The role of municipalities in decarbonizing the heating sector at the local level in Germany

Case study: Regensburg

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Executive Summary

- ✓ The heating sector is a major contributor to CO_2 emissions in Germany. To reach the emission reduction targets set by the 2015 Paris agreement, it is essential for Germany to transition its majority fossil fuel-based heating sector to one powered by renewable energy sources. Since heating generation is often decentralized, municipalities play an important role in decarbonizing Germany's heating sector.
- ✓ In this policy paper, we focus on the case of Regensburg, a role model of the *Wärmewende* on the municipal level. By examining the regulatory and financial aspects of Germany's heating transition, as well as the question of acceptance by key stakeholders in Regensburg's heating transition process, we utilize the framework of a socio-technical system and multi-level analysis to suggest a policy mix that enables the *Wärmewende* for other municipalities in Germany.
- ✓ We highlight that the policy mix regarding the heating transition must ensure consistency, coherence, credibility, and comprehensiveness. We also consider three important dimensions of public policies to orient and guide the policy makers choices: efficiency, effectiveness, and equity.
- ✓ Reviewing Regensburg's path towards the heating transition more in depth, we identified the geographical potential of solar as well as surface near geothermal energy. There is also potential for an increased housing efficiency level as well as using remaining renewable energy sources. The municipality has ambitious targets to reduce its carbon footprint and an Energy Usage Plan with constantly published monitoring reports providing a basis for analyzing the potentials and progress for changes in the energy system.
- ✓ Nevertheless, there are important challenges to be overcome, which will be addressed individually with the main takeaways highlighted at the end of each chapter.
- ✓ We also invite you to read the more specific recommendations regarding the heating transition in Regensburg in Chapter 8.

1. Introduction

Up till now, Germany's energy transition (*Energiewende*) has mainly focused on decarbonizing the electricity production. While Germany made visible progress towards decarbonizing its electricity sector by increasing the share of renewable energy sources over the years, its heating sector is still heavily dependent on fossil fuels. Nevertheless, the energy demand from the heating sector is accountable for almost half of total energy consumption in Germany (Agentur für Erneuerbare Energien 2020a). This shows that there is great potential for Germany's heating sector to reduce its carbon emission and to contribute to reaching the emission reduction targets set out by the 2015 Paris agreement.

Since heating and cooling of buildings, contrary to electricity production, are often decentralized, local communities, as well as municipal governments, play a crucial role in transforming the heating sector. Municipalities are not only key consumers for heating (both for residential and non-residential buildings), but they are also the planning and approving authorities when it comes to the local heating transition. In addition, municipalities are owners of public buildings, and can thus be a role model to residents and local companies in leading the *Wärmewende*[1]. To better understand how the *Wärmewende* can be achieved by local communities and on a municipal level, we examine the case of Regensburg, a small town in Bavaria.

The main target audience of this policy paper are policy makers at national, federal state, and municipal levels in Germany who can use the suggested policy instruments to accelerate the heating transition in Germany. Nevertheless, the present work also aims to contribute and complement other analysis already developed in the topic and can be useful for different actors that are addressing energy transformation issues.

To make sense of the different aspects involving sustainable energy transformation and the heating transition, first, we will identify the theoretical framework in Chapter 2, which will be used in the subsequent chapters to formulate policy recommendations. We then will give an overview of the status quo of Regensburg's heating transition in Chapter 3, illustrating existing policy instruments and institutional setup for the *Wärmewende* on the municipal

[1] The term in German will be used along the text as a synonym of heating transition.

level. The chapter will also outline the potential of different renewable energy sources in Regensburg for heat generation and identify main challenges in Regensburg's *Wärmewende* as well as the key stakeholders.

To extract lessons learned from Regensburg and to accelerate the *Wärmewende* in general, we will examine the regulatory and financial aspects of the heating transition in Chapter 4 and 5, through the framework of a socio-technical system from a multi-level perspective. The chapters will investigate the current policy mix and funding schemes on the European, national, federal state, and municipal level for the *Wärmewende* and identify room for improvement.

Lastly, we will discuss the important question of acceptance in Chapter 6, which is crucial to the adoption of niche technologies, innovative models, and new policies necessary to enable the heating transition. Chapter 7 will present the main conclusion and chapter 8 will summarize the list of policy recommendations derived from the analysis in the previous chapters.

2. Theoretical background

The decarbonization of the heating sector is a challenging task for policy makers. In a more general way, a transition towards a sustainable energy system depends on existing policies, political institutions, and national policy paradigms set by coalitions of actors (Kuzemko et al. 2016). In that sense, different actors represented by enterprises, industries, societal groups, as well as public authorities, can form networks or so-called socio-technical systems. Those systems consist, according to Geels (2004) definition, in networks of agents interacting in a specific technology area under a particular institutional infrastructure. Each socio-technical system includes the production, diffusion and use of a certain technology, and ends up structuring the rules of the game, providing stability to the system, establishing the regime, to use the author's terminology (Geels 2004).

However, even apparently consolidated socio-technical systems are in constant transformation since they are a result of multi-level interactions. Processes of change, as for example the energy transformation, occur when external pressure on the existing set of rules and practices arises, or new technologies have been developed and are able to challenge the existing

order, causing a creative destruction after a window of opportunity opened (Geels 2004).

Moreover, technological innovation depends on the amount of pressure for change, as well as the adaptability of the affected socio-economic structures, institutions, and key actors to adopt a new technology (Dolata 2008). Since it is hard to challenge existing regimes in socio-technical systems due to their stability and path dependencies (Geels 2004), the question of how one can establish structures and pre-conditions promoting new (niche) technologies in the heating sector and pushing the *Wärmewende* becomes particularly interesting.

In the case of the energy transition, the external pressures due to climate change, associated with technological innovations, are important factors that created the window of opportunities for change in this specific socio-technical system. Nevertheless, to overcome resistances and assure a fair transformation, public policies may play a key role guiding the transition. Public policy is hence key to promoting energy transitions in terms of both their speed and direction (Rogge et al. 2017).

According to Kivimaa and Kern (2016), the ideal policy mix for a sustainable transition consists of elements promoting the creation of new niches as well as instruments enhancing creative destruction. Thus, such a policy mix includes, on the one hand, niche creation policies that help to create knowledge, market formation, and entrepreneurial experimentation. On the other hand, the policy mix also includes control policies, changes in regime rules, or reduced support for dominant regime technologies, what might lead to creative destruction (Kivimaa and Kern 2016).

In a broader perspective, an important part of the literature around ideal policy mixes for promoting the energy transformation dedicates the attention to some characteristics which policy makers must ensure in the policies. Using the contributions of Rogger and Reichert (2016), among the characteristics we can name consistency, coherence, credibility, and comprehensiveness. The consistency captures how well the elements of the policy mix are aligned with each other, facilitating the achievement of the policy objectives, while the coherence refers to how logically the policy is related to the same overall aims and how it promotes synergies between different policy areas to achieve the outcomes. The credibility relates to the extent to which the policy mix is believable and reliable, and the comprehensiveness regards the degree to which the instrument mix addresses the market, system and institutional failures, including barriers and bottlenecks (Rogger and Reichert 2016).

Besides those relevant characteristics, it is also relevant to remember that, when trying to

address changes through public policies, a constant process of evaluation and adaptation must occur, to ensure that the policy is going in the right track. Thus, dimensions such as effectiveness, efficiency and equity are still key. According to Nagel (1986), the effectiveness can be defined as the extent to which the policies are achieving their goal, while efficiency will be the result from the ratio benefits and costs. Equity would be defined as the extent to which benefits and costs are spread among the involved public.

Keeping in mind those important characteristics of successful policy mixes, we can now look to the content of specific policies aiming the promotion of the heating transition. In this sense, regarding the sustainable transition of the heating sector, Lowes et al. (2020) recommends a policy mix that first and foremost promotes energy efficiency. Additionally, he will defend that an electrification of the heat sector coupled with a decarbonization of the electricity production as well as tariffs rewarding flexibility of the consumer can push the *Wärmewende*. Hereby, especially the use of heat pumps becomes crucial when it comes to the use of renewable energies in the heating sector. Other technologies might contribute to the transition as well, nevertheless their availability may be limited and depend on local circumstances (Lowes et al. 2020).

Moreover, through the increasing use of heat pumps, also the demand of electricity and grid infrastructure is growing, while the use of renewables increases the volatility of the power grid. Thus, policies managing the energy consumption and promoting *prosumerism*[2] become important tools to reduce the carbon footprint of the heating sector. These demand side policies, aiming to establish more energy efficient housing as well as renewable on-site generation and storage solutions, can help to decarbonize the heating sector and reduce the increasing electricity demand (Jan Rosenow, Richard Cowart, and Samuel Thomas 2019).

Based on the literature review so far, we believe, therefore, that to create a holistic socio-technical change in the heating sector at a local level – in this case Regensburg – a systemic approach becomes necessary. Carbon prizing should be for example considered only as one tool (to create creative destruction) in a mix of various policy approaches to tackle climate change, since transforming a whole system based on the combustion of fossil fuels is not simply done by only implementing a prize for

[2] Term used to refer to people who both consume and produce electricity.

carbon emissions (Rosenbloom et al. 2020). When considering multiple policy tools, policy makers have a great variety of different regulations and funding schemes at hand. At the same time, however, they must be careful not to lose acceptance for the *Wärmewende* and make sure to be using policy tools which are technologically feasible.

3. *Wärmewende* in Regensburg

3.1 Status Quo

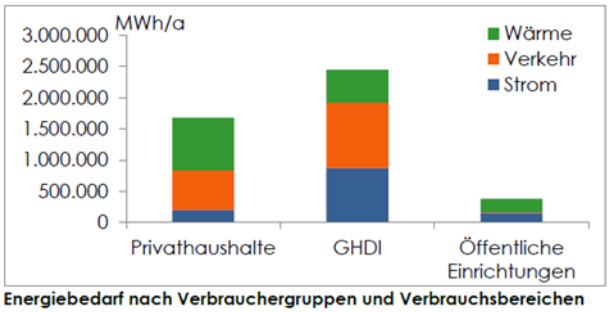
Having introduced the theoretical background that will be used to frame the current policies in place and to suggest further actions in the promotion of the heating transitions, now it is time to look in detail what has been done so far in the municipality of Regensburg, chosen to be our case of study.

Regensburg has been selected by the *Wärmewende* project[3] of the German Federal Foundation for the Environment (DBU) as a model municipality to identify marketable technologies as well as practical policy tools to promote the decarbonization in all German regions. Regensburg has about 168.000 inhabitants and is regarded as a smaller metropolitan city in Germany.

Since over a half of all German citizens lives in medium sized towns or smaller metropolitan cities similar to Regensburg (Statista 2019), the Bavarian city is very suitable as a role model for decarbonizing the heating sector for medium sized cities. Therefore, testing policy tools promoting the *Wärmewende* becomes particularly interesting in Regensburg, although the socio-technical landscape as well as geographical preconditions might differ in other cities.

The main energy consumption in the heating sector of Regensburg is caused by private households, with around 53% of the total amount. The industry and businesses are responsible for 39%, and public buildings for around 8% of consumption of heating energy.

Figure 1: Energy demand in Regensburg by consumption groups 2012



Source: Energy usage plan Regensburg 2012

[3] See more in https://www.waermewende.de/

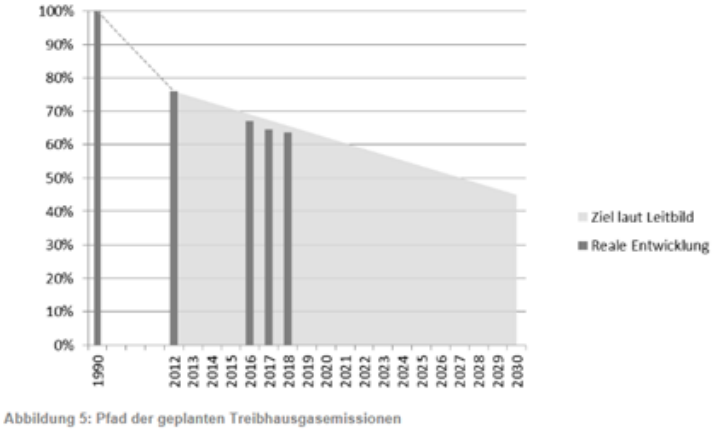
Together with industry and commerce, as well as public buildings, the yearly energy demand in the heating sector was about 1.600 gigawatt hours according to the Energy Usage Plan from 2012 (Team für Technik 2014). This demand even increased over the years up to 2171 GWh energy consumption in the heating sector and is up today responsible for the majority of 54% of the overall energy demand of the city (Regensburg effizient 2019).

