHP installation
	Zagreb	Partly replacing fuel boilers by electric boiler
RO	Tulcea	Replacement of a Heat only Boiler by a CHP
UK	Dundee	Improved operation of an existing CHP installation
	Edinburgh	Improved operation of an existing CHP installation Improved operation of an existing HoB
	Glasgow	Improved operation of an existing CHP installation
	Inverness	Replacement of a Heat only Boiler (HoB) by a CHP
	Perth	Replacement of a Heat only Boiler (HoB) by a CHP
	Stirling	Replacement of steam boilers with condensing boilers

2.7.2 Case 1: replacement of a HoB by a CHP in Tulcea, RO

Tulcea is located in south-east of Romania. The city's district heating network consists of one Heat only Boiler (HoB) with a thermal capacity of 50 Gcal/h that provides hot water to thermal substations, in turn providing heat to 7,157 residential consumers. This heat, howvever, is only delivered between the second half of October till the first half of April (i.e. 6 months/year)

This existing HoB which is located in the north Tulcea. The boiler is old and obsolete and it is oversized in comparison to the current thermal load. Its repair involves high costs that have to be supported by Tulcea City Council, as owner of Tulcea district heating system. As an alternative, the City Council has chosen to replace the existing old and oversized HoB by:

- two CHP gas engines 2 x 4MWt/4MWe
- two boilers to cover the hot water need (2 x 18 MWt)

There were several technical aspects to take into consideration when choosing the CHP plant location:

- the available space
- equipment access
- land ownership
- available pressure in the natural gas grid
- distance to the gas network
- distance to the available electric station
- distance to the heating network
- the location of residential buildings
- distance to the water and sewerage network.

After assessment of all these aspects, it was decided to install the new CHP on the same site as the existing HoB.

The future CHP plant will work in the same working regime as the existing heating source. Both boilers and the gas engines will work only on cold season, from the second half of October until the first half of April. The two gas engines will produce simultaneously thermal energy and electricity, ensuring the maximum possible heat demand, working 16 hours/day on 90% load, approximately six months per year. Part of the produced electricity will be used internally (for own CHP consumption), and surplus, about 20,000 MWh/year, will be sold into the National Power System.

The two heat only boilers will work alternatively and simultaneously from 10 to 100% load in the cold season (the heating season), from the second half of October until the first half of April. The boilers will provide the heat difference demanded by the consumers connected to the district heating network.

The natural gas savings as a result replacement of the old boiler by the new CHP installations and more efficient boilers of the will amount to 1,700 MWh/year.

2.7.3 Case 2: Improved operation of CHP installations in Osijek, HR

The only heat source for the district heating grid of Osijek, HR is a power plant which consists of several heat producing blocks:

- Block “A” is a cogeneration unit with extraction steam turbine
- Blocks “B1” and “B2” are gas turbine units connected to the heat recovery steam generator
- Blocks “C”,”D” and “E”, also called the SBK boilers, are gas fired steam generators.

Block “A” is the main unit for heat production, while other blocks are ancillary units that are used only during the transitional period in late April and early October, or during the unscheduled outage of the Block “A”. SBK boilers are mainly used during the late autumn and throughout the summer for covering the process steam demand.

In order to satisfy both economic and technical targets minimum, the overall efficiency of the power plant needs to be as high as possible. The minimum average yearly efficiency of gas cogeneration units need to exceed 70% in order to receive the maximum feed-in tariff In Croatia. Low variations in heat demand are required in order to reach this threshold. However, the city’s heat demand has high fluctuations throughout the heating season reducing the power plants efficiency by a significant amount; the average yearly efficiency of the CHP block is currently about 61%.

The scope of this STRATEGO case is the optimization of DH system including CHP power plant and SBK boilers. Two scenarios were considered:

- A: the addition of a storage tank
- B: the addition of a storage tanks and industrial heat pumps, enabling the introduction of renewable heat in the system

The total annual CHP block efficiency increases in both scenarios; from current the 60,95% to 71,61 and 71,18% respectively. The annual electricity production increases by 53.910 MWh in the first scenario and by 40.220 MWh in the second. The annual investment cost in the storage tank and the heat pump present a small amount in the annual cash flow of the system as Figure 42 indicates. But the GHG emission reduction potential is considerable thanks to the improved total system efficiency and the reduction of the specific annual GHG emissions per MWh of 5 to 10%.

2.7.4 Case 3: Inclusion of electric boilers in the DH network of Zagreb, HR

Electricity in Croatia is very cheap (90 €/MWh) and with newly formed electricity market CROPEX, started in February 2016, a further power price decline to the same levels as South Pool (average in 2015: 41.27 €/MWh) and HUPX is expected.

In addition, the cogeneration plant TE-TO Zagreb, feeding heat to the city’s district heating grid, has a direct connection to the newly built over ground heat storage tank with a storage capacity of 750 MWh of thermal energy and a power output of 150 MW.

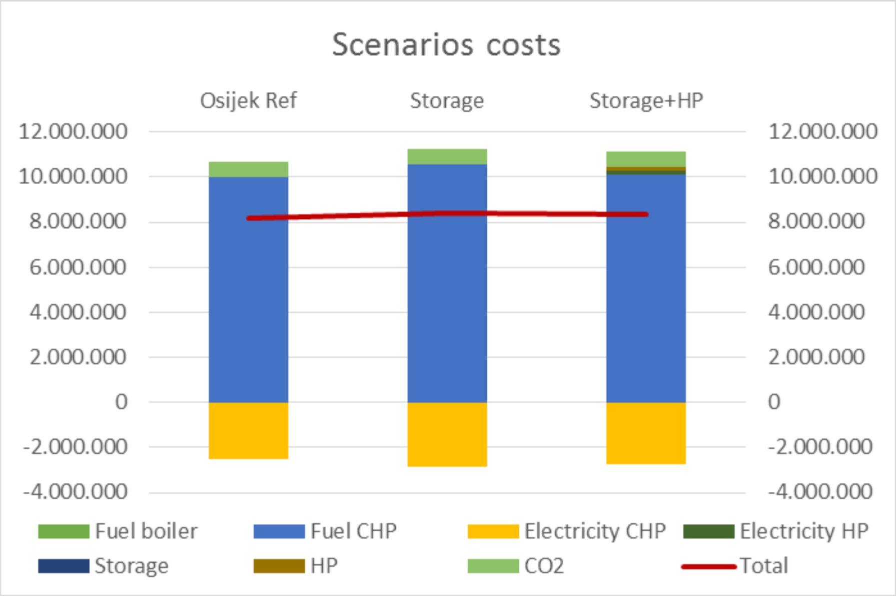


Figure 42: Cost-benefit analysis of the addition of a storage tank and a heat pump to improve a CHP in Osijek, HR

This hypothesis was tested in the course of the STRATEGO project using the heat price equivalent method. The equivalent heat production prices for the cogeneration plant TE-TO Zagreb and for the electric heaters were calculated for every time interval. In time intervals where the equivalent heat production price of one unit was cheaper than the other, the mathematical model prioritised heat delivery from that unit.

Results show that in all of the analysed scenarios equivalent heat production prices from the electric heaters are cheaper in nearly 2.820 time intervals, so the total annual heat delivery from the heaters sums up to about 21.230 MWh for the 5 MW, and about 63.690 MWh for the 15 MW heater.

These results show that the integration of electric heater into the newly built heat storage could be cost effective and eco-friendly as the total emissions of CO_2 could potentially be reduced by up to 2,700 t/a for the implementation of a 5 MW and 8,000 t/a for the implementation of a 15 MW electric heater.

3 STEP 3: Business models for local partners

As part of the local action of the STRATEGO project, the local partners, should develop business models for each project in national languages in close collaboration with public authorities and other stakeholders. A summary of the developed business models should be compiled in a report in English, and it should emphasise their transferability. It was expected that "group" of business models would appear - depending on local circumstances. The task should involve of mature and experienced district heating countries, Sweden and Denmark, and aspects of transferability and applicability should be supported by "roll-out regions" Astury region, Spain and Masovia, Poland as well as Scottish Government.

43 projects have been identified in the STRATEGO project. For these 36 business models have been developed. The number of models is smaller than the number of cases since some business models are identical for multiple projects.

