Policy recommendations to decarbonise European heating and cooling systems

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Date: 22/11/2017

Funded by the Horizon 2020 programme of the European Union

The progRESsHEAT project

The project progRESsHEAT aims at assisting policy makers at the local, regional, national and EU-level in developing integrated, effective and efficient policy strategies achieving a fast and strong penetration of renewable and efficient heating and cooling systems. Together with 6 local authorities in 6 target countries across Europe (AT, DE, CZ, DK, PT, RO) heating and cooling strategies will be developed through a profound analysis of (1) heating and cooling demands and future developments, (2) long-term potentials of renewable energies and waste heat in the regions, (3) barriers & drivers and (4) a model based assessment of policy intervention in scenarios up to 2050. progRESsHEAT will assist national policy makers in implementing the right policies with a model-based quantitative impact assessment of local, regional and national policies up to 2050.

Policy makers and other stakeholders will be strongly involved in the process, learn from the experience in other regions and gain deep understanding of the impact of policy instruments and their specific design. They are involved in the project via policy group meetings, workshops, interviews and webinars targeted to the fields of assistance in policy development, capacity building and dissemination.

Acknowledgement

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the grant agreement No 646573. .

Funded by the Horizon 2020 Programme of the European Union

Web: http://www.progressheat.eu

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1. Executive Summary

Considering the “2°Celsius target” set within the Paris Agreement, CO_2 emissions of the energy sector need to be reduced by about 95 % by the year 2050 towards the 1990’s level. Considering that more than 50% of final energy consumption in the European Union is used for heating and cooling purposes, of which the major part is supplied by fossil fuels (Fleiter et al. 2016), a decarbonisation strategy for this sector needs to be developed.

In order to reach this ambitious target a transition of the heating and cooling (h/c) sector needs to be initiated. It is necessary to increase energy efficiency on the demand side and use renewable energy sources (RES) for heating, cooling and electricity (Figure 1). The importance of measures to reduce energy demand such as deep energy retrofit of buildings or internal energy reuse in industrial processes is emphasized with the “energy efficiency first” principle of the EU energy policy (COM 2016b). However, there are technical and economic limitations as well as non-economic barriers so that even with ambitious measures a significant h/c demand needs to become decarbonised either by direct deployment of renewable energy sources (RES-H/C) or the use of electricity from RES (RES-E).

Although district heating and cooling (DHC) is mainly supplied by fossil fuels in most EU Member states, it is a crucial infrastructure for achieving ambitious climate protection targets in the h/c sector. In densely populated urban areas, with limited potentials for deep renovation and decentralised RES, it might be the essential option to achieve full decarbonisation. DHC systems facilitate the integration of different RES, excess heat or power-to-heat in the same system. Therefore, potentials for efficient and renewable supply need to be assessed considering local demand and supply structures. Furthermore, existing district heating networks need to be upgraded to allow for low temperature heat supply to increase system efficiencies.

The best combination of energy efficiency, decentralised RES-H/C, DHC and power-to-heat options differ from one region to another. There is no uniform strategy for every city and region in Europe but the different technology options need to be applied to varying extent. Thus, local heating and cooling decarbonisation strategies need to be developed taking into account all available options as well as the local heating and cooling demand and supply structures.

Within the progRESsHEAT project all decarbonisation options have been considered and the feasibility of these technologies has been analysed in different case studies.

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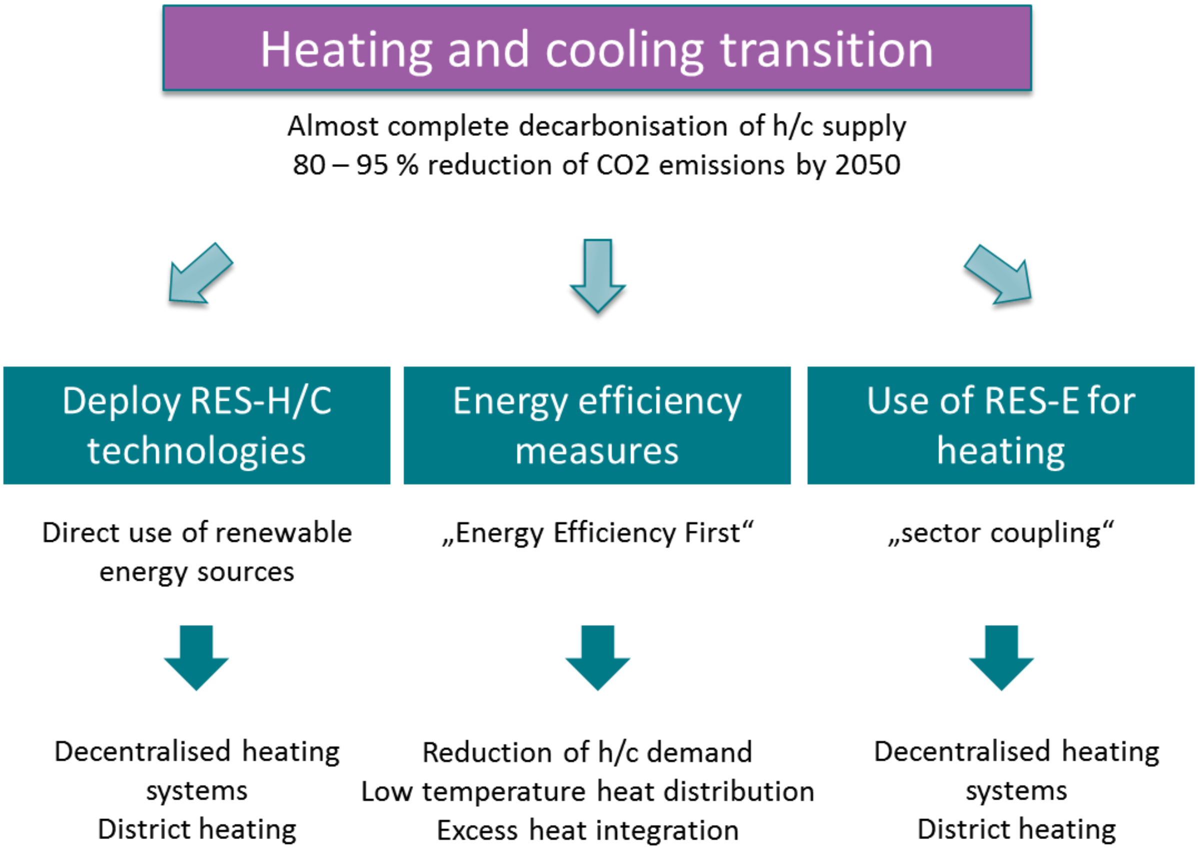

Figure 1: Transition of the heating and cooling sector

For realising the heating and cooling transition, effective policies are required. Contrary to other sectors, where regulations and support schemes need to be rather set on national or even European level in a harmonised manner, decarbonisation of the h/c sector requires a local approach as well:

- The main investors in energy efficiency and heating systems are building owners who cannot be regulated by a national entity as it is in the electricity sector.
- Installers and other craftsmen providing technologies and implementing efficiency measures such as building retrofit operate in regional structures.
- DHC is completely operated and organised on local or regional level mainly by municipal utilities.

Therefore, the progRESsHEAT approach derives policy recommendations not only for national and European, but also for local and regional levels. Figure 2 summarises the policy recommendations that should support policy makers to develop and implement an appropriate technology strategy at local and national level. The suggested policies build on top of each other and a high impact can only be expected if they are implemented as integrated policy packages.

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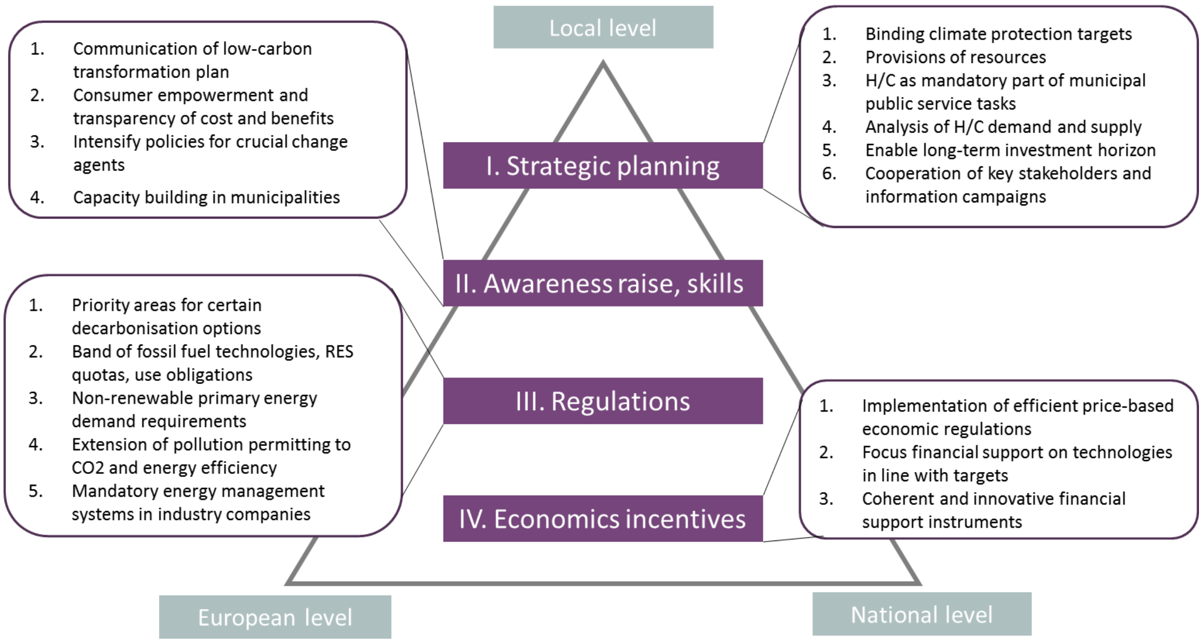

Figure 2: Overview of policy recommendations

Further research and technology development needs to include the following aspects:

1) Improving data availability in the heating / cooling sector in order to better track progress towards a renewable heating and cooling sector. In particular this should cover the fields of non-residential buildings, cooling, district heating grids and available excess heat across European regions.

2) Technology development: Besides further research of renewable heat generation components also efficiency technologies (building envelope, standardisation of renovation measures) as well as research in thermal storage and fourth generation district heating components is strongly needed.

3) System integration: The heating and cooling sector and heating and cooling storage will play a more and more relevant role as a flexibility option for volatile RES-E generation. The further research of how to activate this function in a most effective way is highly needed. This should also explicitly include to the role of low temperature district heating grids.

4) The system integration and sector coupling will pose new challenges regarding effective design of policy instruments, market settings and regulation. In this context, also the multilayer governance of local, regional, national and EU policies needs to be better understood. Future research will have to address these aspects, in order to provide highly needed support to policy makers in the ongoing transition of the heating/cooling and overall energy system.

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2. The progRESsHEAT project

progRESsHEAT is an EU funded research project with a focus on communication and support activities in the framework of Horizon 2020 to support the progress of renewable energies for heating and cooling in the EU. The main objective of the project is to assist policy makers and public authorities at local, regional, national and EU level in the development and implementation of integrated strategies and policies to enforce the use of renewable and efficient heating and cooling solutions in their regions. The project is based on a scientifically guided strategy development and implementation process on the one hand, and a target-oriented dissemination and capacity building process on the other hand, both at the local, regional, national and international levels. Figure 3 shows the national, regional and local focus of activities within the project.

Figure 3: Focus areas for local, regional and national activities in progRESsHEAT

The key results of the project include

(1) local and regional heating and cooling strategy documents for the six municipalities analysed in course of the project,
(2) tailor-made recommendations for policy makers at different policy levels and
(3) information and training packages covering important topics for the decarbonisation of heating and cooling as well as developed assessment tools for the local level.

The following list summarises briefly the activities performed within the project and links to further information and reports, which can be downloaded from the project website.

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Scientifically guided strategy development process

- Local case study analysis in six municipalities across Europe (Figure 3) in close cooperation with the local authorities
  - Analysis of the existing demand and supply structures
  - Development of modelling frameworks for the local quantitative analyses
  - Analysis of renewable energy sources (RES) and efficiency potentials and various technology scenarios for each municipality
  - Empirical analysis of barriers and drivers in each municipality
  - Assessment of policy impact on the technology scenarios
  - Formulation of local heating and cooling strategies until 2050 based on the analytical results and stakeholder discussion process
  - Integration of stakeholders in the entire strategy development process via continuous policy group meetings, workshops and personal contact
- National case study analysis in six EU member States
  - Analysis of existing demand and supply structures
  - Analysis of RES and efficiency potentials and various technology scenarios
  - Analysis of current policy framework in six European cities, their regions and countries
  - Assessment of policy impact on the technology scenarios
- Continuous discussion and assistance process with local, regional, national and EU policy makers (see Figure 4)
  - Policy Groups both at local and national level meeting at least once a year
  - Policy Workshops
  - Webinars on different topics important for the strategy development and implementation process