To decarbonize and reduce this high energy demand, the city has already started some projects to improve the carbon footprint of heating systems in buildings (mainly in public ownership) and made some progress by implementing a policy planning tool in form of an energy usage plan with regularly published monitoring reports. The initial Energy Usage Plan from 2012 points out the potential for the use of renewable energy for electricity and – to some extent – heating consumption. Moreover, the city council decided to set ambitious goals to reduce the carbon footprint of the city in accordance with the climate targets made in the Paris agreement 2015. Thus, the per capita CO_2 emissions should be reduced up to 80% - 95% by the year 2050 compared to the carbon footprint of 1990.

Therefore, the share of renewable energy production within and around the city is planned to be increased significantly as well as a reduction of the energy consumption up to 50% by 2050 compared to the per capita consumption of 2012 (Stadt Regensburg 2017). According to the latest monitoring report, the city is reaching its targets with regard to the reduction of CO_2 emissions, as the figures 2 shows.

Nevertheless, the share of renewable energies produced within the city boundaries remains at a very low share of only 6.9% of the overall consumed energy (Regensburg effizient 2019).

Figure 2: Planned and actual CO_2 emission curve of Regensburg



Source: Energy and Climate monitoring report Regensburg 2019

3.2 Potential of renewable energy in Regensburg

To change the heating system of a whole city towards a renewable regime, it is important to have knowledge about potential renewable energy sources as well as the potential of a higher housing efficiency. The Energy Usage Plan of Regensburg from 2012 shows that there is some potential for some sustainable technologies within the city and its surrounding region. Nevertheless, this potential is limited according to different technologies. Energy production from biomass, wind, or hydropower is already used close to its maximum potential, even though in sum only 80,7 GWh/a (mainly Biomass) have been produced with renewable energy sources in 2012. Nevertheless, the potential to reduce the carbon footprint in the heating sector remains regarding the following technologies:

- Solar Thermal & Solar Photovoltaics

It is possible to use solar radiation for heating in two different ways. On the one hand directly through solar thermal technology. On the other hand, indirectly with electricity produced by photovoltaics for heat pumps (sector coupling). Based on the energy usage plan, different scenarios using the potential solar energy is possible. The best solution according to the usage plan is when solar thermal is combined with solar photovoltaic (PV), since not every rooftop is perfectly suitable for a solar thermal installation (A roof might be too small to provide heating for a multi-family house).

Based on this scenario the combined potential is 511 gigawatt hours energy per year (136 GWh/a solar thermal and 375 GWh/a solar PV) (Team für Technik 2014).

- Geothermal

There is no deep geothermal potential within the city, as well as in the surrounding area of Regensburg. Nevertheless, it is possible in almost all areas to use surface near geothermal energy for the *Wärmewende* (Team für Technik 2014). Electrical driven heat pumps can help to reduce the carbon footprint especially for newly build houses with high efficiency and low heating energy losses. The CO_2 emissions depend on the electricity mix. Thus, using for example PV energy for these devices becomes interesting in terms of a decentralized *Wärmewende*. Nevertheless, it is important to use environmental-friendly refrigerants for the heat pumps, since some devices are using partially fluorinated hydrocarbons (HFKW) which could produce climate-damaging emissions.

Moreover, it is important to consider building density and structure, since heat pumps might emit noise and can be in conflict with

underground infrastructure of a city (Umwelt Bundesamt 2020).

- Other technologies

Besides using the potential renewable energy for heating, other technologies might also be cosidered. By using heat from wastewater, a heating energy potential of 64 GWh/a could be used (with help of heat pumps near sewage canals) (Team für Technik 2014). Other options could be an expansion of the district heating network with heat feed-in from industrial waste heat or other central energy sources (e.g. data centers). Such central energy sources could be combined by power and heat plants. But since those plants are often driven with fossil energy and there is no further potential for biomass as well as deep geothermal energy as energy sources that could be used for a central facility, we decided not to include them in our analysis.

Another important tool to reduce the carbon emissions is increasing the efficiency of buildings. Depending on the year of construction, there is a potential for heat savings of around 24%-52% or 208 GWh/a – 415 GWh/a of all the heating energy consumed by private households in Regensburg (Team für Technik 2014).

In summary, the socio-technological landscape with regard to the *Wärmewende* in Regensburg is in favor of a transition when it comes to the geographical potential of solar as well as surface near geothermal energy. There is a lot of potential for an increased housing efficiency level as well as using remaining renewable energy sources. Additionally, the ambitious targets of the city to reduce its carbon footprint supports the change towards a CO_2 free heating system. The Energy Usage Plan from 2012 and the constantly published monitoring reports provide a basis for analyzing the potentials and progress for changes in the energy system. But some obstacles still remain.

3.3. Main challenges

The renewable energy supply in the heating sector of Regensburg currently remains at a niche level, even though there are good preconditions. To challenge the existing fossil driven heat system and create a holistic sustainable transition, citizens as well as local policy makers face several obstacles. The *Wärmewende* project identified several main challenges. On the one hand path dependencies through the existing heating infrastructure, many different actors and actor coalitions, and on the other hand, difficulties of combining different technologies by the help of sector coupling (Agentur für Erneuerbare Energien 2020b).

Additionally, we assume that the diverse city structure with different preconditions for renewable energies, such as single- and multi-family households, or old town buildings with different rooftop sizes, is also a challenge. Moreover, to support the transition of the heating sector there are several financial support programs as well as regulatory issues on different governmental levels, citizens should be aware of.

These variety of policy approaches makes it difficult for affected citizens and local policy makers to keep an overview. Furthermore, even though the city of Regensburg has an energy usage plan from 2012, a more detailed plan showing all the potential with regard to sustainable heating would be beneficiary. The current energy usage plan for example does not cover information about the supply structure of existing gas networks or a more detailed plan about the heating structure of living and business buildings. Additionally, a strategic planning involving all relevant actors to increase the acceptance is not available. Thus, a concrete plan for the implementation of the *Wärmewende* as specified in the regulations for heat plans of the state of Baden-Württemberg for example could be one area for improvement.[4]

After analyzing the potential technologies and main challenges, we try to give a better overview of the regulatory and financial aspects on various governmental levels as well as who the relevant stakeholders in Regensburg are. And finally, it is a question of acceptance whether the heating transition in the city can be accomplished.

3.4. Identification of main actors and stakeholders

To bring the local *Wärmewende* forward, several relevant stakeholders (public and external) should be considered according to a study of the Heinrich-Böll foundation (Heinrich-Böll-Stiftung 2015). While public institutions and positions are directly located at the local government, private actors are classified as external stakeholders. Nevertheless, external actors can also be funded by public money (like the energy agency or public housing associations) based on this classification.

We identified following relevant public actors in Regensburg: First, the city planning and building department with subdivisions such

[4] More about the heating planning in Baden Württemberg is available here: https://www.kea-bw.de/waermewende/wissensportal/warum-kommunale-waermeplanung#c3348-content-4

as the planning and building office, office for construction, or development. These local public institutions play a crucial role in creating windows of opportunity for the *Wärmewende* regarding city planning processes or guidelines. Moreover, the environmental office of Regensburg is providing information with regard to emission protection as well as climate protection issues. It is therefore connected with the local energy agency. To connect different relevant actors in the transition of the heating sector the Heinrich-Böll Foundation recommends municipalities to have local district managers. Even though the city of Regensburg does have such managers, they are mainly concerned with social issues of the districts.

Finally, a very important role is assigned to the climate protection manager, who connects most of the relevant actors across different fields and initiates new climate protection projects, also in the heating sector. Regensburg does have such a manager which is helpful in connecting different public and external actors of the city and in initiating projects for the *Wärmewende*. Thus, increasing the acceptance and relevance of sustainable (niche) technologies by providing for example a register for potential solar roofs or information about heat pumps. Another important task of the climate manager is raising the awareness of climate change impacts and the importance of a socio-technological change.

Table 1: Relevant public actors

Public institutions and positions	Role
City Planning and building department	Responsible for land planning and development., renovation of buildings
Environmental office	Responsible for climate protection concepts, providing information with regard to Energie- and *Wärmewende*
District manager	Connect different actors in local district (could be any specific topic)
Climate Protection manager	Central actor connecting all different actors and initiating climate protection projects

Source: Own elaboration.

Relevant external actors at the supply side in Regensburg are for example local energy providers such as REWAG. Energy providers play a crucial role when it comes to running and using central heating sources and distributing district heating networks. Other external actors are energy advisers or energy agencies. The agency of Regensburg is responsible for several projects in the city like the energy usage plan or subsidy programs for higher energy efficiency. Moreover, the energy agency also offers advisory for local citizens as well as businesses regarding energy and/or heating transition. Additionally, the energy agency of Regensburg

is operating one of the first energy education centers in the state of Bavaria.

The private house owners are another relevant stakeholder, since they are crucial when it comes to the implementation of demand side policies like the installation of heat pumps. Landlords as well as other citizens have the possibility to form together citizen energy cooperatives to bring the decentralized *Energiewende* forward and profit economically from it. In Regensburg and the surrounding region there is such a cooperative, with 250 members, the *Bürger Energie Region Regensbur*g.

Other important actors on the demand side are housing associations which are responsible for many (often homogeneous) apartments and can decide on central sustainable heating solutions and housing efficiency. In Regensburg currently ten housing associations as well as nine student housing associations are active. Finally, also industrial enterprises can play an important role as stakeholders for the *Wärmewende*. As mentioned earlier, waste heat of the industrial buildings/processes could be used for district heating. According to the Energy Usage Plan, four industrial facilities might have the potential for waste heat utilization.

Table 2: Relevant external actors

External	Role
Energy providers	Supply side, provide and distribute heating energy from central sources
Energy agency	Informing consumers of renewable energy usage options, providing planning (monitoring, energy usage plan) and funding tools
Private houseowners	Crucial for implementation of demand side policies
Citizen energy cooperative	Providing opportunity to all citizens to profit from Energiewende, implementing new projects
Housing associations	Providing living space for many citizens
Industrial enterprises	Possibility to provide waste heat for district heating networks

Source: Own elaboration.

Our analysis of the main actors of the energy sector shows that Regensburg already has good preconditions to bring *Wärmewende* to a next level. Actors such as the climate protection manager as well as the energy agency already connect different agents/stakeholders and initiate new projects promoting the change in the energy and to some extent also in the heating sector. Nevertheless, a stronger inclusion of external actors such as private house owners as well as industrial enterprises is

necessary when it comes to achieving the full potential of renewable energy and avoiding unnecessary heating energy losses of inefficient houses or unused heat from industrial processes in the city. Additionally, appointing local district managers for energy transition projects on a very local level can add another useful actor.

Nevertheless, in the *Wärmewende* are often even more actors involved, e.g. local parties or research facilities like the *Universität Regensburg*. The summary above gives only an overview of the main relevant actors within and around the city.

4. Regulatory aspects

As we have identified the heating sector as central to a successful energy transition in Germany, in particular the heating of private households, it is time to analyze the different policy frameworks applicable in this field. In this section, the emphasis lies on different policy instruments on the European, national, federal, and municipal level that can promote a successful *Wärmewende* on a municipal level. Some policies will support the increase of new technologies and heating models, such as heat pumps or tenant electricity (*Mieterstrom*) and thus promote niche technologies in the heating sector. Other policy instruments will foster the phase out of the established fossil heating solutions and destabilize the current heating regime.