The business models follow the project categories that are described in the previous chapter. It was expected that groups of business models (from the project description) would appear during STRATEGO, and this can be seen in these categories. It has not been possible to identify a generic EU-wide business model, that can be deployed in all cities looking at district heating and cooling. The reason is that the projects are complex with many stakeholders, unique heat sources, large investments and require long-term investments.

On top of that, the business models vary in regards to maturity of the different heat markets. The models are mainly production oriented, focusing on secure heat supply, cost competitive heat solutions, renewable energy choices and efficient heating solutions.

3.1 Preliminary gauging of status on business models

WP 3, task 3.3 requires the Supporting Partners to: *"…gauge the current status on business models in target countries."* The gauging carried out was presented in an Interim Report (Lauersen, 2015). The interim report was based on information requested through an initial assessment survey, conducted by the WP leader, and through a Business Model Template, provided by Task Leader, aimed at framing the discussions of business models to take place during the coaching session in WP4.

The Interim Report concluded that the information received through the assessment survey clearly reflected that most of the identified projects were at a very early stage of development. A few projects were not in a stage of development, but were existing schemes in need of a turn-around and revitalisation as they were basically fighting for survival. This made comparisons and knowledge sharing across all projects difficult or impossible. The Interim Report sought to accommodate both the general level of development as well as the diversity.

3.2 Framework

The development of business models is composed of nine building blocks that together make up the canvas (Osterwalder & Pigneur, 2010), see Figure 43. The canvas has been the overall framework for developing the business models of all the local DHC projects. In the following the building blocks will be summarized in order to create a comprehensive understanding and a general overview of the inputs received.

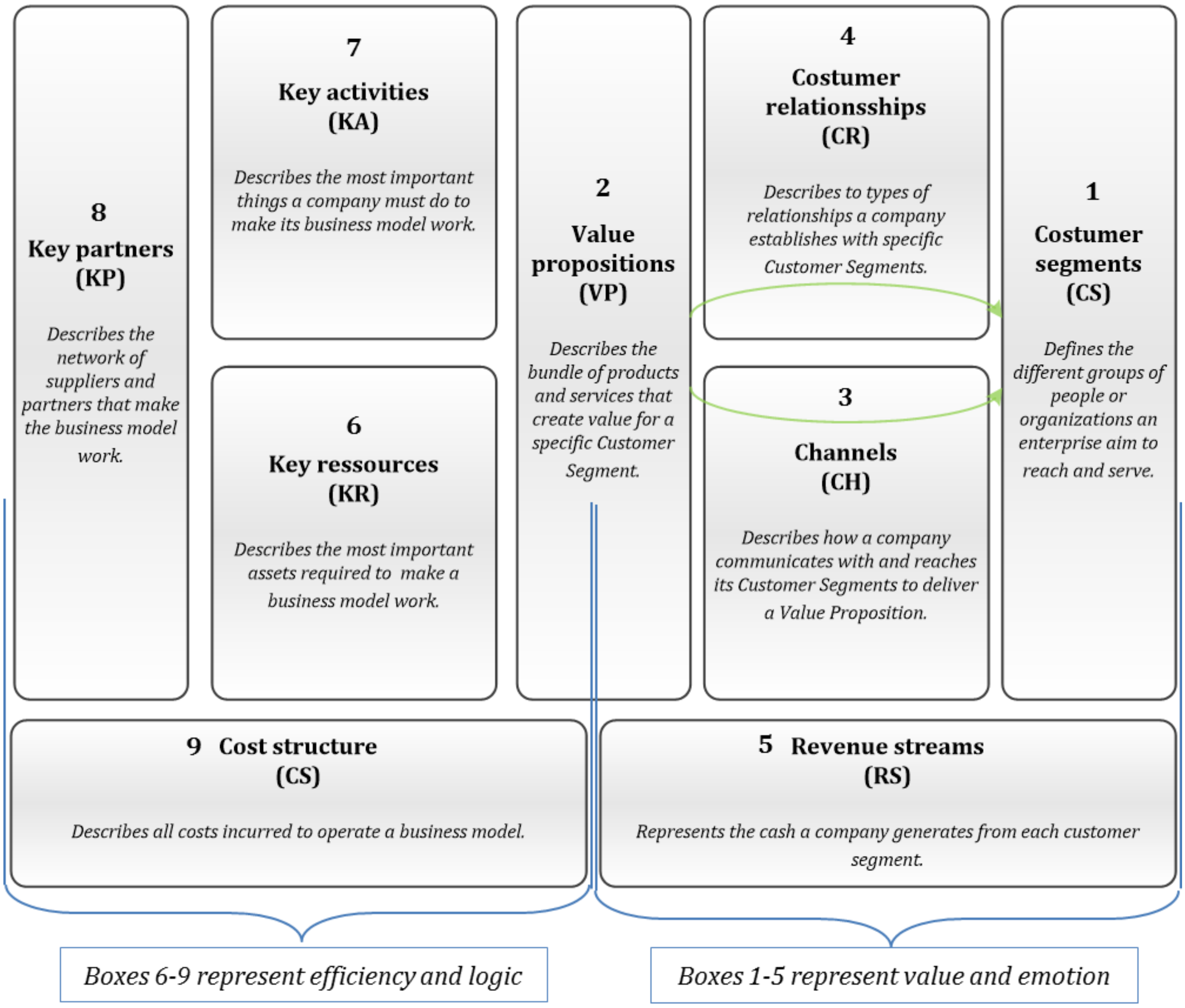


Figure 43: Business model canvas (source: Osterwalder & Pigneur, 2010)

The building blocks of the Business Model canvas consists of two main categories, on the left the block describing the logic and how the business model seeks efficiency and on the right side the business model describing the value and emotions of the business model.

The value category represents building block 1 – 5:

1. Customer segments,
2. value proposition,
3. Channels,
4. Customer relationships and
5. Revenue streams.

The efficiency category represents building block 6-9:

6. Key resources,
7. Key activities,
8. Key partners and
9. 9) Cost structure.

In the following the business models have been summarized for each of the nine building blocks that are visualised in the figure above, and some general comments have been added in each block.

3.2.1 The business models - A general comment

The business models for all the projects received clearly reflects that most of the identified projects still are under development and have not reached "investment grade". A few business models concern not new projects but enhancement of existing or projects in need of a turn-around and revitalisation. While these may be further advanced than the majority, it also makes comparisons and knowledge sharing across all projects difficult or nearly impossible.

That many projects are in a stage of development – at least with regard to their business models – is perhaps not surprising. Developing a new infrastructure in a complex context with multiple stakeholders, and their very different interests, like cities, authorities, customers and final consumers (not necessarily the same – see below), incumbent energy providers, investors etc. cannot be described as an easy task. The task may is complicated if it is part of an even larger project addressing energy poverty, sustainable development of cities or refurbishment of buildings and urban areas. Adding to this are the complexities inherent to district heat as well as other energy sectors like tariff systems and all sorts of technical issues.

3.2.2 Block 1: Customer Segments

The customer segment building block intends to defines the different groups of people or organizations the DH Company aims to reach and serve. Which customer segments the DH Company wish to serve, must be determined when designing the business models, and a clear understanding of their demands is of primary importance. Customers segments identified were:

- Industrial facilities
- Public & commercial buildings
- Multi–residential buildings
- Single family buildings
- Heat distributors (in case of heat wholesaler)
- Developers (buildings/city areas)
- *Additional from finished business models: Surplus heat producers*

These customers are also prevailing in the developed business models, but one case also added surplus heat producers to the customer segment.

Buildings as such are, as sites of consumption, the obvious focus in business models aiming a selling energy for space heating and hot tap water. However, some business models would benefit from clarity on who the actual customer is, or in other words with whom the district heating utility will have a contractual relationship. Consumers or final users of heat as well as households, or the general total population for that matter, are not necessarily identical with the actual customers for district heating. The occupants of a single family house, with a contractual relation to the district heating utility, are also the consumers/final users, but occupants in multi-unit buildings (residential, commercial or public) are normally not. In multi-unit buildings, the most common contractual partner for the district heating utility is the building owner or – in some cases – an ESCO. Even if costs for heating and hot tap water in a building is allocated to individual units (through sub metering or heat cost allocators) this does not constitute a direct contractual utility-customer relation between utility and unit occupants. The EU-Energy Efficiency Directive (EED) may be encouraging such direct contractual relationships, but in most existing buildings this solution is not technically feasible nor economically beneficial and may not even be so in new buildings. In addition, the complexities such direct contractual relationships may entail (on everything from questions on access to in-building installations to possibility for disconnecting non-paying customers (with increases neighbouring units' heat costs)) dissuades even existing, competent district heating utilities from entering into such direct contractual relationships with individual tenets unit tenants/owners.