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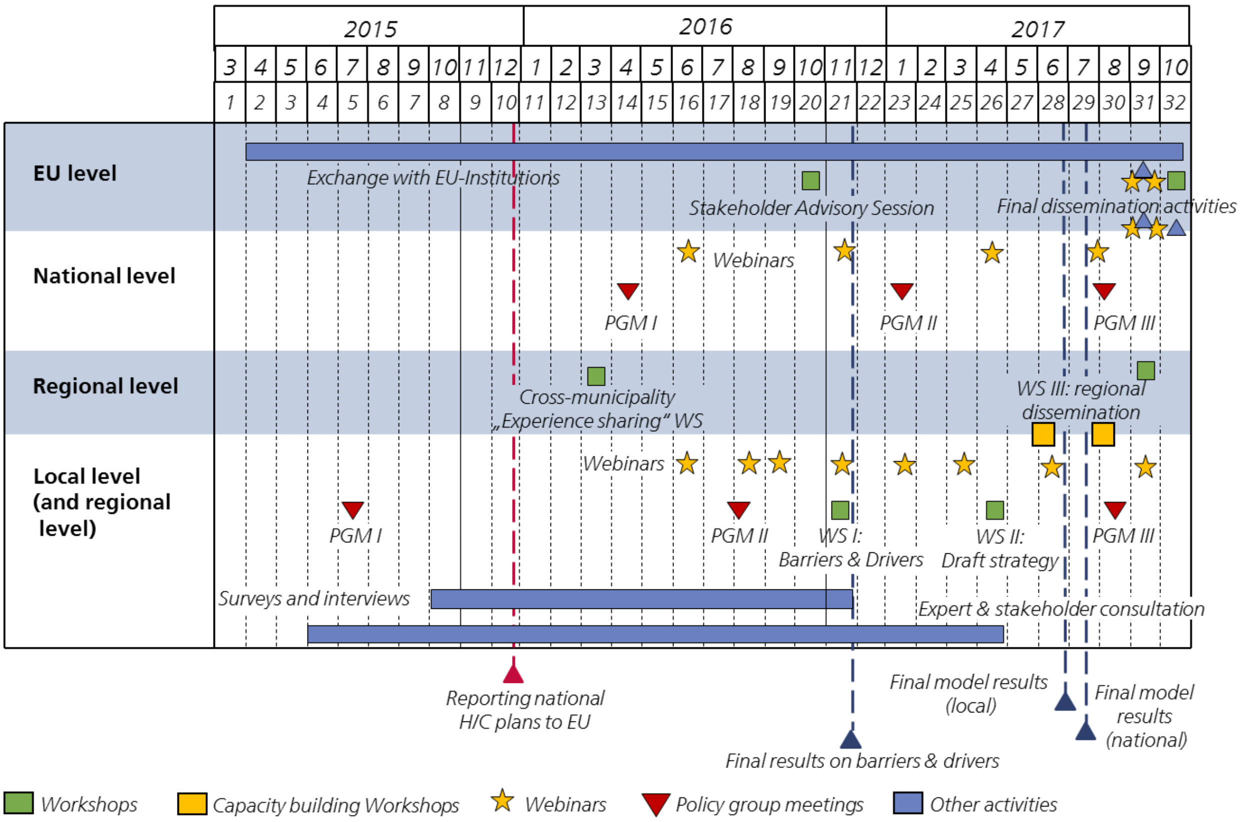

Figure 4: Communication and dissemination activities within progRESsHEAT

Target-oriented dissemination and capacity building process

- Development of modular training materials containing information about technical basics, financial aspects and calculation, policy frameworks and permitting procedures (D6.2)
- Capacity building workshops directed to policy makers and administrative staff as well as industry stakeholders
- Integration of the quantitative analysis results in an online data mapper
- Promotion of the project and its results and the materials through Energy Cities, the European association of local authorities in energy transition

The focus of this report lies on the compiled presentation of the recommendations from the work performed within the project (and other related activities). However, each of the recommendation chapters includes links to other project reports providing a profound description of the methods applied and results generated.

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3. Recommendations for local, national and European policy making

3.1 Strategic heating and cooling planning

Strategic heating and cooling planning is essential for the decarbonisation of the heating sector. There is no general strategy applicable to all regions and cities in Europe. Depending on regional and local potentials of options, the economic situation and the demographic development, different approaches and technology solutions need to be considered. Thus, heating and cooling planning needs to be performed on the local or regional level by the municipal or regional authorities. On European and national level, policies are needed to support a local implementation of heating and cooling planning.

The understanding of strategic heating and cooling planning developed in the progRESsHEAT project is summarised in Figure 5. Thereby, the figure indicates which policy level – local, national or European – is mainly concerned with the respective recommendations.

Recommendations \ Action level	Local	National	European
1. Binding climate protection targets for H/C	!	!	!
2. Provisions of resources for heating and planning		!	
3. H/C planning as mandatory part of municipal public service tasks		!	!
4. Analysis of H/C demand and supply	!		
5. Enable long-term investment horizon	!	!	
6. Cooperation among key stakeholders	!		

Figure 5: Recommendations and levels of action for strategic heating and cooling planning

Binding climate protection targets

An agreement on binding European, national and local targets is a crucial prerequisite in the political process for any implementation of support instruments or technical planning procedures. With policy goals in place, there is a justification and need to allocate human

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resources in the administration. Since h/c planning needs to be conducted locally, a binding target framework set by municipalities is a key driver for an effective and efficient decarbonisation of the h/c sector. From the case studies of the progRESsHEAT project, the relevance of climate projection targets has been observed in particular for the city of *Herten.* The ambitious climate protection plan in *Herten* has been the basis for the implementation of local energy efficiency policies, innovative pilot projects, and information and training campaigns as well as ongoing planning procedures for the future transformation of the district heating network[1].

A sound target framework should include overall CO_2 reduction targets for the local/regional and national energy systems but also sector specific goals with regard to CO_2 savings, energy efficiency or RES. Sector specific targets could be either set for the different economic sectors – households, service and industry. However, a better approach is to categorise different scopes regarding similar decarbonisation options and stakeholders that might need to be addressed with similar policies. Thereby, the categorisation of different end-uses needs to be considered. Sector specific targets could be set for

- Overall heating and cooling demand
- Heating and cooling demand in buildings
- Process heating and cooling demand
- Electricity supply

A reduction target in terms of final or primary energy demand is suitable for the demand sectors, whereas CO_2 saving targets or RES deployment targets are suitable as target indicator for both the supply and demand sectors. Since heating supply is highly decentralised in most European countries, a target on direct RES-H/C deployment might also be relevant for the demand sectors. The target framework should define long-term targets until 2050 considering the long reinvestment cycles in the heating and cooling infrastructure and the building sector. In addition, short and mid-term targets until 2025 and 2030/ 2035 are useful to track the transformation process. The target framework needs to be consistent among different sectors and should present an ambitious but realistic decarbonisation pathway.

The German "Energiewende" presents the a comprehensive target framework. It defines different overall targets, targets for specific sectors, different measurements – CO_2, final energy, primary energy, renovation rate as well as different time-horizons.

Heating and cooling planning as part of public service tasks and provision of resources for local governments

Local administrations need to understand heating and cooling planning as an essential part of the public service tasks. On the one hand this could be supported by granting respective financial measures for municipal authorities. On the other hand an obligation to conduct continuous heating and cooling planning would be an even stronger policy addressing not

[1] For more information refer to the project website

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only front-runner but forcing all municipalities to deal with decarbonisation of their local energy system.

A combination of both – financial and regulatory - policies for incentivising h/c planning is recommended, which needs to be implemented on national as well as on European level. National policy could include heating and cooling planning as part of the self-government tasks of local governments for which they are explicitly obligated by law. Heating and cooling or planning requirements to decarbonise the local energy systems might be included as part of urban planning. In order to fulfil this additional task, local governments need to assign internal workforce and financial resources, e.g. for external engineering consulting. The provisions of adequate financial funds for local authorities or for the establishment of regional energy agencies are therefore essential, either in the framework of national support schemes, tax allocations or European structural funds.

A best practice example for national policy making in provision of adequate resources for municipalities are the two support programs in Germany that finance personnel costs and concepts with regard to climate protection and energy planning. In the framework of the *National Climate Initiative,* municipalities and cities can apply for a financing “climate managers” in the municipal administration (BMUB 2017b). Thereby, up to 65-90 % of the costs for municipalities with insufficient own funds are covered. The National Climate Initiative is funded from revenues of the EU Emission Trading scheme. Another program, administrated by the Federal Development Bank (KfW), focuses on district planning in municipalities or cities and supports the introduction of district managers and the development of h/c planning in districts (KfW 2015). The position of a district manager is supported over a period of maximum 5 years with 250 000 € per district. Costs for the development of the h/c strategy in the respective district are also subject to additional support.

Support and regulate institutional setting to enable long-term investment horizon strategies

A long-term investment horizon is required considering the long payback periods of infrastructures such as heating and cooling retrofits, deep retrofit measures, district heating and cooling and RES-HC technologies. This might be an argument for re-municipalisation of energy infrastructures, since profitability or the projects is likely be too low. Nevertheless, local authorities also have other priorities than heating and cooling planning and high investment and a lack of expertise could be barriers if municipal owned utilities are responsible. Municipal owned utilities are sometimes used to generate income streams used for other municipal services reducing the available capital for investments in heating and cooling infrastructure.

That is, long-term investment horizon need to be incentivised by other means such as favourable financing conditions, specific requirements on technologies and saving measures for grid concessions. Requirements on RES integration or with regard to the transformation to low-temperature DH supply could be set as prerequisite. National policies can also set regulations on heat suppliers in order to attract investors with long-term investment horizon, e.g. with regard to transparency and profit rules.

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A promising example from the local case studies is the city of *Brasov,* which established a new local public service in charge of the district heating system and guiding the restructuring process of the existing system.

The Danish Heat supply Act initially introduced in 1979 is a best practice example on how national policy making successfully stimulated sound market conditions for long-term investments. The legislation states that district heating and cooling suppliers are obliged to charge consumers connected to collective heating supply only the production costs of the heat including depreciation and financing costs. Thus, heat suppliers are not allowed to make any profits (Danish Energy Agency 2017). Municipalities are also not allowed to raise their income for other public services by operation from municipal owned utilities. The Danish Heat Supply Act has therewith largely determined the current stakeholder structure of heat suppliers being mainly consumer and municipality owned companies. Since only the DH company is subject to the non-profit principle and all services such as fuel supply, technology development as well as engineering and consulting service is regarded as commercial activity, technical and service innovations are not hindered.

Analysis of energy demand and supply

In order to derive a consistent target framework, knowledge of consumption patterns as well as localisation of energy sources and sinks is important. A detailed analysis of energy demand and supply shows where and for what energy is consumed and supplied. Therefore, it is key to increase the availability and open access of data. Better geographic data availability includes data on buildings and related heating and cooling demand, excess heat potentials and local RES as well as energy efficiency potentials. Existing geographical data can usually only be obtained to high costs. Open access of such data would significantly decrease the costs of heating and cooling planning. However, national and European funds are needed as well to survey relevant data and improve the current data base and quality. A lack of sufficient data is especially evident with regard to energy demand and excess heat in non-residential buildings. In order to improve data quality, large data research projects are needed. Instead of allocating insufficient funds in research projects, in which data research is only minor tasks, it would be more promising to finance single data research projects for certain fields within the heating and cooling sector and ensure that data is made available at an open source format.

Examples of European projects that aimed at improving the overall data availability in the heating and cooling sector are for instance, *Entranze*[2], *Mapping and analysis of heating and cooling supply*[3], *Building Stock observatory*[4], *EPISCOPE/ Tabula* [5]or *Heat Road Map Europe*[6].

[2] http://www.entranze.eu
[3] Mapping and analysis of heating and cooling supply – project
[4] https://ec.europa.eu/energy/en/eubuildings
[5] http://www.episcope.eu
[6] http://www.heatroadmap.eu

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Within the progRESsHEAT project, detailed analysis of local h/c demand and supply as well as the assessment of potentials for the different decarbonisation options has been conducted for all six local case studies.

Cooperation among key stakeholders and information campaigns

The establishment of cooperation among all relevant stakeholders is important to smoothen the transition to a low carbon heating and cooling sector. The stakeholder analysis within the case study regions of the progRESsHEAT project revealed the different structures in the municipalities as well as the different interests of local authorities, utilities and district heating and cooling (DHC) companies, craftsmen and consumers. Thus, it is essential to align the interests among the different stakeholders and derive common goals such as sustainable energy supply at competitive prices, reliability of energy supply or climate protection targets.

A best practice example is Tartu in Estonia where cooperation and frequent communication between the involved stakeholders enabled a "win-win relationship" (Galindo Fernández et al. 2016).

Within the progRESsHEAT project, similar success factors have been observed such as round tables of relevant stakeholders (Brasov and Litoměřice) or the establishment of cooperation of neighbouring municipalities as seen in Helsingør and Litoměřice.

A promising approach from the national case studies is the dialog process that has been established between the Federal Environment Ministry and the real estate industry in Germany (BMUB 2017a). Thereby, joint working groups develop common ideas and strategies for climate protection in the building sector.

3.2 Awareness raising, skills and competences

Recommendations with regard to awareness raising, skills and competences include local communication activities as well as the involvement and empowerment of consumers and citizens. Furthermore, intermediaries such as craftsmen, architects or project developers as important change agents need to be more addressed by local and national policy.

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Recommendations \ Action level	Local	National	European
1. Communication of low-carbon transformation plan	!		
2. Consumer empowerment and transparency of cost and benefits	!	!	
3. Intensify policies for crucial change agents	!	!	!
4. Capacity building in municipalities	!	!	!

Figure 6: Recommendations with regard to awareness raising, skills and competences

Communication of low-carbon transformation plan

The awareness, acceptance and trust of end-consumers is crucial for a transition of the local heating and cooling sector. Especially the transformation of inefficient, coal based district heating to modern 4th generation networks with innovative and renewable supply needs to be communicated at an early stage. In East and South-East Europe, district heating infrastructure is a great potential asset for the decarbonisation of heating sector. However, networks are often very inefficient and have a bad reputation resulting, for instance, in high disconnection rates in Romania.

Implementation of visible demonstration projects such as small solar DH fields are not only important to gain experience with new technologies, but also to proof feasibility, the willingness to transform current heating supply and establish a new image of DH. In addition, special occasions to present installations to the public can be organised.

Examples from the progRESsHEAT project are the *Energy Week* in *Herten*, Germany or pilot projects in Brasov. During *Energy week*, the local utility informs the public about actual energy topics, like retrofitting of buildings or the use of RES. Local financial service providers complement this offer with information about funding and financing options. Small lighthouse projects, where local citizens are involved, are also presented as a way to motivate further involvement. In *Brasov,* the municipality decided to implement solar collectors in district heating as a visible signal to transform the currently old fossil fuel based network.

Consumer empowerment and transparency about costs and benefits

Municipalities and local utilities need to involve the public in the planning process and be transparent about environmental benefits, investments and heating prices and on how they plan to change the energy supply in the next years.

Galindo Fernández et al. (2016) listed "customer empowerment and willingness to continuously improve the cost-efficiency and environmental performance of the DH system" as one success factor for the case of Gram in Denmark.

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Intensify policies for crucial change agents

So far, the main regulatory, economic and information policies in place focus either on the demand side – building owners, end-consumers – or on the supply side – utilities, technology manufacturers – whereas intermediaries have rarely been addressed by local, national or European policy making.