Since the European Union and the member states share competencies in the field of energy, the European level will be outlined at first. Due to the often more prolonged and complex policy process on the European level - as a result of the great number of actors - policy recommendations will not focus on that governance level. Nevertheless, the policy process at the European level is crucial for developments at the national level and for ensuring long-term planning security. The EU sets the tone with joint agreements, objectives and directives.

Therefore, the next step is to look at national policies that foster the heating transition. In particular, the Renewable Energy Act (*Erneuerbare-Energien-Gesetz*; *EEG*), the Fuel Emissions Trading Act (*Brennstoffemissionshandelsgesetz*) that regulates the CO_2-price, and the Building Energy Act (*Gebäudeenergiengesetz; GEG*) are of importance here. In addition, the state has set targets that can foster the *Wärmewende* of the country. Considering our case Regensburg, the following step would be to take a closer look at the state of Bavaria and the specific targets they have implemented to foster efficient heating. Lastly, the municipal power under the local self-

government act of the German Basic Law (*Grundgesetz*; GG) is disclosed.

4.1. European Level

The European Green Deal was introduced by the new European Commission in 2019 as its light house project, and it sets the targets of climate neutrality until 2050 and the interim target of 55% reduction of GHG emissions until 2030. This agreement establishes the basic framework for sustainable development not only in the heating sector, but in all sectors. By setting long-term targets, the strategy secures member states planning security and communicates abiding commitment to climate change mitigation. One policy plan within the Green New Deal is the establishment of an Energy Union. Energy efficiency and energy security are two of the objectives promoted by the Energy Union, which can be achieved by a transition in the heating sector. Prominent instruments of the Energy Union are the European emissions trading scheme (EU ETS) and the effort sharing for sectors, not included in the ETS (European Commission 2015). Emissions of buildings are included in the effort sharing policy of the Energy Union, which prescribes each member state specific reduction targets that are determined by the national GDP per capita. Contrary to the EU ETS, sectors included in the effort sharing are regulated through national strategies and not on the European level. Therefore, Germany needs to have national solutions for the reduction of emissions in buildings. The overall objective for the included sectors lies at -30% emissions reduction (European Commission n.d.).

To achieve the objectives of 2030 and 2050 under the Green New Deal, the European Commission has announced to review all relevant policy instruments by June 2021. One possible instrument in discussion is the expansion of the EU ETS to additional sectors and adapting the effort sharing among sectors, not included in the emission trading scheme. This will most likely affect the targeting and pricing of the building sector as well. Both emission reduction targets have been endorsed by the heads of member states and indicate a strong union on the global front towards a sustainable future in all polluting sectors, including the heating sector. In addition, the head of the states send a clear signal to their home countries and people, that change is coming and that mitigating the climate crisis is being taken seriously.

One more policy instrument under the Energy Union that influences the heating transition on the national and municipal level, is the Clean Energy for all Europeans packages. This package is particularly important for the

municipal heating transition, since it sets directives for the energy performance of buildings and renewable energy targets for member states. Central to the package is energy efficiency, as it is perceived as the easiest way for consumers to save money and to reduce GHG emissions. After implementation of these EU rules, the member states have 1-2 years to transfer them into national law. The energy performance of buildings directive (EPBD) requires EU countries to establish renovation strategies, publish National Energy and Climate Plans (NECP), set minimum energy performance requirements for new and existing buildings, and announce the "nearly zero-energy buildings" (NEZB) from 31 December 2020 onwards.

In addition, energy performance certificates are introduced, and member states are required to prepare lists with overviews of the financial aids and measures of the government (European Commission 2019). The EPBD is adopted in the German *Gebäudeenergiegesetz*. Especially the required overview of fundings is an effective instrument, as it updates citizens about the different financial aids to improve the energy efficiency of buildings. This is particularly important, because the EPBD falls in line with the "renovation wave" strategy of the EU, which consists of regulatory, financial and enabling measures to at least double the annual renovation rate in EU countries.

As we will see in the upcoming parts of our paper, an accurate overview of the financial support is essential for a successful heating transition in municipalities, since the amount of different funding can be overwhelming and unclear at times. The elements of the Clean Energy for All Europeans Package improve the operating principal of the internal energy market, support a proactive role of energy consumers and encourage more innovation (Eyl-Mazzega and Mathieu 2020). Still, the package also relies on the action of national governments to initiate national energy plans and shape the heating transition.

The renewable energy directive of the Clean Energy Package introduces a binding target of 32% renewables in the European energy mix by 2030, which could be achieved by a higher usage of heat pumps in buildings (Lowes et al. 2020). Establishing general and more sector specific targets on the European level will forward the promotion of new technologies and innovations and the phase out of polluting heating technologies on national levels, because new solutions need to be implemented to meet the targets of the EU. German municipalities will therefore also profit from the general commitment of the member states, since the government has to introduce

policies that will successfully foster a sustainable transition.

4.2. National Level

The central national policy strategies for the heating transition and climate mitigation are the Climate Protection Plan 2050 (*Klimaschutzplan 2050*) and the Climate Protection Program 2030 (*Klimaschutzprogramm 2030*), which introduce measures to uphold the objectives of the Paris agreement and the EU (BMWi 2021). One main policy instrument for the heating transition in Germany is the Climate Protection Law (*Klimaschutzgesetz*), which was passed in 2019 as a result of the *Klimaschutzprogramm 2030* and introduced binding targets for the reduction of GHG emissions across sectors. This commitment on the national level not only sends a positive signal to investors and companies, but also paves the way for a stronger commitment of federal states and municipalities in a sustainable transition. The law adopts the EU targets and additionally regulates the allowed yearly emissions of different sectors, including the energy sector.

The responsible federal ministries are then in charge to implement these yearly goals. If the emission targets are missed, the ministries need to present immediate reconditioning plans and the federal government then decides on further measures. That is how the monitoring of the targets is assured. To ensure transparency, the emission data is being published yearly by the federal environment agency and monitored by an independent expert board which reports back to the German government and *Bundestag* (Die Bundesregierung 2019).

This liability of the binding law also assigns responsibility to the government and the ministries to take real action in the dictated areas. Otherwise, they can be hold accountable for inactivity by the public, if the targets are not met. The law permits buildings an emission quantity of 113 mio. tons of CO_2 in 2021. The amount of emissions is to be reduced by 40 million tonnes to a level of 70 million by 2030. The energy sector is allowed 175 million tons of CO_2 emissions in 2030. Although, the energy industry is the only sector which does not have all annual quantities defined, but only has three fixed goals until 2030 (Bundestag 2019). Thus, the binding laws and the increased transparency create long-term security for planning and investments, renew the long-term climate strategy and also place it on the permanent agenda of the current and upcoming governments (Sina, Stockhaus and Holmes 2019). After all, one must consider that governing coalitions are changing with elections every four years and the heating transition

cannot be disrupted every new power transition. The increased security for investors has the ability to push niche technologies in the heating sector.

Additionally, the heating sector in Germany is being significantly influenced by the *Erneuerbare-Energien-Gesetz*, which fosters the expansion of renewable energies and thus assists in the electrification of the heating sector. The act has been renewed in 2020 and now presents better opportunities, in particular for *Mieterstrom* and PV installations. The main objective of the *EEG* aims at 65% renewable energy in the German energy mix by 2030. To achieve this objective, the self-supply with electricity from PVs has been made more attractive by freeing solar panels, with up to 30 kw installed capacity, from the *EEG* surcharge. This makes the installation of PVs on rooftops of small family homes more attractive and could increase the demand by private households (Bundesministerium für Wirtschaft und Energie n.d.). Increasing PV installations on rooftops could also promote more use of heat pumps, which can be run with the electricity from the PVs or by the *Mieterstrom* model.

An increase in tenant electricity can be an effective way to transform the heating sector. The federal ministry of economic affairs and energy describes *Mieterstrom* as coming directly from solar panels of a residential building to the tenants of the building or district. *Mieterstrom* is financially incentivized by the EEG with the *Mieterstromzuschlag*, and thus makes it more attractive for landlords to adopt. In addition, the *Mieterstrom* can also be distributed within a district and is not limited to one building. On the other hand, so that tenants are protected from exploitation and high prices, landlords are not allowed to make their electricity a condition for signing the lease and the *Mieterstrom* contract is limited to a year (ebd.). Concluding, there are many opportunities under the *EEG* that can push niche technologies and business models like the *Mieterstrom* concept or heat pumps towards a successful *Wärmewende*.

Another regulatory instrument that supports the heating transition of municipalities is the *Gebäudeenergiegesetz*, which implements the requirements of the EU EPBD. The main goal of this law is an increase in renewable energy usage for electricity, heating and cooling and thus it sets standards and mandates for new and existing buildings. According to the act, new buildings have to be constructed as lowest energy buildings (*Niedrigstenergiegebäude*) with the KfW-75 standard and draw heating from at least one renewable energy source. In addition, the energy from renewable sources has to cover at least 15% of the heating and cooling

demand of the building (energie-experten.org n.d.).

Also, the law prescribes energy certificates for buildings which state the CO_2 emissions resulting from primary energy demand or consumption and mandates the phase out of oil heaters from 2026 onwards. In some cases, a compulsory energy consulting must be conducted, e.g. when selling a building or carrying out a major renovation. Further, the *GEG* also supports district solutions. By the end of 2025, it will be possible to meet the requirements of the GEG for the renovation of a building as a neighbourhood (Bundesministerium des Inneren n.d.). Being able to meet the demands as a district is especially important, since it can increase the economic feasibility of the transition and supports solutions that work better on a community of buildings. Local heating solutions are often times even more efficient for a whole neighbourhood than single building solutions (engie 2020). However, municipalities have to identify specific local potentials to make the heating transition effective. While pushing renewable technologies for heating and fostering a creative destruction due to the phase out of oil and gas heating, there is still some critique on the regulations under the *GEG*.

One central criticism is that the lowest energy standard of KfW-75 is not ambitious enough since it is already widely distributed. The higher standard KfW-55 would have been more suitable to achieve the climate neutrality objective for buildings. Although this standard will be reevaluated in 2023, an immediate adaptation would have increased the chances to reach the objective. Another critique is that the energy consulting only refers to services free of charge and so misses out on high quality consulting by pricier state consultants. Especially because adding PVs as a solution to increase the efficiency standard of buildings will require more qualified consulting, since the planning has to be redesigned in this context (energie-experten.org n.d.). Allowing more and high-quality energy consulting, could be another improvement of the *GEG*.

Another driver of the heating transition in municipalities is the newly established National Emissions Trading System (*Nationales Emissionshandelssystem, nEHS*) which targets distributors of fossil fuels in the heating and transport sector. Consequently, heating with oil and gas will become more expensive. The yearly emission quantity for the sectors is limited, and the emission allowances are sold or auctioned. The certificates have a rising fixed price until 2025 that goes up to 55€ per t/CO_2. The following year the certificates are auctioned for a price between 55€ and 65€ per ton. From 2026-2030 the price is left to the market. One

more aspect of the *nEHS* is that heating and energy distributors can transfer their increased costs onto the end consumer (Metschke and Woltering 2021).

For that reason, the federal cabinet has agreed to reduce the burdens for electricity consumers by redirecting the money earned by the emissions trading into the relief of the *EEG-Umlage*. According to the Federal Minister of Environment, Svenja Schulze, this relief leads to social justice in the fight against climate change (Bundesministerium für Wirtschaft und Energie 2020). The carbon pricing also aims at tenants to reflect their heating consumption in general. This should be achieved with the Energy Efficiency Directive (EED) that requires informing tenants yearly about their energy and heat consumption. As a result, the overview should lead to rethinking one's own heating consumption (noventic 2020). Thus, the EED and the *Brennstoffemissionshandelsgesetz* reinforce each other and could lead to a destabilization of the current heating technologies. Although the pricing on fossil heating will drive the *Wärmewende*, there are some relevant critical voices surrounding it.