This is important, because the value offered to customers by supplying district heating to their building may be different from the values desired by those who actually consume the energy. Indeed, low price heat may not benefit occupants of individual units if there is no sub-metering or heat allocation. It may just lower total costs for building operation for the building owner. Similarly, sustainability of heat supply may appeal to final consumers, but leave a building owner, with focus on operational costs, indifferent, unless sustainability of building heat is a competitive advantage when attracting tenants.

3.2.3 Block 2: Value Proposition

The value proposition building block describes the bundle of products and services that creates value for a specific customer segment.

Value propositions contained in the initial gauging of business models were categorized as social objectives (like stable and low prices), environmental objectives (low carbon heat, local emissions etc.), service objectives (stable supply, optimum efficiency of heating system, reliability and so on) and community objectives (security of supply, social & public benefits, city development etc.).

Many of the categories listed above do not seem to have progressed in the direction of quantifiable commodities or services that can be offered to prospective customers. There are examples going in this direction like enhancing existing district heating supply (leading to lower costs for the district heating utility, and thus opportunity to lower prices for existing as well as new customers) or providing additional customer services beyond the traditional "package". In a single case, the value proposition is to offer a new district heating network as a conduit for existing surplus heat producers to sell this heat, thus giving value to otherwise worthless heat, which might even be associated with costs of disposal (running and maintaining cooling towers). A number of business models mention the ambition to provide affordable heat to vulnerable customers, but seem unable, at the current level of development of the business model, to describe exactly how to achieve this admirable ambition.

It would seem appropriate for further development of the business models to distinguish between value proposition to the general public, final users and other stakeholders and the value proposition directed at potential/future customers. Some business models consider the development of district heating as part of a larger scheme for developing sustainability, refurbish neighbourhoods etc., and there is a need to clarify the role of district heating and specify a feasible business model for it.

3.2.4 Block 3: Channels

The channels building block describes the different ways a company communicates with and reaches its customer segments to deliver value proposition. The template used in gauging existing business models suggested five channel phases relevant when introducing district heating:

- Awareness: How can we create awareness about the DH Company’s value proposition?
- Evaluation: How do we help customers evaluate the DH organisation’s value proposition?
- Purchase: How do we allow customers to purchase specifically district heating?
- Delivery: How do we deliver a Value proposition to customers?
- After Sales: How do we provide post-purchase customer support?

If the developed business model concerns enhancing an existing district heating system, the challenges with regard to awareness and evaluation may be influenced by the reputation of the system (or district heating in general). On the other hand, new channels may develop in later phases of the transaction with customers.

One the one hand, most of the developed business models are quite specific when it comes to suggested channels for direct sale (“website” is often mentioned) but on the other hand are not very developed when it comes to the first phases of delivering the value proposition. This probably reflects the state of development of the value proposition, of the identification of targets of communication and perhaps the business model in general.

A few business models are quite precise in identifying the target for communication (a central public building owner) but gives little indication on how to deliver the value proposition.

3.2.5 Block 4: Customer relationship

Describes the types of relationships a company establishes with specific customer segments. Customer relationship can in general range from being highly personal, with customized value proposition, to being automated as in a mass market with undifferentiated value propositions.

Business models for enhancing existing district heating systems clearly enjoys the benefit of having established relationships with customers, and some suggest ways to also enhance these relationships.

Other business models address (briefly) the diversity of customers and employ the range of customer relations, from the highly personal to the impersonal and automated, as described in the interim report.

One business model states that there is no change to end customer relationship as heat procurement replaces gas procurement for centralised heating system. On the other hand, the same business model lists occupants (people) in multi-residential buildings as customer segments. Again in this case, as in others, it seems necessary with a clearer identification of customers (key decision makers in heat procurement) one the one hand and consumers (while benefiting from lower heat costs, they are not decision makers) on the other hand. A key aspect to take into consideration is if the value propositions in the business model actually matters to the key decision makers. Property developers may care for investment levels but give little consideration for later operating costs and service levels as well as environmental aspects.

3.2.6 Block 5: Revenue streams

This block describes the revenues generated from customer segments. There are traditionally two types of (primary) revenue streams in district heating: 1) transaction revenues resulting from one-time customer payments or 2) recurring revenues resulting from on-going payments to either deliver a value proposition to customer or provide post-purchase customer support. Additionally, a business model for a district heating project may involve secondary revenue not arriving from customers but from other sources such as subsidies, sale of electricity (from CHP) or other services.

Most of the business models are very shallow on the information on revenue streams. Most mentions some general considerations. Some mentions broad principles and two have identified a unit price for heat (but gives no consideration to payment structure). Only one business model refers to an actual analysis of the potential revenue stream. There is clearly a need for the developing this aspect of the business models.

3.2.7 Block 6: Key resources

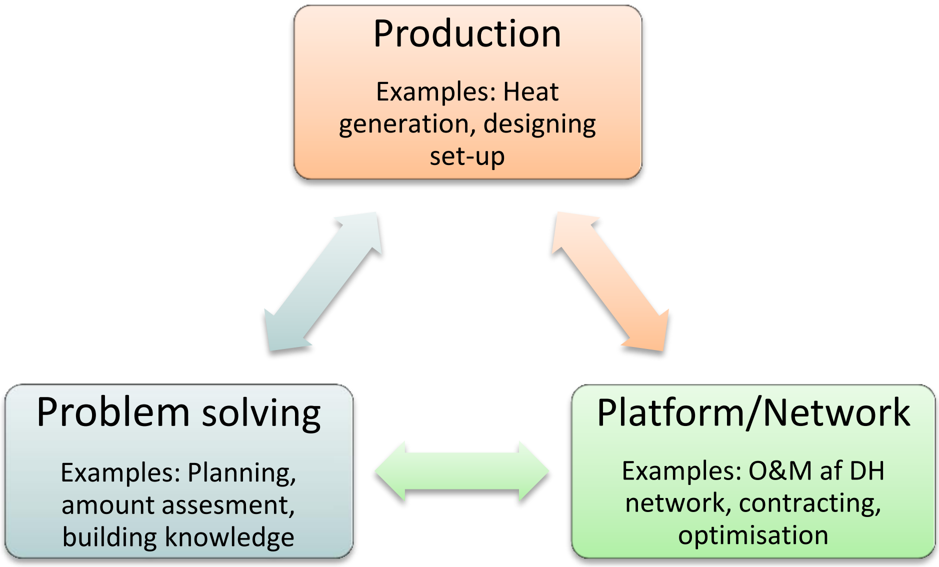
This is the most important block with regard to creating the revenue stream that makes the business model work. Key resources should refer to the internal resources needed to create the offer or value proposition, to reach the market and to maintain the relationships with customers. The Business Model Template operates with four categories of key resources; physical, financial, intellectual or human.

Physical resources (mentioned: heat networks, production assets, fuels etc.) absolutely dominates the business models' views of key resources, while financial resources (mentioned: financing, loans, grants etc.), intellectual resources (specialist and general knowledge, "know-how") and human resources (personnel) play a much smaller role. The approach to resources illustrates a very product related focus with a producer-to-customer relationship. Business models would probably benefit from an approach with more focus on customers, their values and the relationship that could be stablished with them. This would also add to the intellectual resources available to the project.

3.2.8 Block 7: Key activities

The block relates to the most important activities to execute in order to make business model work. They are fundamental to create and deliver the value proposition. Key activities, also known as capabilities, can be categorised as following: Production, Problem solving or Platform/Network (Osterwalder & Pigneur, 2010). Regarding production activities, these can relate to designing, making and delivering a product in remarkable quantity or quality. Regarding problem solving this activity relates to designing new solutions to individual customer problems, which means that business models based on these types of activities require focus on knowledge management and training of employees. The final type of activity relates to designing, operation and maintenance of platform or networks in order to succeed.

The key activities of the majority of the business models include a mix of (technical/practical) activities that - to a great extent - reflects the value proposition. Business models on new developing urban areas or integrating renewable heating sources have a very a production/construction oriented focus, whereas the models for enhancing or expanding networks focus on their operation. Perhaps not surprising, but, similarly to block 7 above, activities directed at customers receives little attention. The word "selling" is mentioned once (selling).