Nevertheless, intermediaries such as craftsmen, architects and planners need to be considered as crucial change agents in the heating and cooling sector. For instance, plumbers are not only the crucial information source for building owners when it comes to heating systems, but they also represent the retail trade business for heating systems. Similar is true for painters, which are the main installers and sellers of outer wall insulation. The core business of these craftsmen is not to sell energy efficiency measures and heating systems and they are often reluctant to new technologies due to the risk and additional skills they need to obtain. Furthermore, profit margins are generally not higher or even lower with the installation of RES-H/C technologies.

Thus, policy needs to address relevant professionals to foster technological skills for the installation of RES-H/C systems as well as general energy consulting and sales skills. In particular, local policy making is required since craftsmen operate on regional or local markets. National policy making is similar important with regard to the establishment of appropriate framework conditions for the single occupational group. The following measures are recommended:

- Regional training of planners, energy auditors, and craftsmen is needed on renewable energy. National policy is required to deliver sufficient funds for local training facilities.
- Local authorities should initiate networks among different professionals in order to foster holistic solutions for energy efficiency in buildings – e.g. plumbers (heating systems), painters (insulation), roofers (insulation, solar)
- On national and European level, policies should establish a new occupation of the “energy craftsman”. Therefore, a change of the national educational regulations of plumbers, painters, electricians and other craftsmen is required in order to isolate and combine the relevant competences needed for the installation of energy efficiency measures and RES installation in a separate occupation of an “energy craftsman”.
- When designing RES-H support policy instruments, a special attention should be given to which extent they also address the role and incentive structure for craftsmen.

Capacity building in municipalities

Strategic heating and cooling planning is a continuous process. External engineering professionals might support local authorities especially in the beginning of the process. However, it is important to enable the workforce of the local authorities to plan, act, check and improve the planned transition of the local energy system. Therefore, capacity building is needed, which introduces and establishes easy-to-use tools for heating and cooling planning at local level.

Thereby, EU funded projects such as progRESsHEAT, Celsius or Hotmaps are important to set standards for capacity building measures and provide easy-to-use tools. Capacity

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building material in the form of usable power point presentations as well as webinars with regard to heating and cooling can be downloaded from the progRESsHEAT website.

The Celsius project has set up a Wiki (Celsius Toolbox) which is a growing knowledge and resource base on district heating and cooling http://celsiuscity.eu/celsius-wiki/

The Hotmaps project aims at providing an open source mapping and planning tool for heating and cooling. The software is a GIS based web tool that is dedicated to support authorities and energy planners in the process of setting up a strategic heating and cooling plan for their region in Europe: http://www.hotmaps-project.eu

3.3 Regulatory instruments

Figure 7 summarizes the recommendations with regard to regulatory instruments fostering the decarbonisation of the heating and cooling sector. Even if regulations need to be mainly adopted on national and European level, there are also important policy recommendations on the local level, such as the possibility to define priority areas for decarbonisation options.

Recommendations \ Action level	Local	National	European
1. Priority areas for certain decarbonisation options	!	!	
2. Ban of fossil fuel technologies, RES quotas, use obligations		!	!
3. Non-renewable primary energy demand requirements		!	!
4. Extension of pollution permits to CO2 and energy efficiency		!	!
5. Mandatory energy management systems in industry companies		!	!

Figure 7: Recommendations and level of action for regulative policy instruments

Definition of priorities for different decarbonisation options in municipal areas

“Heat zoning” has been a successful instrument applied by municipal authorities especially in Denmark in order to avoid double infrastructures in particular for gas and district heating networks (DEA, SoG, and DBDH 2015). Thereby, certain municipal areas are defined as either gas or district heating supply areas with compulsory connection to DH networks in the defined areas.

Based on heat zoning, the idea of priority areas for certain decarbonisation options has been developed within the progRESsHEAT project. It is not only an instrument supporting DH but

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all sustainable options to reduce fossil fuel heating demand. This instrument is clearly linked to the strategic heating and cooling planning. It requires a detailed geographical analysis of heating and cooling demand and supply as well as the owner structures in order to define priority areas for energy efficiency – such as new development areas, deep retrofit measures of buildings, expansion of low temperature district heating networks or decentralised RES-H/C technologies.

Although current district heat supply has a high CO_2 factor in most countries, it might still be a valuable decarbonisation option for many areas. Thus, future transformation to 4th generation DH based RES supply options needs to be considered as well.

So far, such a regulation considering all possible decarbonisation options has not been defined in any of the EU Member States. In the case studies within this project, Helsingør (Denmark) has the broadest experiences with heat zoning. In Ansfelden (Austria), the municipality uses its role as owner of new development areas to ensure a sustainable, 100% renewable heating and cooling supply system. In Brasov, the policy focuses on compulsory connection to the district heating network for new settlement areas.

Ban of fossil fuel heating technologies, RES-quota and use obligations

A decarbonisation of heating and cooling supply in line with the Paris Agreement requires that the share of fossil fuel supply is reduced to a minimum. Currently, fossil fuel systems still exhibit the highest market shares in the European heat market and a significant change of market structure has not been observed in recent years. Thus, effective policies are needed to significantly reduce new installations of fossil fuel systems. Considering the average lifetime of heating systems of between 20 and 30 years, a complete ban of new fossil fuel systems latest should be strived for by 2025.

Still an open question is to which extent renewable gas may play a role for substituting a remaining, small share of fossil natural gas and how a ban of gas boilers should consider such a possible substitution. Renewable gas e.g. could be provided based on biomass or from P2G-plants. However, policies in this context have to take into account the limited potentials of renewable gas compared to current consumption, also considering possible competition for renewable gas from different sectors (in particular industry and transport).

In order to gradually reduce the market shares of fossil fuel based heating systems, different policies are possible:

RES-H/C use obligation – Local / national / European level

RES-H/C use obligations require building owners to supply a certain percentage of the building's heating and cooling demand by renewable energy sources (Burger et al. 2008). In order to be an effective instrument, a RES-H/C use obligation needs to be introduced not only for new but also for existing buildings in case of a heating system change in order to be an effective instrument. Such an instrument can be implemented on local, national and European level. Actually, the current Renewable Directive already requires Member States to introduce RES-H/C use obligations for new and existing buildings in case of major renovation (Directive 2009/28/EG 2009 Articel 13(4)). Only a few Member States have implemented the requirements in national legislation, though.

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Examples for regional and local RES-H/C use obligations are the Renewable Heat Act of Baden-Württemberg in Germany (EWärmeG 2015), or solar use obligations, which have been adopted in several cities such as Barcelona or Marburg (Germany). On national level, the German Renewable Heat Act requires only owners of new buildings to cover a certain share of their heating demand by RES. The current Danish building code comprises a use obligation for new and existing buildings. However, economic efficiency of RES systems is a requirement, which will probably lead to a high share of opt-outs (BR15 2015): "In new buildings and in existing buildings, where significant conversions or alterations are made, part of the total energy supply to the building must be renewable energy if this is technically possible and financially viable". Exempted are however buildings in natural gas areas. The experiences from Germany show that such an instrument has very low effect on the market structures for decentralised heating systems if it leaves space for opt-outs.

Requirements in national building codes – National / European

Requirements on non-renewable primary energy efficiency of heating systems could be integrated in national building codes or as part of the Energy Performance of Buildings Directive. An explicit definition on how minimum efficiency would be adjusted over time is essential in order to define predictable framework conditions for the heating industry, craftsmen and investors.

Minimum energy efficiency classes according to the Energy Labelling Directive (2013/811/EU) – National

Another possibility would be to define minimum requirements on the energy label for newly installed heating systems.

Quota for RES-H/C on fossil fuel and district heating suppliers (EU)

An introduction of a quota for RES-H/C on fossil fuel suppliers has been discussed in preparation of the proposal for the revision of the Renewable Energy Directive (COM 2016a). Thereby, fossil fuel and district heating suppliers would be obliged to increase the share of RES in their supply portfolio or to implement technology solutions such as heat pumps, solar thermal collectors or biomass boilers, which can be accounted as fulfilment of the quota.

Ban of fossil heating systems – National

Beside the above-mentioned regulative policies to increase gradually RES-H/C market shares, a ban of fossil fuel technologies for heating could be adopted in national legislation.

Non-renewable primary energy requirements in building codes

Non-renewable primary energy demand requirements in building codes for new and existing buildings do not only incentivise energy efficiency measures but also decentralised RES-H installations and low carbon DH supply. Considering the long reinvestment cycles in the building sector and for district heating infrastructure, the future reduction of primary energy demand in district heating networks by planned projects in low temperature supply and RES technologies should be considered. Thus, the primary energy assessment would include change in the supply structure, which have not been performed yet but will be conducted in the future. Such a policy would require heat suppliers to conduct the needed projects to

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achieve the required primary energy factor within a certain time period of e.g. 2 to 10 years. Such a regulation would avoid possible welfare losses since transformation of district heating networks and energy efficiency measures in buildings are usually performed by different stakeholders and not simultaneously. When considering future changes in the district heating infrastructure and supply mix, it is crucial to harmonise national building code requirements for single buildings with district or municipal h/c decarbonisation strategies to avoid sub-optimisation.

Extension of existing pollution and immission regulation for industrial sites

Industrial installations of a certain size need to meet imission thresholds defined in national law. The national laws are an opportunity to expand these thresholds to energy use. For instance, the Federal Immission Control Act in Germany states with regard to energy, that installations need to "use energy in an efficient manner" (§5).

It is recommended to assess, whether making this requirement more specific is legally possible. Therewith, installation and operation can be linked to requirements on energy management system certification or site specific GHG reduction targets. In addition, such a regulation could include an obligation to perform an economic evaluation of energy efficiency measures including excess heat use in other sites or DH.

The European Pollutant Release and Transfer Register (E-PRTR) is a publicly available database of more than 30,000 industrial sites containing emission releases to air, water and land for 91 emission types. The data is reported annually by companies to national authorities who forward the information to the EU. An extension of the reporting requirements to include heat as emission type can substantially improve the information basis with regard to excess heat potentials in Europe, as currently such potentials are often only estimated based on CO_2 emissions or other indicators.

Mandatory implementation of energy management systems in industry companies

A mandatory implementation of ISO 50001 energy management systems (EMS) or incentives - such as energy tax discount if EMS are implemented - are effective policies to support energy efficiency measures in the industry sector. Considering the need for an overall heating and cooling strategy, not only measures which directly reduce process energy demand but also implementation of RES for heating and cooling and feed-in of excess heat in district heating should be considered as applicable measures in the EMS.

For instance, in Germany renewable energies in electricity generation are financed via a levy that is paid by electricity consumers as a mark-up to the electricity price. It is currently reaching about 6 €-cent/ kWh for households. Companies can get substantial discounts on this levy if they fulfil a number of requirements, among which the introduction of a certified energy management system (EMS) is one. This has led to a major increase of ISO 50001 certificates in Germany. Similar incentives can be established in other countries. However, it needs to be ensured that implemented EMS are working effectively, e.g. by requiring companies to report which measures have been implemented in the framework of the EMS. This has been done for example in Sweden in the PFE programme (Stenqvist and Nilsson 2012).

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3.4 Improvement of economic conditions

For the last 15 years, the main policy approach for the heating and cooling sector in European Member States have been investment grants or soft loans. Even if these measures have proven to be successful to incentivise new technologies, they have not succeeded with regard to reduction of upfront costs of RES-HC systems and energy efficiency measures. Whereas the financial support instruments in the RES-E sector, especially feed-in tariffs, have been very successful in reducing upfront costs. The support policies have changed the overall market and nowadays, overall investments in new RES-E installations exceed those of conventional electricity generation units. However, the financial burden of the effective RES-E instruments in terms of high levies on consumer electricity price now affects the decarbonisation of the h/c sector since efficient power-to-heat solutions such as heat pumps have economic disadvantages compared to fossil fuel technologies.

In order to improve the economic conditions in the heating and cooling sector, a consistent financial support strategy is needed in every Member States. Figure 8 summarises the recommended elements of such a strategy.

Recommendations \ Action level	Local	National	European
1. Implementation of efficient price-based economic regulations		!	!
2. Focus financial support on technologies in line with targets	!	!	
3. Coherent and innovative financial support instruments		!	

Figure 8: Recommendations to improve economic conditions

Implementation of efficient price-based economic regulations

Increasing the prices of fossil fuels by effective price based schemes has been proven to be an important element to have stable investment conditions in decentralised or large-scale RES-H/C technologies for instance in Denmark and Sweden. The current energy taxation in many EU Member States is not sufficient having a very low impact on the economic efficiency of decarbonisation options. An effective price based system can either be implemented via the energy taxation schemes or by additional CO_2 levies or taxes. A CO_2 tax or levy should be applied to all demand sectors including the non-ETS industry sector and the transport sector. For the ETS sector, a CO_2 floor price could additionally be implemented on European level in order to improve stability in economic framework conditions and allow for long-term planning.

Examples of effective CO_2 taxation can be observed in Denmark and Sweden. The fossil fuel taxation in Denmark is e.g. one of the main reasons why large solar thermal district heating is competitive. The introduction of a carbon tax in Sweden in 1991 led to a significant change in

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the energy sources used in district heating (Steinbach et al. 2011). Therewith, coal has been almost completely replaced by biomass, waste incineration and excess heat as well as large heat pumps.

Focus financial support on technologies in line with targets

A financial support strategy does not necessarily mean to raise the overall budget but to focus the available funds to those technology solutions needed to meet the long-term targets. That is, the overall reduction target in 2050 is the starting point to define which technologies are needed. For instance, the reduction target for heating and cooling demand in buildings defines the level for required retrofit options. Instead of supporting standard retrofits, only ambitious energy efficiency measures, which reduce h/c demand of buildings to a minimum, should be supported. Some Member States such as Germany still provide subsidies for efficient fossil fuel technologies. Even if these technologies might lead to CO_2 savings compared to the previous installed systems, they do not meet the long-term CO_2 targets. Therefore, financial support for efficient fossil fuel heating technologies such as condensing boilers needs to be eliminated immediately.

On the other hand, new and innovative decarbonisation options need to be supported. This also includes 4^{th} generation district heating and the needed transformation of the networks (see chapter 4.2). An example is a new support programme of the Federal Ministry of Economic Affairs in Germany, which started in July 2017. It supports the planning and implementation of multivalent 4^{th} generation district heating systems (BMWi 2014).