The criticism mostly refers to the financial burden on tenants and a too low carbon price (Kersting 2021). Some argue that the carbon price should not be transferred to renters completely but should be split between them and the landlords. By involving landlords, there will be more incentives to invest in less carbon intensive heating technologies. The German Energy Agency (*Deutsche Energie Agentur; dena*) proposes a split of costs according to the energetic conditions of the building. The bigger share of costs goes to the party which has a great influence on the emissions. For example, if the building is very energy efficient, the tenants will tackle most of the costs, since they have the major influence on the emissions by their heating behaviour (dena 2021). Changing the cost distribution would be beneficial for the heating transition in general, since it would lead the affected actor to take action. This would mean either the landlord introducing a new heating technology or the tenant consuming heating more efficiently. Carbon pricing in general has been highly criticized as an insufficient policy instrument for the energy transition (Rosenbloom et al. 2020). According to Rosenbloom et al. (2020) carbon pricing is an instrument that focuses too much on optimizing existing systems and less on system change.

4.3. Federal State Level

Since municipalities operate under the jurisdiction of their federal states, it is of utmost importance what regulatory frameworks the federal states have in place. Bavaria has policies

like the Bavarian Climate Law (*Bayerisches Klimaschutzgesetz*) and Climate Protection Plan (*Klimaschutzplan*), that could support a successful *Wärmewende* in municipalities like Regensburg. A Bavarian Climate Protection Program (*Bayerisches Klimaschutzprogramm*) that lists all instruments to achieve the objectives of the *Bayerisches Klimaschutzgesetz* has been established. Recommendations for municipalities are also included in the Bavarian climate law (Bayerische Staatskanzlei 2020). With these strategies, the Bavarian state commits itself to a transformation towards a greener future and sets the framework for municipalities to start their transformation. Still, the Bavarian government is accused of too little liability for a transformation, because the ability to set binding rules for municipalities was not exploited enough (Bayerischer Rundfunk 2020). Missing binding rules for municipalities, also means losing out on a chance to speed up the heating transition in municipalities. Baden-Württemberg can be perceived as a positive example in this regard, since they have introduced far more binding rules for municipalities, among others a mandatory thermal planning.

By introducing a thermal plan, municipalities are analyzing the potential of their local surroundings and thus identifying possible courses of action (Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg 2019). Baden-Württemberg's approach could act as an example for the revaluation of the *Bayerisches Klimaschutzgesetz*. The *Bayerisches Klimaschutzprogramm* complements the climate protection law and includes two important focal points for the *Wärmewende*. The expansion of renewable energies and the energy efficiency of buildings (Bayerisches Staatsministerium für Umwelt und Verbraucherschutz 2015). Nevertheless, the program and climate law have room for improvement. Both miss out on introducing monitoring capacities, in order to track the progress of established instruments, and both do not establish clear reduction targets aside the 2030 and 2050 objectives (Sebald 2020). In addition, the Bavarian climate protection program could put more emphasis on the heating transition and push new niche technologies in this sector. On the other hand, the state of Bavaria has introduced an Energy Action Program (*Bayerisches Aktionsprogramm Energie*) which sets specific targets for the expansion of renewable energies till 2022. For example, another 3.200 MWp of PV power should be added until 2022. It also sets targets for solar thermal, hydrogen, hydropower bio energy, power to heat, wind energy (Bayerisches

Staatsministerium für Wirtschaft, Landesentwicklung und Energie 2019).

Although the Bavarian Energy Action Program is a positive initial step towards more commitment, it still is not enough to ensure long-term planning security for investors in in the heating sector and it needs to be expanded beyond 2022.

4.4. Municipal Level

Within the framework of local self-government (Art. 28 of the *Grundgesetz*), municipalities have opportunities to act in favour of the heating transition. One of the main instruments municipalities can use, is the authority to plan their own urban land use (*Bauleitplanung*). According to the *Baugesetzbuch,* municipalities should aim at a sustainable urban development when conducting their land use plans (*Bauleitpläne*). Part of the sustainable development are energetically efficient constructions as well as efficient energy supply (Bayerisches Landesamt für Umwelt n.d.). Municipalities can use this ability to plan more of their urban land use in favour of a less carbon intensive heating in residential buildings.

The municipal administration can for example determine the construction mechanisms and orientation of buildings so that rooftops are more suitable for solar thermal installation of PVs. Thus, the biggest potential with this policy instrument lies in the construction of new districts (Sandrock and Maaß 2014). Regensburg has one pilot project that exhausts the possibilities of municipal land use planning, the "Prinz-Leopold-Kaserne"-project (Stadt Regensburg 2019). For the general heating transition in municipalities, this policy instrument could be put more into use when planning new residential buildings and districts. An energy usage plan, a thermal plan or a climate protection plan can be a very beneficial prerequisite for successful land use planning (Energie-Atlas 2020). With that being said, municipalities have some abilities at hand that could foster and speed up a heating transition and introduce new technologies. Therefore, they would need to make use of all the possibilities they have within the *Bauleitplanung* and introduce thermal plans in order to have an overview of the potentials of their locality. Even if the plans are not mandatory within the federal state, they will nevertheless be helpful in the *Wärmewende*.

It can be concluded that there are regulatory frameworks at place that can foster a successful *Wärmewende*. Nonetheless, there are also improvements to be made. Especially considering the German climate protection strategy and the Bavarian approach to the

heating transition. In the case of Bavaria, there needs to be way more binding obligations for municipalities in order to push new technologies in the heating transition. After all, municipalities work within the regulatory framework of their federal state. Still, there are other potentials than regulatory policies, municipalities can use to foster the heating transition. Information campaigns, being role models in their own construction plans, setting new standards are some tools municipalities can use to generate new thinking among their fellow citizens. Regensburg has already made use of some policy instruments, for example under the *Bauleitplanung*. The flagship project "Prinz-Leopold-Kaserne" can be seen as a good example for that. Regardless, a general change in some regulatory aspects, like the distribution of costs in the *nEHS*, would lead to faster and more sustainable solutions in the heating sector. Not only in Regensburg, but in all municipalities.

Key Takeaways	
National Level	• Promote innovative business models such as *Mieterstrom* to engage landlords and tenants in the heating transition. • Split the costs of the carbon pricing for fossil heating between tenants and landlords according to the energy standard of buildings, so that the responsible actor is more likely to take action. • Increase *Niedrigstenergiegebäude* standard of new buildings and introduce it before 2023. • Improve the GEG by allowing more and high-quality energy consulting.
Federal Level	• Concretize the Bavarian climate protection plan with more focus on the heating transition. • Introduce more binding rules for municipalities, among others, a mandatory heating plan in the Bavarian climate law. • Renew the Bavarian Energy Action Program beyond 2022, so that planning security is ensured.
Municipal Level	• Explore the possibilities within municipal land use and push new technologies for heating, even before the phase out of oil heaters. • Introduce thermal plans to have an accurate overview of the potentials of the locality. • Municipalities can function as role models in their own construction plans.

5. Financial Aspects

Once we have already introduced the main frameworks and regulations in place regarding the heating transition, we will dedicate the next session to present the existing financial instruments aiming to support the achievement of the mentioned policy goals. It is important to keep in mind that the alignment and coordination of the promoted measures in relation to the objective is decisive in public policy so that the outcomes can unfold in a target-oriented manner. In this sense, addressing the financial support needed to deploy the technological innovation is fundamental in the process of niche creation.

Financial policies and funding programmes can help to create knowledge, expand new markets, compensate risks, stimulate investments, and support the adoption or replacement of technologies. We will present the main funding mechanism for a heating transition that are relevant for municipalities and its inhabitants, starting from the high level, and concluding with the financing instruments offered by the municipality itself, in this case, by the city of Regensburg. Lastly, we also review the effectiveness of the funding instruments for different technologies and suggest ways to increase their attractiveness and effectiveness.

5.1 European Level

On the European Union Level, the already described European Green Deal provides an action plan to boost the efficient use of resources, restore biodiversity and cut pollution, the decarbonization of the energy sector being one of the key strategic actions. According to the Communication Report published in 2020, the Sustainable Europe Investment Plan will be the main instrument organizing the investment effort across all sectors of the economy (European Commission 2020a). The plan will mobilize at least €1 trillion in sustainable investments over the next decade through the EU budget and associated instruments such as the InvestEU[5]. It will also facilitate sustainable investments for private investors and the public sector creating an enabling framework and will support public administrations with the execution of sustainable projects (European Commission 2020b).

The EU budget foreseen from 2021 to 2027 aims to invest 25% of its total to contribute

[5] See more in https://europa.eu/investeu/home_en

to climate action and spending on the environment. Nevertheless, the funding options are spread across multiple programmes, as the European Agricultural Fund for Rural Development, European Agricultural Guarantee Fund, European Regional Development Fund, Cohesion Fund, Horizon Europe and Life funds[6]. Each of those funds includes different funding sources available to cities, with different focus, operational guidelines and requirements. Municipalities must check if they are eligible to the different programmes and submit their proposals within a specific time frame.

Among all possibilities, it might be relevant to highlight the Renovation Wave Strategy, launched by the European Commission in October 2020, to improve the energy performance of buildings. With the target of at least doubling renovation rates in the next ten years of residential and non-residential buildings and ensuring energy efficiency, the strategy proposes to increase the volume and impact of EU funding by providing more grants, technical assistance, project development support and loans and making it possible to combine different resources (European Commission, 2020c).

To help municipalities to comprehend the multiple funding channels, there are some instruments in place, such as the urban investment advisory platform called Urbis, created within the European Investment Advisory Hub, to support authorities with their urban investment projects. Local authorities and promoters can also make use of the free of charge service called Joint Assistance to Support Projects in European Regions (JASPERS), which provides advisory for cities and regions on strategic planning and supports the preparation of projects in areas benefiting from EU funds. Public and private sectors can also make use of the European Local ENergy Assistance (ELENA), which offers technical assistance for renewable energy and energy efficiency investments, targeting buildings and innovative urban transport (European Commission n.d).

5.2 National Level

When it comes to the heating transition on the national level, the promotion of the

[6] EU funding possibilities in the energy sector can be found under https://ec.europa.eu/energy/funding-and-contracts/eu-funding-possibilities-in-the-energy-sector_en, and a list of funding opportunities for cities under https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/funding-cities_en

substitution or adoption of new technologies in Germany is made mainly by subsidy programs, generally structured as loans and grants. Until recently, the list of national funding programs addressing the municipal heat transition was extensive, including more than twenty different loans and subsidies options. To that list we can add other generally applicable incentives, such as tax and cost reductions or payments and remuneration for generation of electricity by renewable energy systems. The list with the main funding programs can be found in the Appendix (Table 4 & 5).

The most important actors providing financial incentives as the primary instruments to improve efficiency and increase the role of renewables in the heating sector are the Federal Ministry for Economic Affairs and Energy, the Federal Office for Economic Affairs and Export Control (BAFA) and the German investment bank KfW. Third parties such as the Project Management Jülich administers programmes for funding research and innovation. For each program, specific technologies are addressed to promote energy efficiency, reduce CO_2 emissions, combined power-heat generation, and investments in non-residential and residential buildings, and the specific targets can be municipalities, public or private companies, private individuals, or associations. Complementing the financing options already mentioned, there are those incentives provided by the states and municipalities themselves.

Not only individuals, but the municipalities themselves can lack the capacities to evaluate the multitude of programmes available and lack the expertise to implement the best financing schemes. Trying to address this complexity of funding options, the BAFA implemented new guidelines for the Federal Promotion for Efficient Buildings, which started on January 2021, replacing the Market Incentive Programme, the Energy Efficiency Incentive Programme and the Heating Optimization Programme. The guidelines provide a single, comprehensive, and modernized funding instrument that aims, according to the institution, to make the funding significantly more attractive, simplify the application procedures and increase the programme's funding (BAFA, n.d). Applications can be now done online via the BAFA website, and the applicant does not need to previously have had an energy advisor.

5.3 Federal State Level

Incentives from the Free State of Bavaria related to the heating transformation include the *EnergieBonus Bayern*, a support to owners of owner-occupied and two-family houses in addition to the BAFA and KfW funds; the *Bayerisches Modernisierungsprogramm*

(BayModR), which provides low-interest loans for renovations and modernization of rented housing in apartment buildings as well as nursing care places; and the *KommKlimaFöR*, which establishes climate protection in municipalities as funding priority of the Ministry of the Environment (Bayerischen Energieagenturen 2021).