3.2.9 Block 8: Key partners

The block describes the network of suppliers and partners who make the business model work. Key partnerships are advantageous in relation to; optimizing allocation of resources and economic of scale, reduction of risk and uncertainty and acquisition of particular resources and activities. There are several types of partnerships and collaboration; strategic alliance (between non-competitors)/ strategic partnerships between competitors, joint-venture, licensing and outsourcing. Input received from the Interim Report has been added some new *(in italics)* key partnerships mentioned in final business models. Table 13 lists the key partners of the final business models.

Table 13: Several types of partnerships and collaboration between key partners

Strategic alliance (between non-competitors)	Strategic partnerships between competitors	Joint-venture	Licensing	Outsourcing
Local businesses Council Housing association Cities and city officials Social housing Businesses Private company Heating plants, CHP, industrial enterprise with waste heat *New:* *Other projects* *Customers,* *Public Private Partnerships*	Fuel suppliers Energy providers	Financial institutions Commercial lender Future new developments Fuel/data suppliers	ESCO	Installers Measurement companies Equipment suppliers Spare parts companies- local companies

3.2.10 Block 9: Cost structure

Describes all cost incurred to operate a business model in relation to creating and delivering value, maintaining customer relationships and thereby generating revenue. The model distinguishes between two cost structures: cost-driven and value-driven, however most business models are somewhere in between these.

Some business models, and the projects descriptions, (in particular the Croatian and Belgian cases) contain estimates of costs and mentions certain specific cost drivers. Again, the business models in general are in need of further assessment of cost incurred in operations. This assessment is also needed to evaluate the potential revenue streams from customers (and possible support schemes) and thus the economic viability of the business model and the project.

3.3 Maturity of business models

As mentioned in the previous sections are the maturity of business models in majority in the early stages of development. Generally, the business models are very complex and involves a lot of stakeholders. This makes the development of an "investment ready" business model more time consuming than foreseen at the inception of the STRATEGO project.

3.3.1 Project stage of business models

The process of designing a business model are rarely linear and straight forward as the environment around a district heating project is full of ambiguity and uncertainty. Designing a business model requires room for exploration and involves a chaotic phase with a lot of loops and bouncing between research, analyses and prototyping business models. Sometimes new partners join or appear or new technologies are discovered, and this leaves process characterised by uncertainty and opportunism. Figure 44 depicts the process of designing a business model; the business model evolves towards clarity.

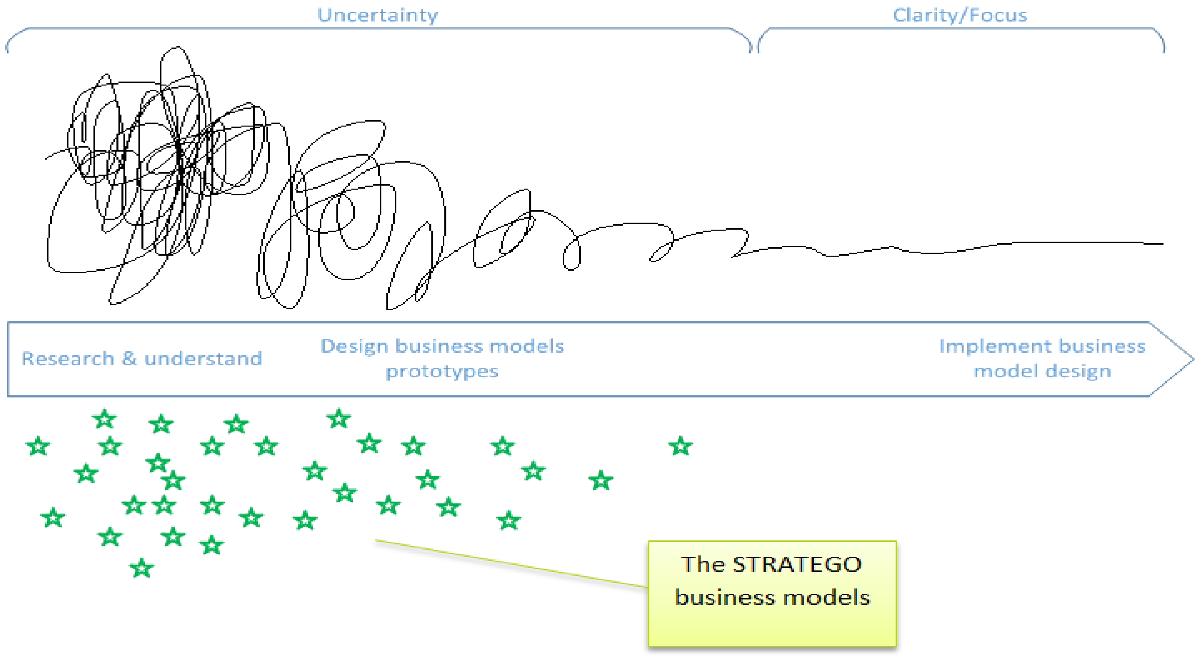


Figure 44: Process of designing a business model

The business models developed in STRATEGO are all in an early stage of their development and the majority is characterised by a lot of uncertainty that can be frustrating when trying to move along with the project.

The main lesson from the business model development in STRATEGO is that business models for district heating and cooling need to be flexible and allowed to changes over time as the focus become clear and uncertainties are sorted out. Further has it been identified that the different heat markets are on different stages of maturity, which also adds to a prolonging of the development.

3.3.2 Business models design process

The process of developing a business model is, as mentioned, rarely neither a linear process, nor is the final version ready by the first try. The framework used for this task arrives from the „business model generation" book by (Osterwalder & Pigneur, 2010) and the partners have been asked to use the business models canvas as the basis for developing business models. According to (Osterwalder & Pigneur, 2010), the process towards the final business model follows 5 phases, as showed in Table 14.

From the 43 projects and the 36 business model that have been developed through the STRATEGO project; it can be concluded that the majority of the business models are in one of the first three phases of the design process and thereby not are close to implementation.

Table 14: The 5 phases of the business model design process (Osterwalder & Pigneur, 2010)

Phase	MOBILIZE	UNDERSTAND	DESIGN	IMPLEMENT	MANAGE
Objective	Prepare for a successful business model design project	Research and analyse elements needed for the business model design effort	Generate and test viable business models options, and select the best	Implement the business model prototype in the field	Adapt and modify the business model in response to market reaction
Focus	**Setting the stage**	**Immersion**	**Inquiry**	**Execution**	**Evolution**
Description	Assemble all the elements for successful business model design. Create awareness of the need for new business model, describe the motivation behind the project, and establish a common language to describe, design, and analyse and discuss business models.	You and the business model design team immerse yourselves in relevant knowledge: customers, technology, and environment. You collect information, interview experts, study potential customers, and identify needs and problems.	Transform the information and ideas from the previous phase into business models prototypes that can be explored and tested. After an intensive business model inquiry, select the most satisfactory business model design.	Implement the selected business model design.	Set up management structure to continuously monitor, evaluate, and adapt or transform your business model.

Mobilize

The mobilisation phase has been one of the overall focuses in STRATEGO – getting stakeholders together and creating awareness for the need for district heating and cooling project in the learning cities. This has been done with great success and all the business models are through STRATEGO beyond this phase and are moving into the next phase – understanding.

Understand

In this phase the focus is to retrieve knowledge that is relevant to the business model. Collecting information about the technology, customers and resources. This has been a focus in STRATEGO where the mapping and planning results are key to district heating and cooling business models. This is also the stage where the stakeholders are selected (and deselected/replaced) according to needs.

The Understanding and the Design phases tend to be parallel, looping between each other as sketching a business model often lead to a need for additional information. And the knowledge from this then lead to change in the design of the business model.

Design

As the knowledge and information are gathered the sketching of the business model starts, and it proceeds to be further explored and tested. By the end of the design phase the most satisfying business model should be chosen.

From all the developed business models in STRATEGO, it can be concluded that the majority are in a stage between the understanding and the design phase – some are further a long and while others still have a need for more information and research. The business models of district heating and cooling tend to be very complex and involve a lot of stakeholders, and the design process easily expands as circumstances change and/or new information is obtained. The experienced countries also have this challenge when developing new projects, as the context (legal framework, fuel prices, stakeholders, partners, areas etc.) in which the business model will be applied changes, but at least they may benefit from experience.