Coherent and innovative financial support instruments

Financial support schemes have to be developed in a coherent way. That is: instruments provided by different public authorities need to be (more) coordinated considering an overall policy strategy. In addition to public grants, contracting schemes, crowdfunding, ESCO's etc. are examples of innovative solutions which are independent from public budgets to support RES-H/C.

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4. Recommendations on technological aspects

Figure 9Figure 1 illustrates the technology elements of the heating and cooling transition needed to achieve an almost complete decarbonisation. The EU commission has declared the “energy efficiency first” principles (COM 2016b) emphasizing the importance of measures to reduce energy demand before addressing the supply structure. However, there are technical and economic limitations as well as non-economic barriers so that even with ambitious measures a significant h/c demand need to be decarbonised either by direct deployment of RES-H/C technologies or the use of electricity from RES. Since the potential for a decentralised use of either RES-H/C or RES-E technologies for h/c supply are also limited especially in densely populated areas, district heating or cooling might not only be the most economically efficient but the only feasible solution to achieve a complete decarbonisation in certain municipal areas. Still an open question is to which extent renewable gas may play a role for substituting a remaining, small share of fossil natural gas. Anyway, the limited potentials of renewable gas compared to current consumption have to be taken into account, also considering possible competition for renewable gas from different sectors (in particular industry and transport). The composition of energy efficiency measures, decentralised RES-H/C technologies, RES district heating and power-to-heat options required for a complete decarbonisation has not been defined yet and is different from place to place. Therefore, a detailed local and regional analysis of heating and cooling demand and supply is needed. Also, there is no uniform strategy for every city and region in Europe but the different technology options need to be applied to varying extent depending on level and placement of demand and supply options.

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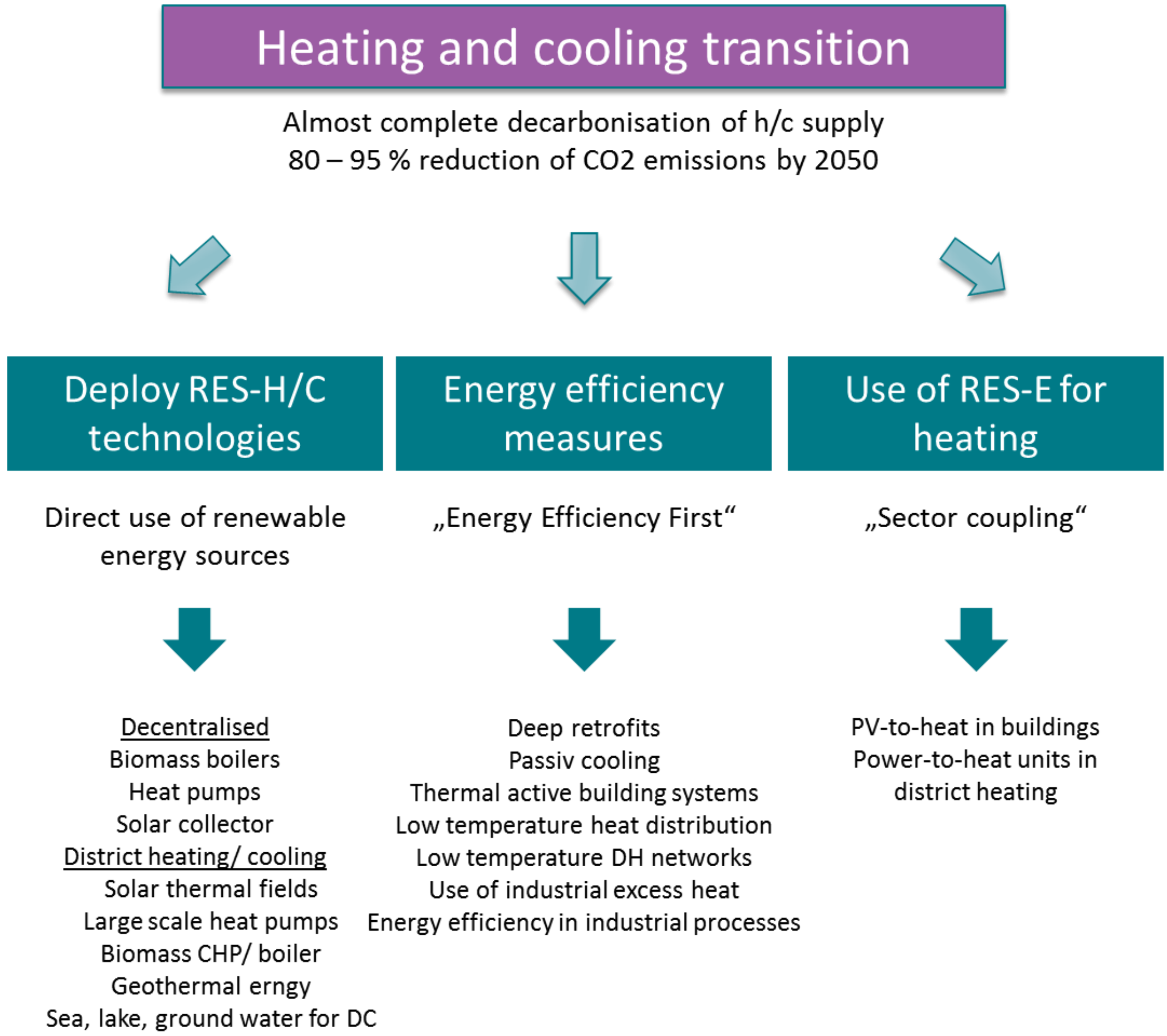

Figure 9: Technology solutions for heating and cooling transition

4.1 Energy efficiency first in buildings, industry and district heating

Improving the current building stock's efficiency is the first prerequisite for achieving low carbon heating and cooling supply. Improved building shells can enable the transition to low-temperature DH networks and increase the share of RES-H/C. Therefore, increased renovation rates are required in order to reach climate targets. However, it has to be noted that the viability of district heating also depends on heat densities and the overall heat demand:

- Levelised costs of heat (LCOH) supply by district heating increase with falling heat demand as seen in the quantitative analyses of the local case studies in Herten, Ansfelden and Brasov. At the same time, a decrease in the distribution temperatures of district heating systems leads to increased generation efficiencies of heat pumps and solar thermal collectors and also allows the integration of low temperature heat sources

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as e.g. certain industrial excess heat streams. Hence, future design of RES-H systems have to consider both demand reduction through efficiency measures and also the influence of the district heating supply temperatures on the efficiency of heat supply technologies and on the potential of the integration different heat sources.

- The levelised costs of heat supply obviously depend on fuel prices and their potential future development. Several scenarios for potential future developments of fuel prices show a decrease of electricity prices mainly due to higher shares of electricity from RES, at least in certain periods of the year. This could decrease the LCOH of heat pumps and direct electric heaters compared to current levels. Furthermore it influences the LCOH of different heat supply portfolios in district heating systems.
- Within several case studies in course of the project these interrelations were analysed. For the city of Herten two related scenarios have been calculated (Figure 10). In scenario 1 the influence of decreasing heat demand through building retrofit on the LCOH as well as the supply of RES in the district heating system is shown. It can be observed that the foreseen demand reduction (around 53%) until 2050 will increase the LCOH of around 70%. Scenario 2 considers DH expansion with the goal of having similar demand throughout the years as in the current situation. In other words, increasing the efficiency of buildings allows connecting more buildings without the need for larger heat pipes etc. It can be observed that the increased share of buildings connected to the DH system can outweigh the reduced demand per building for the case of Herten. The decrease of the LCOH, however, is not only due to higher demand supplied by the DH system, but also due to assumption of reduced electricity prices in the future.

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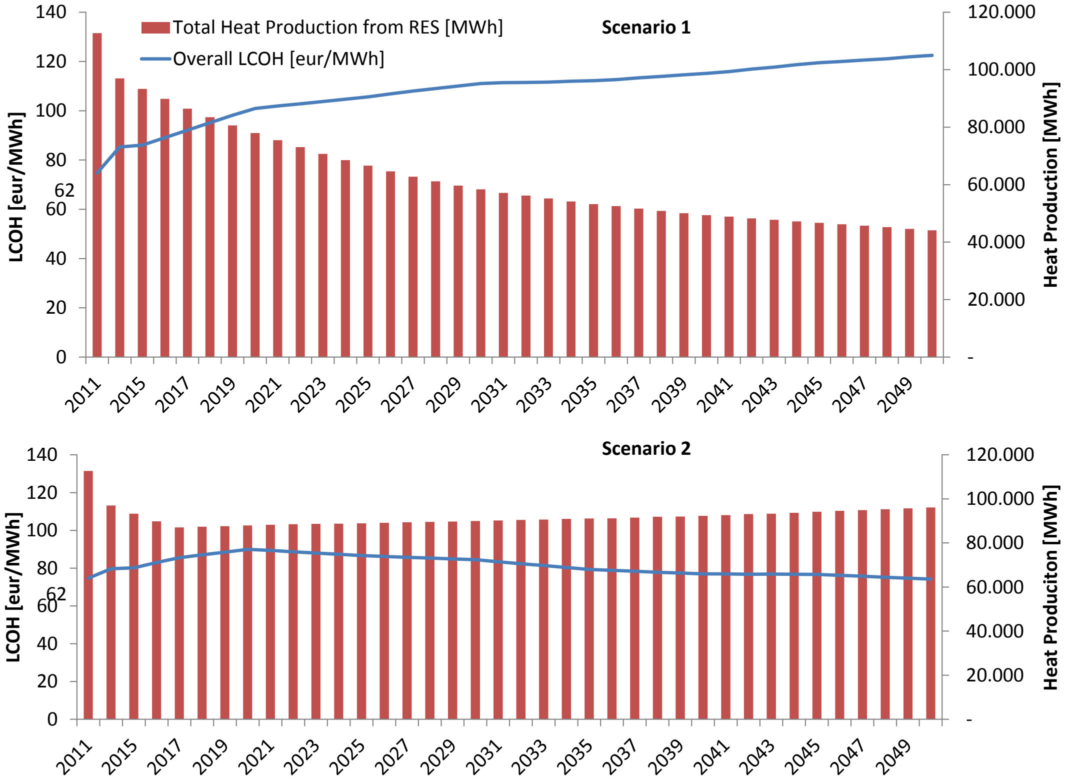

Figure 10: Influence of the deceasing district heat demand (scenario 1) and constant district heat demand (scenario 2) on the LCOH of the DH network in Herten

4.2 Transformation to low-temperature (4th generation) district heating

From numerous existing district heating systems, demonstration plants, and research projects in central (Köfinger et al. 2016) and northern Europe (DEA, SoG, and DBDH 2015) it is observed that a low-temperature district heating (LTDH) system with supply temperatures between 55-70 °C can fully satisfy the end-user's space heating and hot water demand. If properly designed and operated, the LTDH network can supply both existing and new low-energy buildings. The two main advantages of a LTDH network are its increased efficiency and the possibility to integrate higher shares of low temperature RES. By dividing the existing networks into smaller subnetworks, a partial integration of LTDH can be introduced. In Figure 11, several application examples of LTDH networks are presented.

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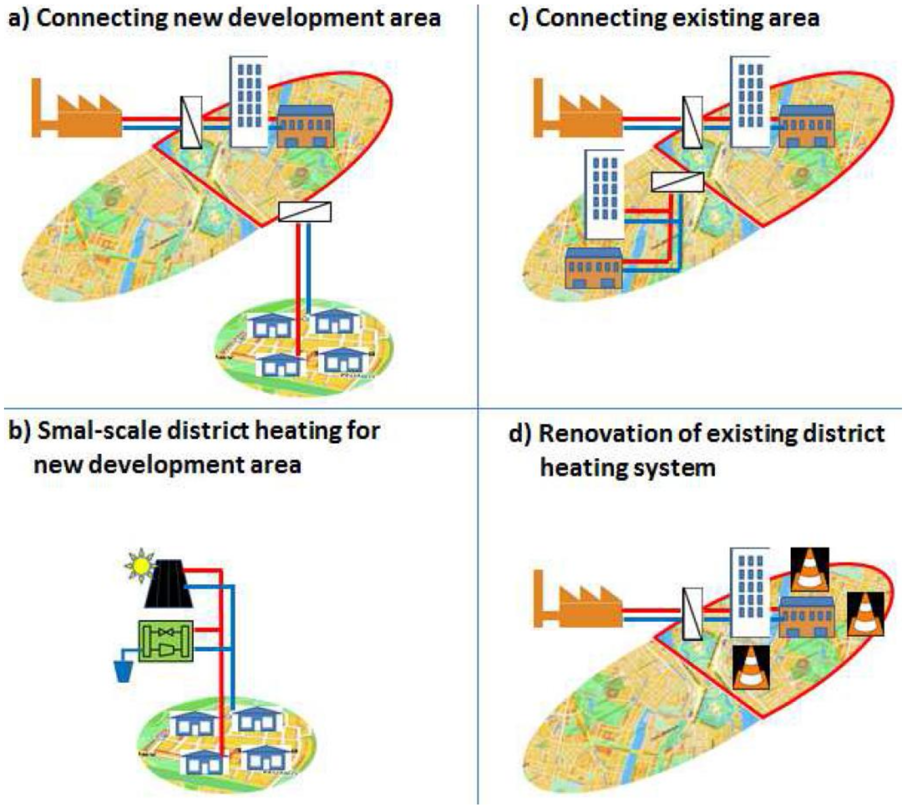

Figure 11: Examples of application of LTDH (Source: Guidelines for LTDH, 2014)

Numerous activities can enhance the integration and transition to LTDH:

- **Develop strategies how to transform the existing heat network towards 4th generation** (i.e. integrate the building renovation and the district heating strategy). By mapping the local conditions, the most suitable areas (district hot spots) for future DH transformation and expansion can be identified. In a pre-study of the European heating market by mapping the local conditions, it was concluded that district heating market share can be increased to 30% in 2030 and 50% in 2050 (Connolly et al.2012).
- **Benchmarking and audits to increase the efficiency of district heating grids**. Key performance indicators should be selected as metrics to benchmark certain areas like prices, efficiency, profitability and sustainability (Farkas, Korhonen, and M. 2011). On the other hand, the energy audit should be an iterative process of data gathering, processing, structuring, presenting and reviewing the collected data.
- **Link to energy efficiency obligations (EEO) according to the European Energy Efficiency Directive (EED).** As a result of the implementation of the European Energy Efficiency Directive most of the district heating utilities in many EU member states are obliged to implement energy savings obligations (VITO and Flemish Institute of Technological Research 2016). With proper planning and zoning of certain districts, the EEO could be used to catalyse the transition to low-temperature district heating networks in the future. By assisting their customers in achieving thermal energy savings, as a

result, the DH utility could decrease the supply temperatures of the network to a lower temperature level.