5.4 Municipal Level

The city of Regensburg also offers its own incentives for promoting the replacement of heating circulation pumps, promoting the hydraulic balancing of the heating systems, the use of renewable raw materials in building refurbishment and the use of renewable heating systems. There are also instruments to promote the connection to a local heating network and ventilation systems with heat recovery and supplements for the KfW funding for the neighbourhood concept, which are initially taking place as a pilot project in the neighbourhoods identified in the energy use plan. The project "Energy Saving Helpers", which offers energy saving assistance packages for low-income households, is also worth mentioning (Regensburg Effizient, n. d).

Aiming to make sense of the instruments implemented in all levels, local agencies try to summarize the funding options through initiatives such as the *Förderkompass*, created by the *Bayerische Energieagenturen*. The city of Regensburg also offers neutral advice related to energy and climate protection that goes beyond presenting the funding options and includes themes like new construction or building renovation, energy efficient household appliances, use of renewable energies, energy saving, electro-mobility, energy efficient lighting, heating modernization and environmental and climate protection. Nevertheless, according to the Monitoring Report from 2019, the use of the consulting services is still low, so as the use of financing options related to buildings renovations and exchange of heating system, as shown in the figures below (Figure 3 and 4).

Figure 3: Uptake of energy advice and consultancies provided by the Energy Agency of Regensburg (EAR) and REWAG

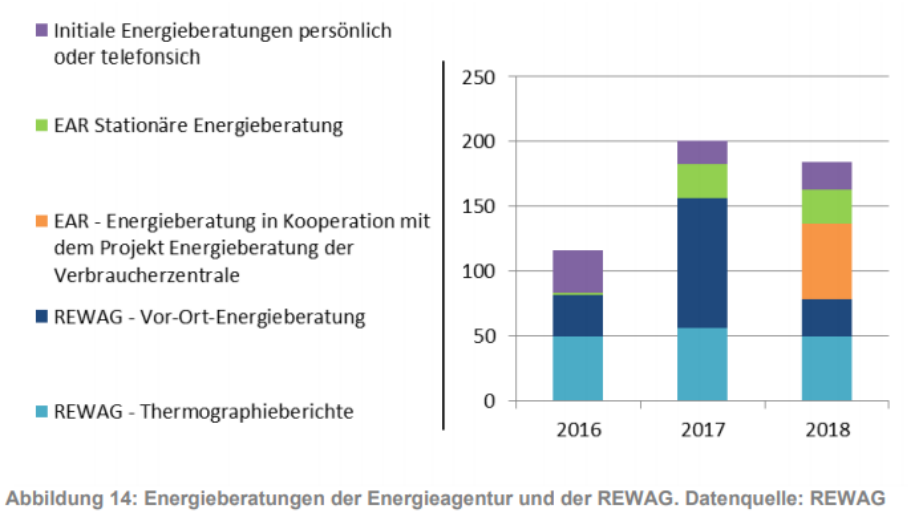


Abbildung 14: Energieberatungen der Energieagentur und der REWAG. Datenquelle: REWAG

Source: REWAG, 2019

Figure 4: Funding cases from Regensburg Efficient funding program

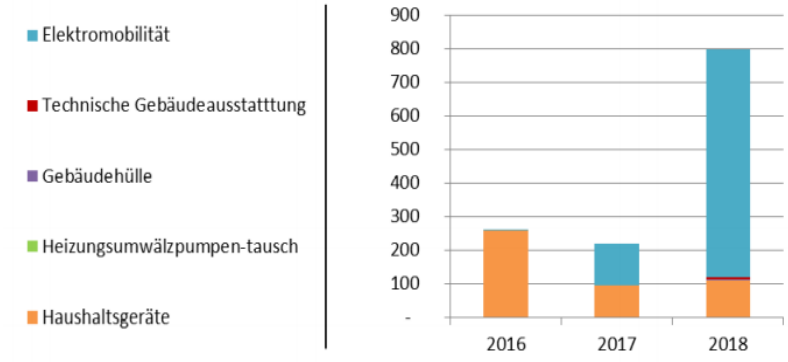


Abbildung 16: Förderfälle der Förderprogramms "Regensburg effizient"

Source: Monitoringbericht, 2019.

Other important actors also contribute so that municipalities and its inhabitants can better apprehend what is necessary for implementing the heating transition. The Agency for Renewable Energies (AEE) and the Fraunhofer Institute for Energy Economics and Energy Systems (IEE) - through the project *Kommunale Wärmewende* - are providing scientific and communicative support to three pilot municipalities, including Regensburg, in the

conversion to climate-friendly heat generation. In the scope of the project, instruments like the *Wärmekompass* allow the user to identify marketable technologies as well as practicable instruments for the heat transition and to promote their implementation.

In December 2020, the AEE online calculator, which supports municipalities in calculating the local value-added effects from the expansion of renewable energies, was updated through a partnership among AEE and the Institute for Ecological Economy Research, on behalf of and in cooperation with the Energy Agency from Rheinland-Pfalz (AEE, 2020). The calculator (*Wertschöpfungsrechner*)[7] aims to help municipalities to estimate the co-benefits associated with the use of renewable energies, such as the positive economic developments in the regions, the jobs created by the operation of renewable energy plants, the profits of the companies responsible for the operation of renewable energy plants and the associated municipal tax revenues. The tool can be an important resource when it comes to assessing the investment cost and potential positive returns for the municipality.

In this sense, we recommend that Regensburg reinforces tools that already exist in the municipality, relying on the support of the local, regional, and national Energy Agencies. A multi-criteria framework to explore trade-offs among financing options could be developed, throughout a partnership with the local University, for example. We also recommend that the municipality uses the full potential of collaborations and keeps benefiting from the support through strategic partnerships such as the *Wärmewende* project, profiting of the expertise of the involved institutions. Besides that, we suggest that Regensburg explores the establishment of new partnerships, such as The Cities Climate Finance Leadership Alliance[8], which can provide support for deploying finance for city level climate action, or the Cities and Regions Interest Group[9], created within the Heat Roadmap Europe 4 project.

5.5 Technology aspects of financing

While funding schemes for private households, companies, and municipalities support demand-side policies that aim at increasing energy efficient building stocks and

[7] See more in https://www.unendlich-viel-energie.de/wertschoepfungsrechner

[8] See more in https://www.citiesclimatefinance.org/

[9] See more in https://heatroadmap.eu/city-region-interest-group/

adoption of new technologies, the need to meet specific technical requirements to qualify for funding also nudges technology providers to continuously come up with more energy efficient solutions in order to reap the benefits of increasing market demand. Policy makers have good intentions to incentivize the adoption of more energy-efficient solutions, however, from end consumers' perspective, it is often difficult to comprehend the technical requirements listed in a funding scheme without professional help. For example, to be eligible for technical bonus under *EnergieSystemHaus*, part of the 10,000 Houses program under Bavaria state's funding scheme *EnergieBonus Bayern*, mentioned above, one needs to meet the following technology specific requirements as shown in Table 3.

Table 3. Funding variation and special requirements for technical bonus for heat pump systems under the *EnergieSystemHaus* program

Technik-variante	Komponenten und Detailanforderungen	TechnikBonus [Maximalbetrag]
Wärmepumpe mit Energiemanagementsystem und offener Schnittstelle		
T1.1	**Erdwärmekollektor mit Sole-System** ▪ Thermischer Speicher mit mindestens 30 l/kW$_{th}$ effektivem Volumen ▪ Speicherdämmung mit Warmhalteverlust $S < 8,5 + 4,25 \cdot V^{0,4}$ bzw. mit U-Wert ≤ 0,20 W/m²K (s. Merkblatt A)	**2.000 €**
T1.2	**Sole- oder CO_2-Erdwärmesonden-System** ▪ Thermischer Speicher mit mindestens 30 l/kW$_{th}$ effektivem Volumen ▪ Speicherdämmung mit Warmhalteverlust $S < 8,5 + 4,25 \cdot V^{0,4}$ bzw. mit U-Wert ≤ 0,20 W/m²K (s. Merkblatt A)	**2.000 €**
T1.3	**Grundwasser-System** ▪ Thermischer Speicher mit mindestens 30 l/kW$_{th}$ effektivem Volumen ▪ Speicherdämmung mit Warmhalteverlust $S < 8,5 + 4,25 \cdot V^{0,4}$ bzw. mit U-Wert ≤ 0,20 W/m²K (s. Merkblatt A)	**2.000 €**
T1.4	**Kompressionswärmepumpen aller Art** ▪ Kombination mit PV-Anlage mit mindestens 5 kW$_p$ Nennleistung ▪ Die PV-Anlage muss für einen optimierten Winterbetrieb mit einem Neigungswinkel zwischen 45° und 90° montiert sein ▪ Bauteilspeicher als thermischer Speicher (Betonkernaktivierung oder Fußbodenheizung mit mindestens 60 mm Estrich oder ver-	**2.000 €**

Source: Bavarian Ministry for Economy, Land Development and Energy, 2019.

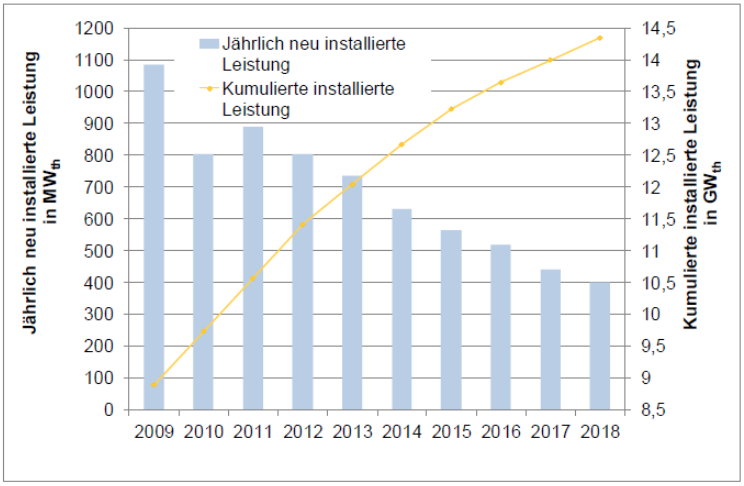
This further illustrates the need for policy makers to include easy to access energy consultancies as part of the program to help private households, companies, and municipalities evaluate different funding opportunities.

To understand the progress funding schemes have made towards increasing the adoption of innovative technologies, we examine three technologies, identified as having the most potential in enabling *Wärmewende* in Regensburg, based on the evaluation of BAFA's Market Incentive Programme (MAP) from 2015 to 2018. (The program has been replaced by Federal Promotion for Efficient Buildings in 2019). Unfortunately, the data in the evaluation report is only available at the national and federal state level for the MAP program. Further investigation into the effectiveness of other regional and municipal funding programs is needed to provide more granular understanding specific to Regensburg.

- Solar Thermal

According to the German Federal association of Solar Economy (*Bundesverbands Solarwirtschaft e.V.*) in 2019, the number of solar thermal systems in operation has increased by more than 60% since 2010. However, 2018 is the seventh year in a row that the annual addition of solar thermal capacity has declined. The newly installed capacity of 400 MWth in 2018 is the lowest in terms of new installation in the past 16 years (BMWi, 2019) as seen in Figure 5.

Figure 5: Annual new installation and cumulative solar thermal capacity 2009 - 2018



Source: German Federal association of Solar Economy, 2019

Bavaria is the 3rd federal state that built the most solar thermal capacity under the BAFA MAP funding program in 2018, after Thüringen and Baden-Württemberg.