Implement and Manage

These phases are as they imply related to implementation of the business models and hereafter to monitor and continually evaluate the business model. Since none of the business models developed in STRATEGO has reach this phase, there is no learning yet to be drawn from this.

The feedback from partners in STRATEGO has been revolving around a general experience of the business model process – **that it takes time and more resources as district heating and cooling projects are, in their nature, complex and affects a large number of stakeholders**.

3.4 The future

An observation about the business models developed in the projects is that they are immature in the sense that they are not ready for investments. One conclusion is that developing district heating and cooling projects, including their business models, is more demanding than foreseen at the inception of the STRATEGO project, which is perhaps not surprising. While the technology in district heating and cooling cannot be seen as the main challenge in project development, the “soft” side of projects (customer and stakeholder relations) is very complex. This is also reflected in that most developed business models have a very production/technology oriented focus and need further development regarding creating value to customers (possibly in the form of offering comfort and an healthy indoor climate).

As the STRATEGO project comes to an end, it is important to ensure that the developed projects, which are technically well described but in need of much further development in order to become "investment grade", are secured resources for further development. The great momentum STRATEGO project has given the projects is important to keep going in order to move the business models forward to a final design and get the projects implemented. This has unfortunately been seen before in cases outside the STRATEGO project.

A second conclusion is that there is a need for a mechanism or support scheme to bring projects like those in the STRATEGO project through to a stage where they have proven their feasibility and have become ready for investment. One example of such a scheme[12] could be the one run by the UK Heat Network Delivery Unit, where support can be obtained not only for initial exercises of heat mapping and energy master planning (like what has been carried out in STRATEGO) but also for the further feasibility study, detailed project development and commercialisation.

All the projects developed in STRATEGO are great projects with environmental benefits, job creating possibilities and can increase the growth of renewable energy technologies. However it is a significant risk that they will perish if left unattended by the end of the STRATEGO project.

3.4.1 Ownership

The issue of ownership is important when developing or revitalising existing district heating and/or cooling schemes. Depending on size and/or structure, the value chain in DHC can be quite long and due to both the technical properties and the scale of investments involved, ownership - partly or total - to assets both influences – and is influenced by – key elements in the business model, like financing partnering, outsourcing etc. Discussion of ownership must therefore be part of the development of the business model.

The District Heating Ownership guide(DHCAN) provides an overview of different ownership structures in (then) CEE and Western European countries. The Guide was intended primarily for policy and decision makers on a national, municipal and utility level who consider a change of ownership or operational schemes, and potentially privatisation of the district heating assets. The guide divides the ownership and management of DH systems into three main groups: solely public, solely private, and public-private partnership with mixed ownership and management. In total, eight mixed models are presented. The Guide does not answer explicitly the question what form ownership should have, since there is no single answer for this question.

The guide identifies a broad – still valid – spectrum with four major alternatives of ownership models for DHC utilities:

- Full public control by the state or municipality
- Full private control
- Mixed ownership and management – public and private
- Not-for-profit community-owned cooperatives.

Whether newer setups like public–private partnership (PPP), Build–operate–transfer (BOT), build–own–operate–transfer (BOOT) or indeed these numerous acronyms really are new or just variations of the above can be discussed. (The period since the issue of the guideline has also seen introduction

[12] Webpage: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/513884/HNDU_overview_round6_April2016.pdf

of regulation on some ownership models.) But the fact is that the choice of development and ownership model for DHC exists and should be an integral part of the choice of business model.

3.5 Transferability to roll-out regions

At the beginning of the STRATEGO project, it was expected that the developed business models would crystallise into one or more overall business models, that afterwards could be transferred directly to every city, region and country across Europe. The experience from WP3 and the designing of business models for district heating and cooling projects in learning countries, has been that it is not possible to identify a generic business model. However, there are experiences to be transferred! The complexity of district heating and cooling are not to be disregarded and it is so very important to allow the design process to take its time and to pay attention to include a flexibility for the business models to develop as the markets mature.

For developing a new project on district heating and cooling, it is advised to use the results from STRATEGO, when starting. The mapping and heating & cooling planning as well as the key points from the business models. The framework used for designing business models (see Figure 43) can be a constructive approach to start discussions among stakeholders and to emphasise what information is needed to get the project moving along.

> *„In Spain DHC systems are not well developed and general public do not know the technology … (why) it is necessary to overcome the barrier of the traditional heating sources. “*
>
> *-FAEN, Spain*

For the roll-out regions, that are part of STRATEGO, the feedback has been to keep the focus on customers and to improve their trust in the DHC technology (showing that is more efficient and sustainable) and on the promoters of the project (proving their capacity to carry out the project) as it is difficult to overcome traditions regarding heating sources. Further do the roll-out regions emphasise that the political and legal contexts, in which a DHC project must be developed, are very important and will in great extent impact the business model. Therefor it is important for roll-out regions and learning countries (and experienced) that the business model is flexible and have a long-term perspective. This however often contradicts with the investor payback period and risk evaluation.

> *„Business models for DHC, especially for Poland and probably other CEE countries, need to be flexible and allowed to change. Unfortunately, the energy sector especially the national legislation poses many problems. “*
>
> *-MAE, Poland*

There is a great potential for DHC projects but support for business models generation is lacking.

When developing new projects on district heating and cooling (especially in roll-out regions and learning regions) it is recommended to focus on:

- Increase trust in the technology by focusing on the “value and emotion” part of the business models canvas (Customers segments, Value proposition, Channels and Customer relationships)

- Allow business models to be flexible and to change over time (to adjusted if regulations or tariffs change)
- Keep the long-term perspective in the business model generation
- Use heating and cooling planning together with the business models canvas to improve the process of project development
- Discuss ownership when preparing projects
- Infrastructure projects are complex, involves many stakeholders and takes time

3.6 Conclusions

For all 43 projects that has been identified in the STRATEGO project, 36 business models have been developed to cover all the projects.

It has not been possible to identify a generic EU-wide business model for DHC projects, that can be deployed in all cities looking at district heating and cooling (DHC) which was the initial ambition of STRATEGO. It has turned out that the projects are complex with many stakeholders, unique heat sources, large investments including long-term investments making a generic model impossible

The development of business models has been based on the Business model canvas (Osterwalder & Pigneur, 2010). The canvas has been the overall framework for developing the business models of all the local DHC projects.

The business models for all the projects received reflect the fact, that most of the identified projects are under development and have not reached “investment grade”. A few business models do not concern new projects but enhancement of existing or projects in need of a turn-around and revitalisation. While these may be further advanced than the majority, it also makes comparisons and knowledge sharing across all projects difficult or near impossible.

The process of designing a business model is not linear. When designing a business model, room is needed for exploration and it involves a chaotic phase with a lot of loops and bouncing between research, analyses and prototyping business models. A key success from STRATEGO has been the increased awareness of district heating investments including the identification of projects and the discussions of business models for implementation.

The learning from the process in STRATEGO is that business models for district heating and cooling need to be flexible and allowed to changes over time as the focus becomes clear and uncertainties are sorted out. Further has it been clear that the different heat markets are on different stages of maturity, which also adds to a prolonging of the development of business models but on the other hand allows business models with long-term development potential.

It is concluded that developing district heating and cooling projects, including their business models, is a lot more demanding than perhaps foreseen at the inception of the STRATEGO project

As the STRATEGO project comes to an end, mechanism or support scheme to bring projects like those in the STRATEGO project through to a stage where they have proven their feasibility and have become ready for investment. Otherwise there is a risk of the projects not being undertaken at all.

For developing a new project on district heating and cooling, it is advised to use the results from STRATEGO, when starting. The mapping and heating & cooling planning as well as the key points from the business models. The framework used for designing business models can be a constructive approach to start discussions among stakeholders and to emphasise what information that’s needed to get the project moving along.

The issue of ownership is important when developing or revitalising existing district heating and/or cooling schemes. Depending on size and/or structure, the value chain in DHC can be quite long and due to both the technical properties and the scale of investments involved, ownership - partly or total - to assets both influences – and is influenced by – key elements in the business model, like financing partnering, outsourcing etc. Discussion of ownership and contractual arrangements between stakeholder must therefore be part of the development of the business model.