4.3 Renewable energy heating and cooling technologies

In order to reach the ambitious and essential climate protection targets all of the responsible actors have to undertake several actions and measures in not only improving the energy efficiency of the existing building stock but also converting the heating and cooling supply to renewable energy sources (RES). Several factors can influence the selection and integration of the heating and cooling technologies like the regional climatic conditions, the availability of certain local RES and the price of the fossil fuel. Hence, for each local case study and region different technology recommendations are observed[7]:

Herten, Germany:

- In order to introduce and implement a significant share of large-scale heat pumps in the existing DH network, a reduced and adjusted electricity price is required. Without support of the operation expenditures (OPEX), large scale heat pumps will not be cost-competitive in DH supply in Germany - particularly if in competition with existing coal-based CHP. Exempting electricity used for large heat pumps from renewable levy which is imposed by the Germany Renewable Act to finance RES-E - similar to the discounts large industrial companies receive in Germany - can be a way to reduce the operating costs of large-scale heat pumps and make them more competitive.
- Including solar thermal fields reduces the cost of heating substantially compared to using heat pumps only.
- For solar thermal district heating networks, the systematic search and development of areas can play a key role. Including designated areas for the use of RES in the city's land-use plan would ease the development of solar thermal fields for investors and could reduce the overall costs.

Matosinhos, Portugal:

- Using excess heat from the local refinery seems very promising, as it is close to the city and not yet used. It is estimated that the current excess heat profile is sufficient to supply the focus area and can be an opportunity to establish a DH grid („door opener"). However, there is no tradition / experience with DH in Portugal (only one network in operation in Lisbon) and the uncertainties about the future perspective of the refinery can pose a real threat for the implementation of the DH network.
- Photovoltaics (PV) can be an option to decarbonize heating and cooling based on decentral heat pumps and compression chillers (particularly attractive with space cooling demand in summer). Due to the higher share of cooling, the electricity demand for H&C purposes is distributed across the year. Building roofs (plus parking roofs for commercial consumers) can provide enough space for the installation of the PV units.

[7] Detailed elaboration of specific technology recommendations for each local case study are available at http://www.progressheat.eu/Reports

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- Attractive tariffs and financial support for heat pumps (HP) and PV are essential. Continuation and broadening of financial support schemes can be crucial for increasing the deployment rate of renewable heating and cooling technologies. The proposed financial support schemes considered in this report are loans with low interest rates of 3% for all renewable heating and cooling technologies and investment grants of up to 30%.

Litoměřice, Czech Republic:

- Cost savings are possible through conversion to DH with construction of a geothermal plant. The results show that of all the scenarios, the district heating based on geothermal expansion is feasible in 2030 and 2050, even without any additional policies. This scenario is the least expensive and results in least CO_2 emissions and the highest renewables penetration, so subject to the given assumptions, proceeding with the geothermal energy appears to be most feasible from both an economic and an environmental perspective.
- Risk management related to exploring geothermal energy is one of the main prerequisites for developing geothermal district heating networks. A best available practice of risk insurance related to geothermal energy is the national insurance fund in France (Angelino, Dumas, and Bartosik 2013), that covers short-term risk (drilling) and long-term risk (development and depletion of the resource).

Helsingør, Denmark:

- Switching towards biomass CHP on a short term can reduce the costs of district heating substantially. However, the results in this report depend on the assumption that tax exemption for biomass will continue. Future changes may however improve the comparable profitability of large-scale heat pumps, avoiding use of the scarce biomass resource. Moreover, the technical improvements of solar thermal plants and thermal storages in the future may also mean, that their costs and efficiencies will drop, improving the business case for a scenario that considers larger shares of solar thermal and heat pumps into the DH network.
- In areas with low heat densities, biomass boilers are cheapest with the current regulation, while heat pumps prevail if e.g. particle emission taxes are imposed.

Ansfelden, Austria:

- For the existing district heating system the calculations showed that integrating industrial excess heat into the district heating system results in multiple benefits for the municipality: The price for district heat with a high share of excess heat from the paper plant can be expected to be significantly lower compared to the current situation, thus making district heat even more interesting for consumers. The resulting price for district heat thereby of course depends on the price paid for the excess heat of the plant. The additional capacities allow for an expansion of the current district heating system replacing mainly individual natural gas boiler. Additionally the use of the peak load boiler and therefore of fuel oil can be lowered.
- For the new development area the cheapest out of the calculated options to supply heat - not taking into account subsidies - is a biomass only network with heat storage of 100 m³. However, to supply the total demand just with biomass may require additional emissions for biomass transportation as the total annual demand exceeds 1000 tons.

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The calculations showed that with additional costs for heat of around +10% without subsidies and around +7% with current subsidy levels, solar fractions of 15% can be reached by installing solar thermal collectors and up to 42% when PV is installed driving a heat pump. This can reduce the biomass demand by up to 40%.
The results show that with the combination of central heat pump + PV higher shares of solar energy can be integrated at lower costs than with solar thermal collectors.

Brasov, Romania:

- As a first step, inefficient parts of the network should get disconnected to cut the losses in each of the district heating systems in the municipality down to 20% of annual produced heat.
- As regards renewable energy supply, a combination of different technologies can be integrated into the separated networks: A small biomass boiler, a heat pump and various solar thermal collectors mounted on the district heating substations and associated buildings.
- A package of several policies allows the highest share of renewables for heating without a strong regulative measure such as forbidding natural gas within the district heating area. Such a package would include investment grants of up to 45%, a CO_2 tax of 35 EUR/t_{co2} and establishment of a public service for the district heating network. Therefore, combining different policies leads to high shares of renewable energy in the system without overstressing one single measure.

Furthermore, it has to be stated that increasing the share of district heating only makes sense from a climate policy point of view when the district heating system is transformed to renewable energy supply. When district heating is forced in by zoning and the prohibition of gas, but the district heating system stays with the fossil reference supply system there is no positive climate mitigation impact, especially if more peak load capacities (mostly fossil heat only boiler) are used.

4.4 Industrial excess heat utilisation in district heating

The industrial excess heat has the potential to supply up to 7% of the total heating demand and 16% of the possible DH demand in the residential and commercial sector in Europe (Connolly et al. 2012). The main prerequisite of the industrial surplus heat utilization is the process of identifying relevant sources and connect those to heat demand. This process can be catalysed by energy audits and guides from existing research projects and practical examples **Error! Reference source not found.**. Furthermore, in order to utilise this potential, several barriers have to be overcome(Persson, Hjelm, and Gustafsson 2012):

- **Financial barriers**: High upfront investment costs, particularly when distances to DH grids are long or grids need to be built. This is even more the case, when industrial companies judge excess heat and DH projects as they judge energy projects internal to the plants, for which they often require short payback times of 2 to 3 years although lifetime of equipment is 20 years or longer.
- **Technical barriers**: concerns of supply security.
- **Organizational barriers**: excess heat counted as a free source by the DH utilities creating mistrust between the parties.

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In order to overcome these barriers, based on several case studies and best practice examples around Europe where excess heat from different industrial manufacturers is used[8] the following policies are recommended:

- Engage top-management, e.g. by including excess heat use / total plant efficiency in KPIs and underline the value of diversification/ resilience if energy supply is based on local resources instead of global markets.
- Regulate excess heat release e.g. in the frame of national immission control acts and assess if a certain mandatory excess heat use can be integrated in laws.
- Improved monitoring and reporting, extend pollution monitoring and reporting to excess heat and include in *European Pollutant Release and Transfer Register (E-PRTR).*
- Heat planning on local and regional level to identify opportunities and initiate projects and bring stakeholders together.
- Risk hedging systems, e.g.in the terms of a contractor scheme or as insurance system.
- Investment grants where needed and payback times are long (though, not for profitable projects with short payback times).
- Blueprint for contractual agreement to ensure fair sharing of responsibilities and profits among the involved partners and lower transaction costs for negotiations.
- Support RD&I on innovative forms of excess heat use, e.g. by using transmission heat of furnaces or produced goods (while today mostly heat from flue gasses is used).

4.5 Transition to low-carbon industrial process heat

Decarbonising industrial process heat is a major challenge in H&C transition due to several reasons. Energy efficiency potentials via best available technologies (BAT) are often limited (max 10%) in many processes of the energy-intensive basic materials industries (cement, steel, glass, aluminium, etc.). Many renewable energy solutions are not feasible due to the high temperature levels and high heat densities required (e.g. heat pumps and solar thermal heat can only supply a low share of industrial process heat). Companies are subject to international competition and difficult to cover with ambitious policies. From a technological point of view, ambitious reduction targets (-80% reduction or more) require new technologies (and innovations) including possibly carbon capture and storage. Thus, ambitious transition policies for the decarbonisation of process heating in the basic materials industries need to focus on the development, market introduction and diffusion of low-carbon production

[8] Excess heat from a refinery in Karlsruhe (Germany): https://www.stadtwerke-karlsruhe.de/
Excess heat from a steel factory in Lulea (Sweden): http://www.northsweden.eu/english/news/ssab.aspx
Excess heat from two paper mills in Sweden **Error! Reference source not found.**

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technologies, which represent a radical change in the current production structure. This policy mix can include the following elements:

- Financial support for R&D and market introduction for new products and processes (e.g. low carbon cement or H_2 based steel production).
- Establishment of a framework that allows large long-term investments in new technologies and products and at the same time avoids carbon leakage by
  - including a CO_2 floor price to the EU Emissions Trading System
  - using public procurement to establish niche markets for low-carbon products
- Changes along the entire value chain towards higher material efficiency and circular economy. Examples for policies are:
  - Re-evaluation of value added tax according to CO_2-intensity of products and lower value added tax for repair services.
  - Assess a reform of the EU ETS to keep CO_2 price signals along the value chain visible for downstream consumers and companies.
  - Evaluate building codes and regulative frameworks in the construction industry to facilitate the use of sustainable building products and efficient use of materials.
- More measures related to CO_2 prices (non-ETS), excess heat use and energy management are discussed in the previous chapters.

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5. Recommendations regarding modelling frameworks for heating and cooling planning

In heating and cooling planning processes, four main tasks can be distinguished (Mirakyan and De Guio 2013):

(1) preparation and orientation,
(2) quantitative analysis,
(3) prioritization and decision, and
(4) implementation and monitoring.

In each of these steps, computer aided tools can be used to inform and support the planning process. In course of the project progRESsHEAT computer based modelling frameworks for heating and cooling planning have been (further) developed, linked to existing tools, and were used for six case studies both at local and national levels. These tools were used in two and a half year case studies and provided support for the planning processes in the six municipalities and countries under investigation in the phases of (2) quantitative analysis and (3) prioritization and decision.

For the six local case studies the existing tool energyPRO[9] was used to analyse the district heating supply. energyPRO calculates cost optimal dispatch of district heating supply opportunities, taking into account technical restrictions as well as hourly time series of demand, variable RE supply and electricity prices. For the deeper analysis of the demand side in the local cases, the Least-Cost-Tool[10] (LCT) was developed. Because buildings are the main sector of interest in local heating and cooling planning at the demand side, this Excel-based tool calculates the cost optimal ratio between renovation activities and supply of heat in the buildings. This includes district heating as one of the supply options and therefore the geographic allocation of buildings with respect to the distance to the existing district heating grid (analysed with available GIS tools) to consider the distribution costs as well. Furthermore, the link to the energyPRO calculations and to the existing bottom-up building stock model Invert/EE-Lab[11] was established. The latter model was used to derive costs and effects of renovation measures in existing buildings in the municipalities on the basis of detailed, disaggregated data on the building stock and costs for renovation measures.

The modelling framework that was used for the six national analyses was set up by linking three existing models: Invert/EE-Lab to represent the demand for heating and cooling in buildings, FORECAST-Industry[12] to cover the industrial heating and cooling demand and usable excess heat potentials from industry, and TIMES[13] to link energy carrier demand and supply for different sectors. TIMES was used to perform least cost optimisation of supply for the electricity and district heating sectors in the six countries given the demands identified with Invert/EE-Lab and FORECAST-Industry.

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9 https://www.emd.dk/energypro/
10 http://www.progressheat.eu/IMG/pdf/progressheat_d2.4_modelling_framework.pdfmethodology
11 http://www.invert.at
12 http://www.forecast-model.eu
13 http://iea-etsap.org/index.php/etsap-tools/model-generators/times

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All tools used for the analyses at local and national level visualise calculated results and indicators. These were defined in course of the project and used in presentations and reports accompanied by description, explanation and discussion, thus informing the planning process during the project.

In this chapter, conclusions and recommendations are compiled with regard to the use of modelling frameworks and tools in planning of heating and cooling infrastructure, which result from the work in progRESsHEAT and other related works. These conclusions and recommendations are structured according to the tasks occurring in the heating and cooling planning process as described above.

(1) Preparation and orientation:

Orientation and preparation of analysis framework

- Targets in the form of indicators should be defined in an unambiguous, clear manner. E.g. the increase of the renovation rate is only a relevant target, if it is linked to a clear definition of how to measure the renovation rate.
- All possible and relevant supply and saving opportunities that assist to reach improved target indicators should be considered in the planning process.
- A stakeholder analysis should be prepared and relevant stakeholders invited to the planning process to ensure ownership and power to implement the plan.
- There exists a variety of different tools for heating and cooling analyses. The choice of the tool that is used for the quantitative analysis should be oriented on the needs of the users, the specific purpose of the analysis and the (research) question that should be answered.
    - Tools should allow for different structures and types of data, as data availability is very different from municipality to municipality and also - but less - from country to country.
    - Tools should provide default data in order to be able to perform analyses even without comprehensive data collection.