One reason for the reluctant uptake in installing new solar thermal system identified in the MAP evaluation report is uncertainty in planning regarding the cost fluctuation and cost competitiveness of solar thermal systems in comparison to existing fossil fuel systems. "For a single-family house with low energy demand, the solar-thermal combined system without the MAP subsidy cost about 0,156 €/kWh (with

MAP support, 0.147 €/kWh) with flat-plate collectors and 0.168 €/kWh (with MAP support, 0.1590 €/kWh) with tube collectors. This means that they are around 14% and 23% higher than the cost of systems running on fossil fuels. Even with MAP support, the solar heat is 7% and 16% more expensive than fossil heat." (BMWi, 2019)

To increase the cost competitiveness of solar thermal and PV systems, we can adopt market mechanisms such as the cellular energy system under the C/sells scheme in Bavaria[10], that promote the exchange of energy and information in decentralized smart grid systems. Other models, such as tenant electricity (*Mieterstrom)* mentioned in the regulatory aspects of *Wärmewende* in Chapter 4 can also promote the installation of solar thermal systems in multi-family buildings by alleviating the financial burden for investment and planning uncertainty for tenants. Lastly, supplementary funding programs at federal state and municipal level can also increase the attractiveness of installing solar thermal systems if the application process and guidelines are made easy to understand by end consumers.

- Heat Pump

According to the Bavarian municipality census 2019, around 73% of all residential buildings in Regensburg are multi-family apartment buildings (Bayerisches Landesamt für Statistik, 2019). MAP evaluation indicates that although there is increase in the installation of heat pump systems in Germany in the past years, the market share of heat pumps in newly constructed buildings are only half as high for multi-family buildings as that of single-family houses, and the market share of heat pumps in the renovation of existing heat supply systems in residential buildings is below 10% (BMWi, 2019).

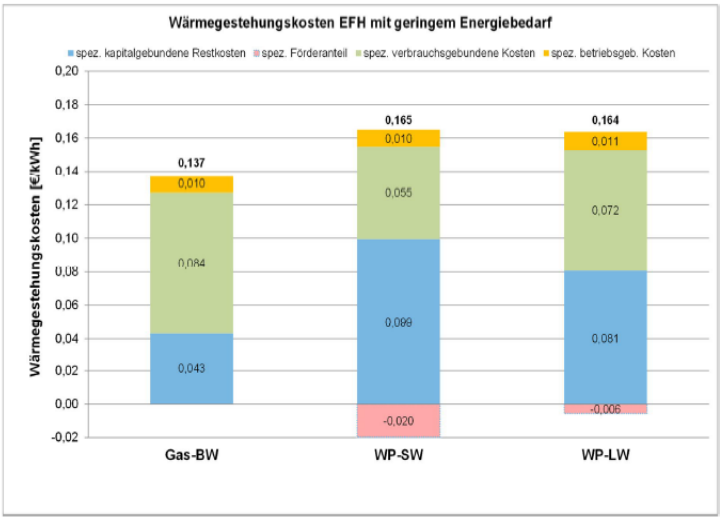
While installing heat pumps for single-family houses also face the challenge of high capital investment for a single payer (shown in the cost breakdown comparison in figure 6), multi-family buildings and old buildings which make up a significant portion of Regensburg's building stock (and in other German municipalities as well) present unique challenges in adopting heat pump technologies. One approach to tackle this challenge is increasing the acceptance of new technologies through education, capacity building, and

[10] https://www.csells.net/de/ergebnisse-c-sells/c-sells-buch/422-buch-1-mit-pdf-4.html

distributing the financial burden of individual consumers through innovative business models.

The following chapter on acceptance goes into detail how each of the mentioned aspects can help enable the heat transition on the local level. Another idea to offset the renovation cost of old buildings is using the funding schemes made available through the "renovation wave" strategy of the EU mentioned in the regulatory aspects in Chapter 4.

Figure 6: Breakdown of heat generation cost for single family houses with low energy demand



Source: Bundesamt für Wirtschaft und Energie, 2019

To further increase the attractiveness of adopting heat pump technologies and ensure the long-term effectiveness of the system in reducing carbon emission, the evaluation report calls for following measures: 1) strengthen user/operator competence through training certificate, 2) formalized system quality check after one year of operation, 3) fund outdoor air heat pumps with less noise emission.

Technology wise, only heat pumps that meet the efficiency requirement (certified) are eligible for the federal funding for efficient buildings (*Bundes-förderung für effiziente Gebäude*, BEG). The list includes manufacture names and heat pump models, which made it easier for consumers and firms to identify qualifying products.

- District Heating

Identified as a key stakeholder in Regensburg's heating transition, the local energy provider REWAG is responsible for the construction of the local heating and cooling network when requested by residents and firms. Heating from the combined heat and power plants (CHP) and biomass heating plants are transported via a well-insulated water pipe system to reach end consumers in the network. Under the MAP program, BAFA funds new construction and expansion of local heating and cooling networks. The amount of funding depends on the average diameter of newly laid heating/cooling lines and the heating mix between CHP, heat from renewable energies, and industrial waste heat.

The MAP evaluation report pointed out that the majority of heating networks that received the BAFA funding have fewer than 10 heat consumers and 74,2% of the applicants are privately liable for the investment and the economic success. This raises the question if the organization forms can meet the long-term economic obligations to maintain the financing of small heating networks. There is also a concern that grid losses increase sharply, especially for small networks with few consumers, which carry the risk that the energy efficiency of the heating network will be less than the total efficiency of having several distributed plants (BMWi, 2019).

This points to two areas for improvement: first, we need to promote innovative organization models that encourage the building of larger heating network which lessens the financial burden on individual consumers. (Two models, the *citizen energy cooperative* and private-public partnerships, are explained in the following chapter on acceptance.) Second, there is a need for technical capacity building that enables applicants and funding organizations to calculate the full cost and energy efficiency of the suggested heating network. This will increase the success rate of funding applications and make sure that the heating network will contribute to emission reduction in the long-term.

Key Takeaways	
EU Level	• Check out EU's Sustainable Europe Investment Plan for funding available to municipalities, e.g., the Renovation Wave Strategy for improving energy efficiency of buildings. • Use EU advisory services such as Urbis, JASPERS, and ELENA to navigate through funding options, obtain support for strategic planning and technical assistance for renewable energy investments.
National & Federal Level	• Extensive funding programs available from Federal Ministry for Economic Affairs and Energy, the Federal Office for Economic Affairs and Export Control (BAFA) and the German investment bank KfW. • Ensure appropriate market organization and adequate regulations of the heat market to avoid inequalities in energy supply and cost distribution. • Bavaria offers *EnergieBonus Bayern, Bayerisches Modernisierungsprogramm (BayModR), and KommKlimaFöR,* in addition to federal funding

Municipal Level	• Establish strategic partnerships by local administrations to utilize existing knowledge and instruments, especially when addressing the trade-offs among financing programmes for municipalities. • Further promote personalized funding advisory and energy consulting services to individuals, companies, and associations. • Consider co-benefits of the heating transition, such as increased economic development, jobs opportunities, and tax revenue. • Make more systematic use of ex post evaluation results to improve the effectiveness of existing policies and measures.

6. Acceptance

Given the strong regional character of a successful heating sector transformation *acceptance* is another key factor. Without acceptance any transformation process will face difficulties – no matter how well the regulatory framework or how generous the financial support. In return, a broad acceptance from various stakeholders can help drive policy approaches, incorporate ideas otherwise excluded and lead to effective, systemic change.

The two major fields of action identified in this paper were the energy efficient renovation of buildings (1) as well as the expansion of renewable heating sources through surface near geothermal energy and solar power (2). Grouping the variety of stakeholders mentioned in the beginning we identified four major groups necessary to increase acceptance in both of these fields. These involve:

A. The public administration,
B. Private households and multi-family homes,
C. Firms and,
D. Energy providers

With regard to acceptance, we want to focus in particular on stakeholders A and B. This is because on the one hand Public Administrations are vital given that an effective long-term transformation of the heating sector requires an adequate regulatory framework which allows for the expansion of renewable energy sources. Putting this regulatory framework in place however, requires time and deliberation. Private households and multi-family homes on the other hand are not only the biggest emitter of heating emission but can also act much quicker and thus bring about faster, short-term change.

First, concerning *Public Administrations*, the key challenge is political salience and priority. Political representatives

need to identify the transformation of the heating sector as a necessary field of action and act accordingly. Political administrations should – in accordance with advocacy groups, planning institutions and the general public – start getting an overview of the status quo and evaluate how they can benefit from their geographical preconditions. Overall, this should aim at defining clear political targets which serve as orientation for households, businesses and investors and help averting conflicting goals by giving policy decision a purposeful direction. These targets should serve as the basis to effectively tackle the two major challenges: incentivizing energy efficient renovation and expanding renewable heating sources from both, the private households and firms.

Wherever possible local administrations need to identify avenues for action and explore the diversity of political instruments available at the local level. Furthermore, they play a key role given the close distance to its constituents and the governance processes they should and can coordinate. Although the successful transformation of the heating sector requires a participatory approach, we acknowledge that this systematic challenge involves a lot of actors. As a result, clear and central focal points should be made available to not only serve as points of contact and information for the wider public but also to support the effective coordination between administrations mentioned above. Especially the local energy can play a crucial role here.

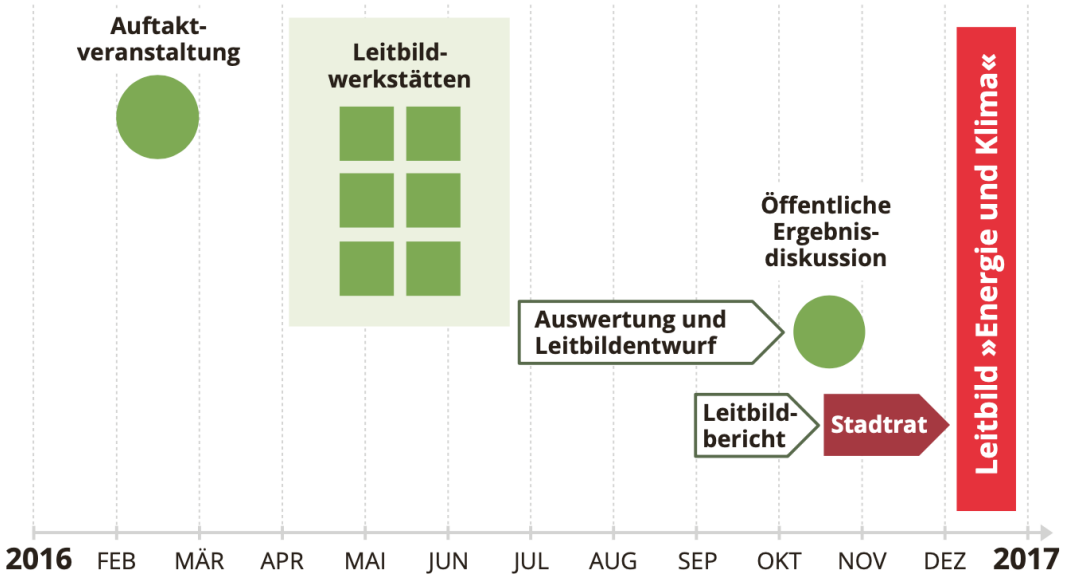
The local administration of Regensburg has already been quite successful in this regard. A first major milestone was the development of an energy usage plan in 2013 as mentioned before. This major strategic planning instrument provides an overview of the current and future energy demand and the energy supply of the municipality, defines potential energy sources and tries to integrate different individual measures into an overall strategy (Stadt Regensburg 2014). One of the main recommendations from the energy usage plan was the development of a purposeful mission statement.

This started in 2016 with the development of the so-called *Leitbild Energie und Klima.* Regenburg's *Leitbild* builds on the energy usage plan and serves two purposes: it defines a clear goal the city wants to reach but also identifies crucial steps along the way (Stadt Regensburg 2017). Given that technological, social or political developments are difficult to predict the main function of the *Leitbild* is to serve as a guiding compass to make sure that overall targets are not lost in sight.