4 STEPS 4 and 5: stakeholders - planning

The two last steps in the procedure to support local authorities in drafting their local heating and cooling plan are dealt with in one single chapter, because there is not as much to report on as on the previous steps. These steps are:

- Involvement of local stakeholders
- Input to local heating and cooling action plans

4.1 STEP 4: Involvement of local stakeholders

The fourth step in the supporting local authorities in making a tangible heating and cooling plan is the discussion of the identified projects with local stakeholders. The aim of these workshops is to define the concepts of the projects in more detail.

Figure 45 shows which stakeholders have been involved in these discussions. The local authorities and district heating grid operators were involved the most. The high involvement of the local authorities indicates that the STRATEGO cases were successful in adding heating (and cooling) to the local political agenda. The high involvement of district heating grid operators is a direct consequence of the many identified projects dealing with district heating grids. Scientific institutes were also involved in many cases, but they were partners of the STRATEGO project, which explains this high involvement.

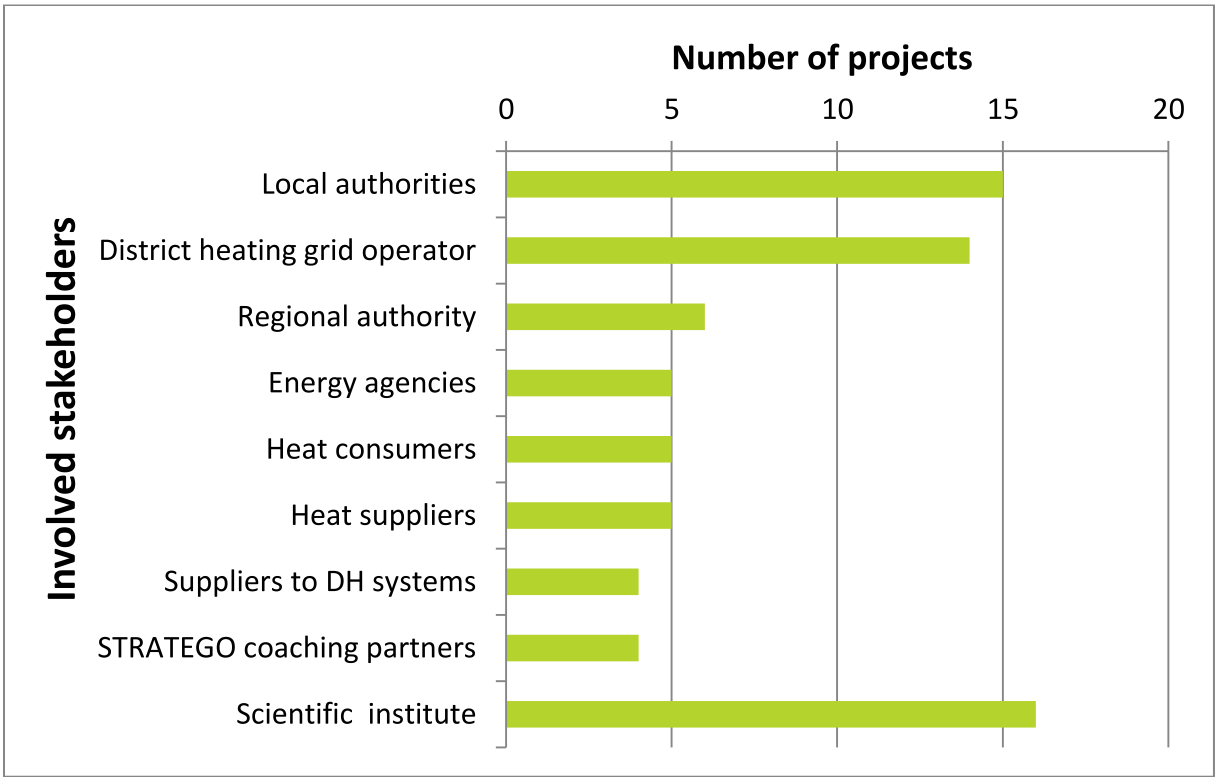


Figure 45: Stakeholders involved in the different STRATEGO cases

Other stakeholders were also involved to discuss the projects, but to a lesser extent. They cover a wide range of stakeholders: regional authorities, energy agencies, heat consumers, heat suppliers and suppliers to district heating systems. STRATEGO coaching partners were involved in some cases, these are partners from other experienced cities with whom the STRATEGO cities can exchange experience with; Frankfurt, DE was for instance the coaching partners for the Romanian cities Tulcea and Alba Iulia and Rotterdam, NL for the Italian cities Milan, Brescia and Bergamo.

This high involvement of stakeholders, directly involved in the project investment, and the moderate involvement of this wider range of stakeholders confirm the observation made in section **Error! Reference source not found. Error! Reference source not found.**; namely that the business models of the identified projects – and by extension the development of the projects themselves – are immature in the sense that they are not ready for investments. Only a few projects indeed were at the stage in which a roadmap or financing options could be specified.

4.2 Input to local heating and cooling action plans

As a fifth and final step in the support to the local authorities, input is given to the local heating and cooling plans. To this end, a document is issued for each of the STRATEGO cities showing the heating and cooling maps made for this city and identifying the areas of priority for first intervention. The document also lists the identified projects, discusses their business model and expected benefits and summarizes the conclusions of the stakeholders meetings on these projects.

The perspective of these documents surpassed the boundaries of the single identified projects for two thirds of the STRATEGO cities and discusses the challenges and opportunities of transforming major parts of the heating and cooling infrastructure in the cities. An example is the strategic masterplan for a city-wide heat network that can cover up to 35% of the council area-wide heat demand,see 2.6.6 Case 5: Biogas from a wastewater treatment plant as a cornerstone for a city-wide heat network in Edinburgh, UK. These documents hence can serve as a first version of a local heating and cooling plan.

The perspective of these documents is more restricted to the identified projects for one third of the STRATEGO cities. Yet, these projects have a significant replication potential and act as showcases for similar projects elsewhere in the STRATEGO cities or other similar cities. Examples are the insulation projects in Alba Iulia, RO or the conversion of industrial estates to district heating in Dessel, BE.

4.2.1 potential roles for local governments in relation to sustainable heating and cooling

The first steps in implementing a heat market often rely on the local government. The degree of involvement of the local government on the development of district heating networks may vary depending on the particular needs, situation and objectives. The United Nations Environment Programme published a report where the different roles for the local government were classified (UNEP, 2015).

First role: local government as planner and regulator

Local governments can catalyse district energy development first and foremost in their role as planner and regulator (UNEP, 2015). Within this category, the local government may take up four main tasks:

- Defining energy strategies and setting targets
- Energy mapping
- Integrated energy planning
- Connecting policies.

Second role: local government as facilitator: enabling actions to leverage finance

High upfront investment may hamper the implementation of district heating and cooling systems. According to (UNEP, 2015), the public sector is the "most important" actor to catalyse investment, with the private sector as a "very important" additional one. The local government may leverage financing in three ways:

- By financing or issuing fiscal incentives
- Providing city assests
- Starting demonstration projects

Third role: local government as provider and consumer

Local government as a provider refers to cities that own or have a stake in local utilities, thus creating leverage to shape the low-carbon pathways of the (e.g. energy, waste) services they provide. The local government is equally a consumer of heating and cooling itself, in public buildings, social housing, hospitals, leisure centres, etc. Thus it is ideally placed to demand the energy services that it deems optimal in return for load and connection certainty.

Fourth role: local government as a coordinator and advocate

This role includes three main activities: supporting projects through market facilitation and capacity building, awareness raising and outreach, and advocating for district energy at other levels of government.

4.2.2 Analysis of the roles of the local government for Veurne, BE

The question which role a local authority can take to support and stimulate the development of a DH network was analysed for the City of Veurne, BE in particular. Veurne is a town located in the very north-west of Belgium. It is a very rural area; Veurne has about 11,400 inhabitants on 96,34 km² (population density of approx. 115 inhabitants / km²). Most of the inhabitant live in the town centre, which is surrounded by meadows and small villages.

There are project ideas to exchange heat between industrial companies in the south of the town. These project ideas were raised by local stakeholders, but the local authorities would like to investigate the feasibility of connecting the new urban and industrial development to this potential DH network as well. Hence, the main question the City of Veurne currently has is which role it can take as local authority to support and stimulate the development of a DH network.