Collection and processing of data

- The collection and integration of local data for the specific case is especially important for: local weather conditions, the energetic performance, the state of renovation and the location of existing buildings, potential future development areas, and in case of an existing district heating infrastructure, its location, the status of the existing distribution system and the mix of the supply infrastructure, as well as potential heat sources including industrial excess heat.
- In many municipalities, different and partly inconsistent data on the building stock and energy infrastructure exists. For example, building related data typically may be collected by the building inspection office, the energy planning office, the utilities, the department granting financial support for building renovation etc. Thus, it is important to involve all departments and persons from the

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administration and from utilities at an early stage and try to set up a process to develop a consistent dataset. If this is not possible, at least the inconsistencies should be made transparent and a consensus on how to deal with these inconsistencies should be achieved.
- The quality of the collected data is essential for the further analysis, i.e. representative data is a prerequisite for sound analyses and robust results.
- Besides the collection and preparation of data, also a mapping process is important to visualize data and thus support the discussion and decision making process. Also, the mapping helps in identifying inconsistencies and possible errors in the data.

(2) Quantitative and comparative analyses of various options in the H/C system:

Scenario development and assessment

- A limited number of relevant technology scenarios should be identified, for which detailed comparative analyses should be performed.
- Scenarios should illustrate different but plausible developments of the future.
- Scenarios, targets and policy framework on local, national (and EU) level should be considered simultaneously as they influence each other. This is, however, difficult to realise in the same modelling framework. It can be performed either by linking the local analysis with a national analysis and informing each other about the ongoing work, or to compare the local analyses with other existing analyses at the national levels that were developed taking into account different local settings in the respective countries.

Important aspects in the quantitative assessment of H/C systems

- Demand and supply developments and characteristics have to be reflected in the same tool and be analysed simultaneously. Both elements of heating and cooling systems comprise several interdependencies, thus a comprehensive analysis has to take these links into account in order to derive sound and robust results.
- The long-term development of the building sector and subsequently the development of heat densities should be considered in the quantitative analysis. This includes the costs and potentials for building retrofitting and their diffusion patterns, as well as the planning of new buildings. The uncertainties which are related with long-term scenarios should not lead to the conclusion, that the long-term developments could be neglected. It is clear that (partly huge) changes in energy demand patterns may be expected, even if the details and exact direction is not always clear.
- Especially for district heating and cooling systems it is essential to take into account the hourly resolution of demand and supply, at least in case of relevant heating or cooling demand.
- With growing relevance of building automation, smart homes and new options for demand response solutions, it becomes more and more relevant to link the heating and cooling sector to the overall energy system development. Thus,

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sector models should be more and more linked to energy system models, in particular electricity market models.

- At the national level modelling the link between heating and cooling and electricity demand and supply is essential. Furthermore, the option to import and export electricity provides important flexibility to the system.

(3) Prioritization and decision:

Multicriteria analysis

- The prioritization should also take into account long-term indicators and avoid short-term traps and lock-in effects. A short-term optimisation might lead to the promotion and uptake of the most economic solutions. However, in the long-run it might be required to go for another package of solutions in order to achieve envisaged high renewable shares or decarbonisation targets.
- Some criteria may be difficult to quantify, but may still be important and should be weighed up against others. One example is local employment, which is often a priority, particularly at municipality level.

Visualisation of results

- Important indicators for assessing heating and cooling scenarios are CO_2 emissions, share of renewable energy, efficiency improvement and related costs. However, no unique solution regarding the required indicators is possible. Rather, the policy questions and policy targets should drive the visualization of results. If there is an explicit policy target for the uptake of renovation measures, then this target should be defined by a clear indicator and this indicator should be shown.
- Mapping is important to take into account the spatial dimension of heating and cooling demand and supply.
- The visualisation of results also triggers the exchange and discussion which should be seen as a key element of the whole planning process.

Support the monitoring and evaluation process

In the frame of the Horizon 2020 programme of the European Union three projects started in the end of 2016 that aim at developing heating and cooling planning tools: Hotmaps[14] THERMOS[15] and PLANHEAT[16]. The target group for using these models are staff members of local, regional and national authorities responsible for heating and cooling planning. Participation in the development and application of the developed tools is highly encouraged in all of the projects.

[14] http://www.hotmaps-project.eu/
[15] https://www.thermos-project.eu/home/
[16] http://planheat.eu/

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Appendix: Local case study summary sheets

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A progRESsHEAT case study

Renewable heating strategy for a new development area

ANSFELDEN
Austria
15,000

1 Key figures

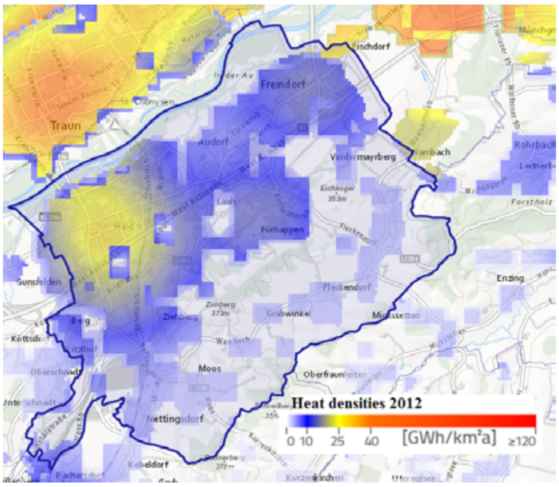

Fig.: Heat density map of Ansfelden
Source: Comprehensive Assessment of the Potentials for Efficient District Heating and High-Efficient CHP
www.austrian-heatmap.gv.at

2 Main challenges

This case study covers the investigation of renewable heat supply options for the new development area «Teilraum 31» in Ansfelden. The area is mainly owned by the municipality which, therefore, can define priorities regarding energy efficiency and renewable energy. The new development area could include ca. 120,000 m². According to the current planning strategy, it will be used for different types of buildings - mainly residential ones, and could reach a plot ratio of 0,45 to 0,55 per building lot. The expected buildings consist of around 100 single-family houses, 200 row houses and 10 small multi-family houses.

They are foreseen to be built as nearly-zero energy buildings and the heating supply of the area will be mainly based on locally-generated renewable heat.

This case study provides a better understanding of potentials and technical solutions. Several renewable possibilities for supplying the new development area from a local district heating network have been investigated under different policy scenarios.

3 Current policies and targets

In Austria, most legislative powers, as well as the financial resources for support measures on the heat market, are under the responsibility of the regional authorities. Local projects, such as in Ansfelden, contribute to achieving regional targets.

In 2017, the energy policy targets were newly defined in the region's energy strategy **Energie-Leitregion OÖ 2050**. Quantitative targets relevant for this case study include:
• A continuous improvement of the heat intensity through a reduction of the ener-gy input per m_2 (climate-adjusted) by 1 % per year
• The further increase in the share of renewables in electricity generation while maintaining current security of supply and making economic use of 80-90 % of the renewable potential in Upper Austria by 2030
• A continuous improvement of energy-related greenhouse gas emissions with a reduction of the emission intensity (GHG to GRPreal, reference year 2014) by 25-33 % by 2030 and by 70-90 % by 2050
• A continuous increase in energy efficiency (final energy to GRPreal) with a reduction of the energy intensity by 1.5-2 % per year.

4 Barriers and drivers

Main barriers
• The current low price of fossil fuels is a major obstacle to innovative investments in renewable energy sources
• Achieving economic viability for a project of a central heat supply system in these new buildings with low heat demand is challenging
• The investment costs for renewable energy systems and energy efficiency measures are higher than for convention-al solutions.

Main drivers:
• The municipality considers renewable energy and energy efficiency a priority
• The support of the OÖ Energiesparverband (regional energy agency) and the know-how of the Technische Universität Wien are very helpful
• A range of subsidies are available for energy efficiency and renewable energy measures, especially for innovative solutions.

5 Results from scenarios and policy assessment

The scenarios and policy assessments led to the following results:
• In the studied case, without policies, the cheapest option to supply heat is a **biomass only network** accompanied by a heat storage of 100 m^3.
• The calculations showed that with additional heat costs of around +7 % (with subsidies) to +10.5 % (without subsidies), solar fractions of 15 % can be generated by installing **solar thermal collectors** and up to 42 % by installing **solar PV** that drives a heat pump. This could reduce the biomass demand by up to 40 %.
• When assuming considerably lower installation costs for solar thermal collectors (e.g. ground mounted instead of roof mounted collectors), the heat generation costs are similar to those of the biomass-only boiler for solar shares up to 25 %. Therefore, emphasis should be put on attempting to reduce investment costs for solar thermal collectors by installing bigger units and using synergies when building a new development area.
• Both solar thermal collectors and a heat pump + PV require additional investments. Certain conditions could make these options more interesting such as higher energy prices or running the heat pump on electricity purchased from the grid when excess electricity from the PV can be fed into the grid.
• The results of the analysis show that under certain conditions, higher shares of solar heat can be integrated at lower costs with the combination of central heat pump and PV than with solar thermal collectors.

6 Recommendations and possible solutions

For the new development area, the folowing policy recommendations should be considered:

• Using existing national and regional financial support schemes for DH network and RES
Subsidies up to 50% of the total investment costs and low-interest rates are already available from the national and regional programs for investment into district heating network infrastructure and RES installations - including biomass boiler, solar thermal collectors and heat pumps

• An integrated planning approach can be enabled by:
- Providing free audits and advice to building owners within potential expansion areas
- Providing additional resources to the local urban development office
- Special marketing campaigns and promotional activities
- Including local housing associations and private renter in strategy development.

7 Outlook and open questions

• The project is at the stage of decision-making regarding the final solution to choose
• Details of the planning process and the timetable for implementation is still to be defined
• A funding application is currently underway.

Interested?
Find more information in the full-text case study on the project website!

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646573

Date of publication: October 2017

Graphic Design: www.TUTTIQUANTI.net

A progRESsHEAT case study

Ensuring energy security and cost-efficient heat supply

BRASOV
Romania
274,500

1 Key figures

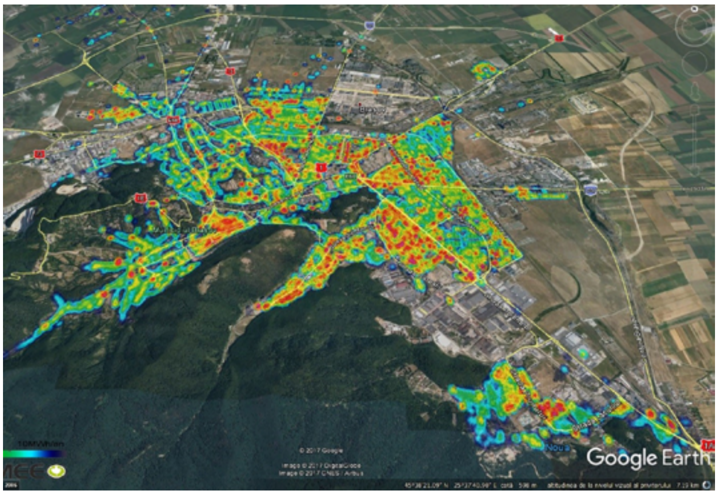

Fig.: Heat density map of Brasov
Source: ABMEE

2 Main challenges

The district heating system of Brasov has gone through several transformations in the attempt to find a solution for the zones located within the urban agglomeration of Brașov. Unfortunately, the lack of vision and the misunderstanding of the advantages of such a system, coupled with a legislation that allows for easily installing natural gas individual boilers, led to a situation where only 4% of the local population was still connected to the DH in 2014 (reference year of the project).

The future of this system is directly linked to the local policies, which should be supported by the population, by the real estate developers and last but not least, by policy makers.

The current strategy is trying to provide insight into the renewable sources that could be used in the future in order to ensure energy security and cost efficient heat supply at local level.

3 Current policies and targets

The current overall targets of the Brașov municipality have been developed in the Sustainable Energy Action Plan (SEAP) for 2010-2020 (2008 as reference year), developed as part of the Covenant of Mayors, which is full part of the strategic political documents for the sustainable development of the city. The general objectives for 2020 are:

- reducing CO2 emissions by 32 %
- reducing of the total energy consumption by 12 %
- reaching a target of 4 % of energy produced from renewable sources in all sectors mentioned in the SEAP.

Regarding the policy measures, the municipal buildings are being submitted to an advanced process of energy upgrading and are permanently monitored (monthly) by the ABMEE (local energy agency), who annually develop an energy performance report for all pre-university educational institutions, based on which the municipality prepares its investment plan. From 2017, ABMEE has been acting as the community energy manager.

4 Barriers and drivers

Main barriers

• The main barrier in Brașov is the lack of interested consumers that has resulted from discontinuity in the heat supply, creating a lack of trust in the district heating system. Most consumers are using individual heating systems. Residential areas have been transformed to use gas boilers. Even new neighbourhoods in Brașov are heated individually or per building, mainly from natural gas. Because of the losses in the distribution system and of an underperforming infrastructure, further and continuous investment in transport and distribution networks is needed.

Main drivers:

• The highly-efficient cogeneration with private investment works well.
• The municipality is the owner of the heating infrastructure and of 11 district small power pants.

5 Results from scenarios and policy assessment

The DH system is split into 4 areas and each area is using a mix of energy sources like natural gas heat boilers and the heat purchased from an external company. The purchased heat is generated from highly-efficient cogeneration plants using natural gas, part of the DH system.

The reference scenario reflects a development where no certain additional action will be undertaken and the current supply situation will persist within the considered time horizon. The heat for the main district heating networks will be purchased from the private company producing heat in **highly-efficient natural gas-fired cogeneration** engines and heat only boilers at a certain price expected for the investigated time horizon. Investments will be made to replace 50 % of the old parts of the network (not renewed within the last 10 years).

In the alternative scenario there will be networks optimization to cut down the losses in each of the district heating systems to 20% of annual produced heat. Also 50% of the not yet renewed networks will be renewed within the considered time horizon to be able to connect additional consumers. Additionally, the public local service will install own production units (A small biomass boiler, solar thermal panels plus heat storage, a heat pump and also refurbishment of district heating plants (transforming substations to district heating plants) in the different parts of the district heating system to bring supply closer to the final consumers. Additional needed heat will be purchased from the private company, part of Brașov DH system.

In order to enable the transformation of the heating and cooling sector of the city of Brașov, a quantitative assessment of the following selected policies has been performed: long term loans for DH infrastructure, support of connection to DH network, CO2 tax, subsidies for RES technologies in DH, zoning.