From the beginning on, the administration of Regensburg acknowledged that the entirety of the municipalities involves all

citizens and multiple actors in the city who all have their own ideas, and tried to incorporate these ideas into the mission statement. The development was thus organized in a broad and inclusive manner. This participatory approach helps to ensure that the present mission statement is not only legitimized by the city council but is also supported by a broad and interested public (ebd.: 8). Core to the development process were so-called *Leitbildwerkstätten* (mission statement workshops) in which the topics mobility and urban development, electricity production and energy efficiency as well as production of heat and efficiency of buildings were discussed (ebd.: 9). Over 100 actors were involved in the course of these workshops with representatives from associations and non-governmental initiatives, numerous business enterprises, universities and research institutions, municipal subsidiaries (including the local energy and water supplier REWAG) as well as interested citizens.

Figure 7: Overview of the mission statement development process



Source: Stadt Regensburg 2017: 10

Figure 8: Overview of the guiding principles of the mission statement

Source: Stadt Regensburg 2017: 12-13

As mentioned before, a successful heating transformation brings many changes to the region with local citizens being at the center of these changes. Sufficient renovation efforts for example are ultimately dependent upon citizens identifying and acknowledging the problem and actually investing accordingly. Increasing acceptance can help with reducing potential barriers which in this case refer to both, mental and financial ones.

Concerning *private individuals* – which include both private households and multi-family homes – four critical avenues to increase acceptance were identified:

a) Education,
b) Capacity Building,
c) Participation and
d) Financial support

a) The decision to renovate the apartment, house or building or to invest into a heat pump is dependent on a variety of financial considerations and mental obstacles including the feeling of being overwhelmed, helpless or simply not knowing what to do next (Baur 2015: 34). Any successful heating

transformation should thus put *education* at its center which should be aimed creating awareness about alternative energy sources, efficient heating behavior and anchoring further avenues for action. This helps citizens to make informed choices - both financially and in their daily routines

b) This is equally true concerning *capacity building*. Both educational support or specific consulting advice citizens should be targeted at building capacities around energy efficient living.

To achieve both targets the City of Regensburg has launched the initiative *Regensburg effizient* which is coordinated by the regional energy agency (Energieagentur Regensburg). The agency is not only responsible for the city but for the wider region as well and offers consulting services for several topics. These include besides others: Consultancy regarding new construction or building renovation, energy-efficient household appliances, use of renewable energy sources, available subsidies, information concerning energy saving and energy-efficient lighting, heating modernization[11]. Finally, the energy agency of Regensburg is planning to open up the *energy education center* um:welt in May 2021. The idea behind the center is to illustrate in an informative and eventful way the relationship between human activity and its influence on the environment and climate and what potential solutions and actions can be taken[12].

c) As mentioned before, it is crucial to not only educate the public about the general challenge of a successful heating transformation but to also include them into various planning processes from as early on as possible. Education and capacity building serve as a vital basis for effective *participation*. Especially when drafting a mission statement including the wider public can be very beneficial. This opens up the possibility for many different ideas and potential problems to be taken into consideration. Additionally, the feeling of inclusion and awareness about the changes within one's region helps to increase acceptance (Baur 2015).

d) Even if mental reservations are successfully overcome, building renovation or the installation of heat pumps is at its core still a financial question. A successful implementation of the heating thus requires economically viable possibilities. Even though there are many

[11] A full list of the services offered can be found here: https://www.regensburg-effizient.de/energie-und-klimaschutz-in-regensburg/energieberatung/

[12] More information about um:welt can be found here: https://www.um-welt.bayern/

options available at both the federal and national level this diversity of funding programs can also make it difficult to choose the right one.

Another important point is to ensure that the energy-efficient refurbishment is designed in a socially responsible way within the municipality, with a distribution of the costs of climate protection fairly among tenants, landlords and the public sector. To democratize the financial burden, alternative financial models can be explored. One promising approach is the *Bürgerenergiegenossenscha*ft (citizen energy cooperative). The cooperative business model ensures an equal voting right in the company and allows for a democratic form of citizen ownership of the respective energy sources. A cooperative could for example build a solar-thermal system on the roof of any citizen willing to participate. The citizen would be remunerated for making the space available whilst the system itself would be deployed and maintained by the cooperative.

This creates a direct financial incentive on the citizen side to make these spaces available and can furthermore raise awareness for the topic in general or pull in interested citizens who might be interested but not (yet) willing to invest in a solar-thermal system themselves. On the other side any financial surplus can be distributed amongst all members of the cooperative. This in turn can incentivize citizens to join a regional cooperative and directly profit from the production of heat in their local area. Additionally, this can create benefits above the mere C02-neutral production of energy. using models like the cooperative one can help to transform the struggle for a renewable heating system from an individualistic mindset of having to renovate one's building or changing one's heating system to the realization that the alignment of willpower and resources can ultimately boost sustainability efforts.

But not only between citizens but also public-private partnerships are valuable possibilities for a cooperative model. A variety of public buildings like schools, kindergartens or other administrative buildings could be supplied by regional cooperatives. This has the advantage that public buildings directly benefit from the production of heat on their roof without having to worry about the installation or maintenance of the system. Overall, the broad possibilities, easy access and financial incentives can help to not only produce economically viable solutions but also increases acceptance as it directly adds value in the local region.

The City of Regensburg already offers information and consultancy about relevant funding programs. Additionally, the "Energy Saving Helpers" offer energy saving assistance

for low-income households. On the flip-side, the possibility of citizen energy cooperatives can be further developed. Especially the possibility of public-private partnerships providing public buildings with renewable energy sources are a promising avenue to further boost the sustainability efforts.

Overall, the heating transformation needs a differentiated and systemic approach. It is not only about replacing non-renewable energy sources with renewable ones, but also about the transformation of a socio-technical system as a whole.

Regensburg has taken effective steps in tackling the *Wärmewende*. From the energy usage-plan and a purposeful mission statement to guide policy decisions to efforts to integrate, support and educate the public. Considering innovative models of (financial) inclusion there is still some room for improvement left, however. These efforts could help reframing the challenge of the *Wärmewende* from an individual struggle of renovating one's home or changing one's heating system to a shared awareness of the problem and an aligned capacity to act.

Key Takeaways	
Inclusiveness by design	• In the process of transforming the heating sector the local citizens should be incorporated into the process from the earliest stage on possible • Being part of – or at least knowing about – what changes are happening within the area helps to increase not only acceptance but also opens the door for a variety of ideas and useful inputs otherwise excluded • Connect the heating transition with energy democracy, giving enough attention to principles such as popular sovereignty, participatory governance, and civic ownership.

Best practice and exchange	• We acknowledge that the transformation of the heating sector is a complex challenge that involves many different actors • At the same time, there is no one-size-fits-all recipe given the local character of the challenge • Municipalities need to exchange and learn from another to make the heating transformation a success story • Examples like Regensburg show that although there still is room for improvement an inclusive heating transformation that is led by clear political targets is possible. We believe that if Regensburg continues on this trajectory, it will become an inspiring best example for other municipalities to look out for and connect with

7. Conclusion

This policy paper aimed to look more in depth at the challenges for a successful heating transition in municipalities, more specifically in Germany, and used the municipality of Regensburg as a case study. Being aware of the efforts already done by several different actors in Regensburg, we tried to recognize some of the good practices that can also be applied in other municipalities across the country. We also tried to identify possible paths for the municipality to address current obstacles, and we hope that the recommendations elaborated over the chapters and summarized below can make a contribution in that direction.

As mentioned before, a good policy mix for the heating transition constitutes of policy instruments that reinforce each other and that support niche technologies in the heating sector, while at the same time, lead to a creative destruction of the existing fossil-driven regime in the heating sector. Limited by the technological potential, we analyzed regulatory aspects, financial aspects, and the issue of acceptance in order to give an overview of existing policy instruments and to offer sound recommendations for the *Wärmewende*, not only in Regensburg, but also for other German municipalities (with similar preconditions).

Therefore, the first step in this policy brief was identifying the status quo of Regensburg's heating transition and the different stakeholders involved. Following, the regulatory frameworks of the European, national, federal state, and municipal levels were discussed and recommendations for the improvement of the framework under which municipalities operate were established. To complement regulatory measures, financial incentives and funding schemes are needed. That is why chapter 5 gave an overview of the

different funding schemes municipalities can use to foster the heating transition and identified technology specific challenges in existing funding schemes. Lastly, the issue of acceptance in the heating transition was analyzed, since there cannot be a successful heating transition without the acceptance of the local community. We highlighted as well that innovative business models can lead to more inclusion in the *Wärmewende* process.

Considering the significant role played by local governments in Germany, we believe that there is still a lot of potential for municipalities to engage in the heating transition in the country, and we hope that the example of Regensburg can help cities in similar contexts to develop and implement more sustainable technological systems for the heating sector.

When designing local policies for the heating transition, policy makers should ensure consistency of elements throughout different levels of policies, coherence of processes, credibility, and comprehensiveness (Rogger and Reichert 2016). Therefore, we argue that a successful heating transition needs reforms in all sectors mentioned above, as well as participation of policy makers at different governmental levels.

We organized the recommendations according to the dimensions presented in the theoretical background regarding the most important elements of public policies that also allows the evaluation of such policies: efficiency, effectiveness, and equity (Nagel, 1986). We believe that orienting the policy mix towards achieving the planned benefits, managing properly the costs, and promoting equity along the energy transition should be key concerns of policy makers and other stakeholders involved in the process. Our policy recommendations aim to create an inclusive heating transition with the potential of successfully guiding a systemic transition towards a sustainable heating regime.

8. Policy recommendations

Efficiency	Renew the Bavarian Energy Action Program beyond 2022, so that planning security is ensured.
	Use EU advisory services to make sense of funding possibilities for municipalities on the European level.
	Establish strategic partnerships by local administrations to utilize existing knowledge and instruments, especially when addressing the trade-offs among financing programmes for municipalities.
	Include public buildings in addition to private cooperatives in Citizen energy cooperatives.
	Further promote personalized funding advisory and energy consulting services to individuals, companies, and associations.
Effectiveness	Increase *Niedrigstenergiegebäude* standard of new buildings to KfW-55 prior to 2023.
	Make more systematic use of ex post evaluation results to improve the effectiveness of existing policies and measures.
	Introduce more binding rules for municipalities, among others, a mandatory heating plan in the Bavarian climate law.
	Concretize the Bavarian climate protection plan with more focus on the heating transition.
	Introduce thermal plans to have an accurate overview of the potentials of the locality.
	Explore the possibilities within municipal land use and push new technologies for heating, even before the phase out of oil heaters and thus function as a role model.
Equity	Split the costs of *Nationales Emissionshandelssystem (nEHS*) between tenants and house owners according to the energy standard of buildings, so that the responsible actor is more likely to act.
	Consider co-benefits of the heating transition, such as increased economic development, jobs opportunities, and tax revenue.
	Ensure appropriate market organization and adequate regulations of the heat market to avoid inequalities in energy supply and cost distribution.
	Promote innovative business models such as *Mieterstrom* or *Bürgerenergiegenossenschaften* to engage landlords and tenants in the heating transition.
	In the process of transforming the heating sector, the local citizens should be included from the beginnig.
	Connect the heating transition with energy democracy, giving enough attention to principles such as popular sovereignty, participatory governance, and civic ownership.