The least what local authorities can do in the new urban development areas / refurbishment areas is considering alternatives for the default heating option (individual gas boilers in many cases); they should pay as much attention to it as to the design and the names of the streets.

The potential roles for the local government of Veurne have been analysed using the role description of (UNEP, 2015). This analysis has indicated that Veurne has a significant role to play as a **planner of heating and cooling** in the town.

- As a minimum, Veurne should integrate energy planning in urban planning. Veurne should, for every new urban development, investigate how heating and cooling should be organised.

It should investigate alternatives next to the default option, which is the provision of natural gas.

- As a next step, Veurne should consider developing a holistic heating and cooling strategy for the whole town. This would provide a frame for local new urban developments and provide inspirations for alternative heating and cooling options.

In relation to the deployment district heating grids in Veurne, it can be observed that:

- Currently, district energy initiatives have a rather ad-hoc character.
- The City of Veurne is relatively small with limited financial means

Hence, it is best to act as a **facilitator** rather than initiator **of district energy development**.

The city's main role is to initiate a more systematic approach to district energy development. Broadly, two stages can be distinguished. A first stage would be devoted to 'setting the stage' with a focus on the roles of regulator and planner and coordinator and advocate:

- Assessment: overview of potentials
- Mapping: also to build institutional capacity
- Energy strategy and targets (possibly with awareness raising)
- Capacity building (including need assessment)
- Scanning financial opportunities
- Closely follow Flanders policy development
- Coalition building, e.g. in the context of the provincial climate action plan or the WVI

A second stage would be about demonstration and implementation with a focus on the roles of facilitating finance and provider / consumer:

- Wait for appropriate timing!
- Perform techno-economic feasibility studies (city of Veurne in the lead)
- Demonstration project (network operators in the lead)
- Facilitating finance
- Become consumer
- Lobbying at the Flemish government (if needed)
- Get the public involved: broader awareness raising, marketing, connection policies

5 Conclusions

In this STRATEGO WP3 entitled "National plan – local action: supporting local authorities" 30 STRATEGO target cities were supported in drafting a local heating and cooling plan. This support was organised in five tasks, as was introduced by Figure 4. These five steps are:

- Mapping of local heating and cooling demand and cooling
- Identification of area of priority for first intervention
- Business models for local partners
- Involvement of local stakeholders
- Input to local heating and cooling action plans.

This approach was applied in a wide range of various conditions as the 30 STRATEGO target cities vary significantly in terms of size, number of inhabitants and state of the existing heating and cooling infrastructure.

The results of this five steps' approach from these 30 STRATEGO target cities have been described in detail by the previous chapters. The aim of this chapter is to draw general conclusions from these results. To this end, this chapter looks at:

- The successes: what went well when carrying out these five tasks
- The challenges: which tasks were harder to carry out
- The needs: the definition of new tools, guidance or attitudes that can help support these harder to carry out tasks
- The success stories: how some cases succeeded to carry out those harder to carry out tasks anyhow despite the challenges

Figure 46 presents these successes, challenges, needs and success stories of each of five tasks. These will now be discussed more in detail.

5.1 Mapping heating / cooling: successes – challenges – needs – success stories

Successes

The heat demand has been mapped for all of the STRATEGO cases. Moreover, more than half the maps are based on the actual or estimated heat demand of individual consumers, resulting in heat demand maps with a higher accuracy. Adding the layout of district heating networks to the heat demand map was quite straightforward in most cases too.

Distinct installations with a significant potential to supply excess heat (such as waste-to-energy installations or power stations) or renewable heat (such as waste water treatment plants) could easily be identified and mapped as well.

Challenges

Mapping the cooling demand on the other hand turned out to be much more challenging. A map of the cooling demand was only for one case, Zagreb more in particular, but it could not be complemented with a map on the cooling infrastructure nor of potential sources of sustainable cooling.

Figure 46: Successes, challenges of the STRATEGO five tasks' approach; identified needs and success stories

Mapping the energy saving potential and mapping diffuse sources of renewable heat (such as the potential of heat pumps, solar hot water boilers or biomass sources) was more demanding as well.

Needs

Mapping heating and cooling demand at local level has demonstrated to be a daunting task. There is a lack of appropriate tools to help local authorities in this task. Extracts from the PETA, the Pan-European Thermal Atlas, showing the heating or cooling demand, were offered to the STRATEGO partners. Yet, local authorities are in a need for a tool in which they can add locally available data themselves to give a more holistic picture. The European Commission has already acknowledged this need and has launched a H2020 call to build such tools. [13]

Apart for the need for appropriate tools, there is also a need for easily accessible data to the local authorities, so that they can have estimates of the heating and cooling demands for the different buildings in the cities or estimates of the sustainable heat supply potential of various sources.

The STRATEGO cases have demonstrated that cooling is blind spot overall. There are significant knowledge gaps on the extent that cooling is needed in various sectors, on the already in place installations to provide cooling and on the alternatives and their associated costs and benefits. Research is needed to fill these knowledge gaps.

Success stories

The lack of sophisticated and appropriate tools should not prevent local authorities to start mapping heating and cooling. In fact, simple maps already can provide inspiration for projects.

One of the simplest heating maps was made for Veurne, BE, see Figure 47. Using commonly available software (MS Word) and a number of symbols, existing heat demand areas (in blue), future heat demand (in yellow) and potential heat supply sources (in red) were indicated in less than an hour. This simple map both has put the already existing ideas into perspective and has given inspiration for new ideas.

5.2 Project definition: successes – challenges – needs – success stories

Successes

Areas of priority and projects have been identified in all cases; this has resulted in the definition of 43 projects over the 30 STRATEGO cases.

The identified projects are showcases of all six categories that are needed to realise an enhanced heating and cooling plan: 1) reduction of heating and cooling demand at end-consumers; 2) refurbishment, expansion of existing district heating networks or new ones; 3) sustainable individual heating and cooling solutions; 4) exploitation of the excess heat potential; 5) exploitation of the renewable heat potential, and 6) improved conversion of fossil fuels.

[13] Call EE-05-2016: Models and tools for heating and cooling mapping and planning. One of the approved proposals is the PLANHEAT project, with the full title: “Integrated tool for empowering public authorities in the development of sustainable plans for low carbon heating and cooling”. The PLANHEAT project has started on October 2016 and runs for three years.

Figure 47: An example of how simple maps can provide inspiration already

Challenges

The costs and benefits could not be assessed for all identified projects. The benefits in terms of energy saved or sustainable energy supplied have been assessed for two third of the projects but these numbers were converted to economic savings for a minority of the projects. Also the costs of the projects have been determined for a minority of the projects.

It could be observed that some of the STRATEGO cases were a combination of some of the six. This demonstrates the synergetic effects of developing of a project of one category on creating opportunities for projects of other categories. The Großschönau case is such an example, see 2.6.2 Case 1: Integrating solar thermal and a heat pump in the rural district heating network of Großschönau, AT. This combination, however, increases the complexity of the project and makes it harder to assess all costs and benefits.

Needs

It turned out from the STRATEGO cases that both more time and data are needed to have accurate assessments of the costs and benefits of the identified projects. The process between identifying projects and elaborating these to prepare investment decisions is a lengthy process that could not be fully completed in the timeline of the STRATEGO project. The data needs are similar to those discussed in the previous subchapter on mapping.

Most of the cases focussed on city centres and many of these cases investigated the possibilities to refurbish, expand or build new district heating networks. Yet, a sustainable heating and cooling strategy should look to all heating and cooling consumers, also those in sparsely populated areas. More such cases should hence be examined.

Success stories

There were some STRATEGO cases for which the costs and benefits were assessed. These cases have in common that they have a very defined focus on a specific project, which makes it more straightforward to define the size of the project and to find information on costs and benefits. Examples of such projects are the thermal rehabilitation of apartment buildings in Alba Iulia, RO or the installation of a heat storage in Karlovac, HR, see 2.2.2 Case 1: Alba Iulia – reduction of heating demand by 40%; and see 2.3.3 Case 2: Inclusion of a heat storage in an existing DH network of Karlovac, HR.

There was also one specific STRATEGO case with specific focus on rural areas where the population density does not allow to deploy natural gas grids, let be district heating grids. This project has been developed as show case for sustainable individual heating systems in sparsely populated areas and its definition was inspired by the six project categories that were defined as a guidance to look for projects to realise the Heat Roadmaps.