6 Recommendations and possible solutions

The quantitative assessment showed that single policies are not enough to tackle all problems district heating faces in Brașov.
It is necessary to combine different policies to ensure a modernization of the DH systems and to bring back confidence and the required consumers, the complex package of local policies being:
• Public service following a long-term investment horizon with a very low profit and therefore assuring the long term loans
• Subsidies for RES DH technologies
• A CO_2 tax of around EUR 35 / tCO_2 should be targeted
• Zoning
• Support to the final consumers for connecting/reconnecting to theDH network
• Increasing the share of RES in the DH system using solar thermal energy, heat pumps, and biomass
• Making consumers the main concern: raising the number of consumers for the DH network and improve the overall efficiency of the system.
• Further collaborating with the current producer (highly-efficient cogeneration).

7 Outlook and open questions

• How will the heating system look like in the following years, in a city that is constantly expanding, where new buildings have already installed individual boilers with no plans to be connected to the DH network?
• Will the local authority be convinced that sound policies are necessary to connect more and more consumers to the DH system and to use as much as possible local RES for heating?
• Will the citizens understand that such an approach will improve air quality, reduce CO_2 emissions and ultimately contribute to improving quality of life in Brașov?

Interested?
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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646573

Date of publication: October 2017

A progRESsHEAT case study

Ensuring energy security and cost-efficient heat supply

HELSINGOR
Denmark
61,600

1 Key figures

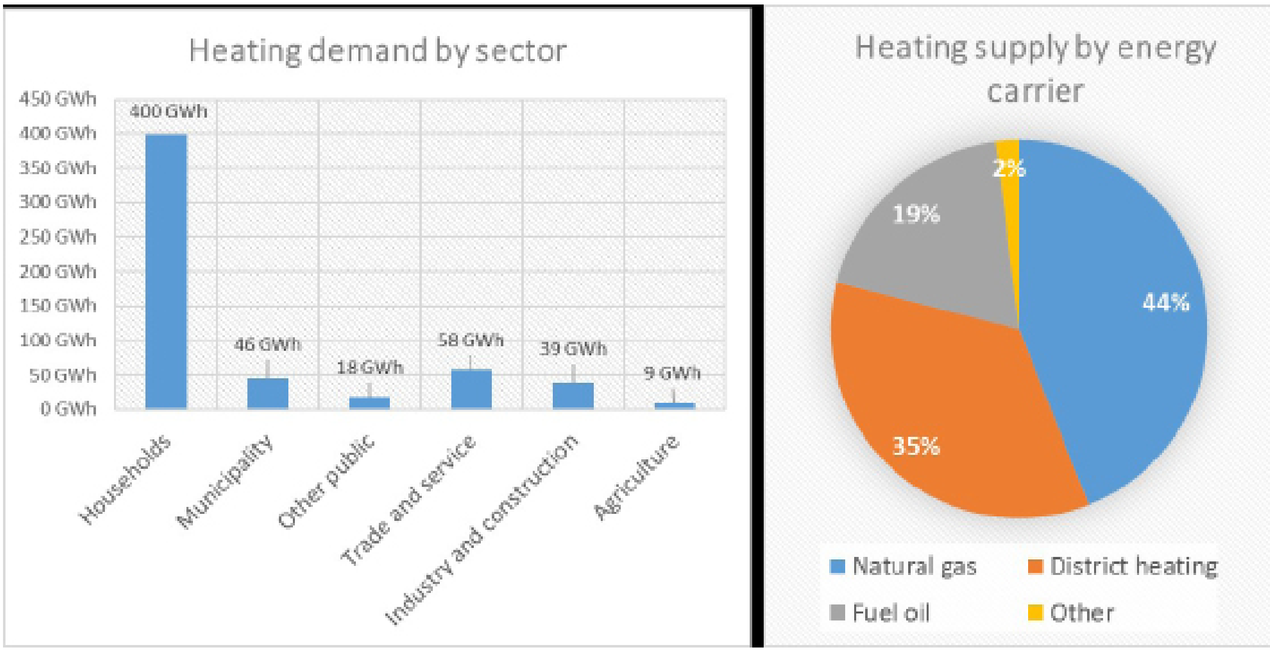

Fig.: District heating energy carrier mix (Rambøll 2014)

2 Main challenges

The key issues to be solved in the foreseeable future which the progRESsHEAT project has highlighted, are some suggestions on how to navigate technical issues and a not always favourable tax regime and to do so with the possibilities available at municipal level, while still being in compliance with regional and national strategies.

3 Current policies and targets

Helsingør developed its own Climate Plan back in 2009. The municipality is part of a regional cooperation programme aimed at developing a Strategic Energy Plan in partnership with all the municipalities in the area, and is a signatory to the European Covenant of Mayors (www.eumayors.eu).
Helsingør uses a set policy instruments, supplemented by knowledge-building instruments, addressing all relevant groups of stakeholder (public institutions, companies, residential sector, energy suppliers, craftsmen…).

In line with ambitious national targets, the municipality of Helsingør aims to reach the following GHG-emission targets:

- **a 25% reduction by 2020** (reference year 2008)
- **reducing CO_2 emissions per capita to <1t** by 2030
- **an annual reduction of 2%**
- Becoming a **CO_2-neutral city by 2050**.

Furthermore, Helsingør has set the following targets regarding renewables:

- a 30% share of RES in the energy supply by 2030
- Electricity and heat demand 100% covered through RES by 2035.

4 Barriers and drivers

Main barriers

- Amongst the identified barriers to the uptake of RES and energy efficiency measures, one of the most important ones is the current tax regime. Indeed, it is very unfavourable to sustainable heating solutions, such as heat pumps and the use of excess heat, notably because of taxes.
- Furthermore, the high investment costs for RES and energy efficiency is also an obstacle.

Main drivers:

- Amongst the most important drivers identified in Helsingør are the municipality's efforts in increasing general awareness.
- The absence of tax on biomass, which encourages a more biomass-based energy supply.

5 Results from scenarios and policy assessment

Two alternatives have been established for the years 2030 and 2050 respectively.

1. Scenario BIO2030 (Reference scenario)
- District heating based on a biomass CHP and a biomass boiler
- Individual supply based on various shares of: Biomass boilers, natural gas boilers and heat pumps.

2. Scenario HP2030
- District heating based on heat pumps and thermal storage
- Individual supply based on various shares of: Biomass boilers, natural gas boilers and heat pumps.

3. Scenario BIO 2050 (Reference scenario)
- District heating based on a biomass CHP and a biomass boiler
- Individual supply based on various shares of: Biomass boilers, natural gas boilers and heat pumps.

4. Scenario Combi2050
- District heating based on heat pumps, thermal storage, solar heating and heat-only biomass boilers
- Individual supply based on various shares of: Biomass boilers, natural gas boilers and heat pumps.

The names of the scenarios relate to the technology used for district heating generation in Forsyning Helsingør, so only the competition with other supply options determines what the fuel mix for the individual supply will be in each scenario. In all scenarios, about 33 GWh of district heat generated from waste and natural gas is supplied yearly from the Norfors neighbouring.

6 Recommendations and possible solutions

The main recommendations for the Helsingør municipality are:

- **Promoting heat savings in buildings**
  - A 40% heat saving can be reached in the municipality's building stock. These savings can be achieved through information campaigns targeting owners of old buildings with a high energy demand and old buildings supplied with oil boilers.
- **Promoting the shift from individual fossil heat supply,** especially in regards to oil boilers
  The project has identified a number of buildings within and close to district heating areas supplied by oil boilers. These are 'low-hanging fruits' which should be converted to district heating.
- **Discouraging the installation of individual biomass boilers** in densely-populated areas through information campaigns
- **Ensuring cheap, CO_2-neutral DH** from Forsyning Helsingør by looking into future investment in profitable RES solutions such as large heat pumps
- **Advocating for a shift to fossil-free district heating** - if continued import from Norfors.

7 Outlook and open questions

For decades, Denmark has had a strong focus on promoting district heating and transitioning away from fossil fuels, and Helsingør is already far ahead.

Developing a heating and cooling roadmap for Helsingør would not be relevant. Nevertheless, the recommendations developed may still prove useful for Helsingør and other Danish municipalities. Data and knowledge generated through research projects such as progRESsHEAT provides useful inputs for validating and adapting the ongoing efforts of the municipalities. As Helsingør is planning to develop a new climate action plan in 2018, the data and knowledge generated through progRESsHEAT will feed this work.

Interested?
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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646573

Date of publication: October 2017

Graphic Design: www.TUTTIQUANTI.net

A progRESsHEAT case study

Decarbonising district heating through solar thermal energy and heat pumps

HERTEN
Germany
60,000

1 Key figures

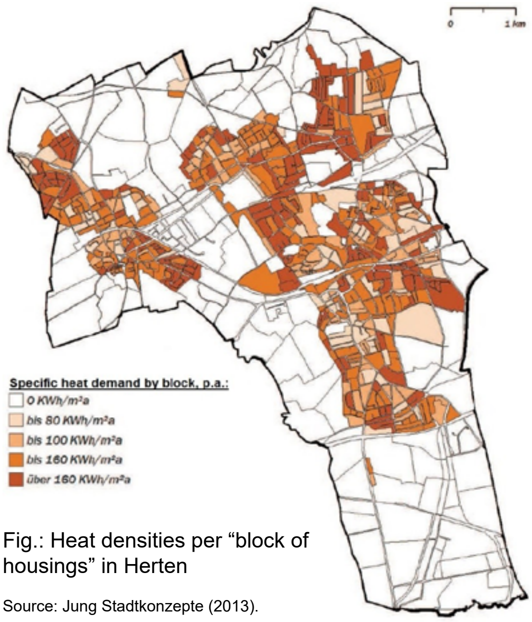

Fig.: Heat densities per "block of housings" in Herten

Source: Jung Stadtkonzepte (2013).

User type / Sector	Electricity	Natural gas	District heating	Fuel oil	Coal
Private Households	126	223	135	85	25
Industry / Commercial	88	84	11	0	0
Public institutions	10	4	5	0	0
Total	**223**	**311**	**151**	**85**	**25**

Table: Final Energy consumption per sector in 2011 by type of energy carrier in Herten (GWh/year).

Source: based on figures from Jung Stadtkonzepte (2013).

2 Main challenges

As the district heating system in Herten is currently supplied with heat from coal-fired Combined Heat & Power (CHP), the approach was to frame a potential alternative mix of centralised heat supply units with a high share of renewable energy sources. It is aimed at designing a system which is technically feasible and to compare it to the current system with regard to the heating costs.

For the case study, it has been decided to generate a possible new mix of supply units for the three largest sub-systems (Innenstadt, Schieferfeld and Kuhstrasse).

For the new mix of generation units, two technologies have been analysed: solar thermal fields with flat plate collectors and possible heat (pit) storage, and ground source heat pumps (brine to water).

3 Current policies and targets

Targets in the heating and cooling sector:
• Reducing heat demand in buildings by 20% by 2020 (compared to 2008)
• Increasing the renovation rate of buildings to 2% per year
• Bring the share of RES-H/C in the heating and cooling demand to 14% by 2020
• Reducing non-renewable primary energy demand by 80% by 2050 (compared to 2008).

The state government enacted a climate protection law in 2011. The targets are the following:
• Reducing CO_2 emissions by 25% by 2020 and by at least 80% by 2050 (compared to 1990).

The targets in Herten's Klimaschutzplan 2020plus with regard to the heating and cooling sector are:
• 3,000,000 sqm of residential and commercial building area should be retrofitted by 2050
• The share of renewables used for heat generation should increase up to 60% by 2050 (compared to 1990)
• The share of CHP in electricity generation should increase up to 60% by 2050 (compared to 1990).

4 Barriers and drivers

Main barriers:
• High investment costs
• Contract agreements
Barriers to the use of heat from waste incineration plants for DH mainly relate to contract arrangements between the plant owner, the municipal energy supplier and the two main energy suppliers in the region.
• Central procurement policy
Barrier to the use of industrial excess heat could be the central procurement policy for large industrial companies. Local production sites with excess heat potential do not have the authority to set up contracts on excess heat delivery even if it would be an interesting option for the local plant manager.
• Dependence on one heating supplier
Notion of being dependent on one locally available DH supplier, while there is the possibility to change the gas supplier easily
• Knowledge and awareness gap regarding renewable heating technologies (amongst installers and craftsmen)
• Missing standard solutions for individual RES systems in existing buildings.

Main drivers:
• Available subsidies
Subsidies for energy-efficient refurbishments are available based on relative CO_2-emission reduction. Furthermore, subsidies for solar thermal installations are provided by the local and supra-regional utilities.
• Continuous investments in district heating network
• Ambitious local climate protection targets
• Development of heating and cooling concepts
An integrated concept for the city centre and a climate protection plan for commercial areas are being developed
• Municipally-owned district heating company
• District-based approaches
The municipality has been developing areas for new buildings and existing buildings with a focus on district heating, low heating demand or individual RES.
• Innovative demonstration and showcase projects
• Campaigns for local installers, households and companies
• Tradition of integrated economy
Industry companies and relevant players are interconnected and can easily communicate.

5 Results from scenarios and policy assessment

Scenario 1: No renovation
• Replacement of the existing heat generators based on the current policies
• No renovation of existing buildings
• District heating network remains supplied by the existing coal-fired CHP units.
Scenario 2: Renovation
• Continuation and intensification of the current policies
• Renovation rate 2015-2030 for single-family homes and multi-family homes is respectively of 2.4% and 1.1%. Renovation rate 2031-2050 is on average of 1%.
• District heating network remains supplied by the existing coal-fired CHP units.
Scenario 3: Renovation + Solar DH
• Energy demand decreases as in Scenario 2
• Integration of 32,000 m^2 of solar thermal collector fields and 6,000 m^3 thermal storage into different parts of the DH network.

__7 scenarios__ have been developed for Herten. Discover all of them in the full-text case study at www.progressheat.eu.

6 Recommendations and possible solutions

In order to enable the transformation of the heating and cooling sector in Herten as assessed in the scenario analysis, a sound policy framework is needed at local and national level. Here, the focus is on policy recommendations at local level.
- Establishment of refurbishment hot spots – integrated planning of retrofits and transformation of the district heating (DH) system to a low temperature system
- Free connection to the DH network and replacement of old heating substations with new 4th generation DH units
- Heat zoning with obligation to connect to DH
- Designated area for solar district heating as part of the city urban planning
- Using existing national financial support schemes for large RES systems.