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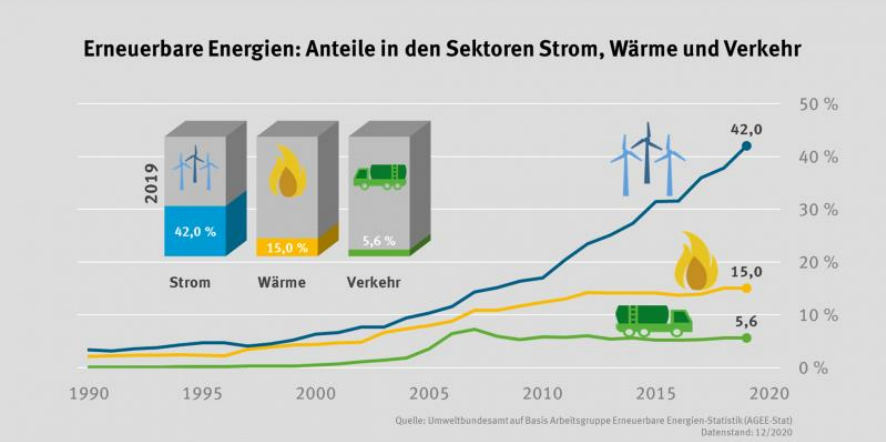
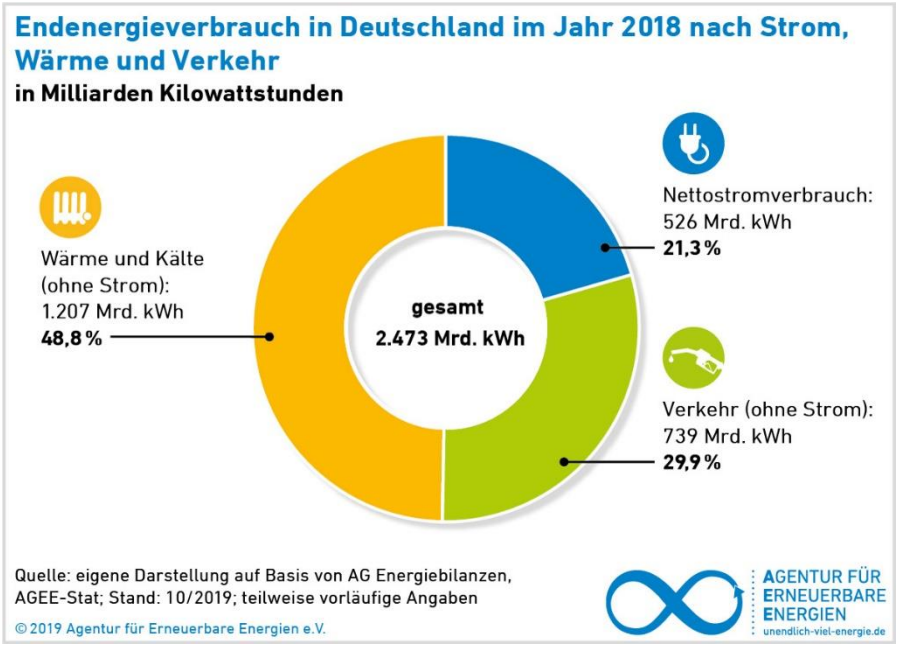
Appendix

Figure 9: Share of renewable energy by electricity, heating, and transport in Germany



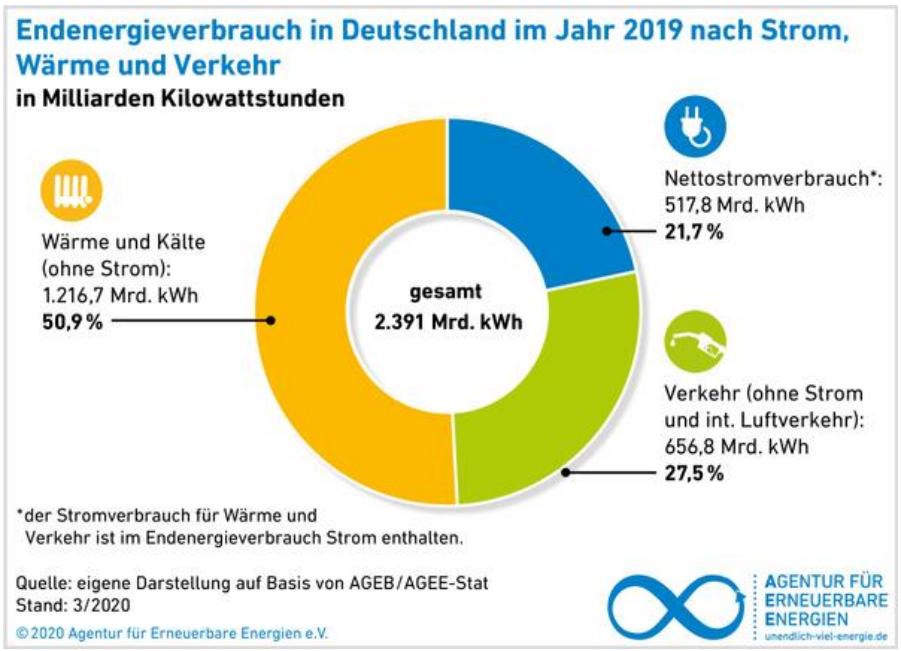
Source: https://www.unendlich-viel-energie.de/mediathek/grafiken

Figure 10: Energy consumption in Germany



Source: https://www.unendlich-viel-energie.de/mediathek/grafiken

Figure 11: Energy consumption in Germany



Source: https://www.unendlich-viel-energie.de/mediathek/grafiken

Table 4. Loans options in the scope of the Heating transition

KfW – IKK – Energetische Stadtsanierung – Quartiersversorgung (201)	Objective: Improve the energy efficiency of municipal infrastructure in the neighborhood. Object: Cooling and heating supply as well as water and wastewater supply Eligible for funding: municipal authorities, their legally dependent companies, municipal associations Special feature: Combination with other public subsidies possible
KfW - IKU - Energetic urban redevelopment - Neighborhood supply (202)	Objective: Improve the energy efficiency of municipal infrastructure in the neighborhood. Object: Heating and cooling supply as well as water supply and waste water disposal Eligible for funding: among others, companies with at least 50% municipal shareholder background, public corporations with majority municipal background

KfW – IKK – Energieeffizient Bauen und Sanieren (217/218)	Objective: Reduction of CO 2 emissions from non-residential buildings in the municipal and social infrastructure sector. Object: new construction, expansion, extension, renovation of efficient buildings and individual measures Eligible for funding: local authorities, their legally dependent companies, associations of local authorities
KfW – IKU – Energieeffizient Bauen und Sanieren (219/220)	Objective: Reduction of CO2 emissions from non-residential buildings in the municipal and social infrastructure. Object: Construction or initial acquisition of energy-efficient non-residential buildings, refurbishment to create an efficient building and individual measures. Eligible: among others, companies with at least 50% municipal shareholder background, public corporations with majority municipal background.
KfW - Renewable Energies "Standard" (270)	Objective: To promote the use of renewable energies for power generation, combined power-heat generation and integration into the energy system. Object: Construction, expansion and acquisition of plants, grids, etc. for the supply/provision of electricity, heat and cooling. Eligible: among others, public companies with their own legal personality, public corporations, municipal special-purpose associations, private individuals.
KfW – Erneuerbare Energien „Premium“ (271)	Objective: Promotion of larger plants for the use of renewable energies in the heating market Object: Construction and expansion of larger plants and networks for heat and cold supply/provision. Eligible for funding: municipalities, local authorities and municipal associations, private individuals, etc.
KfW - Renewables - Premium - Deep geothermal energy (272)	Objective: To promote larger deep geothermal projects for the use of renewable energies in the heat market. Object: Injection wells, construction of deep geothermal plants for the provision of heat and cooling as well as for the combined generation of electricity and heat. Eligible for funding: including municipalities, municipal regional authorities and associations of municipalities, private individuals
KfW - Energy-efficient refurbishment (151/152)	Objective: Energy savings and reduction of CO_2 emissions in existing residential buildings. Object: Acquisition and renovation of KfW Efficiency House, individual measures, renovation of listed buildings, conversion of non-residential space into residential space. Eligible for funding: Sponsors of investment measures in

	and first-time buyers of owner-occupied or rented residential buildings and condominiums.
KfW - Energy-efficient construction (153)	Objective: Construction and initial acquisition of KfW efficiency houses as well as expansion and extension. Object: Investments in residential buildings including residential, retirement and nursing homes. Eligible for funding: Sponsors of investment measures in newly constructed owner-occupied or rented residential buildings and owner-occupied apartments as well as first-time purchasers Special features: Involvement of energy efficiency experts
KfW - Energy-efficient refurbishment - Supplementary loan (167)	Objective: Increasing the use of renewable energies in the heating market Object: Construction and expansion of heating systems for the use of renewable energies Eligible for funding: Sponsors of investment measures in and first-time buyers of owner-occupied or rented residential buildings and condominiums. Special feature: Involvement of energy efficiency experts

Source: Own elaboration, adapted from the Wärmewende Project

Table 5. Subsidies options in the scope of the Heating transition

BAFA – Modellvorhaben Wärmenetzsyteme 4.0	Objective: Demonstration of the new construction or transformation of heat grids into economically and technically feasible heat grid systems 4.0. Object: Feasibility studies and realizations of heat network systems 4.0 Eligible for funding: municipal enterprises, municipalities, municipal special-purpose associations, etc.
BAFA - Energy consulting for non-residential buildings	Objective: To enable an increase in energy efficiency in the public sector by demonstrating the most economically viable investments Subject: Energy consulting services for the preparation of an energy refurbishment concept for non-residential buildings (optional "contracting check") Eligible to apply: all natural persons and legal entities that meet BAFA's formal requirements for an energy consulting service.

BAFA - Market incentive program	Objective: Increase of renewable energies for heat and cold utilization in the building sector. Object: Construction and expansion of efficient systems for the thermal use and integration of renewable energies (incl. replacement of oil heating) Eligible recipients: .a. municipalities, local authorities and municipal special-purpose associations, private individuals Special features: combination with "Energy Efficiency Incentive Program" and "KfW Premium", among others
BAFA - Energy Efficiency Incentive Program	Objective: Use of renewable energies for heat generation in the building sector. Object: Replacement and optimization of inefficient heating systems Eligible recipients: municipalities, local authorities and municipal special-purpose associations, private individuals, etc. Special feature: Prerequisite is funding under the "Market Incentive Program".
BAFA - Promotion heating optimization	Objective: Increase energy efficiency in the building sector Object: Replacement of pumps and/or optimization of the heating system Eligible for funding: including municipalities, local authorities and municipal special-purpose associations, private individuals
KfW - Energy-efficient construction and refurbishment - Construction supervision (431)	Objective: New construction or refurbishment to KfW efficiency house as well as energetic refurbishment with individual measures for residential buildings. Subject: Energy planning and construction supervision by independent experts Eligible for funding: Investors who make use of expert planning and construction support services. Special feature: only possible in combination with KfW 151/152, 153, 430 and with the involvement of energy efficiency experts
KfW - Energy-efficient urban redevelopment (432)	Objective: significant increase in energy efficiency and reduction of CO_2 emissions in the district Object: integrated neighborhood concept and redevelopment manager Eligible for funding: local authorities, their legally dependent own operations Special features: Forwarding of subsidies possible
KfW - Energy-efficient construction and renovation - Fuel cell (433)	Objective: Introduction of fuel cell technology for heat and power supply. Object: Installation of stationary fuel cells in new and existing residential and non-residential buildings.

	Eligible for funding: including municipal authorities, their legally dependent proprietary companies and municipal special-purpose associations, private individuals.
NKI - Municipal Directive	Goal: Accelerate reduction of greenhouse gas emissions and realize measurable greenhouse gas savings in the municipal environment. Objective: among other things, consulting, energy and environmental management systems, networking, potential studies, measures, climate protection concepts and managers Eligible for funding: municipalities and associations, businesses, companies and organizations with at least 25 percent municipal participation.
DBU - Environmental relief	Objective: To promote innovative, model projects for the protection of the environment. Objective: Among other things, energy- and resource-saving development and renewal of neighborhoods, climate and resource-friendly construction, renewable energies - decentralized heat transition, optimization of existing facilities. Eligible for funding: natural persons and legal entities under private and public law
BMU - Environmental Innovation Program (230)	Objective: Avoidance or reduction of environmental pollution. Object: climate protection measures such as energy saving, energy efficiency, use of renewable energies, environmentally friendly energy supply and distribution, etc. Eligible for funding: including local authorities, companies with a majority municipal shareholder background, private individuals.
BMI - Urban development funding	Objective: to take account of climate protection requirements and adaptation to climate change (e.g. energy-efficient neighborhood renewal), among other things. Objective: inter alia, promotion of urban redevelopment (Art. 5), adaptation of urban infrastructure, including basic services Eligible for funding: Municipalities

Source: Own elaboration, adapted from the Wärmewende Project.