5.3 Business models for local partners: successes – challenges – needs – success stories

Successes

In total 36 business models have been developed for the 43 identified projects. The number of models is smaller than the number of cases since some business models are identical for multiple projects.

The development of business models has been based on the Business Model Canvas. The building blocks of the Business Model canvas consists of two main categories; one block describes the logic and how the business model seeks efficiency and one block describes the value and emotions of the business model.

Challenges

The business models of the projects are very complex and involve a lot of stakeholders. This makes the development of an "investment ready" business model more time consuming than foreseen at the inception of the STRATEGO project.

The business models developed in STRATEGO are all in an early stage of their development and the majority are characterised by a lot of uncertainty.

Needs

The main lesson from business model development in STRATEGO is that business models for district heating and cooling need to be flexible and allowed to changes over time as the focus become clear and uncertainties are sorted out. Further it has been identified that the different heat markets are on different stages of maturity, which also adds to a prolonged phase of the development.

It is concluded that developing district heating and cooling projects, including their business models, is a lot more demanding than perhaps foreseen at the inception of the STRATEGO project. This confirms the challenge, observed when defining projects: the development of heating and cooling projects from conceptual idea to investment decision is a complex and time consuming project.

Success stories

The Business Model Canvas has demonstrated to be a useful tool to do that. It allowed to look at the projects from different angles. They put the end-consumer at the heart of the projects. One of the first aspects to define in the business model canvas is the value proposition; this demand the definition of the customer (or the customer segments), their needs and how the projects respond to these needs.

Some of the STRATEGO cases indeed put the end-consumer upfront by proposing for instance locally generated, low carbon heat and electricity (baseload) at low and stable costs. This is for example the case for some of the Croatian or Scottish cases.

5.4 Involvement of local stakeholders: successes – challenges – needs – success stories

Successes

The projects and their business models have been discussed with stakeholders. Those stakeholders directly involved in the implementation of the project were involved the most; i.e. the local authorities and the district heating grid operations in most cases.

Challenges

A wider range of stakeholders was only involved in a minority of cases. These stakeholders are end-consumers, heat suppliers, regional authorities, energy agencies or suppliers to district heating systems and in some cases STRATEGO coaching partners.

Needs

There is a need for a public debate within the STRATEGO target cities on heating and cooling and its transition towards a more sustainable system. Such a public debate would automatically trigger interested stakeholders to participate to the debate, which in turn would widen the range of involved stakeholders.

Success stories

Some STRATEGO target cities succeeded in organising such a public debate, such as Kortrijk, BE or Edinburgh, UK. These two cities both face the challenge whether or not to choose for district heating while there is no such infrastructure yet. As the deployment of district heating networks will have significant impacts on many people, the cities organised public debates involving a wide range of stakeholders to discuss all relevant aspects. The outcome of these public debates is a common understanding of the city’s ambition on heating and cooling and a public approval which smoothens the path for the implementation of the projects, realising the ambition.

5.5 Input in local heating / cooling plans: successes – challenges – needs – success stories

Successes

The final step consisted of providing input to local heating and cooling plans. Thanks to this input and to involvement of the local authorities in the stakeholder meetings, have the identified projects been added to the political agenda of the STRATEGO target cities.

Challenges

Although input has been given to all STRATEGO target cities, only a minority of the local heating and cooling plans reach the level of a strategic master plan. Such a master plan defines strategies for a transition of the heating and cooling system in major parts of the STRATEGO target cities towards a more sustainable system.

Needs

The definition of a strategic master plan requires first of all a political will to start transforming the heating and cooling system, followed by a public debate on the options, their impacts and benefits.

This is a lengthy and time-consuming process. Local authorities might also be in the need for guidance on how to steer this process.

Success stories

The roles of local governments was analysed for one STRATEGO target city (Veurne, BE), using a report of the United Nations Environment Programme as a guideline. This analysis has indicated that the city has a significant role to play as a **planner of heating and cooling** in the town. As a minimum, the city should integrate energy planning in urban planning. As a next step, the city should consider developing a holistic heating and cooling strategic master plan for the whole jurisdiction. This would provide a frame for local new urban developments and provide inspirations for alternative heating and cooling options.

Antwerp , BE is one of the STRATEGO target cities that realised a strategic master plan on heating and cooling. This process has already started in 2009 when the city concluded from its Sustainable Energy Action Plan, drafted in the framework of the Covenant of Mayors, that significant greenhouse gas emission reduction can be achieved from tapping the vast amounts of excess heat from the port and by bringing to the city to heat buildings.

Antwerp developed since that date – and continues to do so – projects to realise this ambition. The first projects stood on their own in an initial phase but act as stepping stones for a future more integrated system. It demonstrates that a strategic master plan at city level frames single projects into a wider context, which guarantees a targeted design and an efficient use of public funds.

5.6 Final conclusions

The discussion of the successes, challenges, needs and success stories of each of the five steps allow to draw some general conclusions.

- The transition towards a more sustainable heating and cooling system at city level begins with the understanding that there is a significant potential in heating and cooling to curb down the city's greenhouse gas emissions. Then there is need for political leadership to start a process of exploring the possibilities and to discuss different options with a wide range of stakeholders.
- The outcome of this process should be a strategic master plan on how to organise this transition towards a more sustainable heating and cooling system in the city. Such a master plan allows to frame single projects into a wider context.
- Individual projects need to be defined to realise the strategic master plan. The five steps' approach, presented in the work package of the STRATEGO project, has demonstrated to provide appropriate guidance to cities for such a process. It was successfully applied to 30 target cities with very different characteristics.
- A first step consists of exploring the possibilities. This requires mapping demand areas and supply points of heating and cooling. The experiences of the STRATEGO cases has shown that there is a need for appropriate tools, access to data and new knowledge on cooling. However, simple maps already can give inspiration for project ideas if they combine information and demand and supply.
- A second step is the project definition. A list of six categories of heating and cooling projects (reduction of demand; district heating/cooling in densely populated areas; sustainable individual heating in other areas; excess heat; renewable heat; improved conversion of fossil fuels) was used in this STRATEGO project. This list has demonstrated to be a useful tool to give guidance to local authorities to define projects.
- A third step is drafting business models for the defined projects. The business model canvas has demonstrated to be a useful tool to carry out this task. It allows to look at the projects from different angles; it especially puts the end-consumer at the heart of the projects. However, the assessment of all costs and benefits of projects is a lengthy process and it takes time before enough details are gathered to draft an investment ready business model for the projects.
- A fourth step is the involvement of stakeholders. An involvement of a wide range of stakeholders can give the necessary support to realise the projects.
- A fifth step is input to the local heating and cooling plan. Ideally, this step is no more than an update of the strategic master plan on how to organise this transition towards a more sustainable heating and cooling system in the city

It is the hope of the STRATEGO project partners that these conclusions will support European cities in replicating the steps taken by the STRATEGO target cities in the framework of this project.

6 Bibliography

The individual STRATEGO cases are reported in separate case sheets; they can be consulted on the webpage http://stratego-project.eu/projects-description/

Carbon Trust Resources and Ramboll Energy. (2014). *Scotland Heat Map - User guide. 2.0 Methodology report.* . Commissioned by the Scottish Government. Version 1.0 .

Cornelis E., M.-H. F. (2015). *Local action: Methodologies and data sources for mapping local heating and cooling demand and supply. Interim report of the STRATEGO project.* Mol, Belgium: VITO.

Grundahl L., R. N. (2016). Comparison of heat mapping methodologies – an analysis of the of top-down and bottom-up approaches. *DHC+ Conference.* Copenhagen: Aalborg University.

Lauersen, B. (2015). *Business Models - Interim Report in the framework of the STRATEGO project.* Kolding, Denmark: Danish District Heating Association - DDHA.

Osterwalder, A., & Pigneur, Y. (2010). *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers / Edition 1.*

UNEP. (2015). *District Energy in Cities - Unlocking the potential of energy efficiency and renewable energy.*

UNEP. (2015). *District Energy in Cities - Unlocking the potential of energy efficiency and renewable energy.*

Van Esch, e. a. (2016). *Hernieuwbare EnergieAtlas Vlaamse gemeenten.* Mol: VITO.