7 Outlook and open questions

The roadmap for Herten is focused on the prospective development and decarbonisation of the DH network.
• 90% of the energy supply for the DH network should come from renewables or excess heat in 2050.
• The final energy supplied for residential heating (hot water and heating) by the DH system should have nearly the same amount in 2050 as in 2011 (approx.150 GWh/a).

Priorities and timelines to implement roadmap need to be discussed with the municipality.

Interested?
Find more information in the full-text case study on the project website!

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 646573

Date of publication: October 2017

Graphic Design: www.TUTTIQUANTI.net

A progRESsHEAT case study

Geothermal energy for ensuring sustainable and affordable heating & cooling

LITOMERICE Czech Republic

24,000

1 Key figures

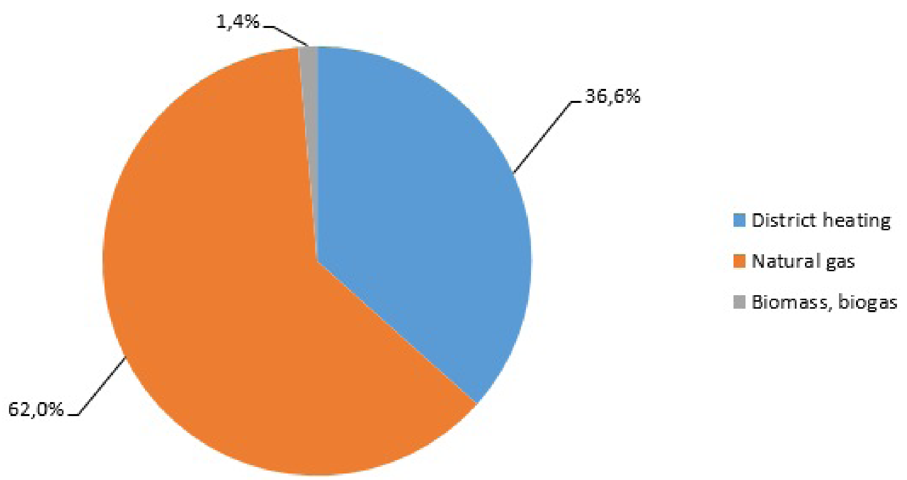

Fig.: Energy mix in Litoměřice

2 Main challenges

- Defining an optimal energy mix for 2030 and 2050
- Developing a feasibility study and a roadmap to buy the CHP plant and network back
- Working on a sound database for developing and implementing the city's Sustainable Energy and Climate Action Plan
- 'Bridging the information gap' through a campaign focused on prevention of disconnection from DH.

3 Current policies and targets

The city of Litoměřice developed an **Energy Concept** in 2009 and adopted a **Municipal Energy Plan** in 2014. The main goal of the municipality is to reduce energy consumption by 20 % by 2030 (baseline year 2012). There are no specific targets regarding renewables (RES) in Litoměřice in the heating and cooling sector.

The city is developing a **Sustainable Energy and Climate Action Plan** as part of the Covenant of Mayors (www.eumayors.eu), which will define specific targets for RES.

Based on an in-depth territorial analysis, the preparatory works for an ambitious geothermal heat plant - with an output up to 40 MWth - started in 2008.

4 Barriers and drivers

Main barriers

- Little financial and operational support to RES – the operational support was cancelled for the most of RES in the Czech Republic
- District heating (DH) system owned by an external body – the municipality has been in a weak position for negotiating and bringing changes to the district heating system
- Lack of information about renewable energy sources – still lot of disinformation about RES and their practical use and benefits in the local context
- Energy savings have been increasing the fixed cost of the DH system
- Preference for ad-hoc projects over complex projects – projects are not prepared according to the Life Cycle Cost method. The projects with a lower investment cost are preferred, which is expected to affect operational costs.

Main drivers:

- Availability of innovative financing programs for RES and EE projects
- A subsidy scheme for solar water heaters
- Mapping the potential of RES installed in the city area
- A good communication process within the geothermal project
- Initial analysis of the potential for CHP and roadmap for the whole process
- Installation of solar systems into common municipal property, e.g. a solar bench
- The European ENGAGE campaign and other information campaigns
- Setting an indicative target for renewable energy
- An Energy Saving Fund supporting complex energy measures.

5 Results from scenarios and policy assessment

In 2050, the optimal mix scenario - characterized by the **expansion of the district heating network and geothermal district heating plant** (Exp Geo 2050) - could achieve the following results:

- Heat savings of 46 % compared to 2015 are achieved with support from the municipal budget
- A renewable energy share of 53-58 %
- The average cost of heating for the end consumers is comprised between EUR 98/MWh and EUR 121/MWh
- The total cost of the heating system for the end consumers is between EUR 14.1 million to 19.3 million/year for different policies
- Saved CO_2 emissions are around 62 kt/year compared to 2015.

The results show that amongst all the scenarios, the district heating system based on a geothermal expansion (GeoExp) is feasible in 2030 and 2050, also when no other policy is implemented.

The GeoExp scenario is the least expensive, shows the best results in terms of CO_2 emissions and has the highest RES penetration rate. Proceeding with the geothermal energy scenario appears to be the most feasible both from an economic and an environmental point of view. Carrying on with the current DH system based on coal and natural gas or expanding it using fossil fuels is not beneficial and in some cases even more expensive than the individual gas boilers scenario.

6 Recommendations and possible solutions

In order to increase the penetration of RES, it is recommended that the city of Litomerice take the following actions:

- Based on a feasibility study and a roadmap, **buy the CHP plant and network back** to have it under municipal property
- Include the **geothermal plant as the main part of its future strategy** for CO_2 reduction into the Sustainable Energy and Climate Action Plan – to be finalised in 2018
- Prepare new - and finalise ongoing - offers for national and EU programs to **cover the investment costs** for the drilling of the geothermal plant
- Establish some **innovative local financial instruments** for RES and EE – a new financial scheme combining sources from the municipal budget, local banks and firms supporting deep renovation of buildings, accompanied by technical advice
- Integrate local RES into sustainable transport – Litoměřice has been working on a pilot project on RES accumulation with the city of Dresden for 2018.
- Develop a new municipal web portal focused on sustainable energy and transport.

Interested?
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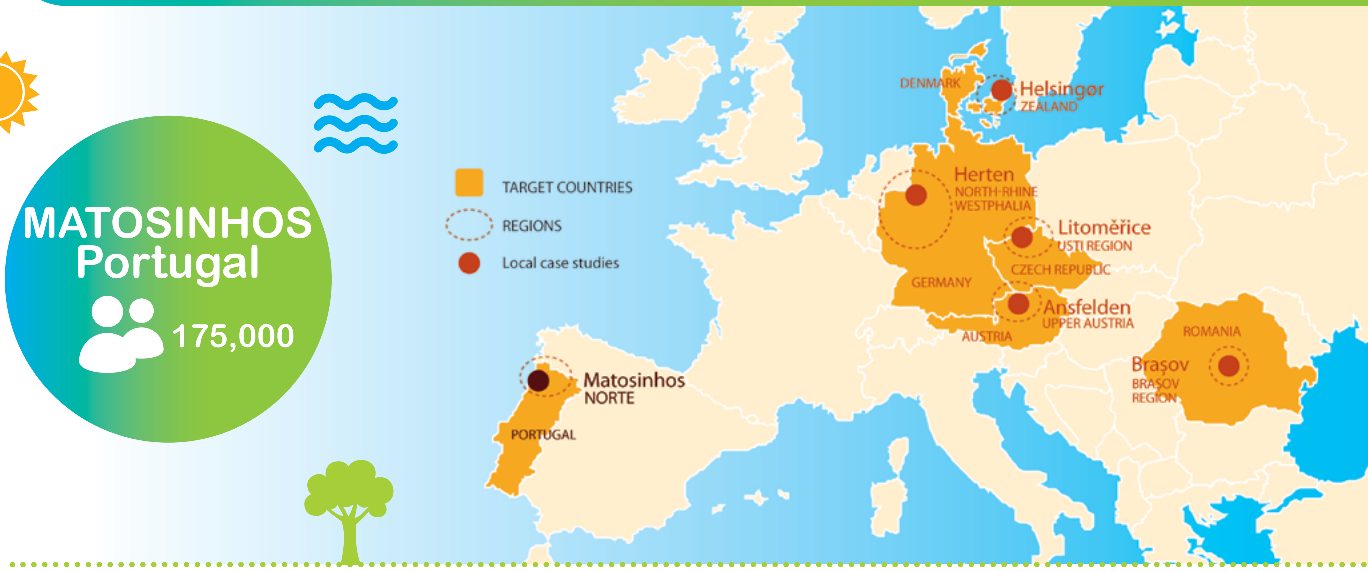
Graphic Design: www.TUTTIQUANTI.net

A progRESsHEAT case study

Developing a renewable heating & cooling system in an unfavourable context



1 Key figures

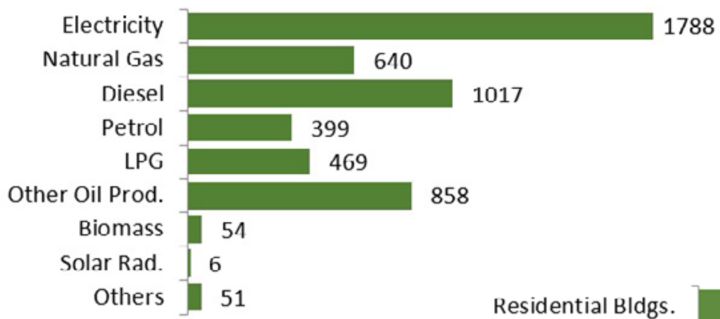


Fig.1 – Primary energy use by energy supply vector in 2009 in Matosinhos (GWh/year)

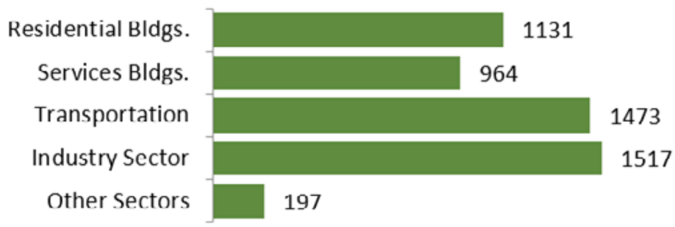


Fig.2 - Final energy demand by sector in Matosinhos in 2009 (GWh/year)

2 Main challenges

Matosinhos' year-round mild weather makes the challenge of decarbonising heating and cooling drastically different from more demanding climates, be it from a business-case as well as from a technical perspective.
Residential heat demand has historically been low. It is expected that the improvements in the building stock will essentially result in an increase of the indoor temperatures, which are low, and therefore will contain any pressure to increase the demand.

The growing services sector and still significant presence of an industrial sector further support them as the clear targets to address in terms of renewable heating and cooling.

3 Current policies and targets

Both at national and local level, there are targets for energy demand reduction (25 % reduction in primary energy demand at national level, 21 % reduction in final energy use at local level, both by 2020), CO_2 emissions reduction (21 % reduction at local level by 2020), and increasing the use of renewable energy sources (31 % of gross final energy at national level, by 2020), which are generally in line with – sometimes even more ambitious than – the EU targets.

These have been promoted by national and local action plans, addressing a broad number of areas, and are supported by financing schemes and programs. However, with the recent economic difficulties, many of these programs have been halted or not renewed. For instance, at some point there were financing programs promoting solar thermal energy in buildings and industry, but those are no longer available.

Still, for both the buildings and industrial sectors, there are certification and verification schemes aiming at encouraging owners (and often making it mandatory) to gradually improve their energy performance.

4 Barriers and drivers

The **mild weather** makes it economically unfeasible or at least more difficult to implement many of the technical solutions used in Northern European countries for heating purposes. Furthermore, there is a **cultural preference for individual solutions** that further complicates the implementation of community or district energy solutions. Municipalities also have **little to no power over the management of energy sources**, grids or vectors explored in the region. The lack of financing options, exacerbated by the economic crisis, is also a reason for the current situation.

The **low heat demand and absence of cooling demand** in the residential sector exclude it from being a target for technical solutions, instead justifying the already-promoted individual use of biomass heat recovery boilers and fireplaces, as well as solar thermal panels and PV with heat pumps. However, excess heat from the industry is still an unexplored topic and constitutes an interesting opportunity.

5 Results from scenarios and policy assessment

While a number of technical solutions were explored for decarbonising the supply of heat and cold to the buildings analysed in Matosinhos, the individual solutions relying on heat pumps coupled with solar panels (PV, thermal or both) end up being significantly more expensive in terms of levelized costs than the district solutions.

So, while these might be easier to implement because they would not have to address the culture of individualism and because the investments would be split between multiple smaller parties, in the end **the district heating and cooling solution would be preferable**.

In particular, the DHC solution relying on the **excess heat from the local oil refinery** could not only make use of the heat that is currently being wasted there (thus improving its overall efficiency) but also supplying the **cheapest heat and cold to large buildings** (while keeping most of the maintenance and operation issues in a single central DHC network operator).

6 Recommendations and possible solutions

Preliminary modelling shows the **clear potential for building a new DHC network** in Matosinhos, using excess heat from the refinery or, alternatively, using heat produced from other renewable sources, to feed the growing business and commercial area currently being developed.
While such a project would certainly face difficulties in its implementation, namely in terms of building the whole required infrastructure, which tends to be quite disruptive in already-established urban areas, the **involvement of local authorities** is essential.
The first step to start building the business case for this solution is to **bring together the relevant stakeholders** in the region, helping overcome the cultural resistance to community solutions, to inform them of the conditions and advantages of the solution, mediating discussions and helping reach long-term consensus and guarantees. The municipality can further help the business case if it establishes **zoning rules** that promote the use of the DHC network by all buildings within its area of influence. With the involvement of key stakeholders and with the backup of the local authorities, investment will probably come along from other interested parties.

7 Outlook and open questions

Initial presentation of this work and discussion with potential stakeholders showed clear interest in exploring these ideas further.

The municipality's involvement is essential and there is now some momentum and motivation to promote the required ongoing discussion to bring the multiple parties together in this common project. Furthermore, the municipality signed a collaboration agreement with INEGI (the Institute of Science and Innovation in Mechanical and Industrial Engineering) with a view to continue exploring the ideas brought about by the progRESsHEAT project and aiming to bring to fruition this strategic solution.

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